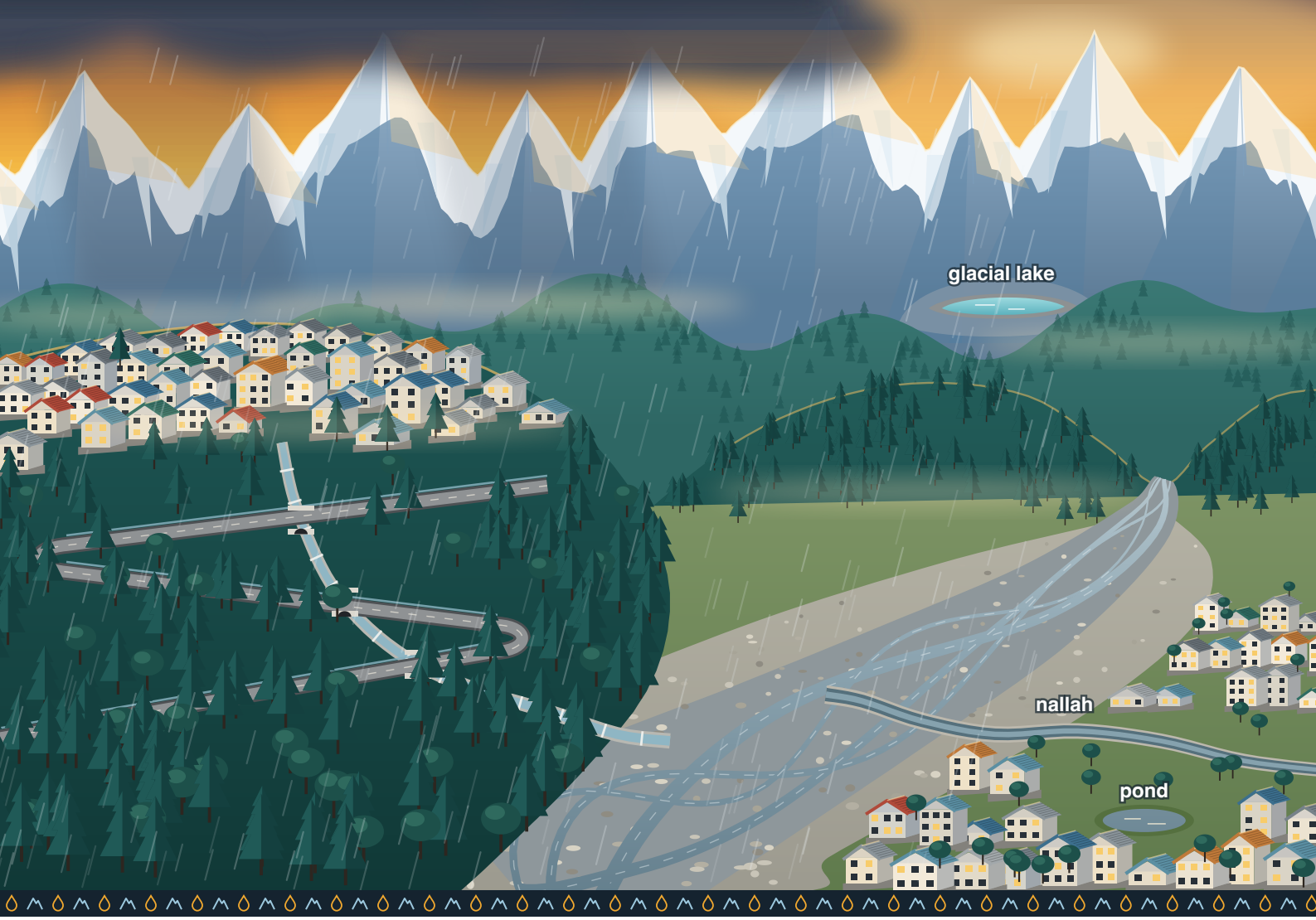
ARUNACHAL PRADESH

Stormwater Design Manual

Standards for the planning, design, construction, operation and maintenance of stormwater systems



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Prepared by

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About this draft

Status. This is Draft v1.0 of the *Arunachal Pradesh Stormwater Design Manual*. It was prepared by Neer as a proposed stormwater design standard for Arunachal Pradesh.

Not adopted. This Manual has not been adopted, notified or endorsed by the Government of Arunachal Pradesh, by its Governor, its Council of Ministers or its Legislative Assembly, or by any of its departments, local bodies or agencies. In particular, it has not been adopted, notified or endorsed by the Department of Urban Affairs (formerly the Department of Town Planning and Urban Local Bodies) or any of its wings, Urban Development, Town Planning, Housing and Urban Local Bodies, by the Directorate of Town Planning, by the Director/Chief Town Planner as the Authority under the Arunachal Pradesh Building Bye-Laws, 2019 or by any Building Permission Committee, by the State Urban and Country Planning Board, the Itanagar Planning Authority or any other Local Planning Authority, by the Itanagar Municipal Corporation (IMC), its Mayor or its Commissioner, by the Pasighat Municipal Council or any other urban local body or Municipal Building Committee, or by the Itanagar and Pasighat Smart City companies. Nor has it been adopted, notified or endorsed by any village authority, Gram Panchayat, community or clan, or by any Deputy Commissioner, including the Deputy Commissioner, Itanagar Capital Complex. Where it names a body, such as the Water Resources Department (WRD), the Public Health Engineering and Water Supply Department (PHED), the Public Works Department (PWD) or PWD (Highways), the Arunachal Pradesh State Disaster Management Authority (APSDMA), the Department of Disaster Management (DDM) or a District Disaster Management Authority, the Arunachal Pradesh State Pollution Control Board (APSPCB), the Department of Environment, Forest and Climate Change, the State Wetland Authority, the North Eastern Electric Power Corporation (NEEPCO) or NHPC, the Gauhati High Court at its Itanagar Bench, the National Green Tribunal (NGT) or the Supreme Court, or a body of the Union or an external or research body, such as the Central Water Commission (CWC), the India Meteorological Department (IMD), the Central Ground Water Board (CGWB), the Central Pollution Control Board (CPCB), the Comptroller and Auditor General of India (CAG), the National Disaster Management Authority (NDMA), the National Institute of Hydrology (NIH) or the North Eastern Regional Institute of Science and Technology (NERIST), it describes the role that body would have if the Manual were adopted. It does not say the body has agreed to that role. Citing a body's document does not make this Manual that body's document.

No legal force. Until a competent authority adopts it, with or without changes, this Manual has no legal force. Until then, the Arunachal Pradesh Building Bye-Laws, 2019 (the APBBL 2019), the Arunachal Pradesh Urban and Country Planning Act, 2007 as amended (the UCP Act), with the Arunachal Pradesh Urban and Country Planning (Amendment) Ordinance, 2025 (Ordinance No. 5 of 2025) and whatever Act replaces it, the Arunachal Pradesh Municipal Act, 2007, the Arunachal Pradesh Municipal Corporation Act, 2019, the Arunachal Pradesh (Land Settlement and Records) Act, 2000 and the customary rights it incorporates, the Master Plan of Itanagar Capital Region-2031, orders of courts and tribunals, and approval conditions in force continue to apply.

Arunachal Pradesh and its land. No part of Arunachal Pradesh lies in the Sixth Schedule to the Constitution, and the State has no District Councils. Article 371H, inserted by the Constitution (Fifty-fifth Amendment) Act, 1986, gives the Governor a special responsibility for law and order; it does not protect customary law or land, as summarised from a published copy of the Constitution. Land is governed by the Arunachal Pradesh (Land Settlement and Records) Act, 2000 (Act No. 10 of 2000), "a comprehensive law for land revenue administration for the whole of the State of Arunachal Pradesh incorporating customary rights on the land". It defines a "community" as "residents of a village as a whole", including "a clan, sub-clan, kindred", and "common land" as land "used or reserved for the common use of a community or a village" (section 2), and it declares the beds of "rivers, streams, nallahs, lakes and tanks" and "all standing and flowing water" to be the property of the Government only where they "are not the property of any person or community" (section 9(1)), as read in a scanned copy. Much of the land in and around the towns is held by communities, clans and individuals; individual titles came with an amendment of 2018, as reported. Nothing in the Constitution limits the State's laws

on land here, as this Manual reads it, and the APBBL 2019 extend "to whole of Arunachal Pradesh" (2.1); but a stream or nallah bed on community or clan land is not Government property. So in this Manual setbacks and corridors are **conditions of building permission and layout approval wherever the bye-laws apply, and guidance elsewhere**. Where no permission is sought, the Manual reaches the public works that the State's departments and agencies execute (Clause 1.5.1(b)) and any body that adopts it; for a household or a community it is guidance only. Land for a public drain or corridor that is not Government or municipal land is secured by agreement with the owner, the clan or the community, by donation or purchase, or reserved in a master plan, a layout or a Town Planning Scheme; this Manual does not assume that land can be taken, and it binds no community or clan on its own land. The State or a local body could take the Manual up in several ways: the Department of Urban Affairs (Town Planning wing) could carry it into the five-year review of the APBBL 2019 (2.2), or notify its corridor as the "norms" that bye-law 2.10.1(e) refers to; IMC could make bye-laws and connection rules under the Municipal Corporation Act, 2019, and the Pasighat Municipal Council could act under sections 194 to 196 of the Municipal Act, 2007; the Itanagar Planning Authority and the other Local Planning Authorities could carry it into master plans, layouts and Town Planning Schemes; APSDMA could refer to it in the "Disaster Prone Area" norms that bye-law 2.10.1(f) anticipates and in district disaster management plans; and PWD and WRD could apply it to their own works. None has done so.

Names. Some places, rivers, gauges and instruments have more than one name or spelling in statutes, sources and on IMD and CWC stations:

- **Pasighat** is **Passighat** in CWC's flood estimation report and in IMD's tables, where its station is Pasighat (A), index 42220; **Ziro**, also called Hapoli, is **"Zero"** in IMD's station list (index 42312); **Aalo** is also Along; **Daporijo** is CWC's **Daporizo**; and **Yingkiong** is CWC's **Yinkiang** or **Yinkiong**. CWC's flood estimation report for subzone 2(a) lists Passighat under the district "Tirap", as printed; the town is in East Siang. District names follow the list of 2024 as reported, and were not verified; **Keyi Panyor** is the district formed round Yazali from Lower Subansiri;
- the **Siang** is the **"Dihang or Siang"** of the CWC plates, and the Yarlung Tsangpo in Tibet; the **Dibang** is the plates' **"Dibang or Sikang"**; and the **Dikrong** of this Manual is the **Dikrang** of some sources. The **Ranganadi** project of NEEPCO is also called Panyor. **Ganga Lake**, near Itanagar, is also **Gyakar Sinyi** and **Gyekar Syenek**. This Manual keeps each source's spelling where it quotes the source;
- the **Itanagar Capital Region** (**ICR**) is the area of the Master Plan of Itanagar Capital Region-2031: Itanagar, Naharlagun, Nirjuli, Doimukh and Banderdewa. The **Itanagar Capital Complex** is the district of the Deputy Commissioner who chairs the Itanagar Planning Authority. The two are kept apart. The municipal area of Itanagar (Itanagar, Naharlagun, Nirjuli and Banderdewa) is the area of **IMC**, the **Itanagar Municipal Corporation**;
- IMD's **Meteorological Centre Itanagar** (**MC Itanagar**) issues the State's bulletins. IMD has no Itanagar station in its tables of extremes; the stations there are Pasighat, Tezu, Ziro and Hayuliang. The daily gauge of **NERIST**'s meteorological laboratory at Doimukh, whose series of 1988–2012 Dabral et al. (2016) analysed, is the only gauge with a published frequency analysis in the capital region;
- CWC's flood estimation reports divide the State two ways. The State north and west of the Lohit is in **subzone 2(a), North Brahmaputra** (report No. NB/18/1991), whose contours stop at the foothills, so that the middle hills and the high ranges lie inside the subzone but in blank map space; the south-east is in **subzone 2(b), South Brahmaputra** (revised report No. SB-2(b)/R-4/44/99, March 2000), whose contours also reach north of the Lohit to Pasighat, Roing and Tezu. These subzones are not the four rainfall zones (AR-Z1 to AR-Z4) and seven hydrologic sub-areas (AR-A, AR-A1, AR-B, AR-C, AR-C1, AR-D and AR-E) that this Manual sets in Annex 2A, nor Zones 1 and 2 of a waterbody setback in Chapter 7;
- CWC's levels at its sites in the State, Passighat, Namsai, Tezu, Miao and others, were read only as SANDRP transcribed them in 2019, and the datum is not stated. This Manual names the gauge, the unit and the datum with every level; and
- in this Manual **"the monsoon" and "the monsoon season" mean the wet season of 1 April to 31 October**. That is not IMD's usage: IMD counts April and May as pre-monsoon months, and the south-west monsoon's normal onset at Itanagar is 5 June (4 June before) and its normal withdrawal 14 October, in

IMD's monsoon normals of 2020, as summarised; no dates were found for Pasighat. The Manual's season begins on 1 April because April and May are already wet and stormy: at Doimukh May brings 505.9 mm, and March to May 24.0% of the year (Chapter 2).

This Manual uses the first form and keeps the others where a title, a source or a station uses them. Some names of bodies and laws need a word of explanation:

- the **Arunachal Pradesh Building Bye-Laws, 2019** (the **APBBL 2019**) are the State's building rules, issued by the "Department of Town Planning and ULBs, Government of Arunachal Pradesh". They "shall extent to whole of Arunachal Pradesh with effect from the date of notification" (2.1) and apply "for a period of FIVE years after which they shall be reviewed. Till such time the reviewed building byelaws are notified, these building byelaws will continue to be in force" (2.2). The "Gazette Notification" page of the copy read is blank, so their notification number, date and gazette reference are not known [TBC]. The Arunachal Pradesh Fire and Emergency Services Act, 2026 (Act No. 12 of 2026) names them as "the 'Arunachal Pradesh Building Bye-laws- 2019'" (section 2(c)), and the Online Building Permission System launched on 30 July 2025 was customised to them, as reported. No amendment was found. Their "Authority" is "The Director/Chief Town Planner of Town Planning & Urban Local Body … till an executing authority is notified" (definition 12). This Manual writes "APBBL 2019, 4.39(14)" for a provision. Two earlier texts are always written in full and are not the current rule: the **Arunachal Pradesh Building Byelaws – 2009, "FINAL DRAFT"**, whose hill-site clause on "landslide prone areas" and the "diversion of the natural flow of water coming from uphill side" is not in the 2019 text, though the report of the ICR Master Plan reproduces it; and the **Arunachal Pradesh Building Bye-Law 2010**, listed as notified on the Town Planning portal, as summarised, and not read. **MBBL 2016**, in Chapters 1 and 10, is the national Model Building Bye-Laws of 2016, not the State's bye-laws;
- the **Arunachal Pradesh Urban and Country Planning Act, 2007** (the **UCP Act**; Act No. 3 of 2008; Notification No. LAW/LEGN-6/2007 of 11 March 2008), whose copy prints its assent as "7th March, 2007", which this Manual reads as probably a misprint for 2008, sets up the State Urban and Country Planning Board and the Local Planning Authorities, which are bodies corporate (section 10(2)); master plans are approved under section 24. The **Master Plan of Itanagar Capital Region-2031** was approved on 3 June 2022 (No. TP-ULB-21011/3/2021-Dir-TP-ULB (E-31358)); the report read is titled "Draft", and whether the approved text differs was not checked [TBC]. **Ordinance No. 5 of 2025** adds Town Planning Schemes, land pooling, local area plans and a definition of a "sponge city", and lets the Government prepare policy documents on a "Sponge City" and a "Risk Informed master Plan" (new section 71(2)(za)); its date of promulgation is not legible in the copy read [TBC]. An amending Bill was passed on 9 March 2026, as reported; its Act number and final text were not found [TBC], and this Manual does not cite the Ordinance's provisions as enacted law. There is no "Arunachal Pradesh Town and Country Planning Act";
- the **Arunachal Pradesh Municipal Act, 2007** (Act No. 4 of 2008; Notification No. LAW/LEGN-21/2007 of 19 March 2008) governs the **Pasighat Municipal Council** and the State's other municipalities. It makes "drainage and sewerage" a core municipal service (section 47(1)(a)), vests public drains, tanks and streams in the Municipality "Notwithstanding anything contained in any other law" (section 102), and requires it to "construct and maintain drains and sewers, and provide a safe and sufficient outfall" for storm water and sewage "in such manner as may not cause any nuisance, whether by flooding" (section 194). Section 104 routes compulsory acquisition through the "Land Acquisition Act, 1894", as printed. Pasighat's municipal area, 10.21 km², was notified on 24 August 2010; the High Court records a notification of 20.12.2012, and the two dates do not agree. The Council has 8 wards, as reported;
- the **Arunachal Pradesh Municipal Corporation Act, 2019** (Act No. 8 of 2019; Notification No. Law/Legn-4/2019 of 30 September 2019) governs **IMC**. It makes "the maintenance and cleaning of drains and drainage works" an obligatory function (section 60(a)), vests public drains and sewage works in the Corporation (section 200), and forbids "foul water into a drain provided for surface water" where separate drains exist (section 203). The Itanagar municipal area was notified on 14 September 2010 under section 4(1) of the 2007 Act; the High Court records a notification of 06.02.2012 under section 6, and the two may both exist. The notification constituting IMC under the 2019 Act was not found [TBC]. IMC has 20 wards; its first mayor was elected in January 2021 and a new council in January 2026, as reported;

- the **Department of Urban Affairs** ("Urban Affairs") was "Re-named as Department of Urban Affairs in 2021", with four wings, Urban Development, Town Planning, Housing and Urban Local Bodies, and lists among its functions "Storm Water Drains; Drainage; Sewerage; Septage Management". It is a works department with a Chief Engineer and 28 divisions. Its Town Planning wing, the **Directorate of Town Planning**, issued the bye-laws, prepared the ICR Master Plan and in 2017 invited bids for a drainage master plan of the capital. The press still writes "UD&H"; this Manual uses that only inside a quotation. The **Itanagar Planning Authority**, the Local Planning Authority for the ICR, is chaired by the Deputy Commissioner, Itanagar Capital Complex; notifications of other Local Planning Authorities, among them Ziro and Namsai, are listed on the Town Planning portal by title;
- **WRD** holds the rivers and their anti-erosion works, as reported; it is named in this Manual as the State groundwater agency, although no State network of observation wells was found, and the only network found is CGWB's, in its North Eastern Region. **PHED** supplies water. The **PWD** and **PWD (Highways)** keep the State's roads and NH-415 and their drains, as reported. **APSDMA**, the Arunachal Pradesh State Disaster Management Authority, is named in full at its first use in each chapter, because another edition of this series uses the same letters; its own documents were not read [TBC]. **DDM**, the Department of Disaster Management, issues the daily situation reports and the **State Emergency Operation Centre** the damage reports, as reported. The District Disaster Management Authorities are written in full. **APSPCB** grants pollution consents. The **State Wetland Authority** is named in the press, and its exact name and constitution were not found [TBC]. **NEEPCO** operates the Pare, Ranganadi and Kameng hydro-electric projects, and **NHPC** the Lower Subansiri project, and is building the Dibang project; their release rules were not found;
- the **NGT** and the **Gauhati High Court at its Itanagar Bench** have shaped the State's sewage and municipal work. The NGT's case on the Senki, the Pachin and the Dikrong (OA 94/2020/EZ, *S. D. Loda v. Union of India & Ors.*) is pending, and its order of 5 January 2023 directed that "no untreated sewage or treated sewage be allowed to enter into the waterbody", as summarised; in OA 606/2018 the State filed an affidavit-cum-six-monthly report in 2025. The Itanagar Bench's judgment of 28 September 2018 in PIL 22(AP)/2018 directed municipal elections. No order on the capital's drains, earth cutting or landslides was found. This Manual cites court and tribunal orders with their status; and
- where a shared clause names a revenue subdivision, this Manual uses the **circle**, as the sources do ("Toru circle"), and where it says "revenue village" it means the village of the circle. Land records are kept by the **land revenue offices of the Deputy Commissioners**; much community and clan land is not in any State register (Chapter 7).

Where a shared clause calls for the local language on a sign, a form field or a basin name, this Manual writes "the local language". **English is the language of the State's laws and administration, and of this Manual**, as reported; no official-language Act was checked for this Manual. Arunachal Pradesh has many tribal languages, among them Nyishi, Adi, Galo, Apatani, Monpa, Mishmi and Tangsa, and no single local language; which spoken language serves as a common language between them was not researched, and this Manual names none. So, as set by this Manual, **signs and flood-depth markers are in English and the local language: the language in local use in the ward or village, as the local body or the village authority uses for its own public notices**, because a sign must be readable by the people it warns. The scripts in use were not researched; where a shared clause says "script", it means the spelling of the name that the local body uses [TBC]. In Annex 7A the field coded LOC holds a water body's name in the local language.

Some local words are used in the text, and are explained again where they first appear:

- a **pond** is this Manual's word for a natural or dug body of standing water. The Manual uses the plain English word because English is the State's working language; because no tribal language is shared across the State; because the Nyishi word *sinyi* means a lake or a tank rather than a small town pond (below); and because the statutes, the ICR Master Plan and the State's wetland survey already write "pond" and "tank" in English. In the shared clauses a "tank" is water impounded by a bund with a surplus weir, which the State hardly has; the tank clauses apply in this Manual to ponds, to lakes and to any other

impounded water. Where a shared list therefore names a pond twice ("tank (pond), lake, pond"), the repetition is the shared text's. Engineered storage is a **detention pond**. A natural pond or lake keeps its own description, and a lake, a spring pool or a reservoir is never called a detention pond;
- a **lake** is a natural body of open water larger than a pond. Most of the State's lakes are high-altitude lakes far from the towns; a **glacial lake** is one held by ice or moraine below a glacier. Ganga Lake, in the Itanagar Wildlife Sanctuary, is the capital's lake;
- a **nallah** is a natural or open channel in or near a town that carries storm water and, in practice, waste water. The word is the bye-laws' ("Distance from Nallah/Stream", 2.10.1(e)), the Land Act's ("nallahs", section 9(1)) and the ICR Master Plan's ("natural drainage system (Nallah)"), and it is part of place names such as Papu Nallah. This Manual spells it "nallah" throughout;
- *Jhot* is the bye-laws' "strip of land permanently left open for drainage purposes. It is not to be used as an access way or a street and is not to be included as a part of setbacks" (APBBL 2019, definition 69). The bye-laws give it no width, and this Manual uses the word for that strip only;
- a **spring** is a natural outlet of groundwater at the surface. In the northern hills of East Siang springs are the only source of water, and in Papum Pare "most of the springs become dry during dry season", as CGWB records; no inventory of the State's springs was found. A **stream** is a natural channel, and a **river** a main channel such as the Siang, the Lohit or the Dikrong;
- in **Nyishi** (called "Dafla" in the source), R. C. Hamilton's *An Outline Grammar of the Dafla Language* (1900) gives, in its English–Dafla vocabulary: **sinyi** "Lake" (about p. 104) and "Tank" (about p. 118), the second word of *Gyakar Sinyi*, as this Manual reads the name; **issi** "Water" (about p. 122); and **selam** "Channel" (about p. 96). Its word for "Spring", *lol*, "is rarely used", by the vocabulary's own note (about p. 118), and its words for "Rain", *pödöng* and *nyadang*, are uncertain in the scanned text; neither is used here; and
- no terms were found in Adi, Galo, Apatani, Monpa, Mishmi or Tangsa: Lorrain's Abor-Miri dictionary was not located, and Needham's grammar of Shaiyang Miri (1886) has no word for pond or drain [TBC].

The page numbers are approximate, read from the scanned text of the vocabulary. These words are glosses: the Manual's working words are pond, lake, nallah, spring and stream, and the Nyishi terms appear only here and in Annex 7E.

Some abbreviations have more than one meaning:

- AMC is the antecedent moisture condition in Chapters 2 and 3; this Manual does not use it for any municipal body;
- IMC is the Itanagar Municipal Corporation, and APSDMA the Arunachal Pradesh State Disaster Management Authority. In other editions of this series the same letters stand for other bodies; in this Manual they mean only these two. Each chapter writes the full name at its first use;
- "APBBL 2019" is the Arunachal Pradesh Building Bye-Laws, 2019, and "MBBL 2016" the national Model Building Bye-Laws 2016. Neither stands for the 2009 Final Draft or the "2010" bye-laws;
- "Authority", in the bye-laws, is the Director/Chief Town Planner, or the executing authority once one is notified (definition 12); the Itanagar Planning Authority is the Local Planning Authority under the UCP Act;
- the ICR is the Itanagar Capital Region of the master plan, never the Itanagar Capital Complex;
- HFL is the highest flood level recorded at a gauge, and DL and WL the danger and warning levels that CWC sets at its sites. None is a design level. CWC has no site on the Senki, the Pachin or the Dikrong at the capital; Passighat's HFL of 157.54 m, on 11 June 2000, is the stage of an outburst flood, 3.58 m above its danger level of 153.96 m, as SANDRP transcribed them; and Chapters 5 and 7 say how this Manual finds a design level;
- MC is IMD's Meteorological Centre Itanagar; DC is a Deputy Commissioner; and
- HEP is a hydro-electric project, as NEEPCO and NHPC name them.

The sense is clear from the context.

Use with care. Clauses and values may change after review. Designers remain responsible for their designs and for checking the data they use. Neer accepts no liability for decisions made on the basis of this draft.

Disclosure. Neer publishes the India Flood Atlas, a national map of modelled 1% AEP flood depth. Clause 6.11.3 names it as one example of a regional map that an Approving Authority may adopt for floor levels. The Manual does not require the Atlas; any map adopted under Clause 7.3.4 may be used.

Comments. Comments and corrections are welcome at info@neer.ai.

Preface

Arunachal Pradesh's towns flood, and fail, for three reasons. The capital's rainfall records show the first: the only frequency analysis in the capital region, of 25 years of NERIST's daily gauge at Doimukh, gives a 25-year day about one contour above the CWC plate, and the plate draws no contour at all north of the town. Itanagar showed the second on or about 14 September 2018, when cloudburst floods in the Modirijo and Donyi Polo catchments killed three people, left at least four missing and washed away the Senki View culvert and the Press Colony bridge, as reported. And Pasighat shows the third, because the Siang that its drains fall to is set by floods that start in Tibet: on 11 June 2000 the breach of a landslide dam on the Yigong raised the river at Pasighat to CWC's highest recorded level, 157.54 m, against a danger level of 153.96 m, as SANDRP transcribed them.

1. **Rainfall that the national products barely cover.** CWC's subzone 2(a) covers the State north and west of the Lohit on paper, but its report (NB/18/1991) draws contours only along the foothills, from about Bhalukpong and Itanagar to Ziro, Likabali, Roing and Tezu, as this Manual reads its plates. Seppa, Bomdila, Dirang, Tawang, Daporijo, Aalo, Mechuka, Yingkiong and Anini, and Pasighat itself on 2(a)'s plates, lie inside the subzone but in blank map space. The south-east is in subzone 2(b), whose contours also reach Pasighat, Roing and Tezu, where the two reports disagree by about one contour. At Itanagar the plates give about 180 mm for the 25-year day and about 200 mm for the 50-year day, read by eye; NERIST's daily gauge at Doimukh, 1988–2012, gives a 25-year 1-day fall of 210.39 mm (Dabral et al., 2016), about 238 mm as a 24-hour depth by this Manual's arithmetic; and the gridded rainfall of NIH-DHAARA gives the Itanagar cell a 50-year day of 472 mm, more than twice the plate. IMD's national set of rainfall intensity curves (Das et al., 2022) has no panel for any Arunachal Pradesh station. IMD's largest day at Pasighat, 652.2 mm on 5 October 1988, is 37% above the next-largest, 476.7 mm on 22 August of the same year, and has not been confirmed. No hourly rainfall from any gauge in the State was found in any primary source.
2. **Steep foothill towns on Siwalik sandstone and shale, where cut slopes and debris fail and water put into the slope moves the ground.** Itanagar and Naharlagun are built on the Siwalik hills, which "form hogback topography" over sandstone, shale and boulder beds, as CGWB describes them, in seismic Zone V with "5 fault lines in the city", as the ICR Master Plan records. On 11 July 2017 a landslide at Laptap, in Papum Pare, killed 14 people after three days of rain, as reported, though the tolls differ, and no rainfall amount for it was published. The press reports drains along the Bage Tinali–Naharlagun road "too shallow and narrow" and choked with earth-cutting debris, and the 2018 floods brought down a landslide from "the dumping area of NH 415", as reported. The APBBL 2019 refuse earth-cutting permission where "the average slope of the topography is more than 30%", limit a cut to 3 m and require a retaining wall "immediately" after cutting (4.39), the strongest slope rule in this series' North-East editions; but they say nothing about putting water into the slope, and they make recharge structures mandatory for every building of 500 m² or more (9.7), on a slope as on a terrace.
3. **Foothill towns on fans and flood plains whose rivers are set by outbursts, glaciers and dams.** Pasighat, Ruksin, Roing, Tezu and Namsai stand on the bhabar fans and flood plains of the Siang, the Dibang, the Lohit and the Noa-Dihing, where "the Bhabar is mostly composed of boulders while flood plain is composed of fine sand and silt", as CGWB writes of Lohit. The Yigong outburst of June 2000 raised the Siang by 5.5 m at Pasighat, in a peer-reviewed analysis as summarised, and in November 2017 the river ran turbid after landslide dams formed in Tibet, as reported. NDMA lists 27 glacial lakes in the State as high-risk, 16 of them in Dibang Valley and 6 in Tawang, as reported. Dams upstream release into town reaches: NEEPCO's Pare dam discharged 1,310 m³/s into the Dikrong above Doimukh on 31 May 2025, as reported, and a flash flood in a side stream swept through the NEEPCO colony at Yazali on 24 June, in 2025 or 2026, as reports disagree.

Over all three lie four more conditions. **The drains carry the towns' sewage**: in the capital "storm water drains being used as sewers", as the ICR Master Plan puts it, and "no ULB is treating sewage. Even the state capital, Itanagar-Naharlagun, lacks a sewage treatment facility", as the observations quoted in the State's affidavit of 2025 to the NGT record. **Land along the streams is community, clan or private land**, and a stream bed on it is not Government property (section 9(1) of the Land Act). **The building rule is statewide, with a strong slope bar but no stream distance**: the APBBL 2019 ask a site

plan to show the "Distance from Nallah/Stream as per the notified rules/norms" (2.10.1(e)), and no such rules or norms were found. And no drain has a design standard: no State, municipal or departmental document fixes a design storm, a return period or a runoff coefficient for any town's drains, and the ICR Master Plan records that "no scheme or work for storm water drains is under execution", with "only 3.7% storm drains along main roads".

Behind all of this lie the State's rivers, lakes, ponds and springs. The Forest Department's survey of wetlands larger than 2.25 ha counts 1,127, of which 944 are high-altitude lakes and only 2 tanks or ponds, and Papum Pare, round the capital, has 6; the first Water Bodies Census counts 993 water bodies, 100 of them urban, and reports none encroached, as summarised. The capital's drains "end up mostly into the Nallah and in some cases, into local ponds or open fields", the ICR Master Plan records, and "rivers like Pachin flowing through densely populated areas had become a waste disposal site". CPCB first listed the Senki at Chandranagar, upstream of the Pachin, among its polluted river stretches in 2025, in Priority V. The capital draws 7 MLD from the Senki by lift and 11 MLD and 7 MLD from the Poma and the Niorch by gravity. Ganga Lake, in the Itanagar Wildlife Sanctuary, faces earth cutting and encroachment, as reported, and Glaw Lake in Lohit became the State's first Ramsar site in August 2026, as reported. No floodplain, waterbody, spring or nallah protection law was found beyond the bye-laws' duty on local bodies to "identify, demarcate, protect and maintain the water bodies" (Annexure E 1.8) and their chapter on natural features.

Design for Arunachal Pradesh therefore has to cover a wet season that begins in April. At Doimukh April brings 227.7 mm, May 505.9 mm and June, the wettest month, 762.8 mm; March to May bring 846.5 mm, 24.0% of the year's 3,531.8 mm, in NERIST's series, and "The state receives rainfall over a period of 8 to 9 months excepting in winter", as the State Action Plan on Climate Change (SAPCC, 2011 draft) records. The south-west monsoon reaches Itanagar on 5 June and withdraws on 14 October, in IMD's normals as summarised, but the damaging storms of the late pre-monsoon cluster in the last ten days of May: the remnants of cyclone Remal gave Bomdila 190 mm in 24 hours on 28–29 May 2024, as summarised from an IMD bulletin, and on 30 May 2025 a landslide swept a vehicle off NH-13 between Bana and Seppa and seven people died, as reported. This Manual's monsoon season is 1 April to 31 October, so that drains are cleared and slopes stabilised before the April storms of the east and the May storms of the capital. Large falls come outside it too, as on 3 and 4 October 1979 at Hayuliang (280.0 mm) and Tezu (222.0 mm), and on 4 February 1961 at Pasighat (137.6 mm), so design statistics use the annual maxima of every month. Snow falls in the high ranges in winter. The annual normals conflict: Itanagar's is given as 3,942.44 mm by CGWB, as summarised, and as 2,289 mm by the ICR Master Plan, which gives no source; Doimukh's as 3,531.8 mm by NERIST and 3,251.67 mm by CGWB, as summarised. This Manual uses none of them as a normal. Underground, the State draws 0.39% of its extractable groundwater (2024, as summarised), and 15 of CGWB's 27 stations in the State stood within 2 m of the ground in August 2025, as summarised, so rainwater is worth storing for use, not putting into the slopes or the flood plains.

National guidance sizes public drains but does not control the runoff that new building adds. This Manual makes stormwater a condition of development approval wherever a building permission is granted. Every development above a modest size must:

- hold frequent rainfall on site, in tanks for use, and in the ground only where the ground can safely take it;
- release the large storms no faster than the undeveloped land did, or slower where catchments already flood; and
- show that its outfall still works when the receiving stream, nallah, river, pond or lake is high, when a dam upstream is releasing, when the main river carries an outburst flood, or when a drain or culvert is choked with debris, silt and garbage.

The Manual also sets how public drains, hill roads and their drains and culverts, hill streams, nallahs, rivers, ponds, lakes, reservoirs and their release reaches, springs and their recharge areas, outfalls and basin-wide master plans are designed, and how drains in steep catchments are protected against debris, sediment and garbage, so that private sites and public works aim at the same standard.

The Manual draws on leading stormwater standards from India and abroad. Each is adapted to Arunachal Pradesh's wet season of April to October; to the capital region of Itanagar, Naharlagun, Nirjuli, Doimukh and Banderdewa, on Siwalik sandstone, shale and boulder beds whose cut slopes slide, with its sandy valley terraces and the flood plains of the Pachin and the Dikrong; to the hill towns of the middle hills, Ziro, Daporijo, Aalo, Seppa and Yingkiong, and of the high ranges, Tawang, Bomdila and Dirang, with snow, glaciers and glacial lakes above them; to the bhabar fans and

flood plains of Pasighat, Roing, Tezu and Namsai, on rivers fed from Tibet and from glaciated ranges; to the release reaches below the dams; to springs and streams that supply the towns; and to towns that stand on community, clan and private land, whose roads and houses lie across the natural lines of drainage on the slopes.

1. **National base.** The CPHEEO *Manual on Storm Water Drainage Systems* (2019). This Manual builds on it and sets higher standards where it allows a State to do so. IRC road-drainage codes, including IRC:SP:42-2014 on hill roads, and the NDMA urban flood guidelines are also used. The drainage chapter of the IRC's hill road manual, IRC:SP:48, was not read for this Manual.
2. **Overall structure.** Kansas City Metro APWA Section 5600 (Version 2025.01), the most recent comprehensive regional standard. It supplies the preserve, retain, detain, convey and maintain sequence and the required retention volume.
3. **Design rainfall.** The CWC *Flood Estimation Reports* for subzone 2(a), North Brahmaputra (1991), in the foothills, and for subzone 2(b), South Brahmaputra (revised, March 2000), in the south-east, as the interim sources, with the higher reading where both plates draw contours; on the Noa-Dihing plain with the 2(b) report's own ratios of short to 24-hour rain, and elsewhere with interim ratios set by this Manual, which are not below any ratio that NIH-DHAARA gives for the State. In the capital region a table set from NERIST's Doimukh series governs, not the plate, because the gauge reads about one contour above it. In the middle hills and the high ranges, beyond the last contour, the design day is not less than floors set by this Manual. Short-storm floors apply in the foothills and on the plain. The design day is checked against the largest reliable days recorded within 25 km, but only within the same domain (the foothills and the plain, or the hills) and never across the foot of the hills; Pasighat's 652.2 mm stays in that check until IMD confirms or withdraws it. Snow-fed and glaciated catchments are treated site by site, with screening for glacial-lake and landslide-dam outbursts. NIH-DHAARA is reported beside the design value and never used as one, and IMD's national curves (Das et al., 2022) are not used, since they have no Arunachal Pradesh panel.
4. **Monsoon practice.** The PUB Singapore *Code of Practice on Surface Water Drainage* (7th ed., 2025), for the fixed-coefficient route for small sites and drainage reserves. Malaysia's MSMA 2 (2012), for monsoon design storms and simplified on-site detention.
5. **Runoff reduction and treatment.** The Georgia Stormwater Management Manual (2016), for runoff reduction and downstream analysis. CIRIA C753 *The SuDS Manual* (2015), for the treatment train. The Mile High Flood District criteria manual, for outlet and storage design.
6. **Local rules.** The APBBL 2019; the UCP Act and Ordinance No. 5 of 2025, as summarised above; the Municipal Act, 2007; the Municipal Corporation Act, 2019; the Land Act, 2000; Article 371H, as summarised; the ICR Master Plan 2031 and the invitation of 2017 for a drainage master plan of the capital; the NGT's orders in OA 94/2020/EZ, as summarised, and the State's affidavit of 2025 in OA 606/2018; and CPCB's list of polluted river stretches of 2025. This Manual follows them or, where disclosed, makes them stricter. The gazette notification of the APBBL 2019, the bye-laws of 2010, the Act that replaced Ordinance No. 5 of 2025, the Land Act as amended in 2018, the notification constituting IMC, APSDMA's own documents, the drainage master plan prepared for the capital in 2021 and the Smart City drainage reports were not read. Every rule cited must be checked against the current text.

Sources: CPHEEO (2019) Part A §4.4–4.5 and Table 4.1; CPHEEO presentation to CSE (August 2023); IRC:SP:50-2013 §6; IRC:SP:42-2014 cl. 7.1.4 and 8.5.1; NDMA (2010) Urban Flooding Guidelines, para 6.6.2; MoHUA Model Building Bye-Laws (2016); Arunachal Pradesh Building Bye-Laws, 2019 (Department of Town Planning and ULBs), definitions 12, 35 and 69, 2.1, 2.2, 2.10, 4.2.1, 4.16, 4.19.1, 4.33, 4.39, Chapters 9, 12 and 14 and Annexure E; Arunachal Pradesh Building Byelaws – 2009, "FINAL DRAFT" (Directorate of Town Planning); Arunachal Pradesh Urban and Country Planning Act, 2007 (Act No. 3 of 2008), ss. 10 and 24, and the (Amendment) Ordinance, 2025 (Ordinance No. 5 of 2025); Arunachal Pradesh Municipal Act, 2007 (Act No. 4 of 2008), ss. 2(85), 47, 49, 102, 104, 194, 196 and 340–343; Arunachal Pradesh Municipal Corporation Act, 2019 (Act No. 8 of 2019), ss. 60, 200 and 203; Arunachal Pradesh (Land Settlement and Records) Act, 2000 (Act No. 10 of 2000), ss. 1, 2 and 9; Arunachal Pradesh Fire and Emergency Services Act, 2026 (Act No. 12 of 2026), s. 2(c); Constitution of India, Article 371H, as summarised; municipal area notifications for Itanagar (14 September 2010) and Pasighat (24 August 2010); Master Plan of Itanagar Capital Region-2031, notice of approval (30 June 2022) and draft report; Department of Town Planning and ULBs, invitation of expressions of interest for a GIS-based Integrated Drainage Master Plan and DPR for Itanagar Capital City (31 October 2017); Department of Urban

Affairs, website; Gauhati High Court, Itanagar Bench, PIL 22(AP)/2018, judgment of 28 September 2018; NGT, OA 94/2020/EZ (orders as summarised by the India Environment Portal), OA 606/2018 (State affidavit, 2025, and amicus observations of 20 March 2026) and OA 148/2025/EZ (CPCB reply of 5 January 2026); CPCB, Polluted River Stretches for Restoration of Water Quality (2025); CAG, Audit Report for the year ended 31 March 2023 (Government of Arunachal Pradesh); Department of Environment, Forest and Climate Change, Status of Truthing and Boundary Demarcation of Wetland of Arunachal Pradesh; CWC, Flood Estimation Reports for North Brahmaputra subzone 2(a), No. NB/18/1991, and South Brahmaputra subzone 2(b) (Revised), No. SB-2(b)/R-4/44/99 (March 2000), Plates 8–10, read by eye; IMD, Extremes of Temperature and Rainfall for Indian Stations (up to 2012); IMD, Monsoon normals (2020), as summarised; Dabral, Kumar and Tana (2016), CIGR Journal 18(4); Das et al. (2022), MAUSAM 73(4); NIH-DHAARA (queried 14 November 2026); Arunachal Pradesh State Action Plan on Climate Change (draft, 2011); CGWB, district booklets for Papum Pare, East Siang, Lohit, Changlang, West Kameng and Tawang; R. C. Hamilton, An Outline Grammar of the Dafla Language (1900); CWC levels as transcribed by SANDRP (2019); reports of the floods and landslides of 2000, 2017, 2018, 2024, 2025 and 2026, of the dam releases and glacial lakes, of the State's lakes and wetlands, of the official language and of the bye-laws' online system (press and secondary sources).

Why this Manual is needed

India has no uniform stormwater design standard. The CPHEEO *Manual on Storm Water Drainage Systems* (2019) is the country's first manual dedicated to storm water drainage, but it is advisory. The Ministry of Housing and Urban Affairs lists it among advisory guidelines and treats urban flooding as a matter for State Governments and urban local bodies. None of the national rules or State building rules reviewed for this Manual makes runoff control a condition of building approval, and neither does the Model Building Bye-Laws 2016.

The national documents leave key values open, or give different answers.

- **Return periods.** CPHEEO recommends 5 years for drains in Class I cities and 2 years elsewhere, and lets a State committee adopt higher values. A 2023 CPHEEO presentation shows a different table. IRC:SP:50-2013 suggests 1–2 years for urban road drains; IRC:SP:42-2014 suggests 5–25 years for road drains and 10–50 years for culverts, by class of road and size of culvert. An engineer designing a drain in Arunachal Pradesh can cite 1, 2, 5, 10 or 25 years, depending on the code chosen.
- **Detention.** CPHEEO describes limiting peak outflow to pre-development rates as general practice. It uses no "shall" and names no storm frequencies.
- **Climate.** The NDMA Urban Flooding Guidelines (2010) call for detention and retention facilities and for rainfall curves adjusted for climate change, but give no sizing rule or return period. The SAPCC (2011 draft) projects annual rainfall 5% to 15% lower in the 2030s and 25% to 35% higher by the 2080s; a press report places the decrease in the 2050s, and the two do not agree. It gives no factor for extreme rainfall.
- **Design rainfall.** No national document gives design rainfall that a designer can apply directly to a given town. Each project chooses its own source. CWC's report for subzone 2(a) (1991) covers almost the whole State on paper but draws contours only along the foothills, and its ratio of the 1-hour to the 24-hour rain, 0.260, built on recording gauges that the pages read do not name, would give Itanagar about 52 mm in an hour on the plate's 200 mm, by this Manual's arithmetic, while NIH-DHAARA gives 78 mm for the same 50-year hour. IMD's 2022 national set of rainfall intensity curves has no panel for Itanagar, Pasighat or any other Arunachal Pradesh station.

Arunachal Pradesh has no drainage design standard of its own. Research for this Manual found no standard, IDF relationship or circular of the Department of Urban Affairs, IMC, the Pasighat Municipal Council or any other local body, the PWD or WRD that fixes a return period, a runoff coefficient or a design rainfall for town storm drains; the bye-laws refer to the National Building Code of 2005, Part 9, for plumbing and drainage (4.19.1.3 and 4.33.1). No IDF relationship with published constants was found for any station in the State. The ICR Master Plan diagnoses the capital's drains, "not engineered … open drains or kutcha drains without any flow gradient", and proposes a network, but sets no design

storm. The Department of Town Planning and ULBs invited expressions of interest in 2017 for a "GIS based Integrated Drainage Master Plan and DPR for Itanagar Capital City", with a horizon of 2038, and stated no return period; a plan prepared by a consultant was reviewed by the Chief Minister in June 2021, as reported, and its adoption was not found. The SAPCC budgets for "Storm water draining in twenty six urban settlements" without criteria. These are plans and budgets, not a State standard. This Manual is offered as a technical companion to the APBBL 2019, the Municipal Act, 2007, the Municipal Corporation Act, 2019, the UCP Act and the ICR Master Plan: it supplies the design storm, detention, slope, water-level and buffer values that they leave open. It has not been adopted by the Department of Urban Affairs, any local body, any community or any other body. In particular:

- **The building rules require rainwater harvesting, but size nothing.** All buildings on plots of 100 m² must submit "the complete proposal of rainwater harvesting" (9.1), public open spaces over 500 m² "shall have arrangements for complete utilization and capture of storm water" (9.6), recharge is mandatory for buildings of 500 m² and more (9.7), and the Authority is to set up a "Rainwater Harvesting Cell" to inspect them (9.8). None gives a storage volume. No rule requires on-site detention, limits peak runoff or sets a design storm; the nearest are a plinth "not less than 300 mm" so that "adequate drainage of the site is assured" (4.2.1.1), and, on sites of 5,000 m² and more, a natural drain whose "inlet and outlet point … should be maintained with adequate size of channel" and an unpaved area of at least 20% of the recreational open space (Table 14.1);
- **The slope rule stops cuts, but not water.** Bye-law 4.39 refuses earth cutting on average slopes over 30%, limits a cut to 3 m, keeps 2.5 m from the property line on the upper terrace, requires a retaining or breast wall "immediately", and makes the owner "clear/dispose-of soil/debris from site or drain". No rule restricts soak pits, recharge structures or infiltration trenches on slopes, on shale or on slope debris, and bye-law 9.7 makes recharge mandatory wherever the building stands;
- **There are no setbacks from streams, springs, ponds or nallahs.** The bye-laws ask a site plan to show the "Distance from Nallah/Stream as per the notified rules/norms" and the "Distance from Disaster Prone Area as per norms set by Disaster Management Authority" (2.10.1(e) and (f)), and neither set of norms was found. The *Jhot* is left open for drainage but has no width;
- **There is no floodplain law.** No floodplain zoning Act or Bill was found, and the bye-laws set no flood plinth beyond 300 mm. They count as hazard-prone the areas flooded by "back flow in drains, inadequate drainage, etc. as identified through local surveys in the development plan of the area", but no such survey was found. A Town Planning Scheme under Ordinance No. 5 of 2025 may include "the filling-up or reclamation of low-lying, swampy or unhealthy area", which can remove the low land and swamps that store floods. This Manual offers a technical method for drawing a design flood line and corridors (Chapter 7); where a line that a master plan, a scheme or a court draws is wider and binds, it governs; and
- **No document sets the river or reservoir level for which an outfall is designed.** CWC's sites at Passighat, Namsai, Tezu and Miao give danger levels and highest flood levels, read only as SANDRP transcribed them and with no datum stated; CWC has no site on the Senki, the Pachin or the Dikrong at the capital, nor on the Dibang at Roing. The release rules of the Pare, Ranganadi, Kameng, Lower Subansiri and Dibang projects were not found. Highest flood levels are records, not design levels, and at Pasighat the highest is an outburst stage.

So each agency and each local body interprets the central manual its own way. IMC, the Pasighat Municipal Council and the other local bodies, the Department of Urban Affairs and the Smart City companies, the PWD and PWD (Highways), WRD, PHED, NEEPCO and NHPC, the communities and clans, their consultants and funding agencies fill the gaps differently. No notification divides the drains between them. IMC holds the public drains in its area by section 200 of the 2019 Act and must maintain and clean them (section 60(a)), and the Pasighat Municipal Council by sections 102 and 194 of the 2007 Act; the Department of Urban Affairs and the Smart City companies build storm drains and hand them over; the PWD builds roadside drains with its roads; WRD keeps the rivers; and outside the municipal areas the drains on community or clan land have no statutory owner. In Itanagar a nallah may run through clan land, the municipal area and a highway culvert before it reaches the Senki or the Pachin. And a reviewer has no common basis against which to check a design.

What this Manual does about it. It turns those open choices into one State standard:

- one source and method for design rainfall across the State, in four rainfall zones and seven hydrologic sub-areas, with a checked station analysis to govern where one exists; the 2(a) plates in the foothills and the 2(b) plates in the south-east, the higher where both draw contours, with the 2(b) ratios on the Noa-Dihing plain and interim ratios elsewhere; a table from NERIST's Doimukh series in the capital region; floors in the middle hills and the high ranges, beyond the last contour; screening for glacial-lake and landslide-dam outbursts on snow-fed and glaciated catchments; and a check of the design day against the largest reliable days recorded nearby that never crosses the foot of the hills (Chapter 2);
- named return periods for every drainage element (Chapters 2 and 6);
- a required pre- versus post-development rule for private sites, with rainwater storage credited only through its use (Chapter 4);
- a required tailwater check for outfalls to streams, nallahs, rivers, ponds and reservoirs: at the capital, a design level for the Dikrong, the Senki and the Pachin from a model with the largest recorded dam release and the highest surveyed flood marks; on the main stems at Pasighat, Tezu, Namsai and Roing, CWC's danger level as the design case and its highest flood level as the check, with the outfall at that level for the whole 72-hour design storm; on the hill streams, a 1% AEP study that allows for debris; and, in release and outburst reaches, release and outburst scenarios (Chapter 5);
- a design flood line, and corridors and setbacks along streams, nallahs and rivers and around ponds, lakes and springs, proposed by this Manual where no line binds, with a corridor at least 15 m from the top of bank on every natural channel draining 8 ha or more, the capital's nallahs, the Senki, the Pachin and the Dikrong among them, offered as the "norms" that bye-law 2.10.1(e) refers to; a condition of building permission and layout approval wherever the bye-laws apply, and guidance elsewhere; and corridor land that is not Government or municipal land secured by agreement with the owner, the clan or the community, never taken (Chapter 7);
- no deliberate infiltration on natural slopes steeper than 10°, on Siwalik shale at any slope, on colluvium, slope debris or fill, in mapped landslide zones, or above a landslide scarp, cut slope or retaining wall, unless a geotechnical certificate allows it; none below the 1% AEP flood level of a river or nallah, on the palaeochannels and swamps of the Pachin and the Dikrong, or where the water table rises within 2 m of the ground; recharge only on the tested sandy terraces of the Naharlagun–Nirjuli–Doimukh valley and the coarse heads of the bhabar fans above the water table; roof runoff to storage for use, with its overflow to lined, stepped drains; the recharge areas of springs kept free of paving and road runoff; and the interception of dry-weather flow before every outfall to the Senki, the Pachin and the Dikrong and to the main stems at Pasighat, Tezu, Namsai and Roing, and before any pond used as storage, where drains carry sewage (Chapters 4 and 8);
- debris racks and traps, allowances for sediment, garbage and blockage, energy dissipation in steep drains, and hill-road drainage that never discharges onto an unprotected slope (Chapters 6 and 9), with drains, nallahs, inlets, racks and culverts cleared and certified ready by 31 March, cleared again by 15 May before the storms of late May, and again by 15 November after the October storms, standby kept from 1 April to 31 October, and, in the high ranges, inlets kept clear of snow and ice from December to March and a snowmelt clearance by 30 April (Chapter 10); and
- basin-wide master plans, so that the agencies that share a basin, and the communities whose land lies within it, plan together (Chapter 11).

It uses the route the CPHEEO manual itself provides: a State may adopt standards higher than the national values (CPHEEO 2019, Table 4.1, Note 2). IMC or the Pasighat Municipal Council, the Itanagar Planning Authority or another Local Planning Authority in a master plan or a Town Planning Scheme, the State in the bye-laws, or a community on its own land can still adopt a stricter standard (Chapter 1).

How to use this Manual

Clauses and commentary. Numbered clauses (for example 4.5.2) are the requirements of this Manual and use "shall". Paragraphs headed **Commentary** explain the reason for a clause and cite its precedent. They are guidance, not requirements. Where a value has no direct precedent elsewhere, the commentary says so and explains why this Manual sets it.

Return periods. Storms are described both by annual exceedance probability (AEP) and by return period. For example, "1% AEP (100-yr)" means a storm with a 1-in-100 chance of being equalled or exceeded in any year.

Illustrative values. Worked examples and figures marked "Illustrative — not design values" show method and scale only. Design values come from the sources set in Chapter 2.

Annexes and forms. Each chapter lists the annexes and forms it relies on. They follow the chapters, grouped by chapter, and hold the forms to submit, worked examples, templates, model text and standard drawings. Annexes that need data not yet collected are marked *To be prepared*. They say what they will contain, and the clause that depends on them states the rule that applies in the meantime.

Figures. All figures are original drawings prepared for this Manual. Where a figure follows a published concept, its caption credits the source.

Where to start.

If you are…	Read first
A developer or architect	Chapter 1 (does it apply?), Chapter 4 (what to provide), Chapter 10 (what to submit)
A design engineer	Chapters 2–6, then 8 and 9
A local body or approving authority	Chapters 1, 10 and 11
A planner or waterbody manager	Chapters 7 and 11

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2	Design Rainfall and Design Storms	Annexes 2
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Abbreviations

Abbreviation	Meaning
ABC Waters	Active, Beautiful, Clean Waters (PUB Singapore's design guidelines)
AEP	Annual exceedance probability
AGU	American Geophysical Union
AIDR	Australian Institute for Disaster Resilience
AMC	Antecedent moisture condition
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APBBL 2019	The Arunachal Pradesh Building Bye-Laws, 2019
APSDMA	Arunachal Pradesh State Disaster Management Authority
APSPCB	Arunachal Pradesh State Pollution Control Board
APWA	American Public Works Association
ARF	Areal reduction factor
ARI	Average recurrence interval
ASABE	American Society of Agricultural and Biological Engineers
ASCE	American Society of Civil Engineers
ASTM	ASTM International (standards)
AWS	Automatic weather station
BMP	Best management practice
BOD	Biochemical oxygen demand
BRE	Building Research Establishment (UK)
BSMP	Basin Stormwater Master Plan
CAG	Comptroller and Auditor General of India
CCTV	Closed-circuit television
CD	Chart datum (coastal term; not applicable in Arunachal Pradesh)
CGP	Construction General Permit (US EPA)
CGWB	Central Ground Water Board
CIP	Capital Improvement Programme

Abbreviation	Meaning
CIRIA	Construction Industry Research and Information Association (UK)
CN	Curve number (SCS/NRCS method)
COD	Chemical oxygen demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CRZ / CZMP	Coastal Regulation Zone / Coastal Zone Management Plan (coastal terms; not applicable in Arunachal Pradesh)
CSE	Centre for Science and Environment
CSTEP	Center for Study of Science, Technology and Policy
CWC	Central Water Commission
CWPRS	Central Water and Power Research Station
DCIA	Directly connected impervious area
DDF	Depth–duration–frequency
DDM	Department of Disaster Management, Arunachal Pradesh
DEM	Digital elevation model
DGWL	Design groundwater level
DID	Department of Irrigation and Drainage, Malaysia
DoNER	Ministry of Development of North Eastern Region
DPR	Detailed project report
DWF	Dry-weather flow
EAD	Expected annual damage
EN	European Standard (Norme Européenne)
EPA	Environmental Protection Agency (United States)
EPD	Environmental Protection Division (Georgia, United States)
EPSG	EPSG code of a coordinate reference system (for example EPSG:32646)
ESC	Erosion and sediment control
EV1	Extreme value type I (Gumbel) distribution
FEPCC	Flood Estimation Planning and Coordination Committee (CWC)
FER	Flood Estimation Report (CWC)
FHWA	US Federal Highway Administration
FRL / MDDL	Full reservoir level / minimum draw-down level
FRL / MWL	Full reservoir level / maximum water level
FRP	Fibre-reinforced plastic
FTL	Full tank level
GIS	Geographic information system

Abbreviation	Meaning
GPT	Gross pollutant trap
GSI	Geological Survey of India
GSMM	Georgia Stormwater Management Manual
HAT / MHWS	Highest astronomical tide / mean high water springs (coastal terms; not applicable in Arunachal Pradesh)
HDPE	High-density polyethylene
HDS	Hydraulic Design Series (FHWA)
HEC	Hydrologic Engineering Center (US Army Corps of Engineers), as in HEC-HMS and HEC-RAS; also FHWA's Hydraulic Engineering Circulars, as in HEC-14 and HEC-22
HFL	High flood level (the highest level recorded at a gauge)
HGL	Hydraulic grade line
HSG	Hydrologic soil group
HTL	High Tide Line (coastal term; not applicable in Arunachal Pradesh)
HWi / HWo	Headwater under inlet control / headwater under outlet control
HY-8	FHWA's culvert hydraulic analysis program
ICR	Itanagar Capital Region (the area of the Master Plan of Itanagar Capital Region-2031; not the Itanagar Capital Complex)
IDF	Intensity–duration–frequency
IIT	Indian Institute of Technology
IMC	Itanagar Municipal Corporation
IMD	India Meteorological Department
IMDAA	The gridded dataset behind NIH-DHAARA's values for Arunachal Pradesh (expansion [TBC])
INCOIS	Indian National Centre for Ocean Information Services
IRC	Indian Roads Congress
IS	Indian Standard (Bureau of Indian Standards)
ISO	International Organization for Standardization
ISRO	Indian Space Research Organisation
IST	Indian Standard Time
KC	Kansas City (Kansas City Metro APWA Section 5600)
KC Metro	Kansas City Metro (the APWA Section 5600 criteria)
KLD	Kilolitres a day
LID	Low impact development
LiDAR	Light detection and ranging (laser survey)
LoS	Level of Service
MARC	Mid-America Regional Council
MBBL 2016	Model Building Bye-Laws 2016 (MoHUA; not the State's bye-laws)
MC Itanagar	Meteorological Centre Itanagar (IMD)

Abbreviation	Meaning
MHFD	Mile High Flood District (formerly UDFCD)
MLD	Million litres a day
MoHUA	Ministry of Housing and Urban Affairs
MSL	Mean sea level
MSMA	Urban Stormwater Management Manual for Malaysia
MW	Megawatt
NBSS&LUP	National Bureau of Soil Survey and Land Use Planning
NCCR	National Centre for Coastal Research
NDMA	National Disaster Management Authority
NEEPCO	North Eastern Electric Power Corporation (operator of the Pare, Ranganadi and Kameng projects)
NEH	National Engineering Handbook (NRCS)
NERIST	North Eastern Regional Institute of Science and Technology, Nirjuli
NGT	National Green Tribunal
NH	National Highway (as in NH-415)
NHO	National Hydrographic Office
NHPC	NHPC Ltd (operator of the Lower Subansiri project; builder of the Dibang project)
NIH	National Institute of Hydrology, Roorkee
NIO	National Institute of Oceanography
NIT	National Institute of Technology
NOC	No-objection certificate
NPDES	National Pollutant Discharge Elimination System (United States)
NRCS	Natural Resources Conservation Service (USDA; formerly the SCS)
NRSC	National Remote Sensing Centre
NSE	Nash–Sutcliffe efficiency
NTU	Nephelometric turbidity unit
NWIA	National Wetland Inventory and Assessment (ISRO)
O&M	Operation and maintenance
OA	Original Application (NGT)
OCR	Optical character recognition (the text layer of a scanned document)
OGC	Open Geospatial Consortium
OSD	On-site detention
PHED	Public Health Engineering and Water Supply Department
PIL	Public interest litigation
PMGSY	Pradhan Mantri Gram Sadak Yojana

Abbreviation	Meaning
POC	Point of comparison
PRF	Peak rate factor
PSD	Permissible site discharge
PTI	Press Trust of India
PUB	PUB, Singapore's national water agency
PWD	Public Works Department, Arunachal Pradesh
PWD (Highways)	The PWD's highways wing
RCC	Reinforced cement concrete
RDSO	Research Designs and Standards Organisation (Railways)
RMSE	Root-mean-square error
RRV	Required retention volume
RWH	Rainwater harvesting
SANDRP	South Asia Network on Dams, Rivers and People
SAPCC	State Action Plan on Climate Change (Arunachal Pradesh; draft, 2011)
SCS	Soil Conservation Service (USDA; now the NRCS)
SH	State highway
SI	International System of Units
SLA	Sea-level allowance (coastal term; not applicable in Arunachal Pradesh)
SOP	Standard operating procedure
SRRG	Self-recording rain gauge
SSR	Site storage requirement
STP	Sewage treatment plant
SuDS	Sustainable drainage systems
SUH	Synthetic unit hydrograph (CWC)
SWMM	Storm Water Management Model (US EPA)
TBC	To be confirmed: a fact or value not yet found in a source
TBL	Top bund level
TCPO	Town and Country Planning Organisation (MoHUA)
TR	Technical Release (NRCS), as in TR-55
TR-55	Technical Release 55 (USDA SCS/NRCS)
TSS	Total suspended solids
UDFCD	Urban Drainage and Flood Control District (now MHFD)
UFRMP	Urban Flood Risk Management Programme (NDMA)
UH	Unit hydrograph

Abbreviation	Meaning
ULB	Urban local body (in Arunachal Pradesh, the Itanagar Municipal Corporation, the Pasighat Municipal Council or another municipality)
URDPFI	Urban and Regional Development Plans Formulation and Implementation (Guidelines)
USACE	US Army Corps of Engineers
USDA	United States Department of Agriculture
UT	Union Territory
UTM	Universal Transverse Mercator
VR	Value rating (of a BMP treating the WQv)
WGS 84	World Geodetic System 1984
WMO	World Meteorological Organization
WPCF	Water Pollution Control Federation
WQv	Water quality volume
WRD	Water Resources Department, Arunachal Pradesh
WSUD	Water-sensitive urban design

CHAPTER 1

Policy, Applicability and Adoption

1.1 Purpose and objectives

1.1.1 This Manual sets the minimum standards for the planning, design, construction, operation and maintenance of stormwater systems in Arunachal Pradesh. It applies to private development and to public works, as set out in Clause 1.5.

1.1.2 The Manual has the following objectives:

- (a) to make stormwater management a **condition of development approval**, so that new development and redevelopment do not increase flood peaks or runoff volumes downstream;
- (b) to retain frequent rainfall on site, so that groundwater recharge is sustained and pollutant loads are reduced;
- (c) to size storage for the long-duration storms of the monsoon season, which fall for days on the hills and the foothills together, saturating the Siwalik slopes and raising the Dikrong, the Siang, the Lohit and the Noa-Dihing against the town drains (by 20 July 2026 the season had brought 173 landslides, 104 floods and 8 flash floods, as quoted in the press from the Department of Disaster Management), from the pre-monsoon storms of April and May to the October storms of the east, as well as for short-duration intensities;
- (d) to design outfalls for the streams, nallahs, rivers and reservoirs into which the towns drain: the steep streams and nallahs of the hill towns and of the hill slopes round Itanagar, which rise within the hour and carry slide debris to free outfalls; the capital's nallahs to the Senki, the Pachin and the Dikrong, which the Dikrong backs up when it carries the releases of the Pare dam and the tailrace of the Ranganadi project; the main stems at Pasighat, Tezu and Namsai, the Siang, the Lohit and the Noa-Dihing, whose stage is set upstream, at Pasighat by outbursts in Tibet; and the reaches below the Pare, Ranganadi, Kameng and Lower Subansiri projects, held and released by their operators, including the case where the outfall is closed;
- (e) to protect tanks (ponds), marshes, rivers, supply channels and surplus courses as part of the drainage system;
- (f) to give every element of the drainage network a safe overland path for the 1% AEP (100-yr) storm;
- (g) to make design inputs, approvals and facility records public, so that designs can be checked and repeated; and
- (h) to make sure that facilities, once built, are maintained and remain effective.

1.1.3 This Manual does not replace the rainwater harvesting (RWH) mandate, the building bye-laws issued by the Department of Town Planning and ULBs, Government of Arunachal Pradesh, which extend to the whole State (the Arunachal Pradesh Building Bye-Laws, 2019), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

> **Commentary.** Arunachal Pradesh's floods come from three sources, often together. The first is the slide and flash flood of the hill slopes round the towns. On 11 July 2017, after three days of rain, a landslide at Laptap in the Toru circle of Papum Pare district buried a family's houses and killed 14 people (14 to 16 in different reports, at about 13:30 or about 15:30 in different reports); no rainfall amount was published (as reported). In the 2017 monsoon the capital's floods badly damaged the "land protection wall of several nallahs and rivulets" and closed NH-415, with traffic diverted via Papu Nallah and Jullang Road (master plan of the Itanagar Capital Region). About 14 September 2018 cloudburst flash floods at Modirijo and Donyi Polo in Itanagar–Naharlagun killed 3 people with at

least 4 missing (later reports give up to 7 dead), damaged more than 90 houses and washed away the Senki View culvert and the Press Colony bridge, with a landslide reported from "the dumping area of NH 415" (as reported); this was September 2018, not 2017. At Niti Vihar in Itanagar a landslide brought down a protection wall and killed 4 people (as reported; date not found). On 23 June 2024 heavy morning rain inundated at least 66 houses in Itanagar and Naharlagun, damaged NH-415, flooded Energy Park and brought a landslide at Niti Vihar; the press called it a cloudburst, but the State Disaster Management Authority's secretary said that IMD recorded 40 mm between 10:30 am and 12:30 pm and "confirmed there was no incident of cloudburst" (as reported). An "Itanagar cloudburst" is also reported for July 2024, about 28 July, with landslides, NH-415 submerged, homes near Energy Park and Bank Tinali flooded and seven relief camps, but the dateline and the publication date conflict (as reported); this Manual keeps the June and July events apart. On 30 May 2025 a landslide swept a vehicle off NH-13 between Bana and Seppa and all seven people in it died (as reported). On 24 June a flash flood from a side stream of about 17 km² struck the Poosa / NEEPCO colony at Yazali in Keyi Panyor district, killing 1 with 4 missing and washing away about 18 quarters (or about 50 houses), while "the main river stayed in its channel"; Down To Earth of 25 June 2026 reports it in 2026, with 73 mm in 24 hours at IMD's gauge, mostly in 3 hours, while EastMojo of 21 July 2026 dates its photographs to 2025 (as reported; the year conflicts).

The second is the river flood of the foothill plains, driven from upstream. On 10–11 June 2000 the breach of the Yigong landslide dam in Tibet sent a flood down the Siang that gave the CWC gauge at Pasighat its highest flood level, 157.54 m on 11 June 2000, 3.58 m above its danger level (CWC data as transcribed by SANDRP, as reported); a peer-reviewed analysis records "a recorded rise of 5.5 m at the Pasighat gauge, 462 km downstream" (as summarised); the impounded volume is given as about 2.015×10^9 m³ in one analysis and as about 2,000 or 3,000 million m³ in others; and the deaths as 30 or as more than 100, some figures including the reaches downstream of the State (all as reported; conflicts). Press claims of a "30 m" rise are inconsistent with the gauge and are not used [U]. In November 2017, after landslide dams formed on the river in Tibet, the Siang at Pasighat ran at 425 NTU against a December normal of 12–15 (as reported); landslide-dam alerts followed in October 2018, and the river ran muddy again in November 2022 (cause unconfirmed) (as reported). NDMA lists 27 glacial lakes in the State as high-risk, 16 of them in Dibang Valley and 6 in Tawang (as reported).

The third is the statewide monsoon flood, with the dams' releases. The remnants of Cyclone Remal brought 190 mm at Bomdila, 120 mm at Miao and 70 mm at Namsai in 24 hours to 29 May 2024 (IMD bulletin, as summarised). From late May to 7 June 2025 floods and landslides killed 12 people with 1 missing, affected 33,200 people in 215 villages of 24 districts and damaged 515 houses, 112 roads, 17 bridges and 51 water-supply schemes, by the State Emergency Operation Centre's count; other reports give 9, 10 and 11 dead and 156 villages (as reported; conflict); the Pare dam on the Dikrong released a peak of 1,310 m³/s on 31 May 2025 (as reported). By 20 July 2026 the season had brought 173 landslides, 104 floods, 80 heavy-rainfall events and 8 flash floods to 594 villages in 337 circles, affecting about 1.49 lakh people, with 15 deaths, 4 in flash floods (Department of Disaster Management, as quoted in the press). APSDMA's official tolls for these events were not found [TBC].

Missing design makes all three worse. No design storm, return period or drain standard was found for the drains of any town in the State; the master plan of the Itanagar Capital Region calls the existing drains "not engineered … open drains or kutcha drains without any flow gradient", finds "only 3.7% storm drains along main roads" and reports "storm water drains being used as sewers"; and the APBBL 2019 control the site plan, cuts and rainwater harvesting, not runoff, and set no distance from any stream, nallah or spring. Their "complete utilization and capture of storm water" on public open spaces of more than 500 m² (9.6) and the 20% of unpaved open space on large sites (Table 14.1) belong to the rainwater-harvesting chapter and the environmental conditions: they set no detention volume, peak flow or release rate, which is why this Manual counts the bye-laws among the instruments that mandate RWH only. Objectives (b) to (e) address the storage, outfall and building-level failures, which a drain-sizing manual alone cannot fix; the slides and the outbursts are answered by the siting, screening, infiltration and debris rules of Chapters 2, 4, 6 and 7, because no drain is sized to carry a debris flow or an outburst.

No national instrument requires on-site detention. CPHEEO (2019) is advisory and describes peak control only as typical practice. NDMA (2010) says detention and retention "will" be included but gives no sizing rule. MBBL 2016 and the Arunachal Pradesh Building Bye-Laws, 2019 mandate RWH only. Objective (a) is therefore the main new

step this Manual takes.

1.2 Stormwater management hierarchy

1.2.1 Every development to which Chapter 4 applies shall consider stormwater measures in the following order. A designer shall not use a lower measure in place of a higher one that is practicable on the site.

1. **Preserve** — keep or restore natural drainage features, tanks, wetlands, permeable soils, trees and overland flow paths (Chapter 7).
2. **Retain** — hold the runoff from the retention depth of Annex 2E on site, by infiltration, reuse or evapotranspiration (Chapters 4 and 8).
3. **Detain** — store larger storms temporarily and release them at or below the rates in Chapter 4, checked against downstream and tailwater conditions (Chapters 4 and 5).
4. **Convey** — carry the remaining flow safely in the minor system, and the 1% AEP flow in the major system (Chapters 6 and 9).

1.2.2 **Maintenance** underlies all four measures. A measure that cannot be maintained by its owner under Chapter 10 shall not be credited.

1.2.3 Credits from higher measures reduce the requirements of lower ones. Preserved areas and retained volume reduce detention storage as set out in Chapter 4.

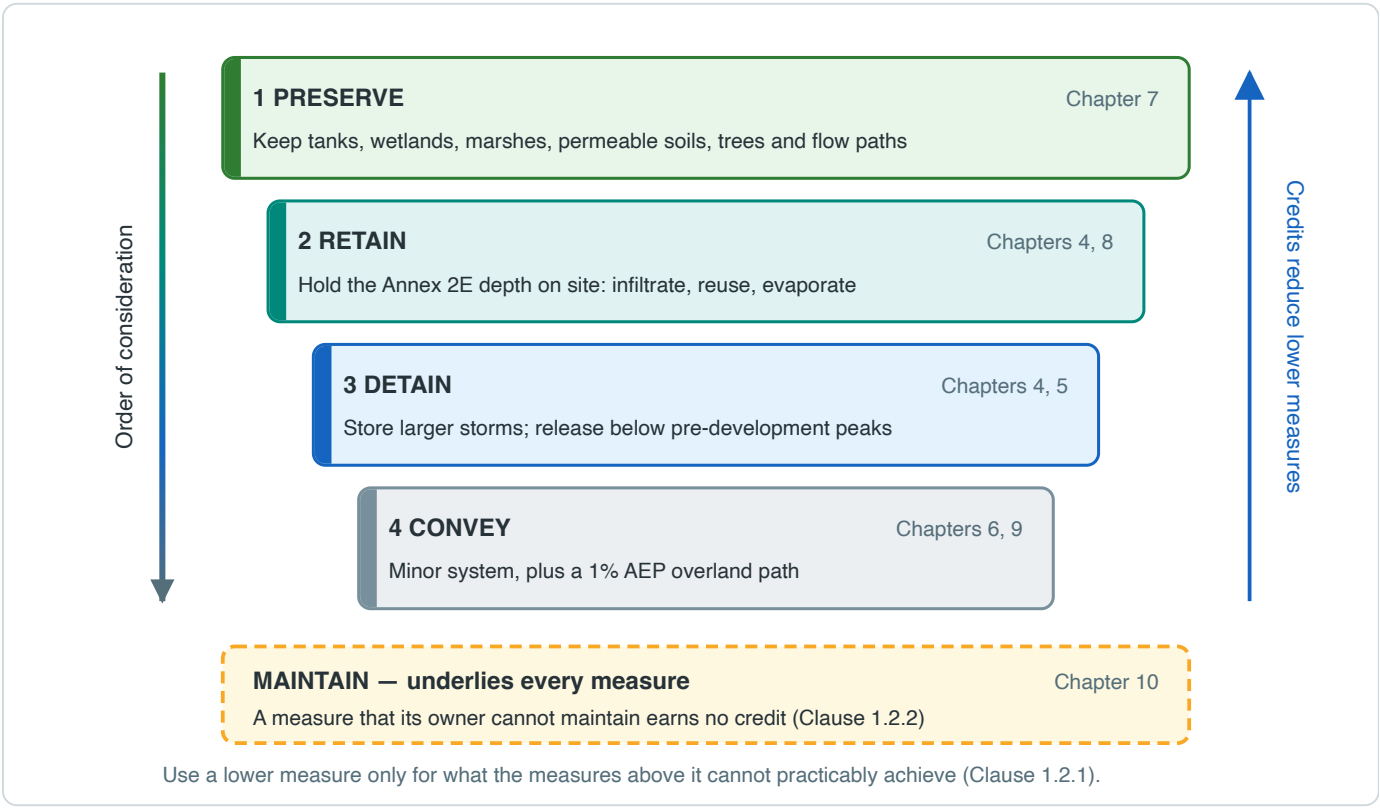

Figure 1.1 — Stormwater management hierarchy: preserve, retain, detain, convey, with maintenance underlying each measure. Original drawing for this Manual, adapted from Mid-America Regional Council / Kansas City Metro Chapter APWA, "Layers of Stormwater Management", APWA 5600 Manual Factsheet, 2025 (concept).

Commentary. The order follows the "layers" of Kansas City Metro APWA Section 5600, Version 2025.01: preserve or restore, retain, detain, convey, maintain (MARC factsheet, 2025). The same logic is behind Georgia's runoff-reduction standard and CSE's "attenuate and infiltrate first" principle (CSE, 2023). For Arunachal Pradesh, the top two layers have a particular meaning. Much of the natural storage that serves the towns lies in their streams and nallahs, the Senki, the Pachin, Papu Nallah and the Dikrong in the capital region, from which Itanagar also draws water (the Senki by lift, 7 MLD; the Poma and the Niorch by gravity, 11 and 7 MLD; master plan of the Itanagar Capital Region); in the springs, which in Papum Pare discharge 0.43–2 litres a second before the monsoon and of which "most … become dry during dry season", and which are the only source in the northern hills of East Siang (CGWB); in the State's lakes and wetlands, 1,127 of 2.25 ha or more, 944 of them high-altitude lakes far from the towns and only two of them classed as a tank or pond (Department of Environment, Forest and Climate Change, wetland truthing), among them Ganga Lake (Gyakar Sinyi) in the Itanagar Wildlife Sanctuary, under encroachment and earth-cutting pressure (as reported), and Glaw Lake in Lohit district, announced on 3 August 2026 as the State's first Ramsar site (as reported); in the ponds and swamps of the valley floors, among them the ponds into which the master plan finds drains and sewage discharged; and in the sandy terrace soils of the Naharlagun–Nirjuli–Doimukh valley, 95.19% sand at NERIST's test plot at Doimukh, with a basic infiltration rate of 1 cm/h (Dabral et al., 2016). The law protects little of this. The Arunachal Pradesh Municipal Act, 2007 vests "all public tanks, streams, reservoirs, and wells" of a municipality in it (s.102), and the Arunachal Pradesh Municipal Corporation Act, 2019 vests "all public streams, springs and works for the supply … of water" in the Corporation; the APBBL 2019 ask every urban local body and planning authority to "identify, demarcate, protect and maintain the water bodies that come under their jurisdiction" and list them (Annexure E 1.8), and list "water bodies (and the areas adjoining the same)" among the natural features to be notified or identified in a master plan (Chapter 12). No statute or bye-law found protects a stream, nallah, spring or pond with a numerical buffer, no floodplain zoning law was found, and no wetland of the State was found notified under rule 4 of the Wetlands (Conservation and Management) Rules, 2017. In the hills the second layer changes. Retention on a slope is storage and reuse, not infiltration: water put into residual soil, slope debris and fill over Siwalik sandstone and shale raises the pressure in the slope, and concentrated discharge onto slopes preceded the Laptap slide of 2017 and the Itanagar slides of 2024 and 2025 (NEER reading of the reports). This Manual therefore bars deliberate infiltration on natural slopes of more than 10°, on Siwalik shale at any slope, on colluvium, slope debris or fill, in mapped landslide zones, above a landslide scarp and within twice the height of a cut or retaining wall upslope of it, unless a geotechnical certificate allows it (Clause 4.11, hill rule); bars it on land below the 1% AEP flood level of the Dikrong, Pachin, Senki, Siang, Lohit, Dibang or Noa-Dihing or of a nallah, on the palaeochannels and swamps of the Pachin and Dikrong flood plains, on pond margins and wherever the seasonal high water table is within 2.0 m of ground (Clause 4.11, floodplain rule); and allows recharge only on the tested terrace sands of the capital's valley and the coarse bhabar fan heads above the water table, because the State's stage of groundwater extraction is 0.39% (CGWB, 2024, as summarised) and recharge is not a design objective (Clause 4.11, recharge rule) (all set by this Manual). Rainwater harvesting elsewhere is storage and reuse. Losing the stream heads, springs and swamps cannot be offset by pipes, and in the hills a drain that puts water into a slope can make it fail.

1.3 Legal basis and status

1.3.1 **Notification.** This Manual shall be given statutory effect by the Government of Arunachal Pradesh through:

- (a) an amendment to the Arunachal Pradesh Building Bye-Laws, 2019 that makes compliance with this Manual a condition of planning permission, building permit, layout approval and completion certificate, for development to which Clause 1.5 applies; and
- (b) bye-laws or standing orders of each urban local body (ULB), adopting the Manual for works executed or approved by that ULB, including the ULB's own drains and roads.

1.3.2 **Higher State standards.** The design return periods and performance criteria of this Manual exceed the national advisory minimums of the CPHEEO Manual on Storm Water Drainage Systems (2019). The State shall constitute, by notification, a high-powered committee (the **State Stormwater Technical Committee**, Clause 1.9) to adopt these higher standards. This is the route that CPHEEO (2019) provides for higher return periods.

1.3.3 **Precedence.** Within its scope, this Manual governs where it is stricter than CPHEEO (2019), IRC:SP:42-2014, IRC:SP:50-2013 or any departmental standard. Where a statute or statutory rule sets a stricter requirement (for example a waterbody setback), the statute governs.

1.3.4 **Design-practice standard for public works.** Departments and ULBs that procure drainage, road or waterbody works shall require compliance with this Manual in detailed project reports (DPRs) and contracts, from the dates in Clause 1.11.

> Commentary. In Arunachal Pradesh the building rules are the Arunachal Pradesh Building Bye-Laws, 2019 (Department of Town Planning and ULBs, Government of Arunachal Pradesh), which define "Act" as the Arunachal Pradesh Municipal Act, 2007 (Act No. 4 of 2008) and the Arunachal Pradesh Urban and Country Planning Act, 2007 (Act No. 3 of 2008). The table of contents of the copy read lists a "Gazette Notification" page, but that page is blank, so the notification number, date and gazette reference are to be confirmed [TBC]. The bye-laws "shall extent to whole of Arunachal Pradesh with effect from the date of notification" (2.1) and are applicable "for a period of FIVE years after which they shall be reviewed. Till such time the reviewed building byelaws are notified, these building byelaws will continue to be in force" (2.2); whether the review, due from 2024, has begun is not known [TBC]. Their "Authority" is "The Director/Chief Town Planner of Town Planning & Urban Local Body, Government of Arunachal Pradesh … till an executing authority is notified" (definition 12). The Arunachal Pradesh Fire and Emergency Services Act, 2026 (Act No. 12 of 2026) names them as the State's building bye-laws: "'Building bye-laws' means the 'Arunachal Pradesh Building Bye-laws- 2019'" (s.2(c)); the Online Building Permission System launched on 30 July 2025 was "customised" to them and processes all permits online (as reported). No amendment was found. Two earlier texts are not the current rule: an "Arunachal Pradesh Building Bye-Law 2010" listed as notified on the Town Planning portal (as summarised; not read), and the Directorate of Town Planning's "FINAL DRAFT" of 2009, whose hill-site clause asked for the "location of landslide prone areas" and for the "diversion of the natural flow of water coming from uphill side"; that clause is not in the 2019 text, although the report of the Itanagar Capital Region master plan reproduces it, and this Manual does not treat it as in force. The APBBL 2019 ask the site plan to show "existing physical features such as well, drains" (2.10.1(j)) and the "Distance from Nallah/Stream as per the notified rules/norms" (2.10.1(e)), for which no rules or norms were found; set a plinth of "not less than 300 mm" (4.2.1.1); bar septic effluent from "an open channel drain or body of water without adequate treatment" (4.16.2(c)); let the Authority require rain-water pipes "to be connected to a drain or sewer" (4.19.1.1); refuse earth-cutting permission "if the average slope of the topography is more than 30%", limit a cut to 3 m and require a retaining or breast wall "immediately" (4.39(4), (11), (14)); require a rainwater-harvesting proposal for plots of 100 m² (9.1) and "complete utilization and capture of storm water" on public open spaces of more than 500 m² (9.6); and ask large sites to keep "the inlet and outlet point of natural drain system" open (Table 14.1). They set no storm-water volume, peak-flow, detention, setback number, flood plinth above 300 mm or design storm.
>
> Land is the second matter. Arunachal Pradesh has no Sixth Schedule area, and Article 371H of the Constitution, inserted by the Constitution (Fifty-fifth Amendment) Act, 1986, gives the Governor special responsibility for law and order; it does not protect customary law or land (as quoted). Land is governed by the Arunachal Pradesh (Land Settlement and Records) Act, 2000 (Act No. 10 of 2000), a law for land revenue administration "incorporating customary rights on the land", which defines "community" to include "a clan, sub-clan, kindred" and "common land" as land "used or reserved for the common use of a community or a village" (s.2(c), (d)), and declares the beds of rivers, streams, nallahs, lakes and tanks the property of the Government only where they "are not the property of any person or community" (s.9(1)). Individual titles were introduced by an amendment of 2018 (s.1A, as reported), and acquisition "exercises have often run into troubled waters" because customary laws hold sway (as reported). Much land near the towns is held by communities, clans and individuals, and stream and nallah beds on it are not Government property. Nothing in the Constitution limits the State's laws on land here, as

Article 371A or the Sixth Schedule does in other North-East editions, and the bye-laws apply statewide (NEER reading). This Manual therefore presents its corridors and setbacks as conditions of building permission and layout approval wherever the bye-laws apply, and as recommendations for works on community land outside any permission; land for public drains is secured by agreement with the owners or the community, by donation (the 2000 Act's own definition of Government land includes land obtained "through donation of the public", s.2(h)), by purchase, or by reservation in a master plan, layout or Town Planning Scheme. Where the State decides that land must be obtained compulsorily, section 104 of the 2007 Municipal Act routes it through the "Land of Acquisition Act, 1894" (as printed), which the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 has replaced for the Union (NEER reading), and section 104(3) also allows "other methods of land assembly including the use of transferable development rights". The Manual states that route; it does not invoke it, and it takes no land. It binds no community or clan on its own land.

The route of Clause 1.3.1 therefore runs several ways, each of which a body could take and none of which has been taken. The Department of Urban Affairs (Town Planning wing) could carry this Manual into the five-year review of the APBBL 2019 (2.2), or notify its 15 m corridor as the "norms" to which 2.10.1(e) refers (Clause 1.3.1(a)). The Itanagar Municipal Corporation could make bye-laws under the Arunachal Pradesh Municipal Corporation Act, 2019 and apply its connection rules (s.203), and the Pasighat Municipal Council could act under sections 194 to 196 of the 2007 Act (Clause 1.3.1(b)). The Government could use the Manual in a "Sponge City" or "Risk Informed master Plan" policy document under the new section 71(2)(za) inserted by the Arunachal Pradesh Urban and Country Planning (Amendment) Ordinance, 2025 (Ordinance No. 5 of 2025), if that power stands in the amending Act, a Bill for which was reported passed on 9 March 2026 and whose Act number and final text were not found [TBC]. The Itanagar Planning Authority and the other Local Planning Authorities could carry drainage reserves and the 1% AEP areas into master plans, layouts and Town Planning Schemes under the Arunachal Pradesh Urban and Country Planning Act, 2007; the Arunachal Pradesh State Disaster Management Authority (APSDMA) could use it in the "Disaster Prone Area" norms that 2.10.1(f) anticipates and in district disaster management plans; and PWD and WRD could apply it to their works. Outside any permission or plan, this Manual reaches only public works executed by the State's departments and agencies (Clause 1.5.1(b)) and any body that adopts it; for a household or a community it is guidance (Commentary to Clause 1.5). This Manual is a draft; neither the Government, any department, the Itanagar Municipal Corporation, the Pasighat Municipal Council, any Local Planning Authority, any village authority or community nor any other authority has adopted it. MoHUA told Parliament in July 2026 that urban flooding "falls under the purview of the State Governments and the ULBs" and listed the CPHEEO manual among "advisory guidelines" (Lok Sabha AU1847). The State therefore needs no central approval to adopt higher standards. CPHEEO's Note 2 to Table 4.1 (§4.4.1.4) allows "a high powered committee constituted by State/UT Government through a notification" to adopt higher return periods. Clause 1.3.2 uses that route so that higher standards are on record for centrally funded schemes.

1.4 Definitions

1.4.1 The following terms apply throughout this Manual. Chapter-specific terms are defined in each chapter (for example Clause 2.2).

Term	Meaning in this Manual
Approving Authority (the Authority)	The body that grants planning permission, building permit or layout approval for a development, or that sanctions a public work: the competent authority for the area: in the area of the Itanagar Municipal Corporation (IMC), the Authority under the Arunachal Pradesh Building Bye-Laws, 2019 (the Director/Chief Town Planner of Town Planning & Urban Local Body, or the executing authority once one is notified, with its Building Permission Committee) for the building permit and the earth-cutting permission (4.39), and IMC for its own drains and the connections to them (sections 60, 200 and 203 of the Arunachal Pradesh Municipal Corporation Act, 2019); in the Pasighat municipal area, the Pasighat Municipal Council for its drains (sections 102, 194 and 196 of the Arunachal Pradesh Municipal Act, 2007) and for building sanction through its Municipal Building Committee (sections 340–343); in a Local Planning Area, the Local Planning Authority (the Itanagar Planning Authority in the Itanagar Capital Region) for layouts, the master plan and Town Planning Schemes under the Arunachal Pradesh Urban and Country Planning Act, 2007; elsewhere, the Authority under the bye-laws, which extend to the whole State (2.1); for a public work, the department or agency that executes it (the Department of Urban Affairs, the Public Works Department (PWD), PWD (Highways), the Water Resources Department (WRD), the Public Health Engineering and Water Supply Department (PHED) or a Smart City company); WRD for any work in or on a river; and, on community or clan land where no permission is sought and no plan applies, the owners or the community by agreement, for whom this Manual is guidance (none has adopted it), or a department for its own works.
Applicant	The owner, developer or department that seeks approval, and its successors in title.
Development	Any building, layout, sub-division, road, paving or land-use change that requires approval under the Arunachal Pradesh Building Bye-Laws, 2019 or that is executed as a public work.
Redevelopment	Development on a site where impervious cover already exists.
Land disturbance	Clearing, grading, excavation, filling or paving of land, measured in plan area over the whole of a common plan of development (Clause 1.5.5).
Impervious area	Roofs, paving, compacted gravel, decks and other surfaces that prevent infiltration. Permeable paving designed to Chapter 8 is counted as pervious only for the area it treats.
New or replaced impervious area	Impervious area created, or removed and rebuilt down to the subgrade, by the development. Resurfacing that leaves the base in place is not "replaced".
Retention	Permanent removal of runoff from the drainage system on site, by infiltration, reuse or evapotranspiration (Chapter 4).
Detention	Temporary storage of runoff with a controlled outlet, emptied after the storm (Chapter 4).
Rainwater harvesting (RWH)	Collection of rainfall for supply or recharge under the RWH mandate. RWH storage is not detention unless Chapter 4 allows it.
Minor system	Drains, pipes and inlets designed for the minor-system AEP of Chapter 6.
Major system	The overland and floodway path that carries the 1% AEP (100-yr) flow (Chapter 6).
Pre-development condition	Greenfield: open land in good condition for the mapped hydrologic soil group. Existing impervious cover is not counted (Chapter 3).
Flood-sensitive catchment	The catchments of the Senki through Itanagar; of the Pachin through Itanagar and Naharlagun; of the Dikrong at Naharlagun, Nirjuli and Doimukh, with Papu Nallah, below the Pare dam and the Ranganadi tailrace; of the NH-415 corridor from Itanagar to Naharlagun; of Modirijo and Donyi Polo; of Pasighat on the Siang; of Tezu on the Lohit; of Namsai and Miao on the Noa-Dihing; of Roing on the Dibang; of the Ranganadi reach at Yazali; and of the glacial-lake and outburst reaches of Tawang and Dibang Valley, and any catchment the Authority notifies (Chapter 4; Annex 1B).
Waterbody	A river, stream, canal, tank (pond), lake, pond, marsh, supply channel or surplus course, whether perennial or seasonal (Chapter 7).
Regional facility	A detention, retention or tank storage facility serving more than one development, built or restored under a basin plan (Chapter 4).
Tier A / Tier B authority	An Approving Authority classed under Clause 1.6.

Term	Meaning in this Manual
Policy supplement	The set of adoptable alternative clauses in Clause 1.7 and Annex 1C.
Drainage report	The preliminary or final report required by Chapter 10.
Registered professional	A person registered under the Arunachal Pradesh Building Bye-Laws, 2019 to prepare and sign the relevant plans, with any further qualification required by Clause 10.6.
Compliance calculator	The State-issued tool for computing and reporting compliance (Clause 10.5).
Maintenance declaration	The registered undertaking by an owner to maintain a stormwater facility (Clause 10.10).
Variance	Approval to depart from a numeric requirement, with equivalent performance shown (Clause 1.10).
Waiver	Approval that a requirement does not apply to a site, on the grounds in Clause 1.10.
Notified	Published by the Government or the State Stormwater Technical Committee in the Arunachal Pradesh Gazette.
Competent authority for the area	The body that grants permission for the site, or executes the work, under the instrument that applies there: in the area of the Itanagar Municipal Corporation (IMC), the Authority under the Arunachal Pradesh Building Bye-Laws, 2019 for the building permit and the earth-cutting permission, and IMC for its own drains and the connections to them (sections 60, 200 and 203 of the Arunachal Pradesh Municipal Corporation Act, 2019); in the Pasighat municipal area, the Pasighat Municipal Council for its drains and building sanction (sections 102, 194, 196 and 340–343 of the Arunachal Pradesh Municipal Act, 2007); in a Local Planning Area, the Local Planning Authority (the Itanagar Planning Authority in the Itanagar Capital Region) for layouts, the master plan and Town Planning Schemes; elsewhere, the Authority under the bye-laws, which extend to the whole State; for a public work, the department or agency that executes it; WRD for any work in or on a river; and, on community or clan land where no permission is sought and no plan applies, the owners or the community by agreement, for whom this Manual is guidance. Where this Manual says "the Authority", the competent authority for the area is meant. This Manual does not bind a community or clan on its own land.
Community land	Land held by a community, which under the Arunachal Pradesh (Land Settlement and Records) Act, 2000 means "residents of a village as a whole and includes a clan, sub-clan, kindred" (s.2(d)), including "common land", land "used or reserved for the common use of a community or a village" (s.2(c)), held under customary rights that the Act incorporates. The beds of rivers, streams, nallahs, lakes and tanks are Government property only where they "are not the property of any person or community" (s.9(1)). Much land near the towns is community, clan or individually held; individual titles were introduced by an amendment of 2018 (s.1A, as reported). Where this Manual reserves a drainage corridor, an easement or a facility site on community, clan or private land, the land is secured by agreement with the owners or the community, by donation, by purchase, or by reservation in a master plan, layout or Town Planning Scheme; it is never taken (set by this Manual).
Jhot	"A strip of land permanently left open for drainage purposes. It is not to be used as an access way or a street and is not to be included as a part of setbacks" (Arunachal Pradesh Building Bye-Laws, 2019, definition 69). The bye-laws give it no width. This Manual uses the word for that strip only.
Nallah	A natural or open urban channel that carries storm water, and often waste water, to a river, as the capital's nallahs carry it to the Senki, the Pachin and the Dikrong; the word of the bye-laws ("Distance from Nallah/Stream", 2.10.1(e)), of the Land Settlement and Records Act (s.9(1)) and of the master plan of the Itanagar Capital Region ("natural drainage system (Nallah)"), and of place names such as Papu Nallah. A nallah draining 8 ha or more is treated as a natural channel under Chapter 7.
Itanagar Capital Region	The area of the Master Plan of Itanagar Capital Region-2031, approved on 3 June 2022 under the Arunachal Pradesh Urban and Country Planning Act, 2007: Itanagar, Naharlagun, Nirjuli, Doimukh and Banderdewa, with the Itanagar Planning Authority as its Local Planning Authority. It is not the Itanagar Capital Complex, the district of the Deputy Commissioner who chairs that Authority.

Commentary. "Replaced" impervious area is defined to the subgrade so that redevelopment of a fully paved site is captured, while routine resurfacing is not. This follows the approach of the APWA 5600 (2025.01) redevelopment triggers (MARC Supplement, 2025).

1.5 Applicability

1.5.1 **Who is covered.** This Manual applies to:

- (a) all development requiring planning permission, building permit or layout approval under the Arunachal Pradesh Building Bye-Laws, 2019;
- (b) all drainage, road, bridge, culvert, waterbody and flood-mitigation works executed by a ULB, a State department, a board, or a State undertaking; and
- (c) works executed by Central agencies or their contractors within Arunachal Pradesh, to the extent that the Authority's approval or no-objection is required.

1.5.2 **Retention and detention threshold.** Chapters 4 and 5 (retention, detention, downstream and tailwater analysis) apply to any development that, over the common plan of development, involves:

- (a) land disturbance of **0.1 ha or more**; **or**
- (b) new or replaced impervious area of **500 m² or more**.

1.5.3 **RWH.** The existing RWH mandate continues to apply under Chapter 9 and Annexure E of the Arunachal Pradesh Building Bye-Laws, 2019 to every building on a plot of 100 m² or more, whose building plans must include "the complete proposal of rainwater harvesting" (9.1; Annexure E 1.1), with recharge mandatory for buildings of 500 m² and more and for parks, parking and plazas (9.7), "complete utilization and capture of storm water" on public open spaces of more than 500 m² (9.6) and inspection by a Rainwater Harvesting Cell before the completion certificate (9.8), but with no storage volume, release rate or design storm, as now. This Manual does not change it.

1.5.4 **Provisions that apply at every size.** The following apply to all development under Clause 1.5.1, whatever its size, unless exempted by Clause 1.5.8:

- (a) no sewage connection to a storm drain (Chapter 8);
- (b) lowest habitable floor and openings at or above the 1% AEP level plus 0.5 m, where a 1% AEP level is mapped or determinable (Chapter 6);
- (c) waterbody setbacks and the no-fill zone (Chapter 7); and
- (d) no obstruction of a natural drainage path or major-system flow path (Chapter 6).

1.5.5 **Common plan of development.** The thresholds of Clause 1.5.2 apply to the total area of a development, including all phases, plots and sub-divisions under one layout approval or one ownership at the date of application. A development shall not be divided to avoid the thresholds.

1.5.6 **Redevelopment.** For redevelopment, the thresholds apply to new plus replaced impervious area. Retention and detention apply to the whole of the new and replaced impervious area, and the pre-development condition is greenfield (Clause 1.4). Where greenfield control cannot be achieved on a constrained redevelopment site, the relief route of Clause 4.5.6 applies: a minimum on-site cut of 50% from existing peaks, with the shortfall paid as fee-in-lieu into basin storage.

1.5.7 **Linear public works.** For roads, widening and other linear works, the impervious area threshold applies to the added impervious area within each drainage catchment crossed. Retention and detention shall be provided within the right of way, or in a regional facility under Chapter 4, where the right of way cannot hold them.

1.5.8 **Exemptions.** The following are exempt from Chapters 4 and 5:

- (a) a single dwelling on its own plot, where the thresholds of Clause 1.5.2 are not met; and
- (b) linear road resurfacing that adds no impervious area.

Exempt development remains subject to the RWH mandate and to Clause 1.5.4.

1.5.9 **Applicability determination.** The Applicant shall record the applicability decision on **Form 1-1** (Applicability Determination) with the first submittal under Chapter 10. The Authority may confirm or correct it at the pre-application stage.

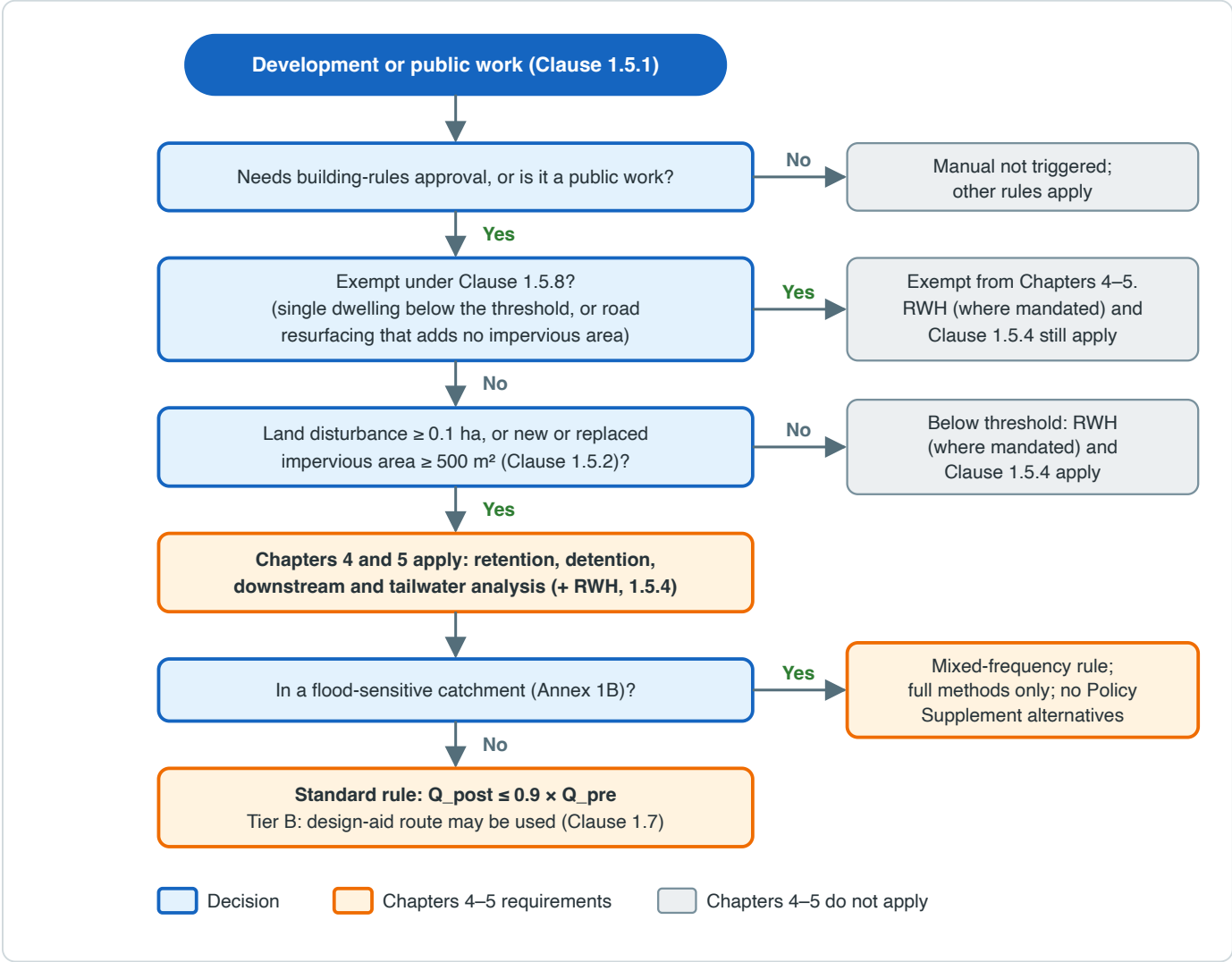

Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.

Commentary. The thresholds have no single direct precedent; they are set by this Manual. Precedents span a wide range:

- Singapore controls peak runoff from developments of 0.2 ha or more (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 7.1.5).
- Malaysia's 2008 DID checklist used on-site detention for sites up to 0.1 ha and community ponds above that.
- The APWA 5600 (2025.01) Policy Supplement offers alternative triggers of ¼ acre (about 0.1 ha) disturbed, or 1 acre (about 0.4 ha) with 10,000 sq ft (about 930 m²) impervious, and warns agencies not to exceed a 1-acre trigger.
- MBBL 2016 makes recharge mandatory for buildings over 500 m².

The 0.1 ha / 500 m² trigger sits at the strict end of these, because typical Arunachal Pradesh plots are small and the cumulative effect of many small plots is what fills Itanagar's drains. For small buildings in Arunachal Pradesh, the APBBL 2019 already require "the complete proposal of rainwater harvesting" with the building plans of every building on a plot of 100 m² (9.1; Annexure E 1.1), not below it (Annexure E 1.4); ask every site plan to show the existing drains and the distance from the nallah or stream (2.10.1(j), (e)); and let the Authority require rain-water

pipes to be connected to a drain (4.19.1.1). None sets a volume, and a harvesting tank is full when the season's storm arrives, so none of it limits what leaves the plot in a design storm. The bye-laws place a septic dispersion system at least 18 m from drinking-water sources and 6 m from buildings (4.16.1), which on a slope puts water into the ground that the hill rule of Clause 4.11 protects; they refuse earth cutting above an average slope of 30% and require a retaining or breast wall "immediately" after a cut (4.39(11), (14)), but no rule asks a single building to carry the water from uphill around its foundations or to discharge its roof water to a lined drain or stable channel rather than down the slope; the 2009 draft's clause on "diversion of the natural flow of water coming from uphill side" is not in the 2019 text. Clause 1.5.4(b) applies to every building whatever its size for this reason. The bye-laws extend to the whole State (2.1), so every building that needs a permit is within reach; where no permission is sought, as for many houses on community or clan land, this Manual is guidance only: a household or a community could use the small-site method of Chapter 4 and the hill rule of Clause 4.11 as guidance. A small building on a hill slope is where a soak pit or soakaway can do most harm, and the Authority may make the hill rule of Clause 4.11 a condition of every building permit, whatever the size of the site (a recommendation of this Manual, not a requirement of Clause 1.5.4); where a septic dispersion trench or soak pit on a slope of more than 10° or on shale cannot be avoided, this Manual recommends that a geotechnical engineer site it, downslope of buildings and cuts, and refers sewage questions to Clause 8.9; the Manual does not override bye-law 4.16.1. Where the recharge that 9.7 makes mandatory for buildings of 500 m² and more falls on a site where the hill rule or the floodplain rule of Clause 4.11 forbids infiltration, the two conflict: this Manual requires storage in place of recharge there, and the applicant seeks the Authority's relaxation; the Manual does not override the bye-law (Table 1.3).

Clause 1.5.4(b) has no direct precedent; this Manual sets it because floor levels are the cheapest protection a building can have, and it would be perverse to protect only large developments. Where no 1% AEP level is mapped, Chapter 6 gives the method for small sites.

1.6 Tiered adoption

1.6.1 **Tier A authorities.** The following are Tier A:

- (a) the Itanagar Municipal Corporation (IMC); and
- (b) every approving authority within the area of the Master Plan of Itanagar Capital Region-2031 (Itanagar, Naharlagun, Nirjuli, Doimukh and Banderdewa), that is, the Itanagar Planning Authority for layouts and the Authority under the APBBL 2019 for building permits, whichever has jurisdiction over a site.

1.6.2 **Tier B authorities.** All other urban local bodies, Local Planning Authorities and other authorities under the bye-laws are Tier B.

1.6.3 **What differs between tiers.** All criteria of this Manual apply in both tiers. The tiers differ only in method and review:

Table 1.1 — Differences between Tier A and Tier B authorities

Item	Tier A	Tier B
Performance criteria (Chapters 2–9)	Apply in full	Apply in full
Hydrologic method for storage	Hydrograph method (Chapter 3)	Hydrograph method, or the design-aid route of Clause 1.7 where eligible
Compliance calculator (Clause 10.5)	Required as a summary	Required; may be the sole calculation on the design-aid route
Policy supplement alternatives (Clause 1.7)	Only with State Stormwater Technical Committee concurrence	May be adopted by council resolution

Item	Tier A	Tier B
Technical review	By the Authority	By the Authority, with Urban Affairs regional support or an empanelled reviewer (Clause 10.7)
Flood-sensitive catchment rule	Applies	Applies

1.6.4 **Moving between tiers.** A Tier B authority may opt into Tier A by council resolution. The Government may notify a Tier B authority as Tier A when it becomes a Corporation, joins the area of the Master Plan of Itanagar Capital Region-2031 (Itanagar, Naharlagun, Nirjuli, Doimukh and Banderdewa), which contains the area of the Itanagar Municipal Corporation, or is found by a post-event review (Clause 10.16) to need the full methods.

1.6.5 **Flood-sensitive catchments override tier.** In a flood-sensitive catchment, whatever the tier, the alternatives of Clause 1.7 are available only as Table 1.2 allows: S-1 (the design-aid route) for sites of 0.5 ha or less (Clause 4.14.1), and S-5 fee-in-lieu where a basin plan has been notified (Clause 1.10.3(d)). S-2, S-3 and S-4 are not available.

> **Commentary.** Itanagar Municipal Corporation, with no drain inventory or drain design standard found, a proposal for 64 km of integrated drains (as reported, undated), "only 3.7% storm drains along main roads" in its capital region (master plan of the Itanagar Capital Region) and administrators in charge from the dissolution of the council in June 2018 until the Corporation's first mayor was elected in January 2021 (PIL 22(AP)/2018; as reported), and a small municipal council with one assistant engineer cannot be asked to review the same hydrograph models. The Kansas City solution was to keep one regional standard and publish adoptable alternatives for the most contested criteria, so that smaller agencies can "opt down" without leaving the standard (MARC Supplement, Nov 2025). The tiers here keep the performance criteria the same in both tiers and vary only the method, so that a building in a Tier B town is protected to the same level as one in Itanagar.

1.7 Policy supplement: adoptable alternatives

1.7.1 The Government shall publish, with this Manual, a **Policy Supplement** (Annex 1C) of alternative clauses. An Approving Authority may adopt one or more alternatives under the conditions in Clause 1.7.3.

1.7.2 The alternatives are:

Table 1.2 — Policy supplement: adoptable alternatives S-1 to S-5

No.	Main-text requirement	Adoptable alternative	Eligibility
S-1	Storage sized by hydrograph method (Chapter 3)	**Design-aid route:** retention and detention volumes taken from the unit-storage tables (m³ per ha, by rainfall zone, soil group and impervious fraction) in Annex 4 and the compliance calculator	Sites ≤ 2 ha outside flood-sensitive catchments; ≤ 0.5 ha within them (as Clause 4.14.1)
S-2	Release rate $Q_{post}(T) \le 0.9 \times Q_{pre}(T)$, computed for the site	**Permissible site discharge (PSD):** a tabulated unit-area release rate (m³/s/ha) by zone and AEP, derived from the $0.9 \times Q_{pre}$ rule	Any site outside flood-sensitive catchments
S-3	Waterbody setback extended to the mapped 1% AEP flood extent plus margin (Chapter 7)	**Fixed-width setback table** by waterbody class, where no 1% AEP extent is mapped. Never less than the Zone 1 minimum of Clause 7.4.7	Waterbodies with no mapped 1% AEP extent
S-4	Downstream analysis by hydraulic model (Chapter 5)	**Screening checklist** of downstream capacity and known flooding, with a model only where the screen fails	Sites < 1 ha, outside flood-sensitive catchments, not discharging to a tidal outfall

No.	Main-text requirement	Adoptable alternative	Eligibility
S-5	On-site detention	Fee-in-lieu toward a regional facility or restored tank storage in a master-planned basin (Chapter 4)	Where a basin plan has been notified

1.7.3 **Conditions on adoption.**

- (a) An alternative shall not lower any criterion below the values of this Manual. S-1 and S-2 are simplified methods for meeting the same criterion. They are not lower criteria.
- (b) A Tier B authority adopts an alternative by council resolution, sent to the State Stormwater Technical Committee within 30 days. A Tier A authority needs the Committee's concurrence before adoption.
- (c) The adopted alternatives shall be published on the Authority's website and in the register of Clause 10.17.
- (d) Retention (Annex 2E depth) cannot be replaced by any alternative, except where fee-in-lieu under S-5 funds equivalent retention in the same basin.
- (e) The tables for S-1, S-2 and S-3 shall be issued by the State Stormwater Technical Committee, and reviewed with Chapter 2 (Clause 2.14).

> **Commentary.** The supplement follows the model of the APWA 5600 (2025.01) Policy Supplement, which gives alternatives for the four most contested criteria (applicability, Rational Method limits, stream setback trigger, and Zone 2 setback width). Two of those map onto S-3 and onto the applicability threshold of Clause 1.5.2. Alternative S-3 copies the APWA answer to the same problem: the 1% AEP extent is not mapped for small drainage areas, so a fixed-width table is offered. S-2 follows the Kansas City 2011 shift from "match existing" to fixed unit-area release rates. Local agencies preferred a set rate because existing conditions were hard to determine consistently (MARC Evolution deck). It also reflects the Sydney Water permissible site discharge (PSD) method. The 2 ha / 0.5 ha limits for S-1 (matching Clause 4.14.1) and the 1 ha limit for S-4 have no direct precedent; they are set by this Manual.

1.8 Relationship with other instruments

1.8.1 This Manual shall be applied together with the instruments below. Where they overlap, Clause 1.3.3 governs.

Table 1.3 — Relationship with other instruments

Instrument	Relationship
Arunachal Pradesh Building Bye-Laws, 2019 (Department of Town Planning and ULBs, Government of Arunachal Pradesh; notification number, date and gazette reference [TBC]: the "Gazette Notification" page of the copy read is blank); named as the State's building bye-laws by s.2(c) of the Arunachal Pradesh Fire and Emergency Services Act, 2026 (Act No. 12 of 2026); no amendment found. Not the current rule: the "Arunachal Pradesh Building Bye-Law 2010" listed on the Town Planning portal (as summarised; not read) and the 2009 "FINAL DRAFT"	Continue. They "shall extent to whole of Arunachal Pradesh with effect from the date of notification" (2.1), are read with any master plan or other statutory plan in force, and are applicable "for a period of FIVE years after which they shall be reviewed. Till such time the reviewed building byelaws are notified, these building byelaws will continue to be in force" (2.2). The Authority is "The Director/Chief Town Planner of Town Planning & Urban Local Body … till an executing authority is notified" (definition 12); permits are processed through the Online Building Permission System, launched on 30 July 2025 and "customised" to the bye-laws (as reported). "Drain" is "A conduit or channel for the carriage of storm water, sewage, waste water or other waterborne wastes in a building drainage system" (definition 35); *Jhot* is "A strip of land permanently left open for drainage purposes. It is not to be used as an access way or a street and is not to be included as a part of setbacks" (definition 69), with no width; "Street" includes "storm water drains, culverts". The site plan shows "existing physical features such as well, drains" (2.10.1(j)), the "Distance from Nallah/Stream as per the notified rules/norms" (2.10.1(e)) and the "Distance from Disaster Prone Area as per norms set by Disaster Management Authority" (2.10.1(f)), neither set of norms having been found; a retaining wall on a sloping site stands at least 0.60 m from the building (2.10.2(a)); a layout is approved under the Arunachal Pradesh Urban and Country Planning Act, 2007 (2.10.3); and a certificate of supervision of "drainage/sanitary works" accompanies the notice (2.10.10, Appendix 'A-3'). The norms for hill towns are "only indicative" (3.2); the plinth is "not less than 300 mm" above the surrounding ground, so located "that adequate drainage of the site is assured" (4.2.1.1); surface drainage must not enter a basement; and natural hazard prone areas include those flooded by "back flow in drains, inadequate drainage, etc. as identified through local surveys in the development plan of the area". They set no storm-water volume, peak-flow, detention, setback number, flood plinth above 300 mm or design-storm rule. The design criteria of Chapters 2–6, the hill, floodplain and recharge rules of Clause 4.11 and the corridors of Chapter 7, whose Zone 1 is at least 15 m and is offered as the "norms" to which 2.10.1(e) refers, are this Manual's proposals; they are not statutory values, and no authority has adopted them. Where the APBBL 2019, a master plan or a statute is stricter, it governs (Clause 1.3.3).
Rainwater harvesting and storm-water capture: APBBL 2019, Chapter 9 and Annexure E; environmental conditions for large sites, Tables 14.1–14.3	Continue unchanged. "All buildings having a plot size of 100 sqm while submitting the building plans for sanction shall mandatorily include the complete proposal of rainwater harvesting" (9.1; Annexure E 1.1), not mandatory below 100 m² (Annexure E 1.4); group housing avoids concrete paving, with "permeable materials … for all open parking spaces" (Table 9.1); public open spaces of more than 500 m² "shall have arrangements for complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites" (9.6); recharge is mandatory for all buildings of 500 m² and more and for parks, parking and plazas (9.7); a "Rainwater Harvesting Cell" inspects before the completion certificate, with 100% monitoring above 1,000 m² and a 10% random survey below (9.8); the Authority "may impose a levy" for failure (Annexure E 1.7); and every urban local body and planning authority is to "identify, demarcate, protect and maintain the water bodies that come under their jurisdiction" and prepare a list (Annexure E 1.8). Sites of 5,000 m² of built-up area and more keep at least 20% of their recreational open space unpaved and "The inlet and outlet point of natural drain system should be maintained with adequate size of channel for ensuring unrestricted flow of water" (Table 14.1). None sets a storage volume, release rate or design storm. This Manual counts stored rainwater against its retention requirement only as reuse (Clause 4.4.3), never as detention. Where 9.7's mandatory recharge falls on a site where the hill rule or the floodplain rule of Clause 4.11 forbids infiltration, the two conflict: this Manual requires storage in place of recharge there, and the applicant seeks the Authority's relaxation; the Manual does not override the bye-law.
Effluents and roof drainage: APBBL 2019, 4.16, 4.19 and 4.33	Continue. Septic tanks follow Part 9 of the National Building Code, with the dispersion system at least 18 m from drinking-water sources and 6 m from buildings (4.16.1), and "Under no circumstances shall effluent from a septic tank be allowed into an open channel drain or body of water without adequate treatment" (4.16.2(c)); "The Authority may require rain-water pipes to be connected to a drain or sewer" (4.19.1.1); rainwater harvesting is "desirable" under Part 9 of the National Building Code (4.19.1.3); and large buildings treat their waste water (4.33.4). The rule against septic effluent in open drains is already in force; the gap is enforcement and the absence of a sewer or septage service (Chapter 8). A dispersion system on a slope of more than 10° or on shale conflicts with the hill rule of Clause 4.11; the Manual recommends that a geotechnical engineer site it and does not override the bye-law.

Instrument	Relationship
Earth cutting and sloping sites: APBBL 2019, 4.39	Continue. Earth-cutting permission is valid for six months; a cut is not more than 3 m high (4.39(4)) and keeps 2.5 m from the property line on the upper terrace (4.39(5)); the owner clears "soil/debris from site or drain to suitable/safer place" (4.39(8)) and builds a retaining or breast wall "immediately" (4.39(11)); and "Earth cutting permission shall not be granted if the average slope of the topography is more than 30%. And the site will be declared as not fit for construction except for plantation", with a penalty of one lakh rupees for cutting without approval and a recommendation by the Building Permission Committee to cancel the land allotment (4.39(14)). The 30% limit (about 17°) is an earth-cutting rule, not an infiltration rule; the hill rule of Clause 4.11 bars deliberate infiltration on natural slopes of more than 10°, and the slope drainage of Chapter 6 attaches to the earth-cutting permission.
Arunachal Pradesh Municipal Act, 2007 (Act No. 4 of 2008; Notification No. LAW/LEGN-21/2007, 19 March 2008; Gazette Extraordinary No. 23, Vol. XV, 19 March 2008; assent 17 March 2008); notification of the Pasighat municipal area (No. DTPMUN-43/2010-2011, 24 August 2010)	Continue. "Drainage and sewerage" is a core municipal service (s.47(1)(a)(ii)), which the municipality may "decide not to take up, or postpone" (s.47(2)) and the State may direct (s.47(3)); other functions include "improving river banks" (s.49). "Notwithstanding anything contained in any other law", the Act vests in the municipality "all public tanks, streams, reservoirs, and wells" and "all public sewers and drains, channels, tunnels, culverts and watercourses, alongside, or under, any street" (s.102(b), (d)). The municipality "shall … construct and maintain drains and sewers, and provide a safe and sufficient outfall … for … proper discharge of storm-water and sewage … in such manner as may not cause any nuisance, whether by flooding", with a proviso that "no sewage shall be discharged into any watercourse until it has been so treated" from a date the State appoints (s.194); public drains and sewage works vest under s.196; "Water-course" includes a river, stream or channel, natural or artificial (s.2(85)); and buildings are sanctioned by a Municipal Building Committee (ss.340–343). Compulsory acquisition runs "under the Land of Acquisition Act, 1894" (as printed) at the municipality's request, and "other methods of land assembly including the use of transferable development rights" are allowed (s.104). Pasighat is the State's Municipal Council under this Act (municipal area 10.21 km²; 8 wards, as reported); the Itanagar municipal area was notified under it on 14 September 2010 (No. DTPMUN-02/2008-2009), and the Gauhati High Court records notifications of 06.02.2012 (Itanagar) and 20.12.2012 (Pasighat) (PIL 22(AP)/2018), a date conflict with the 2010 gazettes; both may exist. Councils first elected on 16.05.2013 were dissolved in 2018 and administrators appointed (PIL 22(AP)/2018).
Arunachal Pradesh Municipal Corporation Act, 2019 (Act No. 8 of 2019; Notification No. Law/Legn-4/2019, 30 September 2019; Gazette Extraordinary No. 373, Vol. XXVI, 1 October 2019; assent 17 September 2019); the notification constituting the Itanagar Municipal Corporation under sections 3 and 4 (not found [TBC]); the Delimitation of Ward Rules, 2019 (as summarised)	Continue. The obligatory functions include "(a) the maintenance and cleaning of drains and drainage works", "(c) the reclamation of unhealthy localities" and "(p) survey of buildings and lands" (s.60); "all public streams, springs and works for the supply, storage and distribution of water" and "all public sewers and all drains, and sewers, culverts and water courses in or under any public street" vest in the Corporation, and public drains and sewage disposal works in the municipal area vest in it under s.200. An owner may connect a private drain to a Corporation drain on application, but may not discharge "foul water into a drain provided for surface water" where separate drains exist, nor, "except with the permission of the Commissioner, surface water into drain provided for foul water", nor connect "directly with a storm water overflow drain" (s.203). Its town-planning-scheme "internal services" include "sewers and drains both for storm and sullage water and necessary provision for their treatment and disposal". The Itanagar Municipal Corporation (IMC) has 20 wards and elected councils in January 2021 and January 2026, and a notice of March 2026 proposed extending its limits to Jullang, Chimpu and nearby villages (all as reported).

Instrument	Relationship
Arunachal Pradesh Urban and Country Planning Act, 2007 (Act No. 3 of 2008; Notification No. LAW/LEGN-6/2007, 11 March 2008; Gazette Extraordinary No. 18, Vol. XV, 14 March 2008; the copy prints the assent as "7th March, 2007", probably a misprint for 2008); the Arunachal Pradesh Urban and Country Planning (Amendment) Ordinance, 2025 (Ordinance No. 5 of 2025; date of promulgation not legible [TBC]); an amending Bill reported passed by the Assembly on 9 March 2026 (as reported; Act number, assent and final text not found [TBC]); the Master Plan of Itanagar Capital Region-2031 (approved under s.24 on 3 June 2022; Notice of approval of 30 June 2022)	Continue. "Building operations" include changes affecting "drainage or sanitary arrangements", and amenities include "sewerage, drainage, public works and other utilities"; Local Planning Authorities are bodies corporate (s.10(2)), among them the Itanagar Planning Authority, chaired by the Deputy Commissioner, Itanagar Capital Complex. The Ordinance adds Town Planning Schemes, land pooling and local area plans; a scheme may include "the filling-up or reclamation of low-lying, swampy or unhealthy area, or levelling-up of land" and "drainage, inclusive of sewerage, surface or sub-soil drainage and sewage disposal"; it defines a "sponge city" as "an area that acts like a sponge, soaking up and retaining water during rain and storms and releasing it slowly", and lets the Government "prepare policy documents for … Sponge City … Risk Informed master Plan" (new s.71(2)(za)). These provisions are cited from the Ordinance; whether and in what form the amending Act keeps them was not found [TBC]. The master plan of the Itanagar Capital Region finds "no proper storm water network for the overall town area", existing drains "not engineered … open drains or kutcha drains without any flow gradient", "only 3.7% storm drains along main roads" and "storm water drains being used as sewers", and proposes a new drainage network (Maps 28–30) and a sewage treatment plant near the Dikrong, with no design storm, return period or runoff coefficient; the report read is titled "Draft" [TBC]. No master plan or drainage plan for Pasighat was found [TBC]. Plans and schemes would show the flood-sensitive catchments, drainage reserves and regional facility sites of this Manual (Chapter 11), and this Manual's compensatory-storage rule applies to reclamation under a scheme.
Arunachal Pradesh (Land Settlement and Records) Act, 2000 (Act No. 10 of 2000), as amended in 2018 (s.1A, as reported); Constitution of India, Article 371H	Apply as they stand. The Act provides "a comprehensive law for land revenue administration for the whole of the State of Arunachal Pradesh incorporating customary rights on the land", commences by notification for different areas (s.1(3)), and defines "common land", "community" (including "a clan, sub-clan, kindred"), "competent authority" ("any officer appointed by the Government"), "Government land" (land acquired "or through donation of the public" for administrative purposes) and "improvement" (including "works for the drainage of" land) (s.2); the beds of rivers, streams, nallahs, lakes and tanks and "all standing and flowing water" are the Government's only where they "are not the property of any person or community" (s.9(1)). Article 371H gives the Governor special responsibility for law and order and does not protect customary law or land (as quoted); the State has no Sixth Schedule area. This Manual takes no land: its corridors and setbacks are conditions of building permission and layout approval wherever the bye-laws apply and recommendations elsewhere, and land for public drains is secured by agreement with the owners or the community, by donation, by purchase, or by reservation in a plan or scheme; the route of s.104 of the 2007 Municipal Act is stated, not invoked.
Official language	English is the language of the State's laws and administration and of this Manual (as reported; no Act was checked for this Manual).
Floodplains, waterbodies, springs and wetlands: no State law found; APBBL 2019 Annexure E 1.8 and Chapter 12; the Wetlands (Conservation and Management) Rules, 2017, with the State Wetland Authority (as reported; its exact name and notification [TBC])	No floodplain zoning Act or Bill, and no statute or bye-law protecting a stream, nallah, spring, pond or wetland with a numerical buffer, was found; no flood zone exists in law. The bye-laws' Chapter 12 lists "sacred groves, hills, hillocks, water bodies (and the areas adjoining the same)" among natural features to be "listed in notification(s) … / identified in Master Plan"; none was found listed. No wetland notified under rule 4 was found; Glaw Lake was announced as a Ramsar site on 3 August 2026 (as reported). The first Water Bodies Census counts 993 water bodies in the State, none encroached (as summarised). The corridors and the spring rule of Chapter 7 are this Manual's proposals.
National Green Tribunal: OA 94/2020/EZ, *S. D. Loda v. Union of India & Ors.* (the Senki, the Pachin and the Dikrong); OA 606/2018 (State affidavit-cum-six-monthly report, 2025; amicus observations of 20.03.2026); OA 148/2025/EZ (Dibang muck); Gauhati High Court, Itanagar Bench: PIL 22(AP)/2018 (municipal elections; judgment 28.09.2018), PIL 21/2021 and the road PIL of 2024 (both as reported)	Apply as directions where they bind; none sets a design standard or a setback. On 5 January 2023 the Tribunal directed in OA 94/2020/EZ that "no untreated sewage or treated sewage be allowed to enter into the waterbody", with quarterly monitoring by APSPCB, and on 8 April 2025 asked the State and the Itanagar Municipal Corporation to file counter-affidavits on faecal sludge treatment (as summarised). In OA 606/2018 the observations quoted in the State's affidavit say that "no ULB is treating sewage. Even the state capital, Itanagar-Naharlagun, lacks a sewage treatment facility". In the Itanagar Bench, PIL 21/2021 directed IMC to fine littering, and the 2024 PIL gave PWD (Highways) two months to repair the Itanagar–Jullang–Naharlagun–Nirjuli road (as reported). No order on the capital's drains, earth cutting or landslides was found. Sewage in storm drains is dealt with in Chapter 8.

Instrument	Relationship
Groundwater: no State rule found	Continue. The State's stage of groundwater extraction is 0.39% (CGWB, 2024, as summarised), so recharge is not a design objective of this Manual (Clause 4.11, recharge rule). No State observation-well network was found; the network is CGWB's [TBC].
Environment (Protection) Act, 1986; Water (Prevention and Control of Pollution) Act, 1974; the Arunachal Pradesh State Pollution Control Board (APSPCB)	Continue. CPCB lists four stretches in the State, all Priority V and first listed in 2025: the Namchik at Kharsang, the Senki at Chandranagar, Itanagar (upstream of the Pachin), the Dibang at Roing and the Subansiri at Gerukamukh; the Pachin itself is not listed (CPCB, 2025). Sewage in storm drains is dealt with in Chapter 8.
Disaster Management Act, 2005; the Arunachal Pradesh State Disaster Management Authority (APSDMA), the Department of Disaster Management, the Deputy Commissioners and the District Disaster Management Authorities	Continue. No "Disaster Prone Area" norms under APBBL 2.10.1(f) and no order of the State fixing a date for pre-monsoon desilting were found; the works calendar of Chapter 10 sets this Manual's dates, beginning with 31 March.
The drainage master plan for the Itanagar Capital Region (expression of interest of 31 October 2017; a consultant's plan reviewed in June 2021, as reported) and the State Action Plan on Climate Change (draft, 2011)	Neither was found adopted, and neither states a design storm. The Action Plan budgets "Storm water draining in twenty six urban settlements" at Rs 15,000.0 million with no criteria; that is a budget line, not a design basis. A drainage master plan, once adopted, would be carried into Chapter 11.
IRC:SP:42-2014, IRC:SP:48 (Hill Road Manual) and the practice of PWD and PWD (Highways) on hill-road drainage; PMGSY's rule that "a drainage plan" be prepared "for each rural road project" (as cited by CAG)	Apply to the drainage of hill roads, cross-referenced from Chapter 6, where they do not conflict with it; the drainage clauses of IRC:SP:48 were not read for this Manual [TBC]. CAG found ₹46.15 crore spent on 49 km of rural roads "wherein no drains were constructed" (CAG, Audit Report 2022-23).
CPHEEO Manual on Storm Water Drainage Systems (2019)	Engineering reference. This Manual sets higher return periods under Clause 1.3.2.
NDMA Guidelines on Management of Urban Flooding (2010) and MoHUA SOP (2017)	This Manual puts into effect the NDMA directives on catchment-based design, detention and retention, waterbody protection and climate-adjusted IDF.
NDMA Urban Flood Risk Management Programme (UFRMP) and AMRUT 2.0	Works funded under these programmes shall comply with this Manual. The development controls of Chapters 4–5 protect the capacity those works create.
IRC:SP:42-2014 and IRC:SP:50-2013	Apply to road drainage only where they do not conflict with Chapter 6.
MBBL 2016, Chapter 9	Model for RWH and for the inspection regime in Chapter 10.

Commentary. RWH in Arunachal Pradesh is framed as a water supply and recharge measure. It works well for that purpose. It cannot, however, be relied on for flood control in the monsoon, because RWH sumps are usually full or the ground saturated by the time a July to September monsoon storm in the foothills, such as those of 11 July 2017 at Laptap and September 2018 at Itanagar, arrives after weeks of rain. The Manual therefore keeps harvest volume and attenuation volume apart, while letting recharge count as retention where it truly removes water from the system.

Arunachal Pradesh is planning and spending on its town drains, but without a design basis. The State Action Plan on Climate Change (draft, 2011) budgets "Storm water draining in twenty six urban settlements" at Rs 15,000.0 million with no design criteria; the Department of Town Planning and ULBs invited expressions of interest in October 2017 for a "GIS based Integrated Drainage Master Plan and DPR for Itanagar Capital City" over 65 km²,

with a horizon year of 2038 and no return period stated; a plan prepared by a consultant was reviewed by the Chief Minister in June 2021, who asked for "a GIS-based and scientifically approved drainage master plan" with trial sectors in Itanagar and Naharlagun (as reported); a storm-water drainage and seepage-management project for Itanagar had its foundation stone laid in June 2018 (as reported); the Itanagar Municipal Corporation sought central funds for 64 km of integrated drains (as reported, undated); and the Itanagar and Pasighat Smart City companies list storm-water drains among their works, Pasighat's with "improperly constructed drainage systems" noted by its Member of Parliament (as reported). The adoption of the drainage master plan was not found, and none of the documents found states a design storm, return period or runoff coefficient. The Comptroller and Auditor General found that three rural road projects costing ₹47.70 crore were taken up "without provision of drain", with "₹46.15 crore on construction of 49 Km roads wherein no drains were constructed", although "It is mandatory under PMGSY to have a drainage plan prepared for each rural road project" (CAG, Audit Report 2022-23). No development-control condition stops new plots in the same catchments from using up the capacity such works create. Linking Chapters 4–5 to approvals closes that gap.

The State's law holds more of the tools than most. The APBBL 2019 apply to the whole State (2.1); ask the site plan to show existing drains and a distance from the nallah or stream (2.10.1(j), (e)) and a certificate of supervision of "drainage/sanitary works" (2.10.10); refuse earth cutting where the average slope exceeds 30% (4.39(14)); let the Authority require roof water to be connected to a drain (4.19.1.1); bar septic effluent from open drains (4.16.2(c)); ask public open spaces of more than 500 m² for "Artificial or natural Storage of storm water runoff from larger sites" (9.6); and ask large sites to keep at least 20% of their recreational open space unpaved and the "inlet and outlet point of natural drain system" open (Table 14.1). The Arunachal Pradesh Municipal Act, 2007 makes "drainage and sewerage" a core municipal service (s.47(1)(a)) and requires a municipality to "construct and maintain drains and sewers, and provide a safe and sufficient outfall … for … proper discharge of storm-water and sewage … in such manner as may not cause any nuisance, whether by flooding" (s.194); the Arunachal Pradesh Municipal Corporation Act, 2019 makes "the maintenance and cleaning of drains and drainage works" an obligatory function (s.60(a)), vests the public drains in the Corporation (s.200) and keeps foul water out of drains provided for surface water where separate drains exist (s.203). The Arunachal Pradesh Urban and Country Planning Act, 2007 makes Local Planning Authorities bodies corporate (s.10(2)) and counts "drainage" among the amenities a plan provides; the master plan of the Itanagar Capital Region, approved on 3 June 2022, proposes a new drainage network for Itanagar and Naharlagun (Maps 28–30); and Ordinance No. 5 of 2025 adds Town Planning Schemes, whose contents include "drainage, inclusive of sewerage, surface or sub-soil drainage and sewage disposal", and defines a "sponge city" as "an area that acts like a sponge, soaking up and retaining water during rain and storms and releasing it slowly". The courts and the tribunal have acted on the rivers: the National Green Tribunal directed on 5 January 2023, in OA 94/2020/EZ on the Senki, the Pachin and the Dikrong, that "no untreated sewage or treated sewage be allowed to enter into the waterbody" (as summarised). What the law lacks is a design standard. None of these instruments says how large a drain must be, which storm it must carry, how much water a hill site may put into its slope, how far a building must stand from a stream, nallah or spring, or how much storage a paved plot removes; and the master plan designs its proposed network on the "topography of the region and flow gradient", with no design storm. This Manual's checks are framed as part of the permission given by the competent authority for the area under the APBBL 2019, not as a separate no-objection certificate. This Manual is offered as a technical companion to these instruments, to the orders of the tribunal and to the drainage works of the towns: it supplies the design storm, detention, hill-site drainage, infiltration and corridor numbers they do not set, and its storage-first rules are an engineering form of the Ordinance's sponge-city definition, as a proposal for the Government, the urban local bodies, the planning authorities and the communities to consider. It is not a policy document under the Ordinance, and none under section 71(2)(za) was found. Neither the Department of Urban Affairs, the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Itanagar Planning Authority, the Water Resources Department nor any other body has adopted it.

1.9 Roles and responsibilities

1.9.1 The responsibilities below apply under this Manual. They do not change any agency's statutory powers.

Table 1.4 — Roles and responsibilities under this Manual

Agency	Role under this Manual
Department of Urban Affairs (Urban Affairs; formerly the Department of Town Planning and ULBs, "Re-named as Department of Urban Affairs in 2021"), with its Urban Development, Town Planning, Housing and Urban Local Bodies wings	Its functions include "Storm Water Drains; Drainage; Sewerage; Septage Management"; a works department since 2005, with a Chief Engineer and 28 divisions, it builds storm drains, sewerage and septage works and hands them to the urban local bodies (department website). Its Town Planning wing (the Directorate of Town Planning) issued the APBBL 2019, administers the Arunachal Pradesh Urban and Country Planning Act, 2007, prepared the master plan of the Itanagar Capital Region and invited the drainage master plan of 2017. Could carry this Manual into the five-year review of the APBBL 2019 (2.2), notify its 15 m corridor as the "norms" of 2.10.1(e), carry the flood-sensitive catchments, drainage reserves, 1% AEP areas and regional facility sites into master plans and Town Planning Schemes, design its drainage works to this Manual, and give regional support to Tier B authorities (Table 1.1), if the Manual were adopted.
The Authority under the APBBL 2019 (the Director/Chief Town Planner of Town Planning & Urban Local Body, "till an executing authority is notified", definition 12) and its Building Permission Committees	Grants building permits and earth-cutting permission (4.39) throughout the State, through the Online Building Permission System since 30 July 2025 (as reported). Would require the drainage report of Chapter 10 with each application, make the hill rule and the corridor of this Manual conditions of permission, and inspect and enforce (Clauses 10.12–10.15).
State Stormwater Technical Committee (Clause 1.3.2)	Would set the higher standards of Clause 1.3.2, issue Annexes, tables and the compliance calculator, concur with Tier A alternatives, decide variances referred to it and review the Manual (Clause 1.12).
Itanagar Municipal Corporation (IMC) (Arunachal Pradesh Municipal Corporation Act, 2019)	Holds the public drains, sewers, streams and springs of its area (s.200; vesting of "all public streams, springs and works for the supply … of water"), with "the maintenance and cleaning of drains and drainage works" an obligatory function (s.60(a)), and controls connections to its drains (s.203). Twenty wards; councils elected in 2021 and 2026 (as reported); a respondent in NGT OA 94/2020/EZ. The notification constituting it under sections 3 and 4 was not found [TBC]. Would apply this Manual to its own works and to drain connections, keep the drain register of its area, receive handed-over assets (Clause 10.14), and could make bye-laws under the 2019 Act.
Pasighat Municipal Council (Arunachal Pradesh Municipal Act, 2007)	Holds the public drains, tanks and streams of its area (s.102, "Notwithstanding anything contained in any other law"), with "drainage and sewerage" a core service (s.47(1)(a)) and the duty to "construct and maintain drains and sewers, and provide a safe and sufficient outfall" (s.194); sanctions buildings through its Municipal Building Committee (ss.340–343). Area 10.21 km² (2010 notification); 8 wards (as reported). Would require the drainage report of Chapter 10, apply this Manual to its works, keep the drain register of its area and could act under sections 194 to 196.
The Itanagar Planning Authority and the other Local Planning Authorities (Arunachal Pradesh Urban and Country Planning Act, 2007), and the Deputy Commissioner, Itanagar Capital Complex, as chairman of the Itanagar Planning Authority	Prepare master plans and approve layouts (APBBL 2.10.3) and, under Ordinance No. 5 of 2025, Town Planning Schemes; notifications of Local Planning Authorities for Ziro, Namsai, Raga, Anini, New Sagalee, Tuting and Nafra are listed on the Town Planning portal (file titles, as summarised). Could carry the drainage reserves, flood-sensitive catchments and storage sites of this Manual into plans, layouts and schemes, and apply its compensatory-storage rule to the "filling-up or reclamation of low-lying, swampy or unhealthy area" that a scheme may include.
The Itanagar and Pasighat Smart City companies	Build works under the Smart Cities Mission, among them storm-water drains (as reported; company names and drain DPRs not read [TBC]). Would design their drainage works to this Manual from the dates of Clause 1.11 and hand them over under Clause 10.14.

Agency	Role under this Manual
Water Resources Department (WRD)	Builds and maintains river and anti-erosion works, among them the Siang schemes for the Mebo villages (as reported). Would supply river levels and flood marks for Chapter 5, consent to any work in or on a river, and apply this Manual to its works. Its works on rivers keep its own calendar. Holds the groundwater role of this Manual (WRD); no State observation-well network was found [TBC].
Public Health Engineering and Water Supply Department (PHED)	Develops and operates water supply, with intakes on the Senki, the Poma and the Niorch for Itanagar (master plan); not researched for this Manual [TBC]. Would protect the spring-recharge areas above its intakes and keep its works clear of the drains of Chapter 8.
Public Works Department (PWD) and PWD (Highways)	Build and maintain the roads, among them NH-415 between Itanagar and Naharlagun, with their side drains, catch-water drains and culverts, which in the hill towns are much of the minor drainage system (as reported). Would apply Chapter 6 and the hill-road rules to them and never discharge a road drain onto an unprotected slope.
The Arunachal Pradesh State Disaster Management Authority (APSDMA), the Department of Disaster Management (DDM) and the State Emergency Operation Centre, the Deputy Commissioners and the District Disaster Management Authorities, and the land revenue offices of the Deputy Commissioners	Prepare for and respond to floods and landslides and report their tolls (DDM's daily situation reports and the Centre's damage reports, as reported; APSDMA's own documents not read [TBC]). Would supply the landslide, flood and glacial-lake inventories used in the screening of Clause 2.3.6(i), set the "Disaster Prone Area" norms that APBBL 2.10.1(f) anticipates, and lead post-event reviews with the Authority (Clause 10.16). The land revenue offices hold the records of settled land; most community and clan land is not in any register.
Arunachal Pradesh State Pollution Control Board (APSPCB)	Monitors the Senki, the Pachin and the Dikrong, quarterly under the Tribunal's order (as summarised). Would receive the records of sewage found in storm drains under Chapter 8.
Department of Environment, Forest and Climate Change and the State Wetland Authority (as reported; its exact name and notification [TBC])	Truthed and demarcated the State's wetlands; administer the Wetlands Rules, 2017; no wetland has been found notified under rule 4. The Authority's consent would be needed before a notified wetland is used for storage or as an outfall (Chapter 7).
NEEPCO (the Pare, Ranganadi and Kameng projects) and NHPC (the Lower Subansiri project, and the Dibang project under construction)	Operate the dams and their gates, whose releases set the river in the reaches below them. Operators, not approving authorities: would supply reservoir levels, release records and release protocols, none of which was found [TBC], for Chapter 5 and the screening of Clause 2.3.6(i).
Communities, clans and village authorities on their own land	Hold much of the land near the towns on which streams, nallahs, springs and corridors lie (Land Settlement and Records Act, 2000). This Manual has no force on community or clan land unless a permission or a plan carries it or the community adopts it: a community could agree drainage corridors, easements and facility sites on its land (Chapter 7), by agreement, donation or sale, and keep its drains and springs clear.
Central Water Commission (CWC), a body of the Union	Publishes the Flood Estimation Reports for subzones 2(a) and 2(b) used in Chapters 2 and 3, and runs the gauges at Pasighat, Namsai, Tezu, Yazali and other sites (as transcribed by SANDRP). Would supply stage records with their datum for Chapter 5 and say whether any revision of the 2(a) report extends its isopluvials into the hills.
Central Ground Water Board (CGWB), North Eastern Region, a body of the Union	Assesses the State's groundwater (stage of extraction 0.39% in 2024, as summarised) and holds the observation wells. Would supply groundwater levels and quality with WRD.
IMD (the Meteorological Centre Itanagar) and NERIST, Nirjuli; road and rail owners	IMD's stations and the automatic stations of its Itanagar centre supply the rainfall records of Chapter 2; NERIST's daily gauge at Doimukh (1988–2012) is the basis of the capital-region table of Clause 2.3.6(c)(ii); both are first data requests of Clause 2.3.6(a). Road and rail owners would apply this Manual to road drainage (Chapter 6), culverts and linear works (Clause 1.5.7).

Commentary. Stormwater in Arunachal Pradesh is split, first, by land. The APBBL 2019 apply to the whole State, and the Authority under them grants building permits and earth-cutting permission everywhere; in the two municipal areas the Itanagar Municipal Corporation and the Pasighat Municipal Council hold the public drains

under their Acts; in a Local Planning Area the Local Planning Authority approves layouts and plans. But much of the land near the towns is held by communities, clans and individuals, with customary rights recognised in the Land Settlement and Records Act, 2000, and the beds of streams and nallahs on that land are not Government property (s.9(1)). The split is then repeated among the bodies that drain the land: the Department of Urban Affairs and the Smart City companies build drains, sewerage and septage works and hand them to the urban local bodies; PWD and PWD (Highways) build the road drains that are much of the minor system in the hill towns; WRD holds the rivers; PHED the water supply; and NEEPCO and NHPC the dams whose releases set the rivers below them. The capital shows why the split matters. Its drains "end up mostly into the Nallah and in some cases, into local ponds or open fields", "Most of the surface water and sewerage gets mixed up resulting in storm water drains being used as sewers", and "no scheme or work for storm water drains is under execution" (master plan of the Itanagar Capital Region). Both municipal Acts vest the public drains in the urban local body and make drainage its duty (2007 Act, ss.47, 102, 194 and 196; 2019 Act, ss.60(a) and 200), but no notification divides the drains of any Arunachal Pradesh town among their owners (NEER reading). Until the State issues such a rule [TBC], this Manual assigns the drainage elements as in Table 1.5, as Chapter 6 does for the drains themselves, and recommends that each town keep a **drain register** giving every reach its owner under this split, its land status (community, clan, individual, municipal or Government land), whether it carries sewage or septic overflow, and its outfall (set by this Manual). The assignment is this Manual's working split for applying its clauses; it does not change any agency's powers, and on community, clan or private land it is put into effect by agreement with the owners or the community, not by acquisition.

Table 1.5 — Working assignment of drainage elements under this Manual

Element	Assigned to
Public drains, sewers, culverts and watercourses in or under streets, and public streams and springs, within the area of the Itanagar Municipal Corporation	IMC (Arunachal Pradesh Municipal Corporation Act, 2019, s.200 vesting; s.60(a) "the maintenance and cleaning of drains and drainage works"; s.203 connections)
The same within the Pasighat municipal area	The Pasighat Municipal Council (Arunachal Pradesh Municipal Act, 2007, s.47(1)(a)(ii); s.102 vesting "Notwithstanding anything contained in any other law"; s.194 drains and outfalls; s.196)
Storm drains, sewerage and septage works built by the Department of Urban Affairs or the Smart City companies	The builder, until handed over in writing to the urban local body
Roadside drains, culverts and scuppers of State roads and of NH-415	PWD and PWD (Highways)
Rivers, their beds and banks, and anti-erosion works	The WRD
Water supply	PHED (not researched [TBC])
Dams, reservoirs and their release reaches	NEEPCO and NHPC (operators)
Drains on community or clan land outside an urban local body	The community (no statutory owner)

This Manual names departments and authorities as the statutes, orders and records name them. A manual that names one owner for each task does not fix institutions by itself, but it removes ambiguity about who signs what.

1.10 Variances and waivers

1.10.1 **Variance.** The Authority may grant a variance from a numeric requirement where the Applicant shows, through a report certified under Clause 10.6, that:

- (a) compliance is impracticable because of site conditions such as a high groundwater table, contaminated soil, rock, or a site area too small for the required facility; and
- (b) the proposed alternative gives equal or better performance at the downstream point of Chapter 5, or the shortfall is made up by fee-in-lieu or off-site works in the same catchment.

1.10.2 **Waiver.** The Authority may waive Chapter 4 detention requirements (not retention) where a hydraulic analysis certified under Clause 10.6 shows that the site discharges directly to the sea, or to a tidal reach with no flood-prone property downstream, and that undetained flow does not worsen the outfall-closed condition of Chapter 5. Arunachal Pradesh has no coast and no tidal reach, so no site in the State qualifies for this waiver. A site that drains to a nallah backed up by the Dikrong, to the Siang, the Lohit or the Noa-Dihing at Pasighat, Tezu or Namsai, to a reservoir or its release reach, or to any river in flood, is in the outfall-closed condition of Chapter 5 whenever the receiving water is high, and detention is not waived for it; nor is it waived for a site because it drains to a steep stream or nallah in the hills.

1.10.3 **No variance or waiver.** No variance or waiver shall be granted for:

- (a) a sewage connection to a storm drain;
- (b) the lowest habitable floor level of Chapter 6;
- (c) any reduction of a waterbody setback below the Zone 1 minimum of Clause 7.4.7, or any fill or construction in the no-fill zone of Chapter 7; or
- (d) the retention requirement in a flood-sensitive catchment, except by fee-in-lieu under Clause 1.7.

1.10.4 **Procedure.**

- (a) The request shall be made on **Form 1-2** (Variance / Waiver Request) with the preliminary drainage report.
- (b) A Tier B authority shall refer any variance on a site of 1 ha or more to the State Stormwater Technical Committee.
- (c) A decision shall state its reasons and any conditions, and shall be entered in the public register of Clause 10.17.
- (d) A variance runs with the approval. It lapses if the approval lapses.

> **Commentary.** The 2006 APWA 5600 included a waivers section (5601.6), and Georgia allows waivers where downstream analysis shows a peak control is unnecessary. The waiver of Clause 1.10.2 is narrow: on a tidal coast, undetained flow can help by passing through before the tide closes the outfall, but only an analysis can show that. This Manual requires every decision to be published because publication deters case-by-case erosion of the standard; in Arunachal Pradesh no statute or bye-law sets a numerical setback from a stream, nallah, spring or drain: the Arunachal Pradesh Building Bye-Laws, 2019 ask the site plan to show the "Distance from Nallah/Stream as per the notified rules/norms" (2.10.1(e)), but no such rules or norms were found, and the master plan of the Itanagar Capital Region reports that the 2017 floods badly damaged the "land protection wall of several nallahs and rivulets" and that the Pachin, "flowing through densely populated areas", had "become a waste disposal site".

1.11 Transition provisions

1.11.1 **Effective date.** This Manual takes effect for new applications **6 months** after notification (the effective date).

1.11.2 **Applications in process.** An application filed complete before the effective date may be decided under the rules in force when it was filed, if a decision is issued within 12 months of the effective date. Otherwise, this Manual applies.

1.11.3 **Phased start for Tier B.** In Tier B authorities, Chapters 4 and 5 apply from **24 months** after notification, except in flood-sensitive catchments, where they apply from the effective date.

1.11.4 **Public works.** DPRs sanctioned before the effective date may proceed as sanctioned. Any DPR revised or re-tendered after the effective date shall comply. Departments shall report non-compliant works in progress to the State Stormwater Technical Committee within 12 months.

1.11.5 **Before the annexes are issued.** Until an annex referred to in this Manual is issued, the Applicant shall use the method stated in the clause, with values agreed with the Authority and recorded in the drainage report.

> Commentary. The 6-month lead time matches the lead time for NIH-DHAARA updates in Clause 2.14.2. Singapore gave a similar interval for its 2025 detention addendum (issued 16 Apr 2025, applied from 1 Oct 2025). The 12- and 24-month periods are set by this Manual to let Tier B authorities train staff and to let the State issue the design-aid tables (Clause 1.7).

1.12 Review and amendment

1.12.1 The State Stormwater Technical Committee shall review this Manual every **10 years**, and after any event that exceeds the 1% AEP design depth as set out in Clause 2.14.1.

1.12.2 Amendments shall be notified in the Gazette, published with a change log, and take effect 6 months after notification unless the notification states otherwise.

1.12.3 Any person may propose an amendment to the Committee. Proposals and the Committee's decisions shall be published.

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Annexes and forms

Annex / Form	Content
1A	List of Tier A authorities, with the boundaries of the Itanagar Municipal Corporation area and of the Master Plan of Itanagar Capital Region-2031
1B	Maps of flood-sensitive catchments
1C	Policy Supplement: text of alternatives S-1 to S-5 and model council resolution
1D	Model APBBL 2019 amendment and model ULB bye-law
Form 1-1	Applicability Determination
Form 1-2	Variance / Waiver Request

CHAPTER 2

Design Rainfall and Design Storms

2.1 Purpose and scope

2.1.1 This chapter sets the rainfall inputs for every hydrologic calculation in this Manual: drain and inlet sizing (Chapter 6), retention and detention sizing (Chapter 4), downstream and tailwater analysis (Chapter 5), and waterbody and tank works (Chapter 7).

2.1.2 It specifies:

- (a) the approved sources of design rainfall depth and intensity;
- (b) how depths are converted between durations, between point and area, and from present to future climate;
- (c) how design storms (hyetographs) are constructed; and
- (d) the storms that must be applied to pre- and post-development conditions.

2.1.3 This chapter applies throughout Arunachal Pradesh. Where the Itanagar Municipal Corporation, the Pasighat Municipal Council, a Local Planning Authority or the Authority under the bye-laws has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

> **Commentary.** Most past drainage failures in Arunachal Pradesh trace to the rainfall input, not the hydraulics. Arunachal Pradesh shows how. No design storm was found for any town's drains in the State: the master plan of the Itanagar Capital Region proposes a new drainage network designed on the "topography of the region and flow gradient", with no design storm, return period or runoff coefficient, and the expression of interest for the capital's drainage master plan (2017) states no return period. The published sources that seem to fill the gap do not. The CWC report for subzone 2(a) covers almost the whole State on paper but draws its isopluvials only along the foothills, so every hill town lies in blank map space; at the capital its plate reads about 200 mm at 50 years, one contour below the only frequency analysis of a gauge in the capital region, NERIST's at Doimukh (Dabral et al., 2016); and its 1-hour ratio of 0.26 against the 0.48 of the 2(b) report across the Lohit gives two neighbouring towns hours that differ by nearly half for the same day. IMD Das et al. (2022) has no Arunachal Pradesh panel, and NIH-DHAARA gives the foothill towns 1.7 to 2.4 times the plates (Clause 2.3.6). The station figures conflict: IMD's Pasighat record, 652.2 mm on 5 October 1988, is 1.37 times the station's next-highest day, of the same year; Ziro's annual maximum is a February day; the master plan gives Itanagar "2289 mm" a year with no source, against 3,942.44 mm in a CGWB summary; and NERIST's Doimukh normal is 3,531.8 mm against 3,251.67 mm in the same CGWB summary (IMD, *Extremes*; master plan; Dabral et al., 2016; CGWB, as summarised). Fixing one transparent source and method for the whole state is the main purpose of this chapter.

2.2 Definitions

Term	Meaning in this Manual
Annual exceedance probability (AEP)	Probability that a given rainfall depth is equalled or exceeded in any one year. A 1% AEP storm is the "100-year" storm. Both forms are used here: T-year = 1/AEP.
IDF / DDF	Intensity–duration–frequency and depth–duration–frequency relationships for a location.
Point rainfall	Rainfall at a single location, as measured by a rain gauge.
Design storm	A hyetograph (rainfall depth versus time) of stated AEP, duration and temporal pattern.
Critical duration	The storm duration that produces the largest peak flow, water level or storage requirement for the element being designed.
Areal reduction factor (ARF)	Ratio of catchment-average rainfall to point rainfall for the same AEP and duration.
Monsoon season (as used in this Manual)	1 April to 31 October. In this Manual "the monsoon" and "the monsoon season" mean this wet season, which takes in the pre-monsoon months of April and May as well as the south-west monsoon; it is the Manual's season, not IMD's, and IMD's south-west monsoon does not begin in April. IMD's normal date of onset of the south-west monsoon at Itanagar is 5 June (4 June in the older normals), and its normal date of withdrawal is 14 October, unchanged (IMD, 2020, as summarised); no Pasighat date was found. The season begins on 1 April for three reasons. The pre-monsoon months are wet: at Doimukh April brings 227.7 mm, May 505.9 mm and June, the wettest month, 762.8 mm, and the pre-monsoon months of March to May 846.5 mm, 24.0% of a year of 3,531.8 mm (NERIST series, via Dabral et al., 2016, citing Dabral et al., 2006); over the State, March to May bring 23.4% of 2,818 mm (State Action Plan on Climate Change, IMD gridded data 1971–2005), and "The state receives rainfall over a period of 8 to 9 months excepting in winter" (the same plan); in West Kameng the "rainy season starts from April and continues up to November" (CGWB). The east has large April and May falls: Hayuliang 278.5 mm on 24 April 1980, Pasighat 234.4 mm on 29 May 1948 and Tezu 181.4 mm on 21 May 1978, with Tezu's April 2010 total 1,087.9 mm and Hayuliang's April 1975 total 1,367.0 mm (IMD, *Extremes*). And the damaging pre-monsoon events cluster in the last ten days of May: the remnants of Cyclone Remal on 28–29 May 2024 (Bomdila 190 mm, Miao 120 mm, Namsai 70 mm in 24 hours; IMD bulletin, as summarised), the landslide that swept a vehicle off NH-13 between Bana and Seppa on 30 May 2025, killing seven, and the Pare dam's release of 1,310 m³/s on 31 May 2025 (as reported). The deadline of 31 March (Chapter 10) falls before the April storms, and the mid-season clearance of 15 May before the late-May cluster. Annual normals conflict, and this Manual chooses none: Itanagar 3,942.44 mm (1993–2002; CGWB, as summarised) and "2289 mm" (master plan of the Itanagar Capital Region, no source given); Doimukh 3,531.8 mm (NERIST) and 3,251.67 mm (CGWB, as summarised); Papum Pare district 3,200 mm, East Siang 2,910.18 mm, Lohit 5,179 mm, Changlang 2,913.8 mm (3,800–4,866 mm in parts), West Kameng 1,607 mm and Tawang about 1,600 mm (CGWB); the State 2,818 mm, with "1000 mm in the higher elevations and 5750 mm in the foot hill areas" (State Action Plan on Climate Change). Snow falls in winter on the high ranges: "Higher regions experience snow fall during winter" (the same plan), and Tawang has "occasional rainfall/snowfall during winter" (CGWB). Pasighat's wettest month on record is July 1948, with 3,386.5 mm (IMD, *Extremes*). The antecedent moisture rule of Clause 2.11.4 and the standby period of Chapter 10 refer to this season.
Storms outside the season	Large falls come after the season in the east, and some in winter. In October, about when the south-west monsoon withdraws, Hayuliang recorded 280.0 mm on 3 October 1979 and Tezu 222.0 mm on 4 October 1979, Pasighat's October monthly record is 1,207.9 mm (1979), and Pasighat's 24-hour record of 652.2 mm fell on 5 October 1988 (IMD, *Extremes*) [U] (Clause 2.3.6(h)); these fall inside the season, which runs to 31 October, but after IMD's withdrawal. In winter Pasighat recorded 137.6 mm on 4 February 1961 and Hayuliang 122.6 mm on 16 February 1973; Ziro's annual record, 150.7 mm on 4 February 1974, is a suspect value [U] (IMD, *Extremes*). Doimukh's November to February total is 142.68 mm, 4.0% of its year (NERIST, via Dabral et al., 2016). The winter is close to dry below the snow, and December to February is this Manual's works window. Design statistics use annual maxima from all months, no works deadline or operating rule shall assume that heavy rain is confined to June–September, and the works calendar of Chapter 10 keeps a mid-season clearance by 15 May, standby to 31 October and a post-season clearance by 15 November for this reason, with a snowmelt clearance by 30 April where snow lies.
Climate factor (CF)	Multiplier applied to present-day design depths to represent the design-life climate.

Term	Meaning in this Manual
Approved source	A rainfall source listed in Clause 2.3.

2.3 Approved sources of design rainfall

2.3.1 **Primary source.** Design rainfall depths and intensities shall be taken from the National Institute of Hydrology, Roorkee **NIH-DHAARA** platform (Design Hydrology and Advanced Rainfall Analysis, nihdhaara.in). Use its IDF / frequency tools for the site's coordinates, for each duration and AEP required by Clause 2.4. In Arunachal Pradesh this clause is suspended until Annex 2A is published: Clause 2.3.6 sets the interim source, and NIH-DHAARA enters it only for the shapes of Clause 2.3.6(d), (e) and (f) and for comparison under (m); it is never a design value in the State.

2.3.2 **Station IDF.** A station-specific IDF relationship may be used in place of 2.3.1 only if all of the following hold:

- (a) it is derived from at least 30 years of recording-gauge (hourly or finer) data;
- (b) it has been published or approved by IMD, the State Hydrology Authority or the approving authority; and
- (c) the gauge is within 10 km of the site, with no major change of terrain or coastal exposure in between.

Where a station IDF is used, the design value shall be the **greater** of the station value and the NIH-DHAARA value.

2.3.3 **Cross-checks (mandatory, not alternatives).** The designer shall report, but need not adopt, the following values for comparison:

- (a) the IMD isopluvial / IDF values of Das et al. (2022), *MAUSAM* 73(4), for durations of 1–24 h;
- (b) for catchments of 25–5,000 km², the 24-hour point rainfall from the CWC Flood Estimation Report for subzone 2(a) (North Brahmaputra), which covers the State north and west of the Lohit (sub-areas AR-A, AR-A1, AR-B, AR-D and AR-E of Annex 2A) but draws its isopluvials only along the foothills, or 2(b) (South Brahmaputra), which covers the south-east (sub-areas AR-C and AR-C1), other than snow-fed and glaciated catchments, to which neither report applies; in the middle hills and high ranges (AR-D and AR-E), which lie inside subzone 2(a) but beyond its last contour, the 2(a) report's unit hydrograph and areal reduction curves are used as a check, and no CWC point rainfall exists there for the cross-check of Clause 2.3.3(b), as applicable.

Where the design value is lower than the CWC subzone 2(a) (North Brahmaputra) or 2(b) (South Brahmaputra) plate, where it draws a contour at the site (the middle hills and high ranges of AR-D and AR-E, inside subzone 2(a) but beyond its last contour, take the floors of Clause 2.3.6(c)(iii) instead) value for the same AEP, the CWC value shall be adopted as a floor.

2.3.4 **Not permitted.** None of the following shall be used as a design rainfall source:

- (a) generalised all-India IDF formulae (for example Kothyari & Garde, 1992);
- (b) rainfall values that cite no source, including vendor or web-calculator tables;
- (c) single-event maxima; or
- (d) design intensities carried forward from a previous project without a stated AEP.

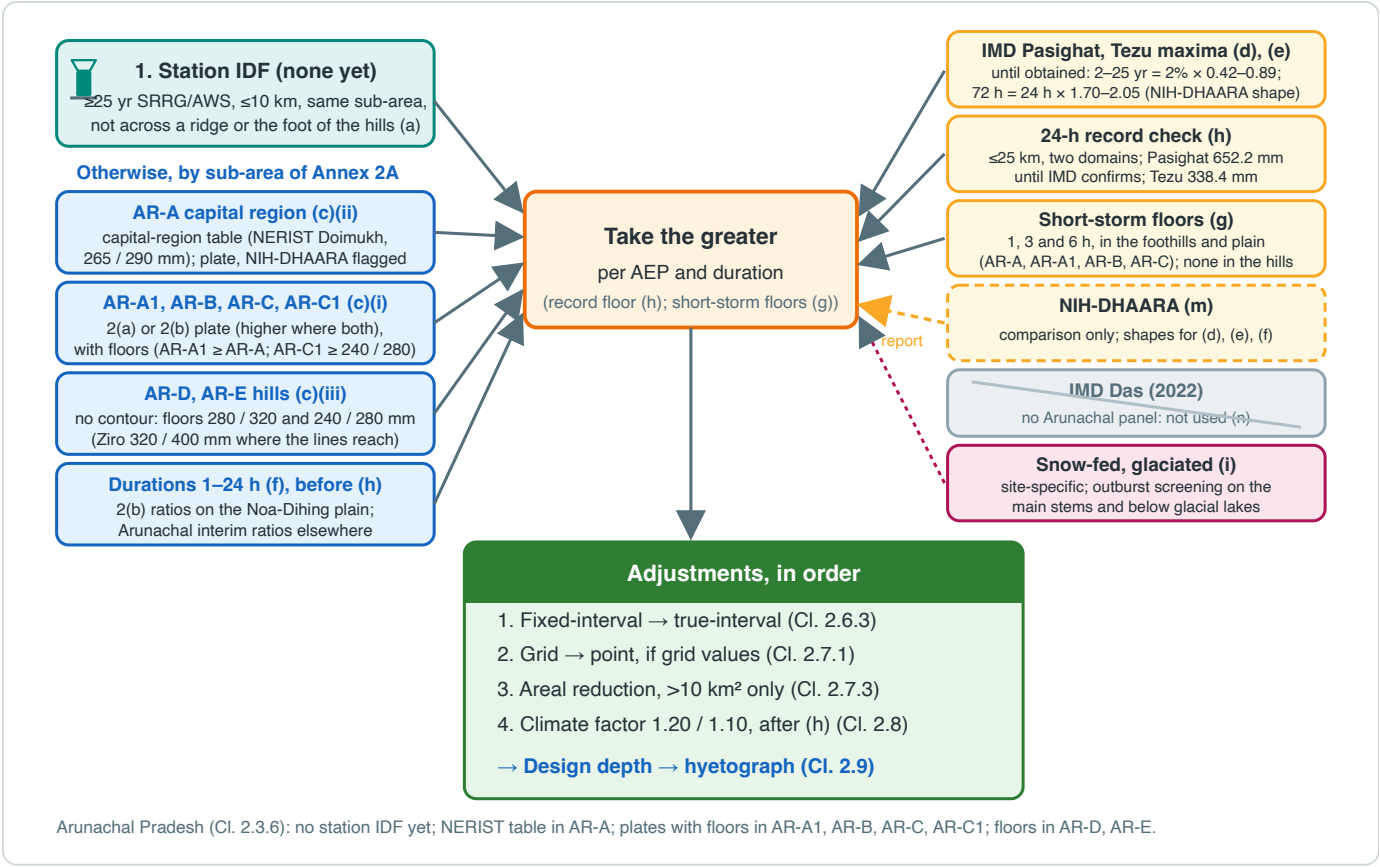

Figure 2.1 — Design rainfall source hierarchy and adjustment sequence. Original drawing for this Manual.

2.3.5 **Version control.** Every submittal shall record the source, its version or access date, the coordinates queried, and the values extracted (Clause 2.13).

2.3.6 **Interim source in Arunachal Pradesh.** Until Annex 2A is published and confirms NIH-DHAARA, or an approved station IDF, for a zone, Clause 2.3.1 does not apply in Arunachal Pradesh, and design rainfall shall be taken as follows:

- (a) **Station IDF.** Where a station IDF fitted to a checked IMD recording-gauge (SRRG) or automatic weather station record of at least 25 years has been published in Annex 2B, it governs, within 10 km of the station and in the same sub-area of Annex 2A, for the durations and AEPs it covers, in place of (f), and subject to (g) and (h); the comparison of Clause 2.3.2 is then made with the 24-hour and longer depths of (c) to (e) and (h). A record is checked when its annual totals and annual maxima have been compared with the IMD normals and station extremes for the station, and every year that disagrees has been explained or removed. An IDF derived from daily data by the one-third rule (Clause 2.6.4) or by any other fixed ratio is not a station IDF. In Arunachal Pradesh Clause 2.3.2(a) is read with 25 years in place of 30, as in the mountain editions of this series, and the gauge shall not be separated from the site by a ridge or by the foot of the hills (set by this Manual, because the State's rain changes over short distances between the plain, the foothills and the ranges: in the 24 hours to 29 May 2024 Bomdila recorded 190 mm, Miao 120 mm and Namsai 70 mm (IMD bulletin, as summarised), and the annual normal is about 1,600 mm at Tawang against 3,200 mm in Papum Pare district (CGWB)). No IDF has yet been published in Annex 2B. No IMD hourly or recording-gauge maximum for any Arunachal Pradesh station, and no IDF with published constants from NERIST, NIT Arunachal or Rajiv Gandhi University, was found for this Manual; NERIST's daily series at Doimukh enters through (c)(ii), not here, and Dabral's depth–duration–frequency paper on Doimukh (*Indian Journal of Hill Farming* 32(1)) was not obtained [TBC]. The first data requests of this Manual are, in order: (1) from the **Meteorological Centre Itanagar**, its station series and the archive, since installation, of its automatic weather stations and automatic rain gauges, with annual maxima for 15 minutes to 72 hours at Itanagar, Naharlagun, Pasighat, Ziro, Aalo, Tawang, Bomdila, Tezu and Roing, the best route to an Arunachal Pradesh IDF; (2) IMD's confirmation or withdrawal of **Pasighat's 652.2 mm of 5 October 1988** (h), and its ruling on

the record set of Ziro; (3) from **NERIST**, the Doimukh daily series extended past 2012, any hourly record, and the depth–duration–frequency paper above; and (4) the daily annual maxima to 2026 of **Pasighat (A) (IMD 42220)** and **Tezu (IMD 01203)**, for (d).

- (b) **Reports, zones and sub-areas.** Two CWC reports cover the State, and neither covers it in full. **Subzone 2(a), North Brahmaputra** (Design Office Report No. NB/18/1991, placed before the Flood Estimation Planning and Coordination Committee at its 49th meeting, 24–25 October 1990) covers zones AR-Z1, AR-Z2 and AR-Z4: its text puts the subzone "between 88° and 97°-20' longitudes (East) and 26° and 29°-25' latitudes (North)", "mostly bounded by international boundaries", and names "Itanagar … and Anini in Arunachal Pradesh" among its important towns (CWC, 2(a)). **Its isopluvials stop at the foothills**, about Itanagar, Ziro, Likabali, Roing and Tezu; north of them the plates are blank, and the base map there is schematic, with river courses and towns such as "Yomtam", "Ningguing", "Anini" and "Chirangla" placed approximately (CWC, 2(a), Plates 8–10; NEER reading). The plates shall not be read north of the last contour. **Subzone 2(b), South Brahmaputra** (Design Office Report No. SB-2(b)/R-4/44/99, March 2000) covers zone AR-Z3; the 2(a)/2(b) boundary leaves the Lohit at about Tezu and runs east-south-east to the Myanmar border, and the 2(b) contours also extend north of the Lohit to Pasighat, Roing and Tezu, overlapping 2(a), with the two disagreeing there by about one contour, 2(a) usually higher (CWC, 2(b), Plates 8–10; NEER reading of the plates, about 0.03–0.1°). The Western Himalayas report, zone 7, covers 73° to 81° E and does not apply. Neither report mentions snow or glaciers for these ranges, and neither unit hydrograph rests on an Arunachal Pradesh catchment: all the gauged catchments of the 2(a) report are railway bridges on the plains of the states the subzone covers (NEER reading). Where the core refers to the CWC report in sub-areas AR-D and AR-E, which lie inside subzone 2(a) but beyond its last contour, the substitutes are (set by this Manual): for areal reduction (Clause 2.7.3), the ARF curves of the 2(a) report; for rural rivers of 25–5,000 km² below the snow, a site study, with the 2(a) unit hydrograph used only as a check; and for the cross-check of Clause 2.3.3(b), none, because no CWC point rainfall exists there. In snow-fed and glaciated catchments neither report applies (i). The rainfall zone and sub-area of the site are those of Annex 2A: zone **AR-Z1 Western foothills**, with sub-areas **AR-A Itanagar capital region (Itanagar–Naharlagun–Nirjuli–Doimukh–Banderdewa)** and **AR-A1 Western foothills (Bhalukpong–Seijosa–Kimin–Yazali)**; zone **AR-Z2 Eastern foothills**, with sub-area **AR-B Siang–Dibang–Lohit foothills (Pasighat–Ruksin–Likabali–Roing–Tezu)**; zone **AR-Z3 South-east**, with sub-areas **AR-C Noa-Dihing plain (Namsai–Chowkham–Bordumsa–Miao)** and **AR-C1 Patkai hills (Changlang–Jairampur–Deomali–Khonsa–Longding)**; and zone **AR-Z4 Hills and high ranges**, with sub-areas **AR-D Middle hills (Ziro–Daporijo–Aalo–Seppa–Basar–Yingkiong)** and **AR-E High ranges (Tawang–Bomdila–Dirang–Mechuka–Anini–Hayuliang)**. AR-Z1 is subzone 2(a), contoured; AR-Z2 is subzone 2(a) at its edge, which the 2(b) contours also reach; AR-Z3 is subzone 2(b); and AR-Z4 is subzone 2(a) beyond its last contour. They fix the source of (c), the factors of (d) and (e), the ratios of (f), the floors of (g), the bounds of the check of (h) and the screening of (i). A catchment that crosses the line between two zones or two sub-areas of Annex 2A takes, at every duration, the higher value of the two (set by this Manual). The town lists of Annex 2A are a guide; their boundaries, which follow the watersheds, the foot of the hills and district lines, are to be confirmed [TBC], and the district names follow the list of 2024 as reported, not verified. Where a town sits on a zone line, as Yazali, Seijosa, Likabali, Jairampur, Deomali, Miao, Tuting and Hayuliang do, the site's coordinates decide, and the higher value governs [TBC].

- (c) **24-hour depth, 2% and 1% AEP (50- and 100-yr).** Where this clause reads a plate, the 24-hour point value at the site is read from the 50- and 100-year isopluvial plates (Plates 9 and 10) of the report of the site's subzone, whatever the catchment area, as follows (all set by this Manual): where the site lies between two contours, the higher contour value is used; where it lies on a contour, the higher of the two contours either side; where it lies at the open end of a line, that line's value, with no step; where it lies inside a closed contour with no higher contour within it, that contour plus one contour interval (a cell labelled ">" that is open only towards the blank map is read as closed); where the 2(a) and the 2(b) plates both draw contours at the site, the higher reading; and where the Plate 10 reading does not exceed the Plate 9 reading, the 1% AEP depth is the 2% AEP depth plus one contour interval, 40 mm. The open-end and two-plate rules are set for this sector because the 2(a) lines end at the foothills and the two reports overlap north of the Lohit. The contours in this sector are 180, 200, 240, 280, 320,

360, 400, 440 and 480 mm. Plates are read by the coordinates of the site, from each plate's own graticule, not by the town labels or by markers carried from another plate, and each reading is recorded on Form 2-1 with the contours on either side. By sub-area:

- (i) **AR-A1, AR-B, AR-C and AR-C1: the plates.** For orientation only, read by eye to about one contour (low confidence; NEER reading of the plates), the readings at 2% / 1% AEP are: in AR-A1, **Bhalukpong 240 / 280 mm** and **Kimin 240 / 280 mm**, at the open ends of the 240 and 280 lines (Seijosa and Yazali were not read [TBC]); in AR-B, **Likabali 440 / 520 mm**, in the ">400" and ">480" cells; **Pasighat 320 / 400 mm**, where the 2(a) plates are blank and the 2(b) plates place it at the open ends of their 320 and 400 lines; **Roing 320 / 400 mm**, at the ends of the 2(a) lines (2(b) 280 / 320 mm); and **Tezu 280 / 320 mm** (2(a); 2(b) 240 / 280 mm); in AR-C, **Namsai 280 / 320 mm**, between the 240 and 280 lines of 2(b) on both plates, so that the 1% AEP depth is the 2% AEP depth plus 40 mm, and **Miao 240 / 280 mm**; and in AR-C1, **Jairampur 240 / 280 mm**, **Changlang and Deomali 200 / 240 mm**, in a closed "<200" pocket, **Khonsa 240 / 280 mm**, on its southern edge, and **Longding 240 / 280 mm** (CWC, 2(a) and 2(b), Plates 9 and 10). Across the Longding border the adjoining Nagaland edition reads one contour higher; the plate governs on each side. Where the Gumbel estimate of (d) for the station of the site is higher for the same AEP, it governs; the 24-hour depth is then checked under (h). Two floors apply (set by this Manual):
  - **AR-A1: not less than the AR-A table of (c)(ii) at every AEP**, because the sub-area is the same Siwalik front as the capital region and the only gauge on that front reads about one contour above the plate (c)(ii); at Bhalukpong and Kimin the table therefore governs.
  - **AR-C1: not less than 240 mm at 2% AEP and 280 mm at 1% AEP**: one contour above the "<200" pocket, Longding's own plate value, and the boundary values of the adjoining Nagaland edition's eastern ranges, so that one storm reads alike across the Patkai. NIH-DHAARA's Khonsa cell (233 mm and 260 mm at 50 and 100 years) and Changlang cell (261 mm and 293 mm) lie within about 10% of the floor, the one part of the State where the platform and the plates agree (NIH-DHAARA; NEER reading).
- (ii) **AR-A: the capital-region table.** In AR-A the 24-hour design depths are those of the following table, set by this Manual from the frequency analysis of NERIST's daily gauge at Doimukh (Dabral et al., 2016, Table 8, lognormal, 1-day), multiplied by 1.13, the fixed-interval factor of Clause 2.6.3 for a single interval, and rounded up to 5 mm. The 5-, 10-, 25- and 100-year 1-day values are printed in the paper; the 2- and 50-year values are NEER arithmetic on the published fit:

AEP (return period)	50% (2-yr)	20% (5-yr)	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)
1-day depth, NERIST Doimukh (mm)	115.9 (NEER arithmetic)	154.36	179.32	210.39	233.3 (NEER arithmetic)	255.95
24-hour design depth, AR-A	135 mm	175 mm	205 mm	240 mm	265 mm	290 mm

  The station, not the plate, governs at the capital, for four reasons. The 2(a) plates read Itanagar at about 180, 200 and 240 mm at 25, 50 and 100 years, in an open "<200" cell with no contour north of the town, so they do not constrain the hills behind it (CWC, 2(a), Plates 8–10; NEER reading). The only frequency analysis in the capital region, 25 years (1988–2012) of NERIST's daily gauge at Doimukh (27°08'39" N, 93°45'05" E, 118 m), published in a peer-reviewed journal, lies about one contour above the plate at every return period (Dabral et al., 2016). The series' principle is that the design value is the greater of the sources (Clause 2.3.2), with the CWC value as a floor (Clause 2.3.3). And Itanagar lies upslope of the gauge and is not drier: CGWB gives annual normals of 3,942.44 mm at Itanagar and 3,251.67 mm at Doimukh (as summarised), while NERIST gives 3,531.8 mm at Doimukh, a conflict this Manual does not settle. The table applies throughout AR-A, beyond the 10 km of (a), because the sub-area is one valley and its hill rim (set by this Manual). The plate readings and NIH-DHAARA (472 mm and 528 mm at 50 and 100 years in the Itanagar cell, 409 mm and 458 mm in the Naharlagun cell, about 1.5 to 1.8 times the table) are recorded on

Form 2-1 and flagged, not used. The table has weaknesses, and this Manual states them: the series is short and daily only; its annual maxima fall after 2008 (62.6–155.7 mm in 2009–2012), which is to be checked against the records of the Meteorological Centre Itanagar (a); its 100-year value extrapolates a 25-year record; and the paper prints "83" for the 100-year 4-day value and both "32" and "132" for the annual number of rainy days, typographical errors (Dabral et al., 2016) [U]. A station fit under (a), once made, replaces the table only where it is higher, until Annex 2A says otherwise. This is the reverse of the plateau and ridge capitals of the adjoining hill editions, where the plate lay above the State's own series: here the gauge lies above the plate, so the gauge governs.

    - (iii) **AR-D and AR-E: no contour.** In the middle hills and high ranges, inside subzone 2(a) but beyond its last contour, the 24-hour depth shall be **not less than 280 mm at 2% AEP and 320 mm at 1% AEP in AR-D, and not less than 240 mm and 280 mm in AR-E**, or the 2(a) plate reading where a contour reaches the site and reads higher. At **Ziro**, at the open ends of the 320 and 400 lines on the edge of the plateau, the plates read **320 / 400 mm** (very low confidence; NEER reading), which governs there and is recorded on Form 2-1. No station, plate or study covers these hills. The foothill contours rise northward by a contour every 5–10 km, so a town beyond the last contour can be one or two contours wetter than it (NEER reading of the plates); the interior has rain-shadow valleys, with annual normals of about 1,600 mm at Tawang and 1,607 mm in West Kameng (CGWB) and "1000 mm in the higher elevations and 5750 mm in the foot hill areas" (State Action Plan on Climate Change), but it also has large single days: Hayuliang 280.0 mm on 3 October 1979 (IMD, *Extremes*) and Bomdila 190 mm on 29 May 2024 (IMD bulletin, as summarised). AR-D's floor is one contour above the western foothills' plate values at Bhalukpong and Kimin and equal to Tezu's; AR-E's equals the western foothills' plate values and, at 1% AEP, Hayuliang's largest recorded day (all set by this Manual). **NIH-DHAARA is not a design value here**: in the foothills, where it can be checked, it runs at 1.7 to 2.4 times the plates and about 1.5 times the NERIST gauge, so its hill cells (308 mm at Ziro, 288 mm at Daporijo, 351 mm at Seppa, 513 mm at Aalo, 328 mm at Bomdila and 129 mm at Tawang, at 50 years) are a bracket only; **Tawang's 129 mm, with 17.4 mm in 1 hour at 50 years, is a snow and rain-shadow cell and not a safe minimum** (NIH-DHAARA; NEER reading). The adjoining hill editions used boundary values or NIH-DHAARA where no plate exists; this Manual uses floors and never NIH-DHAARA, because here the platform can be checked in the foothills and fails the check. Annex 2A replaces the floors with station fits.

- (d) **24-hour depth, 50%, 20%, 10% and 4% AEP (2-, 5-, 10- and 25-yr).** The depth is the Gumbel (EV1) estimate from the annual maximum daily rainfall series, of all months, of the IMD station agreed with the Authority, with 30 or more years of daily record, checked as in (a), multiplied by the fixed-interval factor of Clause 2.6.3. The stations are Pasighat (A) (42220) and Tezu (01203), each for sites within 25 km of it in AR-B; no IMD daily series of any other station in the State was found suitable, and neither series has been obtained [TBC]. Until they are (set by this Manual), outside AR-A the 50%, 20%, 10% and 4% AEP depths are the 2% AEP depth of (c), before the check of (h), multiplied by **0.42, 0.61, 0.73 and 0.89**, and the 4% AEP depth is not less than the 25-year plate value (Plate 8) read as in (c) where a contour reaches the site. The factors are the upper envelope, rounded up to 0.01, of the growth curves of the fifteen NIH-DHAARA cells queried in the State (the 24-hour depth at each AEP divided by the 50-year depth: 0.362–0.413, 0.566–0.601, 0.702–0.726 and 0.873–0.883) (NIH-DHAARA; NEER arithmetic): they take the platform's shape, not its values, and they are the factors of the adjoining Nagaland edition. At Tezu they give about 118, 171, 204 and 249 mm, above Plate 8's 240 mm. The Plate 8 floor governs at Pasighat, at the open end of the 320 line on Plate 8 as on Plate 9, so that its 4% AEP depth is 320 mm, against 285 mm from the factor (NEER reading); at Likabali the factor governs (392 mm, against 360 mm on Plate 8). In AR-A1 the AR-A table of (c)(ii) is the minimum at every AEP. AR-A uses the table of (c)(ii), whose station curve is steeper than the platform's shape (135 / 265 = 0.51 at 2 years, against 0.42). A day of record excluded under (h) is left out of a station series, and the fit with it is reported beside the fit without it on Form 2-1.

- (e) **48- and 72-hour depths.** The Gumbel estimate from the annual maximum 2-day and 3-day rainfall series of the same IMD station, with the fixed-interval factors of Clause 2.6.3, once obtained [TBC], and not less than the 24-hour depth for the same AEP as checked under (h). Until then (set by this Manual), the 72-hour depth is the 24-hour depth after the check of (h) multiplied by **2.05 in AR-A and AR-A1, 1.95 in AR-B, 1.70 in AR-C, 1.75 in AR-C1, 1.90 in AR-D and 1.80 in AR-E**, and the 48-hour depth is interpolated between the 24- and 72-hour depths on

logarithmic axes. The factors are the upper envelope, rounded up to 0.05, of the 50-year 72-hour to 24-hour ratios of the NIH-DHAARA cells in each sub-area or zone: Itanagar 2.04, Naharlagun 2.02 and Bhalukpong 1.81; Pasighat 1.91, Roing 1.87 and Tezu 1.71; Namsai 1.70; Ziro 1.82, Daporijo 1.88, Aalo 1.82 and Seppa 1.79; and Tawang 1.79 and Bomdila 1.55 (NIH-DHAARA; NEER arithmetic). AR-C1 takes the 1.75 of the adjoining Nagaland edition's northern ranges, above its own cells (Khonsa 1.57, Changlang 1.47), so that one storm reads alike across the Patkai. NERIST's 3-day to 1-day ratios run from 1.98 at 5 years to 1.70 at 100 years (Dabral et al., 2016, Table 8; NEER arithmetic), below AR-A's 2.05, which is the margin accepted. The multi-day volume matters because the Dikrong below the Pare dam and the Siang and the Lohit respond to week-long rain: in the 2026 season to 20 July the State recorded 173 landslides, 104 floods and 8 flash floods (Department of Disaster Management, as quoted in the press).

- (f) **Durations of 1 to 24 hours.** The 24-hour depth of (c) or (d), before the check of (h), multiplied at every AEP by the ratios in Table 2B.1 for the site's sub-area (all set by this Manual):
    - in sub-area **AR-C** (Noa-Dihing plain), the ratios of the 2(b) report: 0.48 at 1 hour, 0.62 at 3 hours, 0.74 at 6 hours, 0.81 at 9 hours, 0.87 at 12 hours, 0.91 at 15 hours and 0.95 at 18 hours, the 10-year ratios averaged over the six recording gauges of the report (CWC, 2(b), §4.3.2 and Table 4.1, p. 20). They are the set that the Assam edition uses on the plain downstream, so that one storm reads alike across the border. On Namsai's 280 mm they give about 134 mm in 1 hour at 2% AEP, against 92 mm in NIH-DHAARA's Namsai cell. No recording-gauge or automatic weather station ratio for any Arunachal Pradesh station was found [TBC];
    - in every other sub-area, **AR-A, AR-A1, AR-B, AR-C1, AR-D and AR-E**, the **Arunachal Pradesh interim ratios**: 0.33 at 1 hour, 0.52 at 2 hours, 0.61 at 3 hours, 0.76 at 6 hours, 0.84 at 9 hours, 0.88 at 12 hours, 0.92 at 15 hours and 0.95 at 18 hours. At each duration they are the upper envelope, rounded up to 0.01, of (i) the 50-year duration to 24-hour ratios of the fifteen Arunachal Pradesh NIH-DHAARA cells, with the 3-, 6-, 9-, 15- and 18-hour values interpolated for each cell on logarithmic axes between the platform's 1-, 2-, 4-, 8-, 12- and 24-hour values (the cells' maxima are 0.288 at 1 hour and 0.476 at 2 hours, at Changlang; 0.578 at 3 hours, at Khonsa; 0.732 at 6 hours; 0.795 at 9 hours; 0.845 at 12 hours; 0.884 at 15 hours; and 0.925 at 18 hours); (ii) the ratios of the 2(a) report, 0.260 at 1 hour, 0.457 at 3 hours, 0.615 at 6 hours, 0.720 at 9 hours, 0.805 at 12 hours, 0.875 at 15 hours and 0.930 at 18 hours, averaged over the frequency analyses of 12 IMD recording gauges (CWC, NB/18/1991, §3.1.2, p. 24); and (iii) the interim ratios of the adjoining Nagaland edition, so that the Patkai hills read alike on both sides (NIH-DHAARA; NEER arithmetic). The envelope equals that edition's set.

  The 2(b) ratios are not used in subzone 2(a) or in the hills: 0.48 at 1 hour is about twice the highest Arunachal Pradesh cell north of the Lohit (0.23, at Ziro) and 1.7 times the highest anywhere in the State (0.29, at Changlang); the only sub-daily values found for Itanagar, 40 mm in 2 hours on 23 June 2024 and 52.0 mm "till 12:30" on 27 June 2024 (as quoted; as summarised), are about 2-year falls; and the North-East hill editions rejected the set on their uplands. The hill set is used in AR-A, AR-A1 and AR-B rather than the 2(a) ratios, which the adjoining edition uses on the north bank across the border, because the cells and the adjoining set exceed the 2(a) ratios at every duration; the floors of (g) keep the short durations at the same values on both sides. The 1-hour ratio of 0.26 suggested in the research for this Manual is not used either, because it lies below the cells' maximum and below the adjoining edition's 0.33, and the envelope rule is the series' rule. On the capital's 265 mm the set gives about 87 mm in 1 hour at 2% AEP, against 78 mm in NIH-DHAARA's Itanagar cell, 69 mm with the 2(a) ratio and 127 mm with the 2(b) ratio, before the floor of (g). **The ratios apply to the 24-hour depth of (c) and (d) before the check of (h)** (the Assam edition's form): the records that qualify under (h) are single long monsoon or autumn days, Pasighat's 652.2 mm in October and Tezu's 338.4 mm in July, which carry no information on the hour; the ratio applied to Pasighat's record would give about 215 mm in 1 hour, twice the 1% AEP floor of (g) and more than twice the largest hour on the valley's recording-gauge record. The adjoining Nagaland edition applies its ratios after its check, because its one qualifying record lies one contour from its plate; here the qualifying records exceed the plates by up to 1.6 times. Between the tabulated durations the ratio is interpolated on logarithmic axes; the 2-hour ratio of 2(b), which the report does not give, is interpolated in the same way.

- (g) **Short storms.** In sub-areas **AR-A, AR-A1, AR-B and AR-C**, the foothills and the plain on the edge of the Brahmaputra valley, the 1-, 3- and 6-hour depths for the 10% AEP (10-yr) and rarer shall be not less than the following (set by this Manual), the short-storm floors of the adjoining Assam edition:

Duration	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)
1 hour	70 mm	85 mm	95 mm	105 mm
3 hours	120 mm	145 mm	165 mm	185 mm
6 hours	130 mm	160 mm	180 mm	200 mm

  The reasons are that that edition applies these floors on the north bank and the upper plain directly across the border from Banderdewa, Bhalukpong and Namsai, so that one storm reads alike on both sides; that they come from the largest falls on the valley's recording-gauge record (CWC, 2(b), Annex 4.2); and that NIH-DHAARA's 50-year 1-hour depths in the foothill cells, 78–98 mm, bracket the 95 mm value (NIH-DHAARA). They bind at 1 hour in AR-A and AR-A1 at every AEP and at 3 hours at 2% and 1% AEP (at 2% AEP, 87 mm becomes 95 mm and 162 mm becomes 165 mm), and at 1 hour at Tezu at 10%, 4% and 2% AEP; they do not bind at 6 hours anywhere. **No floor is set in AR-C1, AR-D and AR-E**, as in the adjoining Nagaland edition's hills, because no hill recording gauge exists to base one on and the hill ratios of (f) are already the upper envelope of every cell, of the 2(a) ratios and of the adjoining set. The 2-hour depth shall be not less than the value interpolated on logarithmic axes between the 1-hour and 3-hour depths for the same AEP. Where a station fit later replaces (f), its 1-hour ratio for every AEP shall be not less than 0.33, or 0.48 in AR-C, until Annex 2B is published (set by this Manual). The depths of (f) and the floors are present-day, true-interval values: the fixed-interval factor of Clause 2.6.3 is not applied to plate products or to the floors, and the climate factor of Clause 2.8 is applied to them.

- (h) **24-hour record check, bounded by domain.** The 1% AEP (100-yr) 24-hour depth of (c) or (d) shall be not less than the highest qualifying 24-hour rainfall recorded at any station **within 25 km of the site and in the same domain**, where that record is higher; the record is used as printed, without the fixed-interval factor, and is treated as a 1% AEP depth; and the 2% AEP (50-yr) 24-hour depth is then not less than the record less one contour interval of the plates, 40 mm (all set by this Manual, in the form of the other North-East editions). The domains are two: the **foothills** (AR-Z1, AR-Z2 and AR-C, with the plains across the border within 25 km of a site) and the **hills** (AR-C1 and AR-Z4); a record never counts across the foot of the hills (set by this Manual). A record qualifies only when it is printed by IMD (in *Extremes of Temperature and Rainfall for Indian Stations*, a climatological summary, a monthly or seasonal climate summary, a later IMD table or an IMD press release that names the gauge and the day); the number of years of data at its gauge is confirmed by an IMD table as at least 20; it was made in 1901 or later; it falls in a month in which a fall of that size is plausible for the station; the location of its gauge is known; and it is not contradicted by another IMD table for the same gauge. A record that fails any test is excluded until IMD confirms what it lacks (set by this Manual). Distances are to be measured from IMD's station coordinates, which were not found [TBC]; the distances below are from the approximate town coordinates used in the research for this Manual (NEER arithmetic). The outcomes at present are:
  - **Pasighat (A) (42220), 652.2 mm on 5 October 1988** (IMD, *Extremes*, rainfall data 1916–2012), qualifies, with a flag. IMD prints it in its monthly table for the station (October, p. M21) and in its annual and seasonal (post-monsoon) tables, so no IMD table contradicts it, and October is a plausible month (Hayuliang 280.0 mm and Tezu 222.0 mm on 3–4 October 1979). It is suspect: it is 1.37 times the station's next-highest day, 476.7 mm on 22 August 1988, in the same year; 1.40 times the only Arunachal Pradesh value in Table 7 of the 2(a) report, 467.0 mm at "Passighat" on 11 July 1948 (467.9 mm in IMD's table for the same day, a conflict of 0.9 mm); it falls in an October whose total is not the October record (1,207.9 mm, 1979); and it is later than the report's data (IMD, *Extremes*; CWC, 2(a), Table 7; NEER arithmetic) [U]. **It sets the 1% AEP 24-hour depth at not less than 652.2 mm and the 2% AEP depth at not less than 612.2 mm within 25 km of the gauge in the foothill domain**, which takes in the Pasighat town area; which other places lie within 25 km is to be computed from surveyed coordinates [TBC] (Roing, about 50 km, and Tezu, about 80 km, lie outside). This is the treatment the adjoining Nagaland edition gives its capital's suspect

record: the record passes every test this series sets, so it is kept until IMD rules on it. IMD's confirmation or withdrawal is the second data request of (a); **if IMD withdraws it, the next record governs: 476.7 mm on 22 August 1988**, which sets the 1% AEP depth at not less than 476.7 mm and the 2% AEP depth at not less than 436.7 mm, still about 1.2 times the plate. NIH-DHAARA's Pasighat cell (657 mm and 736 mm at 50 and 100 years) agrees with the record; this is not used as support, because the platform gives twice the plates elsewhere in the foothills (m).
    - **Tezu (01203), 338.4 mm on 2 July 1974** (IMD, *Extremes*, rainfall data 1969–2012), qualifies: it sets the 1% AEP depth at not less than 338.4 mm and the 2% AEP depth at not less than 298.4 mm within 25 km of the gauge in the foothill domain, against a plate reading of 280 / 320 mm; Namsai and Roing, each about 40 km away, lie outside.
    - Flags only, recorded on Form 2-1, none qualifying: **Hayuliang, 280.0 mm on 3 October 1979** (IMD, *Extremes*), whose rainfall data cover only 1971–1985, under 20 years, and which lies at the 1% AEP floor of AR-E in any case; **Ziro, 150.7 mm on 4 February 1974**, excluded [U], because a February day is an implausible annual maximum for the station and every monthly record falls in 1969–1981 although the rainfall period is printed as 1965–2012, which suggests large gaps, and because it lies below every design value in any case (IMD, *Extremes*); **185 mm at the NERIST gauge at Doimukh (1990)**, not an IMD gauge (Dabral et al., 2016); and the values reported from IMD bulletins or in the press: Bomdila 190 mm, Miao 120 mm and Namsai 70 mm in the 24 hours to 29 May 2024 (as summarised); Itanagar 40 mm in 2 hours on 23 June 2024 and 52.0 mm "till 12:30" on 27 June 2024 (as quoted; as summarised); Itanagar "100.30 mm rainfall in the last 24 hours" (year unknown, as reported); and 73 mm in 24 hours, mostly in 3 hours, at the Poosa / NEEPCO colony on 24 June 2026 (as reported).
    - **Across the border:** North Lakhimpur (A) / Lilabari (42309), 261.6 mm on 12 July 1971 (IMD, *Extremes*), qualifies in the Assam edition and lies below every AR-A and AR-A1 value; no other record from across the border within 25 km of an Arunachal Pradesh site raises its depth (NEER reading [TBC]).

  Until Annex 2A is published, the designer lists on Form 2-1 every record within 25 km of the site, with its domain and the tests it passes or fails. The check stops at 24 hours. It raises the 24-hour depth and, through (e), the 48- and 72-hour depths; it does not raise the 1- to 18-hour depths, which (f) takes from the depth before the check, because the records are daily totals and no hourly record of any of them exists.

- (i) **Hazard-first sites, snow-fed catchments and outburst screening.** No drain is sized to carry a slide, a debris flow or an outburst, so siting, setbacks and floor levels govern on: **landslide ground** on Siwalik sandstone, shale and boulder beds, colluvium, slope debris and fill, where a landslide at Laptap killed 14 people on 11 July 2017, the Modirijo and Donyi Polo floods of September 2018 brought a landslide from "the dumping area of NH 415", a protection wall fell at Niti Vihar killing 4 (date not found), the Itanagar storms of June and July 2024 brought slides along NH-415, a landslide swept a vehicle off NH-13 between Bana and Seppa on 30 May 2025, and illegal earth cutting along NH-415 was blamed for a mudslide near Donyi Polo airport (all as reported); **earth cutting**, which the APBBL 2019 refuse above an average slope of 30% (4.39(14)); **bhabar fans and avulsion corridors** where the rivers leave the hills, at Pasighat, Ruksin, Roing, Tezu, Namsai, Bhalukpong and Banderdewa (NEER reading); **the main stems fed from Tibet and from glaciers**, the Siang, Dibang, Lohit, Subansiri, Kameng and Tawang Chu, whose stage is set by outbursts, landslide dams and releases, not by local rain: the breach of the Yigong landslide dam in Tibet gave the CWC gauge at Pasighat its highest flood level, 157.54 m on 11 June 2000, 3.58 m above the danger level (CWC data as transcribed by SANDRP, as reported), with "a recorded rise of 5.5 m at the Pasighat gauge, 462 km downstream" (as summarised), and after landslide dams formed in Tibet the Siang ran at 425 NTU at Pasighat on 27 November 2017, with further alerts in October 2018 (as reported); **glacial lakes**, of which NDMA lists 27 in the State as high-risk, 6 in Tawang, 1 in Kurung Kumey, 1 in Shi Yomi, 16 in Dibang Valley and 3 in Anjaw, while Sanhapo Lake in the Mago Chu basin is reported to have grown from 55.87 ha in 2016 to 87.02 ha in 2026, the outburst of Sangnga Nehgu lake in Tawang is reported without a date, and CWC counted 197 expanding glacial lakes in the State in June 2025 (all as reported; the studies not seen); and **release reaches** below the Pare, Ranganadi, Kameng and Lower Subansiri projects, and the Dibang project under construction. **Snow-fed and glaciated catchments.** Neither CWC report covers them; the State Action Plan on Climate Change lists 52 glaciers (66 km²) in the Kameng basin, 91 (146 km²) in the Subansiri basin and 14 (11 km²) in the Dibang basin. In sub-area AR-E, and in any catchment elsewhere with permanent snow or a glacier

within it, the design rainfall and design flood are site-specific: the method, data and values are agreed with the Authority and WRD and recorded on Form 2-1, and are not less than the values of (c) to (h) for the rain falling on the part of the catchment below the snow [TBC]. For a local town catchment wholly below the snow and without a glacier, (c) to (h) apply as in AR-E. **No design for a site with a glacier, a glacial lake, a landslide dam or a mapped debris fan in the catchment above it, or on the main stem of the Siang, Dibang, Lohit, Subansiri, Kameng or Tawang Chu, is complete without an outburst screening recorded in the drainage report**: it identifies the glacial lakes, moraine and landslide dams and debris fans upstream, from NDMA's list of glacial lakes, CWC's glacial-lake monitoring and the hazard maps of APSDMA and the District Disaster Management Authorities where they exist [TBC], and the release reaches below the dams, whose operators' protocols were not found [TBC], and states whether the site lies on their path; where it does, the siting, setback and floor-level rules of Chapters 6 and 7 govern (all set by this Manual).

- (j) **Cloudbursts.** IMD calls a fall of 100 mm or more in one hour over a small area a cloudburst (as quoted; no IMD primary document was found for this Manual [TBC]). No design rule is drawn from the term. No measured cloudburst rate exists for the State, and no hourly value for any Arunachal Pradesh gauge was found. On 23 June 2024, when the press reported a cloudburst in Itanagar, the State Disaster Management Authority's secretary said that "As per IMD, the rainfall recorded today was 40 mm between 10:30 am and 12:30 pm" and that IMD "confirmed there was no incident of cloudburst"; 66 houses were inundated in Itanagar and Naharlagun (as reported): a fall of about 2-year size that overwhelmed the drains (NEER reading). A "cloudburst" in Itanagar is also reported for July 2024, about 28 July, with conflicting dateline and publication dates (as reported); the two events are kept apart. The capital's 1% AEP 1-hour depth after (g), 105 mm, reaches the 100 mm mark. What a burst brings to a steep catchment that a design storm does not represent is debris and slide material in its first minutes; there the capacity of inlets, debris racks and culverts to stay open governs more than the conveyance of the drain, and Chapters 6 and 9 size them for it.

- (k) **Durations below 1 hour.** No sub-hourly frequency analysis for any station in the State was found in research for this Manual. Until Annex 2B gives one, the ratio of the depth for a duration below 1 hour to the 1-hour design depth is agreed with the Authority, from a published recording-gauge analysis whose source is stated, and recorded on Form 2-1 [TBC]; the average intensity for a duration below 1 hour shall be not less than the 1-hour design intensity for the same AEP (set by this Manual). The time distributions of the 2(a) report (2,207 storms) and of the 2(b) report were not extracted for this Manual [TBC].

- (l) **Order of depths.** For the same AEP, no depth shall be less than the depth for a shorter duration.

- (m) **NIH-DHAARA.** NIH-DHAARA was queried at fifteen points in the State on 14 November 2026 (IMDAA dataset). It is **never a design value in Arunachal Pradesh**, nor a floor or a check: its growth shape is used in (d), its 72-hour to 24-hour shape in (e) and its duration-ratio shape in (f), and its present-day values at the site are reported on Form 2-1 beside the interim values in every sub-area, for comparison only, with its bias stated. In the foothills, where it can be checked, it gives 1.7 to 2.4 times the plates and about 1.5 times the NERIST gauge; in the south-east it lies within one contour of the plates; and in the interior it is plausibly low, Tawang's cell not being a safe minimum. Its 50-year 24-hour depths are 472 mm at Itanagar, 409 mm at Naharlagun, 464 mm at Bhalukpong, 657 mm at Pasighat, 726 mm at Roing, 515 mm at Tezu, 461 mm at Namsai, 233 mm at Khonsa, 261 mm at Changlang, 308 mm at Ziro, 288 mm at Daporijo, 513 mm at Aalo, 351 mm at Seppa, 328 mm at Bomdila and 129 mm at Tawang (NIH-DHAARA, queried 14 Nov 2026). Its projected depths are not used under Clause 2.8.4.

- (n) **IMD Das et al. (2022).** The paper prints IDF curves for 27 cities and none for any station in Arunachal Pradesh (*MAUSAM* 73(4), pp. 895–896). It is not cited for any Arunachal Pradesh value, and the cross-check of Clause 2.3.3(a) is recorded on Form 2-1 as not available.

- (o) **Earlier design values.** No design storm, return period, IDF or runoff coefficient was found for the drains of any town in the State. The State Action Plan on Climate Change (draft, 2011) budgets "Storm water draining in twenty six urban settlements" at Rs 15,000.0 million with no criteria; the master plan of the Itanagar Capital Region proposes a new drainage network (Maps 28–30) with no design storm, return period or runoff coefficient; the

expression of interest of 2017 for a "GIS based Integrated Drainage Master Plan and DPR for Itanagar Capital City" (65 km², horizon 2038) states no return period; the drainage plan reviewed by the Chief Minister in June 2021 and the Itanagar storm-water and seepage project of June 2018 were not seen (as reported); and a SWMM 5.2 study of the drains of Itanagar's C-Sector was seen only as a preprint, its return period not seen (as summarised). Road drains follow IRC practice (Chapter 6). A designer who uses any other value reports it on Form 2-1; the AEPs of Table 2.1 and the depths of this clause apply.

- (p) **Other clauses.** Where Clauses 2.3.2, 2.6.1, 2.7.1 and 2.13, Annexes 2A to 2C and Form 2-1 refer to the NIH-DHAARA value, the value under this clause is meant.

Commentary. NIH-DHAARA is a national, publicly accessible product from a Government of India institution, and it can be queried at any point in the State. That makes it a reproducible default that an approving authority can check. NIH-DHAARA's sub-daily values are derived from hourly records, not disaggregated from daily totals. That makes it the only public source suitable for sizing drains, which depend on short-duration intensity. Its values should still be checked against the long IMD daily record at 24 hours and longer (Annex 2A). In Arunachal Pradesh the platform has not met that purpose where it can be tested. It was queried at fifteen points of the State for this Manual. In the foothills, where both the CWC plates and a gauge exist, its cells give 1.7 to 2.4 times the plates and about 1.5 times the frequency analysis of NERIST's gauge at Doimukh, the only one in the capital region; in the south-east they lie within one contour of the plates; and in the interior its Tawang cell, 129 mm at 50 years in 24 hours, lies below a single day of 190 mm at Bomdila. A source that fails the test where it can be tested cannot be adopted where it cannot, so Clause 2.3.6 uses the CWC plates, the NERIST series, the IMD station records and values set by this Manual until Annex 2A has been done, and NIH-DHAARA is never a design value: it lends only its shapes, the growth of depth with return period, the ratio of the 72-hour to the 24-hour depth and the duration ratios, and is reported beside the design values on Form 2-1. IMD Das et al. (2022) is not cited at all, because it has no panel for any station in the State. Arunachal Pradesh follows the other North-East editions, and three things set its interim source apart. First, the CWC plates cover the State on paper but draw contours only along the foothills. The 2(a) report covers every zone except the south-east, which the 2(b) report covers, but its isopluvials stop roughly 10–40 km inside the State, so every hill and high Himalayan town lies inside the subzone in blank map space. Clause 2.3.6(c) therefore reads the plates, with rules for this sector, where they draw contours; carries the capital's gauge across its valley; and sets floors in the middle hills and high ranges, which no station, plate or study covers. Second, the capital's only frequency analysis lies one contour above the plate. NERIST's 25-year daily series at Doimukh gives a 25-year 1-day depth of 210.39 mm, about 240 mm as a 24-hour depth, against about 180 mm on the 25-year plate (Dabral et al., 2016; NEER arithmetic). In the capitals of the adjoining hill editions the plate lay above the State's own series and governed; here the gauge lies above the plate, so the capital-region table of Clause 2.3.6(c)(ii), taken from the gauge, governs, with its weaknesses stated. Third, the State's qualifying records are long single days far above the plates, Pasighat's 652.2 mm in October 1988 and Tezu's 338.4 mm in July 1974, while its short storms are unmeasured: no hourly value from any Arunachal Pradesh gauge was found. So the duration ratios of Clause 2.3.6(f) are applied before the record check of Clause 2.3.6(h), not after it, the hours of the foothills and the plain are held at the short-storm floors of the Brahmaputra valley across the border, and the 2(b) ratios are kept to the Noa-Dihing plain. The interim rules for the more frequent AEPs, the 48- and 72-hour depths, the reading of the plates, the AR-A table, the floors of AR-A1, AR-C1, AR-D and AR-E, the sub-area of each town, the two sets of ratios, the short-storm floors, the bounded record check, the outburst screening and durations below 1 hour are set by this Manual. Several points are unresolved. The plate values were read by eye, to about one contour, and the 2(a)/2(b) boundary and the last 2(a) contours are known only to about 0.03–0.1° [TBC]. Pasighat's 652.2 mm is suspect, and Ziro's record set is excluded [U]. The NERIST series is short and daily, and its later maxima need checking against IMD's records [TBC]. No storm-drain DPR for any town of the State with its design rainfall analysis was found for this Manual [TBC].

2.4 Design return periods (summary)

2.4.1 Design AEPs are set in the chapters for each element. They are summarised here so that the correct rainfall is extracted at the start of design.

Table 2.1 — Design return periods (summary)

Element	Design AEP (return period)	Check event	Chapter
Minor drains: Itanagar, Naharlagun and Pasighat core and high-density areas	10% (10-yr)	1% (100-yr) overland path	6
Minor drains: other Class I urban areas	20% (5-yr)	1% overland path	6
Minor drains: other areas	50% (2-yr)	1% overland path	6
Arterial roads and crossings	2–4% (25–50-yr)	next higher AEP	6
Collector / local roads	4% / 10% (25 / 10-yr)	2% / 4% (50 / 25-yr), plus the 1% overland path	6
Major (overland) system	1% (100-yr)	—	6
Retention volume	Percentile daily rainfall (Clause 2.10)	—	4
Detention: standard catchments	50%, 10%, 1% (2, 10, 100-yr)	1% emergency spillway	4
Detention: flood-sensitive catchments	Mixed-frequency rule, Clause 2.11	1%	4
Building floor levels	1% + 0.5 m freeboard	—	6
Detention emergency spillway	1% with outlet blocked	0.2% (500-yr) where high hazard	4

> Commentary. These values exceed the CPHEEO (2019) national advisory minimums of 5-yr (Class I cities) and 2-yr (other areas). CPHEEO allows a State to set higher values. The values are set in Chapters 4 and 6, and the table is reproduced here for convenience.

2.5 Design durations

2.5.1 **Conveyance elements** (pipes, open drains, inlets, culverts) shall be designed with the intensity for a duration equal to the time of concentration (Tc) of the contributing area (Chapter 3). The minimum duration is **10 minutes**.

2.5.2 **Storage elements** (detention, retention, tanks, pumped sumps) shall be checked for every duration in the set {1, 2, 3, 6, 12, 24, 48, 72 h}. The largest required storage or water level governs. The 24-, 48- and 72-hour storms are **mandatory** checks at every site, whatever the critical-duration result.

2.5.3 **Tidally influenced outfalls.** For storage draining to a tidally influenced outfall (Chapter 5), the 48- and 72-hour storms shall also be run with the tailwater boundary of Clause 2.12.

> Commentary. Arunachal Pradesh's worst floods have come when days of rain fill the slopes, the reservoirs and the rivers. The Laptap slide of 11 July 2017 came after three days of rain (as reported); at Doimukh the 25-year 3-day depth is 385.01 mm against a 1-day depth of 210.39 mm (Dabral et al., 2016); in late May and early June 2025 the storms that killed seven people on NH-13 on 30 May were followed by a Pare release of 1,310 m³/s on 31 May

and by floods in 215 villages of 24 districts by 7 June (as reported); and by 20 July 2026 the season had brought 173 landslides, 104 floods and 8 flash floods (Department of Disaster Management, as quoted in the press). Pasighat's wettest month on record, July 1948, brought 3,386.5 mm (IMD, *Extremes*). The streams of the hill towns rise within an hour of a burst, but the slides, the slope debris that blocks their culverts, and the rivers and reservoirs that hold the valley-floor outfalls up are set by the whole wet spell, not its peak hour. A rule based only on critical duration, applied to a small site, picks a 1–2 hour storm and misses this failure mode. That is why the long-duration checks are mandatory.

2.6 Sub-daily rainfall

2.6.1 Where NIH-DHAARA or an approved station IDF provides values directly for the required duration, those values shall be used.

2.6.2 Where only daily (24-hour) depths are available for a duration below 24 hours, the sub-daily depth shall be derived using the **ratio set of Annex 2B**. These are duration-to-24-hour ratios calibrated to Arunachal Pradesh recording gauges. They shall not be lower than the ratios that Clause 2.3.6 sets for the site's sub-area: those of the CWC Flood Estimation Report for subzone 2(b) on the Noa-Dihing plain, as on the Burhidihing plain downstream, and the Arunachal Pradesh interim ratios of Clause 2.3.6(f), the upper envelope of the NIH-DHAARA duration ratios of the Arunachal Pradesh cells, of the ratios of the CWC report for subzone 2(a) and of the interim ratios of the adjoining edition's hills, in every other sub-area: the foothills and hills of subzone 2(a), whether its plates draw a contour there or not, and the Patkai hills of subzone 2(b). The subzone 2(b) ratios are not applied in subzone 2(a) or in the hills; in the foothills and on the plain the short-storm floors of Clause 2.3.6(g) also apply; and IMD Das et al. (2022) prints no panel for any Arunachal Pradesh station.

2.6.3 **Fixed-interval adjustment.** Depths from fixed observation windows (for example 08:30–08:30 IST daily data, or clock-hour data) shall be converted to sliding-window ("true interval") depths:

- 1.13 for a single fixed observation interval;
- 1.04 for 2 intervals;
- 1.02 for 3–4 intervals.

This adjustment does not apply where the approved source already gives true-interval values.

2.6.4 The empirical relationship P(t) = P(24)·(t/24)^(1/3) shall not be used for design unless Annex 2B confirms it for the zone concerned.

> Commentary. The one-third power rule is common in Indian project reports, but no primary IMD source for it was found during research for this Manual. It applies one fixed curve shape everywhere: P(1h)/P(24h) = 0.35, P(3h) = 0.50, P(6h) = 0.63 and P(12h) = 0.79. It cannot represent the difference between a short convective burst and a long monsoon soak, and it tends to understate short-duration depths in convective coastal storms. Annex 2B shall tabulate the NIH-DHAARA ratios P(t)/P(24h) against these values by zone. That comparison shows whether the rule is acceptable anywhere in the State and corrects older daily-based analyses. The fixed-interval factors are the standard WMO (Hershfield) values. The IMD 2022 study applies similar clock-hour to any-hour corrections.

2.7 Point, grid and areal rainfall

2.7.1 Design depths are point values. Where an approved source provides grid-average values (for example 0.25° cells), they shall be converted to point values with the grid-to-point factors in Annex 2C before use.

2.7.2 For catchments **≤ 10 km²**, ARF = 1.0.

2.7.3 For catchments **> 10 km²**, apply ARF as follows:

- for 25–5,000 km² in subzone 2(a) (North Brahmaputra), including the middle hills and high ranges beyond its last contour, or 2(b) (South Brahmaputra): use the ARF curves of the applicable CWC Flood Estimation Report;
- for 10–25 km²: interpolate linearly between ARF = 1.0 at 10 km² and the CWC value at 25 km².

2.7.4 An ARF shall never be applied to storage design for a single development site.

> **Commentary.** Gridded and district-average return levels are much lower than point values. For example, NIH-DHAARA's cell over Itanagar gives 472 mm at 50 years in 24 hours, about 1.8 times the 265 mm that this Manual takes from the NERIST gauge at Doimukh and more than twice the CWC plate there, while its Tawang cell gives 129 mm, below the 190 mm that Bomdila received on a single day in May 2024 (NIH-DHAARA, queried 14 Nov 2026; Dabral et al., 2016; IMD bulletin, as summarised). Reanalysis cells smooth the foothills and the ranges together, and an area average hides the falls at its gauges. Neither error can be corrected without the factors of Annex 2C. Using grid values as point values without correction would make site-level design unsafe.

2.8 Climate factor

2.8.1 Until a statewide future-climate rainfall product is adopted, present-day design depths shall be multiplied by the following interim climate factors:

Table 2.2 — Interim climate factors

Duration	Climate factor (CF)
≤ 6 h	**1.20**
> 6 h to 72 h	**1.10**

2.8.2 The CF applies to all elements with a design life of more than 25 years. For temporary works (design life ≤ 5 years), CF = 1.0.

2.8.3 The climate factor does not apply to the retention depth (Clause 2.10) or to the water quality volume depth (Chapter 8). Those depths are percentile or frequent-event statistics of everyday rainfall, not AEP design values.

2.8.4 Where NIH-DHAARA, or a product adopted on review under Clause 2.14, provides projected future-climate depths, those depths shall replace the interim factors.

> **Commentary.** CPHEEO (2019) considers a fixed climate factor "not feasible" nationally and recommends trend testing instead. That leaves designers without a usable number. The 1.20 short-duration factor matches the UK value cited by CPHEEO itself. No design uplift factor has been adopted in Arunachal Pradesh, and none was found in any document read for this Manual. The State Action Plan on Climate Change (draft, July 2011) projects annual rainfall 5% to 15% lower in the 2030s, with "decrease in rainfall … projected for all seasons except pre monsoon for 2030s", and 25% to 35% higher by the 2080s, and sets no extreme-rainfall or IDF factor; Down To Earth reports the plan's decrease as "in the 2050s" (as reported), against the "2030s" of the plan's own text, a conflict this Manual does not settle. The observed record is mixed: the plan reports "spatial variability in rainfall trend (increasing as well as decreasing trend)"; a researcher is reported to find declining totals with more frequent high-intensity events (as reported; no paper seen); and the Meteorological Centre Itanagar has said that one season is not enough to establish a trend (as reported). CSTEP's district projections of 2022 are reported to recommend a

revision of the State plan (as reported). The case for an uplift rests on the size of recent extremes and on the national practice of this series, not on trend statistics. The factors of Table 2.2, 1.20 up to 6 hours and 1.10 for longer durations, are therefore interim values, not Arunachal Pradesh estimates; as in the other editions of this series they are applied after the record check of Clause 2.3.6(h), and they apply to the short-storm floors of Clause 2.3.6(g). NIH-DHAARA's projected depths are not used (Clause 2.3.6(m)); its climate grids for Itanagar, Pasighat and Tezu are a check still to be made [TBC].

2.9 Temporal patterns (design hyetographs)

2.9.1 **Storms up to 24 hours.** Use the nested **alternating-block** method:

- construct the storm from the same IDF relationship (after the climate factor), at time steps no longer than Tc/3 and no longer than 15 minutes;
- place the peak block at **50%** of the storm duration.

2.9.2 **48- and 72-hour storms (monsoon pattern).** Construct as follows:

- (a) The total storm depth equals the design depth for the full duration (48 or 72 h).
- (b) The **final 24 hours** contain the 24-hour design depth for the same AEP, distributed by the alternating-block method of 2.9.1.
- (c) The remaining depth (total minus the 24-hour depth) is spread uniformly over the preceding 24 or 48 hours.

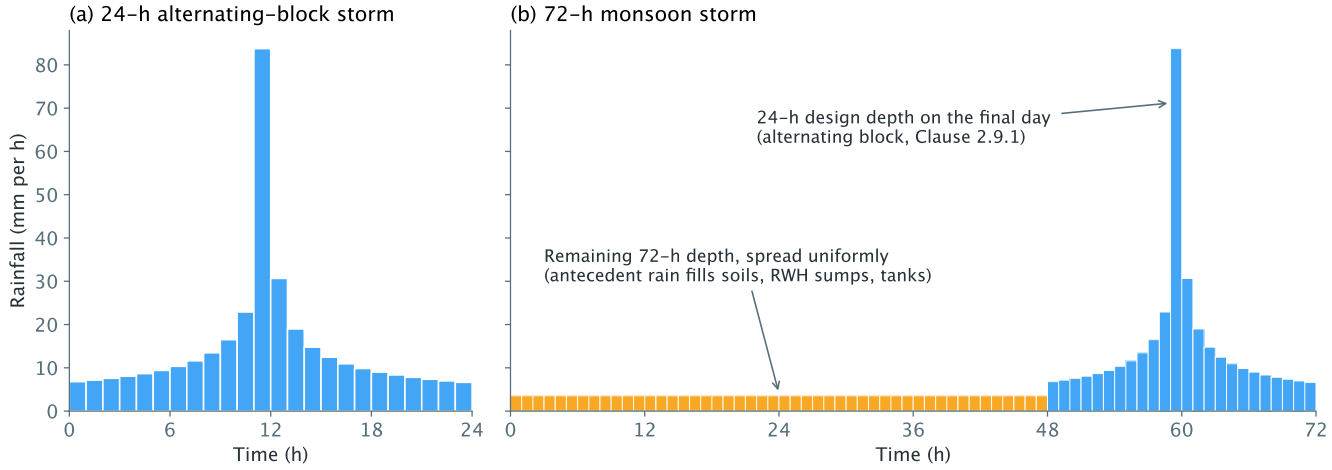

Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.

2.9.3 **Other temporal patterns.** Huff-type or mass-curve patterns derived from Arunachal Pradesh storms may be used instead of 2.9.1 and 2.9.2 only after they are published in Annex 2D. SCS Type I, IA, II and III distributions shall not be used.

2.9.4 **Large catchments.** For catchments of 25–5,000 km², the CWC Flood Estimation Report time-distribution curves may be used, and a sensitivity run with 2.9.1 shall be reported.

> **Commentary.** The alternating-block storm embeds every shorter-duration design intensity in one hyetograph. That makes it conservative and consistent across durations. The 72-hour pattern puts the most intense day last. This reproduces the monsoon sequence of Arunachal Pradesh: by the time the largest falls arrive, from June to September after the storms of April and May, the residual soils, slope debris and fill of the Siwalik foothills are saturated, the Pare and Ranganadi reservoirs are releasing, and the Dikrong, the Siang, the Lohit and the Noa-Dihing are already high against the valley-floor outfalls. SCS distributions are excluded because they come from US convective and Gulf storm data and have no basis in Arunachal Pradesh records.

2.10 Retention rainfall depth

2.10.1 The **retention design depth** is the 24-hour rainfall depth not exceeded on **90%** of days with rain (≥ 2.5 mm) in the long-term record, read from the zone value in Annex 2E.

2.10.2 The site must retain on site the runoff from this depth (Chapter 4). Retention earns a detention credit equal to the reduction in required detention storage found by routing with the retention in place (Clause 4.4.6). The credit is not the retained volume subtracted one-for-one.

> **Commentary.** This follows the Kansas City Metro APWA 5600 (2025.01) Required Retention Volume concept and Georgia's 1.0-inch runoff reduction standard. Both are based on percentile storms. A percentile depth is a statistic of everyday rainfall, not an AEP value, so it is computed from the daily record rather than from the frequency curves.

2.11 Design storms for pre- and post-development comparison

2.11.1 **Same storm for both scenarios.** Pre- and post-development runs shall use the same design storms:

- same AEP, duration, temporal pattern and climate factor;
- same antecedent moisture condition (Clause 2.11.4).

The two runs differ only in land surface parameters and Tc.

2.11.2 **Standard catchments.** For each of the 50%, 10% and 1% AEP storms and each duration in Clause 2.5.2:

> $Q_{post}(T) \leq 0.9 \times Q_{pre}(T)$

2.11.3 **Flood-sensitive catchments** (as listed in Chapter 4: the catchments of the Senki, of the Pachin, of the Dikrong with Papu Nallah, of the NH-415 corridor, of Modirijo and Donyi Polo, of Pasighat on the Siang, of Tezu on the Lohit, of Namsai and Miao on the Noa-Dihing, of Roing on the Dibang, of the Ranganadi at Yazali and of the outburst reaches of Tawang and Dibang Valley, and any catchment notified by the authority). The **mixed-frequency rule** applies:

> Q_{post}(1% AEP, 100-yr) ≤ Q_{pre}(10% AEP, 10-yr), and Q_{post}(50% AEP, 2-yr) ≤ Q_{pre}(50% AEP, 2-yr),

The post-development peak is checked for each duration in Clause 2.5.2. The caps are taken at the **pre-development critical duration**. The 10-yr cap is the largest pre-development 10-yr peak over all durations, and the 2-yr cap is the largest pre-development 2-yr peak over all durations. Each cap applies to every post-development duration.

2.11.4 **Antecedent moisture.** Use **AMC III** (wet conditions) for every design storm, whatever its duration, from 1 May to 15 October at a site in sub-area AR-A (Itanagar capital region), AR-A1 (Western foothills), AR-C (Noa-Dihing plain) or AR-C1 (Patkai hills) of Annex 2A, from 1 April to 31 October at a site in sub-area AR-B (Siang–Dibang–Lohit foothills), and from 1 June to 15 October at a site in sub-area AR-D (Middle hills) or AR-E (High ranges). Use AMC III for every design storm from 1 April to 31 October, in every sub-area, on land below the 1% AEP flood level of the Dikrong, the Pachin, the Senki, the Siang, the Dibang, the Lohit, the Noa-Dihing or another river, stream or nallah, on the palaeochannels and swampy land of the Pachin and Dikrong flood plains, on the margins of a pond and wherever the seasonal high water table is within 2 m of ground. Use AMC III for every design storm at any time of year in a catchment that drains to a reservoir or its backwater, or to a reach below a dam into which the dam releases water, such as the Dikrong below the Pare dam, the lower Ranganadi below the Ranganadi project, the Kameng below the Bichom and Tenga dams and the Subansiri below the Lower Subansiri dam. At any other site or time, use AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm. Use AMC II (average conditions) for every other storm. AMC I is not used for design.

2.11.5 **Pre-development condition.** Pre-development is defined in Chapter 3: greenfield, open land in good condition for the mapped hydrologic soil group. Existing impervious cover is not counted as pre-development.

> Commentary. Matching each site's post-development peak to its own pre-development peak does not protect the catchment. Denver's analysis found that 100% matching at every site still produced 106% of historic peak downstream, which led to the 90% rule. The mixed-frequency rule is stricter. It caps the 100-yr post-development release at what the undeveloped site produced in a 10-yr storm. Malaysia (DID 2008: all ARIs ≤ pre-development 2-yr) is a tropical precedent for this kind of cap. AMC III for long storms reflects that monsoon extremes arrive after weeks of rain. In Arunachal Pradesh the season, the ground and the receiving waters together decide how wet a catchment is. At Doimukh May brings 505.9 mm, two-thirds of June's 762.8 mm, the wettest month (NERIST series, via Dabral et al., 2016), so the foothills are wet before the south-west monsoon arrives; in the Lohit valley April and October bring storms of 180–280 mm in a day (Hayuliang 278.5 mm on 24 April 1980; Hayuliang 280.0 mm and Tezu 222.0 mm on 3–4 October 1979) and Tezu's April 2010 total was 1,087.9 mm (IMD, *Extremes*). On the valley floors the water table lies 2–4 m below ground before the monsoon and 2–5 m after it in the Dikrong valley (CGWB), and 15 of 27 State stations stood within 2 m of ground in August 2025 (CGWB bulletin, as summarised), so low land is wet from the first storms. The Pare, Ranganadi, Kameng and Lower Subansiri reservoirs are held through the season and release through their gates, so a catchment that drains to one of them, or to the reach below its dam, is wet whenever it is spilling. This Manual therefore uses AMC III for every design storm from 1 May to 15 October in sub-areas AR-A, AR-A1, AR-C and AR-C1, from the wet May of the foothills to IMD's normal withdrawal of the south-west monsoon at Itanagar on 14 October, rounded out (IMD, 2020, as summarised); from 1 April to 31 October in AR-B, for the April and October storms of the Lohit valley; from 1 June to 15 October in AR-D and AR-E, the south-west monsoon from its normal onset at Itanagar on 5 June to its withdrawal, rounded out, because the interior has rain-shadow valleys (Tawang about 1,600 mm a year; CGWB); from 1 April to 31 October in every sub-area on land below the 1% AEP flood level of a river, stream or nallah, on the palaeochannels and swamps of the Pachin and Dikrong flood plains, on pond margins and wherever the seasonal high water table is within 2 m of ground; at any time of year in a catchment that drains to a reservoir, its backwater or a release reach; and otherwise after a 5-day total of more than 53 mm, the NRCS growing-season threshold for AMC III; AMC II otherwise (Clause 2.11.4). The research for this Manual suggested AMC III from May to September in the foothills; this Manual widens it to 15 October because the south-west monsoon withdraws from Itanagar on 14 October in IMD's normals. AMC I is not used, because no part of the State is dry enough during the season to justify it. These are interim choices set by this Manual; no study in the State has yet validated AMC classes against observed runoff.

Illustrative scale of the mixed-frequency rule. The values below are not design values. They assume a 2 ha site in a hillside colony in Itanagar draining to the Senki with 24-h depths of 200 mm (10-yr) and 350 mm (100-yr), SCS-CN runoff with Ia = 0.2S, and CN 70 pre-development and CN 92 post-development:

Table 2.3 — Illustrative scale of the mixed-frequency rule (not design values)

Case	Runoff depth	Runoff volume (2 ha)
Pre-development, 10-yr 24 h	111 mm	2,210 m³
Post-development, 100-yr 24 h	325 mm	6,500 m³

The post-development 100-yr storm generates about three times the runoff volume of the pre-development 10-yr storm. A peak-rate cap at the pre-development 10-yr level means most of the difference must be stored and released slowly, so storage of the order of 0.2 m³ per m² of site may be needed. For this reason the rule applies only in flood-sensitive catchments (Clause 2.11.3); elsewhere the 0.9 × Q_pre rule of Clause 2.11.2 applies.

2.12 Joint occurrence with tailwater

2.12.1 For outfalls under tidal or river backwater influence, the design rainfall of this chapter shall be combined with the tailwater conditions of Chapter 5 as follows. The more severe case governs.

- (a) Design rainfall (AEP as required) with a mean high water springs (MHWS) tailwater plus the sea-level allowance.
- (b) A 10% AEP (10-yr) 48-hour storm with the 1% AEP still-water level (tide plus surge) plus the sea-level allowance.

Arunachal Pradesh has no coast, so no outfall in the State is tidal and cases (a) and (b) do not arise. The tailwater is the stream, nallah, river or reservoir into which a town drains: in the capital region, the Dikrong backing up a nallah when it carries the Pare dam's releases and the Ranganadi project's tailrace; at Pasighat, Tezu and Namsai, a main stem whose stage is set upstream, at Pasighat by outbursts in Tibet; below the dams, a reservoir release; and in the hills, a free outfall to a steep stream. For an outfall under river or reservoir backwater, the site storm is combined with the receiving-water level under Clause 5.8.4, which pairs a design event on one side with a 10-yr event on the other in the same way as case (b), and the river and reservoir levels are those of Clause 5.8.2. CWC's sites in the State give levels for some of these rivers: the Siang at Pasighat, with a warning level of 152.96 m, a danger level of 153.96 m and a highest flood level of 157.54 m on 11 June 2000, the stage of the Yigong outburst, 3.58 m above the danger level; the Noa-Dihing at Namsai, 144.8 m, 145.8 m and 146.6 m (31 August 1974), values that SANDRP says "changed without explanation"; and highest flood levels only at Tezu on the Lohit (192.14 m, 16 July 1996), Yazali on the Ranganadi (623.1 m, 14 June 2008), Miao on the Noa-Dihing (241.57 m, 9 July 2004) and Daporijo on the Subansiri (213.9 m, 15 October 1987) (CWC data as transcribed by SANDRP, as reported). There is no CWC site on the Dibang, on the Senki, the Pachin or the Dikrong in the capital region, or at Bhalukpong. The CWC sites on these rivers downstream of the State, tens of kilometres away, are not tailwater for any Arunachal Pradesh town, and the Assam edition governs those reaches. The Dikrong below Doimukh carries the Pare dam's releases, which peaked at 1,310 m³/s on 31 May 2025, under NEEPCO's monsoon advisories on releases through the radial gates, and the Ranganadi project's tailrace, 160 m³/s against an observed Dikrong flood flow of about 2,500 m³/s in a 1994 study; the 1999 flood is the local benchmark (all as reported). No operator's release protocol or warning threshold, and no spillway capacity, was found [TBC]. In the hills the opposite case occurs: at Yazali a side stream of about 17 km² flooded the Poosa / NEEPCO colony while "the main river stayed in its channel" (as reported). So storage and outfalls are checked with the river low and with it high, and for the outfall-closed condition with the local storm falling before, during or after the river's peak. No document found in research for this Manual sets a design receiving-water level for the outfalls of any town in the State [TBC], and Chapter 5 sets the interim rule. Every level is stated on a named datum, as Chapter 5 requires; no source found states the datum of the CWC levels quoted here [TBC].

Commentary. Arunachal Pradesh has no coast, so no outfall is tidal and there is no storm surge; the coincident load is the level of the rivers, nallahs and reservoirs that receive the town drains. Both kinds of coincidence are on record. In late May 2025 the storms that killed seven people on NH-13 on 30 May were followed by the Pare dam's peak release of 1,310 m³/s into the Dikrong on 31 May, above the outfalls of Doimukh and Naharlagun (as reported). At Pasighat the Siang's highest level, 157.54 m on 11 June 2000, came from the breach of a landslide dam in Tibet, with no local storm behind it (CWC data as transcribed by SANDRP, as reported). The opposite case occurs too: on 24 June (2025 or 2026) a side stream of about 17 km² flooded the Poosa / NEEPCO colony at Yazali while "the main river stayed in its channel" (as reported). These levels give no warning of a local storm that falls while they are high. The river levels quoted for the State are transcriptions of CWC data, not readings of a CWC bulletin, and none states its datum, which is why Chapter 5 requires every level to name its source and datum. Because rainfall and surge share a weather cause (in Arunachal Pradesh, which has no coast, the counterpart of surge is the stage of the rivers and reservoirs that receive the town drains, raised by the same monsoon storms that bring the heaviest rain to the towns: the Pare dam's release peaked at 1,310 m³/s on 31 May 2025, the day after a landslide in the late-May storms swept a vehicle off NH-13 between Bana and Seppa, killing seven (as reported); at Pasighat the Siang's stage is also set by outbursts in Tibet, which no local storm accompanies), they cannot be treated as independent. Case (b) is a simple joint-probability surrogate until a statistical joint analysis is adopted.

2.13 Submittal requirements

Every hydrologic submittal shall include a **Design Rainfall Sheet** (Form 2-1) stating:

1. the site coordinates and zone;
2. the source (Clause 2.3), version or access date, and a screenshot or export of the values extracted;
3. a depth table for each AEP and duration used, before and after the fixed-interval factor, grid-to-point factor, ARF and climate factor;
4. the cross-check values of Clause 2.3.3 and the floor check;
5. the hyetographs used, as a table and a plot, for each design storm; and
6. the AMC and pre-development definition adopted.

Figure 2.3 shows the steps of this chapter in the order in which the sheet records them.

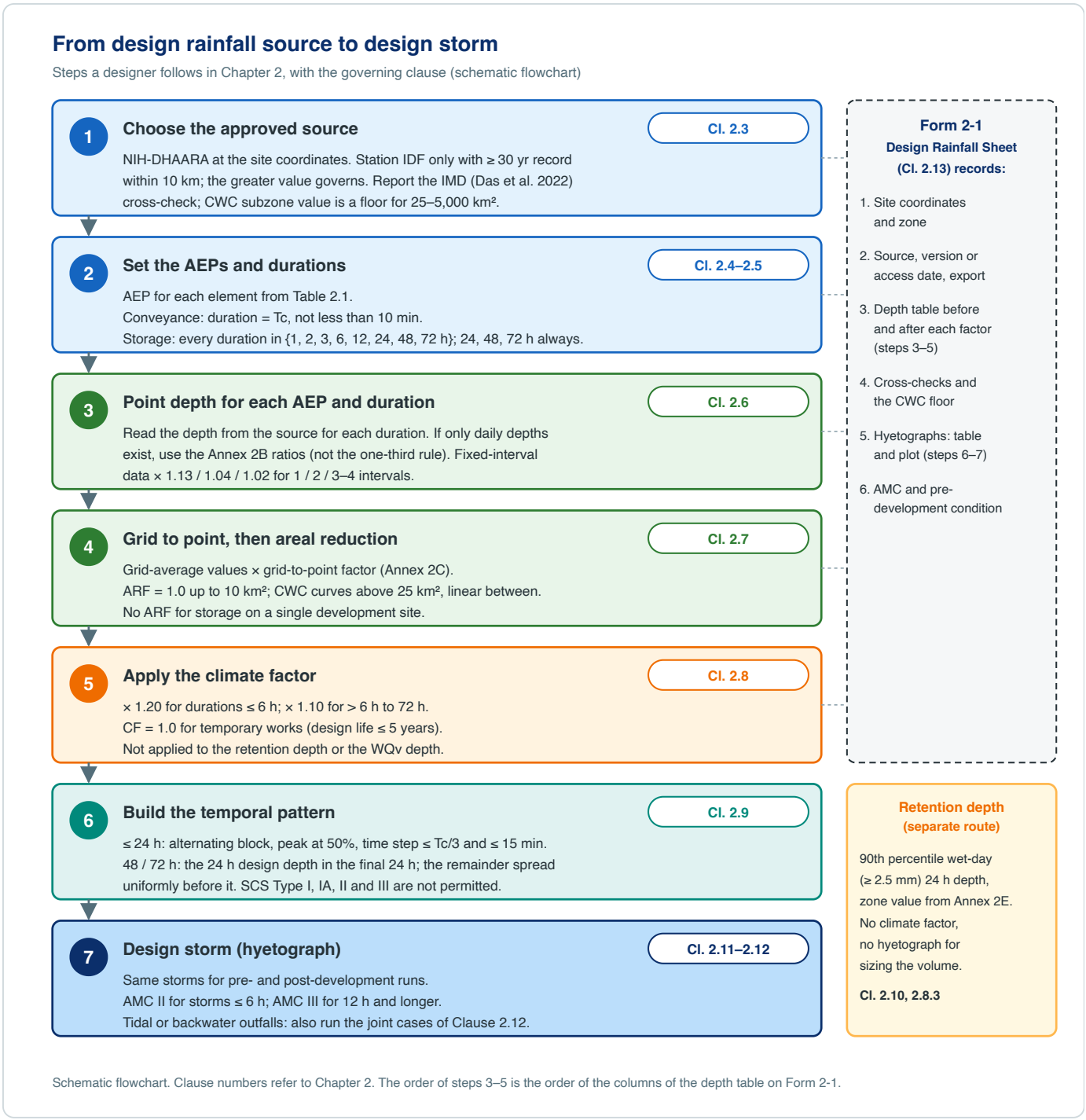

Figure 2.3 — From design rainfall source to design storm: the steps a designer follows (source, AEPs and durations, point depth, grid-to-point and areal reduction, climate factor, temporal pattern, design storm), the clause that governs each step, what Form 2-1 records, and the separate route for the retention depth. Schematic. Original drawing for this Manual.

2.14 Review and update

2.14.1 The approving authority shall review this chapter **every 10 years**. It shall also review it within 2 years of any event in which recorded rainfall exceeds the 1% AEP 24-hour or 72-hour design depth at two or more approved gauges in the State.

2.14.2 Updates to NIH-DHAARA take effect for new submittals 6 months after release, unless the authority notifies otherwise.

References (chapter)

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- Central Water Commission (1991). Flood Estimation Report for North Brahmaputra Subzone 2(a), Design Office Report No. NB/18/1991 (placed before the FEPCC at its 49th meeting, 24–25 October 1990) (Plates 8, 9 and 10, the 25-, 50- and 100-year maps, read by eye from page images; text on the extent, towns, rivers and rainfall of the subzone; §3.1.2, p. 24, the short-duration ratios; the loss rate; Table 7, the heaviest falls, with the Passighat row). https://cwc.gov.in/regional-flood-estimation-report
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- NIH-DHAARA, IDF tool, IMDAA dataset, queried for fifteen points in Arunachal Pradesh on 14 Nov 2026 (tool output). http://117.252.14.251:8080/
- Dabral, P.P., Kumar, A. & Tana, G. (2016). Determination of surface drainage coefficient – a case study of Doimukh (Arunachal Pradesh), India. *Agricultural Engineering International: CIGR Journal* 18(4), 1–10 (NERIST meteorological laboratory, Doimukh, 27°08'39" N, 93°45'05" E, 118 m; daily rainfall 1988–2012; Tables 1, 4 and 8; infiltration test).
- Dabral, P.P. Depth–duration–frequency analysis of Doimukh rainfall. *Indian Journal of Hill Farming* 32(1) (as listed; not obtained [TBC]).
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- Press reports of the storms and floods of July 2017, September 2018, May, June and July 2024, May–June 2025 and June–July 2026, of NEEPCO's release advisories, of the Pare dam's release of 31 May 2025 and of NDMA's glacial-lake list (secondary sources).
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- Kansas City Metro Chapter APWA (2025). Section 5600 Storm Drainage Systems and Facilities, Version 2025.01.
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Annexes

Annex	Content
2A	NIH-DHAARA vs IMD station and IMD gridded checks at benchmark points; zone map
2B	Sub-daily ratios P(t)/P(24h) by zone: NIH-DHAARA (hourly-based) vs the one-third rule
2C	Grid-to-point factors
2D	Arunachal Pradesh temporal patterns (Huff curves)
2E	Retention percentile depths by zone
Form 2-1	Design Rainfall Sheet

CHAPTER 3

Hydrologic Methods

3.1 Purpose and scope

3.1.1 This chapter sets out how design rainfall from Chapter 2 is turned into runoff peaks, volumes and hydrographs for:

- (a) drain, inlet and culvert sizing (Chapter 6);
- (b) retention and detention sizing, and the pre- vs post-development comparison (Chapter 4);
- (c) downstream and tailwater analysis (Chapter 5); and
- (d) waterbody, tank (pond) and regional facility studies (Chapter 7).

3.1.2 It specifies:

- (a) which method may be used for which purpose and catchment size (Clause 3.4);
- (b) how the pre- and post-development land surfaces are defined (Clause 3.3);
- (c) the parameters of each method: runoff coefficients, time of concentration, soils, curve numbers, unit hydrographs and routing (Clauses 3.5–3.12);
- (d) when continuous simulation and model calibration are required (Clauses 3.13 and 3.15);
- (e) the step-by-step pre- vs post-development comparison (Clause 3.14); and
- (f) software acceptance and documentation (Clauses 3.16 and 3.17).

3.1.3 Rainfall inputs (depth, duration, areal reduction, climate factor, temporal pattern and antecedent moisture) are governed by Chapter 2 and shall not be varied in this chapter.

> **Commentary.** The CPHEEO (2019) Manual on Storm Water Drainage Systems gives a full Rational Method procedure and names SWMM for hydrograph work, but it is a drain-sizing guide. It does not say how a regulator should define "pre-development" or which method must be used to test a development against it (CPHEEO Part A §4.4, §8.5.1). APWA Section 5600 does both: it limits the Rational Method, names baseline hydrograph methods, and fixes the land-use assumptions for existing and proposed conditions (KC Metro APWA 5600, 2011, §5602.2–5602.3; Version 2025.01, §5603.4). This chapter follows that model.

3.2 Definitions

Term	Meaning in this Manual
Pre-development condition	The reference land surface defined in Clause 3.3.2, against which post-development runoff is tested. It is not the existing condition.
Post-development condition	The land surface after the proposed works are complete, as defined in Clause 3.3.3.
Point of comparison (POC)	A location where site runoff leaves the site, at which pre- and post-development flows are compared (Clause 3.14).

Term	Meaning in this Manual
Time of concentration (Tc)	The time for runoff to travel from the hydraulically most distant point of the catchment to the point of interest.
Lag (tL)	The time from the centroid of rainfall excess to the peak of the runoff hydrograph.
Hydrologic soil group (HSG)	The NRCS classification (A, B, C, D) of a soil by its minimum infiltration rate when wet (USDA NRCS, NEH Part 630, Ch. 7).
Curve number (CN)	The NRCS parameter that combines soil group, land cover and antecedent moisture into a single runoff-potential index (USDA NRCS, NEH Part 630, Ch. 9–10).
Antecedent moisture condition (AMC)	The soil wetness at the start of a storm: AMC I (dry), II (average), III (wet).
Directly connected impervious area (DCIA)	Impervious surface that drains to a drain, pipe or channel without first flowing over a pervious surface.
Disconnected impervious area	Impervious surface whose runoff flows as sheet flow over a pervious surface before reaching the drainage system, and meets Clause 3.9.3.
Peak rate factor (PRF)	The constant in the unit hydrograph peak equation (484 in US customary units; 0.208 in the SI form of Clause 3.11.2).
Continuous simulation	A model run over a long rainfall record (years), with soil moisture, storage and tank levels carried forward between storms.
Tank cascade	A chain of tanks (ponds) in which the surplus of one tank feeds the next.

3.3 Pre-development and post-development land surface

3.3.1 **Same site, same storm.** Pre- and post-development runs shall cover the same area draining to each POC, and use the same design storms (Clause 2.11.1). They shall differ only in the land-surface parameters of this clause, the resulting Tc, and the stormwater controls.

3.3.2 **Pre-development condition.** The pre-development land surface shall be **greenfield: open land in good condition for the mapped hydrologic soil group**, as follows:

- (a) All land within the site, including land that is now built on, paved, compacted or cultivated, is treated as open land (grass cover > 75%) in good condition. **Existing impervious cover shall not be counted.**
- (b) The curve number is the TR-55 value for "open space, good condition" for the HSG of Clause 3.7: **CN 39 (A), 61 (B), 74 (C), 80 (D)** at AMC II (Table 3.5).
- (c) The HSG is the natural HSG of Clause 3.7, including the dual-group rule for high water table (Clause 3.10.1). No HSG improvement for drainage works is allowed.
- (d) Tc is computed on the pre-development ground surface using unchannelled overland and shallow concentrated flow and natural channels only (Clause 3.6). Existing pipes, lined drains and kerbs are ignored.
- (e) Existing waterbodies, tank waterspreads up to the full tank level (FTL), natural channels and supply or surplus channels are kept as they are, and modelled as water surfaces or channels, not as open land.

3.3.3 **Post-development condition.** The post-development land surface shall represent the proposed works at full build-out:

- (a) Impervious areas shall be measured from the site plan, separately for roofs, paved surfaces, roads and other sealed surfaces, and classified as directly connected or disconnected (Clause 3.9). Lot-size residential rows of TR-55 shall not be used for the site itself.

- (b) Pervious areas disturbed by construction (graded, filled or trafficked) shall be assigned one HSG lower in infiltration capacity than the natural HSG (A to B, B to C, C to D), unless post-construction infiltration tests (Clause 3.7.3) show otherwise. Soil disturbed by construction shall never be classed as HSG A.
- (c) Rainwater harvesting (RWH) sumps shall be treated as full at the start of storms of 12 hours or more, and the roof area draining to them as directly connected for those storms (Chapter 4).
- (d) Retention and detention facilities shall be represented explicitly as storage (Clause 3.12), not by lowering CN.

3.3.4 **Redevelopment.** The pre-development condition of Clause 3.3.2 applies to redevelopment as well. A site that is already fully paved is tested against greenfield, not against its existing state. For the constrained-redevelopment route of Clause 4.5.6, the existing condition shall also be modelled, with existing impervious areas as surveyed, so that the 50% minimum can be checked.

3.3.5 **Off-site areas.**

- (a) For conveyance design (Chapter 6), areas upstream of the site shall be taken at their ultimate land use under the approved master plan or development plan. Where no plan exists, upstream undeveloped land shall be assumed to be at least 35% impervious.
- (b) For the pre- vs post-development comparison, off-site run-on shall be modelled identically in both runs, at its existing condition (Clause 3.14.2).

> Commentary. A greenfield reference stops each redevelopment from being judged against an already degraded baseline. The UK non-statutory standards and KC APWA take the same approach in different forms: APWA caps existing agricultural land at no more than "good condition pasture, grassland or range (C = 0.30, CN = 74)" for HSG C, and forbids disturbed soils from being classed as HSG A or B (KC Metro APWA 5600, 2011, §5602.3A and E). The TR-55 "open space, good condition" values used in (b) are identical to TR-55's "pasture, grassland or range, good" values (USDA SCS TR-55, 1986, Tables 2-2a and 2-2c), so this Manual's pre-development CN equals the APWA cap on HSG C soils. The one-class downgrade for disturbed soils in 3.3.3(b) is set by this Manual as a simpler, less strict version of the APWA rule, suited to the residual soils and slope debris over the Siwalik sandstones, shales and boulder beds of the foothills, the sandy terrace and valley-fill soils of the Naharlagun–Nirjuli–Doimukh valley, the bhabar boulder fans and flood-plain silts of the Siang, Dibang, Lohit and Noa-Dihing, the thin soils over gneiss and schist of the high ranges, and the cut-and-fill ground of the hill towns, where an HSG A to C jump would be excessive. The 35% minimum imperviousness for unplanned upstream land in 3.3.5(a) is the APWA value (2011, §5602.3E.2). Using the master-plan land use for conveyance follows CPHEEO, which requires C to reflect "ultimate development of the catchment as per the master plan" (CPHEEO 2019, Part A §4.4.1.5).

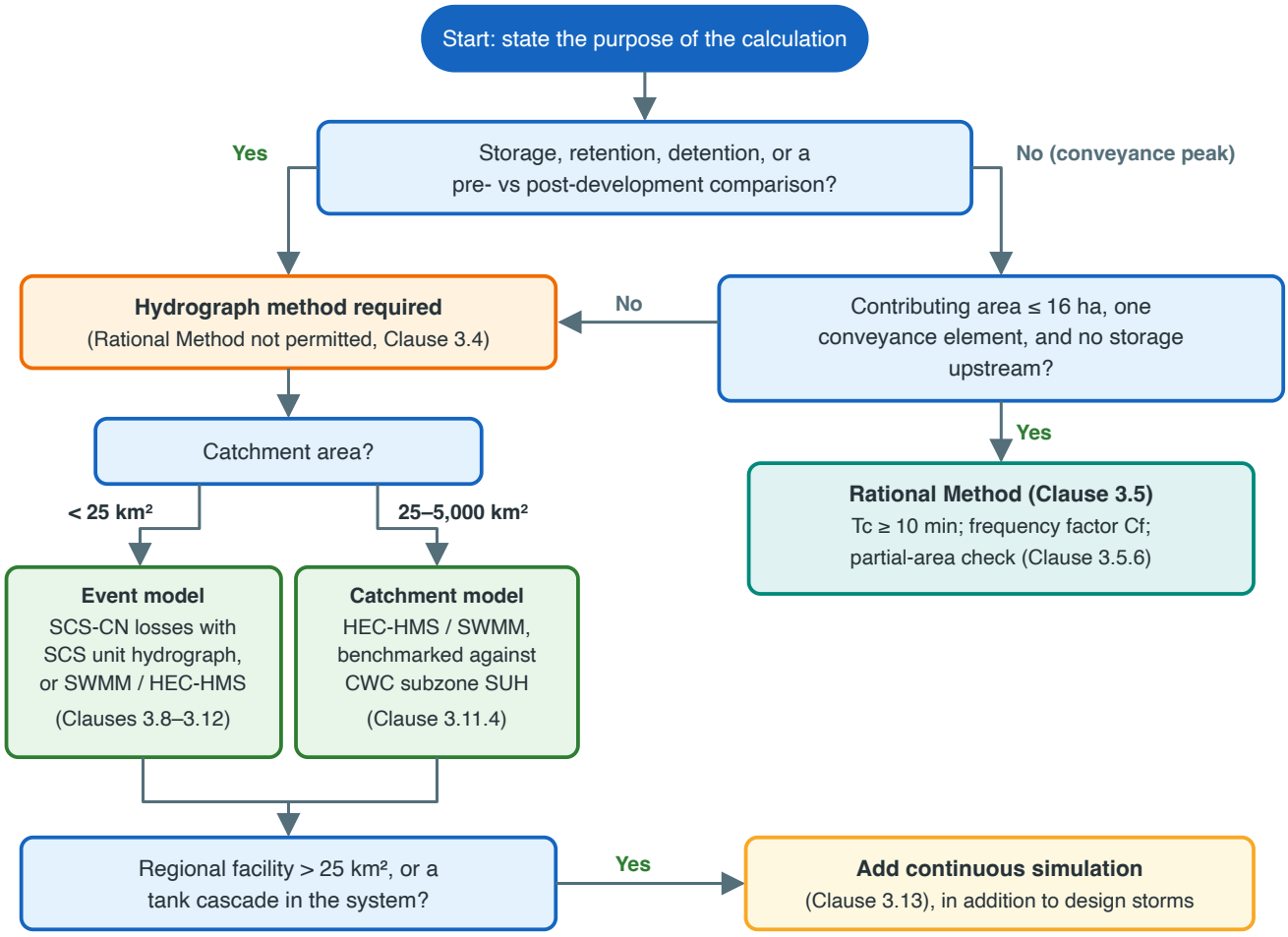
3.4 Selection of method

3.4.1 The method shall be selected from Table 3.1 by purpose and catchment size. Figure 3.1 shows the same rules as a flowchart.

Table 3.1 — Permitted hydrologic methods

Purpose	Catchment / condition	Permitted method	Clause
Peak flow for one conveyance element (inlet, pipe reach, drain reach, culvert)	≤ 16 ha contributing, no upstream storage, no backwater	Rational Method	3.5
Peak flow for conveyance	> 16 ha, or any upstream storage, tank or pond	Hydrograph method (SCS-CN with SCS unit hydrograph, SWMM or HEC-HMS)	3.8–3.12

Purpose	Catchment / condition	Permitted method	Clause
Retention, detention, any storage; pre- vs post-development comparison	Any size	Hydrograph method; **Rational Method not permitted**	3.8–3.12, 3.14
Pipe or drain network with backwater, tidal or tank tailwater	Any size	Hydrograph method with dynamic-wave hydraulic routing	3.12.4; Chapter 5
Catchment-scale flows	25–5,000 km² in CWC subzone 2(a) (North Brahmaputra), including the middle hills and high ranges beyond its last contour, or 2(b) (South Brahmaputra)	HEC-HMS or SWMM, benchmarked against the CWC synthetic unit hydrograph (SUH)	3.11.4
Regional facilities	Draining > 25 km²	Design-storm hydrograph method **plus** continuous simulation	3.13
Tank (pond) cascades	Any size	Design-storm hydrograph method **plus** continuous simulation	3.13
Tier B: small sites under Chapter 1	Within the limits of the design aid	Design aids issued under Chapter 4, which are themselves derived by the methods of this chapter	3.4.4
Small sites, any authority	≤ 1 ha, within the limits of Clause 4.14.3	Fixed-coefficient route of Chapter 4 (fixed release coefficients, rainfall-mass storage)	3.4.4; 4.14.3



Tidal or backwater outfall: route with a dynamic-wave hydraulic model (Chapter 5).

Figure 3.1 — Selection of hydrologic method. Original drawing for this Manual, adapted from KC Metro APWA, Section 5600 Storm Drainage Systems and Facilities, 2011 (§5602.2) and Version 2025.01 (§5603.4, Policy Supplement, 2025).

3.4.2 **Rational Method limits.** The Rational Method shall be used only for catchments of **16 ha or less** and only to compute the peak flow to a **single conveyance element**. It shall **never** be used to size retention, detention or any other storage, nor to derive a hydrograph or runoff volume.

3.4.3 **Hydrograph methods.** Above 16 ha, and for every storage calculation, a hydrograph method shall be used: SCS-CN losses with the SCS (NRCS) unit hydrograph, EPA SWMM, or HEC-HMS. For 25–5,000 km² the CWC synthetic unit hydrograph shall also be computed as a benchmark (Clause 3.11.4).

3.4.4 **Simplified routes.** In Tier B areas (Chapter 1), sites within the limits stated on a design aid issued under Chapter 4 may use that design aid in place of a site-specific hydrograph model. In any area, sites of 1 ha or less may use the fixed-coefficient route of Clause 4.14.3; it is the only exception to the rule in 3.4.2 that rainfall-based peak methods shall not be used for storage. The Rational Method remains available for conveyance under 3.4.2.

3.4.5 **Catchments above 5,000 km².** These are outside the scope of this Manual and require a basin study approved by the Water Resources Department.

> **Commentary.** The 16 ha limit and the single-element rule follow APWA 5600 Version 2025.01, which cut the Rational Method from 200 ac to 40 ac and restricted it to "a single pipe segment". The MARC Policy Supplement adds that it "cannot be used to size runoff reduction practices or determine retention volumes and detention volumes" (MARC, APWA Stormwater Standards Supplement, 2025). CPHEEO (2019, Part A §4.4.1.3) allows the Rational Method up to 8–10 km², which is too large for a method that assumes uniform rainfall intensity over the whole catchment for the whole of Tc and gives no volume. The Rational Method is excluded from storage design because it gives a peak, not a hydrograph, and storage depends on volume and timing.

3.5 Rational Method

3.5.1 **Equation.** The peak flow shall be computed as:

$$Q = C \cdot Cf \cdot i \cdot A / 360$$

where Q is the peak flow (m³/s); C is the runoff coefficient (Table 3.2); Cf is the frequency factor (Table 3.3), with C · Cf ≤ 1.0; i is the rainfall intensity (mm/h) for a duration equal to Tc, from Chapter 2 (with the climate factor of Clause 2.8); and A is the contributing area (ha).

> **Commentary.** This is the CPHEEO equation Qp = 10 C I A, with Qp in m³/h (CPHEEO 2019, Part A §4.4.1.1–4.4.1.3), converted to m³/s.

3.5.2 **Runoff coefficients.** C shall be taken from Table 3.2. Within a range, the designer shall use the upper half of the range unless site data justify a lower value.

Table 3.2 — Runoff coefficient C (for AEP of 10% or more frequent)

Surface or land use	C	Source
Commercial	0.70–0.95	CPHEEO 2019, Table 4.2

Surface or land use	C	Source
Industrial	0.60–0.90	CPHEEO 2019, Table 4.2
Institutional	0.70–0.95	CPHEEO 2019, Table 4.2
Residential, high density	0.60–0.75	CPHEEO 2019, Table 4.2
Residential, low density	0.40–0.60	CPHEEO 2019, Table 4.2
Recreational	0.10–0.25	CPHEEO 2019, Table 4.2
Asphalt	0.70–0.95	CPHEEO 2019, Table 4.2
Concrete	0.80–0.95	CPHEEO 2019, Table 4.2
Brick paving	0.70–0.85	CPHEEO 2019, Table 4.2
Roofs: tiles	0.80–0.90	CPHEEO 2019, Table 4.2
Roofs: metal	0.70–0.90	CPHEEO 2019, Table 4.2
Roofs: concrete	0.70–0.90	CPHEEO 2019, Table 4.2
Lawns, sandy soil, flat (≤ 2%)	0.05–0.10	ASCE/WPCF 1969
Lawns, sandy soil, average (2–7%)	0.10–0.15	ASCE/WPCF 1969
Lawns, sandy soil, steep (> 7%)	0.15–0.20	ASCE/WPCF 1969
Lawns, heavy (clay) soil, flat (≤ 2%)	0.13–0.17	ASCE/WPCF 1969
Lawns, heavy soil, average (2–7%)	0.18–0.22	ASCE/WPCF 1969
Lawns, heavy soil, steep (> 7%)	0.25–0.35	ASCE/WPCF 1969
Undeveloped land (maximum for any condition)	0.30	KC APWA 5600 (2011), §5602.3E

3.5.3 **Frequency factor.** For design AEPs rarer than 10%, C shall be multiplied by Cf from Table 3.3. The product C · Cf shall not exceed 1.0.

Table 3.3 — Frequency factor Cf

Design AEP (return period)	Cf
10% (10-yr) and more frequent	1.00
4% (25-yr)	1.10
2% (50-yr)	1.20
1% (100-yr)	1.25

3.5.4 **Composite C.** Where a catchment contains more than one surface, C shall be the area-weighted value C = Σ(Cj · Aj) / ΣAj, computed from the measured areas of each surface. Cf is applied to the composite C.

3.5.5 **Time of concentration and networks.**

- (a) Tc shall be computed by Clause 3.6 and shall not be less than **10 minutes**.
- (b) For each reach of a network within the 16 ha limit, the peak shall be computed with the cumulative Σ(C · A) upstream of that reach and the longest Tc to that reach. Peaks from upstream reaches shall not be added.

3.5.6 **Partial-area check.** Where a compact, highly impervious part of the catchment has a much shorter Tc than the whole, the peak shall also be computed for that part alone, using its own area, C and Tc. The larger peak governs.

> **Commentary.** The developed-surface coefficients in Table 3.2 are CPHEEO Table 4.2, which CPHEEO adapted from ASCE/WPCF (1969). CPHEEO keeps C constant for all return periods. Table 3.3 instead adopts the APWA antecedent-precipitation factors (KC Metro APWA 5600, 2011, §5602.2A: K = 1.1, 1.2 and 1.25 for 4%, 2% and 1% storms, with C·K ≤ 1.0). These factors matter here because Arunachal Pradesh's rare storms arrive on wet ground (Clause 2.11.4). The 10-minute minimum Tc matches the minimum design duration of Clause 2.5.1. APWA 2011 bounds inlet time between 5 and 15 minutes (§5602.7A). The partial-area check follows CPHEEO's treatment of "partial area effect" (CPHEEO 2019, Part A §4.4.1.7). This Manual requires the upper half of each range in 3.5.2 because Indian urban plots are typically more densely covered than the US land uses behind the ASCE ranges.

3.6 Time of concentration

3.6.1 **General.** Tc shall be computed separately for the pre- and post-development conditions, along the flow path that gives the longest travel time to the point of interest, as the sum of travel times in each flow segment. Tc shall not be less than **10 minutes** for either condition.

3.6.2 **NRCS velocity (segment) method.** The NRCS segment method is the default for all catchments. Tc = Tt(sheet) + Tt(shallow) + Tt(channel), where:

- (a) **Sheet flow:**

  > Tt = 0.091 (n · L)^0.8 / (P2^0.5 · S^0.4)

  where Tt is in hours; n is the sheet-flow roughness from Table 3.4; L is the sheet-flow length (m); P2 is the present-day 50% AEP (2-yr) 24-hour rainfall (mm) from Clause 2.3, without the climate factor; and S is the land slope (m/m).

- (b) **Sheet-flow length.** In urban areas, and for all post-development conditions, the sheet-flow length shall not exceed **30 m**. For pre-development greenfield surfaces, up to 90 m may be used only where survey shows unchannelled planar ground; otherwise 30 m applies.

- (c) **Shallow concentrated flow:** Tt = L / (3,600 V), with V = 4.918 S^0.5 (unpaved) or V = 6.196 S^0.5 (paved), V in m/s, L in m and S in m/m.

- (d) **Channel and pipe flow:** Tt = L / (3,600 V), with V from Manning's equation at bank-full or pipe-full flow.

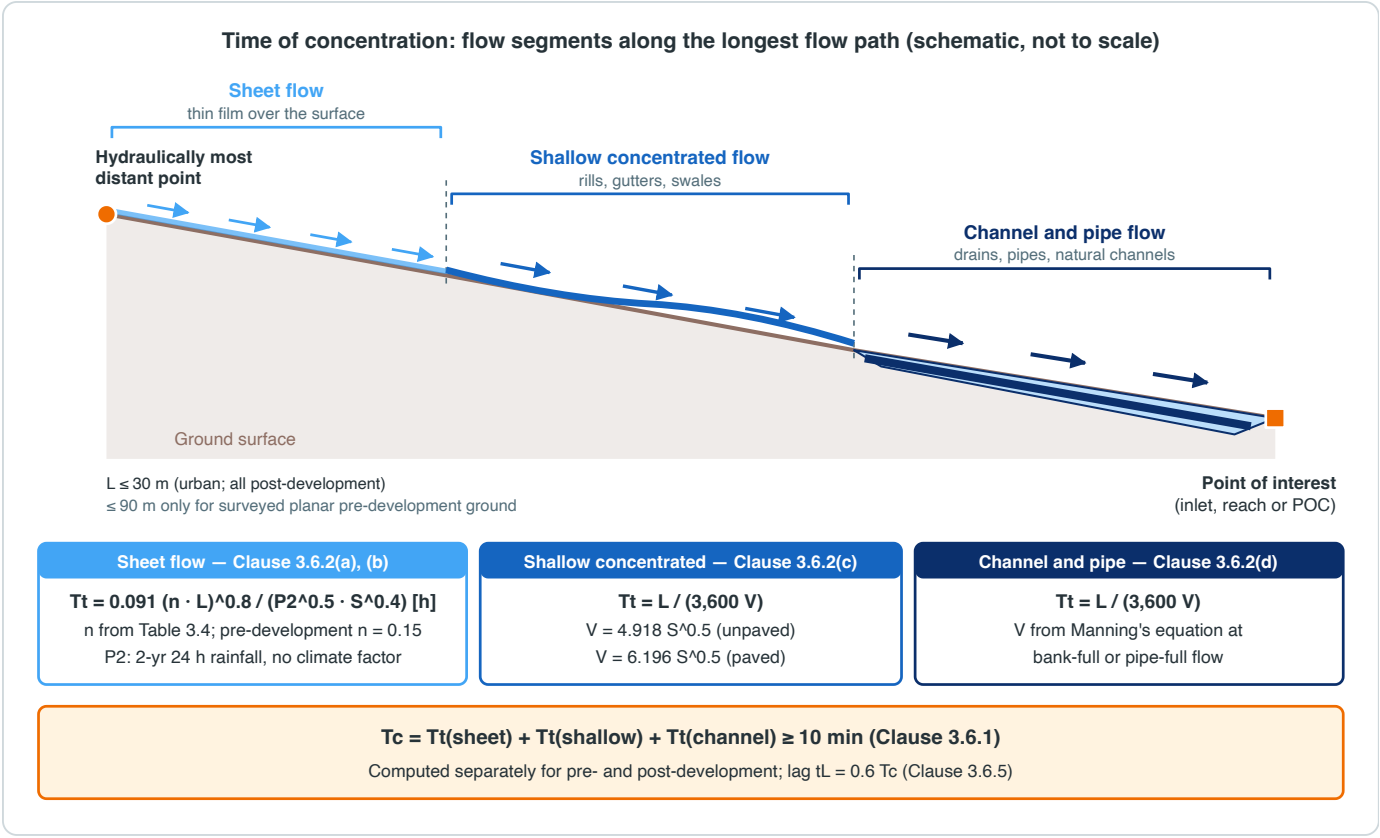


Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986), Ch. 3, and USDA NRCS, NEH Part 630, Ch. 15 (2010).

Table 3.4 — Manning's n for sheet flow (USDA SCS TR-55, 1986, Table 3-1)

Surface	n
Smooth surfaces (concrete, asphalt, gravel, bare soil)	0.011
Fallow (no residue)	0.05
Cultivated, residue cover ≤ 20%	0.06
Cultivated, residue cover > 20%	0.17
Grass: short-grass prairie	0.15
Grass: dense grasses	0.24
Range (natural)	0.13
Woods: light underbrush	0.40
Woods: dense underbrush	0.80

3.6.3 **Pre-development roughness.** For the pre-development greenfield surface of Clause 3.3.2, sheet-flow n shall be **0.15** unless the designer justifies another Table 3.4 value from the natural vegetation of the area.

3.6.4 **Kirpich formula.** The Kirpich formula may be used only as a cross-check, or for pre-development rural catchments with a defined main channel:

```
tc = 0.0195 L^0.77 S^−0.385
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where tc is in minutes, L is the length of the main flow path (m) and S is its average slope (m/m). It shall not be used for urban or post-development catchments.

3.6.5 **Lag.** Where a unit hydrograph method requires lag, tL = 0.6 Tc.

3.6.6 **Check.** Post-development Tc shall normally be shorter than pre-development Tc. Where it is longer, the designer shall explain why in the submittal.

> Commentary. The segment method and its equations are from TR-55 (USDA SCS, 1986, Ch. 3) and NEH Part 630, Ch. 15 (USDA NRCS, 2010). The SI constants are direct conversions of the US equations: 0.007 becomes 0.091 with L in m and P2 in mm, and 16.1345 and 20.3282 ft/s become 4.918 and 6.196 m/s. TR-55 (1986) allowed sheet flow up to 300 ft (≈ 90 m). NEH 630 Ch. 15 states that sheet flow typically lasts no more than about 100 ft (≈ 30 m) before becoming shallow concentrated flow (citing Merkel, 2001), and many US agencies now cap it there. This Manual sets the 30 m urban limit in 3.6.2(b) on that basis: in Indian urban plots, flow reaches a drain, kerb or compound-wall weep hole within a few metres. The undisturbed P2 is used in the sheet-flow equation because P2 is a parameter of the travel-time relationship, not a design load. The default n = 0.15 for greenfield is the TR-55 short-grass value; this Manual adopts it to avoid long pre-development Tc values that would make Q_pre artificially low. The Kirpich formula is the SI form given by Chow, Maidment and Mays (1988, Table 15.1.2), from small agricultural catchments in Tennessee (Kirpich, 1940), so it does not suit urban surfaces. The lag ratio 0.6 is the NRCS value, also used by APWA (2011, §5602.7C).

3.7 Soils and hydrologic soil groups

3.7.1 **Mapping.** HSG shall be assigned from the soil series mapped by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) or the State soil survey agency [TBC], using the soil-series-to-HSG lookup of Annex 3A. The source map and its scale shall be stated.

3.7.2 **Assignment rule.** Where Annex 3A is not yet available for a series, the HSG shall be assigned from the measured saturated hydraulic conductivity and depth to an impermeable layer or water table using the criteria of NEH Part 630, Ch. 7. Until Annex 3A is published, this Manual sets the following interim groups for Arunachal Pradesh. On the valley floors and plains (the valley floor of sub-area AR-A, sub-areas AR-B and AR-C of Annex 2A, and the flat valley land of AR-A1): the sandy terrace and valley-fill soils of the Naharlagun–Nirjuli–Doimukh valley, HSG A or B by texture where the seasonal high water table stands more than 2 m below ground; the coarse bhabar boulder fans of Pasighat, Ruksin, Roing, Tezu, Namsai, Bhalukpong and Banderdewa, HSG A where the seasonal high water table stands more than 2 m below ground; with infiltration practices on either only under Clause 4.11 (recharge rule); and the flood-plain silts and swamps of the Dikrong, the Pachin, the Siang, the Dibang, the Lohit, the Noa-Dihing and the other rivers, with the palaeochannels and swampy land of the Pachin and Dikrong flood plains, and any land where the seasonal high water table is within 2 m of ground, HSG C or D, and HSG D where it is waterlogged. In the hills (sub-areas AR-C1, AR-D and AR-E, the hill rim of AR-A and AR-A1, and every natural slope of more than 10° anywhere): the residual soils and slope debris over the Siwalik sandstones, shales and boulder beds of the foothills, HSG C by test, and HSG D for design on cut slopes, on fills and on shale, whatever group the soil itself would take; and the thin soils over the gneiss and schist of the Bomdila Group and the high ranges, with their bare rock and, in winter, snow, HSG C or D by test. Everywhere: colluvium and slope debris, HSG D for design, with no infiltration credit; and urban fill and the cut-and-fill ground of the hill towns, HSG C, and HSG D where it is clayey or compacted. A field infiltration test is required on every site larger than the limits of the simplified method of Clause 4.14.1, at the depth of the proposed facility; on smaller sites, a soil that

has not been tested shall be given the less permeable of the groups listed for it. Whether an infiltration practice may be built at all is governed by the three infiltration rules of Clause 4.11 (the hill rule, the floodplain rule and the recharge rule), not by its HSG. Clause 3.10.1 applies to all of these groups.

3.7.3 **Site verification.** For every site that relies on retention by infiltration (Chapter 4), the mapped HSG shall be verified by site infiltration tests at the location and depth of each infiltration facility. Where the tests show a lower infiltration capacity than the mapped HSG, the test result governs for both the retention design and the post-development CN. Where they show a higher capacity, the pre-development HSG shall not be changed without the approval of the authority.

3.7.4 **Disturbed and filled ground.** Clause 3.3.3(b) applies.

> Commentary. NBSS&LUP soil maps are typically at 1:250,000 to 1:50,000 scale and classify soils by series and taxonomy, not by HSG. A lookup table is therefore needed (Annex 3A). Site tests matter most where one site can span two groups: at the foot of the hills, where the bhabar fans pass into the flood plains ("The Bhabar is mostly composed of boulders while flood plain is composed of fine sand and silt", CGWB, Lohit district booklet) and the water table rises towards the river; on the valley floor of the capital region, where the sandy terrace soils of the Naharlagun–Nirjuli–Doimukh valley lie beside the palaeochannels and swampy land of the Pachin and Dikrong flood plains; and on hill sites, where a high rate in a pit dug in slope debris, colluvium or fill can be water entering a slope that cannot take it (Clause 4.11). No HSG map or table for Arunachal Pradesh, no soil-series lookup, no SCS-CN calibration and no State soil survey were found during research for this Manual [TBC], and only one measured infiltration rate, at Doimukh. The interim groups follow the soils and geology as the CGWB describes them. Papum Pare district "is underlain mostly by Siwalik group of rocks", with the Bomdila Group, the Miri and Buxa formations and the Gondwana Group to the north; "the Siwalik Hills form hogback topography", and "The entire older metamorphic formation of Paleozoic is overthrusted over the Younger Tertiary Siwaliks" along the Main Boundary Thrust; the hill slopes are "covered by residual soil or slope debris"; "The broad valley between Naharlagun and Nirjuli" is an intermontane valley, and an alluvial plain lies "along the wide flood plain areas of Pachin and Dikrong rivers", with palaeochannels, swampy land, terraces and bars; the foothill piedmont is "Older Alluvium (piedmont deposits) underlain by sandstone, shales and boulders/pebbles of Siwalik formation"; and "The soils in the valley areas are sandy loamy in texture with high acidic content" (CGWB, Ground Water Information Booklet, Papum Pare district). In East Siang the "Gondwana group acts as a run off zone while Siwalik group is the recharge zone", and the piedmont plain "is highly permeable" (East Siang district booklet); in Lohit "The Bhabar is mostly composed of boulders while flood plain is composed of fine sand and silt" (Lohit district booklet); in Changlang the Bordumsa–Miao plain is Recent alluvium and the foothills older alluvium (Changlang district booklet); and in West Kameng and Tawang the rocks are of the Bomdila Group, with valley fills of Recent alluvium (district booklets). The only field test found is NERIST's at Doimukh: a soil of 95.19% sand, 0.01% silt and 4.80% clay, whose double-ring infiltration rate fell from 12 cm/h to a basic rate of 1 cm/h (10 mm/h) after 250–300 minutes (Dabral et al., 2016). The interim groups therefore divide the State in two. On the valley floors and fans the groups follow the texture and the depth to water: A or B on the terrace sands and A on the coarse fan heads where the water is deep, C or D on the flood-plain silts and swamps and wherever the water stands within 2 m of ground (Commentary to Clause 3.10). In the hills the soils may themselves test as HSG C, but they lie on Siwalik sandstone and shale that slide, or thin over gneiss and schist, so cut slopes, fills and shale are designed as D. The only regional measure of losses is the design loss rate of the CWC subzone 2(a) report, 0.24 cm/h (2.4 mm/h), the modal value of 233 flood events on 21 rural bridge catchments on the plains, none of them in the State, of which the report says "The designer can however modify this value as per the local site conditions" (Annex 3E); it is about a quarter of the Doimukh basic rate, which is consistent with catchment-scale saturation in the monsoon season (NEER reading). It, and the 0.35 cm/h of the subzone 2(b) report, shall be used only in rural SUH runs under Clause 3.11.4, not to assign an HSG, not in an urban SCS-CN or SWMM model and not to size an infiltration practice. The interim groups of Clause 3.7.2, the 2 m water-table condition on the valley floors, the design of cut slopes, fills, shale, colluvium and slope debris as group D and the rule for untested soil on small sites are set by this Manual pending a soil-series lookup for Arunachal Pradesh. Steep ground matters as much as soil: Itanagar, the hill rim of Naharlagun, Ziro, Bomdila, Tawang, Seppa, Daporijo, Aalo and Khonsa are hill

towns, Itanagar on Siwalik slopes in Earthquake Zone V with "5 fault lines in the city" (ICR Master Plan 2031), and on their steep streets and hill streams runoff from rock, cut faces and thin soil reaches a channel within minutes; no slope map of any Arunachal Pradesh town was found [TBC]. The following rules are set by this Manual. (a) Tc shall be found by the velocity-based segment method of Clause 3.6.2, segment by segment, and shall not be taken below the 10-minute minimum of Clause 3.6.1, which matches the shortest design duration of Chapter 2 (the 5-minute minimum sometimes used for steep hill catchments is not used in this Manual); the Kirpich formula, derived from small farm catchments of moderate slope, shall not be used even as a cross-check where the average slope of the flow path exceeds 10%. (b) The sheet-flow segment over bare rock, a cut face or a paved hill street shall use the smooth-surface n of Table 3.4 and shall not exceed 30 m. (c) A catchment that runs from the hills onto a valley floor or a fan, such as the Senki and the Pachin above Itanagar and Naharlagun, the nallahs that leave the Siwalik front at Banderdewa and Bhalukpong and the streams that leave the hills above Pasighat, Roing and Tezu, shall be split at the break of slope and the hill sub-area modelled on its own, so that a flatter lower reach does not average away the fast response of the hill; flow in lined drains on steep hill streets is supercritical, and stepped or baffled drains, with energy dissipation at every change of slope and at every outfall onto a slope, are designed under Chapters 6 and 9. (d) Hill and urban catchments of 1–50 km², in the hill towns and on the valley floors alike, are designed by the Rational Method within its limits or by SWMM, with the Tc of (a). On the valley floors, where every urban catchment is far below 50 km², drains are modelled in SWMM with dynamic-wave routing (Clause 3.12.4) for two design cases, and the more severe governs each element: a short urban burst of 1 to 6 hours with the river low and the outfalls free, which tests the drains, as on 23 June 2024, when 40 mm in two hours ("As per IMD, the rainfall recorded today was 40 mm between 10:30 am and 12:30 pm", the secretary of the State Disaster Management Authority, as reported) inundated at least 66 houses in Itanagar and Naharlagun (as reported); and a multi-day storm of 24 to 72 hours with the outfalls backed up, which tests the storage and the outfall-closed case: at Naharlagun, Nirjuli and Doimukh by the Dikrong carrying the releases of the Pare dam and the tailrace of the Ranganadi project (Clause 5.8.5(a) and (d)), and at Pasighat, Tezu and Namsai by the Siang, the Lohit or the Noa-Dihing at its design level (Clause 5.8.5(c)). (e) Rural rivers of more than 25 km² in subzone 2(a) below the snow, such as the Dikrong at Doimukh, the Pachin and the Senki where they exceed 25 km², and the foothill reaches of the Pare, the Kameng, the Ranganadi and the Siyom, take the 2(a) SUH as the benchmark of Clause 3.11.4, and those of the Noa-Dihing plain and the Patkai hills in subzone 2(b) the 2(b) SUH (Annex 3E). Neither SUH rests on a catchment in the State: no catchment in Arunachal Pradesh was gauged for either report, and the 2(a) gauged catchments are railway bridges on the plains. Both are untested on Arunachal Pradesh slopes, so on a hill catchment the SUH result is reported beside the hydrograph model and the reason for any large difference is stated; Clause 3.11.4(d) applies as written. In AR-D and AR-E, beyond the last 2(a) contour, the SUH is run with the design rainfall of Clause 2.3.6, because no CWC point rainfall exists there. (f) In snow-fed and glaciated catchments, in AR-E or elsewhere, such as the upper Kameng, the upper Subansiri, the Siang above Tuting, the Dibang and the Lohit above Hayuliang, no CWC unit hydrograph applies, because neither report covers snow or glaciers (the State Action Plan on Climate Change, 2011, lists 52 glaciers of 66 km² in the Kameng basin, 91 of 146 km² in the Subansiri basin and 14 of 11 km² in the Dibang basin): every cross-drainage structure and outfall of more than 1 km² there needs a site-specific hydrology study, agreed with the Authority and WRD and recorded on Form 2-1, with the design rainfall of Clause 2.3.6 on the part below the snow, the snowmelt, the routing of multi-day storms and the outburst screening of Clause 2.3.6(i); a local town catchment wholly below the snow and without a glacier is designed as in AR-D. (g) Catchments that drain to the reservoirs above the Pare, Ranganadi or Kameng dams, or to the release reaches below them and below the Lower Subansiri dam, are modelled with storage routing and the operator's release scenarios, not by a peak-flow method alone (Clause 3.12; Clause 5.8.5(d)); no operator's release protocol or warning threshold was found [TBC]. (h) No method of this chapter predicts debris flow; in steep catchments the design flow is bulked for sediment and debris, and every inlet and culvert is protected against blockage, under Chapters 6 and 9, as the Modirijo and Donyi Polo floods of September 2018 in Itanagar showed, when the Senki View culvert and the Press Colony bridge were washed away and a landslide was reported from "the dumping area of NH 415" (as reported).

3.8 SCS curve number (SCS-CN) loss method

3.8.1 **Runoff equation.** Runoff depth shall be computed by:

> $Q = (P - Ia)^2 / (P - Ia + S)$ for $P > Ia$; $Q = 0$ otherwise $S = 25{,}400 / CN - 254$

where Q is runoff depth (mm), P is the cumulative rainfall depth (mm), S is potential maximum retention (mm) and Ia is initial abstraction (mm). In hydrograph models the equation is applied to the cumulative rainfall at each time step to obtain incremental rainfall excess.

3.8.2 **Curve numbers.** CN at AMC II shall be taken from Table 3.5, for the HSG of Clause 3.7.

Table 3.5 — Runoff curve numbers, AMC II, Ia = 0.2S (USDA SCS TR-55, 1986, Tables 2-2a and 2-2c)

Cover type	HSG A	HSG B	HSG C	HSG D
Pre-development reference (Clause 3.3.2): open space, good condition (grass > 75%)	39	61	74	80
Open space, fair condition (grass 50–75%)	49	69	79	84
Open space, poor condition (grass < 50%)	68	79	86	89
Impervious: roofs, paved parking, driveways, paved roads with kerbs and drains	98	98	98	98
Paved roads with open ditches (including right-of-way)	83	89	92	93
Gravel roads (including right-of-way)	76	85	89	91
Dirt roads (including right-of-way)	72	82	87	89
Newly graded areas (pervious, no vegetation)	77	86	91	94
Fallow, bare soil	77	86	91	94
Meadow (continuous grass, protected from grazing)	30	58	71	78
Brush, good condition	30	48	65	73
Woods, good condition	30	55	70	77
Woods, fair condition	36	60	73	79
Woods, poor condition	45	66	77	83
Water surfaces, tank waterspreads, wet detention basins	Runoff = rainfall (no losses)			

3.8.3 **Use of Table 3.5.**

- (a) Post-development CN shall be built up from measured surfaces (Clause 3.9). The TR-55 urban district and residential lot-size rows shall not be used for the site.
- (b) Pervious areas in the post-development condition shall use "open space" in the condition the landscape plan will achieve. Where no landscape plan is submitted, fair condition applies.
- (c) Cultivated rows of TR-55 may be used for off-site existing conditions, but never for the pre-development reference of Clause 3.3.2.

3.8.4 **Antecedent moisture.** AMC shall follow Clause 2.11.4: AMC III for every design storm, whatever its duration, from 1 May to 15 October at a site in sub-area AR-A (Itanagar capital region), AR-A1 (Western foothills), AR-C (Noa-Dihing plain) or AR-C1 (Patkai hills) of Annex 2A, from 1 April to 31 October at a site in sub-area AR-B (Siang–Dibang–Lohit foothills), and from 1 June to 15 October at a site in sub-area AR-D (Middle hills) or AR-E (High ranges); AMC III for every design storm from 1 April to 31 October, in every sub-area, on land below the 1% AEP flood level of the Dikrong, the Pachin, the Senki, the Siang, the Dibang, the Lohit, the Noa-Dihing or another river, stream or nallah, on the palaeochannels and swampy land of the Pachin and Dikrong flood plains, on the margins of a pond and wherever the seasonal high water table is within 2 m of ground; AMC III for every design storm at any time of year in a catchment that drains to a reservoir or its backwater, or to a reach below a dam into which the dam releases water, such as the Dikrong below the Pare dam, the lower Ranganadi below the Ranganadi project, the Kameng below the Bichom and Tenga dams and the Subansiri below the Lower Subansiri dam; at any other site or time, AMC III for a design storm that follows, or contains, a 5-day rainfall total of more than 53 mm; and AMC II for every other storm. AMC I is not used. CN for AMC I and III shall be obtained from AMC II by:

> CN(I) = 4.2 CN(II) / (10 − 0.058 CN(II)) CN(III) = 23 CN(II) / (10 + 0.13 CN(II))

The conversion shall be applied **to the pervious component only**. Impervious surfaces stay at CN 98 for all AMC. Composite CNs shall not be converted directly.

Illustrative — not design values. Pre-development reference CNs at AMC III are: HSG A 59.5; HSG B 78.2; HSG C 86.7; HSG D 90.2.

3.8.5 **Initial abstraction.**

- (a) **Default:** Ia = 0.2S, with the CNs of Table 3.5.
- (b) **Sensitivity run (mandatory):** every storage design shall also be run with Ia = 0.05S. For this run, S shall be converted as S0.05 = 1.33 · S0.20^1.15 (S in inches), which in SI is:

  > S0.05 = 25.4 × 1.33 × (S0.20 / 25.4)^1.15 (mm)

- (c) The design shall be based on the default run. The sensitivity results shall be reported on Form 3-2. Where the sensitivity run increases the required retention volume or water quality volume, the larger value governs for that volume.

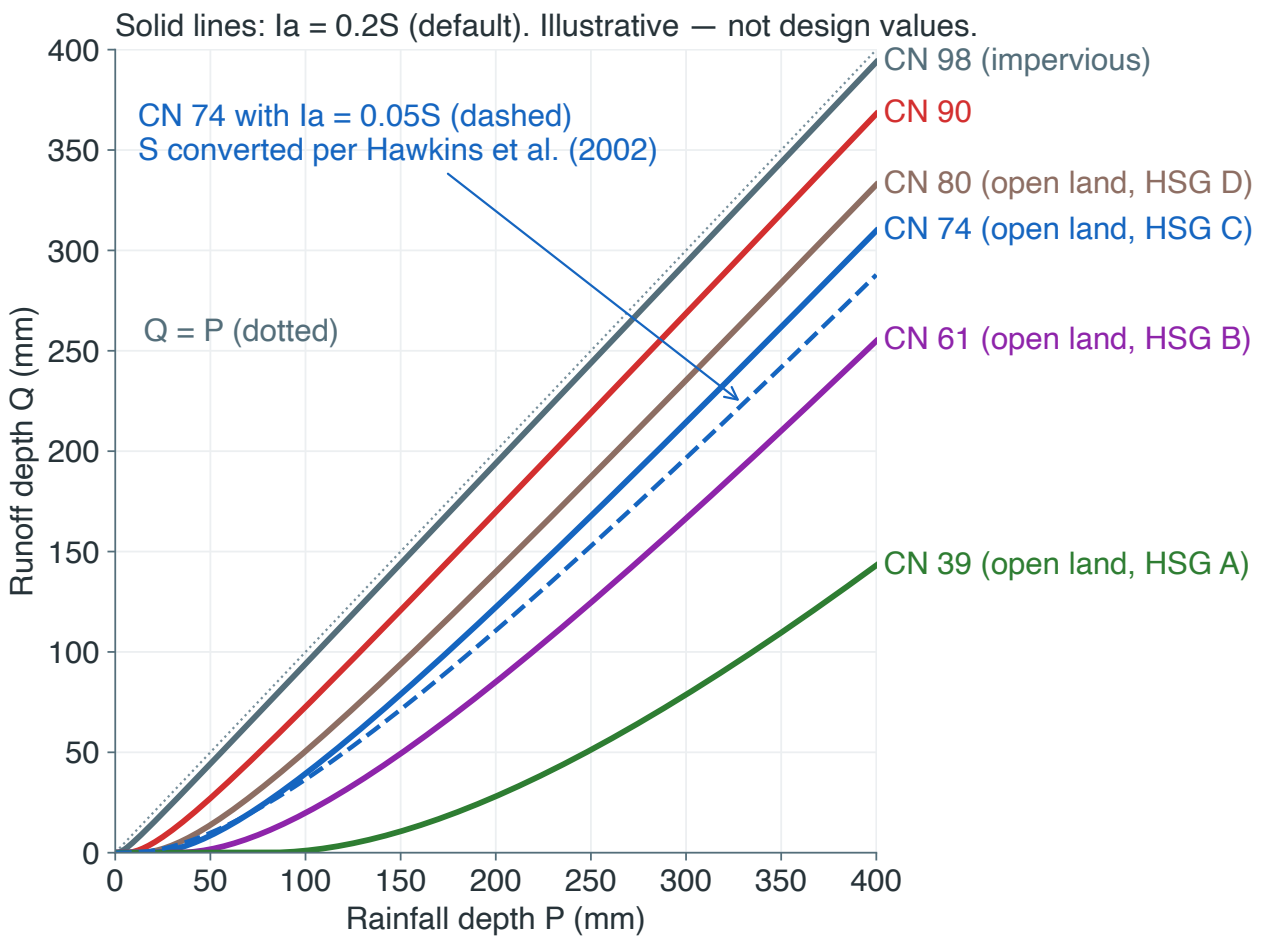

Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion of Hawkins et al. (2002). Illustrative — not design values.

Commentary. Table 3.5 reproduces standard NRCS TR-55 (1986) values. They were derived from US catchments and have not been calibrated in Arunachal Pradesh. The AMC conversion equations are the standard NEH-4 relationships as given by Chow, Maidment and Mays (1988, §5.5). Converting only the pervious component follows APWA, which states that "direct conversion of composite antecedent moisture conditions is not appropriate" (KC Metro APWA 5600, 2011, §5602.2C). Converting a composite CN would wrongly lower the CN of the impervious part.

Ia = 0.2S is the original NRCS ratio. Analysis of US rainfall–runoff data found that 0.05S fits better on average (Hawkins et al., 2002; Woodward et al., 2003), and gave the conversion of 3.8.5(b). NRCS has not formally replaced 0.2S, so this Manual keeps it as the default. Figure 3.3 shows why the sensitivity run is needed: for CN 74, the 0.05S case gives **more** runoff for small storms (about 2.0 mm vs 0.5 mm from 25 mm of rain) but **less** for large storms (about 242 mm vs 262 mm from 350 mm). *Illustrative — not design values.* The ratio therefore matters most for retention and water quality volumes, and the default 0.2S is the conservative choice for peak and detention design. The rule in 3.8.5(c) that the larger retention or water-quality volume governs has no direct precedent; this Manual sets it because the 0.05S case gives more runoff from the small storms that set those volumes.

3.9 Impervious connectivity

3.9.1 **Classification.** Every impervious surface in the post-development condition shall be classified as directly connected (DCIA) or disconnected, and shown on the drainage plan.

3.9.2 **Preferred representation.** In hydrograph models, DCIA and pervious areas shall be modelled as separate sub-areas (or as the separate impervious and pervious fractions of a SWMM subcatchment), each with its own loss parameters. The runoff from disconnected impervious areas shall be routed onto the receiving pervious area.

3.9.3 **Disconnection criteria.** An impervious area may be classed as disconnected only if all of the following hold:

- (a) its runoff discharges as sheet flow onto a pervious area, without a pipe, channel or kerb;
- (b) the pervious flow path is at least as long as the impervious flow path draining to it;
- (c) the pervious area is not compacted, not HSG D, and is protected from paving by the approved plan; and
- (d) for storms of 12 hours or more, it does not drain to an RWH sump or tank (Clause 3.3.3(c)).

3.9.4 **Composite CN.** Where a single composite CN is used instead of 3.9.2, it shall be computed as:

- for directly connected impervious area: $CN_c = CN_p + (P_{imp} / 100)(98 - CN_p)$;
- where total impervious area is below 30% and part of it is disconnected: $CN_c = CN_p + (P_{imp} / 100)(98 - CN_p)(1 - 0.5\,R)$,

where CN_p is the pervious CN, P_{imp} is the percentage of impervious area and R is the ratio of disconnected to total impervious area. The composite CN shall not be used for retention or water quality volumes.

> **Commentary.** The composite equations are from TR-55 (USDA SCS, 1986, Ch. 2, Figures 2-3 and 2-4). This Manual prefers separate representation in 3.9.2 because a composite CN spreads the impervious response over the whole area, which suppresses runoff from small storms. For a site that is 50% directly connected impervious on HSG B open space (CN_p 61), 25 mm of rain gives about 9.9 mm of runoff when the two parts are modelled separately, but only about 1.8 mm with the composite CN 79.5. At 200 mm the two methods agree (139.5 mm vs 138.4 mm). *Illustrative — not design values.* The error is largest for the frequent storms that set retention and water-quality volumes. The disconnection criteria of 3.9.3 are set by this Manual, drawing on common practice in US runoff-reduction manuals. Criterion (d) follows the rule of Clause 3.3.3(c) that RWH sumps are full at the start of monsoon storms.

3.10 Groundwater, high water table and tank backwater

3.10.1 **High water table (dual HSG).** Where the seasonal high groundwater table is within 0.6 m of the ground surface, the soil shall be assigned HSG D for both the pre- and post-development runs, whatever its texture, unless it is permanently drained by works that are maintained under Chapter 10. This rule applies in every case to storms of 12 hours or more, which are run at AMC III (Clause 2.11.4).

3.10.2 **Water-table data.** The seasonal high water table shall be taken as the highest level recorded in the monsoon season (April–October), from site piezometers or trial pits, or from the nearest Central Ground Water Board (CGWB) or WRD observation well, adjusted for ground level.

3.10.3 **Infiltration-based losses.** Where Green–Ampt, Horton or soil-moisture-accounting losses are used instead of SCS-CN, the cumulative infiltration in any storm shall not exceed the storage available in the soil above the seasonal high water table.

3.10.4 **Tank and waterbody backwater.** Where a site or sub-catchment drains to a tank, pond, marsh or other waterbody:

- (a) the water level in the receiving waterbody shall be applied as the downstream boundary of the model, per Chapter 5 and Chapter 7;
- (b) land below the level of the receiving waterbody in the design event (including the tank foreshore below FTL) shall be modelled as water surface or storage, with no losses; and
- (c) where the outfall is submerged by the waterbody level, the routing shall use the dynamic-wave method of Clause 3.12.4.

Commentary. The dual-group rule follows NEH Part 630, Ch. 7 (USDA NRCS, 2009), which places wet soils with a water table within 60 cm (24 in) of the surface in group D in their undrained state, with a dual group (A/D, B/D, C/D) where drainage is feasible. This Manual applies the undrained group to long storms because the valley floors of Arunachal Pradesh are wet in the monsoon season, although most of the State is hill ground where the water runs off. In the capital region the CGWB records water levels of 1–5 m below ground in the semi-consolidated formations of Papum Pare and of 2–4 m before the monsoon and 2–5 m after it in the Dikrong valley, whose alluvial plain "along the wide flood plain areas of Pachin and Dikrong rivers" has palaeochannels and swampy land (CGWB, Ground Water Information Booklet, Papum Pare district). Levels of 1.50–11.13 m below ground are recorded in East Siang (East Siang district booklet), 3.58 m before and 3.52 m after the monsoon of 2008 in Lohit (Lohit district booklet), and 2.62–5.50 m in the dug wells of Bhalukpong in the lean period (West Kameng district booklet). The CGWB's water-level bulletin for the North Eastern Region put 15 of the 27 Arunachal Pradesh stations, 55.56%, at 0–2 m below ground in August 2025 (as summarised). So on the flood plains and in the palaeochannels the water table is within 2 m of ground in the monsoon season, and nearer still beside the Dikrong, the Pachin, the Siang, the Lohit and the Noa-Dihing in flood. In the hills the water is deeper and the ground sheds water, but springs issue from the slopes: in Papum Pare they discharge 0.43–2 L/s before the monsoon and 0.02–2.4 L/s after it, and "most of the springs become dry during dry season" (Papum Pare district booklet); water put into such slopes is the hazard of Clause 4.11. The wet land is therefore the Pachin and Dikrong flood plains with their palaeochannels and swamps, the flood plains and fan toes of the Siang, the Dibang, the Lohit and the Noa-Dihing at Pasighat, Roing, Tezu and Namsai, the land beside the capital's nallahs, the margins of ponds, swamps and reservoirs, and hill sites with perched water or springs. No monsoon water-table depths for individual sites in Itanagar, Naharlagun, Pasighat or the other towns, and no map of the seasonal high water table, were obtained [TBC]; Annex 3A is to supply them. No State observation-well network was found; the wells are the CGWB's, North Eastern Region (Commentary to Clause 4.12).

Clause 3.10.4 reflects the State's receiving waters, which are steep streams and nallahs in the hills, main-stem rivers whose stage is set far upstream at the foothill towns, and reservoirs. Itanagar's drains run to nallahs and to the Senki and the Pachin, and Naharlagun's to the Dikrong; the existing drains "end up mostly into the Nallah and in some cases, into local ponds or open fields" (Master Plan of Itanagar Capital Region-2031, report); and the Pachin "passes through most of the area before it debouches to Dikrang river near Nirjuli" (CGWB, as summarised). There is no CWC site on the Senki, the Pachin or the Dikrong in the capital, or at Bhalukpong, and no State gauge level for any of them was found [TBC]. Below Doimukh the Dikrong carries the releases of NEEPCO's Pare dam, which passed a reported peak of 1,310 m³/s on 31 May 2025 (as reported), and the tailrace of the Ranganadi project, 160 m³/s against an observed Dikrong flood flow of about 2,500 m³/s in a 1994 study by the Central Water and Power Research Station (CWPRS) (as reported); when the river is high, the nallahs of Naharlagun, Nirjuli and Doimukh back up into the town. At the foothill towns the main stems are set upstream: the CWC site on the Siang at Passighat (Pasighat) has a danger level of 153.96 m and a highest flood level of 157.54 m, reached on 11 June 2000 after the Yigong landslide dam in Tibet breached; the Noa-Dihing at Namsai has a danger level of 145.8 m and a highest level of 146.6 m (31 August 1974); and the Lohit at Tezu a highest level of 192.14 m (16 July 1996) (CWC tables as transcribed by SANDRP, 2019; datum not stated [TBC]); there is no CWC site on the Dibang. A site that drains to the reservoirs above the Pare, Ranganadi or Kameng dams drains to a water surface that the operator holds, and Clause 3.10.4(b) applies to the land below the starting level set in the Commentary to Clause 3.12. The CWC levels on the State's rivers downstream in Assam, on the Lohit at

> Dholabazar, the Buridehing at Naharkatia, the Subansiri at Chouldhowaghat and Badatighat and the Ranganadi and the Jia Bharali at their NT Road crossings (as transcribed by SANDRP), are tens of kilometres downstream; they are not tailwater for any Arunachal Pradesh town, and the Assam edition governs those reaches.

3.11 Unit hydrographs and runoff transformation

3.11.1 **Permitted transforms.**

- (a) SCS (NRCS) dimensionless unit hydrograph, curvilinear or triangular, for catchments below 25 km² and for any sub-area of a larger model;
- (b) the SWMM non-linear reservoir with kinematic overland flow;
- (c) Clark or ModClark unit hydrograph in HEC-HMS, where parameters are calibrated under Clause 3.15; and
- (d) the CWC synthetic unit hydrograph, for 25–5,000 km² (Clause 3.11.4).

3.11.2 **SCS unit hydrograph.** The peak and time to peak of the unit hydrograph shall be:

> $q_p = PRF' \cdot A \cdot Q / t_p$, with $PRF' = 0.208$ (SI form of the standard peak rate factor 484) $t_p = \Delta t / 2 + t_L$, $t_L = 0.6\, T_c$

where q_p is the peak flow (m³/s); A is the area (km²); Q is the runoff depth (mm), equal to 1 mm for the unit hydrograph; t_p is the time to peak (h); and Δt is the computation interval (h).

3.11.3 **Computation interval and sub-areas.**

- (a) Δt shall not exceed 0.133 T_c of the smallest sub-area, nor the hyetograph time step of Clause 2.9.1.
- (b) Sub-areas shall be reasonably uniform in HSG, land cover and slope. Pervious and directly connected impervious areas shall be separate sub-areas, per Clause 3.9.2.

3.11.4 **CWC synthetic unit hydrograph.** For catchments of 25–5,000 km² in CWC subzone 2(a) (North Brahmaputra), which covers the State north and west of the Lohit (sub-areas AR-A, AR-A1, AR-B, AR-D and AR-E of Annex 2A) but draws its isopluvials only along the foothills, or 2(b) (South Brahmaputra), which covers the south-east (sub-areas AR-C and AR-C1), other than snow-fed and glaciated catchments, to which neither report applies; in the middle hills and high ranges (AR-D and AR-E), which lie inside subzone 2(a) but beyond its last contour, the 2(a) report's unit hydrograph and areal reduction curves are used as a check, and no CWC point rainfall exists there for the cross-check of Clause 2.3.3(b):

- (a) the SUH parameters, design storm duration, loss rate, base flow, areal reduction and time distribution shall be taken from the applicable CWC Flood Estimation Report, using the catchment's physiographic parameters measured from survey or a DEM;
- (b) the 24-hour design rainfall shall follow Clause 2.3.3(b) and Clause 2.7.3, and the climate factor of Clause 2.8 shall be applied;
- (c) the SUH result shall be reported alongside the HEC-HMS or SWMM result for the existing natural condition; and
- (d) where the hydrograph model gives a lower 1% AEP peak than the CWC SUH, the designer shall either justify the model by calibration under Clause 3.15 or adopt the CWC SUH peak.

3.11.5 **Peak rate factor for flat coastal land.** The standard factor (484; $PRF' = 0.208$) is the default. A lower factor may be used only:

- (a) for unchannelled, flat coastal-plain land without piped or lined drainage;
- (b) in the same way in both the pre- and post-development runs for any land that stays unchannelled; and

- (c) after the authority adopts calibrated values in Annex 3D.

Land drained by pipes, lined drains or kerbs in the post-development condition shall use the standard factor.

> **Commentary.** The SCS unit hydrograph, the 0.6 lag ratio and the 0.133 Tc interval are from NEH Part 630, Ch. 16 (USDA NRCS, 2007). The interval follows from the unit hydrograph geometry: with tp = Δt/2 + 0.6 Tc and Tc + Δt = 1.7 tp, Δt = 0.133 Tc. The SI constant 0.208 is the direct conversion of 484 (cfs, mi², in, h). APWA uses the SCS dimensionless unit hydrograph as its basis (2011, §5602.5). The CWC Flood Estimation Reports give regression equations for SUH parameters, a design storm duration, a constant loss rate and ARF and time-distribution curves for each subzone (CWC 1991 and 2000; see Chapter 2). They were derived from natural, mostly rural catchments with data that predate the reports of 1991 and 2000 (the 21 gauged catchments of the 2(a) report and the 14 of the 2(b) report are railway and road bridges on rural rivers of the plains below the hills, the 2(b) ones observed between the 1960s and 1988, and none of them is in Arunachal Pradesh), so they represent pre-development conditions, not urbanised ones. That is why the SUH is used as a benchmark rather than as the post-development model. Clause 3.11.4(d) mirrors the floor principle of Clause 2.3.3. HEC-HMS has been calibrated against CWC subzone SUH responses in Indian studies, which shows the two can be linked.
>
> The lower-factor option of 3.11.5 is based on the NRCS Delmarva unit hydrograph, which uses a peak rate factor of 284 (PRF' ≈ 0.122) for flat, poorly channelled coastal-plain catchments on the Delmarva Peninsula (Welle et al., 1980, as adopted by NRCS; New Jersey Department of Agriculture, Delmarva bulletin, which uses 285). A lower factor gives a lower, later peak. Used only in the pre-development run, it would lower Q_pre and make the release cap stricter; used in a piped post-development run, it would understate Q_post. Clause 3.11.5(b) prevents both biases.

3.12 Routing

3.12.1 **Storage routing.** Routing through detention and retention facilities, tanks, ponds and any storage behind embankments shall use level-pool (modified Puls, storage-indication) routing with:

- (a) a stage–storage relationship from the design grading or survey;
- (b) a stage–discharge relationship for every outlet (orifices, weirs, surplus weirs, pumps), including the minimum orifice and trash screen of Chapter 4; and
- (c) the tailwater boundary of Chapter 5, where the tailwater affects the outlet rating.

3.12.2 **Channel routing.** Routing through channels and drains shall use the Muskingum–Cunge method, or the Muskingum method with parameters K and X that are derived from channel geometry or calibration. For the Muskingum method, the routing interval Δt shall satisfy $2KX \le \Delta t \le 2K(1 - X)$.

3.12.3 **Incidental storage.** Storage behind road embankments, culverts or boundary walls that is not part of an approved facility shall not be counted in the design unless the authority is satisfied that it will be maintained for the design life.

3.12.4 **Dynamic-wave routing.** Dynamic-wave (full Saint-Venant) routing, in SWMM or HEC-RAS unsteady flow, shall be used where:

- (a) the outfall is under tidal, river or tank backwater (Chapter 5, Clause 3.10.4);
- (b) flow can reverse, or the network has loops or overflow links; or
- (c) the network surcharges in the design event and the hydraulic grade line sets the design.

3.12.5 **Tank cascades.** Tanks in a cascade shall each be routed by Clause 3.12.1, with the surplus weir and sluice ratings and the documented operating rule of Chapter 7. The starting water level in each tank shall be FTL unless continuous simulation (Clause 3.13) supports a lower level.

Commentary. Modified Puls routing for storage and Muskingum–Cunge for channels are the APWA requirements (KC Metro APWA 5600, 2011, §5602.8). APWA also excludes "incidental detention" behind embankments unless it will be maintained, which 3.12.3 adopts. CPHEEO's detention procedure uses the same three inputs as 3.12.1: an inflow hydrograph, a stage–storage curve and a stage–discharge curve (CPHEEO 2019, Part A §8.5.3). The Muskingum stability limits are standard (Chow, Maidment and Mays, 1988, §8.4). This Manual starts ponds and reservoirs at their full or outlet level in 3.12.5 because Arunachal Pradesh's heavy rain falls on waterbodies that are already full, or held up for power, not drawn down for drainage. The Manual's monsoon season runs from 1 April to 31 October. At Doimukh the monthly means rise steeply from April: 227.7 mm in April, 505.9 mm in May, 762.8 mm in June, 638.9 mm in July, 484.5 mm in August, 449.9 mm in September and 206.5 mm in October, and the months of March to May bring 846.5 mm, 24.0% of the year's 3,531.8 mm (NERIST series, as given by Dabral et al., 2016), so the ponds and swamps of the valley floors are full well before the largest storms. Those come from April to October: the IMD 24-hour records are 234.4 mm in the pre-monsoon season (29 May 1948), 476.7 mm in the monsoon (22 August 1988) and 652.2 mm in October (5 October 1988, a value this Manual flags for IMD's confirmation under Clause 2.3.6(h)) at Pasighat; 338.4 mm (2 July 1974) and 222.0 mm (4 October 1979) at Tezu; and 278.5 mm in April (24 April 1980) and 280.0 mm in October (3 October 1979) at Hayuliang (IMD *Extremes*). The starting levels are as follows.

- **Reservoirs of the Pare, Ranganadi and Kameng projects (NEEPCO) and the Lower Subansiri project (NHPC).** No full, maximum or minimum drawdown level, and no datum, was found for any of them [TBC]. NEEPCO issues monsoon advisories on releases through the radial gates of the Pare dam, which passed a reported peak of 1,310 m³/s on 31 May 2025 (as reported); the Ranganadi project diverts the river through a tunnel to the Dikrong, with a tailrace discharge of 160 m³/s (a 1994 CWPRS study, as reported), and released 1,412.57 m³/s into the lower Ranganadi on 9 July 2017 (as summarised in the Assam edition of this series); the first unit of the Lower Subansiri project entered commercial operation on 23 December 2025 (as reported); and no release or flood data were found for the Bichom and Tenga dams of the Kameng project [TBC]. Until the operator states the full and maximum water levels and their datum in writing, a reservoir shall be started at the full level the operator states or, failing that, at its spillway crest from the as-built drawings, recorded in the submittal with that label (set by this Manual), and an outfall below that level is treated as closed for the duration of Clause 5.8.5(d). The operators' release protocols and warning thresholds were not found [TBC].
- **Ponds and swamps.** No pond in an Arunachal Pradesh town was found with a published outlet level, operating rule or level record [TBC]. The capital's drains "end up mostly into the Nallah and in some cases, into local ponds or open fields", and its sewage is drained "to open or vacant land as well as into ponds" (Master Plan of Itanagar Capital Region-2031, report). A pond shall be started at its surveyed spill or outlet level, and, where its outfall is backed up by a river or a nallah, full to that outlet for the whole storm (Clause 5.8.5(g)); the small rain-fed and spring-fed ponds of the hill towns are started full throughout the monsoon season.
- **Lakes.** Ganga Lake (Gyakar Sinyi), in the Itanagar Wildlife Sanctuary about 6 km from Itanagar, and Glaw Lake in Lohit district, reported as the State's first Ramsar site in August 2026 (both as reported), are natural lakes, not storage; no level or outlet data were found for either [TBC], and a site that drains to one starts it at its surveyed spill level.

A gated reservoir is modelled with its gate rule from its operator, and a waterbody is modelled below these levels only where a continuous simulation under Clause 3.13 or a notified operating rule supports it. The window of 1 April to 31 October in Clause 3.13.5(a) is set by this Manual and is the Manual's monsoon season. It starts on 1 April, not with the south-west monsoon, whose normal onset at Itanagar is 5 June (4 June before; IMD, 2020, as summarised), because Doimukh's April and May means already make up about a fifth of its year's rain (NEER sum), "The state receives rainfall over a period of 8 to 9 months excepting in winter" (State Action Plan on Climate Change, 2011), the east has large April storms, such as Hayuliang's 278.5 mm of 24 April 1980 and Tezu's April 2010 total of 1,087.9 mm (IMD *Extremes*), and the ponds, swamps and reservoirs fill on the pre-monsoon rain. It

> ends on 31 October because the monsoon's normal withdrawal from Itanagar is 14 October (IMD, 2020, as summarised) and October storms are real, such as those of 3–4 October 1979 at Hayuliang and Tezu (IMD *Extremes*). Pumps, gates and debris screens are on standby from 1 April to 31 October (Chapter 10).

3.13 Continuous simulation

3.13.1 **When required.** Continuous simulation shall be carried out, in addition to the design-storm analysis, for:

- (a) regional facilities draining more than 25 km²; and
- (b) any system that includes a tank cascade whose storage is counted in the design (Chapter 7).

The authority may also require it for any facility where the starting storage level governs the design.

3.13.2 **Rainfall input.**

- (a) The longest available hourly record from IMD or another approved recording gauge representative of the catchment shall be used.
- (b) Where hourly data are shorter than 30 years, the record shall be extended with the IMD 0.25° gridded daily data. The full gridded record (1901 to present) should be used; at least the most recent 30 years shall be. The daily data shall be disaggregated to hourly by a method stated in the submittal and checked against the hourly gauge for the overlapping years. Grid values shall be converted to point values under Clause 2.7.1 where applicable.
- (c) A future-climate run shall scale the record by the climate factors of Clause 2.8.

3.13.3 **Model content.** The model shall include soil-moisture accounting with evaporation (IMD pan evaporation or equivalent), groundwater or base flow, tank storage with operating rules and irrigation withdrawals, and the tailwater series of Chapter 5 (predicted tides plus a surge allowance for coastal outfalls).

3.13.4 **Use of results.** Annual maxima of water level, storage and volume, and the duration of outfall closure, shall be extracted and fitted by frequency analysis. Results shall be compared with the design-storm results. The more severe result at each AEP governs. Peak flows in drains and channels with a response time of less than one day shall be taken from the design-storm analysis where the continuous record was disaggregated from daily data, because the disaggregated hourly peaks are synthetic.

3.13.5 **Two-step approach.** The continuous simulation need not use the full hydraulic model. It may use a simplified hydrologic and storage model, at a daily or hourly step, that represents the soil moisture, groundwater, tank storage, operating rules and tailwater of 3.13.3. Its results shall then be passed to the design-storm runs of the full hydraulic model as:

- (a) the **starting level of each tank**, taken as the level exceeded on 10% of the days from 1 April to 31 October over the record; and
- (b) the **antecedent soil-moisture condition**, taken from the same days and compared with the AMC rule of Clause 3.8.

The designer shall show that the simplified model reproduces the water balance of the full model for at least one recorded event.

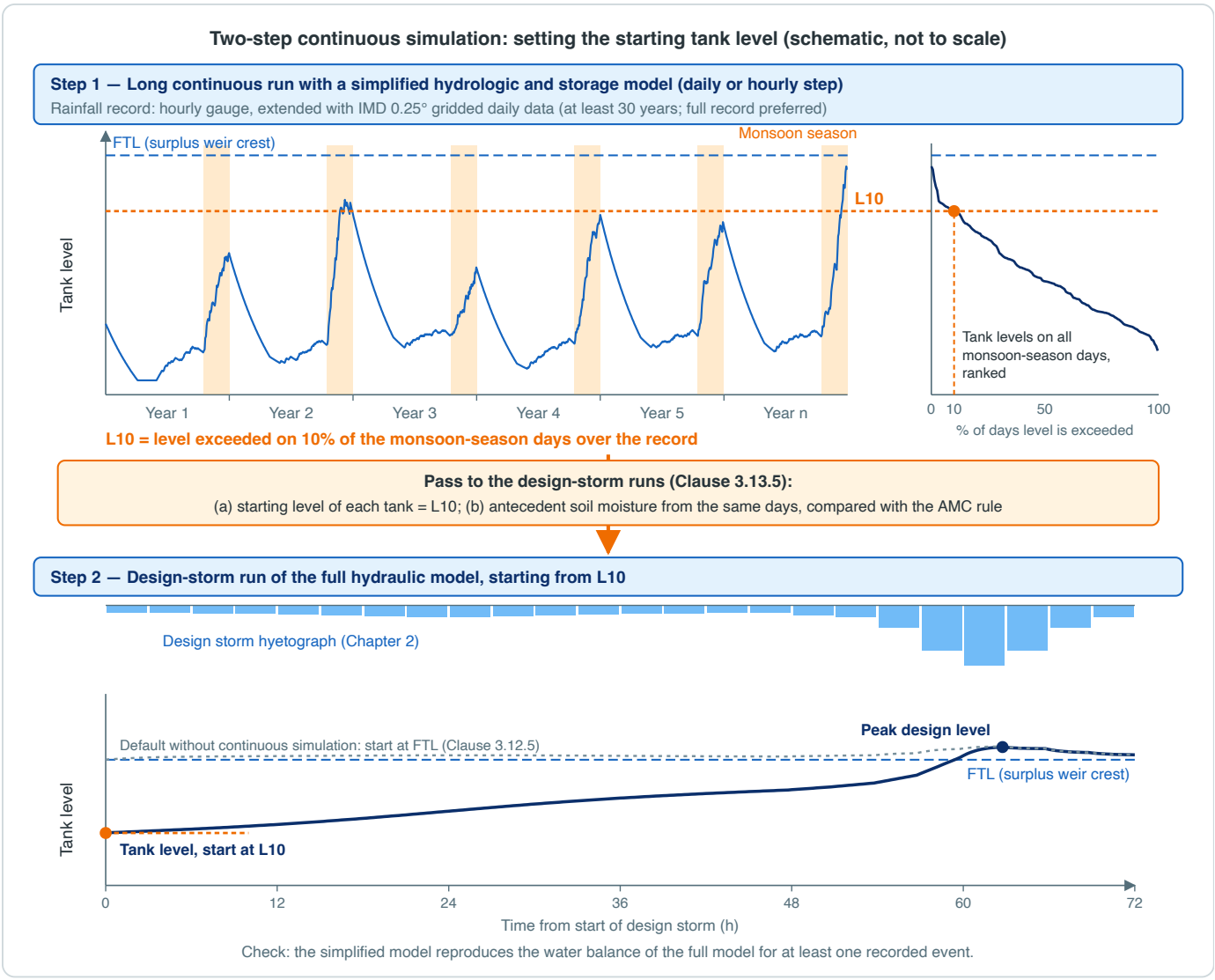

Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 April to 31 October (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in place of the default start at FTL of Clause 3.12.5. Schematic, not real data. Original drawing for this Manual, illustrating the two-step approach set by this Manual in Clause 3.13.5.

Commentary. Design storms assume one starting condition, but in a tank cascade the governing variable is how full the tanks are when the storm arrives, which depends on the weeks of rain before it. An Australian study of 20 real on-site detention systems found that designs based on one temporal pattern, or even an ensemble of ten, "cannot reliably produce an OSD system design that will always be effective" under real rainfall, and continuous simulation showed frequent-event peaks exceeding pre-development levels (Water Science and Engineering, 2019). The 30-year minimum in 3.13.2(b) matches the station IDF rule of Clause 2.3.2; a longer record is better, and the IMD gridded daily record, which starts in 1901, is the practical long series for Arunachal Pradesh. The record length matters less than what the simulation is for. Its main purpose here is to find how full the tanks and soils usually are when a monsoon season storm arrives, and how often heavy rain coincides with a closed outfall. A design storm cannot answer either question, because it starts from one assumed condition. It is not intended to replace design storms for the peak flow in urban drains. Clause 3.13.5 therefore allows the long run to be made with a simple storage model, which takes minutes, and passes the starting tank levels to the detailed hydraulic model, which is then run only for the design storms. Running a detailed 1D–2D city model continuously for decades is rarely practical and is not required. The 10% exceedance level in 3.13.5(a) is set by this Manual: it represents a wet but not exceptional monsoon, so that the design storm arrives on tanks that are already well

filled, as they were in late May and early June 2025, when the statewide floods and landslides followed the storms of the last days of May and the Pare dam passed a reported peak discharge of 1,310 m³/s on 31 May (as reported).

3.14 Pre- vs post-development comparison procedure

3.14.1 The comparison required by Clause 2.11 and Chapter 4 shall be carried out by the following steps. The results shall be recorded on Form 3-2.

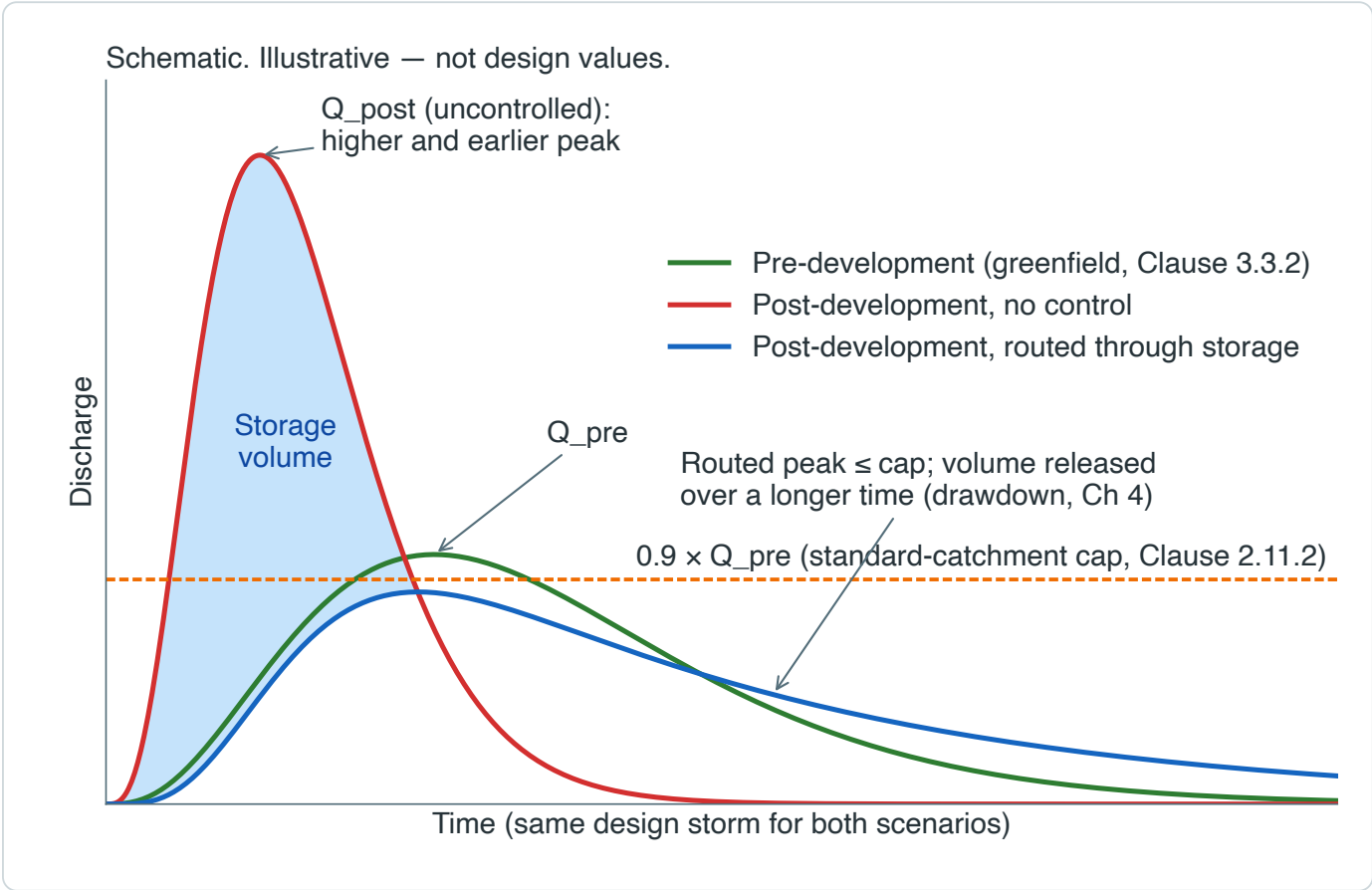

Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro APWA Section 5600, 2025.01. Schematic. Illustrative — not design values.

3.14.2 **Step 1 — Define the site, catchments and points of comparison.**

- (a) Delineate the site and every area that drains to it, from survey.
- (b) Identify each POC where runoff leaves the site. Each POC shall be tested separately. Runoff shall not be diverted from one natural catchment to another to meet the criterion.
- (c) Model off-site run-on identically in both runs, at its existing condition (Clause 3.3.5(b)). Where it passes through the site's storage, the criterion applies to the total outflow at the POC.

3.14.3 **Step 2 — Soils.** Map HSG (Clause 3.7), apply the high-water-table rule (Clause 3.10.1) and record the infiltration tests.

3.14.4 **Step 3 — Pre-development model.** Build the pre-development model per Clause 3.3.2: greenfield CN (Table 3.5), Tc (Clause 3.6, with n = 0.15), and existing waterbodies and channels. Compute CN at AMC II and AMC III.

3.14.5 **Step 4 — Post-development model.** Build the post-development model per Clause 3.3.3: measured impervious areas, connectivity (Clause 3.9), disturbed-soil HSG, CN, Tc, and the proposed retention, detention and outlets as storage (Clause 3.12.1).

3.14.6 **Step 5 — Design storms.** From Chapter 2, prepare for each required AEP (50%, 10% and 1%; 2-, 10- and 100-yr) and each duration in {1, 2, 3, 6, 12, 24, 48, 72 h}:

- the depth with the climate factor (Clause 2.8), ARF = 1.0 for the site (Clause 2.7.4);
- the hyetograph (Clause 2.9); and
- the AMC (Clause 2.11.4).

The same storms shall be used in both runs (Clause 2.11.1).

3.14.7 **Step 6 — Run the pre-development model** for every storm and tabulate $Q_{pre}(T, d)$. For flood-sensitive catchments, identify the largest 10% AEP pre-development peak over all durations; that value is the cap of Clause 2.11.3.

3.14.8 **Step 7 — Run the post-development model without controls** and tabulate $Q_{post}(T, d)$ and runoff volumes. This shows the size of the problem and is reported, not tested.

3.14.9 **Step 8 — Add retention and detention.**

- (a) Represent the retention volume of Chapter 4 as storage that is lost to infiltration or reuse (not released to the POC) within the period verified under Chapter 4.
- (b) Route the remaining hydrograph through the detention storage and outlets (Clause 3.12.1).
- (c) Apply the tailwater of Chapter 5, including the joint cases of Clause 2.12, where the outfall is tidal or under backwater.
- (d) Adjust storage and outlets until Step 9 is met.

3.14.10 **Step 9 — Test the criterion** at each POC, for every AEP and every duration:

- (a) standard catchments: $Q_{post}(T) \le 0.9 \times Q_{pre}(T)$ for the 50%, 10% and 1% AEP (Clause 2.11.2);
- (b) flood-sensitive catchments: Q_{post}(1% AEP) ≤ Q_{pre}(10% AEP), and Q_{post}(50% AEP) ≤ Q_{pre}(50% AEP) (Clause 2.11.3).

The governing duration for storage is the one that needs the largest storage or gives the highest water level; the 24, 48 and 72 h runs are always reported (Clause 2.5.2).

3.14.11 **Step 10 — Sensitivity runs.** Repeat Steps 6–9 for the governing storms with $I_a = 0.05S$ (Clause 3.8.5) and, where a lower peak rate factor is used, with the standard factor (Clause 3.11.5). Report the change in peaks and required storage.

3.14.12 **Step 11 — Associated checks.** Using the final routed model, check the drawdown times, minimum orifice and emergency spillway of Chapter 4, the outfall-closed storage check of Chapter 5, and the downstream analysis of Chapter 5.

3.14.13 **Step 12 — Document** the results on Forms 3-1 and 3-2 (Clause 3.17).

> Commentary. The step sequence follows the standard event-based workflow: delineate; set pre-development CN and Tc; set post-development CN and shorter Tc; run identical storms through a unit hydrograph or kinematic model; compare peaks and volumes; and size storage by modified Puls routing. It adds the Arunachal Pradesh elements: the 48–72 h storms, AMC III, and tailwater. Figure 3.5 shows why the long-duration runs matter: the

> routed peak can meet the cap while the storage holds the volume difference between the post- and pre-development hydrographs, which must then drain within the Chapter 4 limits. The ban on diverting runoff between catchments in 3.14.2(b) stops a site meeting the rule at one POC by moving flow to a neighbour's drain.

3.15 Model calibration and validation

3.15.1 **When required.** Calibration and validation are required for:

- (a) catchment models of 25 km² or more;
- (b) regional facilities and continuous simulation under Clause 3.13;
- (c) city or basin drainage master plans; and
- (d) any model whose parameters differ from the defaults of this chapter (for example a Clark transform or a lower peak rate factor).

3.15.2 **Data.** Calibration shall use observed rainfall (gauges, and radar where available) and observed flows or water levels (WRD gauging sites, IMC or APSDMA level sensors, tank gauges, or surveyed flood marks).

3.15.3 **Events.** At least three independent events shall be used for calibration and at least one further event for validation. At least one event shall be a long-duration monsoon or cyclone event (for example September 2018 (Modirijo and Donyi Polo, Itanagar), 23 June 2024 (Itanagar), July 2024 (Itanagar), late May–June 2025 (statewide, with the Pare release), 24 June 2025 or 2026 (Poosa, Yazali) or the 2017 monsoon (Itanagar), for which the only rainfall in the sources read for this Manual is press values and IMD bulletin snippets [TBC], where data exist).

3.15.4 **Performance.** The submittal shall report, for each event, the observed and modelled peak, volume and time to peak, and for continuous models the Nash–Sutcliffe efficiency (NSE) and percent bias. As a guide, a calibrated model should reproduce event peaks and volumes within ±25%, and a continuous model should achieve NSE ≥ 0.5 and percent bias within ±25%.

3.15.5 **Limits on calibration.** Calibration shall not be used to justify design flows lower than those given by the default methods of this chapter, unless site-specific factors are thoroughly examined and documented and the authority agrees.

3.15.6 **Reasonableness check.** Design peak flows shall be plotted as discharge per unit area against catchment area and compared with the CWC SUH results, regional gauged estimates and known historical floods.

> Commentary. Clauses 3.15.5 and 3.15.6 follow APWA, which states that "model calibration shall not be used to justify discharge estimates that are lower than those provided by the baseline unit hydrograph method" and requires unit discharges to be plotted against tributary area and compared with regression, gauge and historical values (KC Metro APWA 5600, 2011, §5602.9). The event-count and performance values in 3.15.3 and 3.15.4 are set by this Manual. The NSE ≥ 0.5 and ±25% bias thresholds are the "satisfactory" streamflow ratings of Moriasi et al. (2007), which were developed for monthly continuous simulation; their use for event peaks and volumes here is an extension.

3.16 Software acceptance

3.16.1 **Accepted software.** The following are accepted without further demonstration, in a version current at the time of submittal:

- (a) EPA Storm Water Management Model (SWMM 5.x);

- (b) USACE HEC-HMS and HEC-RAS;
- (c) USDA NRCS WinTR-55 and WinTR-20; and
- (d) spreadsheets for the Rational Method and single-area SCS-CN calculations, where every formula and input is shown.

3.16.2 **Other software.** Commercial packages built on the SWMM or HEC engines are accepted if the engine and version are stated. Any other method or software is accepted only if the designer reports, for every sub-area, the peak flow, lag, runoff volume and equivalent CN from both that method and a baseline method of 3.16.1, identifies every difference greater than 5%, and justifies every difference that gives a less conservative result.

3.16.3 **Benchmark problems.** The authority shall publish benchmark test problems (Annex 3C). Software not listed in 3.16.1 shall reproduce them within the stated tolerance.

3.16.4 **Model files.** Native model input and output files shall be submitted with every hydrograph-based design.

> Commentary. The 5% equivalence test is the APWA rule for alternative methods (KC Metro APWA 5600, 2011, §5602.2D). APWA names TR-55, TR-20, HEC-1 and HEC-HMS as baseline methods (§5602.2B). CPHEEO names SWMM for hydrograph and continuous modelling (CPHEEO 2019, Part A §4.4.2). Submitting native model files lets the authority rerun the model and is the main safeguard against unreviewable black-box results.

3.17 Documentation

Every hydrologic submittal shall include:

1. **Form 3-1, Hydrologic Calculation Summary**, stating the method used and why (Table 3.1), the software and version, and the computation interval.
2. **Catchment maps** for the pre- and post-development conditions, showing sub-areas, flow paths used for Tc, POCs, and off-site run-on.
3. **Soils:** the HSG map and its source and scale (Clause 3.7), water-table data (Clause 3.10), and infiltration test results.
4. **Parameter tables** for each sub-area and condition: area, impervious area by type and connectivity, HSG, CN at AMC II and III (or C and Cf), Tc worksheets, and n values.
5. **Rainfall:** the Design Rainfall Sheet (Form 2-1) and the hyetographs used.
6. **Results:** hydrograph tables and plots for each storm; stage–storage and stage–discharge tables; routed outflows; and peak water levels.
7. **Form 3-2, Pre- vs Post-Development Comparison**, with Q_pre, Q_post (uncontrolled and routed) and the criterion for each POC, AEP and duration, and the sensitivity runs of Clause 3.14.11.
8. **Calibration report**, where Clause 3.15 applies.
9. **Model files** (Clause 3.16.4).
10. **A statement by the responsible engineer** that the methods and parameters of this chapter have been used, with any departures listed and justified.

References (chapter)

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- *Arunachal Pradesh State Action Plan on Climate Change* (draft, July 2011; copy uploaded by the Ministry of Environment, Forest and Climate Change) (seasons; glaciers in the Kameng, Subansiri and Dibang basins).
- Department of Town Planning and ULBs, Government of Arunachal Pradesh. *Master Plan of Itanagar Capital Region-2031*, approved on 3 June 2022 (approval No. TP-ULB-21011/3/2021-Dir-TP-ULB (E-31358)), and its report, titled "Draft Master Plan Report for Itanagar Capital Region, GIS Based Master Plan under AMRUT Scheme" (drains, nallahs and ponds; the Pachin and Dikrong flood plains; hazards). https://arunachaltp.nic.in/sites/default/files/Report%20IMP2031.pdf (Internet Archive capture of 28 April 2025)
- SANDRP, "Overview of CWC's flood forecasting sites 2019: North East India" (2 October 2019), transcribing CWC's site tables (Passighat, Namsai, Yinkiang, Tezu, Daporizo, Yazali, Miao, Tuting, Kibithu, Lemeking; and the sites downstream in Assam). https://sandrp.in/2019/10/02/overview-of-cwcs-flood-forecasting-sites-2019-north-east-india/
- Reports on the Yigong outburst of June 2000, the Modirijo and Donyi Polo floods of September 2018, the Itanagar storms of June and July 2024, the floods of late May and June 2025, the Pare and Ranganadi releases and the Poosa / NEEPCO colony flood at Yazali (Down To Earth; EastMojo; Arunachal Times; Eastern Sentinel; NE Now; India Today NE; as reported).
- US EPA. Storm Water Management Model (SWMM 5). US Army Corps of Engineers, Hydrologic Engineering Center. HEC-HMS and HEC-RAS.

Annexes and forms

Annex / Form	Content
3A	Arunachal Pradesh soil series to HSG lookup; seasonal high water table map
3B	Arunachal Pradesh CN calibration and supplementary land covers (forest and scrub of the hills, valley and flood-plain fields, landslide scars, earth cuts and hill-road fills, boulder-bed streams and bhabar fans, snow and bare rock of the high ranges, and pond, swamp and reservoir beds)
3C	Benchmark test problems for software acceptance
3D	Peak rate factor study for flat coastal land
3E	CWC SUH parameters for subzones 2(a) and 2(b), with worked example
Form 3-1	Hydrologic Calculation Summary
Form 3-2	Pre- vs Post-Development Comparison

CHAPTER 4

Site Runoff Control: Retention and Detention

4.1 Purpose and scope

4.1.1 This chapter sets the performance standard that every regulated development shall meet for runoff leaving the site. It covers:

- (a) the order in which runoff-control measures are to be applied (Clause 4.3);
- (b) retention of frequent rainfall, and how retained volume is credited against detention (Clause 4.4);
- (c) release-rate criteria for standard and flood-sensitive catchments (Clause 4.5);
- (d) the procedure for sizing detention storage and outlets (Clauses 4.6 to 4.9);
- (e) facility types, rainwater harvesting (RWH) accounting, and high-groundwater sites (Clauses 4.10 to 4.12);
- (f) regional detention and fee-in-lieu (Clause 4.13);
- (g) simplified methods for small sites: the Tier B tables and the fixed-coefficient route (Clause 4.14); and
- (h) public safety (Clause 4.15).

4.1.2 This chapter applies to land disturbance of **0.1 ha or more**, or new or replaced impervious area of **500 m² or more**, as set in Chapter 1. Single dwellings below that threshold, and road resurfacing that adds no impervious area, are exempt. The existing RWH mandate of the building rules (the "complete proposal of rainwater harvesting" that every building on a plot of 100 m² must include in its plans for sanction under clause 9.1 and Annexure E of the Arunachal Pradesh Building Bye-Laws, 2019 (APBBL 2019), with the provisions of Table 9.1 by building type, ground water recharge for buildings on plots of 500 m² and more under clause 9.7, and the "complete utilization and capture of storm water" asked of public open spaces of more than 500 m² under clause 9.6; none sets a volume, and all are discussed in the Commentary to Clause 4.11) continues to apply to every building it covers, whether or not this chapter applies.

4.1.3 Rainfall inputs come from Chapter 2. Hydrologic methods come from Chapter 3. Tailwater, downstream analysis and the outfall-closed check come from Chapter 5. Water quality volume (WQv) treatment comes from Chapter 8. Where this chapter and those chapters overlap, the more stringent requirement governs.

> **Commentary.** No Indian national rule or Arunachal Pradesh rule found during research for this Manual limits the rate of discharge from a site, and none requires on-site detention or "zero run-off". No Arunachal Pradesh document found sets a design storm, a return period, a runoff coefficient or a time of concentration for any drain. The building rules are the Arunachal Pradesh Building Bye-Laws, 2019 (Department of Town Planning and ULBs, Government of Arunachal Pradesh) (APBBL 2019), which "shall extent to whole of Arunachal Pradesh with effect from the date of notification" (2.1) and are applicable "for a period of FIVE years after which they shall be reviewed. Till such time the reviewed building byelaws are notified, these building byelaws will continue to be in force" (2.2). Their "Authority" is "The Director/Chief Town Planner of Town Planning & Urban Local Body", "till an executing authority is notified" (def. 12). The "Gazette Notification" page of the copy read is blank, so the notification number, date and gazette reference were not found [TBC]; the bye-laws are named as the State's "Building bye-laws" by s.2(c) of the Arunachal Pradesh Fire and Emergency Services Act, 2026 (Act No. 12 of 2026), and the Online Building Permission System launched on 30 July 2025 is reported to be customised to them (as reported). An "Arunachal Pradesh Building Bye-Law 2010" is listed as notified on the Town Planning portal (as summarised) but was not read, and the hill-site clause of the 2009 "FINAL DRAFT" of the bye-laws ("location of landslide prone areas", "diversion of the natural flow of water coming from uphill side") is not in the 2019 text,

although the report of the ICR Master Plan 2031 reproduces it; it is not cited here as in force. The drainage provisions that can be found protect the building and the drain line, not the catchment. The site plan shows "Any existing physical features such as well, drains" (2.10.1(j)) and the "Distance from Nallah/Stream as per the notified rules/norms" and the "Distance from Disaster Prone Area as per norms set by Disaster Management Authority" (2.10.1(e) and (f)), but no such rules or norms were found (NEER reading); a certificate of supervision of drainage and sanitary works accompanies the notice (2.10.10); a retaining wall on a sloping side stands at least 0.60 m from the building (2.10.2(a)); the norms for hill towns are "only indicative" (3.2); the plinth is "so located with respect to the surrounding ground level that adequate drainage of the site is assured" and "not less than 300 mm" (4.2.1.1); "Under no circumstances shall effluent from a septic tank be allowed into an open channel drain or body of water without adequate treatment" (4.16.2(c)); "The Authority may require rain-water pipes to be connected to a drain or sewer" (4.19.1.1); earth cutting needs a permission valid for six months, cuts are not more than 3 m high, a clear setback of 2.5 m is kept from the property line on the upper terrace, the owner clears debris "from site or drain to suitable/safer place", a retaining or breast wall follows "immediately", and "Earth cutting permission shall not be granted if the average slope of the topography is more than 30%. And the site will be declared as not fit for construction except for plantation", with a penalty of one lakh rupees for unapproved cutting and a recommendation to cancel the land allotment (4.39(4), (5), (8), (11) and (14)); every building on a plot of 100 m² includes "the complete proposal of rainwater harvesting" (9.1; Commentary to Clause 4.11); public open spaces of more than 500 m² "shall have arrangements for complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites" (9.6); and on sites of 5,000 m² of built-up area and more, "The inlet and outlet point of natural drain system should be maintained with adequate size of channel for ensuring unrestricted flow of water" and the unpaved area is not less than 20% of the recreational open space (Table 14.1). The bye-laws define a *Jhot* as "A strip of land permanently left open for drainage purposes" (def. 69), with no width, and include among natural hazard prone areas those flooded by "back flow in drains, inadequate drainage, etc. as identified through local surveys in the development plan of the area". They set no stream, spring or drain setback by number, no flood plinth above 300 mm and no runoff limit, and none of these provisions sets a design storm, a release rate, a detention volume or an overflow path. The site plan of 2.10.1, the roof-water connection of 4.19.1.1, the storage of storm water on large open spaces of 9.6 and the natural drains of Table 14.1 are the hooks for this chapter. The municipal Acts make drainage a duty of the local body: a Municipality "shall … construct and maintain drains and sewers, and provide a safe and sufficient outfall … for … proper discharge of storm-water and sewage … in such manner as may not cause any nuisance, whether by flooding" (Arunachal Pradesh Municipal Act, 2007, s.194), and public drains vest in it "Notwithstanding anything contained in any other law" (s.102); in Itanagar "the maintenance and cleaning of drains and drainage works" is an obligatory function of the Corporation (Arunachal Pradesh Municipal Corporation Act, 2019, s.60(a)), public drains and sewage disposal works vest in it (s.200), and no one may discharge "foul water into a drain provided for surface water" where separate drains exist (s.203). The Master Plan of Itanagar Capital Region-2031, approved on 3 June 2022 under s.24 of the Arunachal Pradesh Urban and Country Planning Act, 2007, finds that "no scheme or work for storm water drains is under execution", that the drains are "not engineered", and that "Most of the surface water and sewerage gets mixed up resulting in storm water drains being used as sewers"; it proposes a new drainage network for Itanagar and Naharlagun designed on "topography of the region and flow gradient" (Maps 28–30), with no design storm, return period or runoff coefficient (report, titled "Draft"; whether the approved text differs was not checked [TBC]). A "GIS based Integrated Drainage Master Plan and DPR for Itanagar Capital City" was put out for expressions of interest in October 2017 (65 km², horizon year 2038; no return period stated), and a drainage plan by a consultant was reviewed by the Chief Minister in June 2021 (as reported); its adoption was not found. No master plan or drainage plan for Pasighat was found [TBC]. No highest flood level published by a local authority exists for any town [TBC], and the bye-laws' plinth is 300 mm; this Manual supplies the method (surveyed flood marks, the CWC levels where a site exists, or the modelled 1% AEP level, Chapter 5). There is no Sixth Schedule area in the State, and Article 371H does not protect land (as quoted); but customary rights are recognised in the Arunachal Pradesh (Land Settlement and Records) Act, 2000, much land near the towns is held by communities, clans and individuals, and the beds of streams and nallahs are Government property only where they are "not the property of any person or community" (s.9(1)). So this chapter applies as a condition of building

permission and layout approval wherever the bye-laws apply, which is the whole State (2.1); for a household or a community building on its own land without a permission it is guidance, and its small-site method (Clause 4.14) and the hill rule of Clause 4.11 are offered as such (Chapter 1).

The State's planning law is being rewritten around storage. The Arunachal Pradesh Urban and Country Planning (Amendment) Ordinance, 2025 (Ordinance No. 5 of 2025) defines a "sponge city" as "an area that acts like a sponge, soaking up and retaining water during rain and storms and releasing it slowly", and lets the Government "prepare policy documents for … Sponge City … Risk Informed master Plan" (new s.71(2)(za)); it also lets a Town Planning Scheme provide for "the filling-up or reclamation of low-lying, swampy or unhealthy area, or levelling-up of land". An amending Bill was reported passed by the Legislative Assembly on 9 March 2026 (as reported); its Act number and final text were not found [TBC], so none of these provisions is cited here as enacted law. This Manual's storage-first rules, on-site detention under this chapter, ponds and low land kept as storage, and release at pre-development rates (Chapters 4, 7 and 11), are an engineering form of that definition, and the Manual could be offered as technical input to such a policy document; it is not one, and no policy document under s.71(2)(za) was found. Storage matters here for three reasons: (i) the capital's outfalls back up when the Dikrong carries the releases of the Pare dam, so that water sent faster from the colonies fills the nallahs of Naharlagun, Nirjuli and Doimukh sooner when the river is high; (ii) the outfalls of Pasighat and Tezu back up from the Siang and the Lohit, whose stage is set upstream; and (iii) water sent downstream faster reaches the Assam reaches below the State, on the Ranganadi and the Subansiri below the projects, where the Assam edition governs. Where a Town Planning Scheme fills or reclaims low-lying or swampy land, the compensatory storage of Clause 7.6.4 (Chapter 7) applies to it.

No design basis is in use. The State Action Plan on Climate Change (draft, 2011) budgets "Storm water draining in twenty six urban settlements" at Rs 15,000.0 million with no design criteria; a storm-water drainage project for Itanagar had its foundation stone laid in June 2018 (as reported) and IMC is reported to have sought funds for a 64 km integrated drainage system (as reported), with no design basis seen; Smart City storm-water works in Itanagar and Pasighat are reported, with "improperly constructed drainage systems" noted at Pasighat (as reported), but their DPRs were not read [TBC]; and the bye-laws refer to Part 9 of the National Building Code 2005 for plumbing and drainage (4.19.1.3, 4.33.1), which does not size storm drains for a catchment (NEER reading). The illustrative example of Clause 4.6.7 and Annex 4C, set at a hillside colony in Itanagar draining to the Senki, uses invented 24-hour depths of 110, 200 and 350 mm for the 2-, 10- and 100-yr storms; they are not design values. In the capital region the design depths are those of Clause 2.3.6(c)(ii), 205 mm at 10% AEP and 290 mm at 1% AEP before the climate factor of Clause 2.8 (319 mm with it), so the example's 350 mm lies above the design value and below NIH-DHAARA's 528 mm for the Itanagar cell, which this Manual does not use for design (Clause 2.3.6(m)).

Basements are regulated only against surface water: "Adequate arrangements shall be made such that surface drainage does not enter the basement", and "The walls and floors of the basement shall be watertight" (APBBL 2019, 4.10.4(d) and (e)); no basement rule on flood levels was found. This Manual therefore adds its own requirements for every basement: no detention storage in a habitable basement (Clause 4.10.1); the crest of every basement ramp and the sill of every basement opening at least 0.5 m above the 1% AEP flood level, with basement drainage pumped to the surface drain through a non-return valve (Clauses 6.11.1 and 6.11.4); and no basement in Zone 2 (Clause 7.5.2). In the flood-sensitive catchments of Clause 4.5.3.2, in any catchment notified under Clause 4.5.4, and on the valley-floor, flood-plain and pond-margin land of Clause 4.12.1, it recommends that no basement be permitted where the 1% AEP flood level stands above the surrounding ground; where one is permitted on a valley floor it is watertight, as the bye-laws already require, and checked for flotation with the design groundwater level at ground level (Clause 4.12.3); and wherever a basement or lower floor is cut into a slope, it shall carry the geotechnical certificate of the hill rule of Clause 4.11, with the water behind its walls drained to a lined drain and not to the ground (all set by this Manual). For a sloping site, this chapter also supplies what clause 4.39 of the bye-laws leaves open: runoff from the catchment above the site and above every cut shall be intercepted and carried round the building in the design storms of Chapter 6, and every flow from the site shall discharge to a lined drain or a stable natural channel through an energy dissipator, never onto an unprotected slope, a cut face or fill; where the ground falls steeply, the drain is stepped. These are the Manual's proposals, not

rules of the APBBL 2019. This chapter is written so that it can supply, as a technical companion to the APBBL 2019 and to their five-year review (2.2), to the municipal Acts, to the ICR Master Plan 2031 and its proposed drainage network, and to the public works of the State's departments, the design storm, release rates and storage volumes that they leave open, and so that the Manual's corridor can be offered as the "norms" that 2.10.1(e) refers to; a competent authority could adopt it for those purposes, but none has. In practice the storm drains of the towns carry sewage: "City sewerage is discharged into open drains. The hilly terrain means limited scope for u/g sewer network" (report); "no ULB is treating sewage. Even the state capital, Itanagar-Naharlagun, lacks a sewage treatment facility" (observations quoted in the State's affidavit in NGT OA 606/2018, 2025); and the Senki at Chandranagar, upstream of the Pachin, is listed among polluted river stretches (CPCB, 2025) (Clause 8.9). Retention and detention apply in full on every site whatever the drain carries: every litre a site releases at the peak of a storm takes up capacity in a drain that is already part-filled with sewage. The CPHEEO (2019) manual describes limiting outflow to the pre-development peak as typical practice, but it uses no "shall" and names no storm frequencies (CPHEEO Part A §8.5.1). This chapter turns that description into a development-control requirement.

4.2 Definitions

Term	Meaning in this Manual
Retention	Permanent removal of runoff from the surface drainage system by infiltration, evapotranspiration or reuse, so that the water never reaches the outfall.
Retention depth	The 90th percentile wet-day 24-hour rainfall depth for the site's zone (Clause 2.10, Annex 2E).
Required retention volume (RRV)	The runoff volume from the retention depth over the post-development site (Clause 4.4.2).
Detention	Temporary storage of runoff, released through a controlled outlet at a rate set by Clause 4.5.
Retention credit	The reduction in required detention storage that results from retention practices, determined by routing under Clause 4.4.6. It is **not** the same as the retained volume.
Permissible site discharge (PSD)	The maximum rate at which a site may discharge for a stated AEP, in L/s or L/s/ha.
Site storage requirement (SSR)	The detention storage required per hectare of site under the simplified method of Clause 4.14.
Multi-stage outlet	An outlet structure with separate openings at different levels, each controlling a different AEP (Figure 4.2).
Drawdown time	Time from the peak stored volume until the stated fraction of that volume has been released.
Emergency spillway	A secondary overflow that passes flows above the primary outlet capacity, or all flow when the primary outlet is blocked, without overtopping the embankment.
Freeboard	Vertical distance between the maximum design water level and the embankment crest or other critical level.
Flood-sensitive catchment	A catchment listed in Clause 4.5.3 or notified under Clause 4.5.4.

Term	Meaning in this Manual
Authority	The approving authority under Chapter 1 (the competent authority for the area: in the area of the Itanagar Municipal Corporation (IMC), the Corporation for its own drains and connections (ss.60, 200 and 203 of the Arunachal Pradesh Municipal Corporation Act, 2019) and the Authority under the APBBL 2019 (the Director/Chief Town Planner, or the executing authority once notified, with its Building Permission Committee) for the building permit and the earth-cutting permission (4.39); in the Pasighat municipal area, the Pasighat Municipal Council for its drains (ss.102, 194 and 196 of the Arunachal Pradesh Municipal Act, 2007) and for building sanction (ss.340–343, through its Municipal Building Committee); in a Local Planning Area, the Local Planning Authority (the Itanagar Planning Authority in the Itanagar Capital Region) for layouts and the master plan under the Arunachal Pradesh Urban and Country Planning Act, 2007; elsewhere, the Authority under the APBBL 2019; for a public work, the department or agency that executes it (Urban Affairs, PWD, PWD (Highways), WRD, PHED or a Smart City company); WRD for any work in or on a river; and on community or clan land, the owners or the community by agreement, for whom this Manual is guidance unless a permission or plan carries it, as applicable).
Tier A / Tier B	Adoption tiers defined in Chapter 1. Tier A: the Itanagar Municipal Corporation (IMC), and every approving authority within the area of the Master Plan of Itanagar Capital Region-2031 (Itanagar, Naharlagun, Nirjuli, Doimukh and Banderdewa), that is, the Itanagar Planning Authority for layouts and the Authority under the APBBL 2019 for building permits, whichever has jurisdiction over a site. Tier B: urban local bodies, Local Planning Authorities and other authorities under the bye-laws.

4.3 Order of measures

4.3.1 Every site runoff-control design shall apply measures in the following order, and shall document in the submittal why each earlier step could not do more:

1. **Preserve.** Keep existing waterbodies, ponds, natural drainage lines, wetlands, and permeable soils and vegetation. Avoid fill in flood storage (Chapter 7).
2. **Retain.** Retain the RRV on site by infiltration, reuse or evapotranspiration (Clause 4.4).
3. **Detain.** Detain the remaining runoff so that the release-rate criteria of Clause 4.5 are met for every design storm and duration (Clauses 4.6 to 4.9).
4. **Convey.** Convey the 1% AEP (100-yr) flow safely through the site to the receiving system on a defined overland path (Chapter 6), and check the receiving system downstream (Chapter 5).

4.3.2 Preservation and retention reduce the detention required (Clauses 4.4.6 and 4.4.7). They do not relieve the site of the release-rate criteria of Clause 4.5 or of the downstream analysis of Chapter 5.

> **Commentary.** This order follows the "layers of stormwater management" adopted in the Kansas City Metro APWA Section 5600 Version 2025.01: preserve or restore, retain, detain, convey, maintain (MARC factsheet; MARC Supplement, Nov 2025). Maintenance is the fifth layer and is set in Chapter 10. The 2025.01 manual credits retention and natural-area preservation against detention size (MARC Supplement, Nov 2025). Clause 4.4.6 adopts that credit, and defines it so that it cannot be claimed twice.

4.4 Retention

4.4.1 Requirement

The site shall retain the RRV. Retention shall be achieved by one or more of the following:

- infiltration practices (soakaways, infiltration trenches, permeable pavement with an infiltration base, bioretention);
- rainwater reuse that is drawn down by a demonstrated non-potable demand;

- green roofs and landscape areas that do not drain to the outfall in the retention-depth storm.

The limits of Clause 4.4.4 apply.

4.4.2 Computation of the RRV

> RRV (m³) = 10 × Q_R × A

where:

- Q_R (mm) is the runoff depth from the retention depth P_R (Annex 2E). It is computed with the SCS-CN method for the post-development cover of each sub-area, at AMC II, with Ia = 0.2S (Chapter 3); and
- A (ha) is the area of the site that drains to the outfall.

Q_R shall be computed for each sub-area separately and summed. An area-weighted CN shall not be used where impervious and pervious areas differ by more than 20 CN points.

The volumetric method RRV = 10 × P_R × Rv × A, with Rv = 0.05 + 0.009 × I (I = percent impervious), may be used for sites under 0.5 ha and under the Tier B method.

> Commentary. The Rv formula is the one used in the KC water quality volume (MARC BMP Manual 2012). It is simple to review for small sites. The SCS-CN form is required for larger sites so that the retention computation uses the same runoff model as the detention routing. That keeps the credit computation of Clause 4.4.6 consistent.

4.4.3 Verification

Retention by infiltration shall be supported by:

- (a) site infiltration tests at the location and depth of each practice, at the frequency set in Chapter 8;
- (b) a design infiltration rate of no more than **half** of the measured rate; and
- (c) groundwater evidence showing the seasonal high groundwater table at least **1.0 m** below the base of the practice (Chapter 8).

Retention by reuse shall be supported by a demand calculation showing that the RRV is drawn down within 72 hours by a continuous non-potable use, such as toilet flushing, cooling or irrigation.

> Commentary. The factor of 2 on measured infiltration rate has no direct precedent; this Manual sets it to allow for clogging and for the difference between a test pit and a full-scale practice. Chapter 8 may set a different factor; if it does, Chapter 8 governs.

4.4.4 Limits on retention

4.4.4.1 Infiltration practices shall not be used:

- where the seasonal high groundwater table is less than 1.0 m below the base (Chapter 8);
- on contaminated land;
- within the setbacks from foundations, wells and septic systems set in Chapter 8; or
- on fill, unless tested after placement.

4.4.4.2 Where the RRV cannot be fully retained, the shortfall shall be stated in the submittal. The shortfall shall be treated as WQv under Chapter 8 and shall get no retention credit.

4.4.5 Drawdown of retention

Retention storage shall be emptied by infiltration or reuse within **72 hours** of the end of the retention-depth storm, verified by the tests of Clause 4.4.3.

4.4.6 Retention credit: definition and computation

4.4.6.1 **What the credit is.** The retention credit is the reduction in required detention storage that results when the retention practices are included in the post-development routing. It is computed. It is not assumed equal to the RRV.

4.4.6.2 **Tier A method (routing).** For each design storm and duration of Clause 4.6.3:

- (a) model each retention practice explicitly as a storage that is **empty at the start of the storm**, unless Clause 4.11 says otherwise;
- (b) let the practice fill from the front of the storm, and let it lose water during the storm only at the design infiltration or reuse rate of Clause 4.4.3;
- (c) once it is full, route its overflow to the detention facility; and
- (d) size the detention for the residual hydrograph.

The required detention storage is the largest storage over all storms and durations. The credit is the difference between that storage and the storage required with no retention. No further deduction shall be made.

4.4.6.3 **Tier B method (simplified).** The detention storage required by Clause 4.14 may be reduced by:

> $V_{credit} = C_R \times RRV_{provided}$

where C_R is the retention credit factor from Annex 4B for the zone, soil group and drawdown rate. Until Annex 4B is published, **$C_R = 0$**.

4.4.6.4 Retention that is not verified under Clause 4.4.3 gets no credit.

> **Commentary.** "Credited against detention" (APWA 5600 2025.01) can be read in two ways. One reading subtracts the retained volume from the detention volume, cubic metre for cubic metre. The other routes the storms with retention in place and sees what detention is still needed. The two readings give very different answers in Arunachal Pradesh, because the mandatory 48- and 72-hour storms (Clause 2.5.2) fill any retention practice on the first day, long before the peak arrives on the last day (Clause 2.9.2). Unless the practice keeps infiltrating during the storm, it is full at the peak and does nothing to reduce the peak storage.
>
> The illustrative example in Clause 4.6.7 shows the size of the effect. A 2 ha site with 552 m³ of retention (no infiltration during the storm) needs 138 m³ less detention for the 24-hour storm. That is a credit of about a quarter of the retained volume. For the 48- and 72-hour storms, which govern, the credit is close to zero. Subtracting the retained volume directly would have under-sized the detention by about 545 m³ (about 19%).
>
> This Manual therefore defines the credit as the result of routing. Retention on fast-draining sandy soils, which keeps infiltrating through a multi-day storm, will earn a real credit. Retention that only fills will earn little. Both outcomes are physically correct. Setting $C_R = 0$ until Annex 4B exists is a safe default for Tier B, not a judgement that retention has no value: retention is still required for water quality and recharge (Chapter 8).

4.4.7 Preservation credit

Areas of the site that are permanently preserved in natural cover may be modelled at their pre-development CN in the post-development condition, provided that:

- they are protected by a registered covenant or dedication; and
- their runoff is not concentrated onto impervious surfaces.

This lowers both the RRV and the detention required. No other preservation credit applies.

4.5 Release-rate criteria

4.5.1 General

4.5.1.1 Peak discharge from the site shall be computed by a hydrograph method (Chapter 3) for the pre-development and post-development conditions with identical design storms (Clause 2.11.1). The Rational Method shall not be used for any part of storage sizing.

4.5.1.2 Pre-development is greenfield: open land in good condition for the mapped HSG. Existing impervious cover is not counted (Clause 2.11.5, Chapter 3). This applies to redevelopment as well, subject only to the constrained-redevelopment route of Clause 4.5.6.

4.5.1.3 The criteria apply at each point where runoff leaves the site. Where a site drains to more than one outfall, the criteria apply to each outfall for the area draining to it. Runoff shall not be diverted between catchments.

4.5.2 Standard catchments

For each of the 50%, 10% and 1% AEP (2-, 10- and 100-yr) storms, and for every duration in {1, 2, 3, 6, 12, 24, 48, 72 h}:

> $Q_{post}(T, d) \le 0.9 \times Q_{pre}(T, d)$

4.5.3 Flood-sensitive catchments

4.5.3.1 In the catchments listed below, the **mixed-frequency rule** of Clause 2.11.3 applies, for every duration in Clause 2.5.2:

> Q_{post}(1% AEP, 100-yr) ≤ Q_{pre}(10% AEP, 10-yr), and Q_{post}(50% AEP, 2-yr) ≤ Q_{pre}(50% AEP, 2-yr).

Each cap is the pre-development peak at the duration that maximises it: the 10-yr peak for the 100-yr check, and the 2-yr peak for the 2-yr check. The cap applies to every post-development duration (Clause 2.11.3).

4.5.3.2 The flood-sensitive catchments are:

- (a) **The Senki through Itanagar**: the land of Itanagar that drains to the Senki, including the reach of the Senki View culvert washed away in September 2018 (as reported) and the stretch "Senki at Chandranagar, Itanagar (u/s of Pachin)" listed by CPCB in 2025, down to its confluence with the Pachin;

- (b) **The Pachin through Itanagar–Naharlagun**: the land that drains to the Pachin, with its flood plain, palaeochannels and swampy land, down to its confluence with the Dikrong near Nirjuli;
- (c) **The Dikrong at Naharlagun, Nirjuli and Doimukh, with Papu Nallah**: the land that drains to the Dikrong below the Pare dam and the outfall of the Ranganadi project's tailrace, including Papu Nallah and the other nallahs of Naharlagun, Nirjuli and Doimukh;
- (d) **The NH-415 corridor from Itanagar to Naharlagun**: the land that drains to and across NH-415, with Energy Park, Bank Tinali, Niti Vihar and Abo Tani Colony and the drains of the Bage Tinali–Naharlagun road (as reported);
- (e) **The Modirijo and Donyi Polo catchments**: the land of Itanagar and Naharlagun that drains through Modirijo and Donyi Polo, flooded in September 2018 (as reported);
- (f) **Pasighat on the Siang**: the land of Pasighat that drains to the Siang and its side channels on the river's outburst reach, including Jarkong near the airfield, and the Mebo villages downstream, where erosion is reported (as reported);
- (g) **Tezu on the Lohit**: the land of Tezu that drains to the Lohit and its side channels;
- (h) **Namsai and Miao on the Noa-Dihing**: the land of Namsai and Miao that drains to the Noa-Dihing;
- (i) **Roing on the Dibang**: the land of Roing that drains to the Dibang and to the streams that cross its fan;
- (j) **The Ranganadi reach at Yazali**: the land at Yazali that drains to the Ranganadi and its side streams below the Ranganadi project, including the Poosa / NEEPCO colony flooded on 24 June 2025 or 2026 (the reports conflict; as reported);
- (k) **The glacial-lake and outburst reaches of Tawang and Dibang Valley**: the land of any settlement in Tawang or Dibang Valley district that lies on the path of a glacial lake listed as high-risk by NDMA (as reported), as found by the outburst screening of Clause 2.3.6(i); and
- (l) any catchment notified under Clause 4.5.4.

The boundaries shall be those mapped in Annex 4A.

4.5.4 Notification of further flood-sensitive catchments

4.5.4.1 The Authority may propose that a catchment be notified as flood-sensitive where one or more of the following is documented:

- (a) buildings or arterial roads flooded in an event of 1% AEP or more frequent, on at least two occasions in the previous 20 years;
- (b) receiving drains or channels with capacity below the 10% AEP flow under existing conditions;
- (c) an outfall that is backed up by the Dikrong carrying the releases of the Pare dam and the tailrace of the Ranganadi project, as the nallahs of Naharlagun, Nirjuli and Doimukh are, or by the Siang, the Lohit or the Noa-Dihing at Pasighat, Tezu or Namsai, or that discharges to a reservoir held near its full level or to a release reach below a dam, or that is buried or blocked by the boulders, slope debris and garbage of a hill stream or a nallah, for part of the monsoon season (Chapter 5);
- (d) loss of more than a quarter of the mapped tank and pond storage in the catchment since the earliest available survey; or
- (e) a basin master plan that relies on limiting site discharge.

4.5.4.2 The procedure shall be:

1. The Authority prepares a technical note with the catchment boundary in GIS form and the evidence for 4.5.4.1.
2. The State-level technical committee constituted under Chapter 1 reviews the note.
3. The draft notification and map are published for public comment for at least 60 days.
4. The Government notifies the catchment and the map is added to Annex 4A.
5. The rule applies to applications received **6 months** or more after notification. Applications received earlier are assessed under Clause 4.5.2.

4.5.4.3 A notified catchment may be de-notified only by the same procedure, and only after a basin study shows that the downstream system meets Chapter 5 with all development under Clause 4.5.2.

Commentary. The 0.9 factor is derived from the Denver (MHFD) analysis. In that analysis, ten basins each releasing 100% of the historic 100-yr peak still produced 106% of the historic peak at the outlet; releasing 90% at each gave 97% (UDFCD Full Spectrum Detention Release Rate Memorandum, 2012). The mixed-frequency rule has no direct precedent; the nearest is the Malaysian DID (2008) checklist, which required post-development 2-, 10-, 50- and 100-yr peaks below the pre-development 2-yr peak. The specific "100-yr post ≤ 10-yr pre" form appears in a New Berlin, Wisconsin planning discussion (not an adopted rule). The capital-region entries follow its rivers, nallahs and spine road. Itanagar's drains run to nallahs and to the Senki and the Pachin, and Naharlagun's to the Dikrong; the storm water drainage system "consists of natural drainage system (Nallah) and major drains", the drains are "not engineered … open drains or kutcha drains without any flow gradient", "There is no proper storm water network for the overall town area", "With only 3.7% storm drains along main roads, drainage was marked as a key area of focus", and "rivers like Pachin flowing through densely populated areas had become a waste disposal site" (Master Plan of Itanagar Capital Region-2031, report). In the floods of 2017 the "land protection wall of several nallahs and rivulets" was badly damaged and NH-415 was closed during flash floods, with traffic diverted via Papu Nallah and Jullang Road (report). About 14 September 2018 cloudburst floods in the Modirijo and Donyi Polo areas killed three people, with at least four missing (later reports give up to seven dead; the tolls conflict), damaged more than 90 houses, washed away the Senki View culvert and the Press Colony bridge, and were joined by a landslide from "the dumping area of NH 415" (as reported). On 23 June 2024, 40 mm in two hours ("As per IMD, the rainfall recorded today was 40 mm between 10:30 am and 12:30 pm", the secretary of the State Disaster Management Authority, who added that IMD "confirmed there was no incident of cloudburst") inundated at least 66 houses in Itanagar and Naharlagun, destroyed one house, damaged NH-415 between the two towns, flooded Energy Park and brought a landslide at Niti Vihar and damage in Abo Tani Colony (as reported); a reported "cloudburst" of about 28 July 2024 submerged NH-415 and flooded homes near Energy Park and Bank Tinali (as reported; its date and the June event's are not to be merged). The drains along the Bage Tinali–Naharlagun road are reported to be "too shallow and narrow" and clogged with earth-cutting debris, and an inspection recommended de-silting "upto the Dikrong river" (as reported). The Senki at Chandranagar, upstream of the Pachin, is one of four stretches in the State first listed as polluted by CPCB in 2025, at Priority V (BOD 3.2 mg/L) (CPCB, 2025); the Pachin itself is not listed. Below Doimukh the Dikrong carries the releases of the Pare dam, whose peak was reported as 1,310 m³/s on 31 May 2025, and the 1999 flood is the local benchmark from Jampa to Doimukh (as reported); the Ranganadi project's tailrace also enters it (as reported). No State gauge level for the Senki, the Pachin or the Dikrong was found, and there is no CWC site on them [TBC]. The Pasighat, Tezu and Namsai entries follow the main stems and their CWC sites: the Siang at Passighat, with a highest flood level of 157.54 m on 11 June 2000, 3.58 m above its danger level, from the Yigong outburst in Tibet; the Lohit at Tezu, highest level 192.14 m (16 July 1996); and the Noa-Dihing at Namsai (highest level 146.6 m, 31 August 1974) and at Miao (241.57 m, 9 July 2004) (CWC tables as transcribed by SANDRP); erosion is reported at Jarkong near the Pasighat airfield in 2024 and in the Mebo villages of Seram, Kongkul, Namsing, Gadum-I/II and Mer (as reported). The Roing entry follows the Dibang, on which there is no CWC site; its stretch at Roing is the third of the four CPCB stretches (BOD 3.6 mg/L) (CPCB, 2025). The Yazali entry follows the flash flood of 24 June at the Poosa / NEEPCO colony in Keyi Panyor, from a side stream of about 17 km² while "the main river stayed in its channel": 1 dead and 4 missing, and about 18 quarters or about 50 houses washed away, with 73 mm in 24 hours, mostly in three hours (as reported; Down To Earth places it in 2026 and EastMojo dates its photographs to 2025, and the years conflict); the CWC site on the Ranganadi at Yazali records a highest level of 623.1 m (14 June 2008) (as transcribed by SANDRP). The glacial-lake entry follows NDMA's 27 high-risk glacial lakes in the State, 6 of them in Tawang district and 16 in Dibang Valley, with Kurung Kumey, Shi Yomi and Anjaw holding the rest (as reported). Ziro, Daporijo, Aalo, Seppa, Bomdila, Khonsa, Changlang and Bhalukpong, and the NH-13 corridor between Bana and Seppa, where a landslide swept a vehicle off the road on 30 May 2025 and killed seven (as reported), are candidates for notification under Clause 4.5.4. The notification triggers in 4.5.4.1 have no direct precedent and are set by this Manual. The 6-month lead time follows the update rule of Clause 2.14.2. Clause 4.16 explains why releases below pre-development are needed at all.

4.5.5 Minimum outlet and short-duration 2-yr checks

4.5.5.1 Where the PSD for any AEP and duration is less than the discharge of a **50 mm** orifice (Clause 4.8.2) at the corresponding stage, the 50 mm orifice is deemed to comply for that AEP and duration.

4.5.5.2 Where meeting the 2-yr criterion at a duration of 3 hours or less would require a low-flow orifice so small that the drawdown requirement of Clause 4.7 cannot be met, the designer shall:

- size the low-flow orifice as the smallest opening that meets Clause 4.7; and
- report the resulting 2-yr exceedance for those durations.

The Authority may accept the design if the exceedance is below the discharge of the 50 mm orifice at the 2-yr stage, or if the downstream analysis of Chapter 5 shows no adverse effect.

> Commentary. Under AMC II, a greenfield site produces almost no runoff in a 1- or 2-hour, 2-yr storm, because most of the rain is lost to initial abstraction. A pre-development peak of a few litres per second, compared duration by duration, then forces a very small low-flow orifice. That orifice cannot release the 10-yr volume within 48 hours. Checked as if it were outside a flood-sensitive catchment, the illustrative example of Clause 4.6.7 would need a low-flow orifice of about 75 mm to match the 1-hour, 2-yr pre-development peak. 90% drawdown of the 10-yr volume would then take about 84 hours even with a clean orifice, against the 48-hour limit. The 170 mm orifice that meets drawdown with 50% blockage exceeds the 1-hour, 2-yr pre-development peak by about 11 L/s. Clause 4.5.5.2 resolves that conflict in favour of drawdown, because a basin that is still partly full when the next monsoon storm arrives fails in the event that matters more. KC APWA 5600 (2006) used a 75 mm (3 in) minimum orifice with trash racks. This Manual sets a 50 mm minimum (Clause 4.8.2).

4.5.6 Constrained redevelopment sites

4.5.6.1 **Eligibility.** The relief route of this clause is available only for **redevelopment** where all of the following hold:

- (a) the existing site is at least **60% impervious**, as surveyed before demolition;
- (b) the site is **1 ha or less**; and
- (c) the designer shows, in a Constraint Statement submitted with Form 4-1, that the greenfield criteria of Clauses 4.5.2 or 4.5.3 cannot be met on the site. The statement must show that every storage option of Clause 4.10 has been assessed: rooftop and podium storage, tanks under parking or landscape, permeable paving with sub-base storage, and landscape depressions. It must also give the storage each option can provide.

New development on undeveloped land is never eligible.

4.5.6.2 **Minimum on-site performance.** An eligible site shall provide all of the following on site:

- (a) the full retention volume (Clause 4.4) and the WQv treatment (Chapter 8), with no relief;
- (b) post-development peak discharge no more than **50% of the existing-condition peak** for the 50%, 10% and 1% AEP storms, at each duration of Clause 2.5.2. The existing condition is modelled under Clause 3.3.4; and
- (c) no increase in the 1% AEP water level at any building or road downstream (Chapter 5).

4.5.6.3 **Shortfall.** The shortfall is the detention storage required to meet the greenfield criteria (Clause 4.6) minus the storage provided on site under 4.5.6.2. The applicant shall pay for the shortfall as a fee-in-lieu at the unit rate of Clause 4.13.3. The fee shall be:

- (a) paid into the ring-fenced account of the basin in which the site lies;
- (b) spent only on regional detention or on restoring pond or tank flood storage identified in the basin stormwater master plan (Chapter 11); and

- (c) recorded in the public ledger of Clause 4.13.4, which shall show the volume owed and the volume delivered in each basin.

Where no basin master plan has yet been approved, the fee shall be held for up to **5 years**. If no plan is approved in that time, it shall be spent on restoring tank flood storage in the same basin, with WRD agreement.

4.5.6.4 **Flood-sensitive catchments.** In the catchments of Clause 4.5.3, the route is available under the same conditions. The Authority may, however, refuse it where the downstream analysis of Chapter 5 shows existing flooding of buildings in the 10% AEP event within the analysis extent.

> Commentary. Greenfield is the target for all redevelopment, because a dense city only reduces its runoff as it rebuilds. On small, fully built plots in areas such as the localities along NH-415 in Itanagar and Naharlagun that flood when the drains and nallahs block, among them Energy Park, Bank Tinali, Niti Vihar and Abo Tani Colony (as reported), there is often no space for the full greenfield storage. A rule that cannot be met invites variances and non-compliance, which help no one downstream. This clause follows the approach of the UK Non-statutory Technical Standards for Sustainable Drainage (Defra, 2015, S2–S3). For previously developed sites, those standards require peak runoff "as close as reasonably practicable to the greenfield runoff rate" and never above the pre-redevelopment rate. The fixed 50% minimum reduction has no direct precedent; this Manual sets it to give reviewers a clear number in place of a "reasonably practicable" judgement. The fee-in-lieu turns the shortfall into regional storage in the same basin, so the basin still receives greenfield-equivalent control in total. Retention and water quality get no relief, because they are small volumes that almost every site can hold.

4.6 Detention sizing procedure

4.6.1 Method

Detention shall be sized by hydrograph routing through the stage–storage–discharge relationship of the facility, by level-pool (Modified Puls) or an equivalent numerical method (SWMM, HEC-HMS). Fixed-ratio and Rational-based storage formulae shall not be used. The simplified methods of Clause 4.14 (the Tier B tables and the fixed-coefficient route) are the only exceptions.

4.6.2 Steps

1. Delineate the site and sub-areas. Map HSG and confirm by testing (Chapter 3).
2. Extract design rainfall for 50%, 10% and 1% AEP and every duration in Clause 2.5.2, with the climate factor (Chapter 2, Form 2-1).
3. Build design hyetographs: alternating block for ≤ 24 h; the "peak day last" pattern for 48 and 72 h (Clause 2.9).
4. Compute pre-development hydrographs (greenfield CN; AMC III for storms of every duration from 1 May to 15 October in sub-areas AR-A, AR-A1, AR-C and AR-C1, from 1 April to 31 October in AR-B, from 1 June to 15 October in AR-D and AR-E, and from 1 April to 31 October on land below the 1% AEP level of a river, stream or nallah, on the Pachin and Dikrong palaeochannels and swamps, on pond margins and where the seasonal high water table is within 2 m of ground, at all times in catchments draining to a reservoir, its backwater or a release reach below a dam (Pare, Ranganadi, Kameng, Lower Subansiri), and at other sites and times after a 5-day total of more than 53 mm, AMC II otherwise).
5. Compute the release caps for each AEP and duration under Clause 4.5.2 or 4.5.3.
6. Compute post-development hydrographs with the same storms and AMC, including retention practices (Clause 4.4.6).
7. Choose a trial facility geometry (stage–storage) and a multi-stage outlet (Clause 4.6.5).

8. Route every storm and duration. Use a time step of no more than **5 minutes**, and no more than Tc/3 of the post-development catchment.
9. Check every release against its cap, and check drawdown (Clause 4.7). Adjust the outlet and storage and repeat.
10. Check the tailwater condition of Clause 4.6.6 and the downstream analysis of Chapter 5.
11. Size the emergency spillway and set freeboard (Clause 4.9).
12. Report the governing storm for storage, for each outlet stage, and for the spillway (Clause 4.17).

4.6.3 Storms to be routed

Every facility shall be routed for the full matrix:

Table 4.1 — Design storms to be routed for detention sizing

AEP	Durations (h)	AMC
50% (2-yr)	1, 2, 3, 6, 12, 24, 48, 72	II for ≤ 6 h; III for ≥ 12 h
10% (10-yr)	1, 2, 3, 6, 12, 24, 48, 72	II for ≤ 6 h; III for ≥ 12 h
1% (100-yr)	1, 2, 3, 6, 12, 24, 48, 72	II for ≤ 6 h; III for ≥ 12 h

The 24-, 48- and 72-hour runs are mandatory whatever the critical-duration result (Clause 2.5.2). Where Ia = 0.05S sensitivity is required by Chapter 3, it shall be run for the governing storage case.

4.6.4 Initial conditions

Each run shall start with:

- detention storage empty, down to the invert of the lowest outlet;
- any permanent pool full;
- retention practices empty, except as limited by Clause 4.11; and
- RWH storage full (Clause 4.11).

The 48- and 72-hour storms already contain their antecedent rain, so no further pre-filling is applied.

4.6.5 Multi-stage outlet design

4.6.5.1 The outlet shall have a separate control for each criterion, normally stacked as in Figure 4.2:

- **Stage 1**, at the invert: the low-flow orifice. It releases the WQv over 24–48 h (Chapter 8) and controls the 2-yr release.
- **Stage 2**: an orifice or slot set at or near the maximum 2-yr level. It controls the 10-yr release.
- **Stage 3**: a weir, riser crest or larger orifice set at or near the maximum 10-yr level. It controls the 100-yr release.
- **Emergency spillway**: separate from the primary outlet (Clause 4.9).

Stages may be combined where routing shows that every cap is met.

4.6.5.2 Orifices shall be computed with a discharge coefficient of 0.60 unless a rated device is used. Weirs shall use a coefficient appropriate to their shape. Submerged-outlet and tailwater effects shall be included (Clause 4.6.6).

4.6.5.3 Vortex flow controls and other proprietary devices may be used where the supplier provides a certified head–discharge curve and the minimum clear opening is at least 50 mm.

4.6.6 Tailwater on the outlet

The outlet shall be routed against the tailwater of the receiving system, not free outfall, wherever the receiving water level can rise above the outlet invert. The tailwater shall be:

- for a receiving drain: its water level in the same storm, from the Chapter 5 analysis or, for Tier B, the drain obvert;
- for tidal or backwater-affected outfalls: the levels and joint cases of Clause 2.12 and Chapter 5, including the outfall-closed check (Clause 5.10).

Where tailwater governs, a flap gate shall be fitted to the outlet (Clause 5.11). The storage below the tailwater level shall not be counted as available unless the routing includes the gate closure.

4.6.7 Illustrative example

Illustrative — not design values. This example shows the procedure and the sizes it produces. The inputs are invented to be plausible for a hillside colony in Itanagar draining to the Senki. They are not NIH-DHAARA values and must not be used for design.

Inputs:

- Site: 2.0 ha, flood-sensitive catchment (Clause 4.5.3).
- Land cover: pre-development all pervious, CN 70. Post-development as two sub-areas (Clause 3.9.2): 1.57 ha of directly connected impervious surface at CN 98, never converted for AMC, and 0.43 ha of pervious open space at CN 70, on the same soil as pre-development; the area-weighted CN at AMC II is 92. For storms of 12 h and longer the pervious CN only is converted to AMC III: CN_III = 23·CN / (10 + 0.13·CN) = 84.3 (Clause 3.8.4).
- Time of concentration (Tc): 45 min pre-development, 15 min post-development (used for both sub-areas). SCS triangular unit hydrograph; 5-minute time step.
- 24-h depths: 110, 200 and 350 mm for 2-, 10- and 100-yr (the same 10- and 100-yr values as Clause 2.11).
- Shorter durations: P(t) = P24·(t/24)^0.40, an assumed ratio set and not Annex 2B.
- Longer durations: 48-h and 72-h depths taken as 1.25 and 1.40 × P24, laid out per Clause 2.9.2.
- Storage: vertical-walled, 2,500 m² plan area.
- Outlet, sized so that drawdown is met with the low-flow orifice 50% blocked (Clause 4.8.3). Annex 4C shows the trial outlet that failed this check.
    - Stage 1: 170 mm orifice at the invert.
    - Stage 2: 460 mm orifice with its invert 0.53 m above the floor.
    - Stage 3: none needed, because the 100-yr cap is met by Stages 1 and 2.

Results (discharges in L/s; storage in m³):

Table 4.2 — Illustrative example: peak discharges and storage used, by duration (Illustrative — not design values)

Duration (h)	2-yr pre	2-yr post, detained	10-yr pre	10-yr post, detained	100-yr post, uncontrolled	100-yr post, detained	100-yr storage used	10-yr drawdown, 50% blocked (h)
1	4	15	51	28	922	42	1,426	31.3
2	14	20	84	34	961	79	1,911	32.1
3	19	22	104	37	981	139	1,999	32.8
6	32	25	150	41	1,010	194	2,154	34.2
12	127	30	302	46	1,074	276	2,512	39.0
24	149	32	327	49	1,081	320	2,766	**45.3**

Duration (h)	2-yr pre	2-yr post, detained	10-yr pre	10-yr post, detained	100-yr post, uncontrolled	100-yr post, detained	100-yr storage used	10-yr drawdown, 50% blocked (h)
48	173	34	349	82	1,087	343	**2,913**	44.8
72	180	34	356	84	1,089	343	2,911	44.7

How to read it:

- **100-yr cap.** The cap is the largest pre-development 10-yr peak, 356 L/s (72 h). Every 100-yr detained peak is at or below it; the largest is 343 L/s.
- **2-yr cap.** The site is flood-sensitive, so the 2-yr cap is the largest pre-development 2-yr peak, 180 L/s (72 h; Clause 4.5.3.1). The largest 2-yr detained peak is 34 L/s. At 1, 2 and 3 hours the detained 2-yr peak is above the pre-development peak of the same duration (15 against 4 L/s, 20 against 14 L/s, and 22 against 19 L/s). That comparison is not required here. It would be for a site under Clause 4.5.2, and Clause 4.5.5.2 would then apply.
- **Governing storage.** Storage is governed by the **48- and 72-hour** storms: 2,913 m³, which is 0.146 m³ per m² of site, at a maximum depth of 1.17 m. A design that checked only the critical-duration peak storm (1–3 h here) would have provided about 2,000 m³, roughly two-thirds of what is needed.
- **Drawdown.** With the low-flow orifice 50% blocked (Clause 4.8.3), 90% of the 10-yr storage drains in at most 45.3 h (the 24-hour storm), within the 48 hours of Clause 4.7. A 120 mm orifice would drain it in about 42 h when clean but 54 to 75 h when half blocked, so it fails. Annex 4C shows that trial and the routing step by step.
- **Retention credit.** With an illustrative retention depth of 40 mm, RRV = 552 m³, computed for each sub-area (Clause 3.9.4). Modelled as filling from the start of the storm with no infiltration during it, the retention reduces the 24-hour storage by 138 m³ and the 48- and 72-hour storage by 7 m³ or less. The credit under Clause 4.4.6 is therefore effectively zero for this site.

The order of magnitude, about 0.15 m³ per m² of site, is consistent with the indication in Clause 2.11.

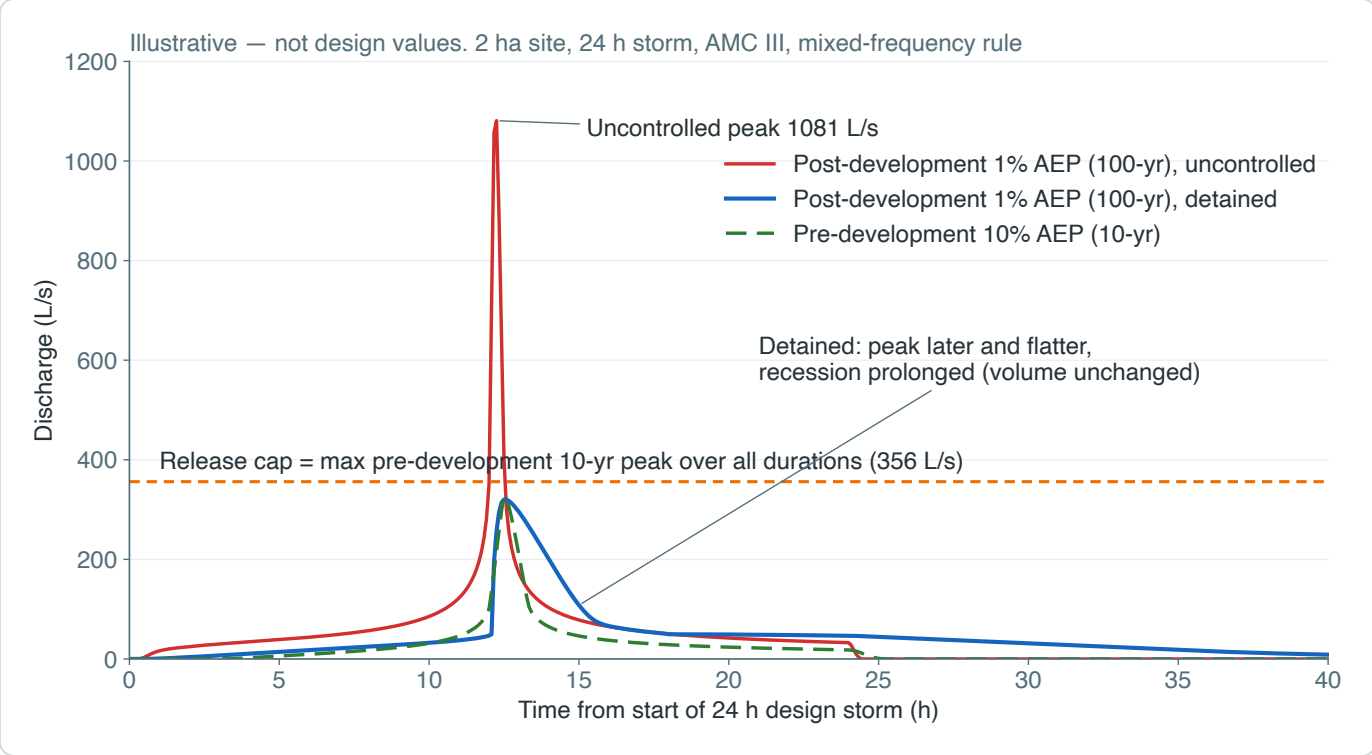


Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA Section 5600 and the Georgia Stormwater Management Manual (2016).

> Commentary. Figure 4.1 shows what detention does and does not do. It cuts and delays the peak. It does not reduce the volume: the area under the detained curve equals the area under the uncontrolled curve, more than twice the pre-development 10-yr volume. The extra volume leaves the site over many hours after the storm. That prolonged release can coincide with the peak of the larger catchment downstream (Clause 4.16), and it must still drain when the outfall is tide-locked (Chapter 5).

4.7 Drawdown

4.7.1 **Detention.** At least **90%** of the maximum volume stored in the 10% AEP (10-yr) storm of each duration shall be released within **48 hours** of the time of maximum storage, by gravity, with the tailwater of Clause 4.6.6.

4.7.2 **Water quality volume.** The WQv shall be released over not less than 24 hours and not more than 48 hours (Chapter 8).

4.7.3 **Retention.** Retention storage shall be emptied within 72 hours by infiltration or reuse (Clause 4.4.5).

4.7.4 **Tidal outfalls.** Where gravity drawdown is prevented by tide for part of each cycle, the 48-hour limit applies with the tidal tailwater modelled. Where it cannot be met by gravity, pumped drawdown shall be provided under Clause 5.12.

> Commentary. KC APWA 5600 (2006) required dry basins to release at least 80% of storage within 24 hours of the inflow peak and to empty within 72 hours. Singapore PUB requires detention to be restored within 4 hours. The 48-hour, 90% rule is longer than PUB's because Arunachal Pradesh storage must hold multi-day volumes. It is still short enough that a basin filled by one monsoon depression will have most of its volume back before the next, which in June 2024, when Itanagar had 40 mm in two hours on 23 June (IMD, as quoted by the State Disaster Management Authority) and 52.0 mm by 12:30 on 27 June (IMD special bulletin, as summarised), and late May and early June 2025, when the landslides of 30 May between Bana and Seppa were followed by statewide floods to 7 June (as reported), followed within days.

4.8 Outlet structures

4.8.1 **General.** Primary outlets shall be:

- unattended, with no moving parts, valves or pumps, except where Clause 5.12 permits pumped drawdown;
- accessible for inspection and cleaning from the surface without confined-space entry, where practicable; and
- built of durable materials. In coastal areas these shall be corrosion-resistant (Clause 4.12.5).

4.8.2 **Minimum orifice.** No control orifice shall be smaller than **50 mm** in diameter, or 50 mm in least dimension for a slot.

4.8.3 **Trash racks and screens.** Every orifice and weir shall be protected by a trash rack or screen. The rack shall:

- have a clear bar spacing no greater than half the smallest opening it protects, and not less than 25 mm;
- have a clear open area at least **10 times** the area of the opening it protects;
- be inclined, or set as a cage around the riser, so that debris rises with the water and does not pin against the bars;
- be removable or hinged for cleaning; and
- for routing, be assumed **50% blocked** at the low-flow orifice when checking drawdown.

4.8.4 **Anti-vortex devices.** Riser crests and orifices that may run under more than 1.5 times their diameter of head shall have an anti-vortex plate or hood (Figure 4.2).

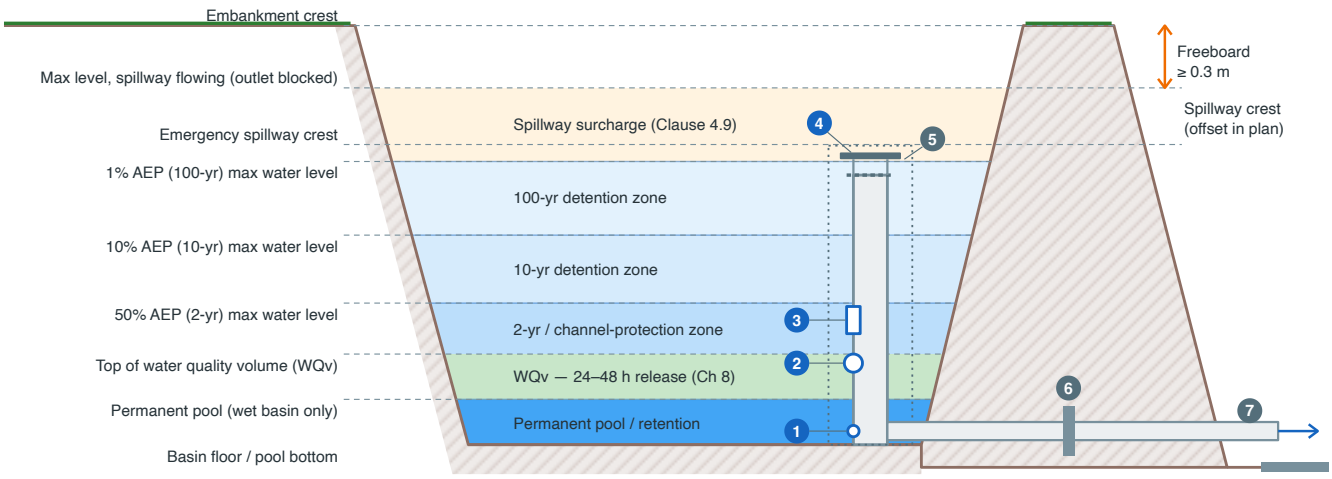
4.8.5 **Outlet barrels.** Outlet barrels through embankments shall:

- be at least 300 mm in diameter (Chapter 6);
- have watertight joints;
- have a filter diaphragm or seepage collars over the length within the embankment; and
- have an energy-dissipating outfall (Chapter 9).

4.8.6 **Isolation.** Facilities serving more than 1 ha shall have a means of isolating the outlet for maintenance, such as a stop-log slot or penstock. In normal service it shall be left fully open.

> **Commentary.** The 50 mm minimum is smaller than the 75 mm (3 in) of KC APWA 5600 (2006), so the trash-rack requirements are correspondingly stricter. The ratios in 4.8.3 (bar spacing at half the opening, open area 10 times the opening, 50% blockage for the drawdown check) have no direct precedent and are set by this Manual. The blockage factor matches the 50% grate clogging factor for sag inlets in Chapter 6. Indian urban drains carry heavy loads of solid waste, so a low-flow orifice without an effective rack will block within one season.

Storage stack and multi-stage outlet — schematic section, not to scale



Key

1 Stage 1 low-flow orifice (≥ 50 mm, Clause 4.8.2) — releases WQv over 24–48 h
2 Stage 1 second orifice — with 1, controls 50% AEP (2-yr) release
3 Stage 2 orifice or weir slot — controls 10% AEP (10-yr) release
4 Stage 3 riser crest / overflow grate with anti-vortex plate — controls 1% AEP (100-yr) release
5 Trash rack enclosing all openings (Clause 4.8.3)
6 Seepage collar or filter diaphragm on outlet barrel
7 Outlet barrel, energy dissipation and outfall apron
Levels and zone thicknesses are diagrammatic only.

Figure 4.2 — Detention storage stack (permanent pool, WQv, 2-yr, 10-yr and 100-yr zones, spillway surcharge and freeboard) and multi-stage riser outlet. Schematic, not to scale. Original drawing for this Manual, adapted from the multi-stage outlet and storage-zone concepts in MARC/KC APWA Section 5600 (2006, 2025.01) and the Mile High Flood District Urban Storm Drainage Criteria Manual, Volume 2 (full-spectrum detention).

4.9 Emergency spillway, freeboard and embankment safety

4.9.1 **Spillway capacity.** Every detention facility formed wholly or partly by an embankment, or whose overflow would reach buildings, shall have an emergency spillway that passes the **1% AEP (100-yr) peak inflow**:

- with the primary outlet assumed fully blocked;
- with the facility full to the spillway crest at the start of the storm; and
- with at least **0.3 m freeboard** from the maximum water level to the embankment crest.

4.9.2 **High-hazard facilities.** A facility is high-hazard if its failure or overflow could:

- endanger life;
- flood a habitable building or critical facility; or
- close an arterial road.

High-hazard facilities shall also be checked for the **0.2% AEP (500-yr)** peak inflow under the conditions of 4.9.1, with the embankment not overtopped.

4.9.3 **Spillway crest.** The spillway crest shall be at or above the 1% AEP maximum water level from routing with the primary outlet working. The recommended clearance is 0.15 m.

4.9.4 **Spillway location.** The spillway shall be:

- on natural ground or a reinforced section, not on fill, unless protected against erosion for the full design flow;
- discharging to the 1% AEP overland flow path of Chapter 6; and
- placed so that its flow does not reach a building.

4.9.5 **Underground and enclosed facilities.** Tanks, vaults and podium storage shall have an overflow route that operates when the outlet is blocked. The route shall carry the 1% AEP inflow to the overland path without surcharging any building, basement or lift pit.

4.9.6 **Embankments.**

- (a) Embankments more than **2 m** high (measured from the downstream toe to the crest) shall be designed by a qualified geotechnical engineer. The design shall include stability, seepage and settlement analysis.
- (b) Side slopes shall be no steeper than 3H:1V on any face that is mown or accessible to the public. Slopes shall be flatter where Clause 4.15 requires.
- (c) Embankments shall have:
  - a crest width of at least 3 m;
  - compacted, engineered fill with a core or cut-off where required by the seepage analysis; and
  - no trees or large shrubs.
- (d) An embankment structure that falls within the Dam Safety Act, 2021 is subject to that Act in addition to this Manual.

4.9.7 **Excavated facilities.** Facilities wholly below the surrounding ground, with no embankment, need not meet 4.9.6. They shall still meet 4.9.1, with the overflow route treated as the spillway.

> Commentary. The spillway criterion (1% inflow, outlet blocked, basin full, 0.3 m freeboard; 0.2% for high hazard) follows the KC APWA 5600 (2006) rule: the spillway passes the 1% storm with 1 ft (0.3 m) freeboard to the top of the dam, assuming zero storage and a clogged primary outlet, with the crest at least 0.5 ft (0.15 m) above the 1% maximum water surface. KC designed dams above 10 ft (3 m) to SCS TR-60 Class C. The 2 m embankment trigger, the 3H:1V slope (KC wet ponds), and the 3 m crest width have no direct precedent and are set by this Manual.

4.10 Facility types

4.10.1 **General.** Any storage that meets Clauses 4.5 to 4.9 may be used. Surface storage that is visible and can be inspected without confined-space entry is preferred. Storage shall not be placed in a habitable basement or in any space whose flooding would endanger life.

4.10.2 **Underground tanks and vaults.**

- (a) Gravity outlet is required where the receiving drain allows it. Pumped outlets are permitted only under Clause 5.12, with a registered maintenance declaration (Chapter 10).
- (b) Access openings shall be provided over the outlet chamber and over every inlet. In tanks over 500 m², they shall be no more than 30 m apart.
- (c) The floor shall fall at least 1% to a sump at the outlet, with a sediment pocket below the low-flow orifice invert.
- (d) The tank shall be ventilated.
- (e) Inlets shall pass through a silt trap or gross pollutant trap (Chapter 8).
- (f) Flotation and groundwater ingress shall be checked under Clause 4.12.

4.10.3 **Rooftop detention.**

- (a) It is permitted on flat roofs designed for the full ponded load with the outlet blocked. The ponding depth shall not exceed **150 mm** unless a structural engineer certifies a greater depth.
- (b) Each roof outlet shall have a flow-control ring or weir with a certified rating, and every roof area shall have at least one overflow scupper, independent of the controlled outlets, that passes the 1% AEP inflow.
- (c) Roofs used for RWH collection may also provide rooftop detention. The detained volume is released through the control, not into the RWH sump.

4.10.4 **Podium and landscape-deck detention.**

- (a) It is permitted above ground level or above a basement car park, provided the structure is designed for full saturation and ponding, and waterproofed.
- (b) The release, overflow and safety rules for rooftop detention (4.10.3) apply.

4.10.5 **Parking-lot detention.**

- (a) It is permitted only on surface parking. Ponding depth shall not exceed:
  - **200 mm** in the 10% AEP storm and **300 mm** in the 1% AEP storm at any parking bay;
  - zero on accessible routes, ramps and pedestrian crossings; and
  - zero in the 10% AEP storm on fire-tender access routes.
- (b) Signs shall warn that the area floods.
- (c) Ponding shall not reach a building wall unless the wall is waterproofed above the 1% level plus freeboard (Chapter 6).

4.10.6 **Multi-use detention (parks, playfields, open space reservation).**

- (a) Open space land may be used for detention, provided its primary use remains available in at least the 50% AEP storm.
- (b) The storage areas shall be graded to drain fully within the times of Clause 4.7.
- (c) A low-flow channel or underdrain shall carry dry-weather and frequent flows, so that the park is not waterlogged.
- (d) The depth and slope limits of Clause 4.15 apply.
- (e) Play equipment and seating shall be placed above the 10% AEP level.

4.10.7 **Ponds and wet basins.**

- (a) A permanent pool shall be at least 1.2 m deep over most of its area to discourage weed growth and mosquito breeding, with a vegetated safety bench at the edge (Clause 4.15).

- (b) Only storage above the permanent pool counts as detention.

Commentary.

- The rooftop depth (150 mm) and parking depths (200 and 300 mm) have no direct precedent. This Manual sets them so that a blocked outlet is noticed before it becomes dangerous.
- The 1.2 m pool depth equals the 4 ft minimum permanent pool of KC APWA 5600 (2006). This Manual adopts it mainly for weed and mosquito control.
- Pumped detention tanks need maintenance declarations in Singapore (PUB Addendum No. 3, April 2025). This Manual adopts the same approach through Chapter 10.
- Using open space for multi-use detention fits what the APBBL 2019 already ask of a site and of open land: public open spaces of more than 500 m² "shall have arrangements for complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites" (9.6); on large sites "The unpaved area shall be more than or equal to 20% of the recreational open spaces" (Table 14.1); and group housing avoids concrete paving, with "permeable materials … for all open parking spaces" (Table 9.1). None of these sets a volume or a release rate (NEER reading). On the tested terrace sands of the Naharlagun–Nirjuli–Doimukh valley and on the coarse bhabar fan heads, on flat ground outside the floodplain rule, a detention area graded into the open space below the level of the road keeps it pervious and usable, which is what 4.10.6 requires, and can also infiltrate under Clause 4.11 (recharge rule). Everywhere else the position is different. Below the 1% AEP flood level, on the Pachin and Dikrong palaeochannels and swamps and wherever the seasonal high water table is within 2 m of ground, a basin in the open space holds groundwater and backwater, not storm water, so detention there is in lined, watertight storage (Clause 4.11, floodplain rule). Ground on a natural slope of more than 10°, Siwalik shale, a terrace held up by a retaining wall, land within twice the height of a cut or wall downslope of it, colluvium, slope debris and fill, and mapped landslide ground are not to be used for ponding, because water held there soaks into the slope (Clause 4.11, hill rule); the bye-laws already refuse earth cutting where the average slope exceeds 30% and declare such a site "not fit for construction except for plantation" (APBBL 2019, 4.39(14)). On such sites, detention is provided in lined tanks, open or closed, with an orifice outlet and an overflow to a lined drain, on rooftops and podiums under 4.10.3 and 4.10.4, or on a level open space only where it stands on rock or on ground that the geotechnical certificate of the hill rule covers; an excavated pond or basin on a slope is not accepted, and paving there is laid on a lined or non-exfiltrating base with an underdrain. Three kinds of land are not open space for this purpose. A pond, lake or spring on the land is preserved under step 1 of Clause 4.3.1; a pond is modelled as a water surface (Clause 3.3.2(e)) that starts at its outlet level (Clause 3.12.5), so only its flood storage above that level can count, and only as Chapter 7 allows; a natural pond keeps its own description and is never turned into a detention pond, and neither is a lake, a spring pool or a reservoir; Ganga Lake in the Itanagar Wildlife Sanctuary is a lake, not storage. The corridor of Chapter 7 along streams and nallahs and round ponds and springs is flood land already: water reaches it first, so it is not counted as detention for the development beside it; no statute sets such a line, and the "Distance from Nallah/Stream as per the notified rules/norms" of the bye-laws' site plan (2.10.1(e)) refers to norms that were not found, while the *Jhot*, "A strip of land permanently left open for drainage purposes" (def. 69), has no width. And land kept open on purpose, such as a spring-recharge area above a town's or village's intake (Clause 4.11; Chapter 7), is not graded or paved for detention. Where open space is used for detention, the signs and depth markers of Clause 4.15.5 are in English and the local language, that is, the language in local use in the ward or village, as the local body or the village authority uses for its own public notices (set by this Manual), because a sign must be readable by the people it warns.

4.11 Rainwater harvesting versus detention accounting

4.11.1 **No double counting.** RWH storage (sumps, tanks, recharge pits and wells provided under the RWH mandate) shall **not** be counted as detention.

4.11.2 **RWH sumps assumed full.** For all routing under this chapter, RWH sumps and tanks shall be assumed **full at the start of every storm**, in every season. Their overflow shall be routed to the detention facility, or directly to the outfall if it bypasses detention. In the latter case the bypass flow counts against the PSD.

4.11.3 **Combined tanks.** A single tank may provide both RWH and detention only if:

- (a) the detention zone lies wholly **above** the RWH overflow level;
- (b) the detention zone is drained by its own gravity control orifice set at the RWH overflow level, meeting Clauses 4.7 and 4.8;
- (c) no pump, valve or user action can hold water in the detention zone; and
- (d) the two zones and the orifice level are shown on the drawings and in the maintenance declaration.

Only the volume between the RWH overflow level and the detention overflow level counts as detention.

4.11.4 **Recharge structures.** Recharge pits, trenches, shafts and wells may count as **retention** (not detention) if they meet Clauses 4.4.3 to 4.4.5. In particular, the seasonal high groundwater table shall be at least 1.0 m below their base. In the routing they are treated under Clause 4.4.6 with the groundwater level for the monsoon season.

4.11.5 **RWH remains mandatory.** Nothing in this chapter reduces the RWH requirement of clauses 9.1 and 9.5–9.8, Table 9.1 and Annexure E of the APBBL 2019, any rainwater harvesting provision of a master plan or layout approved under the Arunachal Pradesh Urban and Country Planning Act, 2007, any condition of a building permission, or any rainwater harvesting rule or direction of an approving authority.

> Commentary. Rainwater harvesting in Arunachal Pradesh is required by one instrument, which does not size it. "All buildings having a plot size of 100 sqm while submitting the building plans for sanction shall mandatorily include the complete proposal of rainwater harvesting"; the system comprises the roof catchment, gutters, down pipes, "Rain water/ Storm water drains", a filter chamber, "Storage Tanks/ Pits/ Sumps" and "Ground Water recharge structures like pit, trench, tube well or combination of above structure" (APBBL 2019, 9.1). Table 9.1 sets the provisions by building type: plotted houses of 100 m² and more build a harvesting structure "with emphasis on both storage & reuse"; group housing, public, commercial and industrial buildings of all plot sizes build one too, with recharge pits or wells, and group housing avoids concrete paving, with "permeable materials … for all open parking spaces". "Recharging of ground water should be made mandatory … for all types of buildings, including Group Housing Societies having a plot area 500 sqm and above", and for parks, parking, plazas and playgrounds (9.7); public open spaces of more than 500 m² "shall have arrangements for complete utilization and capture of storm water" (9.6); and the Authority "shall constitute a Rainwater Harvesting Cell", inspect the structures before issuing completion certificates, monitor every building above 1,000 m² with annual physical verification and the rest by a 10% random survey (9.8). Annexure E makes harvesting mandatory on plots of 100 m² and more (1.1), not below (1.4), lets the Authority "impose a levy for the failure … to provide or to maintain" it (1.7), and asks that structures be placed so as "not to endanger the stability of building or earthwork" (2.2.2). The bye-laws say that "Rainwater can be harvested to the extent of 55,000 liters per 100sq. meters area per year from rooftops" (9.1), but none of these provisions gives a storage volume, a roof-area rate, a drawdown or an infiltration test (NEER reading). **This Manual therefore sets a sizing rule for credit: RWH storage shall hold at least 25 L per m² of roof area** (about 25 mm of rain over the roof). This is set by this Manual. It is the value of the other North-East editions of this series, raised from the 20 L per m² of the mountain editions because the storms that matter here come on wet ground, often on several days running: at Doimukh the mean May rainfall is 505.9 mm and the June mean 762.8 mm (NERIST series, as given by Dabral et al., 2016). A larger minimum was weighed and not adopted, for two reasons: the credit under Clause 4.4 depends on how fast a continuous use empties the tank, not on how much rain falls, so a larger minimum adds cost on every plot without adding credit; and the 100 m² trigger of 9.1

reaches small plots on steep ground, where a larger tank is harder to place safely. A larger tank is always allowed and is credited in the same way, up to the volume that the stated use empties within 72 hours. The rule makes the bye-laws' requirement measurable; it does not replace it. This Manual credits these structures against its own retention requirement (Clause 4.4) as follows:

- An RWH tank under clause 9.1 is RWH storage. It is not detention (Clause 4.11.1), and it is assumed full at the start of every storm (Clause 4.11.2), because in the monsoon season it is full after the first heavy rain. A tank may also provide detention only if it is built as a combined tank under Clause 4.11.3, with a detention zone above its RWH overflow level that drains through its own orifice; only that zone counts.
- An RWH tank counts toward the **retention** requirement of Clause 4.4 only to the extent that it is emptied within 72 hours by a continuous non-potable use, such as toilet flushing or washing, demonstrated under Clause 4.4.3; watering a garden is not a continuous use in the monsoon season. The tank is then modelled under Clause 4.4.6 like any other retention practice. Outside the recharge ground below, storage and reuse is the way retention is provided, and the 25 L per m² is the first part of it.
- Recharge pits, trenches, shafts and wells count as retention only where they meet Clause 4.11.4 and the recharge rule below: they are credited only to the extent that they drain within 72 hours at half the rate measured in a site test (Clauses 4.4.3 and 4.4.5), with their base at least 1.0 m above the seasonal high water table, and the credit is found by routing under Clause 4.4.6, not by deducting their volume.
- **Hill rule.** No deliberate infiltration practice (soakaway, soak or percolation pit, recharge pit, shaft or well, infiltration trench, or permeable paving with an exfiltrating base) shall be built or credited: on natural ground sloping more than 10°; on Siwalik shale, at any slope; on colluvium, slope debris or fill, whatever its slope; in a mapped landslide zone; above a landslide scarp; or upslope of a cut slope or retaining wall within twice the height of the cut or wall — unless a geotechnical certificate by a qualified geotechnical engineer or engineering geologist shows that the added water will not destabilise the slope. On such sites roof runoff goes to rainwater storage of at least 25 L per m² of roof, with overflow to a lined drain, stepped where the ground falls steeply, that discharges through a silt trap and an energy dissipator to a stable natural channel, never onto an unprotected slope. The rule applies in sub-areas AR-C1, AR-D and AR-E of Annex 2A, on the hill rim of AR-A and AR-A1, and on any natural slope of more than 10° anywhere. The APBBL 2019 are its hooks: the earth-cutting rules of 4.39, with the 3 m limit on the height of a cut (4.39(4)), the 2.5 m setback from the property line on the upper terrace (4.39(5)), the duty to clear debris "from site or drain to suitable/safer place" (4.39(8)) and to build a retaining or breast wall "immediately" (4.39(11)), and "Earth cutting permission shall not be granted if the average slope of the topography is more than 30%. And the site will be declared as not fit for construction except for plantation" (4.39(14)); the 0.60 m between a retaining wall and the building (2.10.2(a)); the existing drains on the site plan (2.10.1(j)); and Annexure E's requirement that harvesting structures not "endanger the stability of building or earthwork" (2.2.2). The 30% of 4.39(14), about 17°, is a limit on earth cutting, not an infiltration rule: a slope that may be cut can still be destabilised by water put into it, so the hill rule applies from 10°. Where an earth-cutting permission or a geotechnical report is required, it shall also state whether the site's drainage, storage and any infiltration add water to the slope. On these sites, retention is provided by storage and reuse, and detention by lined tanks, not by ponds or basins on the slope (Commentary to Clause 4.10). The 1.0 m groundwater separation of Clause 4.4.3 does not make an infiltration practice acceptable on a slope: perched water and pore pressure in a slope are the hazard, not the depth to the water table.
- **Septic dispersion on slopes.** "A sub- soil dispersion system shall not be closer than 18 m from any source of drinking water, such as well", and not closer than 6 m to the nearest habitable building (APBBL 2019, 4.16.1). On a slope or on shale a dispersion trench or soak pit puts water into the ground that the hill rule protects. This Manual does not override the bye-law, which also keeps septic effluent out of the open drains (4.16.2(c)). It states the conflict and recommends that, on a natural slope of more than 10° or on shale, a dispersion trench or soak pit be sited by a geotechnical engineer, downslope of buildings, cuts and retaining walls and outside the recharge area of any spring (set by this Manual); sewage and septage are dealt with under Clause 8.9.
- **Floodplain rule.** No deliberate infiltration practice (soakaway, soak or percolation pit, recharge pit, shaft or well, infiltration trench, or permeable paving with an exfiltrating base) shall be built or credited, on the valley floor of sub-area AR-A and in sub-areas AR-B and AR-C: on land below the 1% AEP flood level of the

Dikrong, the Pachin, the Senki, the Siang, the Lohit, the Dibang or the Noa-Dihing or of a nallah; on the palaeochannels and swampy land of the Pachin and Dikrong flood plains; on the margins of a pond (its Zone 1 and Zone 2 under Chapter 7); on flood-plain silts and swamps (HSG C or D, Clause 3.7.2); or wherever the seasonal high water table, the highest level from April to November, is less than 2.0 m below ground. The last condition alone may be set aside where a piezometer record of at least one full April–November season shows that the water table stays at least 2.0 m below ground and at least 1.0 m below the base of the practice (Clauses 4.11.4 and 4.12); the others may not, because a flood or a backed-up nallah puts water over the practice whatever the water table does. On such land roof runoff goes to storage under the RWH credit rule above, and detention is provided in lined, watertight storage, checked for flotation with the design groundwater level at ground level (Clauses 4.12.1 to 4.12.3). The evidence is the CGWB's: 1–5 m below ground in the semi-consolidated formations of Papum Pare and 2–4 m before the monsoon and 2–5 m after it in the Dikrong valley; 1.50–11.13 m in East Siang; 3.58 m and 3.52 m in Lohit in 2008; 2.62–5.50 m in the dug wells of Bhalukpong in the lean period (district booklets); and 15 of the 27 State stations at 0–2 m below ground in August 2025 (water-level bulletin, as summarised) (Commentary to Clause 3.10).

- **Recharge rule.** Recharge is not a design objective in Arunachal Pradesh: groundwater is not short, and the stage of extraction is 0.39% (CGWB, 2024, as summarised). Deliberate recharge is allowed only on tested ground outside the hill and floodplain rules: the sandy terrace and valley-fill soils of the Naharlagun–Nirjuli–Doimukh valley, where NERIST's field test at Doimukh found 95.19% sand and a double-ring infiltration rate falling from 12 cm/h to a basic rate of 1 cm/h after 250–300 minutes (Dabral et al., 2016); and the coarse bhabar fan heads above the water table, where the "Siwalik group is the recharge zone" and the piedmont plain "is highly permeable" (CGWB, East Siang district booklet) and "The Bhabar is mostly composed of boulders" (Lohit district booklet), away from scarps and avulsion channels. It is allowed there only after a field infiltration test, where the seasonal high water table stands at least 2.0 m below ground and with the separation of Clause 4.12, and through a silt trap, a filter and a first-flush diverter ahead of the recharge structure. Iron is the main quality issue in the State's groundwater (Papum Pare springs 0.14–0.78 mg/L; East Siang and Changlang flagged; CGWB district booklets), so no recharge structure shall be placed within 30 m of a dug well or spring used for drinking water (set by this Manual). Everywhere else rainwater harvesting is storage and reuse.
- **Where the bye-laws require recharge on a forbidden site.** Clause 9.7 makes ground water recharge mandatory for buildings on plots of 500 m² and more and for parks, parking, plazas and playgrounds, and Table 9.1 asks for recharge pits or wells on public, commercial and industrial sites. On a site where the hill rule or the floodplain rule forbids infiltration, this Manual does not override the bye-law. It states the conflict plainly: on such a site the Manual requires storage and reuse in place of recharge, with the overflow to a lined drain, and the applicant seeks the Authority's relaxation of any recharge element of the plan, citing this rule and, where one is required, the geotechnical report. Until the Authority relaxes it, the bye-law stands, and a recharge structure built on such a site earns no credit under this Manual.
- **Springs.** Springs supply many hill settlements: in Papum Pare they discharge 0.43–2 L/s before the monsoon and 0.02–2.4 L/s after it, "most of the springs become dry during dry season", and in the northern hills of East Siang springs are the only source (CGWB district booklets); springs were not otherwise researched for this Manual, and no spring inventory or statute was found [TBC]. The Municipal Corporation Act vests "all public streams, springs and works for the supply, storage and distribution of water" in the Corporation. In the recharge area of a spring above a town's or a village's intake, where it has been mapped, no surface shall be paved except for access, no road or parking runoff shall be led into the ground, and no infiltration facility, soak pit or septic tank shall be placed; and drains, cuts and fills shall not intercept the flow to a spring or bury its outlet (the spring rule of Chapter 7, set by this Manual).
- **Polluted runoff.** Runoff from fuel stations, workshops, industrial premises and the like, and from any drain or nallah that carries sewage, as most of the capital's drains do ("storm water drains being used as sewers", Master Plan of Itanagar Capital Region-2031, report), shall not be recharged; road and parking runoff shall be recharged, where the recharge rule allows it at all, only through a surface practice with a filter, such as a

vegetated basin or trench, never directly into a bore or well (Chapter 8). The bye-laws already ask that recharge structures in industrial areas be kept "away from sewer lines, septic tanks, soak pits, landfill and other sources of contamination" (Table 9.1).

In the hills, water put into the ground does not stay where it is put. The capital lies on Siwalik sandstone, shale and boulder beds whose slopes are "covered by residual soil or slope debris" (CGWB, Papum Pare district booklet), in Earthquake Zone V with "5 fault lines in the city" (Master Plan of Itanagar Capital Region-2031, report). The Laptap landslide in Toru circle of Papum Pare killed 14 people on 11 July 2017 after three days of rain (14 to 16 in different reports; as reported), and earth cutting along NH-415 was blamed for a mudslide near the Donyi Polo airport (as reported). On the valley floors, a recharge pit can sit in the water table in the monsoon season, and in the monsoon season an RWH tank is full after the first heavy rain. Treating RWH as detention would therefore credit storage that does not exist when it is needed. That is why this Manual assumes RWH tanks are full at the start of every storm. Applying the assumption to every season keeps one simple rule. The combined-tank provision (4.11.3) lets an owner build one structure, as long as the detention part is empty when the storm arrives. The 25 L per m² sizing rule, the hill rule, the floodplain rule, the recharge rule, the recommendation on septic dispersion, the treatment of the recharge conflict of 9.7, the spring rule and the polluted-runoff rule are set by this Manual. No Arunachal Pradesh source sets a slope or distance threshold for infiltration: the bye-laws' slope number, 30%, governs earth cutting, and a threshold of 15% considered for this Manual is not used. The 10° limit is set by this Manual, as in the mountain editions of this series, because a slope that can carry a building can still be destabilised by water put into it; the shale condition is set by this Manual because the Siwalik shales underlie the capital's slopes and the slides of its hills; and the distance of twice the height of a cut or wall is set by this Manual as a precaution, pending guidance from a geotechnical study for the State [TBC].

4.12 High-groundwater and sandy coastal sites

4.12.1 **Design groundwater level.** Each site in the valley floor of the capital region, where the CGWB records water levels of 2–4 m below ground before the monsoon and 2–5 m after it in the Dikrong valley and 1–5 m in the semi-consolidated formations of Papum Pare (Papum Pare district booklet), with the palaeochannels and swampy land of the Pachin and Dikrong flood plains; the flood plains and fan toes of the Siang at Pasighat (1.50–11.13 m, East Siang district booklet), the Lohit at Tezu (3.58 m before and 3.52 m after the monsoon of 2008, Lohit district booklet), the Dibang at Roing and the Noa-Dihing at Namsai and Miao; the dug-well ground of Bhalukpong (2.62–5.50 m in the lean period, West Kameng district booklet); the land beside the capital's nallahs; the margins of ponds, swamps and reservoirs; and hill sites with perched water or springs, or any area where the groundwater table lies within 3 m of the surface at any time of year shall establish a design groundwater level (DGWL) for the facility. The DGWL is the seasonal high level during or after the monsoon, from:

- (a) site piezometer readings over at least one full April–November season; or
- (b) where (a) is not available, the higher of the CGWB or WRD record for the nearest observation well, plus **0.5 m**, and the design flood level of any adjacent river, stream, nallah, pond or reservoir, including the backwater of the Dikrong below the Pare dam in a Naharlagun or Doimukh nallah and of the Siang, Lohit or Noa-Dihing at a Pasighat, Tezu or Namsai outfall.

For the flotation check of 4.12.3 at sites in the Dikrong and Pachin flood plains of the capital region, with their palaeochannels and swamps, the Siang, Lohit and Noa-Dihing flood plains at Pasighat, Tezu and Namsai, land below the 1% AEP flood level of those rivers, and the pond and swamp margins, where (a) is not available, the DGWL shall be taken as existing ground level.

4.12.2 **Lined storage.** Where the DGWL is less than 1.0 m below the base of a storage facility:

- (a) the facility shall be watertight (lined or of watertight concrete), and no infiltration credit applies (Clause 4.4.4); or

- (b) if unlined, the volume below the DGWL shall not be counted as detention, and groundwater inflow shall be added to the routed inflow.

4.12.3 **Uplift and flotation.** Every below-ground tank, vault, lined pond or chamber shall be checked for flotation:

- with the facility empty;
- with groundwater at the DGWL; and
- for coastal sites, with groundwater also at the major-system tailwater level of Chapter 5, where that is higher.

The factor of safety against uplift, counting only permanent dead loads and ignoring wall friction unless supported by geotechnical design, shall be at least **1.2**. Anchoring by ballast, toe extensions or tension piles may be used.

4.12.4 **Shallow and above-ground storage preferred.** On sites where the DGWL is within 1.5 m of ground, storage should be provided above ground where possible: rooftop, podium, landscape or surface storage. Deep tanks should be avoided.

4.12.5 **Durability.** Concrete and metal parts in contact with saline or brackish groundwater or tidal water shall be designed for the exposure class appropriate to coastal conditions under IS 456:2000. Outlet fittings, trash racks and gates shall be of stainless steel, HDPE, FRP or another corrosion-resistant material.

4.12.6 **Sandy soils with deep groundwater.** Where the DGWL is 1.0 m or more below the base, infiltration retention in sandy soils is encouraged. The design infiltration rate of Clause 4.4.3 applies, and the Chapter 8 requirements on pollution of shallow aquifers shall be met.

> Commentary. Arunachal Pradesh is landlocked, so the coastal provisions of this clause, the tidal water levels of 4.12.1 and 4.12.3, do not apply in the State, and no saline groundwater was reported in the assessments read for this Manual [TBC]. Iron is the main quality issue: spring water in Papum Pare carries 0.14–0.78 mg/L, and iron is flagged in East Siang and Changlang (CGWB district booklets); and "The soils in the valley areas are sandy loamy in texture with high acidic content" (CGWB, Papum Pare district booklet). Wherever a site test shows iron-rich or acid groundwater, the exposure provisions of 4.12.5 apply to concrete and metal parts as if the groundwater were aggressive, with the exposure class set from the test (set by this Manual). Groundwater lies at two kinds of depth. On the valley floors it is shallow: 1–5 m below ground in the semi-consolidated formations of Papum Pare and 2–4 m before the monsoon and 2–5 m after it in the Dikrong valley (Papum Pare district booklet), 1.50–11.13 m in East Siang, 3.58 m and 3.52 m in Lohit in 2008, and 2.62–5.50 m in the dug wells of Bhalukpong in the lean period (district booklets), with 15 of the 27 State stations at 0–2 m below ground in August 2025 (CGWB, North Eastern Region water-level bulletin, as summarised), and the water higher still beside the Dikrong, the Pachin, the Siang, the Lohit and the Noa-Dihing in flood and beside the nallahs when they back up. In the hills it is deeper, but perched water and springs occur in the slopes. The Pachin and Dikrong flood plains with their palaeochannels and swamps, the main-stem flood plains and fan toes at Pasighat, Roing, Tezu and Namsai, the land beside the nallahs, the pond, swamp and reservoir margins, and hill sites with perched water or springs are the wet cases. There an unlined tank fills with groundwater before the storm, and an empty lined tank can float, especially when a river in flood, a backed-up nallah, a pond at its outlet level or a reservoir near its full level raises the water table beside it. The design groundwater level of 4.12.1(b) therefore takes the design flood level of the adjacent river, stream, nallah, pond or reservoir where that is higher than the well record, and on the Dikrong and Pachin flood plains, on the Siang, Lohit and Noa-Dihing flood plains at Pasighat, Tezu and Namsai, below the 1% AEP flood level of those rivers and on the pond and swamp margins it is taken as existing ground level for the flotation check unless piezometers show otherwise. On a hill site, a deep tank is not preferred even where groundwater is deep, because a leaking tank on a slope is an infiltration practice by another name: storage on a slope, on shale or on slope debris shall be lined and watertight, and its leakage and overflow taken to a lined drain (Clause 4.11). The April–November monitoring season of 4.12.1(a) is set by this Manual to cover the Manual's monsoon season of 1 April to 31 October, whose pre-monsoon storms can raise the water table in April and May, and the post-monsoon high after the withdrawal in mid-October; a reading taken in March understates the design level. The observation wells are those of the CGWB, North Eastern Region; no State observation-well network was found,

and the role this Manual gives WRD as the State's groundwater agency is set by this Manual pending a State network [TBC]. No monsoon water-table depths for individual town sites in Itanagar, Naharlagun, Pasighat or the other towns, and no map of the seasonal high water table, were obtained [TBC]. The factor of 1.2, the 0.5 m allowance, the "ground level" default for the valley floors, the flood plains and the pond, swamp and reservoir margins, and the exposure rule for iron-rich or acid groundwater have no direct precedent; this Manual sets them because no published site-scale seasonal groundwater depths for Arunachal Pradesh were found during research.

4.13 Regional detention and fee-in-lieu

4.13.1 **Where permitted.** In a basin covered by a Basin Stormwater Master Plan approved under Chapter 11, a development may meet all or part of its detention requirement through:

- (a) a regional detention facility identified in the plan; or
- (b) a fee-in-lieu paid toward restoration of pond or tank storage identified in the plan.

4.13.2 **Conditions.** Regional detention or fee-in-lieu shall be accepted only where:

- (a) the regional facility or restored tank is operational, or is funded and scheduled to be operational within **3 years**. Until then, interim on-site detention is required.
- (b) the conveyance from the site to the facility carries the 1% AEP post-development flow without increasing water levels at buildings or roads between them (Chapter 5);
- (c) the storage credited at a tank is the **flood storage** only. This is the volume between full tank level (FTL) and the maximum water level the bund and surplus weir can safely hold, plus any volume below FTL that a notified operating rule commits to empty before the monsoon. Storage below FTL that is held for irrigation or supply through April to October shall not be credited.
- (d) the tank meets Chapter 7: surveyed FTL, a documented operating rule, and a maintained surplus weir;
- (e) the site still provides **retention** (Clause 4.4) and **WQv** treatment (Chapter 8) on site; and
- (f) in flood-sensitive catchments, the regional facility meets the mixed-frequency rule for its whole contributing area.

4.13.3 **Fee.** The fee-in-lieu shall be computed as:

> Fee = (detention volume required on site under Clause 4.6, m³) × (unit rate, ₹/m³, notified by the Authority)

The unit rate shall include land, construction and 10 years of maintenance. Fees shall be held in a ring-fenced basin account and spent only on the facilities named in the plan.

4.13.4 **Ledger.** The Authority shall keep a public ledger of:

- detention volume credited to each regional facility;
- volume delivered; and
- fees received and spent.

> Commentary. The Malaysian DID (2008) checklist favoured community ponds over on-site detention for sites above 0.1 ha. Studies of on-site detention show that its benefit depends on location and fades with distance downstream (Colorado State University thesis; McEnroe for Kansas City), and that a pond low in the catchment can synchronise with the main-stem peak (*Water* 2016). Regional storage therefore has to be sited by basin modelling, not simply aggregated.

Arunachal Pradesh has no tank or pond Act, and no pond, lake or reservoir in or near its towns was found to be operated for flood control under a documented rule. The first Water Bodies Census counted 993 water bodies in the State, 893 rural and 100 urban, with none reported encroached (as summarised from an answer in the Rajya Sabha); the Forest Department's truthing lists 1,127 wetlands of more than 2.25 ha, 944 of them high-altitude lakes and only 2 tanks or ponds, with 6 in Papum Pare district (Department of Environment, Forest and Climate Change); Glaw Lake in Lohit district is reported as the State's first Ramsar site, announced on 3 August 2026 (as reported); and no wetland notified under rule 4 of the Wetlands (Conservation and Management) Rules 2017 was found [TBC]. The bye-laws ask every urban local body and Planning Authority "to identify, demarcate, protect and maintain the water bodies that come under their jurisdiction" and prepare a list (APBBL 2019, Annexure E 1.8); no such list was found [TBC]. The State's regional storage near its towns is of four kinds: the reservoirs above the Pare, Ranganadi and Kameng dams of NEEPCO and the Lower Subansiri dam of NHPC; the few small ponds and swamps of the valley floors, among them the ponds that the capital's drains and sewage reach (Master Plan of Itanagar Capital Region-2031, report); the lakes, such as Ganga Lake in the Itanagar Wildlife Sanctuary; and the low land of the Pachin and Dikrong flood plains and of the main-stem flood plains at Pasighat, Tezu and Namsai, which no floodplain law protects (none was found). Four points follow:

- A pond on the record may not be a working pond, and a lake is not a detention basin. No inventory of the ponds within the municipal areas or the ICR Master Plan 2031 area, with their beds, rims and outlets, was found [TBC]. A pond is credited only after a survey shows its bed, rim and outlet, and only for the storage above its outlet level; a natural pond keeps its own description and is never turned into a detention pond, and neither is a lake, a spring pool or a reservoir; engineered storage is called a detention pond. Ganga Lake is a lake in a sanctuary and is never counted as detention. A spring-recharge area is not storage for detention (Commentary to Clause 4.11). Where a pond is used as storage, the dry-weather flow of the drains that reach it is intercepted before it (Clause 8.9), because the capital's drains carry sewage: "storm water drains being used as sewers" (report).
- A reservoir is not spare capacity for a site. The reservoirs are held for power through the season, their releases are set by the operators for the whole river, and their storage below the starting level of Clause 3.12.5 is not credited (Clause 4.13.2(c)); storm water spilled to a reservoir, or to the reach below a dam, can be relied on only with the written agreement of the operator for a stated flow and level. NEEPCO and NHPC are the operators whose data the design needs, not approving authorities.
- A pond or check dam in the bed of a hill stream or a nallah is not regional detention unless it is designed for debris and garbage. The hill streams carry boulders and slope debris in every large storm, and the capital's drains are "chocked with the solid wastes" (report); such a facility is credited only for the storage left after the sediment and debris volume of Chapter 6, with a debris rack or trap at its inlet, a geotechnical check of its bund and abutments, its failure path mapped, and a maintenance budget for clearing it after each large storm (Chapters 9 and 10). A regional facility on a slope is also subject to the hill rule, and one on a valley floor to the floodplain rule, of Clause 4.11; in a snow-fed or glaciated catchment no storage is credited without the site study of the Commentary to Clause 3.7.
- No notification divides drains between owners [TBC]. Until one is made, this Manual follows the working split of Chapter 1 and the Commentary to Clause 6.9: public drains, sewers, culverts and watercourses in or under streets, and public streams and springs, as IMC's in its area (Arunachal Pradesh Municipal Corporation Act, 2019, s.200; s.60(a); s.203) and the Pasighat Municipal Council's in its area (Arunachal Pradesh Municipal Act, 2007, ss.47(1)(a)(ii), 102, 194 and 196); storm drains, sewerage and septage works built by the Department of Urban Affairs and the Smart City companies as theirs until handed over in writing to the urban local body; roadside drains, culverts and scuppers on State roads and NH-415 as PWD's and PWD (Highways)'; rivers, their beds and banks and anti-erosion works as WRD's; water supply as PHED's (not researched [TBC]); the dams, reservoirs and release reaches of NEEPCO and NHPC as theirs, as operators; and drains on community or clan land outside an urban local body as the community's, with no statutory owner. Each town keeps a drain register giving every reach its owner, its land status (community, clan, individual, municipal or Government land), whether it carries sewage or septic overflow, and its outfall (set by this Manual). This is the Manual's working split, not a statutory one; where land is community, clan or private land, a drainage corridor or easement is secured by agreement with the owners or the community, by donation or purchase, or by reservation in a plan, never taken.

> The first point is the basis of condition 4.13.2(c) in Arunachal Pradesh. A pond gives flood storage only above its outlet level, unless a notified operating rule commits it to be lowered before the monsoon season. The 3-year operational limit and the 10-year maintenance allowance have no direct precedent and are set by this Manual.

4.14 Simplified methods for small sites

4.14.1 **Applicability.** Tier B local bodies may permit the simplified method for sites of **2 ha or less** outside flood-sensitive catchments. In flood-sensitive catchments, it may be used for sites of **0.5 ha or less**. All other sites shall use Clause 4.6. Until Table 4.3 (Annex 4B) is published, all Tier B sites shall also use Clause 4.6.

4.14.2 **Method.**

1. Read the PSD (L/s/ha) and SSR (m³/ha) for the site's zone, HSG and post-development imperviousness from **Table 4.3** (Annex 4B).
2. Required storage: V = SSR × A − V_credit (Clause 4.4.6.3).
3. Permissible discharges: Q_PSD,T = PSD_T × A for the 2-yr and 100-yr stages.
4. Select the low-flow orifice and upper control from the standard outlet table in Annex 4B (orifice sizes for the PSD at the stated depths), subject to the 50 mm minimum.
5. Provide a spillway or overflow under Clause 4.9, the RWH accounting of Clause 4.11, and the safety provisions of Clause 4.15.
6. Complete Form 4-2 (Tier B site sheet).

Table 4.3 — Tier B permissible site discharge and site storage requirement (template)

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
AR-Z1 Western foothills: AR-A Itanagar capital region (Itanagar–Naharlagun–Nirjuli–Doimukh–Banderdewa)	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AR-Z1 Western foothills: AR-A1 Western foothills (Bhalukpong–Seijosa–Kimin–Yazali)	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AR-Z2 Eastern foothills: AR-B Siang–Dibang–Lohit foothills (Pasighat–Ruksin–Likabali–Roing–Tezu)	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AR-Z3 South-east: AR-C Noa-Dihing plain (Namsai–Chowkham–Bordumsa–Miao)	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AR-Z3 South-east: AR-C1 Patkai hills (Changlang–Jairampur–Deomali–Khonsa–Longding)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
AR-Z4 Hills and high ranges: AR-D Middle hills (Ziro–Daporijo–Aalo–Seppa–Basar–Yingkiong)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
AR-Z4 Hills and high ranges: AR-E High ranges (Tawang–Bomdila–Dirang–Mechuka–Anini–Hayuliang)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]

Worked example (illustrative — not design values).

A 0.4 ha residential layout in a Tier B Municipality, in a flood-sensitive catchment, with about 80% directly connected impervious area (area-weighted post-development CN about 92). Suppose Table 4.3 had been computed and gave the per-hectare equivalent of the Clause 4.6.7 example:

- PSD 100-yr = 356 / 2.0 = 178 L/s/ha
- SSR = 2,913 / 2.0 ≈ 1,460 m³/ha
- PSD 2-yr ≈ 17 L/s/ha

Then:

- Storage: V = 1,460 × 0.4 = **584 m³**. C_R = 0, so there is no retention credit.
- 100-yr release: 178 × 0.4 = **71 L/s**.
- 2-yr release: 17 × 0.4 = **7 L/s**. At about 1 m head this needs a low-flow orifice of about 60 mm, above the 50 mm minimum (Clause 4.8.2).
- Layout options:
  - a 400 m² underground tank 1.5 m deep; or
  - 250 m² of podium storage at 0.3 m (75 m³) plus a 350 m² tank 1.5 m deep (525 m³).
  - Rooftop storage at 150 mm over 1,200 m² of roof (180 m³) could replace part of the tank.
- RWH sumps are additional, and are assumed full (Clause 4.11).

> **Commentary.** Australian councils use permissible site discharge and site storage requirement tables in the same way (Sydney Water OSD guide; the Upper Parramatta River Catchment Trust handbook listed SSR of about 455 m³/ha). The illustrative SSR here, about 1,460 m³/ha, is much larger. That is the expected effect of combining a mixed-frequency cap with mandatory 48–72-hour storms at AMC III. MSMA 2 in Malaysia offers a similar simplified OSD method for sites under 5 ha. The MARC policy supplement offers smaller Kansas City municipalities adoptable alternatives within the regional standard; Clause 4.14 follows that model for Tier B.

4.14.3 **Fixed-coefficient route.** As an alternative to Clauses 4.6 and 4.14.2, the designer of any site of **1 ha or less**, under any Approving Authority and in any catchment, may size detention by Clauses 4.14.4 to 4.14.7. The route shall not be used where:

- (a) the site counts tank or waterbody storage in its design (Chapter 7);
- (b) any part of the site lies within a waterbody setback (Chapter 7); or
- (c) the site drains to a tank cascade whose storage is counted in a downstream design.

The route sets the release caps by fixed coefficients and does not need Table 4.3. It may therefore be used before Annex 4B is published. Retention (Clause 4.4), drawdown (Clause 4.7), outlets (Clause 4.8), the spillway (Clause 4.9), the downstream and tailwater checks (Chapter 5) and water quality (Chapter 8) still apply.

4.14.4 **Release caps.** Two caps apply at each point where runoff leaves the site:

$Q_{cap,10} = 2.78 \times C_{10} \times i_{10} \times A$ and $Q_{cap,2} = 2.78 \times C_2 \times i_2 \times A$

where Q_cap is in L/s; A is the site area (ha); i_10 and i_2 are the 10% AEP (10-yr) and 50% AEP (2-yr) rainfall intensities (mm/h) for a **15-minute** duration at the site, from the sources of Chapter 2, with the climate factor of Clause 2.8; and C_10 and C_2 are the fixed coefficients of Table 4.3A for the site's hydrologic soil group (Clause 3.7). For a site with more than one soil group, the coefficients are area-weighted.

Table 4.3A — Fixed release coefficients (provisional)

Hydrologic soil group	C_10	C_2
A (sandy, well drained)	0.05	0.02
B	0.08	0.03
C	0.15	0.08
D (clay, poorly drained)	0.25	0.15

Q_cap,10 is the maximum release for **every storm up to and including the 1% AEP (100-yr) storm**, in every catchment. Q_cap,2 is the maximum release for the 50% AEP (2-yr) storm. Where a cap is smaller than the discharge of a 50 mm orifice at the corresponding stage, the 50 mm orifice is deemed to comply (Clause 4.5.5.1).

4.14.5 **Storage.** The detention storage V (m³) is the larger of V_100 and V_2, each the largest over the durations d of Clause 2.5.2 (1 to 72 hours):

V_100 = max over d of [10 × C_v × P_100(d) × A − 1.8 × Q_cap,10 × d]

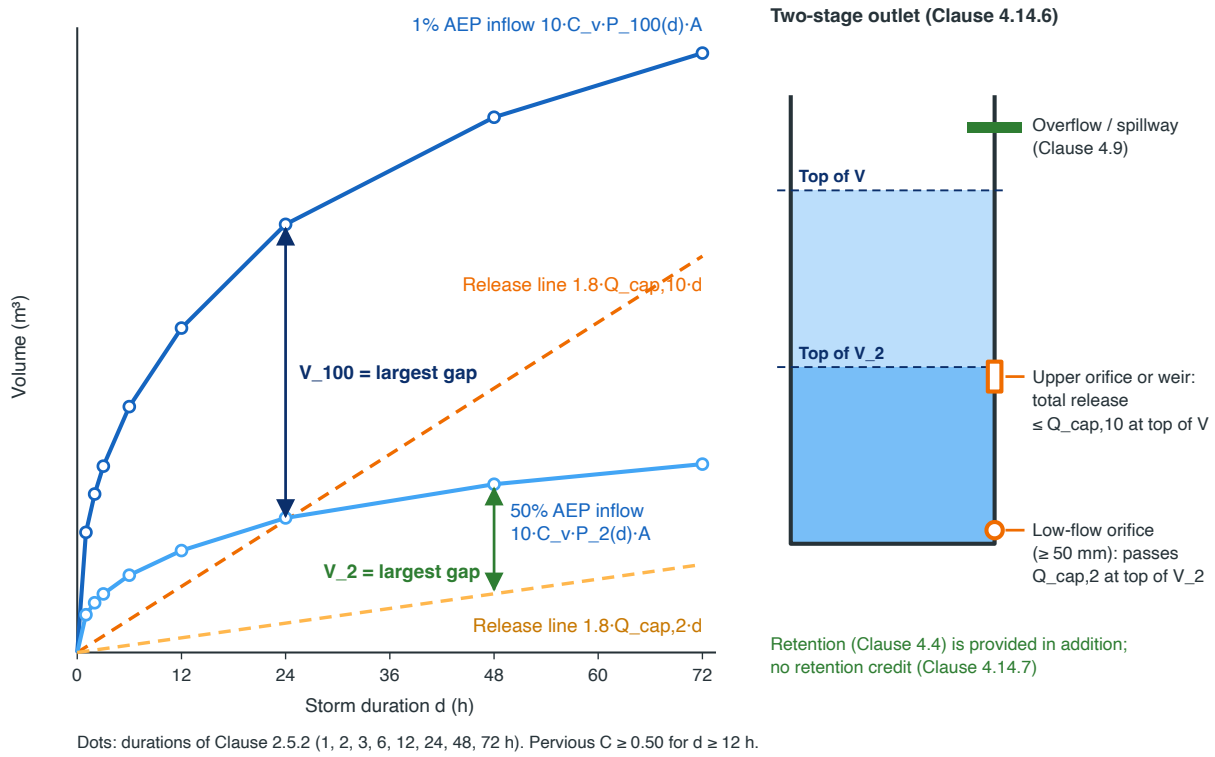
V_2 = max over d of [10 × C_v × P_2(d) × A − 1.8 × Q_cap,2 × d]

where P_100(d) and P_2(d) are the 1% and 50% AEP rainfall depths (mm) for duration d (hours), with the climate factor; and C_v is the post-development volumetric coefficient: the composite C of Table 3.2 (upper half of each range), multiplied by Cf of Table 3.3 for the 1% AEP. For durations of 12 hours or more, C for every pervious surface shall be taken as not less than **0.50**. The factor 1.8 assumes an average release of half the cap over the storm (3.6 × 0.5).

4.14.6 **Outlet.** The outlet shall be a two-stage control: a low-flow orifice that passes Q_cap,2 when the storage holding V_2 is full, and an upper orifice or weir that limits the total release to Q_cap,10 at the top of V. The outlet table of Annex 4B may be used once it is published.

4.14.7 **Retention.** The retention volume of Clause 4.4 is provided in addition to V. No retention credit (Clause 4.4.6) is taken under this route.

Fixed-coefficient route for sites of 1 ha or less (Clauses 4.14.3–4.14.7) — schematic, not to scale



Dots: durations of Clause 2.5.2 (1, 2, 3, 6, 12, 24, 48, 72 h). Pervious C ≥ 0.50 for d ≥ 12 h.

$Q_{cap,10} = 2.78 \times C_{10} \times i_{10} \times A$; $Q_{cap,2} = 2.78 \times C_2 \times i_2 \times A$; (L/s; A in ha; i in mm/h)

C_{10}, C_2 from Table 4.3A by soil group; i_{10}, i_2 for a 15-minute duration with the climate factor (Clause 2.8)

$V = \max(V_{100}, V_2)$; $V_T = \max$ over d of $[\ 10 \times C_v \times P_T(d) \times A - 1.8 \times Q_{cap} \times d\ ]$ (m^3) ; 1.8 = 3.6 × 0.5 (average release of half the cap)

Figure 4.3 — Fixed-coefficient route for sites of 1 ha or less (Clauses 4.14.3 to 4.14.7): the release caps Q_cap,10 and Q_cap,2 from Table 4.3A; the storage V as the largest gap, over the durations of Clause 2.5.2, between the cumulative inflow 10·C_v·P(d)·A and the release line 1.8·Q_cap·d, for the 1% and 50% AEP storms; and the two-stage outlet that passes Q_cap,2 at the top of V_2 and Q_cap,10 at the top of V. Schematic, not to scale. Original drawing for this Manual, adapted from the rainfall mass-curve (inflow minus outflow) storage concept and the single-coefficient peak cap of the PUB Code of Practice on Surface Water Drainage, 7th ed. (cl. 7.1.5).

Commentary. The fixed-coefficient route follows Singapore, which caps the peak runoff from every development of 0.2 ha or more with one runoff coefficient, C = 0.55, applied to the 10-yr storm (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 7.1.5, Addendum No. 3, 2025). It is quick to apply and quick to check: the cap needs only the site area, the soil group and two intensities. PUB's 0.55 is not used here, because Singapore's baseline is the existing urban drainage system, while this Manual's baseline is greenfield land (Clause 4.5.1.2). The coefficients of Table 4.3A are set by this Manual from the greenfield curve numbers of Clause 3.3 (CN 39, 61, 74 and 80 for soil groups A to D). They are the ratios of runoff to rainfall that those curve numbers give for 1-hour depths typical of the foothills round Itanagar, rounded down. They are therefore **provisional**. The State Stormwater Technical Committee shall confirm or revise them against NIH-DHAARA values for each zone when it issues Annex 4B.

The route is deliberately **stricter** than the full method, so that simplicity costs the developer storage rather than costing the people downstream. The 100-yr release is held to about the greenfield 10-yr peak everywhere, which is the flood-sensitive rule of Clause 4.5.3; the storage assumes the outlet releases only half the cap on average; pervious ground is assumed wet in long storms; and no retention credit is taken. A designer who wants a smaller tank can use the full method of Clause 4.6. The storage formula is the rainfall-mass (inflow minus outflow)

method. Clause 3.4.2 otherwise forbids rainfall-based peak methods for storage, because they ignore the shape of the hydrograph; this route is a stated exception because its conservative assumptions cover that error for small sites, and the 24- to 72-hour durations are always checked.

4.15 Safety, fencing and multi-use

4.15.1 **Depth limits for publicly accessible storage.** Where the public has access to a storage area (parks, playfields, open space, school grounds):

- (a) maximum depth in the 10% AEP storm: **0.45 m**;
- (b) maximum depth in the 1% AEP storm: **1.2 m**, except in a fenced zone under 4.15.3;
- (c) side slopes: no steeper than **4H:1V**, with at least a quarter of the perimeter at **6H:1V** or flatter for escape; and
- (d) no vertical drop greater than **0.3 m** within the storage area or at its edge.

4.15.2 **Wet basins.** Permanent pools shall have:

- a safety bench at least 3 m wide, no more than 0.3 m below the normal water level; and
- an emergent planting fringe that deters entry.

4.15.3 **Fencing.** A fence at least **1.2 m** high, of a non-climbable design with a lockable gate, is required around any part of a storage that:

- has a vertical wall or headwall drop greater than **0.6 m**;
- exceeds 1.2 m depth in the 1% AEP storm with slopes steeper than 4H:1V; or
- contains an outlet structure with an opening larger than 300 mm that is not grated.

4.15.4 **Outlets.** Every inlet and outlet opening larger than 300 mm accessible to the public shall be fitted with a grate or rack. The grate shall be designed so that a person pinned against it can escape: low approach velocity, inclined, with a large open area.

4.15.5 **Signs and depth markers.** Every publicly accessible storage shall have signs in the local language and English stating that the area floods during rain, and a depth marker at the deepest point.

4.15.6 **Confined spaces.** Underground tanks shall have lockable covers. They shall be marked as confined spaces, and the maintenance declaration (Chapter 10) shall state the entry procedure.

4.15.7 **Vector control.** Dry storage shall drain completely (Clause 4.7) and have no low points that pond for more than 72 hours. Wet basins shall meet Clause 4.10.7.

> Commentary. The numeric limits in Clause 4.15 have no single direct precedent. They are drawn from common international practice, for example KC APWA 5600 (2006), which required at least a quarter of a dry-pond perimeter at 5:1 or flatter, a 20 ft (6 m) clearance from property lines and a 15 ft (4.6 m) maintenance strip. They are made somewhat stricter here because multi-use storage on open space land and in schools will be used by children during the monsoon. Standing water in dry basins is a mosquito-breeding risk, so complete drainage (Clause 4.15.7) is a public-health requirement, not an amenity.

4.16 Basis: why peak matching alone fails

Commentary. This section has no requirements. It records why this chapter requires release **below** pre-development rates, retention, long-duration checks and a downstream analysis, rather than simple peak matching.

1. **Timing.** Detention lowers a site's peak but stretches its hydrograph (Figure 4.1). Downstream, the stretched releases from many sites overlap with each other and with the main-stem peak. In Denver's study, ten basins each releasing 100% of the historic 100-yr peak produced 106% of the historic peak at the outlet. Only releasing 90% at each site brought it to 97% (UDFCD memo, 2012). A Colorado State University thesis found that location-blind on-site detention "can actually increase peak flows above post-development peaks". An optimisation study found that a downstream pond performed worse than upstream ponds because its outflow synchronised with the main stem (Water 2016, 8(7):290).
2. **Volume.** Detention does not remove volume. In the illustrative example, the post-development 100-yr storm produces about three times the runoff volume of the pre-development 10-yr storm (Clause 2.11). Only retention, or storage that empties to somewhere other than the receiving drain, reduces volume.
3. **Scale.** Kansas City modelling (McEnroe, 2005) found that uniform 3 cfs/ac control reduced Q100 by 36% in a 200-ac watershed. With the same control everywhere, Q100 still rose by 40% at 14 sq mi, and the benefit faded beyond about 1–2 sq mi. The KC committee concluded that "'match existing' can harm streams" (MARC Evolution deck). Georgia makes a ten-percent downstream analysis mandatory for the same reason: "Due to peak flow timing and runoff volume effects, some structural practices fail to reduce discharge peaks to pre-development levels downstream" (GSMM 2016).
4. **Design-storm dependence.** An Australian study of 20 real on-site detention systems found that designs using even ten temporal patterns "cannot reliably produce an OSD system design that will always be effective" under real rainfall (Water Science and Engineering, 2019). This is why Clause 4.6.3 routes the full duration matrix rather than one critical storm.
5. **Closed outfalls.** In Arunachal Pradesh the governing failure takes three forms. On the valley floor of the capital region it is a river that backs up into the nallahs: Naharlagun's drains run to the Dikrong (Master Plan of Itanagar Capital Region-2031, report), and below Doimukh the Dikrong carries the releases of the Pare dam, reported at a peak of 1,310 m³/s on 31 May 2025 (as reported), and the tailrace of the Ranganadi project, so the nallahs of Naharlagun, Nirjuli and Doimukh cannot empty while the operator releases and the river is high. At the foothill towns it is a main stem whose stage is set far upstream: the CWC level of the Siang at Passighat reached 157.54 m on 11 June 2000, 3.58 m above its danger level, when the Yigong landslide dam breached in Tibet (as transcribed by SANDRP), a stage that local rain did not cause and that no drain at Pasighat can discharge against; the Lohit at Tezu and the Noa-Dihing at Namsai stand in the same way above their towns' outfalls when they are high. No gate or flap gate on any town outfall was found [TBC], and no stage record of how long the Dikrong, the Siang, the Lohit or the Noa-Dihing stays above a town's outfalls was obtained [TBC]. Everywhere in the hills the outfall can also be closed by debris and garbage: hill streams rise within minutes and carry boulders, slope debris and solid waste that bury outfalls and block culverts, as in September 2018, when the Senki View culvert and the Press Colony bridge in Itanagar were washed away (as reported), and the capital's drains are "chocked with the solid wastes" with "heavy silting" (report). No document was found that sets a design river level for any outfall; Chapter 5 sets the design level and the closure to be assumed (Clause 5.8.5), and Chapters 6 and 9 the debris and blockage allowances. A perfectly orificed basin behind a closed outfall simply fills. No release-rate rule can fix that; it is handled by the outfall-closed check of Chapter 5.

The response in this Manual is layered:

- release below pre-development (Clause 4.5);
- retain the frequent storms (Clause 4.4);
- route long monsoon storms (Clause 4.6.3);
- prefer regional storage in the pond system (Clause 4.13); and
- check downstream and at the outfall (Chapter 5).

> Kansas City's own history shows the price. On a test site, peak matching needed 3.0 ac-ft of storage and the 2011 comprehensive criteria needed 4.9 ac-ft (MARC Evolution deck). Over-detention costs more storage. That is the cost of protecting the catchment rather than only the site boundary.

4.17 Submittal requirements

Every site runoff-control submittal shall include a **Site Runoff Control Report** (Form 4-1) containing:

1. the Design Rainfall Sheet (Form 2-1) and the hydrology inputs (Chapter 3);
2. the evidence for the order of measures under Clause 4.3.1;
3. the RRV computation, infiltration tests, groundwater evidence and drawdown calculation (Clause 4.4);
4. the retention credit computation (Clause 4.4.6);
5. the release-rate criterion applied, standard or flood-sensitive, with the Annex 4A map extract (Clause 4.5);
6. a results table in the format of Clause 4.6.7 for every AEP and duration, with the governing case highlighted;
7. stage–storage and stage–discharge tables and plots, and inflow/outflow hydrographs for the governing cases;
8. the drawdown calculation (Clause 4.7);
9. outlet details, including orifice sizes and levels, trash racks and anti-vortex devices (Clause 4.8);
10. the spillway or overflow calculation, freeboard and hazard classification, and the geotechnical report where required (Clause 4.9);
11. the RWH and detention accounting, with tank sections showing zone levels (Clause 4.11);
12. the design groundwater level and flotation check (Clause 4.12);
13. the downstream and tailwater report (Chapter 5, Form 5-1); and
14. the safety provisions (Clause 4.15) and the draft maintenance declaration (Chapter 10).

Tier B sites using Clause 4.14.2 shall submit Form 4-2 in place of items 6 and 7. Sites using the fixed-coefficient route (Clause 4.14.3) shall submit Form 4-3 in place of items 6 and 7.

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Annexes and forms

Annex / Form	Content
4A	Flood-sensitive catchment boundaries (GIS); shallow-groundwater zone map
4B	Tier B tables: PSD and SSR (Table 4.3), retention credit factor C_R, standard outlet sizes; confirmed fixed release coefficients (Table 4.3A)
4C	Worked example (Tier A) with full routing tables
Form 4-1	Site Runoff Control Report
Form 4-2	Tier B Site Sheet
Form 4-3	Fixed-coefficient Route Sheet (Clauses 4.14.3 to 4.14.7)

CHAPTER 5

Downstream and Tailwater Analysis

5.1 Purpose and scope

5.1.1 This chapter sets two checks that every regulated development and every public drainage project must pass.

- **The downstream analysis** (Clauses 5.3 to 5.5) confirms that the project does not make flooding worse below its outfall.
- **The tailwater analysis** (Clauses 5.6 to 5.13) sets the water level the system discharges into, including tide, storm surge, sea-level rise, river backwater and sand-bar closure. It also requires the system to cope when its outfall is closed.

5.1.2 This chapter applies to:

- (a) every site to which Chapter 4 applies;
- (b) every minor- and major-system drainage project under Chapter 6; and
- (c) every regional detention or tank restoration project under Clause 4.13 and Chapter 7.

5.1.3 Rainfall and joint-occurrence inputs come from Chapter 2, in particular Clauses 2.5.3 and 2.12. Hydrologic methods come from Chapter 3. Site release criteria come from Chapter 4. Hydraulic design of gates, culverts and pumps follows Chapter 9.

5.1.4 **No tidal outfalls in Arunachal Pradesh.** Arunachal Pradesh is landlocked: it has no coast, no tide and no Coastal Regulation Zone, and the monsoon reaches it only as rainfall on its foothills, valleys and ranges; that rainfall is dealt with in Chapter 2, not as a tidal or surge level. No outfall in the State discharges to the sea, a tidal creek or an estuary, so the provisions of this chapter that depend on tide, storm surge, sea-level rise or a river mouth do not apply in Arunachal Pradesh: Clause 5.7 and Annex 5A, cases J1 to J3 of Table 5.2, the tidal lock windows of Clause 5.10.3, the seawater requirement of Clause 5.11.3(a) (gates and seats shall still be of corrosion-resistant materials, and shall resist abrasion by gravel and boulders and attack by the sewage that the nallahs carry), and Clause 5.13. They are kept so that the clause numbers of this Manual match its other State editions. In Arunachal Pradesh the receiving water is one of six kinds: a river of the capital region, the Senki, the Pachin or the Dikrong, reached through a nallah (the Manual's word for a natural or open urban channel, as the bye-laws, the Land Act and the Master Plan use it), which backs up when the river is high and, on the Dikrong, when the Pare dam releases; a stream or nallah of the hills, ungauged, steep and laden with gravel, boulders, slide debris and garbage; the main stem of a large river at a foothill town, the Siang at Pasighat, the Lohit at Tezu, the Noa-Dihing at Namsai or the Dibang at Roing, whose stage is set far upstream by rain, snowmelt and outbursts in Tibet and the high ranges; a reservoir or the reach below a dam of NEEPCO or NHPC; a river that leaves the State into Assam or Bhutan; or a pond, natural or man-made; and:

- (a) its tailwater is set by Clauses 5.6 and 5.8, including Clause 5.8.5;
- (b) where Clauses 5.10 to 5.12, Form 5-1 or Chapter 6 refer to the J1 tailwater or the J1 tidal curve, the minor-system tailwater of Clause 5.6.2 or 5.8.5 applies, as a time series where the receiving level varies; where they refer to the J2 tailwater or to HAT + surge + SLA, the major-system tailwater applies: the design-AEP river level of Clause 5.8.4(b), or the major-system tailwater of Clause 5.8.5, whichever is higher at the outfall; and

- (c) the outfall-closed check of Clause 5.10 applies where an outfall is closed by a river of the capital region, a nallah, a hill stream, a main stem, a reservoir or its release reach, a pond or a receiving drain, with the locks and closures of Clause 5.8.5(a) to (g) in place of the tidal lock windows.

Commentary. The drains of Arunachal Pradesh's towns fail in places that site design does not see, and in six different ways. The first is the capital's nallahs. Itanagar's drains run to nallahs and the Senki and the Pachin, and Naharlagun's to the Dikrong; they "end up mostly into the Nallah and in some cases, into local ponds or open fields", and the Master Plan finds "no proper storm water network for the overall town area" and drains "not engineered" (Master Plan of Itanagar Capital Region-2031, report). The Dikrong below Doimukh carries the Pare dam's releases, with a peak of 1,310 m³/s on 31 May 2025 (as reported), and the Ranganadi project's tailrace. The second is the hill stream. In September 2018 the floods of the Modirijo and Donyi Polo catchments washed away the Senki View culvert and the Press Colony bridge, with a landslide reported from "the dumping area of NH 415" (as reported). The third is the main stem. The Siang at Pasighat set its highest flood level, 157.54 m against a danger level of 153.96 m, in the flood from a landslide-dam breach in Tibet in June 2000 (CWC's levels as transcribed by SANDRP, as reported), and the town's bank erodes (as reported). The fourth is the reservoir and its release reach: the Pare, Ranganadi, Kameng and Lower Subansiri projects release into the reaches of towns, and no operator's release protocol was found. The fifth is the river that leaves the State, whose nearest CWC sites are in Assam, tens of kilometres downstream. The sixth is the pond: the drains and sewage of the capital run into ponds (Master Plan report). The outfalls also belong to one body while the drains above them belong to others: the rivers are WRD's to look after, the dams NEEPCO's and NHPC's to operate, the town drains the Itanagar Municipal Corporation's or the Pasighat Municipal Council's, the road drains the Public Works Department's, and the drains on community and clan land the community's, and no rule divides them (Chapter 6, Clause 6.9). No document found during research sets a design level for any river, stream, reservoir or pond outfall in the State, or a design standard for any town drain. A detention basin that meets every release rate in Chapter 4 still fails if the river stands above its outfall, if the stream has buried its outlet in gravel or garbage, or if the dam upstream is releasing. This chapter makes these failure modes part of the design. Arunachal Pradesh has no tidal outfall, so Clause 5.1.4 says which of the chapter's coastal provisions fall away and what takes their place.

5.2 Definitions

Term	Meaning in this Manual
Analysis point	A location on the downstream system where pre- and post-project conditions are compared (Clause 5.3.3).
Contributing catchment	The whole area draining to an analysis point, on and off site.
Major drain	A channel listed as a major drain in the basin plan or Annex 5B, or any river, WRD canal, the Senki, the Pachin and the Dikrong in the Itanagar capital region, Papu Nallah and the nallahs of the Modirijo and Donyi Polo catchments, the Dikrong below the Pare dam and the Ranganadi below Yazali, any drain built or held by the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Department of Urban Affairs, a Smart City company, PWD or PWD (Highways) with an internal width of 1.0 m or more, and every stream, nallah or other natural channel that drains 8 ha or more, whether or not it is lined, piped or covered, or a tidal creek.
Chart datum (CD)	The datum of the published tide tables and nautical charts, to which tidal heights are referred.
Mean sea level (MSL)	Average sea level over a long period at a tide gauge.
MHWS	Mean high water springs: the average of high waters at spring tides.
HAT	Highest astronomical tide: the highest level predicted under average meteorological conditions over a full tidal cycle (18.6 years).

Term	Meaning in this Manual
Storm surge	The rise in sea level above the astronomical tide caused by wind and low pressure, mainly during cyclones.
Still-water level	Astronomical tide plus surge, excluding individual waves.
Sea-level allowance (SLA)	The allowance added to present-day tidal levels for sea-level rise over the design life (Clause 5.7.4).
Tailwater	The water level at the downstream end of a drain, outlet or storage.
Tide-lock	The condition in which the tailwater is at or above the upstream water level, so a gravity outfall cannot discharge.
Lock window	A period during which the outfall-closed check of Clause 5.10 sets gravity discharge to zero.
Sand bar	A bar of beach sand that partly or fully closes a river mouth or creek inlet.
Project datum	The levelling datum used on the project drawings. It must be tied to a Survey of India benchmark (Clause 5.7.2).

5.3 Extent of the downstream analysis

5.3.1 The downstream analysis shall start at each site or project outfall. It shall continue downstream to the **first** of:

- (a) the point at which the project area is **10% or less** of the contributing catchment;
- (b) the next **tank, pond** or other waterbody with a surplus weir or controlled outlet; or
- (c) the next **major drain**, or the sea.

The end point itself shall be analysed (Figure 5.1).

5.3.2 Where the analysis ends at a tank or pond under 5.3.1(b), it shall report:

- the change in the tank's maximum water level; and
- the change in surplus-weir discharge, for the AEPs and durations of Clause 5.4.3.

If the maximum water level rises, the analysis shall continue below the surplus weir to the next end point.

5.3.3 Analysis points shall be set at least at:

- (a) each site outfall;
- (b) each confluence with a drain or channel whose contributing catchment is at least half that of the receiving drain at that point;
- (c) each culvert, bridge or road crossing;
- (d) each location recorded as flood-prone by the local body, IMC, APSDMA or WRD; and
- (e) each building or road segment lying within the 1% AEP flood extent along the route. Representative points may be used where buildings are closely spaced.

5.3.4 **Small sites.** For sites of less than **0.5 ha**, the Authority may accept a simplified downstream statement (Form 5-2) in place of the full analysis, where all of the following hold:

- the receiving public drain has documented capacity for its minor-system design flow (Chapter 6);
- no flood-prone location is recorded within 500 m downstream; and
- the site does not drain to a tidal or backwater-affected outfall.

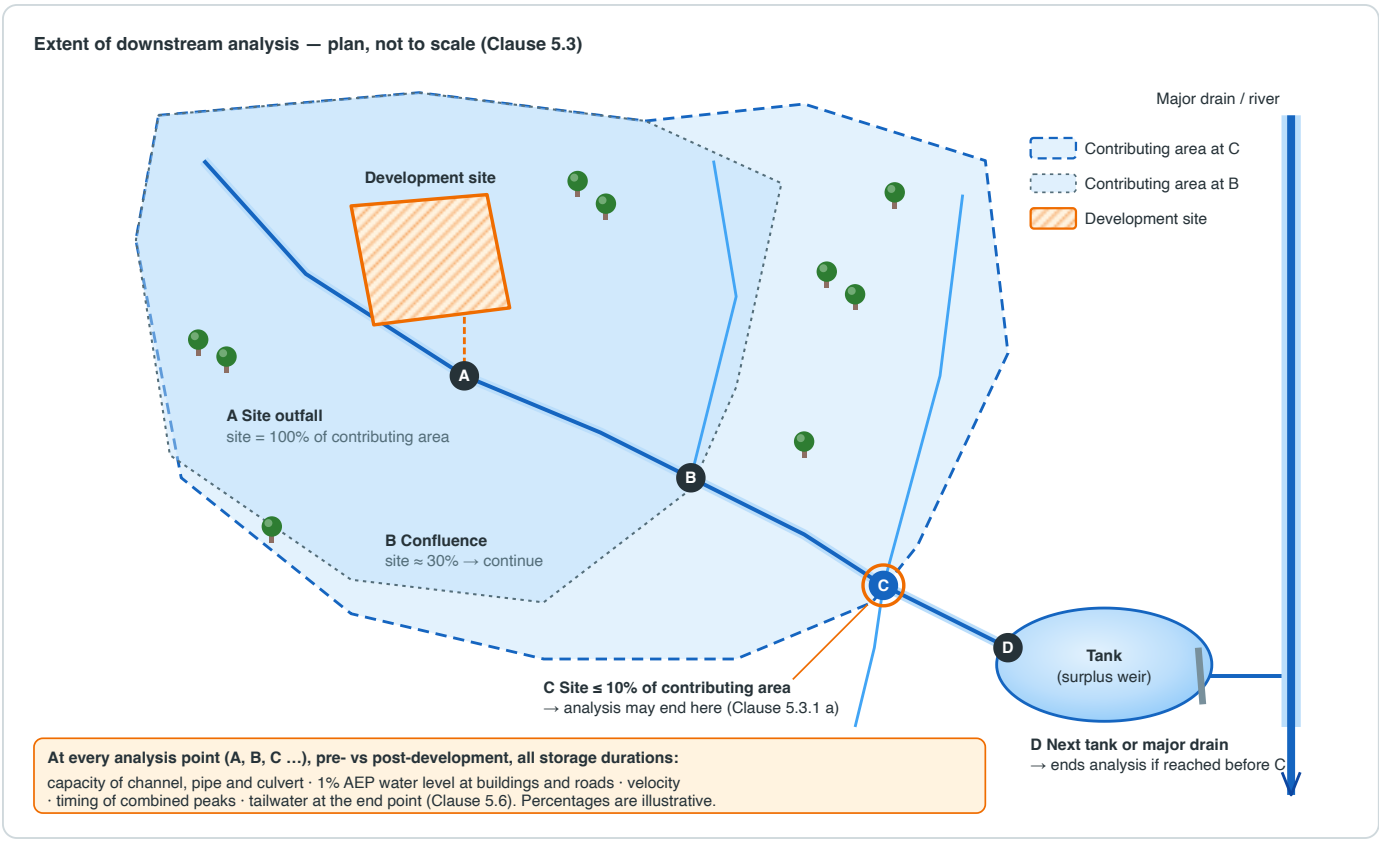

Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next pond or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia Stormwater Management Manual (2016, Vol. 2 §3.1.9) and KC APWA Section 5600 (2006, 5601.5).

> Commentary. The 10% rule has established precedent. KC APWA 5600 (2006) required the downstream system to be analysed "to the point the development's land mass is less than 10% of the total watershed". The Georgia manual makes the ten-percent analysis a mandatory standard (GSMM 2016, Standard #8). The tank or major-drain end point has no direct precedent; this Manual adds it for Arunachal Pradesh. In the hill towns, where a colony's drain runs down a nallah to a stream, and the stream to a river many kilometres below, as Itanagar's drains run by their nallahs to the Senki, the Senki to the Pachin and the Pachin to the Dikrong near Nirjuli, and in the foothill towns on the main stems, where the drains of Pasighat, Tezu and Namsai run to the Siang, the Lohit and the Noa-Dihing and on to the Brahmaputra, the 10% point can lie many kilometres downstream, across several tanks. A tank with a working surplus weir changes the hydrograph completely, so the analysis is better ended there and the tank level reported. Clause 5.3.2 prevents that end point from hiding a rise in the tank level. The small-site statement (5.3.4) and its 500 m distance have no direct precedent and are set by this Manual.

5.4 What the analysis must check

5.4.1 **Scenarios.** Each analysis shall compare:

- (a) **Existing**: the present downstream system and present land use of the whole contributing catchment, with the project site at its pre-project state; and
- (b) **With project**: the same, with the project and all its controls (Chapter 4) in place.

Where the Authority's basin plan defines future land use, the Authority may also require:

- (c) **Future**: the catchment fully developed under the plan, all to Chapter 4 standards, with and without the project.

5.4.2 **Quantities to be checked at every analysis point:**

- (a) **Capacity**: peak flow against the capacity of every channel, pipe, culvert and crossing, for the minor-system AEP of that element (Chapter 6) and for 1% AEP;
- (b) **Flood levels**: 1% AEP maximum water level at buildings (at the lowest opening) and on roads (at the crown and at the deepest point);
- (c) **Velocities**: peak velocity for 50%, 10% and 1% AEP;
- (d) **Timing of combined peaks**: the hydrograph at each confluence, showing the time to peak of the project outflow and of the receiving drain; and
- (e) **Duration of inundation**: on roads and at buildings, the time above the Chapter 6 depth limits.

5.4.3 **Storms.** The analysis shall use:

- 50%, 10% and 1% AEP;
- the duration set of Clause 2.5.2, at least the durations that give the highest level at each analysis point (these will usually be longer than at the site); and
- the 24-, 48- and 72-hour storms in every case.

The AMC rule of Clause 2.11.4 applies. Areal reduction follows Clause 2.7, applied to the contributing catchment at each analysis point and never to the site storage.

5.4.4 **Method.** The analysis shall:

- use a hydrograph method that combines hydrographs at confluences (SWMM, HEC-HMS, or an equivalent);
- include a hydraulic model with backwater (SWMM dynamic wave, HEC-RAS, or equivalent) wherever tailwater or backwater affects any analysis point; and
- not use the Rational Method at any analysis point, because it cannot represent timing.

Off-site areas shall be modelled at their present land use. Upstream detention shall be included only where it is built, maintained and documented.

5.4.5 **Tailwater.** The downstream end of the model shall use the tailwater of Clauses 5.6 to 5.9 and the sand-bar condition of Clause 5.13 where applicable.

> **Commentary.** Clause 5.4.2(d) exists because detention changes when the site's water arrives, not only how much arrives (Clause 4.16). A Colorado State University thesis and a *Water* (2016) optimisation study both found that delayed site releases can coincide with the main-stem peak and raise it. Georgia's manual states the result directly: some structural practices "fail to reduce discharge peaks to pre-development levels downstream" because of "peak flow timing and runoff volume effects" (GSMM 2016). The duration-of-inundation check (5.4.2(e)) matters in the Itanagar capital region, whose nallah outfalls lie below the Dikrong when it is high and carries the Pare dam's releases, as in the statewide floods of late May and early June 2025, when the dam's peak discharge was reported at 1,310 m³/s (as reported), and where NH-415 between Itanagar and Naharlagun was closed in the 2017 floods, with traffic diverted via Papu Nallah and Jullang Road (Master Plan of Itanagar Capital Region-2031, report), and was submerged in the reported Itanagar "cloudburst" of July 2024, when homes near Energy Park and Bank Tinali flooded and seven relief camps were opened (as reported); and in the foothill towns on the main stems, Pasighat, Tezu and Namsai, whose outfalls lie below the Siang, the Lohit and the Noa-Dihing when those rivers are high. Detention that prolongs releases can lengthen that time even when it lowers the peak.

5.5 Acceptance criteria

5.5.1 The project is acceptable if, at every analysis point and for every AEP and duration of Clause 5.4.3, comparing "with project" to "existing":

- (a) the 1% AEP maximum water level does not rise by more than **10 mm** at any habitable building, at any building's lowest opening, or on any road carriageway;
- (b) no building that is not flooded in the existing case is flooded with the project, and no building or road that meets the Chapter 6 freeboard or depth limits in the existing case fails them;
- (c) peak flow does not exceed the existing peak at the minor-system AEP of each element, or at 1% AEP;
- (d) peak velocity in lined channels stays within the permissible velocity for the lining (Chapter 6: 3.0 m/s maximum); and
- (e) in unlined or natural channels, peak velocity for 50% and 10% AEP does not increase by more than **10%**, unless protection is provided under Chapter 9.

5.5.2 The duration of inundation under 5.4.2(e) shall be reported. The Authority may refuse a project that increases the duration of road closure on an arterial or emergency route.

5.5.3 **Where the criteria are not met**, the project shall do one or more of the following:

- (a) reduce release rates or increase storage (Chapter 4);
- (b) build downstream improvements, with the consent of the owner of the downstream system. These shall not transfer the problem further downstream, and shall be re-analysed under this chapter;
- (c) contribute to a regional facility under Clause 4.13; or
- (d) under Clause 5.5.4, change the release strategy.

5.5.4 **Timing exception.** Where the analysis shows that detention raises downstream levels because of timing, the Authority may vary the site release-rate criteria of Clause 4.5. This applies only where the site discharges within the lower tenth of the contributing catchment, directly to a major drain, tidal creek or the sea, and only on the following conditions:

- (a) the varied strategy meets 5.5.1;
- (b) the retention requirement (Clause 4.4) and WQv treatment (Chapter 8) are met in full; and
- (c) the outfall-closed check (Clause 5.10) is met.

> **Commentary.** The 10 mm tolerance (5.5.1(a)) has no direct precedent. It is meant to be at or below the numerical precision of a typical one-dimensional model, so that "no increase" can be tested without arguing over rounding. The 10% velocity tolerance is likewise set by this Manual. The timing exception in 5.5.4 follows the Georgia manual, where the downstream analysis can show "that peak controls are not needed" and allow them to be waived (GSMM 2016, Standard #8). It is limited here to sites low in the catchment, which is where synchronisation with the main-stem peak is most likely (*Water* 2016, 8(7):290). It is not available above that, because the evidence on scale (Clause 4.16) shows that early release from many upstream sites raises peaks.

5.6 Tailwater: general and non-tidal outfalls

5.6.1 Every drain, outlet and storage shall be designed against a stated tailwater. A free outfall shall be assumed only where the outlet invert is above the maximum receiving water level for the case being checked.

5.6.2 **Minor-system tailwater, non-tidal.** The tailwater is the receiving system's water level at the time of the minor-system peak, from the downstream model. Where no model exists, use:

- for a receiving pipe, its obvert; or
- for a receiving open drain, its full-bank level less freeboard (Chapter 6).

5.6.3 **Major-system tailwater, non-tidal.** The tailwater is the receiving system's 1% AEP water level, unless Clause 5.8 allows a coincident lower level.

5.6.4 **Tidal and backwater outfalls.** Clauses 5.7 to 5.13 apply in addition.

5.6.5 **Storage elements.** Detention, tanks and pumped sumps shall be routed with a time-varying tailwater (Clause 4.6.6), not a constant level, wherever the tailwater varies with tide or with the receiving system's hydrograph.

5.7 Tidal tailwater: datums, surge and sea-level allowance

5.7.1 **Design tailwater levels.** For outfalls to the sea, tidal creeks, estuaries, backwaters and tidal reaches of rivers and canals:

Table 5.1 — Design tailwater levels for tidal outfalls

Design case	Tailwater
Minor-system design (Chapter 6)	**MHWS + SLA**
Major-system design and storage design	**HAT + surge + SLA**, with the surge term defined in Clause 5.7.3
Joint case (Clause 2.12(b))	1% AEP still-water level + SLA

The SLA is **+0.3 m minimum** (Clause 5.7.4). The cases to be run are listed in Clause 5.9.

5.7.2 **Sources and datums.**

- (a) **Tidal levels.** MHWS, HAT and MSL shall be taken from the current edition of the Indian tide tables published by the National Hydrographic Office (NHO) or by the Survey of India, for the nearest standard or secondary port, or from the port authority's published tidal levels. The edition and port shall be stated.
- (b) **Datum conversion.** Tide-table heights are referred to chart datum. They shall be converted to the project datum through a documented connection between chart datum, the tide gauge zero and a Survey of India benchmark. The offset and its source shall be stated on Form 5-1.
- (c) **Estuaries, creeks and canals.** For outfalls inside estuaries, creeks, backwaters or tidal canals (for example the estuaries of the coastal States; there is none in Arunachal Pradesh, Clause 5.1.4), tidal levels may differ from the open coast. Open-coast levels shall be used unless measured levels over at least one spring–neap cycle, or a calibrated hydrodynamic model, justify a different value. No reduction below open-coast levels shall be taken without such evidence.
- (d) **Interim.** Until Annex 5A is published, the designer shall obtain the values directly from the sources in (a) and record them.

5.7.3 **Storm surge.**

- (a) **Major-system and storage design.** The surge term in "HAT + surge" is the **10% AEP (10-yr) storm surge** for the coastal segment, given in Annex 5A. The 1% AEP surge is used only in the joint case of Clause 2.12(b), with the 10-yr 48-hour storm. That keeps the two cases symmetric, so that a rare rainfall is never paired with a rare surge.
- (b) **Joint case.** The 1% AEP still-water level for Clause 2.12(b) is taken from Annex 5A.
- (c) Until Annex 5A is published, both values shall be taken from a site-specific study using INCOIS, IMD or NCCR surge hindcasts or return-level analyses. The study shall state its source, method and record length.

- (d) Wave set-up shall be added where the outfall faces the open sea without a protected entrance.

5.7.4 **Sea-level allowance.** The SLA shall be:

- (a) **+0.3 m** minimum for every element;
- (b) greater than 0.3 m where the State, the Itanagar Planning Authority or the Authority adopts a higher projection for the planning area; and
- (c) assessed for the design life of the element. For elements with a design life of more than 50 years, the designer shall report the effect of a sea-level rise of twice the SLA as a sensitivity run.

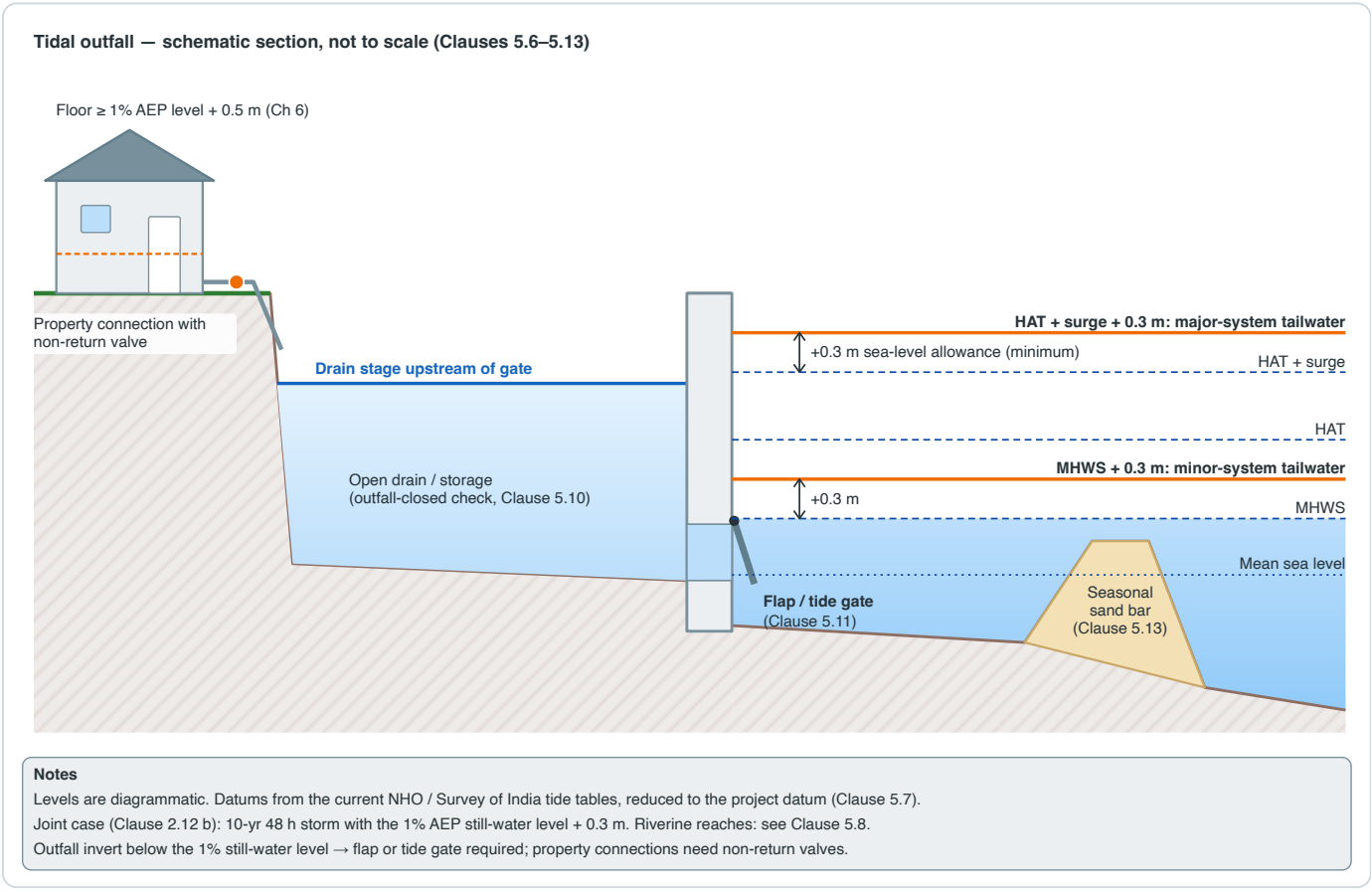

Figure 5.2 — Tidal outfall: flap gate, property non-return valve, and the design tailwater levels (MHWS + 0.3 m for the minor system; HAT + surge + 0.3 m for the major system), with a seasonal sand bar at the mouth. Schematic, not to scale. Original drawing for this Manual, adapted from the tidal tailwater table in MoHUA/CPHEEO Manual on Storm Water Drainage Systems (2019), Part A, Table 6.2.

Commentary. CPHEEO (2019) Table 6.2 sets the design tailwater for coastal outfalls as:

- MHWN to MHWS for a minor storm (more frequent than 1 in 5 years);
- MHWS to HAT for a major storm; and
- "Effect of climate change: additional 0.3 m".

CPHEEO also says the joint probability of storm, tide and surge "should" be considered, with the state maritime board consulted. This Manual takes the upper end of each CPHEEO range, adds surge for the major system, and makes the joint case explicit (Clause 2.12). CPHEEO does not require surge to be added; this Manual adds it because the surge records of the coastal States showed why it is needed there; Arunachal Pradesh has no coast, and the surge term does not arise in the State, which a Bay of Bengal storm reaches only as rainfall on its foothills and ranges, as the remnants of Cyclone Remal did on 28–29 May 2024 (Chapter 2).

> Indian tide tables have been published by the Survey of India since the nineteenth century (Survey of India, Tidal Predictions). Current Indian tidal predictions also appear in the NHO's tide tables. One port document describes the current edition as covering 95 Indian ports, based on NHO observations and on data from civil ports, NIO and INCOIS (Adani Ports, Dahej tide table 2025, citing NHO INP-12). INCOIS runs coastal tide gauges and issues storm-surge and swell-surge warnings. None of these is used for design in Arunachal Pradesh, which has no coast, and Annex 5A is not prepared for the State (Clause 5.1.4).

5.8 Riverine backwater

5.8.1 **Where it applies.** Outfalls to rivers and canals whose water level in a storm can exceed the outfall invert shall be designed with riverine backwater. This includes:

- the **Senki**, the **Pachin** and the **Dikrong** in the Itanagar capital region at **Itanagar**, **Naharlagun**, **Nirjuli**, **Doimukh** and **Banderdewa**, **Papu Nallah**, and the nallahs that drain the capital to them, with the Dikrong below the Pare dam and the Ranganadi tailrace (Clause 5.8.5(a));
- the streams and nallahs of the hill towns, among them those of the **Modirijo** and **Donyi Polo** catchments at Itanagar and the streams of **Ziro**, **Bomdila**, **Tawang**, **Seppa**, **Daporijo**, **Aalo**, **Khonsa**, **Changlang**, **Yingkiong** and **Anini**, and the side streams of main rivers, such as the stream that flooded Poosa and the NEEPCO colony at **Yazali** (Clause 5.8.5(b));
- the **Siang** at **Pasighat** and its side channels, the **Lohit** at **Tezu**, the **Noa-Dihing** at **Namsai** and **Miao**, the **Dibang** at **Roing**, the **Kameng** at **Bhalukpong** and the **Subansiri** at **Daporijo** (Clause 5.8.5(c));
- the reaches below the **Pare**, **Ranganadi**, **Kameng** (Bichom and Tenga) and **Lower Subansiri** dams and the **Dibang** project, and their reservoirs (Clauses 5.8.3 and 5.8.5(d));
- the main stems of the **Siang**, **Dibang**, **Lohit**, **Subansiri**, **Kameng** and **Tawang Chu**, and every stream below a glacial lake, a moraine or landslide dam or a mapped debris fan (Clause 5.8.5(e));
- the **Lohit**, the **Burhidihing**, the **Subansiri**, the **Ranganadi** and the **Kameng** (Jia Bharali) where they leave the State, whose CWC sites lie in Assam (Clause 5.8.5(f));
- the ponds, among them the ponds of the capital region that receive its drains and sewage (Clause 5.8.5(g));
- any drain or channel of the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Department of Urban Affairs, a Smart City company, PWD or PWD (Highways), and any drain or stream on community or clan land, that receives storm water (Clause 5.8.5(h)); and
- elsewhere: any river or WRD channel listed in Annex 5B.

5.8.2 **River levels.** River water levels shall be taken from:

- (a) WRD design flood levels or recorded highest flood levels for the reach, where published; or
- (b) a hydraulic model (HEC-RAS or equivalent) of the river reach. The model shall use:
  - the river design flood from a hydrograph method (Chapter 3), with continuous simulation where Chapter 3 requires it;
  - the tidal boundary of Clause 5.7 at the mouth; and
  - the sand-bar condition of Clause 5.13.

5.8.3 **Reservoir and tank releases.** Where a reservoir or tank upstream can release to the river (for example NEEPCO's Pare dam on the Dikrong above Doimukh, whose releases run past Doimukh, Nirjuli and Naharlagun, and its Ranganadi (Panyor) project at Yazali, which diverts Ranganadi water into the Dikrong and releases into the lower Ranganadi), the river level shall include the release given by the reservoir's operating rule for the storm being checked. Where there is no published rule, it shall include the largest recorded release.

5.8.4 **Coincidence of site storm and river flood.** Unless a joint-probability study is accepted by the Authority, the more severe of the following governs:

- (a) the site design storm (AEP as required), with the river at its **10% AEP (10-yr)** level; and

- (b) the site **10% AEP** storm, with the river at its design-AEP level (1% AEP for the major system).

The two storms in each pair shall have the same duration and timing where they are generated by the same rainfall event.

5.8.5 **The capital's nallahs and the Dikrong, hill-town streams, the main stems at Pasighat, Tezu, Namsai and Roing, reservoirs and release reaches, outburst and landslide-dam reaches, the Assam reaches, ponds, and consents and lines.**

- (a) **The capital's nallahs to the Senki, the Pachin and the Dikrong.** For an outfall in the Itanagar capital region (sub-area AR-A of Annex 2A) to the Senki, which runs through Itanagar to the Pachin; to the Pachin, which "passes through most of the area before it debouches to Dikrang river near Nirjuli" (CGWB, as cited); to the Dikrong at Naharlagun, Nirjuli and Doimukh, including through Papu Nallah; directly, through a gate or flap gate in a bank or wall, or through a pumping station; or into a nallah or drain that ends in one of them, as the town's drains do: they "end up mostly into the Nallah and in some cases, into local ponds or open fields" (Master Plan of Itanagar Capital Region-2031, report):
    - **No CWC site and no State level.** There is no CWC site on the Senki, the Pachin or the Dikrong in the capital region (SANDRP's 2019 transcription of CWC tables, as reported), and no gauge level of WRD, the Itanagar Municipal Corporation (IMC) or any other body for these rivers was found during research [TBC]. The Dikrong below Doimukh carries the releases of NEEPCO's Pare dam above it (item (d)), and the tailrace of NEEPCO's Ranganadi project, which diverts water from the Ranganadi into the Dikrong (160 m³/s, against an observed Dikrong flood flow of about 2,500 m³/s, in a 1994 CWPRS study, as reported). Every level used shall name its gauge and its datum; where no gauge exists, the designer shall say so on Form 5-1.
    - **Two failure cases.** The capital's drains fail in two ways, and both shall be checked: (i) **with the river low and the drains blocked**, as on 23 June 2024, when "As per IMD, the rainfall recorded today was 40 mm between 10:30 am and 12:30 pm" (the disaster management secretary, as quoted) and at least 66 houses in Itanagar and Naharlagun were inundated (as reported), and wherever drains "chocked with the solid wastes" and "heavy silting" (Master Plan report) stop the flow: the drain is routed to a free outfall with its section as surveyed, net of silt, solid waste, slide debris, vegetation and encroachment, and with its culverts and inlets blocked as Clauses 6.3.6(h) and 6.3.6(m) require; and (ii) **with the river high and the outfalls backed up**: the tailwater of this item applies, with the Dikrong carrying the release of item (d).
    - **Interim design tailwater.** For the major-system and storage cases (Clause 5.8.4(b)), the tailwater at an outfall to the **Dikrong** shall be the higher of: (i) the **1% AEP level at the outfall** from a hydraulic model (Clause 5.8.2(b)) of the Dikrong and the nallah, from the outfall to beyond the next confluence downstream, with the rainfall of sub-area AR-A on the valley and of the river's own sub-areas in the hills above it (Clause 2.3.6), the AMC of Clause 3.8.4, the release of item (d) from the Pare dam and the Ranganadi tailrace, and the channel as surveyed in its present condition, net of encroachment, silt, solid waste and vegetation; and (ii) the Dikrong at the **flood mark of the largest recorded release**, that of 31 May 2025, when the Pare dam's peak discharge was reported at 1,310 m³/s (as reported), surveyed at the outfall or transferred to it with the water-surface slope of the model or of the surveyed marks, and tied to a Survey of India benchmark. The design shall be **checked** with the river at the **1999 flood mark**, the flood that residents cite as the benchmark from Jampa to Doimukh (as reported), and at the highest flood mark surveyed at the outfall from the floods of 2017, September 2018, June and July 2024 and May–June 2025 or a later flood, from debris lines, silt marks and the accounts of residents, and from the records of IMC, WRD, the Deputy Commissioner, Itanagar Capital Complex, or the community, with its source stated, with the outfall closed and the stored volume held; where that check level is above the design level, the floor levels of Clause 6.11 and the storage of the outfall-closed check are set from it. For an outfall to the **Senki or the Pachin**, the tailwater is the higher of the 1% AEP level from the model of item (i), run with the Dikrong at the design level of this item at the Pachin's confluence near Nirjuli as its downstream boundary, and the highest flood mark surveyed at the outfall from those floods. For the cases with the river at its 10% AEP level (Clause 5.8.4(a)) and for the minor-system tailwater, the river stands at its 10% AEP level from the

same model, or at the design level of this item until that level has been computed. No flood mark has yet been surveyed or tied to a datum [TBC], and no outfall to these rivers or their nallahs shall be designed without item (i) and the flood-mark survey (set by this Manual).

    - **Gates, flap gates and pumps.** Where an outfall passes through a gate or flap gate, or a pumping station, the designer shall identify the body that operates each, and obtain the sill of each gate, the crest of the bank or wall, the installed pumping capacity and the operating levels, including the river level at which each gate is closed, every level with its datum and its tie to the gauge used. No gate, flap gate or pumping station on any outfall in the capital region, and no operator or operating rule for one, was found during research [TBC]. At a gated outfall the tailwater is the higher of the river level beyond the gate and the maximum level in the drain behind it, computed by routing the drain as a closed storage for as long as the river stands above the level behind it, with the inflow of its whole catchment, its storage as surveyed in its present condition, net of silt, encroachment, solid waste and vegetation, and an outflow of no more than the pumping capacity that the operator confirms in writing is available in a storm, and in no case more than the installed capacity of the permanent pumps less the largest pump, with gravity discharge through the gate only while the river is lower than the level behind it (set by this Manual). A pond behind the gate starts the storm full to its outlet level (item (g)). Portable dewatering pumps brought in for an event, and capacity that has been sanctioned or proposed but not commissioned, shall not be counted. Pumps shall deliver against the design level of this item, and every pump, panel and control shall remain operable with the river at that level and the land behind the bank ponded (Clause 5.12.5).
    - **River lock.** The outfall-closed check of Clause 5.10 applies with a single lock: the outfall stands at the design tailwater of this item for the **whole of the 72-hour storm** of Clause 5.10.2, and where a gate or flap gate would shut, no gravity discharge is credited for **not less than 72 hours**, or for as long as a stage record or the model shows the river above the outfall invert, or above the level at which the gate is closed if that is lower, where that is longer (set by this Manual). The lock covers the whole of the 48- and 72-hour storms, so that storage and pumping handle the full storm volume (Clause 5.9.4). With the gate still closed, the volume stored in the storm shall be **pumped down** to the level at which the storm started within **48 hours** of the end of the storm, the drawdown time of Clause 4.7, so that the storage is ready for the next storm while the river stays high (set by this Manual). A shorter lock may be used only where the outfall invert is above the design level of this item, or where an analysis of a stage record under Clause 5.10.6 shows it and the Authority approves it.
    - **Gate failure, encroachment and works not built.** Floor levels and pumped outfalls behind a gate, wall or bank shall also be checked with the gate failed open and the land and drains behind it filled to the river level beyond it. Buildings, fill and dumped waste in a nallah or river channel, including the Pachin, which "flowing through densely populated areas had become a waste disposal site" (Master Plan report), are not channel and shall not be counted as conveyance or storage; a drain, widening, desilting or diversion that has been proposed but not completed, such as the new drainage network proposed in the Master Plan (Maps 28–30), shall not be counted.
- (b) **Hill-town streams.** For an outfall to a stream or nallah of the hills, in the hill rim of sub-areas AR-A and AR-A1 and in sub-areas AR-C1, AR-D and AR-E, such as the streams that came down the Modirijo and Donyi Polo catchments to the Senki in September 2018, and the streams of Ziro, Bomdila, Tawang, Seppa, Daporijo, Aalo, Khonsa, Changlang, Yingkiong, Anini and the other hill towns, or to a drain that ends in one:
    - **No gauge.** None of these streams has a gauge or a published flood level [TBC]. They are steep and short, rise within minutes of a burst of rain, and carry gravel, boulders and slide debris from slopes of Siwalik sandstone, shale and boulder beds, of residual soil and slope debris, and, in the high ranges, of gneiss and schist, and below the towns they carry garbage. In the floods of September 2018 the Senki View culvert and the Press Colony bridge were washed away, and a landslide from "the dumping area of NH 415" was reported (as reported). The receiving system of each outfall shall be confirmed by survey.
    - **Design level.** The tailwater for the major-system and storage cases shall be the highest of: (i) the 1% AEP level at the outfall from a study of the stream, made with a hydrograph method of Chapter 3 for the whole catchment above the outfall, with the rainfall of its sub-area under Clause 2.3.6, the AMC of Clause 3.8.4 and the bulking factor of Clause 6.3.6(g) on the peak flow, and routed through a hydraulic model (Clause 5.8.2(b)) of the channel as surveyed, net of encroachment, silt and solid waste, with the crossings

downstream blocked as Clauses 6.3.6(h) and 6.3.6(m) require; (ii) the level at the outfall of any flood study of the stream made by or for WRD or the local body, where it gives one [TBC]; and (iii) the highest flood level surveyed at the outfall from flood marks, such as debris lines, silt and scour marks and the accounts of residents, of the floods of September 2018, June and July 2024, May–June 2025 or a later flood, and from the records of the local body, the Deputy Commissioner or the community, with its source stated. No outfall to such a stream shall be designed without items (i) and (iii) (set by this Manual).

  - **The side stream, not the main river.** Where a town lies beside a main river and a side stream enters it, the side stream's flood is a design case of its own. At Yazali the flash flood at Poosa and the NEEPCO colony came from a side catchment of about 17 km² while "the main river stayed in its channel" (EastMojo, 2026, as reported): 1 dead and 4 missing, with about 18 quarters or about 50 houses washed away (as reported), on 24 June 2026 in one report and 24 June 2025 in another, which dates its photographs to that year (as reported; the year is in conflict). There the side stream, studied under item (i), governs the town's outfalls, and the Ranganadi's level under items (c) and (d) is a further case to check, not the only one.
  - **Bed level, scour and aggradation.** The designer shall survey the bed of the stream at the outfall and for at least 100 m upstream and downstream, and state the range within which the bed has moved, from past surveys, cross-sections, exposed foundations and pipes, and the records of the local body. The outfall invert, and the seat of any flap gate on it, shall stand at least **0.5 m above the highest bed level** found in that range within 50 m downstream of the outfall, and the foundation of the outfall structure and its apron shall be taken below the scour depth computed under Chapter 9 (Clause 9.6) for the 1% AEP flow with the bulking factor (set by this Manual).
  - **Siting.** An outfall shall be built into the bank and shall not project into the bed or the active channel, taken for this Manual as the land flooded once in 5 years (set by this Manual). It shall discharge in the direction of the stream's flow, with the bank protection and the energy dissipation that Chapter 9 requires at every outfall onto a slope or into a ravine, and no pipe, interceptor or chamber of the drainage system shall be laid along the bed of the stream. No muck, spoil or excavated material from the works shall be placed in the stream or where a storm can carry it into one (Clause 6.3.6(k)). No outfall shall discharge onto an unprotected slope, to a spring or its recharge area, or to a stream above a spring or an intake that supplies a town or village, such as the Senki above the intake of Itanagar's lift supply (Chapter 7) (set by this Manual).
  - **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall-closed check of Clause 5.10 applies with a single lock that lasts for the design storm plus the stream's recession, computed under item (i) for as long as the stream stays above the invert, and **not less than 24 hours**; where the 48- and 72-hour storms of Clause 5.10.2 are run, the lock lasts for the whole storm, and where no hydrograph of the stream has been computed, for the whole storm (Clause 5.9.4) (set by this Manual). Where the stream itself ends in a river backed up under item (a) or (c), or in a release reach of item (d), the longer lock governs.

- (c) **The main stems at Pasighat, Tezu, Namsai and Roing.** For an outfall in sub-areas AR-B and AR-C, or anywhere else, to the main stem of a large river, the Siang at Pasighat and its side channels, the Lohit at Tezu, the Noa-Dihing at Namsai and Miao, the Dibang at Roing, the Kameng at Bhalukpong or the Subansiri at Daporijo, directly, through a gate or flap gate, or into a channel that ends in one:
  - **The CWC sites.** The CWC sites in the State, as transcribed by SANDRP in 2019 from CWC tables (as reported; the datum is CWC's and is not stated [TBC]), are: level-forecast sites on the Siang at **Passighat** (warning level 152.96 m, danger level **153.96 m**, highest flood level **157.54 m** on 11 June 2000), on the Noa-Dihing at **Namsai** (warning level 144.8 m, danger level **145.8 m**, highest flood level **146.6 m** on 31 August 1974, values that SANDRP says were "changed without explanation") and on the Siang at Yinkiang (Yingkiong) (warning level 303.0 m, danger level 304.0 m, no highest flood level); and level-monitoring sites, with a highest flood level only, on the Lohit at **Tezu** (**192.14 m**, 16 July 1996), the Subansiri at Daporizo (Daporijo) (213.9 m, 15 October 1987), the Ranganadi at Yazali (623.1 m, 14 June 2008), the Noa-Dihing at **Miao** (**241.57 m**, 9 July 2004), the Siang at Tuting (420.43 m, 6 September 2010), the Lohit at Kibithu (1,229.8 m, 25 July 2016) and the Subansiri at Lemeking (1,107.16 m, 27 July 2016). There is no CWC site on the Dibang, and none on the Kameng at Bhalukpong.

    - **The stage is set upstream.** On these rivers the level at a town outfall is set by rain, snowmelt, outbursts and releases far above the town, not by the town's storm. The Passighat highest flood level is an **outburst stage**: it was set on 11 June 2000 by the flood from the breach of the Yigong landslide dam in Tibet, 3.58 m above the danger level (CWC's levels as reported), and a peer-reviewed analysis gives "a recorded rise of 5.5 m at the Pasighat gauge, 462 km downstream" (as summarised); press reports of a "30 m" rise do not agree with the gauge and are not used.
    - **Interim design tailwater.** For the major-system and storage cases, the tailwater at the outfall shall be the **CWC danger level at the nearest site on the same river**, transferred to the outfall by a survey that ties the outfall, the gauge zero and a Survey of India benchmark, with the water-surface slope of a model or of surveyed flood marks between them (set by this Manual): at Pasighat **153.96 m** at the Passighat site and at Namsai **145.8 m** at the Namsai site, before transfer. The design shall be **checked** with the river at the **CWC highest flood level**, transferred in the same way (Passighat 157.54 m; Namsai 146.6 m), with the outfall closed for the whole storm (Clause 5.9.4); the floor levels of Clause 6.11, the flood immunity of pumps and controls (Clause 5.12.5) and the storage of the outfall-closed check are set from it where it is higher. At Tezu and Miao, where only the highest flood level was transcribed, and at Daporijo, the **highest flood level is both the design and the check level** until CWC gives a danger level [TBC]. At Roing and Bhalukpong, which have no site, the tailwater is set as in item (a), by a model and surveyed flood marks (the interim river rule of the hill editions of this series). In every case the 1% AEP level from a hydraulic model of the reach (Clause 5.8.2(b)) governs wherever it is higher. For the cases with the river at its 10% AEP level (Clause 5.8.4(a)) and for the minor-system tailwater, the river stands at the danger level, or at the 10% AEP level of the model where no danger level exists.
    - **Gates, flap gates and storage.** An outfall whose invert lies between the danger level and the highest flood level shall have a flap gate (Clause 5.11) and the storage, or the pumping, that holds the storm while the river stands above the invert; no outfall to a main stem shall rely on gravity discharge at the check level. No gate, flap gate or pumping station on any main-stem outfall, and no operator for one, was found during research [TBC]; where one exists or is proposed, the routing, pump and gate-failure rules of item (a) apply to it.
    - **River lock.** The lock of item (a) applies: the outfall at the design tailwater for the whole of the 72-hour storm, no gravity discharge for not less than 72 hours where a gate or flap gate would shut, or longer where a stage record shows the river above the invert for longer, and pump-down within 48 hours (set by this Manual). No stage hydrograph of any of these sites was found [TBC]; a stage record, once obtained, governs under Clause 5.10.6.
    - **Erosion and channel shift.** These towns stand on bhabar fans and flood plains whose rivers move. At Pasighat the Siang has eroded land at Jarkong near the airfield (2024) and at the Mebo villages of Seram, Kongkul, Namsing, Gadum-I and Gadum-II and Mer (as reported), against which WRD has carried out anti-erosion schemes (₹35 crore under DoNER in 2019, with a proposal of ₹228–250 crore pending, as reported). An outfall shall not be placed on a bank that is eroding or in an avulsion channel of a fan; it shall be set back from the bank as Chapter 7 requires, and its foundation and apron taken below the scour depth computed under Chapter 9 (Clause 9.6). These reaches are hazard-first sites (Clause 2.3.6(i)): no outfall, pumping station or storage shall be placed in the path of a channel shift.
- (d) **Reservoirs and release reaches.** For an outfall to the reach of a river below a dam, among them the **Dikrong** below NEEPCO's Pare dam, the **Ranganadi** below NEEPCO's Ranganadi (Panyor) project at Yazali, the **Kameng** below the Bichom and Tenga dams of NEEPCO's Kameng project, the **Subansiri** below NHPC's Lower Subansiri project at Gerukamukh, and the **Dibang** below NHPC's Dibang Multipurpose Project, which is under construction (status not researched [TBC]), or to a reservoir itself:
    - **Operator data.** NEEPCO and NHPC operate the dams. Their levels, spillway ratings, operating rules and release records, in writing, are the data this item needs, and the designer shall ask the operator for them; this Manual does not make NEEPCO or NHPC an approving authority. Work in or on the river below a dam needs WRD's consent (item (h)), and the owner's or the community's agreement for community, clan or private land.

- **Reservoir outfalls.** For an outfall to a reservoir, the tailwater for the major-system and storage cases is the reservoir's **maximum water level (MWL)** as its operator publishes it, or **FRL plus the surcharge in its design flood**, computed from the rating of its spillway with the gates operated only as the operator's written rule provides; where neither has been published, it is **FRL + 0.5 m** (set by this Manual) [TBC], and in every case not less than the highest level recorded at the reservoir. No full reservoir level, maximum water level or datum for any of these reservoirs was found during research [TBC]. The reservoir starts every design storm at its full reservoir level, which is also the minor-system tailwater, and an outfall below the design level is closed for the **whole of the 72-hour storm** of Clause 5.10.2 and of every shorter storm, with storage and pumping handling the full storm volume (Clause 5.9.4). The drawdown zone is part of the reservoir, and no outfall structure, pumping station or storage shall be built in it.
- **Release reaches.** For an outfall to a river below a dam, in addition to the cases of Clause 5.8.4, the site design storm (each AEP required) and the 72-hour storm shall be run with the river at the level that results from the **largest recorded release** of the dams above, routed to the outfall, with the flow of the catchment below them as it occurred, and with the release placed before, during and after the site storm (set by this Manual). Until the operator states a larger recorded release and its duration, the releases are: on the Dikrong, the Pare dam's peak discharge of **1,310 m³/s** on 31 May 2025 (as reported), with the Ranganadi tailrace of 160 m³/s (as reported) added; and on the Ranganadi below Yazali, **1,412.57 m³/s**, the release of 9 July 2017 into the lower Ranganadi (an IIT report prepared for the Assam State Disaster Management Authority, as summarised), checked at Yazali against CWC's highest flood level of 623.1 m (14 June 2008, as reported). On the Kameng, the Subansiri and the Dibang no release or flood record was found [TBC]; the Lower Subansiri project, of 2,000 MW, put its first unit into commercial operation on 23 December 2025 and reached 1,000 MW with its fourth, with the rest targeted by December 2026 (as reported). There the release is the dam's **spillway capacity**, which the designer shall obtain from the operator in writing [TBC], and no outfall to those reaches shall be designed without it (set by this Manual). The lock of item (a) applies for **not less than 72 hours**, and, where the outfall invert is below the river level of the release, for as long as the release lasts where the operator gives its duration [TBC] (set by this Manual). No attenuation by the storage of any reservoir shall be credited to the river below, and no gate shall be assumed to open earlier or wider than the operator's records show. These reaches are hazard-first sites (Clause 2.3.6(i)).
- **Release scenarios, not notices.** No release protocol or warning threshold of NEEPCO or NHPC was found during research [TBC]; NEEPCO issues monsoon advisories on controlled releases through the Pare dam's radial gates, the latest seen in June 2026 (as reported), and those are notices. No design shall rely on a notice or warning of a release, on a reservoir being drawn down before a storm, or on a gate being opened early, late or partly: the release scenarios of this item govern (set by this Manual). The Pare dam is also credited in the press with having eased the 2025 floods from Jampa village to Doimukh (as reported); the scenarios hold whether or not a dam eases a flood, because they do not credit it.

- (e) **Outburst and landslide-dam reaches.** For an outfall on the main stem of the Siang, the Dibang, the Lohit, the Subansiri, the Kameng or the Tawang Chu, or on any stream below a glacial lake, a moraine or landslide dam, or a mapped debris fan, the outburst screening of Clause 2.3.6(i) shall be recorded in the drainage report, and the design is not complete without it. The evidence is the State's own: the Yigong outburst of June 2000 "washed out every bridge downstream from Yigong Tso to Pasighat" (as reported), with deaths given as 30 in some reports and more than 100 in others, some of them counting Assam (as reported; in conflict); in November 2017, after landslide dams formed in Tibet, the Siang at Pasighat was turbid at 425 NTU on 27 November (as reported); landslide-dam alerts were issued along the Siang in October 2018 (as reported); NDMA lists 27 high-risk glacial lakes in the State, 6 in Tawang, 1 in Kurung Kumey, 1 in Shi Yomi, 16 in Dibang Valley and 3 in Anjaw (as reported); an outburst of Sangnga Nehgu lake in Tawang is reported to have washed away "more than five bridges" (as reported; date not found); and CWC counted 197 expanding glacial lakes in the State in June 2025 (as reported). No drain, culvert or outfall is sized for an outburst. Where the screening shows that the site lies on the path of one, the siting, setback and floor-level rules of Chapters 6 and 7 govern: no outfall structure, pumping station or storage shall be placed in the path; every outfall to the reach shall have a flap gate (Clause 5.11); and floors shall stand 0.5 m above the higher of the 1% AEP level and the highest recorded outburst level, which at Pasighat is the highest flood level of 157.54 m transferred to the site (set by this Manual). The Tawang Chu flows on into Bhutan, and no level for it was found [TBC].

- (f) **The Assam reaches.** The Lohit, the Burhidihing, the Subansiri, the Ranganadi and the Kameng leave Arunachal Pradesh and run into Assam, where the nearest CWC sites on them are (SANDRP's 2019 transcription of CWC tables, as reported; datum not stated [TBC]): the Lohit at **Dholabazar** (danger level 128.27 m, highest flood level 130.07 m, 22 September 2012); the Burhidihing at **Naharkatia** (danger level 120.40 m, highest flood level 122.69 m, 17 June 1973) and at Margherita (highest flood level 137.51 m, 26 August 1988); the Subansiri at **Chouldhowaghat** (danger level 100.43 m, highest flood level 101.31 m, 27 July 1972) and at **Badatighat** (danger level 82.53 m, highest flood level 86.21 m, 28 July 1972); the Ranganadi at its **NT Road crossing** (danger level 94.81 m, highest flood level 95.92 m, 2 July 1979); and the Jia Bharali, the Kameng below Bhalukpong, at its **NT Road crossing** (danger level 77.00 m, highest flood level 78.50 m, 26 July 2007). These sites lie tens of kilometres downstream and are not the tailwater of any Arunachal Pradesh town; **the Assam edition governs those reaches**. For an outfall in Arunachal Pradesh, a level at one of these sites, or a level that the Assam edition gives, is used only as a lower bound on the downstream boundary of a river model, which shall start far enough downstream that the boundary does not govern the level at the outfall; no level shall be carried upstream from these sites to an Arunachal Pradesh outfall (set by this Manual).
- (g) **Ponds as receiving storage.** For an outfall to a pond, natural or man-made, directly or through a drain that ends in it, such as the ponds into which the capital's drains and sewage run: the Master Plan report records "the sewerage being drained to open or vacant land as well as into ponds" and industrial effluents discharged untreated "into artificial ponds":
    - **Starting level.** The pond starts every design storm **full to its outlet level**: the crest of its outlet weir or overflow, the sill of its gate or the invert of the channel that drains it, or, where it has no defined outlet, its highest monsoon water line surveyed and tied to a Survey of India benchmark, and in every case not less than the highest level recorded at it (set by this Manual).
    - **Design level.** The tailwater for the major-system and storage cases is the level reached when the inflow of the pond's whole catchment is routed through its stage–storage relation from that starting level, with its outlet closed for as long as the nallah or river beyond it stands above the outlet (items (a) and (c)), and with the project's discharge included (Clause 5.12.3). The stage–storage relation shall be surveyed: none was found for any pond in the State [TBC]. The minor-system tailwater is the starting level.
    - **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall is closed for the whole storm (Clause 5.9.4), and where the pond itself drains to a river-backed outfall, the lock of item (a) applies to both. A pond with no outlet is a closed basin, and an outfall to it is closed for the whole storm.
    - **Storage is the system's.** The storage of a pond is part of the drainage system: it shall not be credited to one project, and no project shall reduce it; a Town Planning Scheme's "filling-up or reclamation of low-lying, swampy or unhealthy area" (Arunachal Pradesh Urban and Country Planning (Amendment) Ordinance, 2025, Ordinance No. 5 of 2025, whose final form as an Act was not found [TBC]) is subject to the compensatory storage of Chapter 7. Engineered storage is a detention pond; a natural pond or lake keeps its own description, and a spring pool or a reservoir is never a detention pond. **Ganga Lake** (Gyakar Sinyi), in the Itanagar Wildlife Sanctuary about 6 km from Itanagar (as reported), is a lake in a sanctuary and not storage: it shall not be counted as storage or detention for any project, and an outfall to it is subject to Chapter 7. Under the bye-laws, every urban local body and planning authority is "to identify, demarcate, protect and maintain the water bodies that come under their jurisdiction" and to prepare a list (APBBL 2019, Annexure E 1.8); no such list was found [TBC]. A pond on community, clan or private land needs the written consent of its owner or the community for any discharge to it; within the Pasighat municipal area public tanks vest in the Municipal Council (Arunachal Pradesh Municipal Act, 2007, s.102(b)), and in the IMC area public streams, springs and works for the storage of water vest in the Corporation (Arunachal Pradesh Municipal Corporation Act, 2019), whose consent is then also required (set by this Manual). No drain that carries sewage shall discharge to a pond without the interception and screens of Clause 6.3.6(e) and Clause 8.9.
- (h) **Consents and lines.** No outfall structure, gate, pumping station or drain shall be built in the bed, bank or floodplain of a river or on an anti-erosion work without the consent of WRD; the procedure for that consent was not found during research [TBC]. Storm water shall not be discharged to a drain of another body without the written consent of that body: to a public drain vested in IMC (Municipal Corporation Act, 2019, s.200), the consent of the Corporation, under its procedure for connections, which forbids "foul water into a drain provided

for surface water" where separate drains exist and any direct connection "with a storm water overflow drain" (s.203); to a drain of the Pasighat Municipal Council, which "shall … construct and maintain drains and sewers, and provide a safe and sufficient outfall" (Municipal Act, 2007, ss.102, 194 and 196), the Council's consent, no procedure for connections having been found [TBC]; to a road drain or culvert, that of the Public Works Department (PWD) or PWD (Highways); to a drain built by the Department of Urban Affairs or a Smart City company and not yet handed over, that of its builder; and to a drain or stream on community or clan land, that of the owners or the community, for which no written procedure was found [TBC] (set by this Manual). An outfall or drain carried across land that is not the applicant's needs the written agreement of its owner or, on community land, of the community: the beds of rivers, streams, nallahs, lakes and tanks are Government property only where they are "not the property of any person or community" (Arunachal Pradesh (Land Settlement and Records) Act, 2000, s.9(1)), so many nallah beds near the towns are not, and the Manual does not take land for an outfall; that agreement, recorded on Form 5-1, is the hook (set by this Manual). For a release reach or a reservoir, the operator's written data of item (d) are required. Where consent is given, the discharge shall not exceed the rate the consent allows; the tailwater is the higher of the channel's design water level as its owner states it in writing and its level in the coincident case of Clause 5.8.4, computed from all the storm water it receives and with its downstream boundary at the level of items (a) to (g); the channel shall be taken in its present condition, net of silt, solid waste, vegetation and encroachment and with its narrowest section as surveyed, and a widening, desilting or diversion that has been proposed but not completed shall not be counted; and the outfall shall have a flap gate (Clause 5.11) where the design water level or the computed level is above the outfall invert. The designer shall also check the outfall against the lines that bind at the time of design (Chapter 7): the bye-laws ask that the site plan show the "Distance from Nallah/Stream as per the notified rules/norms" (APBBL 2019, 2.10.1(e)), and no such rules or norms were found (NEER reading); *Jhot*, "A strip of land permanently left open for drainage purposes" (APBBL 2019, def. 69), has no width; the corridor of Clause 7.4 is this Manual's own proposal; no floodplain zoning law exists and no flood zone has been notified; and the bye-laws' plinth of "not less than 300 mm" (4.2.1.1) is not a flood level, so the 1% AEP level of this clause and the floor levels of Clause 6.11 govern. Orders of the National Green Tribunal, among them the direction of 5 January 2023 in OA 94/2020/EZ on the Senki, the Pachin and the Dikrong that "no untreated sewage or treated sewage be allowed to enter into the waterbody" (as summarised), are directions to their parties, not lines for this clause; their bearing on drains that carry sewage is dealt with in Clause 8.9.

No pump, gate or dam operation that helps drainage, such as pumping a drain, nallah or pond down before a storm, closing a gate late, opening a gate while the river is higher than the land behind it, or drawing down a reservoir or opening a dam's gates early, shall be assumed unless the operator's written records show it. Where the outfall invert is below the tailwater of this clause, the outfall shall have its own flap gate (Clause 5.11) and, where the outfall-closed check requires it, pumping (Clause 5.12), with the pumped volume included in the routing of the drain, the nallah, the pond or the river (Clause 5.12.3). Pumping shall not be used to move water into a pond, a reservoir or another catchment without the consent of its owner or custodian, or onto a slope.

> Commentary. In large continental river basins, a site storm and a river flood are usually treated as roughly independent. That is the basis of tables of coincident frequencies such as FHWA HEC-22 Table 7.3. Arunachal Pradesh's rivers break that assumption in both directions. In the capital region the Dikrong's catchment lies in the hills just above the towns, and the late-May storms that fill it fall on the towns too: the Pare dam's peak release of 1,310 m³/s on 31 May 2025 came in the statewide floods of late May and early June 2025 (as reported). On the main stems the river and the town's storm can be unrelated: the Siang's highest level at Pasighat was set by an outburst in Tibet in June 2000 (as reported), not by rain on the town, so the river can be high when the town is dry, and a town storm can fall on a river already high with snowmelt and the rain of the ranges. And beside a main river a side stream can flood while the river stays low: at Yazali the flash flood at Poosa and the NEEPCO colony came from a side catchment of about 17 km² while "the main river stayed in its channel" (EastMojo, 2026, as reported), so a local storm with the river low is a design case of its own (Clause 5.8.5(a) and (b)). The two cannot be treated as independent, and a local storm can fall before, during or after the river peak. Clause 5.8.4 therefore pairs a design event on one side with a 10-yr event on the other, in the same way as Clause 2.12(b). This pairing has no direct precedent. It is more severe than an independence assumption would give.

Clause 5.8.3 reflects the dams above the rivers of Arunachal Pradesh's towns. NEEPCO's Pare dam stands on the Dikrong above Doimukh: it issues monsoon advisories on controlled releases through its radial gates (the latest seen in June 2026, as reported), and its peak discharge on 31 May 2025 was reported at 1,310 m³/s, with the plant credited with easing the floods from Jampa village to Doimukh, where the 1999 flood is the local benchmark (as reported). NEEPCO's Ranganadi (Panyor) project at Yazali diverts Ranganadi water through a tunnel into the Dikrong, with a tailrace discharge of 160 m³/s against an observed Dikrong flood flow of about 2,500 m³/s (a 1994 CWPRS study, as reported), and released 1,412.57 m³/s into the lower Ranganadi on 9 July 2017 (an IIT report prepared for the Assam State Disaster Management Authority, as summarised), the same release that the Assam edition uses for the reach downstream; a change in the Dikrong's channel downstream was reported in November 2025 (as reported). NHPC's Lower Subansiri project, of 2,000 MW at Gerukamukh, put its first unit into commercial operation on 23 December 2025 and reached 1,000 MW with its fourth unit, with the rest targeted by December 2026 (as reported). No release or flood data were found for NEEPCO's Kameng project, with its Bichom and Tenga dams, and the status of NHPC's Dibang Multipurpose Project, under construction, was not researched [TBC]. No operator's release protocol, warning threshold, spillway rating, full reservoir level or release record was found for any of these dams, and no datum is stated for any level [TBC]. Until the operators give them, Clause 5.8.5(d) uses the largest release found (1,310 m³/s on the Dikrong, with the Ranganadi tailrace; 1,412.57 m³/s on the Ranganadi) and, where none was found, the spillway capacity in the operator's writing. The river levels downstream in Assam come from SANDRP's copies of CWC tables; their datum and gauge zero are to be confirmed with CWC [TBC].

Clause 5.8.5 is set by this Manual. In Arunachal Pradesh the tailwater at a town outfall is set not by the tide but by a river of the capital region that backs up into a nallah and carries a dam's releases, by a hill stream that no one gauges and whose bed moves, by a main stem whose stage is set far upstream, by a reservoir and the releases of its dam, by a river that runs out of the State into Assam, or by a pond at its outlet level, and no document found during research gives a design level for any of them. No design standard for any town drain in the State was found: the Arunachal Pradesh Building Bye-Laws, 2019 have no storm-water rule beyond the site plan of 2.10.1, the roof-water connections of 4.19.1.1 and the storm-water capture of 9.6, and the Master Plan of Itanagar Capital Region-2031 proposes a new drainage network "taking into consideration of the topography of the region and flow gradient" (report) without a design storm or return period. The State has no floodplain zoning law, and no flood level has been published for any reach of the capital's rivers (Chapter 7).

The first is the capital's nallahs. Item (a) treats them as a case of their own because the capital drains through them, because they carry its sewage as well as its storm water ("storm water drains being used as sewers", Master Plan report), and because they fail in two opposite ways: on 23 June 2024 a two-hour fall of 40 mm (IMD, as quoted), about a two-year storm, inundated at least 66 houses (as reported), with drains choked by solid waste and silt; and with the Dikrong high, the outfalls cannot discharge. A design checked only for one of these fails in the other, so item (a) asks for both. The Dikrong has no CWC site and no published level, so item (a) uses the interim river rule of the hill editions of this series, a model and surveyed flood marks, and adds the release: the design case is the Dikrong at the flood mark of the largest recorded release, the Pare dam's 1,310 m³/s of 31 May 2025 (as reported), because that is the river at its worst that people saw, and the check case is the 1999 flood mark, the local benchmark (as reported), with the marks of 2017, 2018, 2024 and 2025 beside it; the 1% AEP model stands beside both and governs wherever it is higher. This is the research's own recommendation, which has no datum yet [TBC]. The lock is not less than 72 hours and covers the whole 72-hour storm, the longest design storm of this Manual, because the Dikrong carries the multi-day rain of the hills behind the capital and the dam's releases on top of it; no stage record of the Dikrong was found to set a different period, and one, once obtained, governs under Clause 5.10.6 [TBC]. The 48-hour pump-down is the drawdown time of Clause 4.7: a storage still full when the next storm comes on a river that is still high does not exist for that storm. No gate, flap gate or pump was found on any outfall, so item (a) asks the designer to find the operator of each, as the Assam edition does, rather than assuming one.

The second is the hill stream. Item (b) follows the stream rule of the mountain editions of this series: a study with the bulking factor of Clause 6.3.6(g), surveyed flood marks, the higher of the two, and an invert at least 0.5 m above the highest bed level surveyed downstream, a margin set by this Manual for the aggradation that a stream

laden with slide debris can show in a single flood. The lock is the storm and the stream's recession, and not less than 24 hours, shorter than the 72 hours of the large rivers, because the streams are small and fall within hours of the rain stopping. Item (b) also names the side stream, because at Yazali the flood that left one dead and four missing came from a side catchment of about 17 km² while the Ranganadi stayed in its channel (as reported): a town beside a main river is not safe because the main river is.

The third is the main stem. Item (c) follows the Assam edition's form for outfalls backed up by a large river whose stage is set upstream, and uses the levels that CWC already watches. The danger level is the design case because it is the level that CWC forecasts and warns against at these sites; the highest flood level is the check, because at Pasighat it is an outburst stage, 3.58 m above the danger level, from a landslide-dam breach in Tibet (as reported), which no town storm can be designed to discharge against but which the floors, the pumps and the storage must survive. Where CWC transcribed only a highest flood level, at Tezu and Miao, that level serves for both until a danger level is given [TBC], which is conservative by design. The 7-day lock that the Assam edition uses on the Brahmaputra is not used, because no stage record of these reaches was found to justify it, and the check at the highest flood level already treats the outfall as closed for the whole storm; a stage record, once obtained, governs [TBC]. The towns on these rivers also lose their banks: an outfall placed on the eroding bank at Pasighat would be lost with it (as reported), so item (c) keeps outfalls off eroding banks and out of a fan's avulsion channels.

The fourth is the reservoir and its release reach. Item (d) follows the reservoir rule of the North-East hill editions. A reservoir at its full level does not fall for the rest of the season but passes its inflow over its spillway, so an outfall below its design level is closed for the whole 72-hour storm; no level of any reservoir in the State was found, so FRL + 0.5 m, the freeboard that this Manual uses for floor levels (Clause 6.11.1), is a floor, not an estimate of the surcharge [TBC]. On the Dikrong and the Ranganadi the largest release found is used, and the Ranganadi tailrace is added on the Dikrong, because the two arrive in the same river; on the Kameng, the Subansiri and the Dibang no release was found, so the spillway capacity in the operator's writing is required, which is conservative by design: a tailwater set too low floods a colony, while one set too high only costs storage. A warning helps people leave a reach but does not change the level an outfall must withstand, so item (d) designs for the release and not for the warning.

The fifth is the outburst. Item (e) does not size anything for an outburst, because no drain can be sized for the flood that "washed out every bridge downstream from Yigong Tso to Pasighat" (as reported); it asks that the outburst screening of Clause 2.3.6(i) be done and recorded, and that siting, setbacks and floor levels keep people and plant out of the path. The sixth is the river that leaves the State: item (f) names the CWC sites in Assam only to say that the Assam edition governs those reaches, and that a model of an Arunachal Pradesh outfall must reach far enough downstream that Assam's levels bound it from below and do not decide it.

The seventh is the pond, and the eighth the consents and lines. A pond that a drain fills is storage that the system needs, and item (g) starts it full to its outlet, as the plains editions of this series do for their wetlands, because a pond at the end of a wet week has no room left; a lake in a sanctuary, Ganga Lake, is not storage at all. Item (h) asks for the owner's consent and design level because a design that discharges to a channel, a river or a pond cannot be checked without them, and because the drains belong to several bodies and, on community and clan land, to no body the State appoints. The beds of streams and nallahs near the towns are often community land (Land Settlement and Records Act, 2000, s.9(1)), so an outfall across them needs the community's agreement; the Manual does not take land for an outfall. The lines of item (h) decide where an outfall can be built, not its level: the bye-laws refer to a distance from a nallah or stream "as per the notified rules/norms" that were not found, *Jhot* has no width, and the Manual's own corridor (Clause 7.4) is its proposal, so item (h) names them and applies none of them as law.

5.9 Joint-probability cases

5.9.1 Every element draining to a tidal or backwater-affected outfall shall be checked for the cases below. The most severe governs each design quantity: storage, water level, pipe size and pump capacity.

Table 5.2 — Joint-probability cases for tidal and riverine outfalls

Case	Rainfall	Tailwater	Applies to	Basis
J1	Minor-system design AEP, Tc to 24 h	MHWS + SLA (tidal curve)	Minor system	Clause 2.12(a); Clause 5.7.1
J2	1% AEP, all durations of Clause 2.5.2	HAT + surge + SLA	Major system, detention, tanks, pumped systems	Clause 5.7.1
J3	10% AEP, **48 h**	1% AEP still-water level + SLA	Major system, detention, tanks, pumped systems	Clause 2.12(b)
J4	Design AEP, **48 h** (72 h reported)	Tidal curve per J1 with two **6 h lock windows** (Clause 5.10)	All storage and every gated or tide-affected outfall	Clause 5.10
R1	Site design AEP	River at 10% AEP level	Riverine outfalls	Clause 5.8.4(a)
R2	Site 10% AEP	River at design-AEP level	Riverine outfalls	Clause 5.8.4(b)

5.9.2 For storage elements, the 48- and 72-hour storms shall be run with the J2 and J3 tailwaters (Clause 2.5.3).

5.9.3 For tidally influenced riverine outfalls, R1 and R2 shall be run with the river model's downstream boundary at the J1 tidal curve. The Authority may also require them at J2.

5.9.4 Where tailwater is constant at a level above the outfall invert for the whole storm, the case is treated as a fully closed outfall. Storage and pumps shall then handle the full storm volume.

> Commentary. Clause 2.12 sets two joint cases. Case (a) is design rainfall with MHWS plus the sea-level allowance. Case (b) is the 10-yr, 48-hour storm with the 1% still-water level. This Manual adds HAT plus surge for major-system design (Clause 5.7.1). Case J2 combines these. J4 is the outfall-closed check, which tests the timing of tide against the storm rather than a single level. Rainfall and surge share a cyclone cause, so they cannot be treated as independent (Clause 2.12 commentary). These cases are simple surrogates, to be replaced when a statistical joint analysis of IMD rainfall and tide-gauge records is adopted.

5.10 Outfall-closed (tide-locked) storage check

5.10.1 **Where it applies.** The check applies to:

- every storage facility;
- every minor- and major-system element; and
- every pumped system

whose outfall invert is below HAT + surge + SLA, or which drains to a reach subject to tide-lock or sand-bar closure (Clause 5.13).

5.10.2 **Storm.** Use the 48-hour design storm built per Clause 2.9.2 (peak day last), at:

- the AEP of the element: 1% AEP for detention, tanks and the major system; the minor-system AEP for minor drains; and

- AMC III.

The 72-hour storm shall also be run and reported.

5.10.3 **Lock windows.** Unless a site study under 5.10.6 gives otherwise:

- (a) the outfall is closed for **two consecutive lock windows of 6 hours each**, centred on two consecutive high tides of the local tidal curve. For a semi-diurnal tide, the window starts are therefore about 12.4 hours apart.
- (b) During each lock window, gravity discharge is **zero**.
- (c) Between lock windows, gravity discharge is computed against the J1 tidal curve, including the head loss of the flap gate and any non-return valve.
- (d) The first lock window shall be placed so that it is centred on the peak 1-hour block of the final 24 hours of the storm. A second run with the first window **starting** at that peak block shall also be made. The more severe governs.

5.10.4 **Requirement.** Storage plus pumping (where provided) shall hold the inflow so that, throughout the check:

- (a) the maximum stage in any detention facility stays below its emergency spillway crest, so the spillway does not operate. Where the outfall-closed stage is higher than the 1% AEP maximum water level of the free-outfall design, it becomes the facility's 1% AEP maximum water level for Clause 4.9.3, and the spillway crest, freeboard and wall height are set from it;
- (b) the maximum stage in the minor and major systems meets the Chapter 6 limits: building floor levels, and street depths of no more than 150 mm at the crown and no more than 350 mm at the deepest point; and
- (c) no property connection surcharges above the lowest opening it serves, or a non-return valve is fitted under Clause 5.11.

In volume terms, over each lock window and the full storm:

> $V_{inflow} \le V_{storage\ available} + V_{pumped} + V_{gravity\ (between\ locks)}$

This shall be demonstrated by routing, not by a single volume balance. The release from each facility after a lock window ends may exceed the release caps of Chapter 4, because the facility is emptying into a drain that has just reopened. That release shall be included in the downstream analysis (Clauses 5.4 and 5.9).

5.10.5 **Drawdown after the storm.** After the second lock window, the storage shall drain under the J1 tidal curve. The drawdown requirement of Clause 4.7 shall be met, with pumping where gravity cannot meet it (Clause 5.12).

5.10.6 **Site study.** A longer or shorter lock may be used where a site study gives a time series of still-water level for the design case. The study may use a calibrated hydrodynamic model, gauge records of past events, or a surge hindcast. Locks shorter than the default require the Authority's approval. A longer lock shall be used where:

- sand-bar closure (Clause 5.13) or river backwater (Clause 5.8) keeps the outfall closed for longer; or
- the gauge record shows tailwater above the outfall invert for more than 6 hours per tide in comparable past events.

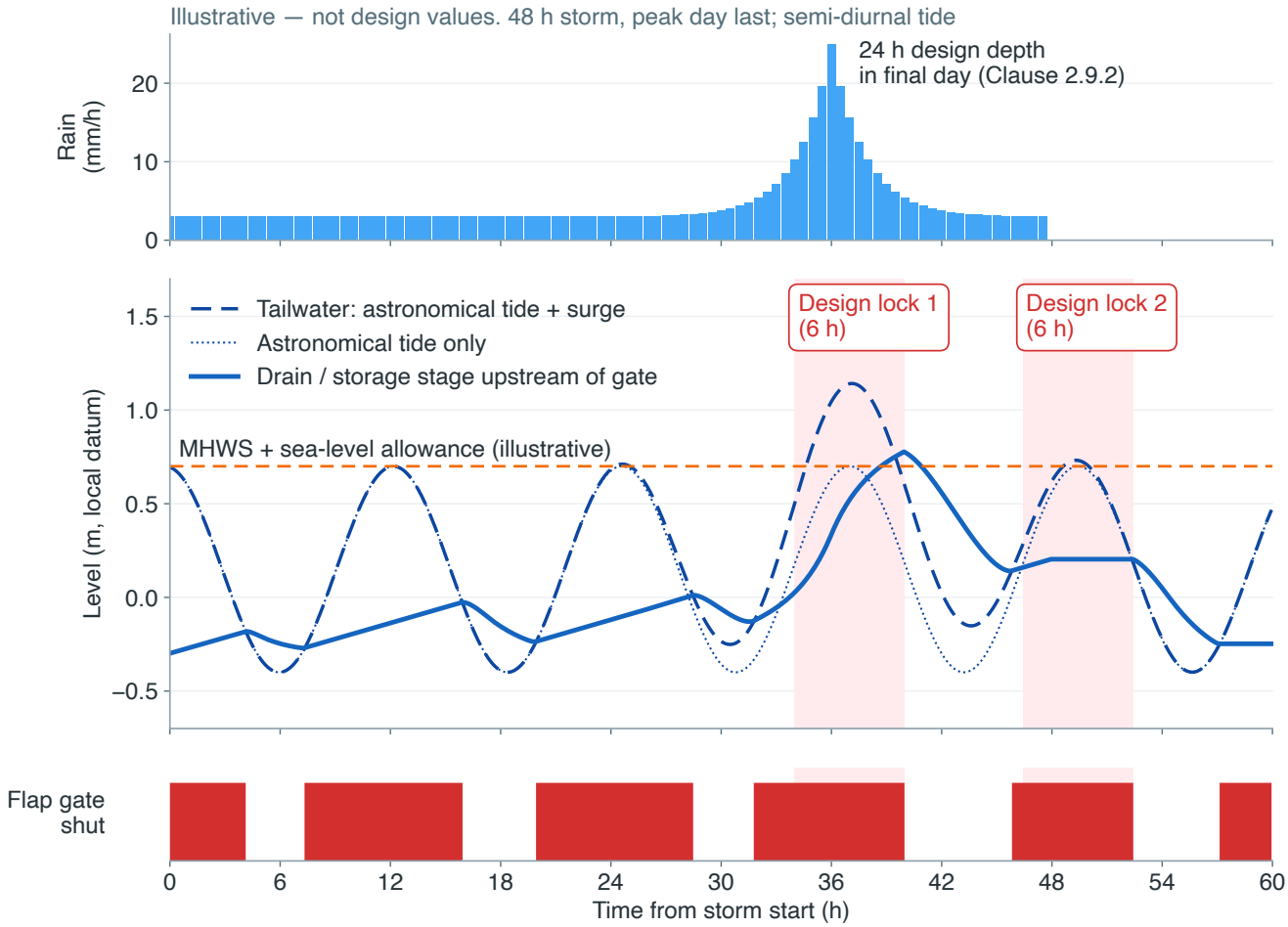

Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal tailwater and joint-probability concepts of MoHUA/CPHEEO Manual on Storm Water Drainage Systems (2019), Part A, §6.3.6.

Commentary. The outfall-closed check is the distinctive Arunachal Pradesh requirement in this Manual. In Arunachal Pradesh it applies where an outfall is shut not by the tide but by the Dikrong, the Senki or the Pachin backing up a nallah of the capital, by the Dikrong carrying the Pare dam's release, by a hill stream that has risen over the outlet or buried it in gravel, slide debris and garbage, by the Siang, the Lohit, the Noa-Dihing or the Dibang standing high at Pasighat, Tezu, Namsai or Roing, by a reservoir or the release of its dam, or by a pond at its outlet level. The main stems are set far upstream: the Siang at Pasighat reached its highest flood level of 157.54 m, 3.58 m above its danger level, in the outburst flood of June 2000 (CWC's levels as transcribed by SANDRP, as reported); and the storms that raise the rivers last for days, as in the 2026 season, which by 20 July had brought 173 landslides, 104 floods and 8 flash floods (the Department of Disaster Management, as quoted). That is why Clause 5.8.5 replaces the two 6-hour windows described below with a lock of at least 72 hours on the Dikrong and the main stems, held for the whole 72-hour storm, the storm and the stream's recession and at least 24 hours on the hill streams, at least 72 hours and as long as the release lasts on a release reach, and a closure for the whole storm at a reservoir or pond outfall below its design level and at a main-stem outfall checked at the highest flood level. A rate rule cannot help when there is no outlet: an orificed basin behind a closed gate simply fills.

The default of two consecutive 6-hour locks has no direct precedent. It represents gravity outfalls failing to discharge for about half of each tidal cycle around the two high tides nearest the storm peak. Figure 5.3 shows why both windows matter. The first lock catches the storm peak. The second arrives before the storage has drained, so the stage rises again.

> Placing the first window on the rainfall peak is deliberately unfavourable. Cyclone rainfall and surge share a cause, and Clause 2.12 already treats them as dependent. The check replaces neither the J2 and J3 level checks nor the downstream analysis; it adds a test of timing and volume.

5.11 Flap gates, tide gates and non-return valves

5.11.1 **Where required.** A flap gate, tide gate or equivalent non-return device is required on every outfall whose invert is below the **1% AEP still-water level** (Clause 5.7.3). It is also required on outfalls into irrigation channels under Clause 5.8.5.

5.11.2 **Hydraulics.** The design shall include:

- the gate's head loss and opening head, from the manufacturer's certified head–discharge curve; and
- the reduction in effective outfall capacity when the gate is partly open.

Gates shall not be assumed to seal perfectly in the outfall-closed check unless they are tested.

5.11.3 **Construction.**

- (a) Gates, hinges and seats shall be of corrosion-resistant materials suitable for seawater (Clause 4.12.5).
- (b) The gate shall be set so that sand, silt or debris on the downstream side cannot hold it shut or open. Where the bed is mobile, the gate invert shall be raised above the bed, or the approach shall be protected.
- (c) A trash screen shall be provided upstream where the gate could be jammed by debris.
- (d) A stop-log slot or penstock shall be provided upstream for maintenance isolation on outfalls larger than 600 mm.
- (e) The gate chamber shall be accessible at all tides, with its access above HAT + surge + SLA.

5.11.4 **Non-return valves on property connections.** A non-return valve, or a backwater valve with an accessible cleaning eye, is required on every property drainage connection where the lowest opening served is below:

- the major-system tailwater (J2) at the point of connection; or
- the maximum stage in the outfall-closed check (Clause 5.10).

Basement drainage shall in addition be pumped to a level above both, with its own non-return valve.

5.11.5 **Inspection.** Gates and valves shall be inspected and operated:

- before **31 March** each year;
- after every event in which they closed against a storm flow; and
- as set in the maintenance plan (Chapter 10).

> **Commentary.** The requirement for gates below the 1% still-water level is set by this Manual. The construction details follow common coastal-drainage practice. A gate that is jammed open by debris lets the tide into the drain. A gate held shut by a sand bank turns a gravity outfall into a dead end. In Arunachal Pradesh the outfalls do not cross a beach, but some of them end in a nallah or a river that backs up when the Senki, the Pachin or the Dikrong is high, some in the reach of the Dikrong below the Pare dam, and some in the main stems at Pasighat, Tezu, Namsai and Roing. No gate or flap gate on any town outfall in the State was found during research [TBC], so the gates that matter today are the radial gates of the dams above the towns: NEEPCO issues monsoon advisories on controlled releases through the Pare dam's radial gates (as reported), and the dam's peak discharge on 31 May 2025 was reported at 1,310 m³/s (as reported). A gate opened in a hurry raises the river below; a gate held shut or jammed by debris raises the reservoir and every outfall that drains to it; a flap gate on a nallah, once one is fitted, held open by silt, gravel or garbage lets the river into the town, and one buried by a rising bed on a bhabar fan

> stays shut. NEEPCO and NHPC operate the dams and WRD looks after the rivers, while the drains that reach them belong to the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Department of Urban Affairs, the Smart City companies, PWD and PWD (Highways) and, on community and clan land, the communities; no release protocol or warning threshold of any dam was found during research, and no rule linking the operation of any gate to the levels of the drains was found [TBC]. A gate and the drains behind it can therefore belong to different bodies. The 31 March inspection date is set ahead of the monsoon.

5.12 Pumped outfalls

5.12.1 **When required.** Pumping shall be provided where gravity discharge cannot meet:

- the outfall-closed check of Clause 5.10;
- the drawdown requirement of Clause 4.7; or
- the J2 and J3 cases.

Pumping shall not be used where a gravity solution meets these requirements.

5.12.2 **Capacity.**

- (a) The duty pumps together, with the storage provided, shall pass every case of Clause 5.9 (including J4), demonstrated by routing.
- (b) **Standby** capacity at least equal to the largest duty pump shall be installed (duty + 1 standby as a minimum).
- (c) Pump capacity shall be stated at the static head for the **J2** tailwater, not at mean tide.

5.12.3 **Effect on the receiving water.** Pumped discharge to a river, canal or creek shall be included in the river or creek level analysis of Clause 5.8. Pumping that raises the receiving water level above the acceptance criteria of Clause 5.5 elsewhere is not permitted.

5.12.4 **Power supply.** Pumping stations shall have either:

- two independent power supplies; or
- standby generation for 100% of the duty capacity, with on-site fuel for at least **72 hours** of duty operation.

Changeover shall be automatic.

5.12.5 **Flood immunity.** Electrical panels, control equipment, generators and fuel storage shall be set above the higher of:

- the 1% AEP flood level + 0.5 m; and
- HAT + surge + SLA + 0.5 m.

Access to the station shall remain usable in the 1% AEP event.

5.12.6 **Discharge arrangement.** Rising mains shall discharge:

- over a level above the J2 tailwater; or
- through a non-return valve and a flap gate.

The arrangement shall prevent back-siphoning.

5.12.7 **Controls and monitoring.** Each station shall have:

- automatic level control;
- remote alarms for high level, pump failure and power failure, sent to the operator; and
- a level and run-time log kept for at least 5 years.

Wet wells shall be sized to keep pump starts within the manufacturer's limits.

5.12.8 **Screens.** Inlet screens shall be provided with a cleaning method that works during a storm (a mechanical rake, or duplicate screens).

5.12.9 **Testing.** Every pumped outfall shall be test-run at full duty, including on standby power, before **31 March** each year. Private pumped systems shall be covered by a registered maintenance declaration (Chapter 10).

> Commentary. Duty + standby, 72 hours of fuel and flood-immune electrics have no single direct precedent and are set by this Manual. The 72-hour fuel figure matches the longest mandatory design storm (Clause 2.5.2). A pump station that depends only on grid power can stop exactly when it is needed, because supply to flooded areas is often switched off for safety. Singapore's April 2025 amendments added annual maintenance declarations for pumped detention tanks (PUB Addendum No. 3). Clause 5.12.9 and Chapter 10 adopt the same approach. Clause 5.12.3 prevents pumping that simply moves water from one tide-locked drain into a tide-locked river.

5.13 Sand-bar closure of river mouths

5.13.1 **Where it applies.** This clause applies to outfalls into any river or creek whose mouth is subject to seasonal sand-bar closure. That includes the mouths of the coastal States (there is none in Arunachal Pradesh: Clause 5.1.4), and any other mouth listed in Annex 5B.

5.13.2 **Assumption at the start of the monsoon.** The mouth shall be assumed **closed** by a bar at the start of the April–October season, at the crest level of the most recent pre-monsoon survey. This applies unless the Water Resources Department certifies that:

- a mouth-maintenance programme (dredging, bar cutting or training walls) has kept the mouth open at the start of each of the previous three monsoon seasons; and
- the programme is funded for the current season.

5.13.3 **Tailwater with a closed mouth.** With the mouth closed, the tailwater at the outfall shall be the higher of:

- (a) the tidal tailwater of Clause 5.7; and
- (b) the level in the river reach behind the bar, computed with the bar as a weir at its surveyed crest level. That level shall include the river flow of Clause 5.8 and the head needed to pass the flow over or through the bar.

5.13.4 **No credit for emergency cutting.** Bar cutting or breaching during the storm shall not be assumed in design, unless the Water Resources Department has a documented operating procedure, with equipment stationed for it. Where it does, the bar may be assumed lowered to the procedure's target level only after the time the procedure states.

5.13.5 **Outfall-closed check.** Where the closed-mouth level of 5.13.3(b) exceeds the outfall invert for longer than the default lock windows, the lock duration of Clause 5.10 shall be extended to that period.

> Commentary. Arunachal Pradesh has no coast and no river mouth, so Clause 5.13 does not apply in the State (Clause 5.1.4). Its nearest inland counterparts are the silt, gravel, boulders, slide debris, vegetation and garbage that the nallahs and hill streams leave at an outfall, a culvert or a gate, and the beds of the rivers on the bhabar fans, which rise and shift. The Master Plan of Itanagar Capital Region-2031 finds drains "chocked with the solid wastes" and "heavy silting" because "Regular cleaning of drains is not taking place", and the Pachin "a waste disposal site" (report); drains along the Bage Tinali–Naharlagun road are reported to be "too shallow and narrow" and clogged by earth-cutting debris (as reported); and in September 2018 culverts and a bridge in Itanagar were washed away, with a landslide from "the dumping area of NH 415" (as reported). A flap gate held open or shut by silt, debris or waste, an outlet buried by a rising bed or left hanging by scour, or a gate that cannot be moved, turns

> a designed outfall into a dead end or a back-flow path. No gate on any town outfall was found, and no rule linking the operation of any dam's gates to the levels of the drains above or below it was found during research [TBC]. Clause 5.8.5 deals with both by setting outfalls above the range of bed movement and by giving no credit for a gate operation or a storage that the operator's records do not show. Clause 5.13.2 has no direct precedent. It puts the burden of proof on showing that the mouth is open rather than assuming it.

5.14 Documentation

Every project subject to this chapter shall submit a **Downstream and Tailwater Report** (Form 5-1). It shall contain:

1. a plan of the analysis extent showing:
    - the site;
    - each analysis point with its contributing catchment area and the site's percentage of it; and
    - the end point and the reason it was chosen (Clause 5.3);
2. the model description:
    - software and version;
    - the network schematic, with survey sources for the drains and crossings;
    - land use and CN for off-site areas;
    - any upstream detention included; and
    - calibration or validation evidence where available;
3. for each analysis point, AEP and duration, the existing and with-project:
    - peak flow;
    - time to peak;
    - maximum water level and velocity; and
    - duration of inundation (Clause 5.4);
4. the comparison against Clause 5.5, with each failure identified and the remedy adopted;
5. the tailwater derivation:
    - tide-table edition and port;
    - MHWS, HAT and MSL relative to chart datum;
    - the datum connection to the Survey of India benchmark and the project datum;
    - surge source and value;
    - SLA; and
    - river levels and their sources (Clauses 5.6 to 5.8);
6. the joint-case table of Clause 5.9 with results;
7. the outfall-closed check (Clause 5.10):
    - storm and lock alignment;
    - stage hydrographs; and
    - the volume balance for each lock window;
8. a schedule of flap gates, tide gates and non-return valves, with certified head–discharge data (Clause 5.11);
9. pumped outfall design, power supply, flood immunity and controls, where provided (Clause 5.12);
10. the sand-bar assumption and supporting WRD certification, where relevant (Clause 5.13); and
11. inspection and maintenance requirements for Chapter 10.

Small sites under Clause 5.3.4 shall submit Form 5-2 (Simplified Downstream Statement) instead.

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Annexes and forms

Annex / Form	Content
5A	Tidal datums (MSL, MHWS, HAT vs CD and Survey of India datum), surge allowances and 1% still-water levels by coastal segment
5B	Major drains, riverine outfall reaches, and river mouths subject to sand-bar closure; map
5C	Worked example: outfall-closed check for a hillside colony in Itanagar draining to the Senki
Form 5-1	Downstream and Tailwater Report
Form 5-2	Simplified Downstream Statement (small sites)

CHAPTER 6

Minor and Major Drainage Systems

6.1 Purpose and scope

6.1.1 This chapter sets the level of service and the hydraulic criteria for the conveyance system that carries runoff from a development, a road or a public drainage scheme to a receiving waterway, tank or outfall. It covers:

- (a) the dual drainage concept: a minor system and a major system (Clause 6.3);
- (b) design return periods by land use and road class (Clause 6.4);
- (c) street hydraulics: spread, depth and flow hazard (Clause 6.5);
- (d) inlets, including clogging (Clause 6.6);
- (e) pipes and open and covered drains (Clause 6.7);
- (f) hydraulic grade line analysis (Clause 6.8);
- (g) overland flow paths, ponding at sags and building floor levels (Clauses 6.9 to 6.11);
- (h) culverts and road crossings (Clause 6.12); and
- (i) Arunachal Pradesh construction-practice requirements for covered drains, silt, solid waste, utilities and desilting access (Clause 6.13).

6.1.2 The detailed hydraulic design of individual structures (culverts, channels, energy dissipators, screens, pumps, gates, manholes) is in Chapter 9. Rainfall is in Chapter 2, runoff methods in Chapter 3, on-site storage in Chapter 4, tailwater in Chapter 5, waterbodies in Chapter 7 and water quality in Chapter 8.

6.1.3 This chapter applies to all public drains, all roads with kerbs or roadside drains, and all private drainage systems in developments that meet the applicability thresholds of Chapter 1. In Tier B local bodies, the simplified procedures and design aids referred to in Chapter 1 may be used for elements serving ≤ 16 ha, but the criteria of this chapter still apply.

> Commentary. Arunachal Pradesh's drains were not designed against any State or municipal standard: none was found during research, and no document found gives a design return period, runoff coefficient or drain size for any town. The Arunachal Pradesh Building Bye-Laws, 2019 ask for a site plan showing "Any existing physical features such as well, drains" (2.10.1(j)) and a certificate of supervision of "drainage/sanitary works" (2.10.10), and refer to the National Building Code, 2005, Part 9 for plumbing and drainage (4.19.1.3, 4.33.1), with no design storm. The Master Plan of Itanagar Capital Region-2031 finds that "There is no proper storm water network for the overall town area", that the drains are "not engineered … open drains or kutcha drains without any flow gradient", that "no scheme or work for storm water drains is under execution", and that "With only 3.7% storm drains along main roads, drainage was marked as a key area of focus"; it proposes a new network "taking into consideration of the topography of the region and flow gradient" (Maps 28–30), with no design storm or return period (report). The expression of interest for a "GIS based Integrated Drainage Master Plan and DPR for Itanagar Capital City" (Department of Town Planning and ULBs, 31 October 2017) states no return period, and the plan reviewed by the Chief Minister in June 2021 was not seen and its adoption was not found (as reported). The drains also work in a setting that the plains editions of this Manual do not meet. In the capital and the hill towns they collect water from slopes of Siwalik sandstone, shale and boulder beds, "covered by residual soil or slope debris" (CGWB, Papum Pare), that deliver gravel, boulders and slide debris with every storm, and earth cutting adds its spoil; they carry sewage, because "Most of the surface water and sewerage gets mixed up resulting in storm water drains being used as sewers" (Master Plan report); and they end in hill streams that no one gauges, in nallahs that back up

when the Dikrong is high or the Pare dam releases, or, at Pasighat, Tezu, Namsai and Roing, in main stems whose stage is set far upstream. The road drains of the hills are the drains of the land above them: the CAG found that three PMGSY projects costing ₹47.70 crore were taken up "without provision of drain", with "₹46.15 crore on construction of 49 Km roads wherein no drains were constructed", although "It is mandatory under PMGSY to have a drainage plan prepared for each rural road project" (CAG, Audit Report 2022-23). The drains are also divided among owners: the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Department of Urban Affairs, the Smart City companies, PWD and PWD (Highways), WRD, PHED, NEEPCO and NHPC and, on community and clan land, the communities all build or hold drains and receiving waters, and no rule divides them (see the Commentary to Clause 6.9). Fixing the rainfall (Chapter 2) is only half the answer. The other half is a second, surface-level system that carries the flows the pipes cannot, without flooding buildings. That is the dual drainage concept of this chapter, taken from Kansas City Metro APWA Section 5600 (5601.8, Levels of Service), which requires every element to have a 1% AEP overflow path.

6.2 Definitions

Term	Meaning in this Manual
Minor system	Inlets, pipes, covered drains and open drains that carry runoff up to the minor design AEP of Table 6.1 without surcharge above the limits of Clause 6.8.
Major system	The surface flow paths (streets, overland flow paths, open channels, floodways and storage) that carry flow above the capacity of the minor system, up to the 1% AEP (100-yr) event.
Overland flow path	A defined surface route, in public land or a recorded easement, that carries major-system flow to a receiving waterway.
Spread (T)	Width of flow in the gutter and carriageway, measured from the face of the kerb.
Sag	A low point on a road or flow path from which water can leave only through an inlet or by ponding to an overflow level. A trapped sag has no surface overflow route.
Clogging factor	The fraction of an inlet's clean hydraulic capacity assumed lost to debris (Clause 6.6.3).
Hydraulic grade line (HGL)	The line joining the free-surface levels in a conduit system, or the piezometric levels where the system is under pressure.
Covered drain	A rectangular drain, usually beside a road, closed by cast-in-situ or precast cover slabs that form a footpath.
Sediment allowance	The depth or area of a drain or pipe assumed filled with silt when its design capacity is computed (Clause 6.7.8).
Check event	An AEP rarer than the design AEP at which the combined minor and major system must still meet the limits of Table 6.2.
High-density area	An area notified as such by the approving authority under Clause 6.4.4.
Class I area	An urban local body with a population of 1 lakh or more (the CPHEEO definition).

6.3 The dual drainage concept

6.3.1 Every drainage system shall be designed as two systems that work together:

- (a) a **minor system** that carries the minor design flow of Table 6.1 below ground or in drains, keeping streets usable and spread within Table 6.2; and

- (b) a **major system** that carries all flow above the minor-system capacity, up to the 1% AEP (100-yr) flow, on the surface without entering buildings and within the depth and hazard limits of Clause 6.5.

6.3.2 **Every element has a 1% path.** Every inlet, sag, pipe, drain, culvert and storage element shall have an identified 1% AEP overland flow path to a receiving waterway, tank or outfall. The path shall be shown on the drainage plan (Clause 6.15).

6.3.3 **Major-system design flow.** The major system at any point shall carry the 1% AEP peak flow less the minor-system capacity at that point. The minor-system capacity used in this subtraction is the capacity of the inlets after the clogging factors of Clause 6.6.3, or the pipe capacity, whichever is less. At sags and at any location used to set building floor levels, the major system shall also be checked with the minor system **fully blocked** (Clause 6.10.3).

6.3.4 **Rainfall and method.** Design flows shall use the rainfall of Chapter 2 (including the climate factor of Clause 2.8) and the methods of Chapter 3:

- (a) the Rational Method only for catchments ≤ 16 ha and a single conveyance element. It shall not be used to accumulate flows down a network whose total catchment exceeds 16 ha;
- (b) a hydrograph method with hydraulic routing (for example SWMM, HEC-HMS with a hydraulic model, or an equivalent 1D/2D model) for networks above 16 ha and for any network with storage, pumping or a tidal outfall;
- (c) a minimum time of concentration of 10 minutes.

6.3.5 **No transfer between catchments.** Neither the minor nor the major system shall divert flow from one natural catchment to another unless the approving authority accepts a catchment-wide study showing no adverse effect.

6.3.6 **Drains that carry sewage, and hill and foothill drains.** No town in Arunachal Pradesh has a working sewer network or treats its sewage: in the capital "Most of the surface water and sewerage gets mixed up resulting in storm water drains being used as sewers" (Master Plan of Itanagar Capital Region-2031, report), and "no ULB is treating sewage" (observations quoted in the State's affidavit in NGT OA 606/2018, 2025), so the public drain or nallah that receives storm water from a site or a public drainage project normally also carries sewage and sullage, and often the overflow of septic tanks, although the bye-laws forbid it (APBBL 2019, 4.16.2(c)) (Clause 8.9); and in the hills the drains also carry silt, gravel, boulders, slide debris, the spoil of earth cutting and garbage. This chapter applies to the storm-water system up to the point of connection and to every public drain, with the following additions (all set by this Manual).

Items (a) to (e) apply wherever the receiving drain or nallah carries dry-weather flow of sewage or sullage, whatever its owner calls it:

- (a) **Separation on site.** Storm water and waste water shall be collected in separate systems within the site, each with its own last inspection chamber at the site boundary, so that the storm-water system can be connected to a separate public storm drain, without rework on the site, when one is built or when the sewers of the area are commissioned. Where the Authority allows only one connection to the receiving drain, the two systems shall meet only in a final chamber after both inspection chambers. The site plan of the bye-laws, which already shows "Any existing physical features such as well, drains" (APBBL 2019, 2.10.1(j)), the certificate of supervision of "drainage/sanitary works" (2.10.10), the Authority's power to "require rain-water pipes to be connected to a drain or sewer" (4.19.1.1), and the rule of the Municipal Corporation Act, 2019 that no one shall discharge "foul water into a drain provided for surface water" where separate drains exist (s.203), are the hooks for this item. Septic-tank effluent shall enter neither system (APBBL 2019, 4.16.2(c)). Clause 6.13.7 applies to every storm drain within the site.
- (b) **No rise in the peak inflow.** A development to which Chapter 4 applies shall meet Chapter 4 at each connection to a drain that carries sewage, as at any other site outfall (Clause 4.5.1.3). A development below the thresholds of Clause 1.5.2 shall not raise the peak inflow above that of the site before the development: where it adds impervious area, the roof water of the added area shall pass through a rainwater harvesting or storage tank with a controlled overflow before it reaches the connection.
- (c) **Tailwater and backflow.** The HGL of Clause 6.8 shall be started from the level in the receiving drain at the connection in the coincident event, taken from the owner's model where one exists and otherwise at the drain's obvert or top of bank (Clause 5.6.2). Where the receiving drain or nallah ends at an outfall backed up by the Senki,

the Pachin or the Dikrong, or by a main stem at Pasighat, Tezu, Namsai or Roing, the outfall-closed check of Clause 5.10 applies with the lock of Clause 5.8.5(a) or (c). A non-return valve (Clause 6.8.8) shall be fitted on every connection, storm or foul, to a drain that carries sewage wherever the lowest drainage fitting or opening it serves is below the cover or bank level of the receiving drain at the connection.

- (d) **Capacity, velocity, access and odour.** A public drain or nallah that carries sewage shall be designed as a combined channel until the sewers of its area are connected: its storm capacity used in Clause 6.3.3 shall be the capacity left after its dry-weather flow, measured or estimated from the population served; it shall reach the minimum velocity of Clause 6.7.3(a) at its dry-weather flow, or have a low-flow channel in its invert that does, so that sewage solids do not settle between storms; where it is covered, it shall have the access openings of Clause 6.13.2, with covers and vents placed so that odour does not reach homes and footpaths; and it shall be cleanable by machine from those openings, without anyone entering it. Flow above its storm capacity, or above what the inlets admit, shall be carried on the surface by the major system (Clauses 6.3.2 and 6.9), and floor levels shall be set under Clause 6.11 with the drain surcharged.
- (e) **Interception and screens before outfalls; separation planned by the Authority.** Every public drain or nallah that carries sewage shall have dry-weather-flow interception and a screen before its outfall to the Senki, the Pachin or the Dikrong, to the Siang, the Lohit, the Noa-Dihing or the Dibang at Pasighat, Tezu, Namsai or Roing, and before any pond used as storage, designed under Clause 8.9 so that it does not reduce the drain's storm capacity, and no new storm drain shall be brought to a pond without that treatment. The Authority shall identify in its master plan (Chapter 11) the areas where a separate public storm drain is feasible, among them the areas that the sewerage proposed in the Master Plan of Itanagar Capital Region-2031 would serve, and elsewhere the storage that will hold back the combined peak; where a separate public storm drain is available at the site boundary, the site's storm-water system shall be connected to it and not to the drain that carries sewage. The Conveyance Design Report (Form 6-1) shall state whether each receiving drain carries sewage, the source of that information, and how items (a) to (e) are met.

Items (f) to (m) apply to every element of the minor and major systems that receives runoff from a hill catchment, which in this Manual means land in sub-areas AR-C1, AR-D and AR-E of Annex 2A and in the hill rim of sub-areas AR-A and AR-A1, any catchment whose natural ground slopes more than 10% on average, and every stream or nallah that comes down from the hills, including where it runs out across the valley floor of the capital region or the bhabar fans of sub-areas AR-A1, AR-B and AR-C:

- (f) **Debris racks and traps.** Every inlet, drain or pipe entrance and culvert that receives flow from **1 ha or more** of unbuilt hill land (forest, scrub, cultivated or bare slope, a quarry, a cut slope, a dumping area or a slide scar), or from a stream or nallah of the hills whatever its catchment, shall have a debris rack or a debris trap upstream of it, designed under Chapter 9 (Clause 9.8), with machine access and a stable place to stockpile what it catches, which shall not be a slope, a stream, a nallah or the margin of a pond. With 50% of the rack blocked, the element it protects shall still pass its design flow, and the overflow route shall not send the flow onto a building or an unprotected slope. Racks and traps shall be cleared by 31 March, again by 15 May after the April storms, and after the season by 15 November (Chapter 10); in the high ranges, where snow lies in winter, they shall be kept clear of snow and ice from December to March and cleared again after the snowmelt by 30 April. The volume of a debris basin is to be set in Chapter 9 [TBC].
- (g) **Bulking factor.** The design flow of every channel, drain, pipe, culvert and crossing that receives flow from a hill catchment shall be the clear-water peak flow of Chapter 3 multiplied by a bulking factor of **1.25**, for the minor design flow, the check event and the 1% AEP flow; elsewhere the factor is 1.0. The factor applies to capacity, freeboard and velocity; it does not apply to the runoff volume used for storage (Chapter 4). A larger factor shall be used where a sediment study of the catchment gives one. A catchment that the screening of Clause 2.3.6(i) shows to be prone to debris flow or landslides, or that drains a mapped slide, slide scar, fan, glacial lake or the path of a channel shift, is not designed by a bulking factor: no building, outfall, pumping station or storage shall be placed in that path, and the drains are designed for the bulked flow only [TBC].
- (h) **Blockage.** The blockage check of Clause 6.12.4 shall assume 50% of the inlet area blocked for every culvert and pipe entrance with a span or diameter below **3.0 m**, and 20% for larger ones, whether or not a debris rack is provided. Grate inlets keep the clogging factor of Table 6.5, and kerb openings on grade take the sag value of 20%.

- (i) **Sediment and minimum velocity.** Drains and pipes that receive flow from a hill catchment, or that run across the bhabar fans and the valley floor at the foot of the hills, shall reach a velocity of at least **1.0 m/s** at the minor design flow, in place of the minimum of Clause 6.7.3(a). Where the gradient does not allow it, a sediment trap shall be provided upstream and the sediment allowance of Clause 6.7.8 doubled (Clause 6.7.4).
- (j) **Steep drains and steep streets.** Where the gradient of a drain gives a velocity above the limits of Clause 6.7.3(b), or a Froude number above 0.8, at the design flow, the drain shall be a lined chute, a stepped channel or a series of drop structures designed under Chapter 9 for the bulked flow of item (g), with the freeboard of Table 6.7 for steep channels and an energy dissipator at every change to a flatter gradient and at the outlet. No unlined drain shall be laid on a gradient on which the velocity exceeds the limit of Chapter 9 for its bed material. On a street steeper than 5%, grate-only inlets shall not be used, and inlets shall be placed by the calculation of Clause 6.6.4 with the bypass flows of a steep gutter; on a street steeper than 10%, the flow shall be intercepted by transverse grated channels or kerb inlets at a spacing that keeps the street flow within the limits of Table 6.3 in the check and 1% AEP events. Where the 1% AEP flow cannot be kept within those limits on the carriageway, the excess shall be carried in a lined side channel or stepped drain, and the street, unless it is a notified evacuation route, is treated as closed in that event. Steps and footpaths that carry flow shall have a lined side channel.
- (k) **Hill roads as the minor system.** On every road and street in a hill catchment as this clause defines it, and on any road elsewhere that crosses one, the drainage of a road is the minor system for the land above it as well as for the road. Every such road and street shall have, as works of the road's owner, PWD, PWD (Highways), the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Department of Urban Affairs or, on community land, the community:
    - (i) a lined catch-water drain above every cut slope where the land above drains towards the road, discharging to a natural channel or a cross-drainage work and not over the cut;
    - (ii) lined side drains on the hill side (IRC:SP:42-2014, cl. 8.5.1);
    - (iii) a cross-drainage work at every stream and nallah, and culverts or scuppers at intervals such that no side drain exceeds its capacity at the design AEP of Table 6.1 with the factors of items (g), (h) and (m);
    - (iv) at the outlet of every scupper, culvert and side drain on the valley side, a lined chute, cascade or pipe carrying the flow to a stable natural channel or a public drain, with an energy dissipator, so that road runoff is **never discharged onto an unprotected slope**, fill, retaining wall or the land of a building below, by PWD, PWD (Highways) or any other owner of a road;
    - (v) culverts of at least the size of Clause 6.12.5, designed under Clause 6.12 and not less than IRC:SP:42-2014 cl. 7.1.4 requires for the road; where the drainage provisions of IRC:SP:48-1998, the Hill Road Manual, which were not read for this Manual [TBC], are stricter than this item, they apply; and on a rural road, the drainage plan that PMGSY already requires "for each rural road project" (as cited by the CAG, Audit Report 2022-23), designed under this item; and
    - (vi) no muck, spoil, slide debris or excavated material from the construction, widening or maintenance of the road, or from earth cutting beside it, placed in or beside a stream, a nallah or another line of natural drainage, or on a slope from which a storm can carry it into one, and every culvert, side drain and natural drain that such material has blocked cleared by 31 March and after every slide, so that the runoff of its catchment reaches the nearest stream or river.
- (l) **Sloping sites and earth cutting.** On a site where the land above drains towards a building, its cut or its retaining wall, the runoff of that land shall be intercepted above them by a lined diversion drain sized for the minor design flow of Table 6.1 from the land above it, with the factors of items (g), (h) and (m), with a 1% AEP flow path that does not pass through or against the building. The space between a building and the cut or retaining wall above it, which the bye-laws already set at "a minimum distance of 0.60 meter" (APBBL 2019, 2.10.2(a)), shall be paved or lined and drained so that water does not stand against the building or soak into the foot of the cut, and both shall discharge to a public drain or a stable natural channel as item (k)(iv) requires, not onto the slope below. Roof and paved-area runoff on such a site follows the hill rule of Clause 4.11. These items give a design standard to what the bye-laws already ask of earth cutting: a cut of no more than 3 m in height (4.39(4)), a clear setback of 2.5 m from the property line on the upper terrace (4.39(5)), soil and debris cleared "from site or drain to suitable/safer place" (4.39(8)), a retaining wall or breast wall built "immediately" on completion of the cutting (4.39(11)), and no earth-cutting permission "if the average slope of the topography is more than 30%" (4.39(14)). During construction, runoff shall be kept off the existing drainage courses and led to sediment traps (Chapter 8).

- (m) **Garbage-laden flows and the hill–plain break.** Every drain outfall to a nallah of the capital region, to the Senki, the Pachin or the Dikrong, or to a main stem at Pasighat, Tezu, Namsai or Roing, and every public drain or culvert where a stream or nallah below a settlement enters it, shall have a solid-waste trap or screen designed under Chapter 9 (Clause 9.8), with access for cleaning by hand or machine and a place to store what it catches that is not a stream, a nallah, a pond margin or a slope, cleared on the dates of item (f) and after every heavy-rainfall day (Chapter 10). The blockage of item (h) shall be taken to include solid waste whether or not a trap is provided, and the capacity of an existing drain or nallah shall be taken net of the silt, vegetation and waste surveyed in it (Clause 6.7.8). Where a stream or a drain that receives one leaves the hills and reaches flatter ground, as the streams do on the valley floor of Naharlagun, Nirjuli and Doimukh and on the bhabar fans at Pasighat, Ruksin, Roing, Tezu, Namsai, Bhalukpong and Banderdewa, a silt trap designed under Chapter 9 shall be provided above the point where the gradient falls, sized for the sediment of item (i), with machine access and a stockpile place of the same kind, and cleared on the same dates. A trap, screen or bund placed in a stream or nallah shall not raise its 1% AEP level at any outfall (Clause 5.8.5(a) and (b)) and shall be designed to be overtopped without damage. A trap is not a treatment work: dry-weather flow is intercepted under item (e) and Clause 8.9.

Commentary. The CPHEEO (2019) manual defines major and minor systems in its glossary but gives no return period for the major system. APWA 5600 (2006, 5601.8) requires the system to convey the 1% peak and, where in-system capacity is less, an overflow system to carry the remainder. Clause 6.3.3 subtracts only the *clogged* inlet capacity, not the full pipe capacity, because in practice the pipes cannot take more water than the inlets admit. The fully-blocked check at sags has no direct precedent; this Manual sets it because of the Itanagar experience that drains under footpaths are often silted or blocked by solid waste when the heaviest rain arrives (CPHEEO 2019 Part A, Ch 1 and 2, Figures 1.2 and 2.1 on solid waste dumping in drains). The prohibition on inter-catchment transfer follows the DID Malaysia 2008 submission checklist, which prohibits inter-catchment diversion. Clause 6.3.6 is set by this Manual for Arunachal Pradesh, and it has two parts because the State's drains fail in two ways that the criteria of this chapter, which assume clear storm water on gentle ground, do not see. The first is sewage. The capital has no sewer to send it to: "Absence of a sewerage network, resulting in the sewerage being drained to open or vacant land as well as into ponds"; "City sewerage is discharged into open drains. The hilly terrain means limited scope for u/g sewer network"; and "There is no sewage treatment plant present in the city" (Master Plan of Itanagar Capital Region-2031, report). The State's own report to the National Green Tribunal quotes the observation that "no ULB is treating sewage. Even the state capital, Itanagar-Naharlagun, lacks a sewage treatment facility" (affidavit in OA 606/2018, 2025), and in OA 94/2020/EZ the Tribunal directed on 5 January 2023 that "no untreated sewage or treated sewage be allowed to enter into the waterbody" of the Senki, the Pachin and the Dikrong (as summarised). CPCB lists the Senki at Chandranagar, upstream of the Pachin, in Priority V (CPCB, *Polluted River Stretches*, 2025), and the Master Plan calls the Pachin "a waste disposal site". The rules are already there: the bye-laws forbid septic effluent "into an open channel drain or body of water without adequate treatment" (APBBL 2019, 4.16.2(c)), the Municipal Corporation Act, 2019 separates foul and surface water where separate drains exist (s.203), and the Municipal Act, 2007 bars sewage from any watercourse "until it has been so treated" from a date the State appoints (s.194). The gap is enforcement and the absence of a sewer or septage service. Items (a) to (e) follow the combined-sewer rules of the plains editions of this series: a site keeps its storm water separate up to the boundary, so that a town can separate its system street by street as sewers come, without going back into every plot; a development does not add to the peak of a drain that carries sewage; a non-return valve guards every connection, because what comes back up a surcharged drain is sewage; the drain is designed as the combined channel it is, with its capacity taken net of its dry-weather flow; and the outfall to a river or a pond is intercepted and screened. Clause 8.9 proposes the transition.

The second is the hills. Itanagar, Naharlagun and the foothill towns stand on rocks of the Siwalik group, whose hills "form hogback topography" and whose slopes are "covered by residual soil or slope debris" (CGWB, Papum Pare), and the capital lies in Earthquake Zone V with "5 fault lines in the city" (Master Plan report). The slopes fail at the drains and the cuts: on 11 July 2017 a landslide at Laptap, in Papum Pare, killed 14 people after three days of rain (14 to 16 in different reports, as reported); in the 2017 floods "the land protection wall of several nallahs and rivulets" in the capital was badly damaged and NH-415 closed (Master Plan report); in September 2018 the floods of the Modirijo and Donyi Polo catchments washed away the Senki View culvert and the Press Colony

bridge, with a landslide reported from "the dumping area of NH 415" (as reported); a protection wall collapsed in a landslide at Niti Vihar in Itanagar, killing four people (as reported; date not found); illegal earth cutting along NH-415 was blamed for a mudslide near Donyi Polo airport (as reported); the drains along the Bage Tinali–Naharlagun road were found "too shallow and narrow" and clogged by earth-cutting debris, and an inspection recommended de-silting "upto the Dikrong river" and three culverts between the police station and the NERIST gate (as reported); and at Yazali on 24 June 2026 (or 2025, the year is in conflict) a flash flood in a side channel left one dead and four missing at Poosa and the NEEPCO colony (as reported), a debris-blocked channel breach on the research's reading (NEER reading). The CAG found that PMGSY roads costing ₹46.15 crore had been built "wherein no drains were constructed" (CAG, Audit Report 2022-23), and the Master Plan records landslides along the highway from the Dikrong's undercutting. The National Green Tribunal is hearing a case on the disposal of muck from a hydro project on the Dibang (OA 148/2025/EZ). No Arunachal Pradesh allowance for debris, bulking or blockage was found during research [TBC], and no Indian guidance on bulking factors, debris racks or debris basins [TBC], so each number in items (f) to (m) is an interim value with a stated reason, the same as in the mountain editions of this series. The 1 ha trigger for a debris rack reflects the time of concentration on hill slopes, a few minutes, so that even a small unbuilt slope delivers stones, gravel and leaves to an inlet in the first burst of a storm. The bulking factor of 1.25 is the factor for a flow that carries a fifth of its volume as sediment (bulking factor = 1 / (1 − sediment fraction by volume)): about the most that a drain can carry and still behave as a water flood. A flow with more sediment than that behaves as a debris flow, which no drain can be sized for; that is why item (g) keeps buildings and outfalls out of a debris-flow or slide path rather than sizing a drain for it, and why the factor is to be replaced by a sediment study as soon as one is made [TBC]. The 3.0 m limit in item (h) doubles the core's 1.5 m because boulders, timber and waste block openings that leaves alone do not. The 1.0 m/s minimum in item (i) replaces the 0.6 m/s of CPHEEO, which is based on carrying fine sand of 0.09 mm, because hill drains carry gravel. The bye-laws' only slope number is 4.39(14)'s 30% (about 17°), above which earth cutting is refused and the site "declared as not fit for construction except for plantation"; it is a limit on cutting, not a drainage rule, and item (l) gives the drainage of the cuts the bye-laws do allow a design standard. On a 10% street, the hazard limit of 2.0 m/s is reached when sheet flow on a concrete surface is only about 30 mm deep, which is why item (j) takes the flow off steep carriageways. IRC:SP:42-2014 (cl. 8.5.1) already treats hill roads differently: their side drains are "normally restricted to 60 cm" in width and lined because "rolling stones cause high friction", "culverts are required at closer intervals compared to those in plain areas", and "stepped chutes/baffles are to be provided where the longitudinal bed slope exceeds critical". Items (k) and (l) keep road and site runoff off unprotected slopes, because water discharged onto a slope raises its pore pressure (Clause 4.11), and give a design standard to the earth-cutting rules of 4.39 and to the drainage that the 2009 draft of the bye-laws asked for on hill sites, which the 2019 text does not carry. Item (m) deals with garbage and with the foot of the hills. The Master Plan finds the drains "chocked with the solid wastes", with "heavy silting" because "Regular cleaning of drains is not taking place" (report); a trap catches waste only if it is placed where the waste arrives and cleared when it fills, and a trap built in a stream must not raise the stream at the outfalls it protects. Where the streams leave the hills they drop their load on the valley floor and the bhabar fans, whose boulders and gravels the rivers rework (CGWB, Lohit and East Siang), which is why item (m) puts a silt trap at the break. The clearance dates are the Manual's works calendar (Chapter 10): the mid-season clearance falls on 15 May, as in the adjoining Nagaland edition, and not on 31 May, the date of the Assam edition downstream, because the damaging pre-monsoon storms of the State cluster in the last ten days of May (28–29 May 2024; 30 and 31 May 2025, as reported) and a clearance due at the end of that month falls in the storms it is meant to precede; in the high ranges a snowmelt clearance follows by 30 April. The clause deals with debris and garbage at the drain; it does not ask for the concrete channelisation of the streams or the nallahs, whose capacity has been lost to encroachment and waste, not to roughness.

6.4 Design return periods

6.4.1 The minor system, roads and crossings shall be designed for the AEPs of Table 6.1. Where both a land-use row and a road-class row apply to an element, the **rarer** AEP (longer return period) governs.

Table 6.1 — Design AEPs for conveyance (matches Clause 2.4)

Element	Design AEP (return period)	Check event	Basis
Minor system: Itanagar, Naharlagun and Pasighat core and other high-density areas	10% (10-yr)	1% (100-yr) overland path	This Manual (see Commentary)
Minor system: other Class I areas	20% (5-yr)	1% overland path	This Manual; CPHEEO Table 4.1
Minor system: other areas	50% (2-yr)	1% overland path	This Manual; CPHEEO Table 4.1
Arterial road drainage and crossings	2% (50-yr) for arterials that are notified evacuation or emergency routes; 4% (25-yr) for other arterials	Next higher AEP: 1% for a 2% design; 2% for a 4% design	This Manual (25–50-yr); split set by this Manual
Collector road drainage and crossings	4% (25-yr)	2% (50-yr)	This Manual
Local road drainage and crossings	10% (10-yr)	4% (25-yr)	This Manual
Road underpasses and other trapped sags on public roads	2% (50-yr)	1% (100-yr)	This Manual (Clause 6.10.5)
Airports, railway stations, power stations and other critical infrastructure	1% (100-yr) in Class I areas; 2% (50-yr) elsewhere	—	CPHEEO 2019 Table 4.1
Major (overland) system, every element	1% (100-yr)	—	This Manual
Building floor levels	1% level + 0.5 m freeboard	—	This Manual (Clause 6.11)

6.4.2 **Check events.** At the check event of Table 6.1, the combined minor and major system shall carry the check-event flow within the 1% AEP limits of Table 6.2 and without water entering any building. The 1% overland path requirement of Clause 6.3.2 applies in addition to the check event.

6.4.3 **Higher standards.** An approving authority may adopt a rarer AEP for any element, including through the high-powered committee route in Note 2 of CPHEEO Table 4.1. It shall not adopt a more frequent AEP than Table 6.1.

6.4.4 **High-density areas.** The approving authority shall notify, by map, the high-density areas to which the 10% AEP minor-system standard applies. Until it does, the 10% AEP standard applies to:

- (a) in Itanagar and Naharlagun, the localities that the sources name for flooding, Energy Park, Bank Tinali, Niti Vihar and Abo Tani Colony (June and July 2024), the Bage Tinali–Naharlagun road and its drains, and the Modirijo and Donyi Polo areas (September 2018) (as reported), with the boundary of each to be confirmed by the Itanagar Municipal Corporation and, for parts on community or clan land, with the community [TBC]; in Pasighat, no locality is named for flooding in the sources found [TBC], so item (b) applies there;
- (b) in Pasighat and in every other urban local body area, the area that the applicable master plan, once one is notified, identifies as the core area, old town or central business district, and, until then, the main market of the town and its densely built centre, as the urban local body identifies them by map [TBC]; and
- (c) any area in a Tier A body where the master plan permits a floor space index above the base value for the zone.

6.4.5 **Retrofit.** Where an existing drain cannot practicably be enlarged to the Table 6.1 AEP, the shortfall shall be made good by upstream storage (Chapter 4), regional storage (Chapter 7) or an improved major-system path. The approving authority shall record the residual level of service.

> **Commentary.** The values in Table 6.1 match the Clause 2.4 summary and add rows for underpasses and critical infrastructure. They exceed the CPHEEO (2019) national advisory minimums of 5-yr for Class I cities and 2-yr elsewhere (CPHEEO Part A, Table 4.1). Note 2 of that table allows a State committee to adopt higher values. The 10-yr tier for high-density areas follows Gupta (IIT Bombay), who recommends "1 in 10 year for residential-high density", and Malaysia's MSMA 2, which uses 10-yr minor and 100-yr major systems for link houses, apartments, commercial and industrial land. The road values resolve a conflict in Indian codes. IRC:SP:50-2013 recommends 1–2 years for urban road drains. IRC:SP:42-2014 suggests 25 years for urban roadside drains and a check flood at the next higher return period. APWA 5600 (2006) uses 50-yr for arterial, 25-yr for collector and 10-yr for residential street crossings. Table 6.1 adopts the APWA tiers and the IRC:SP:42 check-flood concept. Splitting arterials into 50-yr evacuation routes and 25-yr others has no direct precedent and is set by this Manual. The 50-yr standard for underpasses is likewise set by this Manual, because an underpass is a trapped sag where the failure mode is deep water on a live carriageway. The default high-density areas in Clause 6.4.4 are set by this Manual and apply until the approving authority notifies a map.

6.5 Street hydraulics: spread, depth and flow hazard

6.5.1 **Gutter flow.** Flow in a triangular kerb-and-gutter section shall be computed with the modified Manning (Izzard) equation:

> Q = (Ku / n) · Sx^(5/3) · SL^(1/2) · T^(8/3)

where Q is the gutter flow (m³/s), Ku = 0.376 (SI), n is the Manning roughness of the gutter (Table 6.6), Sx is the cross slope (m/m), SL is the longitudinal slope (m/m) and T is the spread (m). Composite and depressed gutter sections shall be analysed by the methods of FHWA HEC-22 (4th edition, 2024).

6.5.2 **Spread and depth limits.** Street flow shall not exceed the limits of Table 6.2.

Table 6.2 — Street flow limits

Road class	Minor design event (Table 6.1)	Check event and 1% AEP event
Arterial	Spread shall leave at least one through lane in each direction clear of water. No flow across the crown.	Depth ≤ 150 mm at the crown and ≤ 350 mm at the deepest point; hazard limits of Clause 6.5.3
Collector	Spread T ≤ 3 m. No flow across the crown except at a sag intersection.	As above
Local	Spread T ≤ 3 m. Flow shall not overtop the kerb.	As above
All classes, at intersections	Cross-flow over the crown ≤ 0.03 m³/s at sag intersections and superelevation transitions; none at mid-block sags.	As above

6.5.3 **Flow hazard limits.** In the check event and the 1% AEP event, the product of depth (D, m) and velocity (V, m/s) of street and overland flow shall not exceed the limits of Table 6.3.

Table 6.3 — Flow hazard limits for streets and overland flow paths

Location	Required hazard class (Table 6.4)	Limits
Carriageways of all roads	H2 or better	D·V ≤ 0.6 m²/s; D ≤ 0.35 m (Table 6.2); V ≤ 2.0 m/s
Footpaths, pedestrian crossings, school, hospital and transit-stop frontages	H1	D·V ≤ 0.3 m²/s; D ≤ 0.3 m; V ≤ 2.0 m/s
Notified evacuation and emergency routes	H1	D·V ≤ 0.3 m²/s; D ≤ 0.3 m; V ≤ 2.0 m/s
Overland flow paths in public open space or easements, away from roads	H3 or better, with warning signs	D·V ≤ 0.6 m²/s; D ≤ 1.2 m; V ≤ 2.0 m/s

Table 6.4 — Combined flood hazard vulnerability classes (reproduced for reference)

Class	Description	D·V limit (m²/s)	Depth limit D (m)	Velocity limit V (m/s)
H1	Generally safe for vehicles, people and buildings	≤ 0.3	0.3	2.0
H2	Unsafe for small vehicles	≤ 0.6	0.5	2.0
H3	Unsafe for vehicles, children and the elderly	≤ 0.6	1.2	2.0
H4	Unsafe for vehicles and people	≤ 1.0	2.0	2.0
H5	Unsafe for vehicles and people; buildings vulnerable to structural damage	≤ 4.0	4.0	4.0
H6	Unsafe for vehicles and people; all buildings vulnerable to failure	> 4.0	—	—

Source: AIDR Guideline 7-3, *Technical flood risk management guideline: Flood hazard* (2014), Tables 1 and 2, modelled after Smith and Wasko (2012).

6.5.4 Depth and velocity for Clause 6.5.3 shall be taken from the gutter-flow calculation for simple sections, or from a 1D or 2D hydraulic model where flow leaves the kerb-and-gutter section.

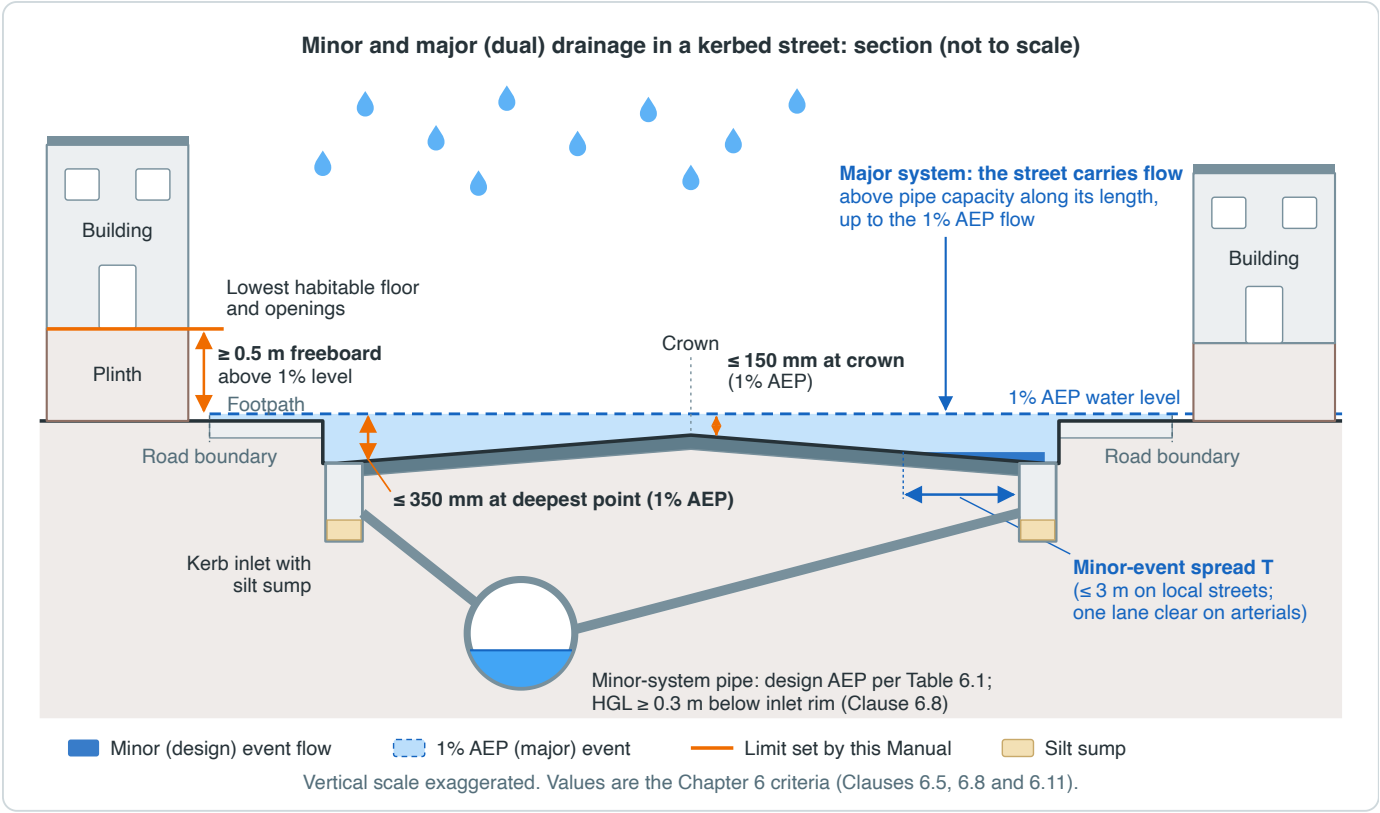

Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

> **Commentary.** The Izzard form of Manning's equation with Ku = 0.376 is used both in FHWA HEC-22 and in the CPHEEO (2019) manual (Part A, Example 5.5, where the constant is written Kc = 0.376). The arterial spread rule (one lane clear) and the 3 m spread for local and collector streets are close to the APWA 5600 (2006, 5604.2) limit of 12 ft (3.66 m) from the back of kerb in each outside lane. The cross-flow limit of 0.03 m³/s is the SI equivalent of the APWA limit of 1.0 cfs at intersection sumps and superelevation transitions, with no cross-flow at mid-block sumps. The 150 mm and 350 mm depth limits are close to the APWA 5600 limits for 1% overflow at road crossings (7 in, about 180 mm, at the crown; 14 in, about 360 mm, at the deepest point). Mumbai's criterion of no flooding above 15 cm (IRC:SP:50-2013, §6.4.1) is a local precedent for the 150 mm crown value.
>
> The hazard classes of Table 6.4 are the combined hazard curves published by the Australian Institute for Disaster Resilience (AIDR Guideline 7-3, 2014), which are modelled after Smith and Wasko (2012). Requiring H2 or better on carriageways means the 1% depth limit of 350 mm (Table 6.2) governs the depth, and the D·V product controls fast, shallow flow on steep streets. H2 is described as "unsafe for small vehicles". Two-wheelers are the dominant vehicles on Arunachal Pradesh streets, so the 1% event must be treated as a road-closure event on all roads except notified evacuation routes, which must meet H1. The assignment of hazard classes to locations in Table 6.3 has no direct precedent and is set by this Manual.

6.6 Inlets

6.6.1 **Inlet types.** Inlets may be kerb-opening inlets, grate inlets, combination inlets (a grate with a kerb opening) or slotted and trench drains. On public streets:

- (a) kerb-opening or combination inlets shall be used, unless the approving authority accepts grate-only inlets for a specific location;

- (b) inlet openings shall be set at road level, with a gutter depression where practicable, so that water is not held on the carriageway by a raised kerb or footpath;
- (c) grates in carriageways, cycle lanes and footpaths shall be of a bicycle- and pedestrian-safe pattern (Chapter 9, Clause 9.11).

6.6.2 **Inlet capacity.** The clean capacity of inlets on grade and in sags shall be computed by the methods of FHWA HEC-22 (4th edition, 2024), or from tested ratings published by the manufacturer for the exact grate and kerb-opening geometry. The empirical kerb-inlet equations of CPHEEO (2019) Part A §5.6.2 may be used as a cross-check only.

6.6.3 **Clogging factors.** The design capacity of every inlet shall be its clean capacity reduced by the clogging factors of Table 6.5:

Table 6.5 — Inlet clogging factors (share of clean capacity assumed lost)

Inlet type	On grade	In a sag
Grate	50%	50%
Kerb opening	10%	20%
Combination	Apply the grate and kerb factors to each part separately	Apply the grate and kerb factors to each part separately

Design capacity = (1 − clogging factor) × clean capacity.

6.6.4 **Inlet spacing.** Inlets shall be located by a sequential calculation that starts at the top of each gutter run. At each inlet, the intercepted flow is computed, and the bypass flow is added to the gutter flow arriving at the next inlet. Spacing shall be such that the spread limits of Table 6.2 are met everywhere in the minor design event. In addition:

- (a) inlet spacing shall not exceed 30 m on kerbed roads, whatever the calculation gives;
- (b) inlets shall be provided at every sag, immediately upstream of pedestrian crossings and intersections, upstream of bridge decks and superelevation transitions, and at the end of every gutter run;
- (c) bypass flow from the last inlet of a run shall not be passed onto a road of a higher class or into private land.

6.6.5 **Sag inlets.** At a sag on a kerbed road:

- (a) the sag inlet's design capacity (after clogging) shall be not less than the total minor design flow arriving at the sag;
- (b) flanking inlets shall be placed on each side of a sag on any road where ponding could spread beyond the Table 6.2 limits, and at every underpass;
- (c) the ponding at the sag shall comply with Clause 6.10.

6.6.6 **Inlet connections.** The pipe connecting an inlet to the main drain shall have a diameter of at least 300 mm and shall be laid at a gradient that gives at least 0.9 m/s at the inlet's design flow.

6.6.7 **Silt sumps.** Every inlet chamber on a public road shall have a silt sump at least 300 mm deep below the invert of its outlet pipe, accessible for cleaning from the surface.

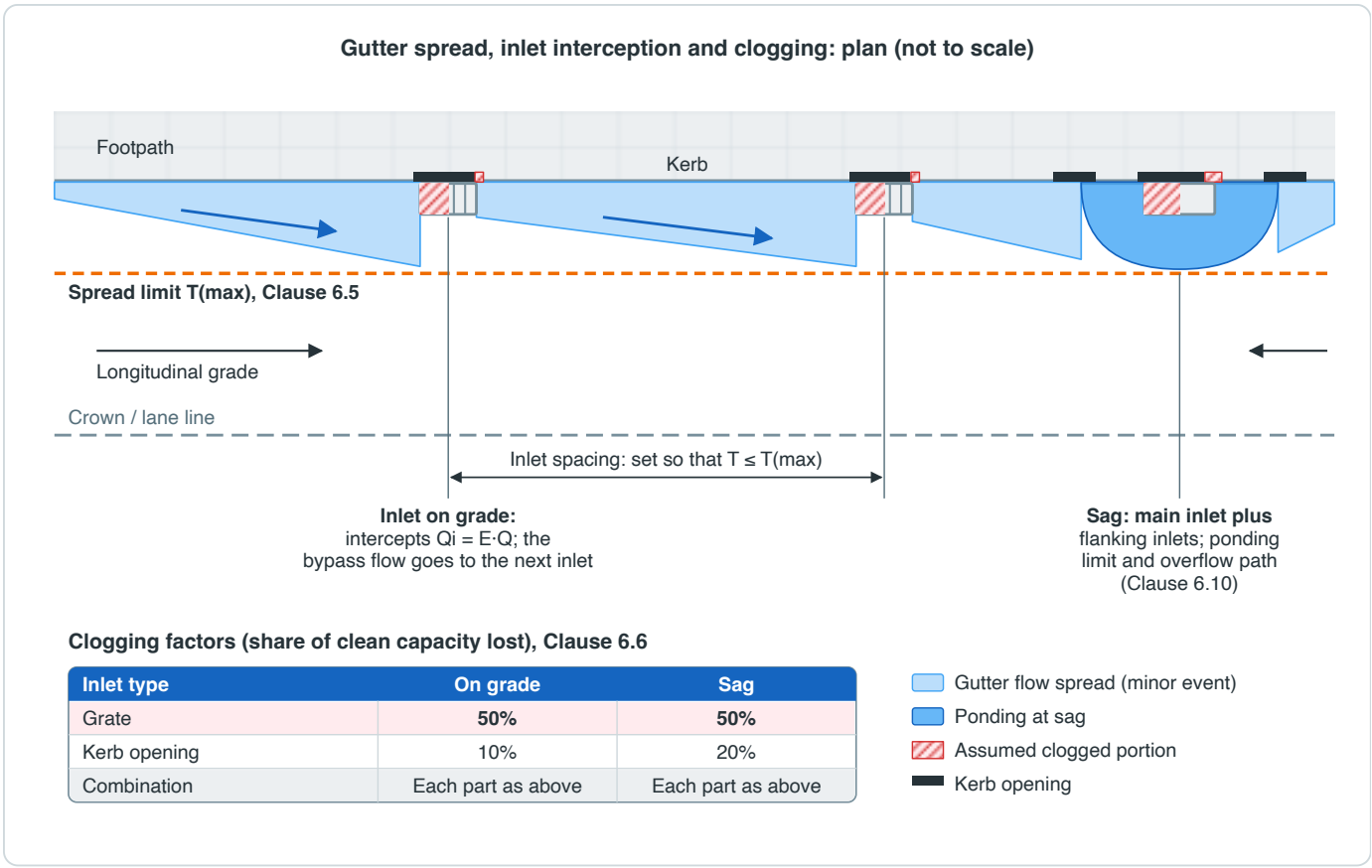

Figure 6.2 — Gutter spread, inlet interception and clogging. Original drawing for this Manual, adapted from FHWA, HEC-22 Urban Drainage Design Manual (3rd ed., 2009; 4th ed., 2024) and CPHEEO, Manual on Storm Water Drainage Systems (2019).

Commentary. The clogging factors are more severe than the APWA 5600 (2006, 5604.2) rating of sump inlets at 80% of theoretical capacity (a 20% reduction), because grates in Arunachal Pradesh streets are routinely blinded by plastic and leaves. CPHEEO (2019) Part A shows solid waste dumped in drains as a primary cause of drain failure (Figures 1.2 and 2.1). APWA 5600 (2006) allows only kerb-opening inlets on public streets; Clause 6.6.1(a) is less strict because combination inlets are useful on flat roads. No standard inlet, kerb-channel or covered-drain detail of PWD, PWD (Highways), the Itanagar Municipal Corporation, the Pasighat Municipal Council or the Department of Urban Affairs was found during research [TBC]; the Arunachal Pradesh Building Bye-Laws, 2019 allow the Authority to "require rain-water pipes to be connected to a drain or sewer to a covered channel formed beneath the public footpath to connect the rainwater pipe to the road gutter or in any other approved manner" (4.19.1.1), without a detail. The 30 m maximum spacing and the treatment of combination inlets in Table 6.5 have no direct precedent and are set by this Manual. Roads on the valley floor of Naharlagun, Nirjuli and Doimukh and on the plains at Pasighat, Tezu and Namsai are flat, which shortens the calculated spacing anyway; on the steep streets of Itanagar and the hill towns gutter flow runs fast and passes inlets by, which Clause 6.3.6(j) deals with. A fixed cap stops a single blocked inlet from leaving a long dry gutter run. The 300 mm silt sump is set by this Manual. It matches the 0.3 m sump shown on the CPHEEO catch-basin detail (CPHEEO 2019, Figure 5.9).

6.7 Pipes and open and covered drains

6.7.1 **Uniform flow.** Pipe and drain capacity shall be computed with Manning's equation:

> V = (1/n) · R^(2/3) · S^(1/2); Q = A · V

where V is the mean velocity (m/s), n is the Manning roughness (Table 6.6), R is the hydraulic radius (m), S is the friction slope (m/m), A is the flow area (m²) and Q is the discharge (m³/s). Where backwater from a tailwater, a junction or a structure affects the water level, a gradually varied flow (standard step) or hydraulic network model shall be used, and the HGL requirements of Clause 6.8 apply.

6.7.2 **Manning roughness.** Design values of n shall be taken from Table 6.6. For concrete pipes and masonry or concrete drains, the design value shall be not less than the "fair" or "rough" condition value listed, to allow for sediment, biofilm and ageing.

Table 6.6 — Manning's n for design (from CPHEEO 2019)

Material	Condition	n (CPHEEO)	Minimum design n in this Manual
Cement concrete pipe (collar joints)	Good / fair	0.013 / 0.015	0.015
Spun concrete pipe (RCC, PSC) with S/S joints	Manufacturer's design value	0.011	0.013
HDPE / uPVC pipe	—	0.010	0.011
Plastic (smooth), asbestos cement	—	0.011	0.011
Concrete drain, steel trowelled / wood trowelled	—	0.014 / 0.015	0.015
Sand and cement plaster	—	0.015	0.015
Brick masonry	Good / rough	0.015 / 0.017	0.017
Masonry	Bad condition	0.020	0.020
Rubble set in cement	—	0.017	0.017
Earth channel	Regular, good / ordinary	0.020 / 0.025	0.025
Earth channel	With stones and weeds / poor	0.030 / 0.035	0.035
Earth channel	Partly obstructed by debris or weeds	0.050	0.050
Gutter: concrete	—	0.013	0.013
Gutter: hot-mix asphalt	—	0.015	0.015
Gutter: sprayed seal	—	0.018	0.018

Source of the CPHEEO column: CPHEEO (2019) Part A, Table 5.1 (itself from the CPHEEO Manual on Sewerage and Sewage Treatment Systems, 2013) and Table 5.8 (gutters).

6.7.3 **Velocity limits.** At the minor design flow:

- (a) minimum (self-cleansing) velocity: **0.6 m/s** in open and covered drains and **0.9 m/s** in pipes;

- (b) maximum velocity: **3.0 m/s** in lined drains and in pipes, unless the drain or pipe is designed as a chute under Chapter 9. CPHEEO permits up to 6.0 m/s in plastic or plastic-lined pipes in hilly regions; this may be used in Itanagar, Naharlagun, Ziro, Bomdila, Tawang, Seppa, Daporijo, Aalo, Khonsa, Changlang, Yingkiong and Anini and other hill towns with the approving authority's agreement;
- (c) maximum velocity in unlined and vegetated channels: Chapter 9, Table 9.2;
- (d) the Froude number of flow in open and covered drains shall not exceed 0.8 at the design flow, unless the drain is designed for supercritical flow under Chapter 9.

6.7.4 **Gradient.** Each pipe and drain shall be laid at a gradient that achieves Clause 6.7.3(a). Where flat terrain or a fixed outfall level makes this impossible, the designer shall:

- (a) report the velocity achieved;
- (b) double the sediment allowance of Clause 6.7.8; and
- (c) provide access for mechanical desilting at the spacing of Clause 6.13.2.

6.7.5 **Pipe flow condition.** Pipes shall be sized so that the minor design flow does not exceed the pipe-full capacity. The greater discharge that a circular pipe carries at about 0.95 of its depth shall not be relied on.

6.7.6 **Minimum sizes.**

- (a) Pipes: 300 mm internal diameter; **450 mm** for public mains.
- (b) Open drains: bed width 0.3 m.
- (c) Covered public drains (drains closed by cover slabs): clear internal width **0.6 m** and clear internal depth **0.6 m**.

6.7.7 **Cover to pipes.** Pipes shall have at least 0.6 m of cover to finished level, and at least 0.9 m under carriageways unless a structural design for the traffic load is submitted. Where the seasonal high groundwater table is within 1 m of the pipe crown, the pipe shall be checked for flotation with the pipe empty (CPHEEO 2019, Table 11.2) and anchored where necessary.

6.7.8 **Sediment allowance.** The design capacity of open drains, covered drains and pipes of 600 mm diameter or more shall be computed with the following depth of sediment at the invert:

- (a) open and covered drains: the greater of **75 mm** and **10%** of the clear internal depth;
- (b) pipes of 600 mm diameter or more: **5%** of the internal diameter;
- (c) pipes below 600 mm: no allowance, but Clause 6.7.3(a) shall be met.

The Manning n for the reduced section shall be that of the drain material in Table 6.6.

6.7.9 **Freeboard in open and covered drains.** At the minor design flow, the water surface (computed with the sediment allowance) shall be below the top of the drain wall, or below the soffit of the cover slab in a covered drain, by at least the freeboard of Table 6.7.

Table 6.7 — Minimum freeboard in open and covered drains

Drain	Minimum freeboard	Source
Bed width up to 300 mm	100 mm	CPHEEO 2019 Table 5.3 (from IRC:SP:50-2013)
Bed width 300–900 mm	150 mm	CPHEEO 2019 Table 5.3
Bed width 900–1,500 mm	300 mm	CPHEEO 2019 Table 5.3
Wider drains and engineered channels, Q < 3 m³/s	450 mm	CPHEEO 2019 Table 5.12 (from IS 7784 (Part 1): 1993)
Q 3 to < 30 m³/s	600 mm	As above
Q 30 to < 300 m³/s	900 mm	As above
Q 300 to < 3,000 m³/s	1,200 mm	As above

Drain	Minimum freeboard	Source
Q ≥ 3,000 m³/s	1,500 mm	As above
Any roadside drain	Not less than 150 mm	IRC:SP:42-2014
Steep (supercritical) channels	Equal to the flow depth	CPHEEO 2019 §5.3.2

At bends, the freeboard shall be measured from the water level on the outside of the bend, including the superelevation $\Delta y = V^2 T / (2\,g\,r_c)$, where T is the top width and r_c the centreline radius (CPHEEO 2019, Eq. 5.29).

6.7.10 **Bends and junctions.**

- (a) The centreline radius of a bend in a drain shall be at least 3 times the drain width (CPHEEO 2019 §5.3.3). In engineered channels it shall be at least 2 times the top width and not less than 30 m (CPHEEO 2019 Table 5.11).
- (b) Where drains meet, a junction sump shall be provided with an internal width of at least twice the width of the outgoing drain. Incoming drains shall enter at less than a right angle to the outgoing flow, and the outgoing invert shall be below the sump floor so that water does not stand in the sump (CPHEEO 2019 §5.3.4).

6.7.11 **Manholes and access chambers on pipes.** Manholes shall be provided at every junction, change of size, alignment or gradient, and at the head of every pipe. Spacing on straight runs shall not exceed Table 6.8.

Table 6.8 — Maximum spacing of manholes on straight pipe runs

Pipe diameter	Maximum spacing
300–600 mm	40 m
700–1,000 mm	100 m
1,050–1,400 mm	150 m
1,500 mm and above	300 m

Source: CPHEEO 2019 Table 11.5. Manhole sizes, drops and covers: Chapter 9, Clause 9.12.

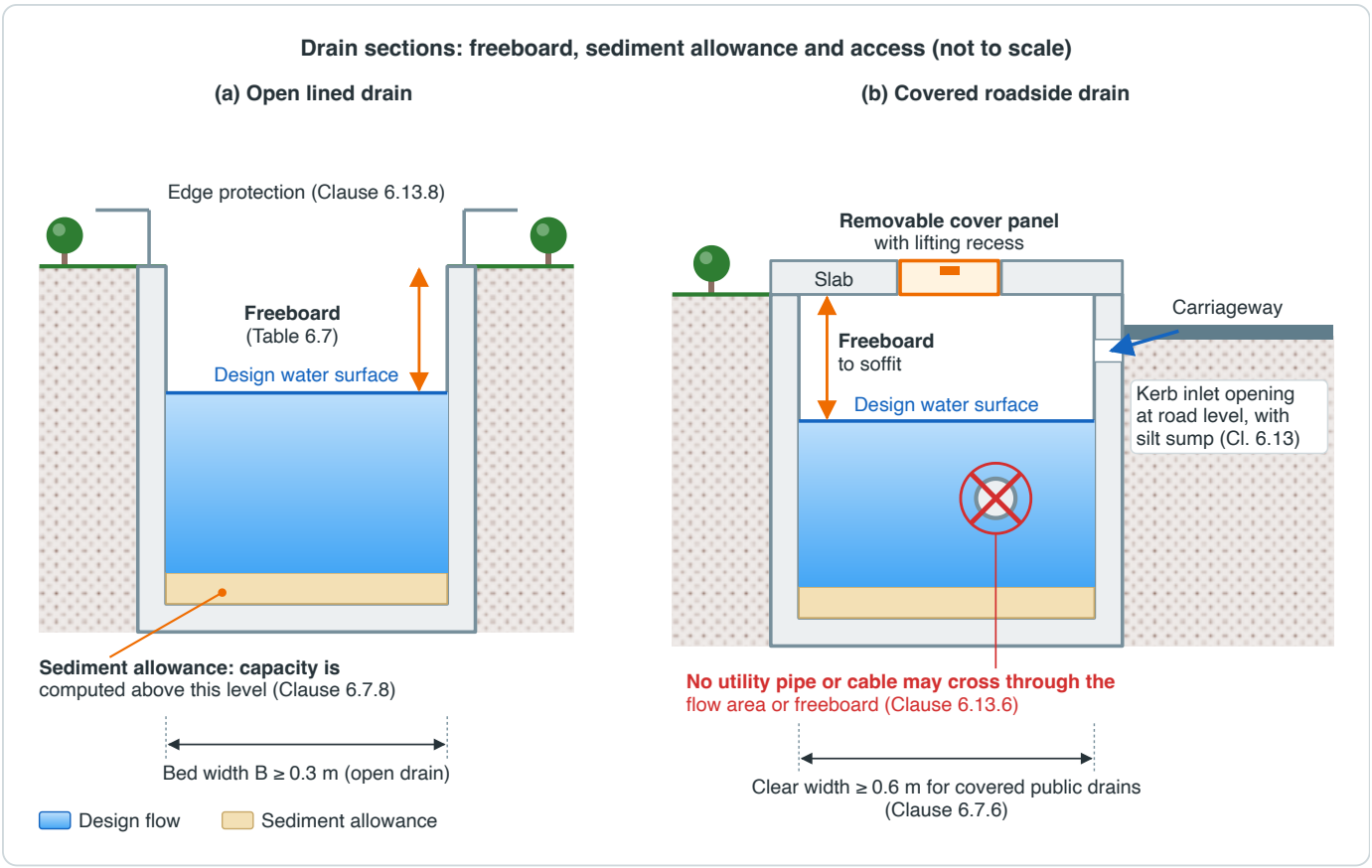

Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.

Commentary. The n values are those of CPHEEO (2019) Table 5.1. The higher minimum design values have no direct precedent; this Manual sets them because CPHEEO notes that the 0.011 value for spun pipes "may be taken as given by the manufacturer". That is a clean-pipe value, and Arunachal Pradesh drains carry heavy silt and solid waste. The 0.6 m/s minimum velocity is CPHEEO's (Table 5.2), based on carrying 0.09 mm sand (§5.3.1). The 0.9 m/s value for pipes is stricter, because a silted pipe cannot be cleaned as easily as an open drain. The 3.0 m/s maximum is from CPHEEO Table 5.2 (WPCF/ASCE 1982). The Froude limit of 0.8 is from CPHEEO §5.3, which advises avoiding critical flow because the water surface becomes unstable.

The 0.6 m × 0.6 m minimum for covered drains has no direct precedent and is set by this Manual. A covered drain narrower than this cannot be desilted by hand or by small machines through a cover opening, and silted, inaccessible drains were a recurring finding after the floods of the Itanagar capital region, whose drains the Master Plan finds "chocked with the solid wastes", with "heavy silting" because "Regular cleaning of drains is not taking place" (Master Plan of Itanagar Capital Region-2031, report), and whose drains along the Bage Tinali–Naharlagun road were found "too shallow and narrow" and clogged by earth-cutting debris (as reported), and in towns whose drains carry their sewage ("storm water drains being used as sewers", Master Plan report). The 0.6 m minimum cover is the value used in the CPHEEO (2019) worked pipe-design computation sheet (Part A, Chapter 5). The 0.9 m cover under carriageways is set by this Manual.

The sediment allowance values (75 mm or 10% for drains, 5% for large pipes) are set by this Manual. No Indian standard sets a sediment allowance for design. Itanagar's experience is that drains run partly full of silt for much of the year, so a capacity computed for a clean section overstates the real capacity.

The CPHEEO freeboard table (Table 5.3) prints the first row as "Beyond 300 mm bed width". Read with the second row ("Beyond 300 mm & up to 900 mm"), the first row must mean "up to 300 mm"; Table 6.7 is written that way. The CPHEEO manhole spacing table (Table 11.5) gives overlapping ranges (700–1,050 mm and 1,000–1,400 mm); Table 6.8 removes the overlap by assigning 1,050 mm to the 150 m class.

6.8 Hydraulic grade line

6.8.1 **HGL analysis.** For every pipe and covered-drain network, the designer shall compute the HGL for the minor design event and for the check event, starting at the outfall and working upstream. The analysis shall include friction losses and losses at junctions, manholes, bends, inlets, outlets and gates.

6.8.2 **Starting water level.** The starting (tailwater) level at the outfall shall be the higher of:

- (a) the tailwater level of Chapter 5: mean high water springs (MHWS) plus the sea-level allowance of +0.3 m for minor-system design at tidal outfalls, and the level in the receiving drain, river or tank for the coincident event at other outfalls; and
- (b) the level computed at the outlet pipe from the critical depth and the pipe diameter, (dc + D)/2, where the receiving water is lower.

6.8.3 **Minor-event limit.** In the minor design event, the HGL shall be at least **0.3 m below** the rim of every inlet and the cover level of every manhole and access chamber.

6.8.4 **Check-event and 1% limit.** In the check event and the 1% AEP event, the HGL may rise above the inlet rims. Water that leaves the minor system shall then be carried by the major system within the limits of Table 6.2 and shall not enter any building. Manholes that can surcharge above ground in these events shall have bolted or locked covers (Chapter 9, Clause 9.12).

6.8.5 **Structure losses.** Losses at manholes and junctions shall be computed by the energy-based access-hole method of FHWA HEC-22 (2009 or 2024 edition), or by an equivalent method in an approved hydraulic model. A simplified loss-coefficient method ($h = K V^2/2g$) with coefficients from HEC-22 may be used for Tier B networks below 16 ha.

6.8.6 **Invert and soffit levels.** Where pipe size increases at a manhole, the soffits (crowns) of the incoming and outgoing pipes shall be matched, or the outgoing soffit set lower. The outgoing invert shall not be higher than the lowest incoming invert. Vertical drops in manholes shall follow Chapter 9, Clause 9.12.

6.8.7 **Gates and valves.** The head loss through flap gates and non-return valves in the open position shall be included in the HGL (Chapter 9, Clause 9.10).

6.8.8 **Private connections.** Building drainage that connects to a public drain whose 1% HGL is above the building's lowest drainage fitting shall have a non-return valve.

Commentary. The 0.3 m clearance between the minor-event HGL and the inlet rim is set by this Manual. It keeps a margin for losses that a model underestimates, and it stops water from bubbling out of inlets in the event the system is designed for. In Arunachal Pradesh many town drains end in a nallah that backs up when the Senki, the Pachin or the Dikrong is high, in a hill stream that no one gauges and whose bed moves, in the reach of the Dikrong below the Pare dam, or in a main stem at Pasighat, Tezu, Namsai or Roing (Clause 5.8.5). The capital's drains "end up mostly into the Nallah and in some cases, into local ponds or open fields" (Master Plan of Itanagar Capital Region-2031, report), and none of the capital's rivers has a gauge or a published flood level. No flood level of any nallah or stream, and no design level of any outfall, was found during research. A drain whose HGL is started from a free outfall, or computed one length at a time without the river or stream level, fails in exactly that

way. An HGL computed from the outfall, with the tidal tailwater of Chapter 5, exposes those errors at design stage. The MHWS plus 0.3 m starting level is from CPHEEO (2019) Table 6.2. The access-hole method is described in HEC-22 from the 2009 edition onward.

6.9 Major system: overland flow paths, easements and drainage reserves

6.9.1 **Streets as the primary major system.** Streets shall be graded so that the 1% AEP major-system flow is carried along the road reserve to a receiving waterway without being trapped, except at sags designed under Clause 6.10.

6.9.2 **Overland flow paths outside streets.** Where a major-system path leaves the road reserve, it shall be:

- (a) in public land, in the open space of a layout, or in an easement recorded on the layout approval and the title;
- (b) at least as wide as the 1% AEP flow top width plus 0.5 m on each side, and not less than 3.0 m;
- (c) kept free of buildings, compound walls, fences, fill, stored materials and planting that would obstruct flow;
- (d) graded to a continuous fall with no sag that lacks an outlet; and
- (e) within the hazard limits of Table 6.3.

6.9.3 **Compound walls.** A compound wall or fence shall not be built across a mapped overland flow path. Where a wall must cross one, it shall have openings with a total area that passes the 1% AEP flow with a 50% blockage, without raising the upstream water level above the limits of this chapter.

6.9.4 **Access along open drains.** Open drains with a top width of 2 m or more shall have a maintenance access strip at least 3.5 m wide along one bank, connected to a public road at intervals of not more than 500 m.

6.9.5 **Supply channels, surplus courses and tanks.** Tank supply channels and surplus courses are part of the major system and shall be protected under Chapter 7.

6.9.6 **Drainage reserves.** A drainage reserve is a strip of land, including the drain, kept free of buildings so that the drain can be maintained, widened and used as a flood path. A drainage reserve shall be provided:

- (a) along every public drain or channel with an internal width of 1.0 m or more that runs through or along a layout or site being developed or redeveloped;
- (b) along every drain or channel shown in an adopted Basin Stormwater Master Plan (Chapter 11), at the width of the future drain in that plan; and
- (c) along every new public drain with an internal width of 1.0 m or more built by a public body.

6.9.7 **Width.** The reserve shall be not less than the width in Table 6.9, measured from the drain's internal width W. The width is based on the **required** drain size (for a planned drain, the size in the master plan), not the existing size. Where the access strip of Clause 6.9.4 is wider than the margin in Table 6.9, the wider governs.

Table 6.9 — Minimum drainage reserve width (adopted from PUB Singapore)

Internal width of drain, W	Open drain	Closed (covered) drain
1.0 m to 1.2 m	3.0 m	W + 0.6 m
more than 1.2 m to 3.0 m	W + 2.6 m	W + 1.6 m
more than 3.0 m to 4.5 m	W + 3.5 m	W + 1.6 m
more than 4.5 m to 6.0 m	W + 4.5 m	W + 3.0 m
more than 6.0 m to 9.0 m	W + 6.0 m	W + 3.0 m
more than 9.0 m to 25.0 m	W + 7.5 m	W + 3.0 m

Internal width of drain, W	Open drain	Closed (covered) drain
more than 25.0 m	W + 12.0 m	W + 3.0 m

For an open drain, the larger part of the margin shall be on the side used for maintenance access.

6.9.8 **Use and protection.**

- (a) The reserve shall be shown as a separate plot on the layout or site plan and transferred to the Approving Authority free of cost, as roads and open space reservations are. Where the drain is a Water Resources Department channel, the reserve is transferred to the Water Resources Department.
- (b) No building, compound wall, fence, ramp, step, fill or other structure shall be built in the reserve. Compound walls and boundary fences shall stand outside it.
- (c) The access strip in the reserve shall be level and continuous, and connected to a public road. Bollards or posts and chains may be used at entrances to keep out vehicles other than maintenance vehicles.
- (d) Where the reserve is not fenced off, its edge shall be marked with concrete markers at not more than 50 m spacing.
- (e) Services shall cross under the drain, with at least 1.0 m clearance below the invert, or over it on an approved structure. Services shall not run along the reserve inside the drain section.
- (f) A structure within 2 m of the edge of the reserve shall be designed to remain stable when the drain is excavated to 1.0 m below its invert. The design shall be signed by a qualified structural engineer.
- (g) The reserve counts toward the site's open space requirements only where the Approving Authority's rules allow it; it does not reduce any setback required by Chapter 7.

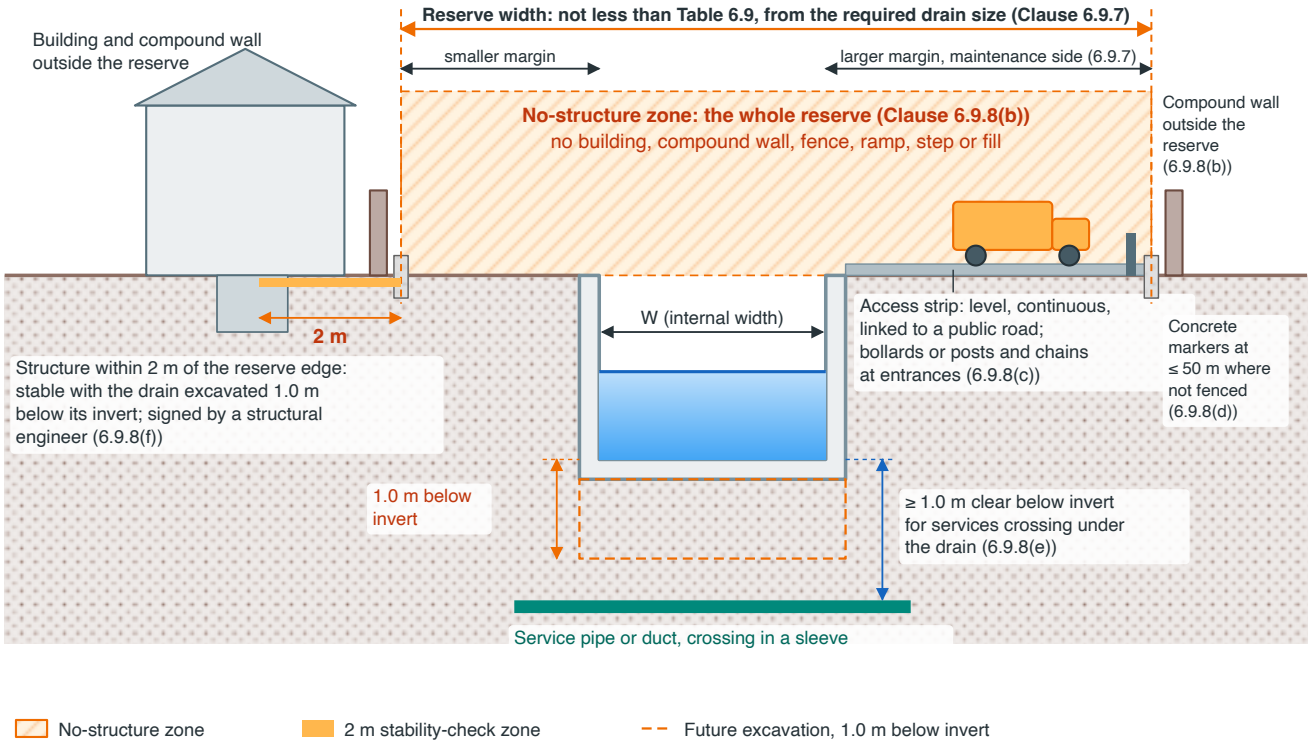

Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, Code of Practice on Surface Water Drainage (7th ed., with Addendum No. 3, 2025), clauses 5.1, 5.3, 9.6 and 9.7 and Appendix 1.

Commentary. Drainage reserves follow Singapore, where "the width of a drainage reserve is based on the required drain size" and the reserve is set aside as a separate plot, "kept free of all encumbrances" (PUB Code of Practice on Surface Water Drainage, 7th ed. with Addendum No. 3, 2025, cl. 1.1). Table 6.9 reproduces PUB's Appendix 1 widths. Clauses 6.9.8(b) to (f) follow PUB clauses 5.1 (no structure within a drain or drainage reserve), 5.3 and 5.3.1 (stability for excavation 1.0 m below the invert; engineer's calculations within 2 m of the reserve), 9.6 (level, continuous access, with bollards or posts and chains) and 9.7 (markers at a maximum of 50 m). The 1.0 m clearance for services crossing under a drain is from PUB's development-plan guidance. In Arunachal Pradesh, buildings and compound walls are often built up to the edge of a drain, so it cannot be widened or desilted by machine. Reserving the land when a plot is developed or redeveloped is the cheapest time to secure it, because widening later needs land acquisition. Basing the width on the master-plan drain size (6.9.6(b)) protects the land a future drain will need. Arunachal Pradesh has no reserve width, setback or buffer along any stream, nallah, spring or drain in any statute or bye-law found during research (NEER reading). What exists is a reference to one: the site plan of the bye-laws must show the "Distance from Nallah/Stream as per the notified rules/norms" and the "Distance from Disaster Prone Area as per norms set by Disaster Management Authority" (APBBL 2019, 2.10.1(e) and (f)), and no such rules or norms were found [TBC]. The bye-laws also define *Jhot*, "A strip of land permanently left open for drainage purposes. It is not to be used as an access way or a street and is not to be included as a part of setbacks" (def. 69), without a width; ask a large site to keep "The inlet and outlet point of natural drain system … with adequate size of channel for ensuring unrestricted flow of water" (Table 14.1); and list "water bodies (and the areas adjoining the same)" among the natural features to be "listed in notification(s) to be issued by the State Government / identified in Master Plan" (Chapter 12). The Master Plan of Itanagar Capital Region-2031 proposes 30 m green buffers along new roads, not streams. Within municipal limits, the public drains and watercourses vest in the local body: in the Itanagar Municipal Corporation's area "all public sewers and all drains, and sewers, culverts and water courses in or under any public street" and "all public streams, springs and works for the supply, storage and distribution of water" (Arunachal Pradesh Municipal Corporation Act, 2019; s.200 for drains), and in the Pasighat municipal area "all public tanks, streams, reservoirs, and wells" and "all public sewers and drains, channels, tunnels, culverts and watercourses" (Arunachal Pradesh Municipal Act, 2007, s.102, "Notwithstanding anything contained in any other law"). A Town Planning Scheme under the Arunachal Pradesh Urban and Country Planning (Amendment) Ordinance, 2025 (Ordinance No. 5 of 2025) may include "the filling-up or reclamation of low-lying, swampy or unhealthy area, or levelling-up of land", the main statutory risk to ponds, swamps and low land kept as storage (Chapter 7); the Ordinance's final form as an Act was not found [TBC]. None of these gives a reserve width along a stream or a nallah. For this Manual, as its own proposal and not as the meaning of any rule, the bank of a channel is its top of bank, and the edge of a pond or a reservoir and the outlet of a spring are as Chapter 7 defines them (definitions after Clause 7.2); every stream, nallah and other natural channel that drains 8 ha or more is a natural channel under Clause 7.4.1(b), including the capital's nallahs, the Senki, the Pachin and the Dikrong, whoever maintains it and whether or not it is lined, piped or covered (all set by this Manual). This Manual therefore gives the reserve a width, as its own proposal and not as a statutory width: a **hydraulic corridor** made up of the reserve of Table 6.9, based on the drain size needed to carry the design flow with the bulking factor of Clause 6.3.6(g) (Clause 6.9.7), the access strip of Clause 6.9.4 on the access bank, and, along every natural channel that drains 8 ha or more, the setbacks of Clause 7.4 measured from its top of bank, with a Zone 1 of at least 15 m and a Zone 2 to the 1% AEP extent plus 10 m; where a court order or a later notified rule sets a wider line, that line applies for as long as it binds, and the widest governs (Chapter 7). No statute sets any line, so the corridor is a NEER proposal throughout. It is offered as the "notified rules/norms" to which 2.10.1(e) of the bye-laws refers, which the State could notify; it applies to new development and redevelopment approved under this Manual, not to existing buildings, and Clause 7.4.7 allows no variance below it. The bye-laws extend "to whole of Arunachal Pradesh" (2.1), and nothing in the Constitution limits the State's laws on land here, but much land near the towns is held by communities, clans and individuals, and the beds of rivers, streams, nallahs, lakes and tanks are Government property only where they are "not the property of any person or community" (Arunachal Pradesh (Land Settlement and Records) Act, 2000, s.9(1)). So the corridor is **a condition of building permission and layout approval wherever the bye-laws apply, and a recommendation for works on community land outside any permission**; the Manual binds no community or clan on its own land. Zone 1 land and the reserve that is community, clan or private land is **secured by agreement with the owners or the community**, by

donation (the 2000 Act's own definition of Government land includes land obtained "through donation of the public"), by purchase, or by reservation in a master plan, layout or Town Planning Scheme, recorded on the layout approval and in the land record where one exists, and is not taken; where it is so secured, the transfer of Clause 6.9.8(a) is made by that recorded agreement rather than by a transfer of title (set by this Manual). Where the State decides that land for a public drain must be obtained compulsorily, the Municipal Act, 2007 routes it through the "Land of Acquisition Act, 1894" (as printed), which the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 has replaced for the Union (NEER reading), and also allows "other methods of land assembly including the use of transferable development rights" (s.104); the Manual states that route and does not invoke it. The corridor should be shown as land kept free along drainage lines in the master plans and layouts of the Itanagar Planning Authority and the other Local Planning Authorities, and checked at building permission, where the site plan already has to show the existing drains (2.10.1(j)) and the distance from a nallah or stream (2.10.1(e)), rather than made a new NOC.

The reserve matters because the drains of Arunachal Pradesh's towns are divided among owners, and no rule divides them. Both municipal Acts make drainage a duty of the local body: the Corporation's obligatory functions include "the maintenance and cleaning of drains and drainage works" (2019 Act, s.60(a)), and a Municipality "shall … construct and maintain drains and sewers, and provide a safe and sufficient outfall … for … proper discharge of storm-water and sewage … in such manner as may not cause any nuisance, whether by flooding" (2007 Act, s.194). Yet the Department of Urban Affairs, a works department with a Chief Engineer and 28 divisions whose functions include "Storm Water Drains; Drainage; Sewerage; Septage Management" (department website), builds storm drains, sewerage and septage works; the Smart City companies of Itanagar and Pasighat build drains among their works (as reported); PWD and PWD (Highways) build the roadside drains with the roads, among them NH-415, the Itanagar–Naharlagun spine (as reported); WRD looks after the rivers and anti-erosion works; PHED supplies water (not researched [TBC]); NEEPCO and NHPC operate the dams above the towns; and on community and clan land outside a local body's area the drains have no statutory owner. No notification dividing the drains of any Arunachal Pradesh town among these bodies was found during research (NEER reading). For the purposes of this Manual, and until the State issues such a rule [TBC], the drains are assigned as follows: public drains, sewers, culverts and watercourses in or under streets, and public streams and springs, in the IMC area to the **Itanagar Municipal Corporation** (2019 Act, ss.60(a), 200 and 203), and in the Pasighat municipal area to the **Pasighat Municipal Council** (2007 Act, ss.47(1)(a)(ii), 102, 194 and 196); storm drains, sewerage and septage works built by the **Department of Urban Affairs** or a **Smart City company** to their builder until they are handed over in writing to the local body; roadside drains, catch-water drains, scuppers and culverts on State roads and NH-415 to **PWD** or **PWD (Highways)**; rivers, with their beds, banks and anti-erosion works, to **WRD**; water supply to **PHED**; the dams, reservoirs and their release reaches to **NEEPCO** and **NHPC** as operators; and drains on community or clan land outside a local body's area to **the community** (set by this Manual). Each town shall keep a **drain register** that gives every reach its owner under this assignment, its land status (community, clan, individual, municipal or Government land), whether it carries sewage or septic overflow, and its outfall (set by this Manual). Under Clause 6.9.8(a), the reserve along a channel assigned to WRD is transferred to, or secured for, the Water Resources Department, by agreement where the land is community, clan or private land. Where a channel's status is disputed, the corridor follows the channel and not its name: the capital's nallahs are at once storm drains, carriers of sewage and the outfalls of the town to its rivers (Clause 8.9). No approved city drainage master plan with a design return period was found for any town in the State, and no design storm for any town drain: the Master Plan proposes a new network "taking into consideration of the topography of the region and flow gradient" without one, the "GIS based Integrated Drainage Master Plan and DPR for Itanagar Capital City" tendered in 2017 states no return period, and IMC's proposal for a 64 km integrated drainage system was seen only as reported. A drain sized to fit the land left beside it cannot be enlarged, which is why the reserve is based on the required size. Until a Basin Stormwater Master Plan is adopted (Clause 6.9.6(b)), the required drain size of Clause 6.9.7 is the size computed by the designer under this chapter. This Manual does not prescribe a lined or an unlined section, except where Clause 6.3.6(j) and Chapter 9 require lining on steep gradients; it requires the section to meet the velocity limits of Clause 6.7.3 and Chapter 9, and a reserve wide enough for an unlined or vegetated section keeps both options open.

> **Commentary.** Requirements 6.9.2(b)–(e), 6.9.3 and 6.9.4 have no direct precedent and are set by this Manual. Compound walls around individual plots are almost universal in Arunachal Pradesh and are one of the most common ways that overland flow paths get blocked. The 50% blockage assumption for wall openings is set to match the grate clogging factor of Clause 6.6.3. The 3.5 m access width is set by this Manual, sized for a small excavator or desilting vehicle. For comparison, APWA 5600 (2006, 5608.4) requires a 15 ft (about 4.6 m) maintenance access strip for detention facilities.

6.10 Ponding at sags and low points

6.10.1 **Minor event.** At every sag, the minor design flow shall be removed by inlets (after clogging) with ponded spread within Table 6.2.

6.10.2 **1% AEP event.** At every sag:

- (a) the ponded depth shall not exceed 350 mm at the deepest point of the carriageway;
- (b) a surface overflow route shall be provided (for example over a lowered kerb and footpath into a designated overland flow path), so that the ponding level cannot rise above the overflow level; and
- (c) building floor levels around the sag shall comply with Clause 6.11.

6.10.3 **Fully-blocked check.** At sags, the 1% AEP ponding level shall also be computed with the minor system fully blocked and all flow leaving by the surface overflow route. Floor levels around the sag shall be set from the higher of the two ponding levels.

6.10.4 **Trapped sags.** Where a sag has no surface overflow route, the inlets and conduits (after clogging) shall carry the 1% AEP flow, and the approving authority shall agree the arrangement.

6.10.5 **Road underpasses.** Underpasses and other trapped sags on public roads shall:

- (a) be drained by a minor system (with pumping under Chapter 9, Clause 9.9, where gravity drainage is not possible) designed for the 2% AEP (50-yr) flow, checked at the 1% AEP flow;
- (b) have flanking inlets at both approaches to intercept flow before it reaches the low point;
- (c) be protected from inflow from surrounding streets by raised approach crests where practicable; and
- (d) have depth markers and automatic warning or closure signals that operate at 150 mm depth on the carriageway.

> **Commentary.** The fully-blocked check, the trapped-sag rule and the underpass requirements have no direct precedent and are set by this Manual. No record of a flooded road underpass in the State was found during research [TBC]. The roads already act as the major system, and in the hills as its steepest part: NH-415 between Itanagar and Naharlagun was closed in the 2017 floods (Master Plan of Itanagar Capital Region-2031, report), damaged on 23 June 2024 and submerged in July 2024 (as reported); on 30 May 2025 a landslide swept a vehicle off NH-13 between Bana and Seppa, and all seven people in it died (as reported); and the CAG found rural roads built "without provision of drain" under PMGSY (CAG, Audit Report 2022-23). Clause 6.10.5(d) links the 150 mm crown depth limit of Table 6.2 to the point at which traffic should stop.

6.11 Building floor levels

6.11.1 The lowest habitable floor, and every opening through which water could enter a building (doors, ventilators, basement ramps, lift pits and service entries), shall be at least **0.5 m above the 1% AEP flood level**.

6.11.2 The 1% AEP flood level is the highest of:

- (a) the 1% AEP major-system water level in the street or overland flow path next to the building (Clauses 6.9 and 6.10, including the fully-blocked check at sags);
- (b) the 1% AEP flood level of any river, channel, tank or waterbody (Chapter 7); and
- (c) the 1% AEP level with the tailwater of Chapter 5; and
- (d) where the Approving Authority has adopted a 1% AEP flood depth map under Clause 7.3.4, the ground level at the plot plus the mapped 1% AEP depth.

6.11.3 **Default where no level has been computed.** For a plot below the Chapter 1 thresholds, or where no 1% AEP level has been computed for the plot, the lowest habitable floor and openings shall be at least the higher of:

- (a) **0.65 m above the highest crown level of the road on which the plot fronts**; and
- (b) where an adopted 1% AEP flood depth map covers the plot, **the ground level plus the mapped 1% AEP depth plus 0.5 m**.

The Approving Authority may adopt a regional map, such as a State-approved map or a published national map of modelled 1% AEP flood depth (for example the India Flood Atlas), until a local study replaces it. A map that does not model storm surge shall not be used in place of Clause 6.11.6.

6.11.4 **Basements.** The crest of every basement ramp and the sill of every basement opening shall meet Clause 6.11.1. Basement drainage shall be pumped to the surface drain through a non-return valve.

6.11.5 **Services.** Electrical panels, transformers, standby generators, lift machinery and pumps that serve a building shall meet Clause 6.11.1.

6.11.6 **Coastal band.** The coastal band is the land within **500 m** landward of the High Tide Line along the sea front, as defined by the CRZ Notification, 2019, with the High Tide Line as demarcated in the approved Coastal Zone Management Plan. Where the Survey of India Hazard Line lies further inland than 500 m, the band extends to the Hazard Line. Within the coastal band, in addition to Clauses 6.11.1 to 6.11.5:

- (a) the lowest habitable floor and every opening shall also be at least **0.5 m above the coastal flood level**, which is the 1% AEP still-water level (Clause 5.7.3(b), Annex 5A) plus **twice** the sea-level allowance of Clause 5.7.4 (so at least 0.6 m), because buildings have a design life of more than 50 years (Clause 5.7.4(c));
- (b) where the plot fronts the open beach, the coastal flood level shall include wave set-up from a site study;
- (c) no habitable room, electrical service room or plant listed in Clause 6.11.5 shall be placed in a basement; and
- (d) every basement opening, ramp crest and ventilation opening shall meet Clause 6.11.6(a).

Clause 6.11.6 does not authorise any construction that the CRZ Notification prohibits. Where both apply, the stricter governs.

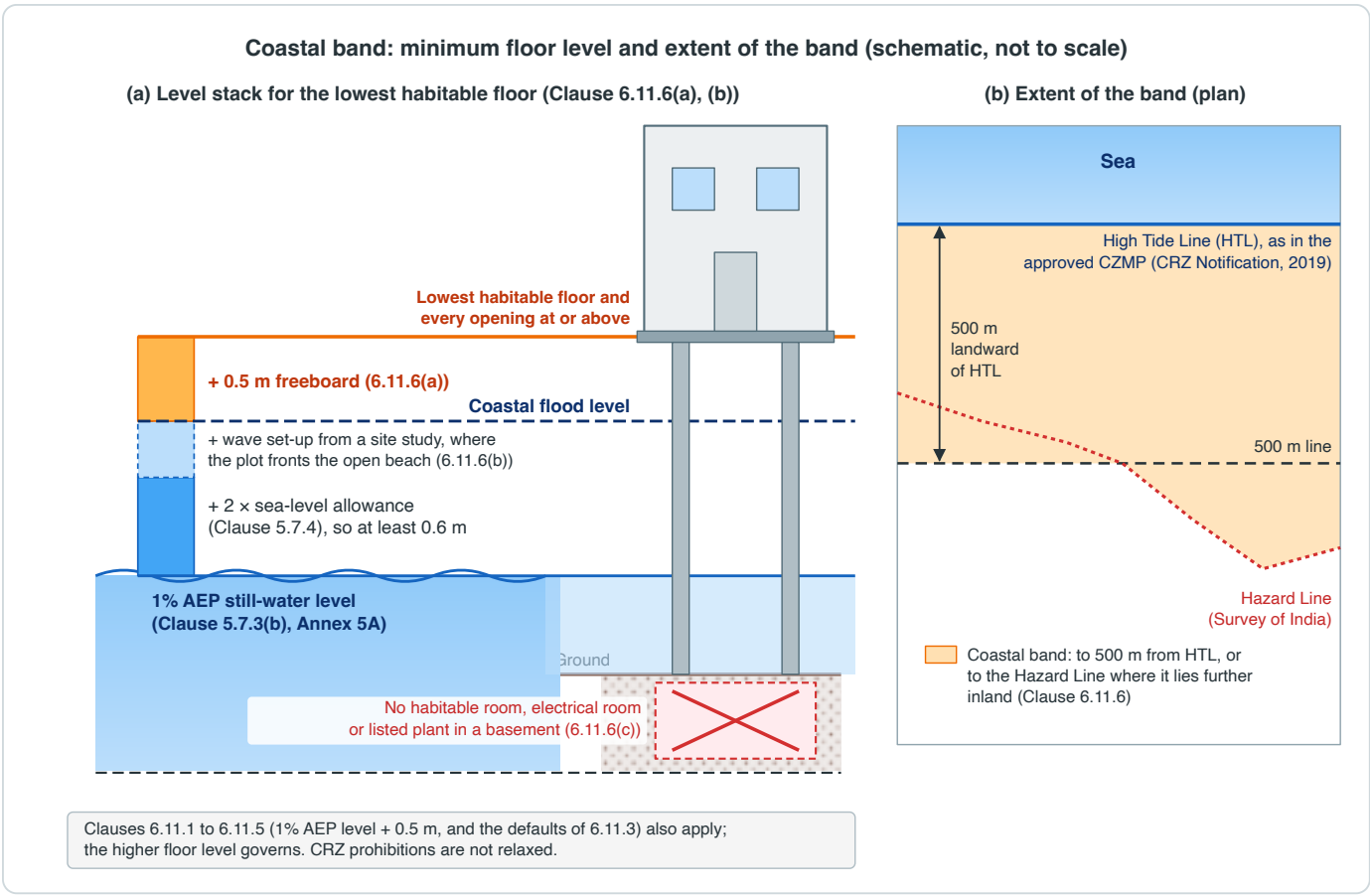

Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further inland (Clause 6.11.6). Original drawing for this Manual, adapted from the CRZ Notification, 2019 (para 1(i) and Annexure IV) and PUB Singapore, Code of Practice on Surface Water Drainage (7th ed.), cl. 2.1.1.

Commentary. The 0.5 m freeboard above the 1% AEP level follows the DID Malaysia 2008 checklist (platform and lowest floor at 100-yr ARI + 0.5 m). It is more than the APWA 5600 (2006, 5601.8 A2) requirement of 1 ft (about 0.3 m) above the 1% stage. The 0.65 m default in Clause 6.11.3 is derived from the other limits of this chapter, not separately sourced: the 1% water level at the crown may be up to 150 mm (Table 6.2), plus the 0.5 m freeboard. It has no direct precedent and applies to plots where no flood level exists. URDPFI (2015) also links minimum plinth levels to flood frequency in its flood-plain zoning, which is covered in Chapter 7.

Clause 6.11.3(b) lets a small plot use a mapped 1% AEP depth where no local study exists, instead of guessing from the road level alone. Modelled national maps are coarse (about 30 m), and most model rainfall and river flooding but not storm surge, which is why 6.11.3 keeps the road-crown check and Clause 6.11.6 sets a separate coastal rule.

The coastal band of Clause 6.11.6 uses the 500 m line of the CRZ Notification, 2019 (G.S.R. 37(E), para 1(i): "the land area from High Tide Line ... to 500 meters on the landward side"), because every coastal authority already maps it and it needs no new survey. The Hazard Line, demarcated by the Survey of India to show the extent of flooding and shoreline change, extends the band where it lies further inland (CRZ Notification, 2019, Annexure IV). The band takes the coastal level from the joint-case still-water level of Chapter 5 rather than from the rainfall map. The higher standard reflects the setting: a coastal flood rises with the sea, cannot be drained while the tide is up, and will rise further with the sea. Singapore takes the same approach with a fixed minimum platform level of 4.0 m above datum on its southern coast and 4.5 m on its northern coast, whatever the rainfall flood level (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 2.1.1). Each coastal State's tide and surge levels vary too much along its coast for one fixed level, so this Manual uses the computed still-water level instead. Using twice the sea-

level allowance applies the sensitivity case of Clause 5.7.4(c) as the design case, because a building, unlike a drain, cannot easily be raised later. The basement restriction in 6.11.6(c) is set by this Manual: a basement in the coastal band fills from the sea as well as from rain, and cannot be pumped out to a tide-locked outfall. Arunachal Pradesh has no coast, no High Tide Line and no Coastal Regulation Zone, so the coastal band is empty in the State and Clause 6.11.6 does not apply there. Clauses 6.11.3 and 6.11.4 matter instead. The Arunachal Pradesh Building Bye-Laws, 2019 set a plinth "not less than 300 mm" above the surrounding ground, "so located with respect to the surrounding ground level that adequate drainage of the site is assured" (4.2.1.1), and no floor level above any flood level. Their only flood rule is the definition of a "Natural hazard prone area", whose flood-prone areas include those "flooded under conditions of heavy intensity rains, inundation in depressions, back flow in drains, inadequate drainage, etc. as identified through local surveys in the development plan of the area". No local authority has published a highest flood level for any town [TBC], no development plan with such a survey was found, and no flood zone exists in law (Chapter 7), so the rules give no level to build to. For this Manual, the floor levels of Clause 6.11.1, 0.5 m above the 1% AEP flood level, govern; in the capital region, where no 1% AEP level has been computed for the Senki, the Pachin, the Dikrong or a nallah, the level is taken as the highest flood level surveyed from the flood marks of Clause 5.8.5(a) where that is higher, and on the main stems at Pasighat, Tezu, Namsai and Roing as the check level of Clause 5.8.5(c), the CWC highest flood level transferred to the site, where that is higher (set by this Manual). Clause 6.11.3, which sets the lowest habitable floor and every opening 0.65 m above the road crown where no flood level has been computed, and Clause 6.11.4, which applies the same level, or 0.5 m above the 1% AEP flood level, to the crest of every basement ramp and the sill of every basement opening, are set by this Manual and add to the rules. The bye-laws already ask that "Adequate arrangements shall be made such that surface drainage does not enter the basement"; on the valley floors and the flood plains a basement is also checked for flotation with the groundwater at ground level where no piezometer readings exist (Clauses 4.12.1 and 4.12.3). On a hillside the road crown is not always the right reference: a building below a road takes the road's runoff, so Clause 6.11.2(a) sets its floor and openings from the 1% AEP level of the flow path past it, with the uphill diversion and the drained space against the cut of Clause 6.3.6(l) in place, and a floor or basement cut into a slope also needs the geotechnical certificate of the hill rule of Clause 4.11; the bye-laws already keep "a minimum distance of 0.60 meter" between a retaining wall on the sloping side and the building (2.10.2(a)). The hill-site clause of the 2009 "FINAL DRAFT" of the bye-laws, which asked for "proposals for diversion of the natural flow of water coming from uphill side of the building away from the foundation", is not in the 2019 text and is not treated as in force. Along the streams, nallahs and rivers, near the ponds and springs and on the shore of a reservoir, the lines of Chapter 7 also apply.

6.12 Culverts and road crossings

6.12.1 **Design AEP.** A culvert or bridge that carries a road over a drain or waterway shall pass the design AEP flow of Table 6.1 for that road class without overtopping the road, and with the headwater limits of Chapter 9, Clause 9.4. Where the waterway is a State highway or national highway crossing, the design AEP shall also be not less than that of IRC:SP:42-2014 §7.1.4 for the span. The rarer AEP governs.

6.12.2 **Check event and 1% AEP.** At the check event and at the 1% AEP event, the crossing and the road together shall pass the flow:

- (a) with overtopping depth ≤ 150 mm at the road crown and ≤ 350 mm at the deepest point of the road;
- (b) within the hazard limits of Table 6.3;
- (c) with no overtopping at all of arterial roads that are notified evacuation routes; and
- (d) without raising the 1% AEP flood level at any upstream building or property boundary above the level for the existing condition, unless the affected owners and the approving authority agree.

6.12.3 **Where overtopping is not permitted.** Overtopping in the 1% AEP event is permitted only where the structure span is less than 6 m **and** the 1% AEP peak flow is not more than 7 m³/s, unless a guard rail is installed downstream of the overtopping section. Otherwise, the crossing shall pass the 1% AEP flow without overtopping.

6.12.4 **Blockage check.** The 1% AEP check shall be repeated with a blocked inlet:

- (a) 50% of the inlet area blocked for culverts with a span or diameter below 1.5 m; and
- (b) 20% blocked for larger culverts.

The results of this check shall meet Clause 6.12.2(a) and (d).

6.12.5 **Minimum size.** Culverts under public roads shall be at least 900 mm in diameter, or 900 mm × 900 mm for box culverts.

6.12.6 **Hydraulic design.** Culvert hydraulics, including inlet and outlet control, tailwater, road overtopping and outlet protection, shall follow Chapter 9, Clauses 9.4 and 9.6.

> Commentary. The design AEPs are those of Table 6.1. The overtopping limits are the street-depth limits of Table 6.2. The span and flow threshold in Clause 6.12.3 is the SI conversion of APWA 5600 (2006): overtopping allowed only where the structure span is under 20 ft and the 1% peak is 250 cfs or less, unless a downstream guard fence is installed. IRC:SP:42-2014 (§7.1.4) sets 25-yr for NH/SH culverts up to 2 m span and 50-yr for 2–6 m spans. The blockage percentages in Clause 6.12.4 and the 900 mm minimum size have no direct precedent and are set by this Manual. The 50% value matches the grate clogging factor.

6.13 Arunachal Pradesh construction-practice requirements

6.13.1 **Covered roadside drains.** Where a roadside drain is covered by slabs that form a footpath:

- (a) it shall be designed as an open channel with the freeboard of Table 6.7 measured to the soffit of the cover slab, and its HGL shall meet Clause 6.8 measured to the footpath and inlet levels;
- (b) road runoff shall enter through openings in the drain wall at road level (Clause 6.6.1(b)), each with a silt sump (Clause 6.6.7), at the spacing of Clause 6.6.4;
- (c) footpath runoff shall enter through slots or grated openings in the cover, not by ponding on the footpath; and
- (d) the clear section shall meet Clause 6.7.6(c).

6.13.2 **Removable covers and access openings.** Covered drains shall have:

- (a) removable cover panels at not more than **10 m** centres, each at least 0.6 m long and spanning the full clear width, with recessed lifting points, liftable by two workers or by a hand-operated lifting device, and flush with the footpath;
- (b) access chambers with a clear opening of at least 0.6 m × 0.6 m at every junction, bend and change of section, and at not more than **30 m** centres on straight runs; and
- (c) covers rated for the traffic or pedestrian load at their location (Chapter 9, Clause 9.11).

6.13.3 **Silt traps.** In addition to the inlet sumps of Clause 6.6.7, silt trap chambers shall be provided:

- (a) upstream of every culvert under an arterial road;
- (b) upstream of every pump station and detention facility; and
- (c) at every outfall to a tank, river or other waterbody (with the gross pollutant trap required by Chapter 8).

Each silt trap shall be sized to hold the sediment expected between scheduled cleanings, using the sediment yield in Annex 6B, and shall be reachable by a desilting vehicle.

6.13.4 **Garbage and gross pollutant screens.** Screens shall be provided where an open drain enters a covered drain, a pipe or a culvert, and at outfalls under Chapter 8. Each screen shall:

- (a) be designed under Chapter 9, Clause 9.8;

- (b) have a bypass or overflow, so that a fully blinded screen does not flood properties or the road beyond the limits of this chapter; and
- (c) be checked hydraulically with 50% of its area blocked.

6.13.5 **No building over drains.** No structure other than an approved crossing or a removable cover shall be built over a public drain. Shop frontages, ramps and steps that cross a drain shall be removable or shall leave access openings that meet Clause 6.13.2.

6.13.6 **Utilities.** No water main, sewer, power or telecom cable, gas pipe or duct shall be laid along, or pass through, the flow area or freeboard of any drain. A utility that must cross a drain shall:

- (a) cross above the cover soffit or below the drain invert, inside a sleeve; and
- (b) be shown on the drainage plan with its level.

Where an existing utility crossing obstructs a drain, its area shall be deducted from the drain section, with a 50% blockage allowance for the debris it traps, until the utility is relocated. The utility owner shall relocate it when the drain is rebuilt.

6.13.7 **Sewage.** No sewage connection is permitted to a storm drain (Chapter 8). Covered drains shall be built with sealed joints where they run next to sewers.

6.13.8 **Edge protection.** Open drains deeper than 1.0 m beside a footpath, a carriageway or a public open space shall have railings or barriers. Open drains of any depth shall not be left uncovered across a footpath.

6.13.9 **As-built levels.** The as-built invert levels of every public drain, pipe and manhole shall be surveyed and submitted (Chapter 10). Inverts shall be within ±15 mm of design. An HGL re-check shall be submitted where they are not.

6.13.10 **Desilting.** Public drains shall be desilted before the monsoon season each year, as set out in Chapter 10.

> Commentary. Clause 6.13 has no direct precedent; this Manual sets it on the basis of Arunachal Pradesh practice. Most urban drains in the State are covered roadside drains under footpaths. They are often built with continuous cast-in-situ slabs and few openings, so they cannot be cleaned and fill with silt and solid waste within a season. CPHEEO (2019) notes that uncovered channels "are prone to the dumping of garbage" (Part A, Ch 2), which is why the drains are covered. Covering without access openings simply moves the problem out of sight. NDMA (2010) recommends that pre-monsoon desilting be complete by 31 March. In Arunachal Pradesh that date is also the start of the wet season as this Manual defines it. IMD's normal onset of the south-west monsoon at Itanagar is 5 June and its normal withdrawal 14 October (IMD, 2020, as summarised), but the storms come earlier: at Doimukh May brings 505.9 mm and April 227.7 mm, and the pre-monsoon months 24.0% of the year's rain (NERIST series, Dabral et al., 2016); "The state receives rainfall over a period of 8 to 9 months excepting in winter" (State Action Plan on Climate Change, 2011); and the damaging pre-monsoon events cluster in the last ten days of May, as on 28–29 May 2024, when Bomdila had 190 mm in 24 hours (IMD bulletin, as summarised), on 30 May 2025, when a vehicle was swept off NH-13 between Bana and Seppa (as reported), and on 31 May 2025, when the Pare dam's discharge peaked at 1,310 m³/s (as reported). Storms also come after the withdrawal, in the east: Hayuliang 280.0 mm on 3 October 1979 and Tezu 222.0 mm on 4 October 1979 (IMD *Extremes*). No order of IMC, the Pasighat Municipal Council, the Department of Urban Affairs or any other body fixing a completion date for desilting was found during research [TBC]. So Clause 6.13.10 refers to the monsoon season as this Manual defines it, 1 April to 31 October, and Chapter 10 requires desilting and the clearance of silt, debris, garbage and slide material from drains, nallahs, inlets, racks, traps and culverts to be complete by 31 March, with gates, flap gates and any pumps certified ready on the same date (Clauses 5.11.5 and 5.12.9), and cut slopes stabilised by then (APBBL 2019, 4.39(11)); a mid-season clearance of inlets, culverts, racks, silt traps and the nallah mouths by 15 May, after the April storms and before the late-May storms, earlier than the 31 May of the Assam edition downstream because a clearance due at the end of May falls in the storms it is meant to precede, as the adjoining Nagaland edition also found; standby from 1 April to 31 October; and a post-season clearance of silt, debris and slide material in every town by 15 November, after the October storms of the east. In the high ranges, where snow

lies in winter, inlets, culverts and racks are kept clear of snow and ice from December to March; where snow or frozen ground prevents the desilting before 31 March, it is done in the 15 November clearance and a snowmelt clearance follows by 30 April. These dates are set by this Manual. WRD's works on rivers keep WRD's own calendar.

No rule of the Arunachal Pradesh Building Bye-Laws, 2019 forbids building over a drain in so many words, but the bye-laws define *Jhot*, "A strip of land permanently left open for drainage purposes. It is not to be used as an access way or a street and is not to be included as a part of setbacks" (def. 69), without a width, and ask large sites to keep "The inlet and outlet point of natural drain system … with adequate size of channel for ensuring unrestricted flow of water" (Table 14.1). The capital's drains are "chocked with the solid wastes", "Regular cleaning of drains is not taking place and hence heavy silting happens", and the Pachin "had become a waste disposal site" (Master Plan of Itanagar Capital Region-2031, report); drains along the Bage Tinali–Naharlagun road are reported to be "too shallow and narrow" and clogged by earth-cutting debris, with an inspection recommending de-silting "upto the Dikrong river" (as reported). This Manual allows a drain to be covered only with the access openings of Clause 6.13.2, and natural streams and nallahs are open channels with a drainage reserve (Clause 6.9), which should not be covered, decked or built over. Where a drain is covered, Clause 6.13.2 applies to it in full; where it is open beside a footpath or a carriageway, Clause 6.13.8 applies. In the hill towns many drains run beside steps and footpaths on steep ground, where an open drain is a fall hazard and a covered one cannot be cleared of stones and waste without its access openings.

Clause 6.13.7 is not yet the practice, and it cannot be until sewers exist. "City sewerage is discharged into open drains. The hilly terrain means limited scope for u/g sewer network", and "There is no sewage treatment plant present in the city" (Master Plan report); "no ULB is treating sewage. Even the state capital, Itanagar-Naharlagun, lacks a sewage treatment facility" (observations quoted in the State's affidavit in NGT OA 606/2018, 2025); and CPCB lists the Senki at Chandranagar, upstream of the Pachin, as a polluted stretch (CPCB, *Polluted River Stretches*, 2025). The bye-laws already forbid that "effluent from a septic tank be allowed into an open channel drain or body of water without adequate treatment" (APBBL 2019, 4.16.2(c)), and the Municipal Corporation Act, 2019 bars "foul water into a drain provided for surface water" where separate drains exist (s.203): the gap is enforcement and the absence of a sewer or septage service, not the rule. Clause 8.9 sets how dry-weather flow in storm drains is surveyed and intercepted until the connections are removed, including the rule that interception shall not reduce the capacity of the drain (Clause 8.9.5(b)).

The 10 m and 30 m spacings and the ±15 mm tolerance have no direct precedent and are set by this Manual. Clause 6.13.6 responds to the common sight of water mains and cables running through drains. Each one traps debris and reduces the section. Mechanical cleaning through cover openings, rather than manual entry, is assumed throughout, consistent with the Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013.

6.14 Outfalls

6.14.1 Outfalls shall be designed for the tailwater conditions of Chapter 5. Outfalls below the 1% AEP still-water level shall have flap or tide gates or non-return valves (Chapter 5 and Chapter 9, Clause 9.10).

6.14.2 Outfall protection and energy dissipation shall be designed under Chapter 9, Clause 9.6. Outfalls to tanks and waterbodies shall also meet Chapters 7 and 8.

6.15 Submittal requirements

Every conveyance submittal shall include a **Conveyance Design Report** (Form 6-1) containing:

1. a catchment plan showing sub-catchments, the minor system, inlet locations and the major-system overland flow paths for the 1% AEP event (Clause 6.3.2);
2. the land-use and road-class AEP adopted for each element (Table 6.1), and the high-density area status;
3. design flows, with the rainfall sheet of Chapter 2 and the method of Chapter 3;
4. gutter spread, depth and D·V checks for the minor, check and 1% events (Tables 6.2 and 6.3);
5. an inlet schedule with clean capacity, clogging factor, design capacity and bypass flow (Clause 6.6);
6. pipe and drain design tables with n, velocity, sediment allowance and freeboard (Clause 6.7);
7. HGL profiles for the minor and check events, with the tailwater used (Clause 6.8);
8. sag ponding levels, including the fully-blocked check (Clause 6.10);
9. a floor-level schedule for every building (Clause 6.11);
10. culvert and crossing calculations (Clause 6.12 and Chapter 9); and
11. a utilities-crossing schedule and access-opening layout for covered drains (Clause 6.13).

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Annexes and forms

Annex / Form	Content
6A	Standard inlet types for Arunachal Pradesh with capacity curves (on grade and sag)
6B	Sediment yield for silt-trap sizing and calibration of the sediment allowance
6C	Standard drawings: covered roadside drain with removable covers, access chamber, inlet with silt sump
Form 6-1	Conveyance Design Report checklist

CHAPTER 7

Waterbodies, Ponds, Lakes and Setbacks

7.1 Purpose and scope

7.1.1 This chapter treats waterbodies as part of the drainage system. It sets the rules for:

- (a) identifying and mapping every waterbody that a development or public work affects;
- (b) the setback zones around waterbodies, and the uses allowed in each zone;
- (c) fill in flood-prone land, and the compensatory storage needed where fill is allowed;
- (d) counting tank (pond) storage, including tank cascades, as design storage;
- (e) restoring and desilting tanks and ponds;
- (f) protecting supply channels, surplus courses, inlets and outlets;
- (g) wetlands, marshes and estuaries, which in Arunachal Pradesh, a landlocked State, means Glaw Lake in the Kamlang Tiger Reserve, the State's first Ramsar site (announced on 3 August 2026, as reported), Ganga Lake (Gyakar Sinyi) in the Itanagar Wildlife Sanctuary, the palaeochannels and swampy land of the Pachin and Dikrong flood plains, the ponds, the seepage ground of springs, the reservoirs with their drawdown zones, the 1,127 wetlands of more than 2.25 ha truthed by the Forest Department (944 of them high-altitude lakes), and any wetland notified under the 2017 Rules (none was found notified);
- (h) the interface with encroachment and its removal;
- (i) fee-in-lieu contributions to regional tank storage (with Chapter 4); and
- (j) the safety of tank bunds and other embankments.

7.1.2 This chapter applies to every development and public work to which this Manual applies under Chapter 1 and that:

- (a) adjoins a waterbody or lies wholly or partly within its setback (Clause 7.4);
- (b) discharges to a waterbody, directly or through a drain, within the downstream analysis extent of Chapter 5; or
- (c) alters a waterbody, its bund, sluice, surplus weir, supply channel or surplus course.

7.1.3 Where a statute or statutory rule sets a wider setback or a stricter restriction, the statute governs (Clause 1.3.3). Nothing in this chapter authorises any work that the Arunachal Pradesh Building Bye-Laws, 2019, the Arunachal Pradesh Municipal Act, 2007, the Arunachal Pradesh Municipal Corporation Act, 2019, the Arunachal Pradesh Urban and Country Planning Act, 2007, as amended, and the master plans and schemes made under it, the Arunachal Pradesh (Land Settlement and Records) Act, 2000 and the customary rights it incorporates, the Wetlands (Conservation and Management) Rules, 2017, or any other law, prohibits.

> Commentary. Arunachal Pradesh has no Act for the protection of ponds, lakes, streams, nallahs or springs, and no floodplain law or Bill was found. Its waterbodies are touched by one statewide building rule, by its municipal, planning and land law, by the customary rights under which much land and water near the towns are held, by the wetland rules and by the courts. The **Arunachal Pradesh Building Bye-Laws, 2019** (the APBBL 2019; Department of Town Planning and ULBs, Government of Arunachal Pradesh) extend "to whole of Arunachal Pradesh" (clause 2.1); they ask the site plan to show "existing physical features such as well, drains" and the "Distance from Nallah/Stream as per the notified rules/norms" (clause 2.10.1(j) and (e)), but no such rules or norms were found; they define the *Jhot* as "A strip of land permanently left open for drainage purposes" (definition 69) without a width; they refuse earth-cutting permission where "the average slope of the topography is more than 30%" (clause

4.39(14)); and they ask every urban local body and planning authority "to identify, demarcate, protect and maintain the water bodies that come under their jurisdiction" and to prepare a list (Annexure E, item 1.8), of which none was found (Clause 7.4, Disclosure). In the area of the **Itanagar Municipal Corporation (IMC)** "all public streams, springs and works for the supply, storage and distribution of water" and "all public sewers and all drains … in or under any public street" vest in the Corporation, and "the maintenance and cleaning of drains and drainage works" is an obligatory function (**Arunachal Pradesh Municipal Corporation Act, 2019**; the function is s.60(a), and the public drains vest under s.200); in a municipality such as Pasighat "all public tanks, streams, reservoirs, and wells" and "all public sewers and drains, channels, tunnels, culverts and watercourses" vest in it "Notwithstanding anything contained in any other law" (**Arunachal Pradesh Municipal Act, 2007**, s.102). The **Arunachal Pradesh Urban and Country Planning Act, 2007** provides for master plans, and the **Master Plan of Itanagar Capital Region-2031** was approved on 3 June 2022; Ordinance No. 5 of 2025 adds Town Planning Schemes, whose contents may include "the filling-up or reclamation of low-lying, swampy or unhealthy area, or levelling-up of land", and an amending Bill was reported passed on 9 March 2026 (as reported; its Act number and final text were not found [TBC]); the reclamation clause is the main statutory risk to ponds, swamps and low-lying storage (definitions after Clause 7.2). Land is governed by the **Arunachal Pradesh (Land Settlement and Records) Act, 2000**, which incorporates "customary rights on the land" and vests the beds of rivers, streams, nallahs, lakes and tanks in Government only where they are "not the property of any person or community" (s.9(1)); much land near the towns is community, clan or individual land, and individual titles came only with a 2018 amendment (s.1A, as reported). Wetlands are the concern of the Forest Department, which has truthed 1,127 wetlands and demarcated the boundaries of 997, and of the **State Wetland Authority** (a memorandum with Wetlands International South Asia in 2024 is reported; its exact name and the notice constituting it were not found [TBC]); Glaw Lake became the State's first Ramsar site on 3 August 2026 (as reported), and no wetland notified under rule 4 of the 2017 Rules was found. In this chapter **NEEPCO** means the North Eastern Electric Power Corporation Ltd, which operates the Pare reservoir on the Dikrong above Doimukh, the Ranganadi project at Yazali and the Kameng project, the impounded waters with gates, releases and an operator that release into town reaches; it is named as the operator whose levels and records a design uses, not as an approving authority, and NHPC is named in the same way for the Lower Subansiri and Dibang projects. The custodians of the ponds, springs and lakes are recorded one by one in the inventory (Annex 7A). Who regulates where, and who is the competent authority for each area, including on community and clan land, is set out in Chapter 1.

This Manual treats every recorded waterbody as drainage infrastructure. Five features set Arunachal Pradesh apart. The first is the **nallah**: "the storm water drainage system consists of natural drainage system (Nallah) and major drains", and the roadside drains "end up mostly into the Nallah and in some cases, into local ponds or open fields" (Master Plan of Itanagar Capital Region-2031); the floods of 2017 badly damaged the "land protection wall of several nallahs and rivulets" and closed NH-415, with traffic diverted by Papu Nallah and Jullang Road (the same plan). The second is the **foothill river of the capital**: Itanagar's drains run to the nallahs and the Senki and the Pachin, and Naharlagun's to the Dikrong; the Pachin "passes through most of the area before it debouches to Dikrang river near Nirjuli" (CGWB, as summarised); and the Dikrong below Doimukh carries the releases of the Pare dam (a peak of 1,310 m³/s on 31 May 2025, as reported); none of the three has a gauge level. The third is the **main stem fed from Tibet, glaciers and snow**: the Siang at Pasighat, the Lohit at Tezu and the Noa-Dihing at Namsai, whose stage is set upstream, as the Yigong landslide-dam outburst of June 2000 set the CWC's highest flood level at Pasighat, 157.54 m against a danger level of 153.96 m (as reported); above them lie the **glacial lakes**, of which NDMA lists 27 as high-risk (Tawang 6, Kurung Kumey 1, Shi Yomi 1, Dibang Valley 16, Anjaw 3; as reported). The fourth is the **lake and wetland**: 1,127 wetlands of more than 2.25 ha were truthed in 19 districts, 944 of them high-altitude lakes, 24 aquaculture ponds, 12 ox-bow lakes, 8 waterlogged areas, 3 lakes, 2 tanks or ponds, 1 reservoir and 1 paddy field, with 130 entries found to be shadows, and only 6 in Papum Pare (Forest Department); the capital's lake is **Ganga Lake (Gyakar Sinyi)**, in the Itanagar Wildlife Sanctuary about 6 km from Itanagar, under pressure from encroachment and earth cutting (as reported). The fifth is the **spring**: the springs of Papum Pare discharge 0.43 to 2 L/s before the monsoon and "most of the springs become dry during dry season", and in the northern hills of East Siang springs are the only source (CGWB); no statute keeps building or drains away from a spring, and springs were not researched for this Manual [TBC]. The **ponds** are few and small in the towns: the first Water Bodies Census counted 993 water bodies, 893 rural and 100 urban, and none encroached (as summarised from a Rajya Sabha answer), and the master plan's ponds receive drains and sewage (Clause 8.9,

Commentary). Arunachal Pradesh has no irrigation tank cascades; the tank clauses of this chapter apply to the ponds, the lakes, the reservoirs and any other impounded water. This chapter gives the design rules that protect the storage and conveyance of these waterbodies. It does not replace the bye-laws, the municipal, planning and land law, the customary rights of communities, clans and owners, the wetland procedures, or the directions of the Gauhati High Court (Itanagar Bench), the National Green Tribunal and the Supreme Court.

7.2 Definitions

Term	Meaning in this Manual
Waterbody	A river or stream, such as the main stems fed from Tibet, glaciers and snow (the Siang, the Dibang, the Lohit, the Subansiri, the Kameng and the Tawang Chu), the rivers of the capital region (the Dikrong, the Pachin and the Senki) and the Noa-Dihing on the south-eastern plain; hill stream (a small, steep stream, perennial or seasonal, into which the drains of a hill town fall); nallah (a natural or open urban channel, such as Papu Nallah at Naharlagun and the nallahs into which Itanagar's drains run; a channel is selam in Nyishi, Hamilton 1900, c. p. 96); drain; pond, natural or dug, private, community or public; lake or wetland, such as Ganga Lake (Gyakar Sinyi) in the Itanagar Wildlife Sanctuary and Glaw Lake in the Kamlang Tiger Reserve (a lake is sinyi in Nyishi, Hamilton 1900, c. p. 104); glacial or moraine-dammed lake, such as the 27 high-risk glacial lakes that NDMA lists in the State (as reported); reservoir, such as those of the Pare and Ranganadi projects, with its drawdown zone; spring with its recharge area; supply channel or surplus course, perennial or seasonal (as in Chapter 1).
Tank (pond)	A waterbody impounded by an earthen bund, fed by its own catchment and/or a supply channel, with a surplus weir and one or more sluices.
Tank cascade	A chain of tanks in which the surplus or sluice outflow of one tank feeds the next (as in Chapter 3).
Full tank level (FTL)	The crest level of the surplus weir (spillway, overflow or outlet) of a tank, or the permanent crest of its regulating structure. The tank holds water up to FTL without spilling.
Maximum water level (MWL)	The highest water level in a tank when the surplus weir passes the tank's design flood. For this Manual, it is the greater of the level recorded by the Water Resources Department and the level computed for the 1% AEP (100-yr) inflow with the climate factor of Clause 2.8 (Clause 7.7.4).
Top bund level (TBL)	The crest level of the tank bund.
Waterspread	The area of a tank submerged at FTL.
Foreshore	The land around a tank between the FTL contour and the MWL contour. Foreshore land is flooded whenever the tank surpluses, and is part of the tank's flood storage.
Supply channel (stream, nallah or feeder channel)	A channel that brings water from a river, anicut or upstream tank into a tank.
Surplus course	The channel that carries the overflow of a surplus weir to the next tank, a river, a drain or the sea.
Sluice (sluice, spillway gate or regulator)	A controlled outlet through a tank bund, usually to an irrigation channel.
Top of bank	For a channel, the break in slope at the edge of the channel. Where it cannot be identified, the edge of the water surface at the 50% AEP (2-yr) flow.
1% AEP flood extent	The land flooded by the 1% AEP (100-yr) flood with the climate factor of Clause 2.8, from a hydraulic model that meets Chapter 3 and Chapter 5, or from a map adopted by the Authority under Clause 7.3.4.
Floodway	The waterbody and the adjoining land that must be kept free of obstruction to pass the 1% AEP flood without raising the 1% AEP water level by more than **0.1 m** at any point (Clause 7.6.1). For a tank, all land below MWL.
Flood fringe	The part of the 1% AEP flood extent outside the floodway.

Term	Meaning in this Manual
Zone 1 (waterbody protection zone)	The inner setback zone defined in Clause 7.4.3.
Zone 2 (flood fringe setback)	The outer setback zone defined in Clause 7.4.4.
Setback	Zone 1 and Zone 2 together.
Compensatory storage	Excavated storage that replaces flood storage lost to fill, under Clause 7.6.4.
Flood cushion	Storage below FTL kept empty, under a documented operating rule, to absorb a flood (Clause 7.8).

Arunachal Pradesh terms. The following terms are used in this chapter in addition to those above (see also Annex 7E):

Term	Meaning in this Manual
Pond	A pond, natural or dug, private, community or public. "Pond" is used in plain English because English is the working language of the State and of this Manual (as reported), no single tribal language is shared across the State, and the one local word found, Nyishi *sinyi*, means "Lake" and "Tank" (Hamilton 1900, c. pp. 104 and 118) rather than a small urban pond (Annex 7E); the statutes, the Master Plan of Itanagar Capital Region-2031 and the wetland truthing already use "pond" and "tank" in English. A pond with a controlled outlet is a tank under Clause 7.2: its outlet gate is its sluice, and its FTL is the level at which it spills over its outlet with any gate closed, found by survey. A pond with an uncontrolled outlet has its FTL at the crest of that outlet. A natural pond or lake keeps its own description, such as Ganga Lake (Gyakar Sinyi). Engineered storage built under this Manual is a "detention pond", never a natural or community pond, a lake, a spring pool or a reservoir.
Nallah	A natural or open urban channel, as the APBBL 2019 ("Distance from Nallah/Stream", clause 2.10.1(e)), the Arunachal Pradesh (Land Settlement and Records) Act, 2000 ("nallahs", s.9(1)) and the Master Plan of Itanagar Capital Region-2031 ("natural drainage system (Nallah)") use the word, and as in place names such as Papu Nallah. A nallah that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whether it is lined, piped or covered, whether it is dry for most of the year, and whatever it carries; until sewers exist it is also a combined channel (Clause 8.9, Commentary). It carries boulders, slide debris and garbage in flood: its inlets and culverts take the racks, bulking and blockage of Clause 6.3.6(f) to (h). Its top of bank is the edge of its channel as built, or of its active bed where that is wider, or, where it has been narrowed, the edge shown in any record or survey of its earlier width, whichever is wider (Clause 7.13.1). This definition is set by this Manual.
Hill stream	A small, steep stream, perennial or seasonal, below a hill town, into which the town's drains and nallahs fall (plain English; Annex 7E). Every hill stream that drains 8 ha or more is a natural channel under Clause 7.4.1(b), and the rules for a nallah apply to it. This definition is set by this Manual.
Jhot	"A strip of land permanently left open for drainage purposes. It is not to be used as an access way or a street and is not to be included as a part of setbacks" (APBBL 2019, definition 69). The bye-laws give it no width. In this Manual the word means that strip only; where a Jhot is shown on an approved plan, it lies within Zone 1 or is added to it, and it never reduces Zone 1.
Recorded waterbody	A pond, lake, reservoir, stream, hill stream, nallah, spring or wetland shown in any source of Clause 7.3.3(a): a record of a land revenue office of a Deputy Commissioner, a community, clan or owner; IMC's or a municipality's record of what vests in it; a list prepared under Annexure E 1.8 of the APBBL 2019; a map of the Master Plan of Itanagar Capital Region-2031 or another master plan; the Water Bodies Census; the Forest Department's wetland truthing; NDMA's glacial-lake list; NEEPCO's or NHPC's records; or a town's drain register. A recorded waterbody is part of the drainage system for this Manual. Where it is proposed to be filled, in whole or part, a drainage assessment under Chapters 3 to 5 shall show the storage and flow paths lost and their effect upstream and downstream, and the lost storage shall be replaced under Clause 7.6.4 before any design relying on the filling is approved. This definition and rule are set by this Manual.

Term	Meaning in this Manual
Low-lying land and reclamation	Land below the 1% AEP flood level of a river, stream or nallah, the palaeochannels and swampy land of the Pachin and Dikrong flood plains, paddy fields that hold water in the season, and the margins of a pond are flood storage. Ordinance No. 5 of 2025 lets a Town Planning Scheme include "the filling-up or reclamation of low-lying, swampy or unhealthy area, or levelling-up of land"; whether the provision stands in the amended Act was not found [TBC], and the Ordinance is cited here as the Ordinance, not as enacted law. For this Manual such reclamation, under any scheme or none, is fill: where it lies below the 1% AEP flood level, or on the margin of a pond, the storage it removes is replaced under Clause 7.6.4 (1:1 in bands of not more than 0.3 m), in the same reach and before or with the fill, and is secured under Clause 7.6.4(f); the replacement is not counted as detention (Clause 7.6.5). This Manual does not override a scheme; it states the storage the scheme must keep. This reading is set by this Manual.
Boundary of a pond, lake or reservoir	For this Manual, the boundary of a pond or lake under Clauses 7.3.3 and 7.13.1 is the largest of its recorded boundary (including a boundary demarcated in the Forest Department's wetland truthing), its surveyed FTL and the outer edge of its water in the season of 1 April to 31 October shown by dated imagery or survey of recent years. The boundary of a reservoir is the highest level its operator states in writing, stated to the datum of Clause 7.3.5; no full reservoir level was found for the Pare, Ranganadi or Kameng reservoirs [TBC]. The drawdown land of a reservoir below that level is part of the reservoir. This reading is set by this Manual.
Reference lines for setbacks	No statutory reference line exists in Arunachal Pradesh (Clause 7.4, Disclosure). Two lines are used, and the setback that reaches furthest from the water governs: (a) the FTL of a pond, lake or reservoir, the outlet or the edge of the chamber or pool of a spring, or the top of bank of a channel, with Zone 1 of Clause 7.4.3 measured from it; and (b) the 1% AEP flood extent of Clause 7.3.4, with the 10 m of Clause 7.4.4 added. A Jhot on an approved plan and any distance shown under clause 2.10.1(e) of the APBBL 2019 are stated on Form 7-1, but they never reduce Zone 1. This rule is set by this Manual.
Spring; spring recharge area	A spring is a place where groundwater comes out at the surface (Nyishi *lol*, "Spring … But the word is rarely used", Hamilton 1900, c. p. 118, is not used; Annex 7E). A spring is a waterbody for Clause 7.3, and its Zone 1 under Clause 7.4 is measured from its outlet or the edge of its chamber or pool. Its recharge area is the area upslope from which it is fed, as a hydrogeologist maps it; above a drinking-water intake that area is a no-paving zone, except for access, into which no road runoff is infiltrated, no soak pit or septic tank is placed, no drain is cut that would intercept the flow to the spring, and no fill is placed that would bury its outlet (Clause 8.8.1). No storm drain or sewer is laid within Zone 1 of a spring, and no drain or fill is laid across its outlet, except a lined drain below the outlet that carries its overflow away. A spring pool is never a detention pond. This definition and these rules are set by this Manual; springs were not researched for this Manual [TBC].
Glacial or moraine-dammed lake	A lake held by a glacier, moraine or landslide dam, of which NDMA lists 27 high-risk lakes in the State (as reported), and such as the landslide-dam lake on the Yigong in Tibet whose breach in June 2000 raised the Siang at Pasighat to the CWC's highest flood level (as reported). It is a waterbody for Clause 7.3 and a hazard to be screened under Clause 2.3.6(i) and mapped under Chapter 5; it is **never** a design outfall or design storage, and no drain under this Manual discharges to it. This rule is set by this Manual.
Community land; landholder	Land held by a community (in the 2000 Act, "residents of a village as a whole", including "a clan, sub-clan, kindred"), a clan or an individual under the customary rights that the Arunachal Pradesh (Land Settlement and Records) Act, 2000 incorporates, inside or outside a town; "common land" is land "used or reserved for the common use of a community or a village" (s.2). Its landholder is the community, clan or owner, and the beds of rivers, streams, nallahs, lakes and tanks on it are not Government property (s.9(1)). Zone 1 land that is not Government or municipal land is secured for this Manual by a written agreement with the owners or the community, by donation (the Act's own definition of Government land includes land obtained "through donation of the public"), by purchase, or by reservation in a master plan, layout or Town Planning Scheme, and is not taken. Where the State decides that land must be obtained compulsorily, section 104 of the Arunachal Pradesh Municipal Act, 2007 routes it through the "Land of Acquisition Act, 1894" (as printed), which the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 has replaced for the Union (NEER reading), and its section 104(3) also allows "other methods of land assembly including the use of transferable development rights"; this Manual states that route and does not invoke it. On community land outside any permission or plan this chapter is guidance, unless the owners or the community take it into an agreement of their own. This rule is set by this Manual.

7.3 Inventory and mapping of waterbodies

7.3.1 **Statewide inventory.** The Authority, with the Water Resources Department and the land revenue offices of the Deputy Commissioners, shall maintain a GIS layer of every waterbody in its area (Annex 7A). For each waterbody it shall record:

- (a) its type (Clause 7.2), name and survey numbers;
- (b) its custodian (the Itanagar Municipal Corporation (IMC) within its limits (for the public streams and springs, the works for the supply of water, and the public sewers, drains, culverts and water courses in or under any public street, which vest in it under the Arunachal Pradesh Municipal Corporation Act, 2019, and for the drains whose maintenance and cleaning are its obligatory function under section 60(a)), the Pasighat Municipal Council or another municipality within its limits (for the public tanks, streams, reservoirs and wells, and the public sewers, drains, channels, culverts and watercourses alongside or under any street, which vest in it under section 102 of the Arunachal Pradesh Municipal Act, 2007), the Department of Urban Affairs or a Smart City company (for the storm drains, sewerage and septage works they build, until these are handed over to the urban local body), PWD or PWD (Highways) (for the drains and culverts of their roads, NH-415 among them), the Water Resources Department (for rivers and anti-erosion works), PHED (for water-supply sources and intakes), NEEPCO (for the Pare, Ranganadi and Kameng reservoirs and the reaches below them, as operator) or NHPC (for the Lower Subansiri and Dibang projects, as operator), the Forest Department (for the wetlands it has truthed and demarcated, and for Ganga Lake in the Itanagar Wildlife Sanctuary, whose charge it is reported to have taken), the State Wetland Authority (for a notified wetland; none was found), a community, clan or individual owner (for land and water held under the customary rights that the Arunachal Pradesh (Land Settlement and Records) Act, 2000 incorporates; the beds of rivers, streams, nallahs, lakes and tanks are Government property only where they are "not the property of any person or community", section 9(1)), a village authority, a colony developer (for the drains of a layout until they are handed over), or another body);
- (c) its boundary as recorded in Revenue records;
- (d) for tanks: FTL, MWL, TBL, the surplus weir crest length and type, sluices, the supply channel and the surplus course, each with its datum;
- (e) its position in any tank cascade, with the upstream and downstream tanks;
- (f) the 1% AEP flood extent, where mapped; and
- (g) known encroachments, with the date recorded.

7.3.2 **Project mapping.** Every drainage report shall include a Waterbody Sheet (Form 7-1) showing all waterbodies:

- (a) within the site;
- (b) within 100 m of the site boundary; and
- (c) downstream, to the extent of the downstream analysis of Chapter 5.

The sheet shall show, on a plan at a scale of 1:1,000 or larger for (a) and (b):

- the Revenue record boundary;
- the surveyed FTL or top of bank;
- the MWL contour (tanks) and the 1% AEP flood extent;
- Zone 1 and Zone 2 (Clause 7.4); and
- every supply channel, surplus course, sluice and surplus weir.

7.3.3 **Sources.** Waterbodies shall be identified from all of the following. Where they conflict, the larger waterbody extent governs:

- (a) records of the land revenue offices of the Deputy Commissioners under the Arunachal Pradesh (Land Settlement and Records) Act, 2000, which are thin, because much land near the towns is held by communities, clans and individuals under the customary rights that the Act incorporates and is in no State register: individual titles came only with the 2018 amendment (section 1A, as reported), and the beds of rivers, streams, nallahs, lakes and tanks are Government property only where they are "not the property of any person or community"

(section 9(1)), so that the records of the communities, clans and owners are also needed (none was read for this Manual [TBC]); the public streams, springs, drains and water courses that vest in the Itanagar Municipal Corporation under the Arunachal Pradesh Municipal Corporation Act, 2019, and the public tanks, streams, reservoirs, wells and drains that vest in a municipality under section 102 of the Arunachal Pradesh Municipal Act, 2007; the list of the water bodies in its jurisdiction that every urban local body and planning authority is to prepare under Annexure E 1.8 of the APBBL 2019 (none was found [TBC]); the maps of the Master Plan of Itanagar Capital Region-2031, with its "natural drainage system (Nallah)" and the flood plains of the Pachin and the Dikrong; the first Water Bodies Census (993 water bodies, 893 rural and 100 urban, none encroached, as summarised from a Rajya Sabha answer); the Forest Department's truthing and boundary demarcation of 1,127 wetlands, of which 997 have been demarcated; NDMA's list of high-risk glacial lakes (as reported); NEEPCO's and NHPC's records of the levels and land of their reservoirs; and each town's drain register (Chapter 6);

- (b) NEEPCO and village authority tank registers and records of FTL and MWL;
- (c) the Authority's inventory (Clause 7.3.1) and any list published under court directions;
- (d) historical topographic maps and satellite imagery, including the ISRO National Wetland Inventory and Assessment; and
- (e) a site survey by a licensed surveyor, levelled to the datum stated in Clause 7.3.5.

7.3.4 **Flood extent maps.** The Authority may adopt 1% AEP flood extent or flood depth maps for its area. A depth map adopted under this clause also sets floor levels under Clause 6.11. Where a map has been adopted, it shall be used unless a site hydraulic study under Chapters 3 and 5 shows a larger extent. Where no map has been adopted, the Applicant shall determine the 1% AEP extent by a hydraulic study for:

- (a) any site in a flood-sensitive catchment (Chapter 1);
- (b) any site of 1 ha or more adjoining a waterbody; and
- (c) any site where the Authority so requires.

For other sites, the fixed-width setback of Clause 7.4.6 may be used.

7.3.5 **Datum.** All levels in this chapter shall be stated to one datum, stated on every drawing. Where NEEPCO records use a local or older datum, the conversion to the project datum shall be surveyed and stated.

> Commentary. Arunachal Pradesh has no floodplain law and no flood line. No floodplain zoning Act or Bill was found, and no flood zone, flood line or riverbank setback has been drawn for any town. The bye-laws' definitions treat as natural hazard prone the areas of "significant flood flow or inundation, or landslides/mud flows/avalanches", including those "flooded under conditions of heavy intensity rains, inundation in depressions, back flow in drains, inadequate drainage, etc. as identified through local surveys in the development plan of the area" (APBBL 2019), and clause 2.10.1(f) asks the site plan to show the "Distance from Disaster Prone Area as per norms set by Disaster Management Authority"; no such survey or norms were found. The Master Plan of Itanagar Capital Region-2031 maps the geomorphology of the capital, with an "Alluvial Plain … along the wide flood plain areas of Pachin and Dikrong rivers", palaeochannels, swampy land, terraces and flood plains, and proposes a new drainage network (Maps 28 to 30), but it draws no flood line and gives no design storm; Pasighat has no master plan or drainage plan that was found [TBC]. The rivers of the capital are not gauged: there is no CWC site on the Senki, the Pachin or the Dikrong, and the operator of the Pare dam issues release advisories but no stage record for the Dikrong was found. The main stems are gauged only at a few CWC sites, with levels as transcribed by SANDRP and no datum stated [TBC]: the Siang at Pasighat (danger level 153.96 m; highest flood level 157.54 m on 11 June 2000, the Yigong outburst), the Noa-Dihing at Namsai (145.8 m and 146.6 m) and the Lohit at Tezu (highest flood level 192.14 m, 16 July 1996) (all as reported). No local authority has fixed a highest flood level for any town [TBC], and the bye-laws' plinth is "not less than 300 mm" above the surrounding ground (clause 4.2.1.1), which is not a flood level. The best evidence of flood extent is therefore on the ground: the marks of the 1999 flood on the Dikrong, the 2017 floods in the capital, the Modirijo and Donyi Polo floods of September 2018, the floods of June and July 2024 at Energy Park, Bank Tinali, Niti Vihar and Abo Tani Colony, and the floods of late May and June 2025 (as reported), and the evidence of residents. Clause 7.3.4 lets the Authority adopt flood maps once they exist; until then the Applicant produces the 1% AEP extent for larger and flood-sensitive

sites, with the river backing up the nallah under Clause 5.8.5(a) and (c), the bulking of Clause 6.3.6(g) on hill streams and nallahs, and the surveyed flood marks of Clause 5.8.5, and the floor levels of this Manual (the 1% AEP level + 0.5 m) govern where they are higher than the bye-laws' 300 mm plinth. Levels shall be stated to one datum (Clause 7.3.5). Clause 7.3.3 makes the larger of the recorded and surveyed extents govern, because the Revenue boundary and the surveyed water edge often differ, and either may have been reduced by encroachment. The 100 m search band in Clause 7.3.2 is set by this Manual.

7.4 Setbacks

7.4.1 **Waterbodies to which setbacks apply.** Setbacks apply to:

- (a) every waterbody recorded under Clause 7.3.1 or found under Clause 7.3.3, whatever its size; and
- (b) every natural channel, whether recorded or not, that drains **8 ha** or more at the site.

7.4.2 **Two zones.** The setback has two zones, shown in Figure 7.1:

- **Zone 1 (waterbody protection zone)**, next to the waterbody; and
- **Zone 2 (flood fringe setback)**, outside Zone 1.

7.4.3 **Zone 1 width.** Zone 1 is measured outward from the FTL contour (tanks, lakes and ponds) or from the top of bank (channels). Where both apply, use whichever gives the wider zone. Zone 1 extends to the **greatest** of:

- (a) **15 m**, the minimum set by this Manual along every natural channel draining 8 ha or more, including the capital's nallahs, the Senki, the Pachin and the Dikrong, and round every pond, lake, reservoir and spring (no statute, rule or bye-law found in Arunachal Pradesh sets any distance from a stream, nallah, spring, pond or drain: clause 2.10.1(e) of the APBBL 2019 asks the site plan to show the "Distance from Nallah/Stream as per the notified rules/norms", but no such rules or norms were found, and the bye-laws' Jhot, a "strip of land permanently left open for drainage purposes", has no width; the 15 m is offered as the norms that clause refers to, which the State could notify; see the Disclosure below);
- (b) the outer edge of the floodway (Clause 7.6.1); and
- (c) for a tank, the MWL contour.

7.4.4 **Zone 2 width.** Zone 2 extends from the outer edge of Zone 1 to the **1% AEP flood extent plus 10 m**. Where the 1% AEP flood extent lies inside Zone 1, Zone 2 is 10 m wide.

7.4.5 **Statutory and approval setbacks.** Where a statute, a statutory rule, a condition of planning permission or a line of the Master Plan of Itanagar Capital Region-2031, or of another master plan, layout or Town Planning Scheme under the Arunachal Pradesh Urban and Country Planning Act, 2007, as amended (the master plan's map of the natural drainage system and the flood plains of the Pachin and the Dikrong sets no width); a condition of the building permission or earth-cutting permission under the APBBL 2019 (the "Distance from Nallah/Stream as per the notified rules/norms" of clause 2.10.1(e), whose norms were not found; the "Distance from Disaster Prone Area as per norms set by Disaster Management Authority" of clause 2.10.1(f), whose norms were not found either; a Jhot under definition 69; the limits on earth cutting of clause 4.39); the consent of the Water Resources Department for a work in or on a river or anti-erosion work; NEEPCO's or NHPC's conditions for a work that drains to, or lies next to, one of their reservoirs or the reach below its dam; the agreement of the owners or the community for a drain or corridor on customary land; the views of the State Wetland Authority or the Forest Department for a work in or next to a notified or demarcated wetland or a lake in a sanctuary; or a direction of the Gauhati High Court (Itanagar Bench), the National Green Tribunal or the Supreme Court (none setting a distance from a stream, nallah, pond or spring in Arunachal Pradesh was found; Clause 7.4, Disclosure) sets a setback wider than Zone 1 or Zone 2, the wider setback governs for the uses it restricts.

7.4.6 **Fixed-width setback where no 1% AEP extent is available.** Where Clause 7.3.4 does not require a hydraulic study and no map has been adopted, the setback (Zone 1 plus Zone 2) shall be not less than the following, measured as in Clause 7.4.3:

Table 7.1 — Fixed-width setback where no 1% AEP extent is available

Waterbody	Total setback (Zone 1 + Zone 2)	Of which Zone 1
Channel draining 8 ha to 65 ha	25 m	15 m
Channel draining 65 ha to 20 km²	40 m	15 m
Channel draining more than 20 km², and rivers	50 m	20 m
Tank, lake or pond	MWL contour + 25 m	to MWL contour, and not less than 15 m from FTL
Marsh, estuary or backwater	as notified by the Authority, and not less than 50 m	15 m

This table is the alternative S-3 of the Policy Supplement (Annex 1C) and may be adopted under Clause 1.7.

7.4.7 **Minimum in all cases.** No setback under this chapter, and no variance under Clause 1.10, shall reduce Zone 1 below 15 m (Clause 1.10.3(c)).

> Commentary. The 15 m minimum is set by this Manual, as the floor of a hydraulic corridor, because there is nothing else to measure against: no statute, rule or bye-law found in Arunachal Pradesh sets any distance from a stream, nallah, spring, pond or drain. The Arunachal Pradesh Building Bye-Laws, 2019, which extend "to whole of Arunachal Pradesh" (clause 2.1), ask the site plan to show the "Distance from Nallah/Stream as per the notified rules/norms" (clause 2.10.1(e)), but no such rules or norms were found; they define the Jhot as "A strip of land permanently left open for drainage purposes" (definition 69) without a width; and on sites of 5,000 m² or more of built-up area they ask that "The inlet and outlet point of natural drain system should be maintained with adequate size of channel for ensuring unrestricted flow of water" (Table 14.1). The 15 m is offered as the norms that clause 2.10.1(e) refers to, which the State could notify. It applies to new development and redevelopment approved under this Manual, not to existing buildings. It is offered as a condition of building permission and layout approval wherever the bye-laws apply, which is the whole State, and as a recommendation for works on community land outside any permission; where Zone 1 land is community, clan or private land, it is secured by agreement with the owners or the community, by donation, by purchase, or by reservation in a master plan, layout or Town Planning Scheme, and is not taken. It is this Manual's proposal, not a statutory width, and it never reduces a wider line of a plan, permission or order (see the Disclosure below). Extending the setback to the mapped 1% AEP extent plus a margin follows the Kansas City Metro APWA Section 5600 (2025.01) two-zone structure:
>
> - APWA Zone 1 (streamside) is measured from top of bank, and only utility and road crossings are allowed in it.
> - APWA Zone 2 is the 1% AEP flood extent plus 10 ft (about 3 m), for streams draining 20–40 acres.
> - APWA lowered the trigger for stream setbacks from 40 acres to 20 acres (about 8 ha) in 2025.01.
>
> (MARC, APWA 5600 Policy Supplement, Nov 2025.) Clause 7.4.1(b) adopts the 8 ha trigger. This Manual's 10 m margin is wider than APWA's 10 ft and has no direct precedent. This Manual sets it because Arunachal Pradesh flood maps are mostly coarser than US maps, the only level land in an Arunachal Pradesh hill town is usually a narrow valley floor or terrace beside a stream, and Naharlagun, Nirjuli and Doimukh, Pasighat, Tezu and Namsai stand on the flat valley floors, fans and flood plains of the Dikrong, the Siang, the Lohit and the Noa-Dihing, whose levels back up the towns' nallahs (so a small error in level moves the flood edge a long way), and the margin gives room for maintenance access along the waterbody.

The fixed-width table in Clause 7.4.6 is set by this Manual. Its channel widths are scaled from the 2006 APWA default stream buffers, which were 40 ft, 60 ft, 100 ft and 120 ft (12, 18, 30 and 37 m) for drainage areas of less than 40 acres, 40–160 acres, 160–5,000 acres and more than 5,000 acres (KC APWA 5600, 2006, §5605.3). They are rounded up and floored at the 15 m minimum. APWA offered a fixed-width table for the same reason: communities objected that the 1% extent is often unmapped for small drainage areas (MARC Supplement, 2025). The table should be replaced by mapped extents as soon as the Authority adopts them.

URDPFI (2015) reserves the area flooded at a 10-year frequency for parks and playgrounds, and allows residential use in the 25-year flood zone only on stilts, with minimum plinth levels and no basements. This chapter is stricter. It keeps habitable buildings out of the whole 1% AEP extent plus margin, because the 1% AEP (100-yr) event is the major-system standard of this Manual (Chapter 6).

Arunachal Pradesh has no distance from water in any law found for this Manual. The **Arunachal Pradesh Building Bye-Laws, 2019** "shall extent to whole of Arunachal Pradesh with effect from the date of notification" (clause 2.1); they were to be reviewed after five years, and "Till such time the reviewed building byelaws are notified, these building byelaws will continue to be in force" (clause 2.2); their notification number and date were not found, because the gazette page of the copy read is blank [TBC]. Their "Authority" is "The Director/Chief Town Planner of Town Planning & Urban Local Body … till an executing authority is notified" (definition 12). Seven of their provisions touch water. Clause 2.10.1 asks the site plan to show "(j) Any existing physical features such as well, drains" and "(e) Distance from Nallah/Stream as per the notified rules/norms" and "(f) Distance from Disaster Prone Area as per norms set by Disaster Management Authority"; no such rules or norms were found. Definition 69 defines the *Jhot*, "A strip of land permanently left open for drainage purposes. It is not to be used as an access way or a street and is not to be included as a part of setbacks", with no width. Clause 4.39 governs earth cutting: no permission "if the average slope of the topography is more than 30%", the site then being "not fit for construction except for plantation" (4.39(14)); a cut no higher than 3 m (4.39(4)); 2.5 m from the property line of a plot on the upper terrace (4.39(5)); the owner to clear soil and debris "from site or drain to suitable/safer place" (4.39(8)); and a retaining or breast wall "immediately" on completion of the cut (4.39(11)); with a penalty of ₹1 lakh for cutting without approval and a recommendation to cancel the land allotment. Clause 2.10.2(a) keeps 0.60 m between a retaining wall on a sloping side and the building. Table 14.1 asks large sites to keep "The inlet and outlet point of natural drain system … with adequate size of channel for ensuring unrestricted flow of water". Chapter 12 lists natural feature areas, among them "water bodies (and the areas adjoining the same)", to be "listed in notification(s) … / identified in Master Plan"; none listed was found. And Annexure E 1.8 asks the urban local bodies and planning authorities to identify, demarcate, protect and maintain their water bodies and to prepare a list; none was found. The earlier "FINAL DRAFT" of 2009 had a hill-site clause on "location of landslide prone areas" and the "diversion of the natural flow of water coming from uphill side"; it is not in the 2019 text, although the Master Plan of Itanagar Capital Region-2031 reproduces it, and it is not cited here as in force. The **Arunachal Pradesh Municipal Corporation Act, 2019** and the **Arunachal Pradesh Municipal Act, 2007** vest public streams, springs, tanks, drains and watercourses in IMC and the municipalities, but set no distance. The **Master Plan of Itanagar Capital Region-2031** proposes 30 m green buffers along new 30, 45 and 60 m roads; they are along roads, not streams. The **Arunachal Pradesh (Land Settlement and Records) Act, 2000** leaves the beds of streams, nallahs, lakes and tanks with their owners where they are "the property of any person or community" (s.9(1)). No order of the Gauhati High Court (Itanagar Bench), the National Green Tribunal or the Supreme Court setting a distance from a stream, nallah, pond or spring in Arunachal Pradesh was found. Clause 7.4.7 makes 15 m the floor of Zone 1 everywhere.

Disclosure. Arunachal Pradesh **has no distance from water in any statute, rule or bye-law found for this Manual**: the APBBL 2019 ask the site plan to show the "Distance from Nallah/Stream as per the notified rules/norms" (clause 2.10.1(e)), but **no such rules or norms were found**; their *Jhot* is "A strip of land permanently left open for drainage purposes" (definition 69) with no width; the Municipal Corporation Act, 2019 and the Municipal Act, 2007 vest public streams, springs and drains in IMC and the municipalities but set no distance; the Master Plan of Itanagar Capital Region-2031 draws no stream corridor; and no floodplain zoning law or Bill was found, so **no flood zone exists in law**. The **15 m minimum** Zone 1 of Clauses 7.4.3 and 7.4.7, and every value derived from it in Table 7.1, is **set by this Manual** as a hydraulic corridor: along every natural channel draining 8 ha or more,

including the capital's nallahs, the Senki, the Pachin and the Dikrong, and round every pond, lake, reservoir and spring. So are the setback zones of Clause 7.4, the 1% AEP extent that governs Zone 2, this Manual's reference lines and its reading of the boundary of a pond, lake or reservoir, and the rules on nallahs, hill streams, springs, glacial lakes, community land and reclamation (definitions after Clause 7.2). They are **this Manual's proposal, not a statutory width or rule**, and no government body, urban local body, planning authority, village authority, community or other body has adopted or endorsed them. The 15 m is **offered as the "norms" that clause 2.10.1(e) of the APBBL 2019 refers to, which the State could notify**. It applies to **new development and redevelopment approved under this Manual, not to existing buildings**; Clause 7.4.7 allows no variance below it; it is offered as **a condition of building permission and layout approval wherever the bye-laws apply, which is the whole State (clause 2.1), and as a recommendation for works on community land outside any permission**; and where Zone 1 land is community, clan or private land, it is **secured by agreement with the owners or the community**, by donation, by purchase, or by reservation in a master plan, layout or Town Planning Scheme, **never taken**: the beds of rivers, streams, nallahs, lakes and tanks are Government property only where they are "not the property of any person or community" (s.9(1) of the Arunachal Pradesh (Land Settlement and Records) Act, 2000). Where the State decides that land for a public drain must be obtained compulsorily, section 104 of the Arunachal Pradesh Municipal Act, 2007 routes it through the "Land of Acquisition Act, 1894" (as printed), which the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 has replaced for the Union (NEER reading), and allows "other methods of land assembly including the use of transferable development rights" (s.104(3)); **this Manual states that route and does not invoke it**. The setback is applied as **whichever line reaches furthest** (definitions after Clause 7.2), so the Manual is stricter than every line that exists and no less strict anywhere. What exists, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **The APBBL 2019, in force throughout the State** (clause 2.1; notification number and date not found [TBC]): the site plan's drains, wells and "Distance from Nallah/Stream" (clause 2.10.1(j) and (e)), with no number; the Jhot of definition 69, with no width; the bar on earth-cutting permission above an average slope of 30%, the 3 m limit on a cut, the 2.5 m from the upper terrace and the retaining wall "immediately" (clause 4.39); the 0.60 m between a retaining wall and the building (clause 2.10.2(a)); the natural drains of large sites (Table 14.1); the plinth "not less than 300 mm" above ground (clause 4.2.1.1); and the water bodies that each urban local body and planning authority is to list and protect (Annexure E 1.8), of which no list was found. Their five-year review (clause 2.2) was due from 2024; whether it has begun is not known [TBC].
- **Plans.** A line of the Master Plan of Itanagar Capital Region-2031, approved on 3 June 2022, or of another master plan, layout or Town Planning Scheme under the Arunachal Pradesh Urban and Country Planning Act, 2007, as amended: a scheme's drainage could carry the corridors of this chapter; a scheme's "filling-up or reclamation of low-lying, swampy or unhealthy area" (Ordinance No. 5 of 2025; its final form as an Act was not found [TBC]) is fill under Clause 7.6.4 (definitions after Clause 7.2).
- **Customary land.** On community, clan or individual land the owners' or the community's agreement governs; this chapter is guidance there unless a permission, plan or agreement carries it.
- **Glacial lakes.** No statute or rule sets a distance from a glacial lake or its outburst path. NDMA lists 27 high-risk glacial lakes in the State, and the CWC reported 197 expanding glacial lakes in it in June 2025 (both as reported); these lakes are hazards, not design storage, and a site below one is screened under Clause 2.3.6(i), with the siting, setback and floor-level rules of this chapter and Chapter 6 governing where the site lies on an outburst path (set by this Manual).
- **Wetlands, custodians and courts.** Any wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (none was found) and the waters the State Wetland Authority lists (Clause 7.12); the wetlands the Forest Department has demarcated; Ganga Lake within the Itanagar Wildlife Sanctuary; the Water Resources Department's lines at its rivers and anti-erosion works; NEEPCO's and NHPC's at their reservoirs; and the orders of the Gauhati High Court (Itanagar Bench), the National Green Tribunal and the Supreme Court as they stand (none setting a distance from water was found).

This Manual sets 15 m as the floor because nothing else sets any width; because a nallah needs room for its flood, for cleaning machines and for the boulders, slide debris and garbage it carries; because 15 m is above the smallest APWA default stream buffer (12 m) from which Table 7.1 is scaled; and because a channel in the Siwalik hills needs room for the debris it brings down. The reasons for the corridor are the record: the floods of 2017

damaged the "land protection wall of several nallahs and rivulets" (Master Plan of Itanagar Capital Region-2031); in September 2018 the Modirijo and Donyi Polo floods washed away the Senki View culvert and the Press Colony bridge (as reported); the master plan finds the drains "chocked with the solid wastes", with "heavy silting", and the Pachin turned into "a waste disposal site"; and Ganga Lake is reported to be under pressure from encroachment and earth cutting. Until a statute, rule, notified norm under clause 2.10.1(e), master plan, Town Planning Scheme, agreement or court adopts it, the 15 m minimum is this Manual's recommended standard, and the bye-laws, the plans, the owners' and communities' agreement and the orders above remain the only legal controls. Approving authorities should state in each approval which was applied.

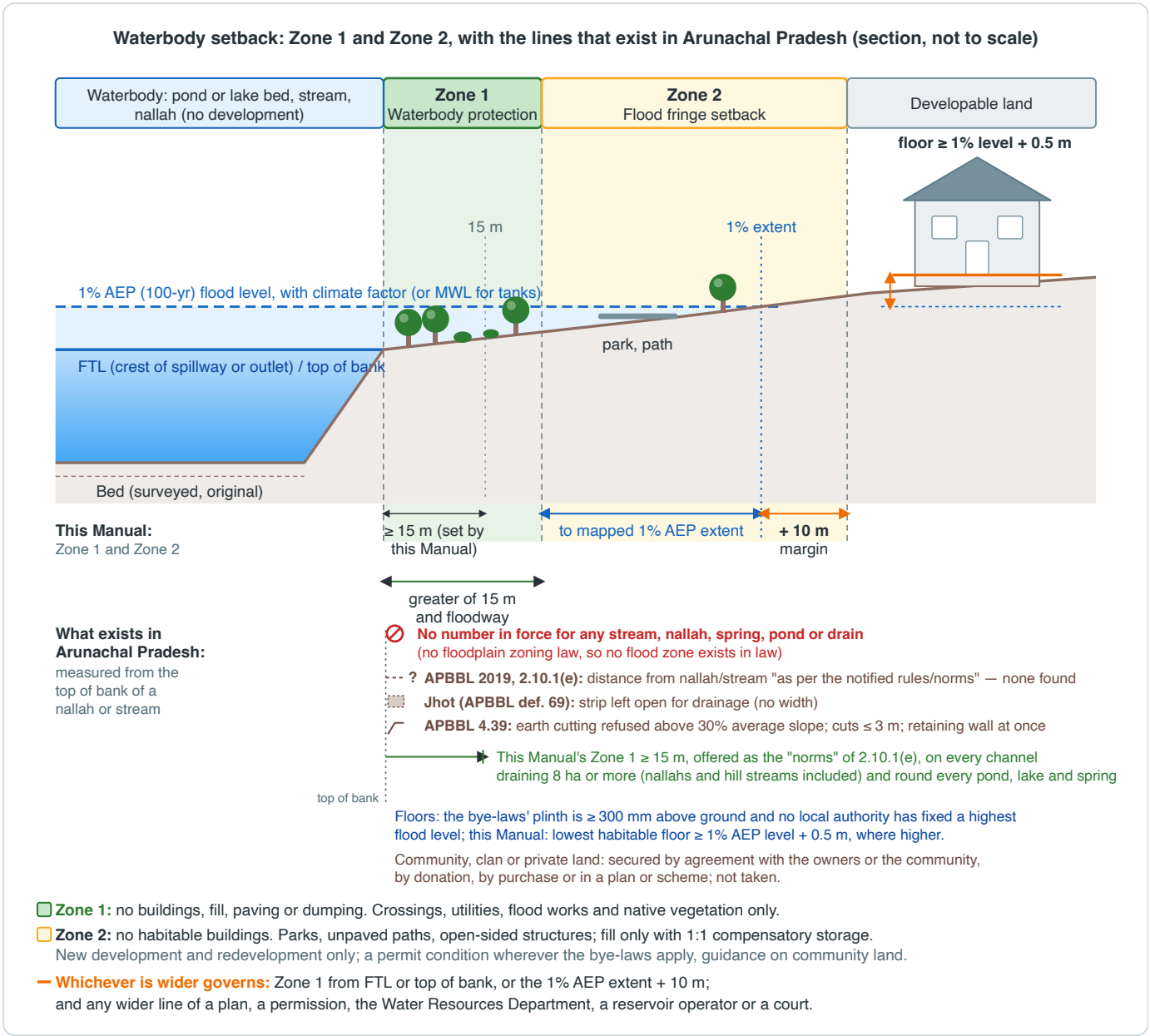


Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).

7.5 Uses permitted in each zone

7.5.1 **Zone 1.** No building, fill, paving, retaining wall, boundary wall, compound wall, dumping of earth, debris or solid waste, storage of materials, or construction-stage stockpile shall be placed in Zone 1. Only the following are permitted, each subject to the custodian's NOC:

- (a) road, rail and utility crossings that meet Clause 7.10.3;
- (b) flood and drainage works: outfalls, inlet structures, gross pollutant traps, sluices, surplus weirs, bund strengthening and bank protection;
- (c) native vegetation, planting and habitat works;
- (d) unpaved or permeable footpaths and maintenance tracks at existing ground level; and
- (e) waterbody restoration under Clause 7.9.

7.5.2 **Zone 2.** No habitable building, basement, school, hospital, fuel store or hazardous-material store shall be placed in Zone 2. The following are permitted:

- (a) all uses permitted in Zone 1;
- (b) parks, playgrounds, open-air sports fields and urban agriculture;
- (c) open-sided structures (shelters, pavilions) with no walls that obstruct flow;
- (d) surface parking with permeable surfacing at existing ground level, where the 1% AEP flood depth is not more than 0.3 m;
- (e) retention, detention and water quality facilities under Chapters 4 and 8, provided they are outside the floodway and their storage is not counted twice (Clause 7.6.5); and
- (f) fill, only for (a) to (e) or for essential public infrastructure, and only with compensatory storage under Clause 7.6.4.

7.5.3 **Fences.** Fences in Zone 1 and Zone 2 shall be open (chain-link or railing) with no plinth wall above existing ground level, so that they do not obstruct flow or trap debris.

7.5.4 **Open space reservation.** Zone 2 land may be counted toward the open space required by the Arunachal Pradesh Building Bye-Laws, 2019, where the Authority agrees. Zone 1 land shall be handed over to the custodian or kept free of private use, as the Authority decides.

> Commentary. The permitted uses follow APWA 2025.01: in Zone 1, only utility and road crossings; in Zone 2, linear utilities, trails and open-sided structures; no clearing, grading, fill or paving in either zone without approval (MARC Supplement, 2025). Clause 7.5.2 adds parks and playgrounds, the uses URDPFI (2015) allows in the 10-year flood zone. The ban on walls in Clauses 7.5.1 and 7.5.3 responds to hill-town and nallah-side practice: compound walls along channels and tanks act as dams in floods, and are often the first step toward encroachment. The 0.3 m depth limit for parking in Clause 7.5.2(d) has no direct precedent and is set by this Manual.

7.6 Floodway, flood fringe and compensatory storage

7.6.1 **Floodway delineation.** The floodway shall be delineated by a hydraulic model of the 1% AEP flood (with the climate factor), using the encroachment method: the conveyance of the flood fringe is removed equally from both banks until the 1% AEP water level rises by 0.1 m. Where the floodway has not been delineated, the whole 1% AEP flood extent shall be treated as floodway. For a tank, all land below MWL is floodway.

7.6.2 **No fill in the floodway.** No fill, building, embankment, raised road or other obstruction shall be placed below the 1% AEP flood level within the floodway, except the works permitted in Zone 1 under Clause 7.5.1(a) and (b). Those works shall be shown by hydraulic analysis to raise the 1% AEP water level by no more than 0.01 m, upstream or downstream,

outside the Applicant's land.

7.6.3 **Fill in the flood fringe.** Fill below the 1% AEP flood level in the flood fringe is permitted only:

- (a) for uses permitted under Clause 7.5.2, or outside the setback where the Authority has notified a developed-fringe area under Clause 7.6.6; and
- (b) with compensatory storage under Clause 7.6.4.

7.6.4 **Compensatory storage.** Where fill is placed in the flood fringe, compensatory storage shall be provided that (Figure 7.2):

- (a) replaces at least **1.0 m³ of storage for each 1.0 m³ of fill** placed below the 1% AEP flood level;
- (b) is provided at **equivalent levels**: the volume lost and the volume replaced shall be balanced in each elevation band of not more than **0.3 m**, from the normal water level (or the 50% AEP level, where higher) up to the 1% AEP flood level;
- (c) is in the same reach of the same waterbody, hydraulically connected to it, and not further downstream than the fill;
- (d) drains freely by gravity back to the waterbody as the flood recedes, with no pumping and no permanent pool below the normal water level;
- (e) is built before, or at the same time as, the fill is placed; and
- (f) is secured by a covenant or handover so that it is never filled later.

7.6.5 **No double counting.** Compensatory storage shall not be counted as detention or retention storage under Chapter 4. Detention and retention storage placed within the 1% AEP flood extent shall be counted only for the volume above the 1% AEP flood level, unless a model of the joint event (Clause 2.12) shows that it is available.

7.6.6 **Developed-fringe areas.** The Authority may notify, by map, areas of existing built-up land within the 1% AEP flood extent but outside the floodway, where it is impractical to apply Zone 2 to redevelopment. In a notified developed-fringe area:

- (a) redevelopment may be approved without the Zone 2 restriction;
- (b) the lowest habitable floor and all openings shall be at least 0.5 m above the 1% AEP flood level (Chapter 6);
- (c) basements are not permitted;
- (d) the redevelopment shall cause no net loss of flood storage below the 1% AEP flood level (Clause 7.6.4), and stilt construction may be used for this; and
- (e) Zone 1 continues to apply in full.

> **Commentary.** The 1:1 compensatory storage at equivalent levels is set by this Manual. A simple volume balance is not enough: storage excavated below the normal water level is full before the flood arrives and gives no flood benefit. Storage gained high up does not replace storage lost low down, because the low storage is used in every flood and the high storage only in the largest. Balancing volume within each elevation band avoids both problems. The 0.3 m band, the 0.01 m allowance for crossings, and the use of the encroachment method in Clause 7.6.1 are set by this Manual; the encroachment method is the standard way to delineate a floodway in a one-dimensional hydraulic model. The 0.1 m limit on the rise in the 1% AEP water level is tighter than the 1 ft (about 0.3 m) used by the US National Flood Insurance Program. The Naharlagun–Nirjuli–Doimukh valley floor and the flood plains of the Pachin and the Dikrong, the fans and flood plains of the Siang, the Lohit and the Noa-Dihing at Pasighat, Tezu and Namsai, the margins of the ponds, and the terraces beside the hill streams are flat, so a small rise in level spreads flooding over a wide area, and many small encroachments along the same channel add up.
>
> In Arunachal Pradesh no law fixes a line from which a setback is measured, so the line comes from this Manual. The difference matters most at the reservoirs, whose levels move through the year with the operator's releases: a line drawn from the edge of the water in the dry months would leave the drawdown land open to building, and no full reservoir level was found for any of them [TBC]. It matters at the ponds, swamps and paddy land of the valley floors, whose edges spread in the season and whose margins are the low land that a Town Planning Scheme may

fill or reclaim (Ordinance No. 5 of 2025); and it matters at Ganga Lake, whose edge is under pressure from encroachment and earth cutting (as reported). This Manual gives every pond, lake and reservoir a boundary measured from a high level, not from the water's edge on the day of survey: the edge of a pond or lake in the season, its boundary as demarcated in the Forest Department's wetland truthing and the operator's highest level of a reservoir are part of its boundary (definitions after Clause 7.2), the foreshore up to MWL is its flood storage, and the reclamation of low or swampy land below the 1% AEP flood level is fill whose storage is replaced under Clause 7.6.4. Treating all land below MWL as floodway (Clause 7.6.1) means that no new building or fill is approved in a tank foreshore.

The developed-fringe mechanism of Clause 7.6.6 is set by this Manual. Large parts of Itanagar and Naharlagun along the Senki, the Pachin, the Dikrong and NH-415, where the floods of June and July 2024 reached Energy Park, Bank Tinali, Niti Vihar and Abo Tani Colony and those of September 2018 the Modirijo and Donyi Polo areas (as reported), and the flood plains of the Pachin and the Dikrong, which the Master Plan of Itanagar Capital Region-2031 describes as palaeochannels, swampy land, terraces and flood plains, and of Pasighat beside the Siang, whose bank erosion reached Jarkong near the airfield in 2024 (as reported) already lie within the 1% AEP extent. A blanket Zone 2 ban on redevelopment there would stop the replacement of older, lower buildings with buildings raised above flood level. The mechanism follows the URDPFI (2015) approach for the 25-year flood zone (stilts, minimum plinth, no basements), applied here to the 1% AEP extent.

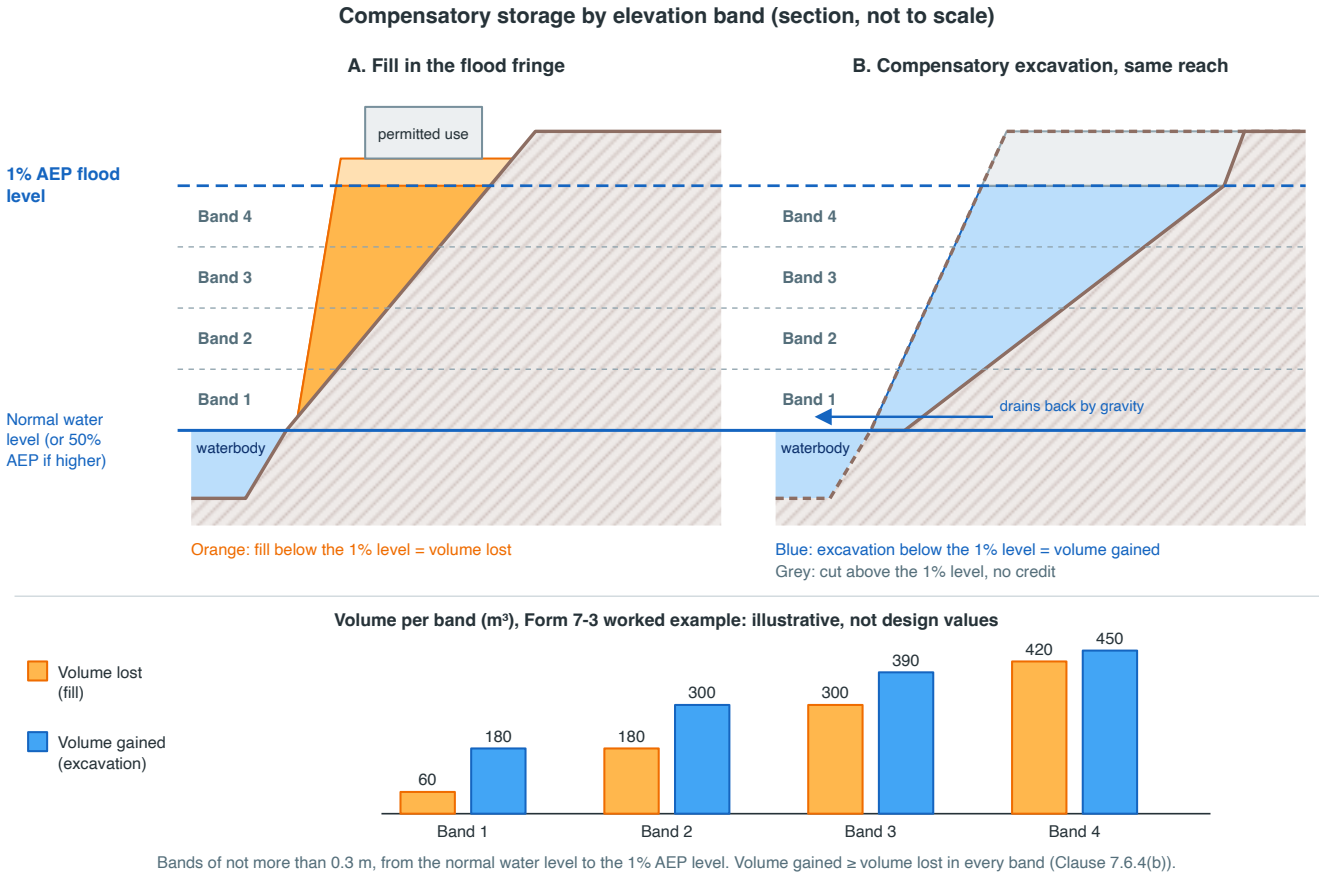


Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation draining back to the waterbody by gravity. Band-by-band calculation on Form 7-3. Original drawing for this Manual, illustrating the method of Clause 7.6.4, which is set by this Manual.

7.7 Tank cascades as design storage

Arunachal Pradesh has no tank Act and no irrigation tank cascades, and its standing waters range from small ponds in the towns to high-altitude lakes and the reservoirs of hydroelectric projects. The storages that matter for urban drainage are of five kinds. The first is the **reservoirs** that release into town reaches: the Pare reservoir of NEEPCO on the Dikrong above Doimukh, whose releases go through radial gates under monsoon advisories and peaked at 1,310 m³/s on 31 May 2025 (as reported); the Ranganadi project at Yazali, whose reservoir released 1,412.57 m³/s into the lower Ranganadi on 9 July 2017 (as summarised from a study of the reach downstream) and whose tailrace sends about 160 m³/s into the Dikrong (as reported); NEEPCO's Kameng project, for which no release or flood data were found [TBC]; NHPC's Lower Subansiri project on the State's southern border, whose first unit went into commercial operation on 23 December 2025 (as reported); and NHPC's Dibang project, under construction [TBC]. No full reservoir level, spillway rating or release protocol was found for any of them [TBC]. Their releases enter a design as inflow and tailwater (Clauses 5.8.3 and 5.8.5(d)), and none is a tank for these clauses unless its storage is counted, with the operator's written levels and concurrence. The second is the **lakes**: Ganga Lake (Gyakar Sinyi), in the Itanagar Wildlife Sanctuary, is a lake in a sanctuary and never storage for a development; Glaw Lake in the Kamlang Tiger Reserve is a Ramsar site (as reported); the Forest Department's truthing lists a lake of about 8.2 ha in Papum Pare at 27.075 N 93.569 E that is probably Ganga Lake (NEER reading, not confirmed). No levels, areas or outlet records were found for any lake [TBC]; they are modelled as existing features and never counted. The third is the **ponds**: few and small in the towns, natural, dug or aquaculture ponds (24 aquaculture ponds and 2 tanks or ponds among the truthed wetlands), and the master plan's ponds that receive drains and sewage and the "artificial ponds" that receive industrial effluent. They are modelled as existing features where they intercept runoff but are not counted as storage unless Clause 7.7.1 is met, because they are not surveyed, have no controlled outlet and, on the valley floors, stand full to their outlets when the nallah they drain to is backed up by the river (Clause 5.8.5(g)). The fourth is the **glacial lakes** of the high ranges, which are hazards and never storage (definitions after Clause 7.2). The fifth is the **springs**, which are protected for their water and never counted as storage. These are the waterbodies for which Figure 7.3 and Clause 7.8 matter: in a hill town every drain ends in a nallah or hill stream, and on a valley floor every drain ends in a nallah that the river backs up. Any pond, lake or reservoir whose storage is to be counted is subject to Clause 7.7.1 in full, with NEEPCO, NHPC or the other custodian, and the custodian of each pond and lake shall be confirmed for the inventory (Annex 7A) [TBC].

7.7.1 **When tank storage may be counted.** The storage of a tank or tank cascade may be counted as design storage (in a basin plan, a regional facility or a fee-in-lieu scheme under Clause 7.11) **only** where all of the following are met:

- (a) **Surveyed levels.** FTL, MWL, TBL, the surplus weir crest and length, and the sluice sill levels have been surveyed to the datum of Clause 7.3.5 within the previous 5 years.
- (b) **Stage–storage curve.** A stage–storage curve has been derived from a bathymetric and topographic survey of the waterspread and foreshore within the previous 5 years, or after the last desilting, whichever is later.
- (c) **Operating rule.** A documented operating rule has been agreed with the custodian (Clause 7.8).
- (d) **Maintained structures.** The surplus weir, sluices and bund are maintained under an O&M plan (Chapter 10), and the latest pre-monsoon inspection found them serviceable.
- (e) **Custodian concurrence.** NEEPCO, or the other custodian, concurs in writing.

Storage in a tank that fails any of (a) to (e) shall not be counted, though the tank shall still be modelled as an existing feature (Chapter 3).

7.7.2 **Modelling.** Tank cascades shall be modelled under Clause 3.12.5 (level-pool routing of each tank, with surplus weir and sluice ratings) and Clause 3.13 (continuous simulation). The whole cascade, from the uppermost tank whose surplus can reach the site or facility to the next river, major drain or sea outfall, shall be modelled together, including, for a hill town, every nallah and hill stream that falls from the ridges and slopes to the river below, the springs above the town's intakes, and the stream itself down to the river or reservoir whose level sets its tailwater (Clause 5.8.5(a), (b) and (d)), and, on a valley floor or foothill plain, every nallah with the ponds it passes, down to the Dikrong, the Siang, the Lohit or the Noa-Dihing, whose level backs it up (Clause 5.8.5(a), (c) and (g)), as shown in Figure 7.3.

7.7.3 **Starting level.** The starting level in every tank shall be **FTL** for the design-storm analysis. A lower starting level may be used only under a flood-cushion operating rule that meets Clause 7.8.

7.7.4 **Design maximum level.** For the 1% AEP inflow with the climate factor, routed through the cascade:

- (a) the computed maximum level shall be not higher than MWL (as defined in Clause 7.2); and
- (b) the freeboard from the computed maximum level to the lowest point of the bund (TBL) shall be not less than NEEPCO's freeboard standard for the tank.

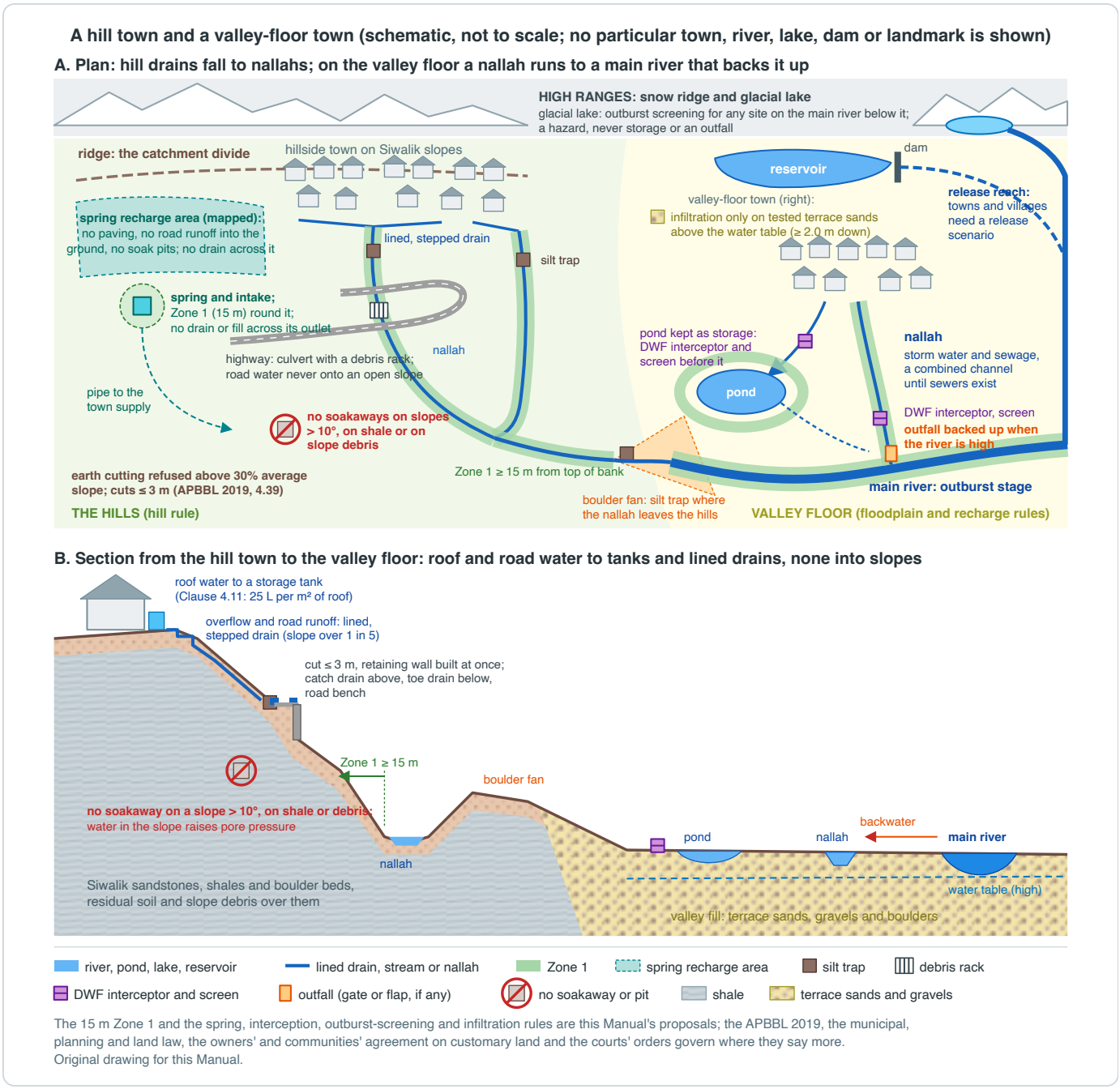
Where (a) or (b) fails, the tank storage above FTL shall not be counted until the surplus weir capacity is increased or the bund raised under Clause 7.7.6.

7.7.5 **Creditable volume.** The creditable design storage of a tank is the volume between the starting level (Clause 7.7.3) and the computed maximum level of Clause 7.7.4, less any volume already committed to another facility or scheme.

7.7.6 **Changes to FTL, weirs and bunds.** No surplus weir crest shall be raised or lowered, no shutters or falling boards shall be added, and no bund shall be raised, cut or breached except under a design approved by the custodian that:

- (a) routes the cascade under Clause 7.7.2;
- (b) shows the effect on flood levels in the foreshore and upstream, and on flows in the surplus course and downstream; and
- (c) checks the bund under Clause 7.14.

> Commentary. This Manual allows tank cascades to be used as design storage subject to three basic conditions (surveyed FTL, a documented operating rule and maintained surplus weirs). Clause 7.7.1 adds the stage–storage survey and the custodian's concurrence, because the storage a tank actually offers depends on its silt level and on who controls the sluices. The 5-year survey interval is set by this Manual.
>
> The FTL starting level follows Clause 3.12.5. Arunachal Pradesh's ponds and reservoirs may be full at any time in the season. The Pare dam's peak discharge of 1,310 m³/s came on 31 May 2025, in the late-May storms, and NEEPCO issues monsoon advisories on controlled releases through its radial gates (as reported); the Ranganadi project released 1,412.57 m³/s into the lower Ranganadi on 9 July 2017 (as summarised). The Manual's season begins on 1 April because the pre-monsoon months are wet: at Doimukh April brings 227.7 mm, May 505.9 mm and June, the wettest month, 762.8 mm, and March to May together 846.5 mm, 24.0% of the year (NERIST series, Dabral et al., 2016); "The state receives rainfall over a period of 8 to 9 months excepting in winter" (State Action Plan on Climate Change, 2011); and in West Kameng the "rainy season starts from April and continues up to November" (CGWB). Storms follow the season in the east: Hayuliang recorded 280.0 mm and Tezu 222.0 mm on 3 and 4 October 1979 (IMD). No record of how long any pond stays at or above its outlet level in a wet spell was found [TBC]. On a valley floor a pond connected to a nallah also fills from the nallah when the Dikrong, the Siang, the Lohit or the Noa-Dihing backs it up. While a pond or reservoir is full, it stores nothing more below FTL, the drains and streams that flow into it discharge against its level, and its release adds to the flow in the channel below it. A tank cascade passes floods from one tank to the next, so a design that counts storage in one tank and ignores the surplus arriving from the tank above it will overstate the benefit. That is why Clause 7.7.2 requires the whole cascade to be modelled.



The 15 m Zone 1 and the spring, interception, outburst-screening and infiltration rules are this Manual's proposals; the APBBL 2019, the municipal, planning and land law, the owners' and communities' agreement on customary land and the courts' orders govern where they say more.
Original drawing for this Manual.

Figure 7.3 — A hill town and a valley-floor town: a glacial lake, a spring, nallahs, a pond, a main river and a reservoir (schematic, not to scale; no particular town, river, lake, dam or landmark is shown). A: in plan, a glacial lake below a snow ridge drains to the main river; no design rests on it, and any site on the main stem below it needs an outburst screening (Clause 2.3.6(i)), because the river's stage there is set by outbursts and releases, not by the town's rain. The hill town stands on Siwalik slopes: its drains are lined and stepped where they fall steeply, pass silt traps, and reach the nallahs and hill streams through a debris rack at each highway culvert, because a hill drain carries more silt, gravel, slide debris and garbage than any other load (Clauses 6.3.6 and 8.12). Upslope of the town's intake a spring comes out; its recharge area, as a hydrogeologist maps it, is kept free of paving, road runoff and soak pits, and no drain crosses it or buries its outlet (Clause 8.8.1). The nallah leaves the hills at a boulder fan, where silt traps catch what it brings down, and crosses the valley floor. There the town's nallah runs to the river, whose level backs up the outfall when the river is high (Clause 5.8.5(a) and (c)); a pond kept as storage receives the nallah only after a dry-weather-flow interceptor and screen, because the drains carry sewage (Clause 8.9); and infiltration is allowed only on tested terrace sands with the water table at least 2.0 m below ground (Clause 4.11, recharge rule). Upstream, a reservoir held by a dam releases water into a reach whose towns and villages need a release scenario (Clause 5.8.5(d)). Zone 1 along every stream and nallah draining 8 ha or more is at least 15 m from the top of its bank, offered as the norms that clause 2.10.1(e) of the APBBL 2019 refers to. B: in section, from the hill town to the valley floor, roof water goes to a storage tank (Clause 4.11)

and its overflow and the road runoff go by a lined drain through a trap to the nallah, because no soakaway is placed on a slope steeper than 10°, on shale or on slope debris; a cut of not more than 3 m has a retaining wall built at once, a catch drain above it and a toe drain below it, and no earth cutting is permitted where the average slope exceeds 30% (APBBL 2019, clause 4.39); and the valley floor's pond and nallah sit on alluvium where the water table is high. The 15 m minimum and the spring, interception, outburst-screening and infiltration rules are this Manual's proposals; the APBBL 2019, the municipal, planning and land law, the agreement of owners and communities on customary land and the courts' orders govern where they say more. Original drawing for this Manual.

7.8 Operating rules and pre-monsoon flood cushion

7.8.1 **Operating rule content.** Every tank whose storage is counted under Clause 7.7 shall have a written operating rule, agreed by the custodian and kept with the O&M plan (Chapter 10). It shall state:

- (a) the levels and dates for filling, holding and drawdown through the year;
- (b) the sluice and regulator settings at each level;
- (c) who operates the sluices and regulators, and who may order a release;
- (d) the maximum release rate, set so that the release, added to the flow from the downstream catchment, does not cause flooding of buildings downstream;
- (e) the forecast and warning triggers (IMD district warnings, APSDMA alerts, and city forecast systems where available) and the actions taken at each trigger;
- (f) communication with downstream ULBs and residents before any release; and
- (g) the records to be kept: daily levels in the monsoon, releases, and gate settings.

7.8.2 **Flood cushion.** A tank may be operated with a flood cushion (a level below FTL during part of the monsoon), and the cushion counted under Clause 7.7.3, only where:

- (a) the tank has a gated sluice, regulator or other controllable outlet able to draw the tank down to the cushion level in the time stated in the rule;
- (b) the operating rule fixes the cushion level and the dates it applies;
- (c) continuous simulation (Clause 3.13) shows that the cushion is available at the start of a design storm in at least **90%** of monsoon seasons in the record, allowing for the rain that usually comes before the peak storm;
- (d) the custodian accepts any loss of irrigation or water-supply yield, and any agreed compensation is recorded; and
- (e) the release needed to create or restore the cushion meets Clause 7.8.1(d).

7.8.3 **No storage credit without control.** Where a tank has no controllable outlet, no flood cushion shall be assumed, whatever the past practice.

7.8.4 **Coordination.** For tanks under NEEPCO control, the operating rule shall be NEEPCO's rule. This Manual does not authorise any other body to operate a NEEPCO tank.

> Commentary. No pond or lake in Arunachal Pradesh was found with a written operating rule, and most ponds have no gates to operate. The Pare dam has radial gates and NEEPCO issues monsoon advisories on its releases (as reported), but no operator's release protocol, warning threshold or spillway rating was found for the Pare, Ranganadi, Kameng or Lower Subansiri projects [TBC]. Their releases show why a rule matters: the Pare dam discharged 1,310 m³/s on 31 May 2025, in the late-May storms, and is credited with reducing floods from Jampa to Doimukh (as reported), while the Ranganadi project released 1,412.57 m³/s into the lower Ranganadi on 9 July 2017 (as summarised); this Manual takes no view on either operation, and asks only that the operator's levels, releases and warnings be in writing. Without an agreed rule with dates, levels, release rates and a named operator, storage in a pond or reservoir cannot be relied on, and a release made without warning to the towns and villages downstream is itself a flood. Clause 7.8.2 turns that principle into a rule that can be checked, with a reliability test,

because a cushion that is refilled by the April and May storms gives no protection when a July to September monsoon storm in the foothills, such as those of 11 July 2017 at Laptap and September 2018 at Itanagar, arrives after weeks of rain. The 90% reliability in Clause 7.8.2(c) has no direct precedent and is set by this Manual.

For a natural pond, Clause 7.8.3 is the governing condition: with no controllable outlet, no cushion is assumed, a design that relies on the pond routes the storm through it from its outlet level, and the outflow over the outlet is limited by the nallah, drain or stream below it, which shall be shown to carry it with the debris of Clause 6.3.6(f) to (h). For a reservoir, a design takes the operator's level and release for the storm being checked (Clause 5.8.3), not a drawdown the operator has not agreed to in writing. Many ponds are community, clan or private property under customary rights, which is why Clause 7.8.2(d) requires the custodian to accept any drawdown, and why no detention pond built under this Manual is described as a natural or community pond. Ganga Lake and the other lakes in sanctuaries and reserves are never drawn down or counted for a development.

7.9 Restoration, desilting and deepening

7.9.1 **Pre-works survey.** Before any desilting or restoration, the proponent shall:

- (a) survey the waterspread, foreshore, bund, weirs and sluices (Clause 7.7.1(a) and (b));
- (b) find the original bed level by test pits or augering on a grid, and from historical records where available; and
- (c) where the tank receives urban runoff or sewage, test the silt for heavy metals and other contaminants before disposal is planned.

7.9.2 **Desilting limit.** Desilting shall remove accumulated sediment down to the original bed level. It shall not deepen the tank below the original bed, except under Clause 7.9.3.

7.9.3 **Deepening.** Deepening below the original bed is permitted only where a hydrogeological report shows that:

- (a) it will not cut through a clay or silt layer that holds water in the tank or protects an aquifer from polluted water;
- (b) in coastal areas, it will not draw saline water into the tank or the aquifer; and
- (c) the extra storage will be refilled and used, and will not stand stagnant below the sluice sill.

Storage created below the lowest sluice sill shall not be counted as flood storage.

7.9.4 **Safe edges.** Where the public has access to the waterbody edge:

- (a) side slopes shall be no steeper than **1V:4H** from 0.5 m above FTL down to 1.2 m below FTL, or a level safety bench at least 3 m wide shall be provided between 0.3 m and 0.5 m below FTL; and
- (b) no isolated deep pit or vertical cut shall be left in the bed.

7.9.5 **Storage not to be reduced.** Restoration shall not reduce the storage below MWL. Islands, walkways, bund widening into the waterspread, ring roads, parking, buildings and "lake-front" platforms within the waterspread or foreshore shall be counted as lost storage and shall be offset under Clause 7.6.4.

7.9.6 **Silt disposal.** Desilted material shall not be placed within the setback, on the bund (except for approved bund strengthening), or on any flood path. Silt found to be contaminated shall be disposed of as the Arunachal Pradesh State Pollution Control Board (APSPCB) directs.

7.9.7 **Inlet treatment.** Every restoration of a tank that receives urban runoff shall include sediment and gross pollutant control at each inlet: a sediment forebay, a constructed wetland inlet zone, or a gross pollutant trap (Chapter 8), so that the restored storage does not silt up again.

7.9.8 **Timing.** Desilting shall be completed, and the waterbody made safe, by **31 March** each year (Chapter 10).

Commentary. No State or municipal order fixing a date for the pre-monsoon cleaning of drains, nallahs or ponds was found. The Master Plan of Itanagar Capital Region-2031 records that drains are "chocked with the solid wastes" and that "Regular cleaning of drains is not taking place and hence heavy silting happens"; the drains along the Bage Tinali–Naharlagun road are reported to be "too shallow and narrow" and clogged by debris from earth cutting, with an inspection recommending de-silting "upto the Dikrong river" (as reported); and the bye-laws make the plot owner clear soil and debris "from site or drain to suitable/safer place" (APBBL 2019, clause 4.39(8)). The material to be removed is therefore slide and cutting debris and garbage as much as silt. The date of 31 March in this Manual is set by this Manual, before its season begins on 1 April, because the pre-monsoon months are wet (May at Doimukh brings 505.9 mm, NERIST series) and large April storms fall in the east (Hayuliang 278.5 mm on 24 April 1980, IMD); a mid-season clearance of inlets, culverts, racks, silt traps and the nallah mouths is due by 15 May, after the April storms and before the storms of the last ten days of May (Remal on 28 and 29 May 2024, the slide on NH-13 between Bana and Seppa on 30 May 2025 and the Pare release of 31 May 2025, as reported), and a post-season clearance by 15 November, after the October storms of the east; where snow or frozen ground prevents desilting before 31 March in the high ranges, a snowmelt clearance follows by 30 April (Chapter 10). The Water Resources Department's river works keep that department's calendar. Excavation to "increase capacity" is governed by Clause 7.9.3. In a pond fed by springs in its bed, deepening can cut the springs off or break the silt and clay that hold the water; on a valley floor, where the water table stands 2 to 5 m below ground in the Dikrong valley and within 2 m at many stations (CGWB), deepening can open the bed to the shallow aquifer through the drains that feed the pond. This Manual allows no spring-fed pond to be deepened below its original bed or its bed to be lined or cemented, and no pond on a valley floor that receives a drain or nallah to be deepened below its original bed until the dry-weather flow of every inflow is intercepted (Clause 8.9). The 31 March deadline matches the pre-monsoon inspection date of Chapter 10. The limits on deepening are set by this Manual. Deepening tanks to "increase capacity" is common, but it can breach the silt and clay layer that holds water in the tank, it can let polluted urban water reach the aquifer, it can draw salt water toward the coast, and it creates storage below the sluice sill that never empties and gives no flood benefit. Deep pits with steep sides are also a drowning hazard. The slope and bench values in Clause 7.9.4 are adapted from common pond-safety practice; they have no Arunachal Pradesh precedent.

7.10 Supply channels, surplus courses, inlets and outlets

7.10.1 **Part of the major system.** Supply channels and surplus courses are part of the major drainage system (Chapter 6). They shall be protected as waterbodies, with Zone 1 and Zone 2 setbacks under Clause 7.4.

7.10.2 **No closure or covering.** No supply channel or surplus course shall be closed, filled, diverted, covered, culverted along its length, or converted into a road or a closed drain, except under a design approved by the custodian that keeps or increases its 1% AEP capacity and its access for maintenance.

7.10.3 **Crossings.** Every road, rail, utility or access crossing of a waterbody, supply channel or surplus course shall:

- (a) pass the 1% AEP flow (with the climate factor), or the surplus of the upstream tank at its MWL, whichever is greater, with the freeboard required by Chapter 9;
- (b) not reduce the waterway width at the crossing below the full channel width as recorded in Revenue records or as surveyed, whichever is greater;
- (c) keep the channel bed level and grade; and
- (d) not raise the 1% AEP water level by more than the limit in Clause 7.6.2.

7.10.4 **Capacity.** The design capacity of a surplus course shall be the greater of the surplus weir discharge at MWL and the 1% AEP flow from its own catchment, combined as the cascade model (Clause 7.7.2) shows.

7.10.5 **Protection at structures.** Outlets of surplus weirs and sluices, and drain outfalls into waterbodies, shall have energy dissipation and scour protection designed under Chapter 9, so that the flow leaving them does not erode the bund, the bank or the channel bed.

7.10.6 **Drain outfalls into waterbodies.** A storm drain outfall into a tank, channel or wetland shall:

- (a) have its invert at or above the normal water level of the receiving waterbody, unless the drain is designed for submerged outfall under Chapter 5;
- (b) be located and aligned so that it does not cut through or weaken a tank bund;
- (c) have a gross pollutant trap and first-flush treatment (Chapter 8); and
- (d) not carry sewage or dry-weather flow (Chapter 8).

Commentary. This Manual protects supply channels and surplus courses as part of the major system. In urban areas they are often the first to be lost. Surplus courses are narrowed by culverts and compound walls, and supply channels are covered and turned into roads, which cuts the tank off from its source or leaves its surplus with nowhere to go. In Arunachal Pradesh the public drains vest in the urban local body and their care is its duty: in the area of the Itanagar Municipal Corporation "all public sewers and all drains, and sewers, culverts and water courses in or under any public street" and "all public streams, springs and works for the supply … of water" vest in the Corporation, its public drains and sewage disposal works vest under section 200, and "the maintenance and cleaning of drains and drainage works" is an obligatory function (s.60(a), Arunachal Pradesh Municipal Corporation Act, 2019); in a municipality such as Pasighat "drainage and sewerage" is a core municipal service (s.47(1)(a)), the public tanks, streams, drains, channels, culverts and watercourses vest in it "Notwithstanding anything contained in any other law" (s.102), and it "shall … construct and maintain drains and sewers, and provide a safe and sufficient outfall" (s.194, Arunachal Pradesh Municipal Act, 2007). In practice the Department of Urban Affairs, a works department with a Chief Engineer and 28 divisions whose functions include "Storm Water Drains; Drainage; Sewerage; Septage Management", builds storm drains, sewerage and septage works; PWD and PWD (Highways) build roadside drains with their roads, NH-415 among them; the Water Resources Department handles rivers and anti-erosion works; and drains on community or clan land outside a town have no statutory owner. No notification dividing the drains among their owners was found; Chapter 6 gives this Manual's working split and each town's drain register. The record shows a network that is mostly the nallahs themselves: "the storm water drainage system consists of natural drainage system (Nallah) and major drains"; "There is no proper storm water network for the overall town area"; the existing drains are "not engineered … open drains or kutcha drains without any flow gradient"; and "With only 3.7% storm drains along main roads, drainage was marked as a key area of focus" (Master Plan of Itanagar Capital Region-2031). The floods of 2017 badly damaged the "land protection wall of several nallahs and rivulets" and closed NH-415, with traffic diverted by Papu Nallah and Jullang Road (the same plan); in September 2018 the Modirijo and Donyi Polo floods washed away the Senki View culvert and the Press Colony bridge, with a landslide reported from "the dumping area of NH 415" (as reported); and an inspection of the drains along the Bage Tinali–Naharlagun road recommended three culverts between the police station and the NERIST gate (as reported). On rural roads the CAG found that "It is mandatory under PMGSY to have a drainage plan prepared for each rural road project", yet "₹46.15 crore on construction of 49 Km roads wherein no drains were constructed" had been spent (Audit Report for the year ended 31 March 2023). Under Clause 7.10.2 a nallah that drains 8 ha or more may be covered only under a design that keeps its 1% AEP capacity and its access for cleaning. Neither the bye-laws' Jhot, which has no width, nor the municipal vesting keeps a stream or nallah at its recorded width once it has been lined, covered, built over or filled with debris and garbage, which is the failure Clauses 7.10.2 and 7.10.3 are written to prevent. Clause 7.10.3(b) prevents a crossing from narrowing a channel to its current, encroached width.

7.11 Fee-in-lieu and regional tank storage

7.11.1 Where a basin plan has been notified, and the Authority has adopted alternative S-5 of the Policy Supplement (Clause 1.7), a development may pay a fee in lieu of on-site detention under Chapter 4. The fee shall be applied to restoring or creating storage in a tank, pond or regional facility in the same basin.

7.11.2 Tank storage funded by fee-in-lieu shall:

- (a) meet Clause 7.7.1 in full before it is counted;
- (b) be downstream of the contributing development and upstream of the flood-prone area it is meant to protect;
- (c) be created, or under construction, before the development it serves is occupied, or within a period the basin plan fixes; and
- (d) be recorded in the register of Clause 10.17 with the developments that funded it, so that the same volume is not sold twice.

7.11.3 Fee-in-lieu does not replace:

- (a) the retention requirement of Chapter 4, which is always met on site; or
- (b) the water quality requirement of Chapter 8, which is met on site or in a regional facility treating the same runoff before it reaches the tank.

> Commentary. Chapter 4 provides for fee-in-lieu toward restored pond or tank storage in master-planned basins. Malaysia's 2008 DID checklist allowed on-site detention only for small sites and required community ponds for larger areas (DID, 2008). In Arunachal Pradesh no shared form of storage is required by the building rules as a detention measure: the APBBL 2019 require a rainwater-harvesting proposal on plots of 100 m² (clause 9.1) and ask public open spaces of more than 500 m² for "complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites" (clause 9.6), but they set no volume, release rate or design storm (Chapter 4). The Master Plan of Itanagar Capital Region-2031 proposes a new drainage network "taking into consideration of the topography of the region and flow gradient" (Maps 28 to 30), with no storage. The State's planning law points the other way: Ordinance No. 5 of 2025 defines a "sponge city" as "an area that acts like a sponge, soaking up and retaining water during rain and storms and releasing it slowly" and lets the Government prepare policy documents for a "Sponge City" and a "Risk Informed master Plan" (new section 71(2)(za)); no such policy document was found, and the Ordinance's final form as an Act was not found [TBC]. This Manual keeps ponds, swamps and low land as storage first, because the capital's outfalls back up when the Dikrong carries the Pare releases, because Pasighat's and Tezu's back up from the main stems, and because water sent downstream faster reaches the towns and villages below and the reaches across the State's border (Chapters 4 and 11); its storage rules are an engineering form of the Ordinance's definition and could be offered as technical input to such a policy document, which this Manual is not. On the hill slopes there is little flat land on which a regional pond could be built, and none may be built on a slope, on shale or on slope debris where Clause 4.11 bars infiltration; a regional facility there is a lined tank or a lined detention structure, a detention pond and never a natural pond or lake. None of these sets a technical standard for counting storage. Clause 7.11.2(b) matters because a tank downstream of the flood-prone area protects nothing. Clause 7.11.3 keeps retention on site: it is the volume-control layer of this Manual, and a regional tank cannot recharge the aquifer under the developed site.

7.12 Wetlands, marshes and estuaries

7.12.1 **Scope.** This clause applies to marshes, swamps, backwaters, estuaries, and tidal creeks and lagoons, including:

- (a) wetlands notified under the Wetlands (Conservation and Management) Rules, 2017 or listed by the State Wetland Authority;
- (b) any wetland notified under the 2017 Rules, to its notified boundary (none was found notified), and Glaw Lake in the Kamlang Tiger Reserve, a Ramsar site since 3 August 2026 (as reported), to its designated boundary;
- (c) Ganga Lake (Gyakar Sinyi) in the Itanagar Wildlife Sanctuary; the 1,127 wetlands of the Forest Department's truthing, to the boundaries demarcated for 997 of them; the palaeochannels and swampy land of the Pachin and Dikrong flood plains; the ponds; the seepage ground of springs; and the reservoirs with their drawdown zones, each to the boundary of Clause 7.13.1 and the 1% AEP extent of Clause 7.3.4 (a river, stream, nallah or reservoir itself is a waterbody under the rest of this chapter); and
- (d) any other pond, marsh or wetland that the Authority notifies, that the wetland authority lists, that an urban local body or planning authority lists under Annexure E 1.8 of the APBBL 2019, or that the Gauhati High Court (Itanagar Bench), the National Green Tribunal or the Supreme Court directs to be protected.

7.12.2 **No drainage of wetlands.** No drain, channel, cut or pump shall be designed to drain a wetland, to lower its normal water level, or to reduce the period for which it is wet, except under a plan approved by the wetland authority.

7.12.3 **Inflows.** Every drain discharging into a wetland in Clause 7.12.1 shall:

- (a) meet Clause 7.10.6;
- (b) pass through water quality treatment for the WQv of its catchment (Chapter 8) before entering the wetland; and
- (c) where practicable, spread its flow across a vegetated margin rather than discharge at one point.

7.12.4 **Hydraulic connectivity.** Roads, embankments and utility corridors across or along a wetland shall have openings that:

- (a) pass the 1% AEP flow without raising the 1% AEP water level by more than the limit in Clause 7.6.2; and
- (b) keep the wetland's normal water exchange, including tidal exchange in estuaries, with openings spread along the crossing so that no part of the wetland is cut off.

7.12.5 **Storage counted at basin scale only.** Wetland storage shall be included in basin and regional models. It shall not be counted as detention for any individual development.

7.12.6 **Tidal wetlands and estuaries.** For estuaries and tidal wetlands:

- (a) tailwater shall be taken from Chapter 5 (Clause 2.12 joint cases);
- (b) works shall also comply with the Coastal Regulation Zone Notification in force; and
- (c) mouth-opening works, training walls and dredging are outside the scope of this Manual and need their own studies.

7.12.7 **No dumping.** No solid waste, construction debris or dredged material shall be placed in a wetland or its setback.

> **Commentary.** Arunachal Pradesh's wetlands are overwhelmingly high-altitude lakes far from the towns. The Forest Department's *Status of Truthing and Boundary Demarcation of Wetland of Arunachal Pradesh* lists 1,127 wetlands of more than 2.25 ha in 19 districts (Dibang Valley 384, Anjaw 231, Tawang 188 and Papum Pare 6 among them): 944 high-altitude lakes, 24 aquaculture ponds, 12 ox-bow lakes, 8 waterlogged areas, 3 lakes, 2 tanks or ponds, 2 rivers, 1 reservoir and 1 paddy field, with 130 entries found to be shadows; 103 were truthed on the ground and 894 remotely, and boundaries have been demarcated for 997. **Glaw Lake** in the Kamlang Tiger Reserve was announced as India's 101st Ramsar site, and the State's first, on 3 August 2026 (as reported; its area was not confirmed and is not given here). **Ganga Lake (Gyakar Sinyi)**, a natural lake in the Itanagar Wildlife

Sanctuary about 6 km from Itanagar, is reported to be under pressure from encroachment and earth cutting; the Forest Department is reported to have taken charge of its rejuvenation, and an application before the National Green Tribunal alleges illegal road construction in the sanctuary (as summarised; allegations only). The **State Wetland Authority** is reported to have signed a memorandum with Wetlands International South Asia on high-altitude wetlands in 2024 (as reported); the notification constituting it under rule 5 of the Wetlands (Conservation and Management) Rules, 2017 and its exact name were not found [TBC], and no wetland notified under rule 4 was found. No water-quality data were found for any lake or pond. A drain outfall, desilting, diversion or gate operation in or next to a notified wetland, a demarcated wetland or a lake in a sanctuary or reserve therefore needs the views or permission of the wetland authority or the Forest Department where their rules reach it, as well as compliance with this chapter; for the ponds, springs, swamps and paddy land they do not reach, this chapter, the custodian and, on customary land, the owners or the community are the only controls. Clause 7.12.2 targets a specific risk: drains built to relieve flooding next to a marsh can drain the marsh itself, and once it is dry it is encroached. Sewage reaches Arunachal Pradesh's rivers, nallahs and ponds through the drains (Clause 8.9, Commentary). The Master Plan of Itanagar Capital Region-2031 records sewage "being drained to open or vacant land as well as into ponds" and finds that "The natural water bodies such as ponds and streams are getting polluted"; the CPCB placed the Senki at Chandranagar, Itanagar, upstream of the Pachin, in Priority V in 2025; and the National Green Tribunal directed on 5 January 2023, in the case on the Senki, the Pachin and the Dikrong, that "no untreated sewage or treated sewage be allowed to enter into the waterbody" (as summarised). Clauses 7.10.6(d) and 7.12.3 therefore cannot yet be met by most existing outfalls in Itanagar, Naharlagun and Pasighat. In Arunachal Pradesh they apply in full to every new outfall, and every existing outfall to the Senki, the Pachin, the Dikrong, a main stem or a pond is taken to carry dry-weather flow and comes under the annual survey and the interception of Clauses 8.9.4 and 8.9.5 until its sources are removed. Every drain or nallah that enters a pond also passes a silt trap and a solid-waste trap first (Figure 7.3; Clause 6.3.6(m)), because the pond is the end of its catchment's drainage and has no other way to lose the silt and garbage. No drain discharges to Ganga Lake, Glaw Lake or a glacial lake.

7.13 Encroachment interfaces

7.13.1 **Boundary.** For design under this Manual, the boundary of a waterbody is the larger of its Revenue record boundary and its surveyed FTL (or top of bank), as in Clause 7.3.3. Setbacks are measured from that boundary.

7.13.2 **No reliance on encroached land.** No design shall:

- (a) count, as storage or conveyance, land within a waterbody boundary that is occupied by encroachment, unless its removal is ordered and funded; or
- (b) treat the encroached width of a channel as its design width.

7.13.3 **Public works in encroached reaches.** Where a public drainage work passes through an encroached reach:

- (a) it shall be designed for the full waterbody width (Clause 7.13.1);
- (b) where the full width cannot be cleared before the work is built, the design report shall state the interim capacity and the flood risk until it is cleared; and
- (c) the work shall be built so that the full width can be restored later without rebuilding it.

7.13.4 **Boundary marking.** Every development adjoining a waterbody shall, before the completion certificate:

- (a) mark the outer edge of Zone 1 on the ground with permanent survey markers at intervals of not more than 30 m and at every change of direction; and
- (b) show the setback zones on the approved layout plan and in the sale documents of every plot that includes setback land.

7.13.5 **Retaining walls.** No retaining wall, bund or embankment shall be built along the edge of a waterbody, within Zone 1, to protect or reclaim land, except to protect existing public infrastructure under the custodian's approval.

> **Commentary.** Arunachal Pradesh's controls on building and dumping along its nallahs, streams and lakes have come from the bye-laws and from the National Green Tribunal more than from the courts of the State: no order of the Gauhati High Court (Itanagar Bench) on the capital's drains, earth cutting or landslides was found. The Tribunal's case on the Senki, the Pachin and the Dikrong, O.A. 94/2020/EZ, has been pending since November 2020; on 18 August 2022 it refused further time for the State's counter-affidavit, and on 5 January 2023 it directed that no sewage enter the rivers and that the APSPCB monitor them quarterly (as summarised). Under PIL 21/2021 the High Court directed IMC to fine littering (as reported). The master plan finds the Pachin "a waste disposal site" and the drains "chocked with the solid wastes"; illegal earth cutting along NH-415 was blamed for a mudslide near the Donyi Polo airport (as reported); and Ganga Lake is reported to be under encroachment and earth-cutting pressure, with an encroachment survey by the Principal Chief Conservator of Forests and the district administration promised and an inspection of alleged earth cutting by an Additional District Magistrate with the "Save Ganga Lake Mission" (as reported). The first Water Bodies Census recorded none of the State's 993 water bodies as encroached (as summarised); that finding does not show the state of the nallahs and stream banks (NEER reading). The bye-laws' penalty of ₹1 lakh for earth cutting without approval, with a recommendation to cancel the land allotment (clause 4.39(14)), is the strongest local control that touches a channel. Land along many streams and ponds is held by communities, clans and individuals under customary rights, and the beds of streams, nallahs, lakes and tanks on it are not Government property (s.9(1) of the Arunachal Pradesh (Land Settlement and Records) Act, 2000; Chapter 1). This Manual cannot evict anyone. It can stop designs from treating encroachment as permanent (Clause 7.13.2), make public works restorable to full width (Clause 7.13.3), and make the setback visible on the ground and in property documents so that new buyers know it is there (Clause 7.13.4). The 30 m marker interval is set by this Manual.

7.14 Safety of tank bunds and embankments

7.14.1 **Dam Safety Act screening.** For every tank, and every embankment built or altered under this Manual, the designer shall determine whether it is a "specified dam" under the Dam Safety Act, 2021. Under the Act, a specified dam is a dam:

- (a) more than 15 m high, measured from the lowest point of the general foundation area to the top of the dam; or
- (b) between 10 m and 15 m high, where the crest length is not less than 500 m, or the reservoir capacity is not less than one million m³, or the maximum flood discharge dealt with by the dam is not less than 2,000 m³/s, or the dam has specially difficult foundation problems, or the dam is of unusual design.

Where it is a specified dam, the Act and the requirements of the State Dam Safety Organisation govern, in addition to this Manual.

7.14.2 **Hazard class.** Every tank bund and detention embankment that is not a specified dam shall be given a hazard class:

- **High hazard:** a breach could flood a habitable building, a school, a hospital, an arterial road or critical infrastructure.
- **Low hazard:** any other case.

7.14.3 **High-hazard embankments.** For high-hazard tank bunds and embankments:

- (a) the surplus weir or spillway shall pass the 1% AEP inflow at MWL with the freeboard of Clause 7.7.4(b), and shall be checked for the 0.2% AEP (500-yr) inflow without overtopping the bund (as for detention basins in Chapter 4);

- (b) a breach analysis shall map the area flooded by a breach at MWL;
- (c) an emergency action plan shall be prepared, with the warning and evacuation arrangements for the breach area; and
- (d) the design shall be certified and independently checked under Clause 10.6.

7.14.4 **Inspection.** Every tank whose storage is counted under Clause 7.7, and every high-hazard embankment, shall be inspected before the monsoon (by 31 March) and after every heavy-rainfall event (Chapter 10) for seepage, slips, cracks, animal burrows, trees on the bund, and blockage of the weir and sluices.

7.14.5 **No unauthorised cutting.** No person shall cut, lower or breach a tank bund or surplus weir during a flood except under the custodian's emergency procedure.

> Commentary. The definition of a specified dam is quoted from the Dam Safety Act, 2021 (Act 41 of 2021). The Act defines a "dam" as an artificial barrier constructed across rivers or tributaries to impound or divert water. It excludes flood embankments, dikes and guide bunds. No pond or lake in Arunachal Pradesh was found to be held by a bund high enough to be a specified dam, though the bunds and outlets of the ponds and lakes were not surveyed for this Manual [TBC]; each outlet work or bund shall be screened under Clause 7.14.1. The dams of the Pare, Ranganadi, Kameng, Lower Subansiri and Dibang projects are dams across rivers under the Act; their heights were not researched for this Manual [TBC]. A glacial or moraine-dammed lake is held by ice, moraine or landslide debris, not by a built bund, and is screened as a hazard under Clause 2.3.6(i), not under this Clause. Where the storage of a pond or reservoir is counted under Clause 7.7, its bund, outlet works or dam is a tank bund for Clause 7.14.2 unless the Act applies. Whether a tank bund that is not across a river or tributary is a "dam" under the Act is not clear from its text. In Arunachal Pradesh the embankments that matter most to the towns and villages below them are the dams of the hydroelectric projects and the natural dams of glaciers, moraines and landslides, and the hazards below them are the release and the outburst. The Pare dam released a peak of 1,310 m³/s into the Dikrong above Doimukh on 31 May 2025, and the 1999 flood remains the local benchmark on that reach (as reported); the Ranganadi project released 1,412.57 m³/s on 9 July 2017 (as summarised); and on the Siang the breach of the Yigong landslide dam in Tibet on 10 June 2000 raised the river at Pasighat to the CWC's highest flood level, 157.54 m, 3.58 m above its danger level, and is reported to have "washed out every bridge downstream from Yigong Tso to Pasighat", with reported deaths of 30 to more than 100 (the figures conflict, and some include deaths downstream of the State) (all as reported). NDMA lists 27 high-risk glacial lakes in the State, and a lake in the Mago Chu basin of Tawang is reported to have grown from 55.87 ha in 2016 to 87.02 ha in 2026 (as reported; the study was not seen). No operator's release protocol, warning threshold or breach map for any dam, and no emergency action plan for any dam, pond or lake, was read for this Manual [TBC]. A failed or overtopped bund floods the land below it, and a release or outburst made without warning floods it too, which is why Clause 7.14.3 asks for breach mapping and an emergency action plan for high-hazard embankments, and why Chapter 5 treats release reaches and outburst reaches as flood-sensitive outfalls (Clause 5.8.5(d) and (e)). The hazard classes, the breach analysis and the emergency action plan for high-hazard tanks are set by this Manual. They extend the Chapter 4 requirement for detention basins (1% AEP spillway with outlet blocked, 0.2% AEP for high-hazard basins) to tanks that are counted as design storage.

7.15 Submittal requirements

Every drainage report for a development or work under Clause 7.1.2 shall include:

1. the **Waterbody Sheet (Form 7-1)** under Clause 7.3.2, with the setback zones and their basis (mapped extent, hydraulic study or fixed width);
2. the hydraulic study of the 1% AEP extent and floodway, where Clause 7.3.4 requires it;
3. the **Compensatory Storage Calculation (Form 7-3)**, by elevation band, where fill is proposed in the flood fringe;

4. for any tank storage counted: the **Tank Storage Credit Sheet (Form 7-2)**, with the survey, stage–storage curve, operating rule, cascade model results and custodian concurrence of Clause 7.7.1;
5. for any crossing, outfall or work in Zone 1: the custodian's NOC and the hydraulic analysis of Clause 7.6.2 or 7.10.3;
6. for restoration or desilting: the pre-works survey, silt tests and hydrogeological report of Clause 7.9; and
7. for any embankment: the Dam Safety Act screening and hazard class of Clause 7.14.

7.16 Review and update

7.16.1 This chapter shall be reviewed with the rest of the Manual (Chapter 1). The fixed-width table of Clause 7.4.6 shall also be reviewed within 2 years of the Authority adopting 1% AEP flood maps for its area.

7.16.2 Where the Authority adopts new 1% AEP flood maps, they apply to new submittals **6 months** after adoption, unless the Authority notifies otherwise.

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Annexes and forms

Annex / Form	Content
7A	Statewide waterbody GIS layer and inventory fields
7B	Fixed-width setback table (alternative S-3, with Annex 1C)
7C	Template tank operating rule, with flood cushion
7D	Desilting and restoration specification
7E	Glossary of Nyishi waterbody terms and regional variants
Form 7-1	Waterbody Sheet
Form 7-2	Tank Storage Credit Sheet
Form 7-3	Compensatory Storage Calculation (by elevation band)

CHAPTER 8

Water Quality and Recharge

8.1 Purpose and scope

8.1.1 This chapter sets the requirements for the quality of stormwater leaving a site or a public drainage system, and for groundwater recharge. It covers:

- (a) the water quality volume (WQv) and the water quality design flow;
- (b) the treatment train, and the selection and design of best management practices (BMPs);
- (c) the criteria for infiltration and recharge;
- (d) the exclusion of sewage and dry-weather flow from storm drains;
- (e) gross pollutant traps, first-flush treatment and screens at outfalls to waterbodies;
- (f) how rainwater harvesting (RWH) fits with retention and detention;
- (g) erosion and sediment control during construction; and
- (h) monitoring.

8.1.2 This chapter applies to every development and public work to which Chapter 4 applies (Chapter 1). Clauses 8.9 (sewage) and 8.12 (construction erosion and sediment control) apply to every development that needs a building permit or layout approval, and to every public drainage work, whatever its size.

8.1.3 Retention under Chapter 4 is the first and preferred form of water quality control. Runoff retained on site is treated in full. The rest of this chapter applies to the part of the WQv that is not retained.

> Commentary. CPHEEO (2019) is the only Indian manual that covers stormwater quality in any detail. Its Chapter 9 reproduces US event mean concentrations, but cautions that "in an Indian context the values would be much higher" because drains receive night soil, urine and food waste, and it sets no Indian numeric criteria (CPHEEO 2019, Part A §9.5). Its Chapter 10 describes water-sensitive urban design, LID and SuDS treatment trains (CPHEEO 2019, Part A Ch. 10). This chapter turns that guidance into requirements. It follows the treatment approach of the MARC/APWA BMP Manual (2012), now merged into APWA 5600 (2025.01), with the Malaysian 3-month ARI water quality storm (MSMA 2, 2012) and the Georgia water quality volume (GSMM, 2016) as tropical and US benchmarks.

8.2 Definitions

Term	Meaning in this Manual
Water quality volume (WQv)	The runoff volume that must be retained or treated, from the water quality rainfall depth (Clause 8.4).
Water quality rainfall depth (P_wq)	The greater of the retention depth (Annex 2E, Clause 2.10) and the 24-hour 3-month ARI depth (Annex 8A).

Term	Meaning in this Manual
3-month ARI depth	The 24-hour rainfall depth equalled or exceeded on average four times a year, from a partial-duration series of the long-term daily record.
Water quality design flow (Q_wq)	The peak flow from the 3-month ARI storm, used to size flow-through devices and diversion structures (Clause 8.4.5).
Runoff coefficient for WQv (Rv)	The volumetric runoff coefficient for small storms, Rv = 0.05 + 0.009·I.
BMP	A best management practice: a structural or non-structural measure that reduces pollutant loads or runoff volume.
Treatment train	Two or more BMPs in series, from source to site to regional scale (Clause 8.5).
Pretreatment	A BMP that removes coarse sediment, litter and oil before runoff reaches a filter or infiltration BMP.
First flush	The early part of a runoff event, which usually carries the highest concentrations of sediment, litter and oil.
Gross pollutant trap (GPT)	A device that captures litter, plastics, vegetation and coarse sediment, typically above about 5 mm.
Dry-weather flow (DWF)	Flow in a storm drain when it has not rained for at least 72 hours. In a separate storm system, DWF is evidence of sewage, sullage, groundwater infiltration or illicit discharge.
Cross-connection	Any pipe, channel or opening that lets sewage or sullage (grey water from kitchens, bathrooms and laundries) enter a storm drain.
Infiltration facility	A facility designed to store runoff below the ground surface, or in a depression, and let it soak into the soil: infiltration trenches and basins, unlined bioretention, permeable pavement with an open base, soakaways, recharge pits and recharge wells.
Seasonal high groundwater table	As defined in Clause 3.10.2: the highest level in the monsoon season.
Hotspot	A land use with a high risk of spills or contaminated runoff (Clause 8.8.8).
Level of Service (LoS) / Value Rating (VR)	The scoring system of Clause 8.6, from the MARC/APWA BMP Manual (2012).

8.3 Objectives and pollutants of concern

8.3.1 Stormwater treatment under this Manual shall aim to:

- (a) remove litter, plastics and other gross pollutants before they reach a waterbody;
- (b) remove suspended sediment, and the metals, nutrients and oil carried on it;
- (c) keep sewage and sullage out of storm drains and waterbodies;
- (d) recharge groundwater where soils and groundwater depth allow, without polluting it; and
- (e) prevent erosion and sediment discharge during construction.

8.3.2 The design shall address the following pollutants for every site, and the hotspot pollutants of Clause 8.8.8 where they apply:

Table 8.1 — Pollutants of concern, sources and primary controls

Pollutant	Main sources in Arunachal Pradesh towns	Primary control
Gross pollutants (plastics, litter, vegetation)	Streets, markets, open dumping in drains	Source collection; GPTs and screens (Clause 8.10)

Pollutant	Main sources in Arunachal Pradesh towns	Primary control
Suspended sediment	Construction sites, unpaved roads and verges, road wear, drain silt	Erosion and sediment control (Clause 8.12); pretreatment; filtration
Oil, grease and fuel	Roads, parking, fuel stations, workshops, bus depots	Oil-grit separators at hotspots; bioretention
Pathogens and organic load (BOD)	Sewage and sullage cross-connections, animal waste	Exclusion and DWF interception (Clause 8.9)
Nutrients (N, P)	Sewage, fertiliser, food waste, detergents	Exclusion; bioretention; wetlands
Heavy metals	Roads, roofs, industrial yards	Filtration; sedimentation

> **Commentary.** Gross pollutants and sewage come first in Clause 8.3 because they dominate the pollution of urban waterbodies in Arunachal Pradesh, and because no treatment BMP works for long if they are not removed. CPHEEO (2019) notes that Indian drains carry night soil, urine and food waste (Part A §9.5). In its WSUD procedure it lists TSS, total nitrogen, total phosphorus and gross pollutants as the key pollutants (Part A Ch. 10). AMRUT 2.0 funds the harvesting of rainwater "through storm water drains into water body (which is not receiving sewage/effluent)" (Lok Sabha unstarred question AU1419), which only works if sewage is first kept out of the drains.

8.4 Water quality volume and design flow

8.4.1 **Water quality rainfall depth.** The water quality rainfall depth is:

> $P_{wq} = \max(P_{ret}, P_{3m})$

where:

- P_{ret} = the retention depth for the site's zone (Annex 2E, Clause 2.10), mm; and
- P_{3m} = the 24-hour 3-month ARI depth for the site's zone (Annex 8A), mm.

8.4.2 **Water quality volume.** The WQv shall be computed as:

> $WQv = (P_{wq} / 1000) \times Rv \times A$

where:

- WQv is in m³;
- A = the contributing area, m²;
- $Rv = 0.05 + 0.009 \cdot I$; and
- I = the impervious percentage of the contributing area (0–100), after the connectivity rules of Clause 3.9.

The Rv form above may be used only for sites under 0.5 ha and under the Tier B simplified method (Clause 4.14). This is the same limit as for the retention volume (Clause 4.4.2). For all other sites the WQv shall be computed with the SCS-CN method, as the retention volume is: WQv (m³) = 10 × Q_{wq} × A, where Q_{wq} (mm) is the SCS-CN runoff from P_{wq} for each sub-area and A is in ha.

8.4.3 **Climate factor.** The climate factor of Clause 2.8 shall not be applied to P_wq. P_ret and P_3m are frequency statistics of ordinary rainfall, not AEP design depths.

8.4.4 **WQv met by retention.** The volume retained on site under Chapter 4 counts toward the WQv in full. Where the retained volume is equal to or greater than the WQv, no further treatment is required for that area, except:

- (a) pretreatment of inflows to each retention facility (Clause 8.5.3);
- (b) hotspot controls (Clause 8.8.8); and
- (c) the outfall requirements of Clause 8.10, where the site discharges to a waterbody.

8.4.5 **Water quality design flow.** Flow-through devices (swales, filter strips, oil-grit separators, GPTs) and diversion weirs for off-line BMPs shall be sized for Q_wq. Q_wq shall be computed from the 3-month ARI intensity at the time of concentration of the contributing area:

- (a) by the Rational Method, where Chapter 3 allows it (a single element draining no more than 16 ha); or
- (b) as the peak of a hydrograph method using the 3-month ARI 24-hour depth with the alternating-block pattern of Clause 2.9.1.

8.4.6 **Bypass.** Flows above Q_wq shall bypass flow-through and off-line treatment devices without washing out the material already captured. The bypass shall be part of the minor or major system (Chapter 6).

8.4.7 **Drawdown.** Where the WQv is held in an extended-detention BMP (wet pond, constructed wetland or dry extended-detention basin), it shall be released over **24–48 hours** (Chapter 4).

> Commentary. The WQv depth is the runoff from the 3-month ARI storm or the retention depth, whichever is greater. The 3-month ARI is the Malaysian water quality design storm (MSMA 2, 2012). The Malaysian 2008 checklist gave its depth as about 40 mm and said it captures 90% or more of 24-hour storm runoff volume (DID, 2008). The Arunachal Pradesh value must be computed (Annex 8A). Georgia sets its WQv as the runoff from 1.2 inches (about 30 mm), the depth that covers 85% of storms in an average year, and requires 80% removal of the average annual post-development TSS load (GSMM 2016, Vol 1, Standard #4). Kansas City's water quality storm is the 1.37-inch (about 35 mm) event that produces up to 90% of the runoff from all 24-hour storms in a year (MARC BMP Manual, 2012).
>
> The Rv formula is from the MARC/APWA BMP Manual (2012), which computes WQv = P × Rv with Rv = 0.05 + 0.009·I. Rv is used instead of the SCS curve number because the CN method greatly understates runoff from small storms on pervious ground. Not applying the climate factor (Clause 8.4.3) has no direct precedent; this Manual does so because it treats P_wq like the retention depth, as a statistic of ordinary rainfall. Bypass of larger flows and the 24–48 hour drawdown follow Chapter 4; MARC (2012) required at least 40 hours of extended detention of the WQv.
>
> **Illustrative — not design values.** For a 1.0 ha site with 80% impervious cover and an assumed P_wq of 50 mm:
>
> - Rv = 0.05 + 0.009 × 80 = 0.77
> - WQv = (50 / 1000) × 0.77 × 10,000 = 385 m³

8.5 Treatment train and pretreatment

8.5.1 **Treatment train.** Water quality control shall be designed as a treatment train, in the order shown in Figure 8.1:

- (a) **source controls** on the plot: roof runoff to RWH, rain gardens, permeable paving, disconnection of impervious areas, and silt traps at inlets;

- (b) **site controls**: bioretention, swales, filter strips, infiltration, oil-grit separators at hotspots, wet ponds and extended detention; and
- (c) **regional controls**, for public drainage: GPTs and DWF interceptors at outfalls, constructed wetlands at tank inlets, and regional ponds.

8.5.2 A development shall meet the WQv on site, through (a) and (b). Regional controls under (c) may count toward a development's WQv only where a regional facility treating the same runoff has been built under a notified basin plan (Clause 7.11).

8.5.3 **Pretreatment.** Every bioretention cell, infiltration facility, permeable pavement receiving run-on, wet pond and constructed wetland shall have pretreatment at each concentrated inflow. Pretreatment shall be a sediment forebay, grass filter strip, silt trap or proprietary device that holds at least **10% of the WQv** of its contributing area, or that is sized for Q_wq for flow-through devices.

8.5.4 Pretreatment shall be accessible for cleaning without entering or disturbing the main BMP.

> **Commentary.** The treatment train follows CPHEEO (2019, Part A §10.2.3, SuDS treatment train) and CIRIA C753 *The SuDS Manual* (2015). It is also the order of priorities of this Manual: preserve, retain, detain, convey (Chapter 1). The 10% forebay volume has no Indian precedent; it is a common sizing rule for forebays in US manuals. In Arunachal Pradesh, unpaved verges, construction sites and drain silt deliver a heavy sediment load. Bioretention and infiltration facilities without pretreatment clog, often within a year or two.

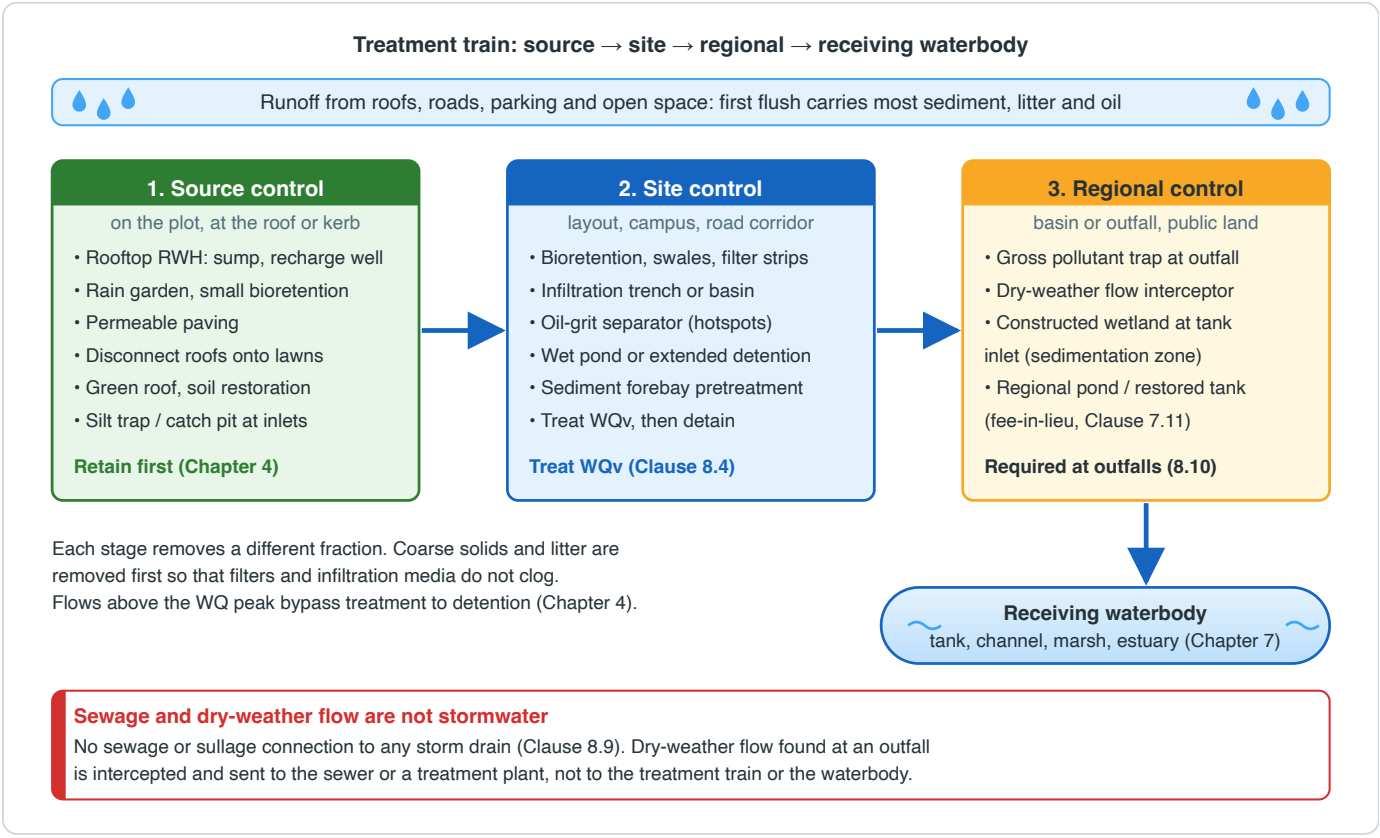


Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater Quality, 2012.

8.6 BMP selection: Level of Service and Value Rating

8.6.1 **Method.** In Tier A areas, the BMPs for each site shall be selected by the Level of Service (LoS) method of this Clause. In Tier B areas, the simplified route of Clause 8.6.5 may be used.

8.6.2 **Required Level of Service.** For a site that is not redevelopment, the required LoS depends on the change in curve number (ΔCN) from pre- to post-development (Chapter 3):

Table 8.2 — Required Level of Service for sites that are not redevelopment

ΔCN	Impact	Required LoS
17 or more	High	8
7 to 16	Moderate	7
4 to 6	Low	6
1 to 3	Minimal	5

For redevelopment (existing impervious cover of 20% or more of the site), the required LoS shall be taken from Annex 8B.

8.6.3 **Value Rating.** Each BMP treating the WQv has a Value Rating (VR) from Table 8.3. The site's composite VR is the area-weighted average of the VRs of the BMPs serving each part of the site. Treatment trains get a composite VR under Annex 8B. The composite VR shall be equal to or greater than the required LoS.

8.6.4 **Conditions for a Value Rating.** A BMP earns its VR only if:

- (a) it is sized for the WQv (or Q_wq for flow-through devices) of the area credited to it;
- (b) it meets the design requirements of Clause 8.7 and, for infiltration, Clause 8.8; and
- (c) it has pretreatment under Clause 8.5.3.

8.6.5 **Tier B simplified route.** In Tier B areas, the requirement of Clause 8.6.3 is deemed met where the whole WQv of the site is either:

- (a) retained on site under Chapter 4; or
- (b) treated by a bioretention cell, rain garden or infiltration facility designed under Clauses 8.7 and 8.8, with pretreatment.

Table 8.3 — BMP Value Ratings and suitability in Arunachal Pradesh

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Terrace sands and fan heads (recharge rule)	Laterite / hard rock	Slopes, shale, colluvium and fill / floodplain and high water table	Arunachal Pradesh notes
Native vegetation (preserved)	9.25	All	High	Suited	Suited	Suited	Counts only for preserved, undisturbed area
Rain garden / infiltration	9.0	Sediment, metals, oil, nutrients	High	Suited if 1.0 m separation met	Conditional (test)	Not suited	Mosquito control: drain within 48 h
Bioretention	8.5	Sediment, metals, oil, nutrients	Medium–high (unlined); low (lined)	Suited	Suited, with underdrain	Lined, with underdrain	Media source and phosphorus content to be specified

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Terrace sands and fan heads (recharge rule)	Laterite / hard rock	Slopes, shale, colluvium and fill / floodplain and high water table	Arunachal Pradesh notes
Permeable pavement	7.5	Sediment, metals, oil	Medium–high	Suited	Conditional	Lined only	Not where run-on carries heavy silt
Extended detention wetland	7.0	Sediment, nutrients, metals	Low	Conditional (water balance)	Suited	Suited	Good at tank inlets (Clause 7.9.7)
Media / sand filter	6.0	Sediment, metals	Low	Suited	Suited	Suited (lined)	Needs frequent cleaning
Extended wet detention (wet pond)	5.0	Sediment, metals, some nutrients	Low	Conditional (water balance)	Suited	Suited	Dry-season water balance (Clause 8.7.8)
Vegetated filter strip	5.0	Sediment	Low–medium	Suited	Suited	Suited	Mostly as pretreatment
Native vegetation swale	4.0	Sediment, oil	Low–medium	Suited	Suited	Suited	Not where Q_wq velocity is high
Extended dry detention	4.0	Coarse sediment	Low	Suited	Suited	Suited	Combine with detention (Chapter 4)
Proprietary / hydrodynamic devices	3.0–5.0	Coarse sediment, oil, litter	None	Suited	Suited	Suited	VR from verified test data only
Signage (public education)	+0.25	—	—	—	—	—	Added to composite VR

The VR column is from the MARC/APWA BMP Manual (2012), Table 4.4. The suitability columns and notes have no direct precedent and are set by this Manual.

> **Commentary.** The LoS and VR method is from the MARC/APWA Manual of Best Management Practices for Stormwater Quality (2012), Tables 4.2 and 4.4. The VRs combine a water quality score, based on effluent TSS concentrations in the International Stormwater BMP Database, with scores for volume reduction, temperature, and oils and floatables. The method suits Arunachal Pradesh for two reasons. It rewards volume reduction and preservation, which also serve recharge. It can also be checked by a reviewer without water quality modelling. Its weakness is that the scores come from US data. Arunachal Pradesh stormwater carries more litter and more sewage than the US runoff behind the scores (CPHEEO 2019, §9.5), so this Manual requires GPTs and DWF exclusion separately (Clauses 8.9 and 8.10) and does not let a VR stand in for them.

8.7 BMP design summaries

8.7.1 **General.** Each BMP shall be designed to the requirements below and to Annex 8D (BMP design sheets). The dimensions given are **recommended starting values** where marked; the designer shall justify any departure. Every BMP shall be designed for safe passage of flows above Q_wq (Clause 8.4.6) and shall have access for maintenance (Chapter 10).

8.7.2 **Bioretention and rain gardens** (Figure 8.2).

- (a) Surface ponding depth not more than **300 mm** above the mulch, with an overflow at the maximum ponding level.
- (b) Surface ponding drained within **48 hours**.
- (c) Filter media 600–900 mm deep: an engineered sandy loam with low fines and low phosphorus content (Annex 8D), with a 50–75 mm mulch layer.
- (d) A transition (choker) layer and a gravel drainage layer below the media.
- (e) A perforated underdrain where the design infiltration rate of the native soil (Clause 8.8.4) is below the rate needed to meet (b), or where the cell is lined.
- (f) Unlined cells shall meet the infiltration criteria of Clause 8.8. Cells that cannot meet them, and cells at hotspots, shall be lined.
- (g) Plants: native or naturalised species tolerant of both waterlogging and long dry spells.

8.7.3 **Vegetated swales.**

- (a) Trapezoidal or parabolic section, with side slopes no steeper than 1V:3H.
- (b) Longitudinal slope 0.5% to 4%, with check dams where steeper.
- (c) Flow depth at Q_wq not more than the height of the grass, and velocity at Q_wq not more than 0.3 m/s.
- (d) The 1% AEP flow (or the bypass) shall not erode the swale (Chapter 9 permissible velocities).
- (e) Where longitudinal slopes are below 1% or the subsoil is poorly drained, an underdrained ("dry") swale with filter media.

8.7.4 **Vegetated filter strips.**

- (a) Receive sheet flow only, with a level spreader where flow arrives concentrated.
- (b) Length in the direction of flow at least 5 m, and slope 1% to 8%.
- (c) Used mainly as pretreatment for bioretention, infiltration and swales.

8.7.5 **Permeable pavement.**

- (a) Run-on from impervious areas not more than twice the permeable area, and no run-on from unpaved or eroding areas.
- (b) Base reservoir of clean, open-graded aggregate, sized to hold its share of the WQv in its voids.
- (c) An open base (infiltrating) only where Clause 8.8 is met; otherwise lined with an underdrain, and then counted as filtration only.
- (d) Structural design for the traffic loading by the road authority's standards.
- (e) Not at hotspots, and not where the surface will be resurfaced with impermeable material.

8.7.6 **Infiltration trenches and basins** (Figure 8.3).

- (a) Pretreatment under Clause 8.5.3 in every case.
- (b) Trenches filled with clean washed aggregate, with a void ratio confirmed by test, wrapped in geotextile on the sides and top, on a sand base.
- (c) An observation well to the base of each trench.
- (d) Storage volume = WQv (or the retention volume of Chapter 4, where greater) held in the voids; emptied within 72 hours at the design infiltration rate.
- (e) An overflow to the minor or major system at grade.
- (f) Not brought into service until the contributing area is stabilised (Chapter 10).

8.7.7 **Wet ponds (extended wet detention).**

- (a) A permanent pool of at least the WQv, plus extended detention of the WQv above the pool, released over 24–48 hours.
- (b) A sediment forebay at each inlet (Clause 8.5.3).
- (c) Length-to-width ratio of the flow path at least 3:1, with no short-circuiting.

- (d) Permanent pool depth 1.0–2.5 m, with a safety bench (Clause 7.9.4).
- (e) A dry-season water balance (Clause 8.7.8).
- (f) The detention storage of Chapter 4 may sit above the extended detention level.

8.7.8 **Water balance for permanent pools.** Wet ponds and wetlands shall be shown, by a monthly water balance using IMD rainfall and pan evaporation, to keep at least 50% of the permanent pool volume (or the minimum wetland depth) through the driest year in 10. They shall not be topped up with groundwater, potable water or sewage. Where the balance fails, a dry extended-detention basin or a constructed wetland with a smaller permanent pool shall be used instead.

8.7.9 **Constructed wetlands.**

- (a) An inlet sedimentation pond (forebay) followed by a shallow vegetated macrophyte zone.
- (b) Extended detention of the WQv above the normal water level, released over 24–48 hours, with an extended detention depth not more than 0.5 m.
- (c) A flow path length-to-width ratio of at least 3:1, with deep zones across the flow path to spread the flow.
- (d) A high-flow bypass so that floods do not scour the macrophyte zone.
- (e) Where built at a tank inlet, the wetland shall sit within the tank's setback but outside its waterspread, and its storage shall not be counted as tank storage.

8.7.10 **Gross pollutant traps.**

- (a) Sized to treat Q_wq, with all flows up to the 1% AEP passing without washing out captured material.
- (b) Capture of gross pollutants down to about 5 mm.
- (c) Head loss included in the hydraulic grade line of the drain (Chapter 9), with the screen assumed **50% blocked**.
- (d) Storage for captured material sized for the cleaning interval of the O&M plan, and not less than the 3-monthly cleaning of Chapter 10.
- (e) Vehicle access for cleaning by suction or grab.

8.7.11 **Oil-grit separators.**

- (a) Required at the hotspots of Clause 8.8.8 that involve fuel or oil: fuel stations, vehicle workshops and washing bays, bus and truck depots, and parking areas of more than 50 spaces.
- (b) Sized for Q_wq, with a high-flow bypass.
- (c) Not to be used as the only treatment: they shall be followed by a filtering BMP where the site needs a VR above 5.

8.7.12 **Silt traps and catch pits.**

- (a) At every inlet that receives runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody.
- (b) A sump at least 300 mm below the outlet invert.
- (c) Silt traps are pretreatment only and earn no VR.

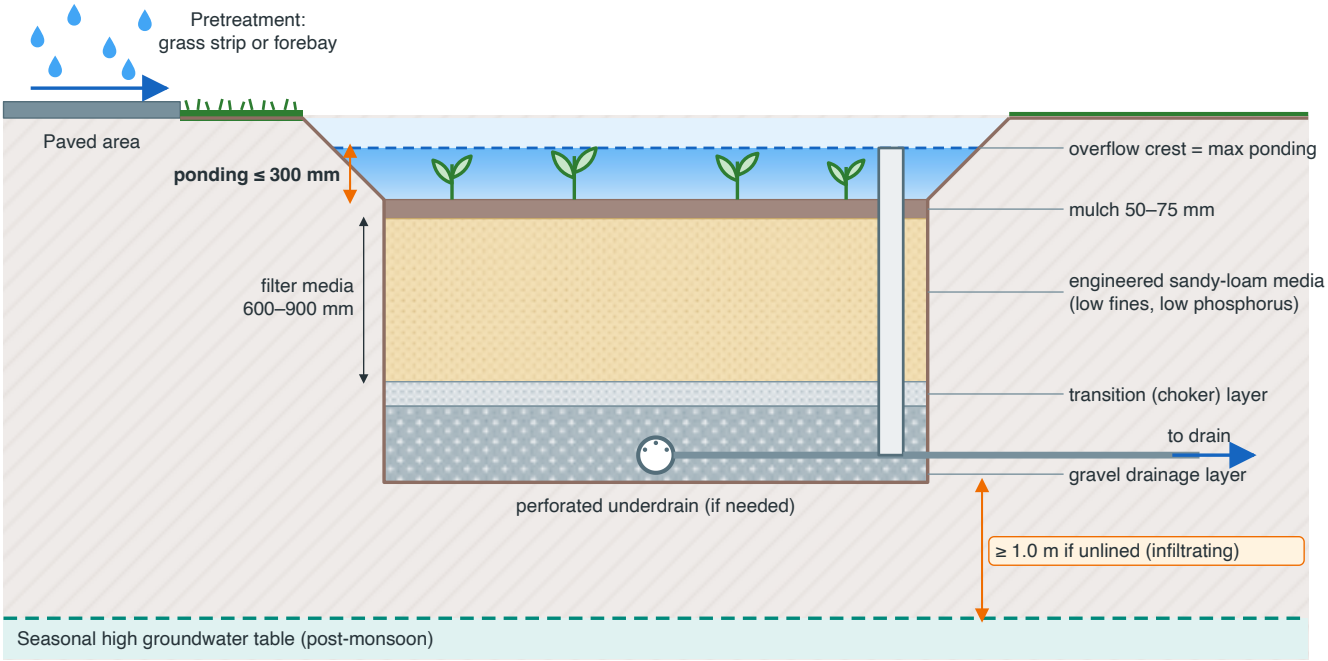
> **Commentary.** The design summaries draw on the MARC/APWA BMP Manual (2012), the Georgia Stormwater Management Manual (2016, Vol 2), CIRIA C753 *The SuDS Manual* (2015) and PUB Singapore's ABC Waters Design Guidelines. The dimensions are typical of those manuals but have not been calibrated in Arunachal Pradesh. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in Arunachal Pradesh. Surface ponding in bioretention and rain gardens must drain within 48 hours (Clause 8.7.2(b)), well inside the time mosquito larvae need to develop. This is consistent with the 24–48 hour WQv drawdown of Clause 8.4.7.
> - **Dry seasons.** Most of Arunachal Pradesh's rain falls in the monsoon season of 1 April to 31 October: at Doimukh the months of November to February bring 142.68 mm, 4.0% of the year (NERIST series, Dabral et al., 2016), and the State "receives rainfall over a period of 8 to 9 months excepting in winter" (State Action

Plan on Climate Change, 2011); storms still come outside the season, in October in the east and occasionally in winter (Chapter 2). From November to March ponds fall and springs weaken: "most of the springs become dry during dry season" in Papum Pare, and in the northern hills of East Siang springs are the only source (CGWB). In the towns the feed of a drain, nallah or pond in the dry months is often sewage and sullage, because no town treats its sewage and the drains are "being used as sewers" (Master Plan of Itanagar Capital Region-2031; Clause 8.9, Commentary). A wet pond or constructed wetland whose water balance (Clause 8.7.8) cannot keep its permanent pool through the dry months on its own catchment's runoff is not to be used; on the hill slopes, where Clause 4.11 bars infiltration on slopes, shale and slope debris and there is little flat land, the practical forms are lined bioretention with an underdrain, swales on gentle ground, storage for use, and lined extended dry detention. In the high ranges, where snow lies in winter, a BMP is also designed so that ice and snow do not block its inlet and outlet (Chapter 10). Clause 8.7.8 applies to BMPs, which shall not be topped up with sewage; ponds, lakes, springs and wetlands are waterbodies under Chapter 7 and are not to be used as treatment for a development. Wet ponds that dry out turn into stagnant pools or are used for dumping. Clause 8.7.8 requires a water balance and bans topping up with sewage, which is a common practice for keeping urban ponds "full".

- **Litter and silt.** GPTs and silt traps are treated as essential, not optional, because Arunachal Pradesh drains carry heavy litter and silt loads. The 50% blockage factor for screens matches the grate clogging factor of Chapter 6.

The 50-space threshold for oil-grit separators, the 5 mm GPT capture size, the 0.3 m/s swale velocity and the other dimensions in this Clause have no direct precedent and are set by this Manual.

Bioretention cell (rain garden): section, not to scale



Lined version (no infiltration): impermeable liner below the gravel layer. Required at pollution hotspots and wherever the 1.0 m separation to seasonal high groundwater cannot be met.

Dimensions as set in Clause 8.7.2.

Figure 8.2 — Bioretention cell (rain garden) in section: pretreatment, surface ponding, filter media, transition and gravel layers, underdrain, overflow, and the 1.0 m separation to seasonal high groundwater for an unlined cell. Original drawing for this Manual, adapted from MARC/APWA, Manual of Best Management Practices for Stormwater Quality, 2012, and CIRIA, The SuDS Manual (C753), 2015.

8.8 Infiltration and recharge criteria

8.8.1 **Groundwater separation.** An infiltration facility is permitted only where the **seasonal high groundwater table is at least 1.0 m below the base** of the facility. There is no exception in Arunachal Pradesh, which has no coastal sand areas (Clause 8.8.9). For this Clause the seasonal high groundwater table is the highest level found from April to November, which covers the season of 1 April to 31 October and the month after it (Clause 3.10.2). Arunachal Pradesh needs the three rules of Clause 4.11 here, and Clause 8.8.1 applies with the following. **(i) No infiltration on hill slopes, shale or slope debris (Clause 4.11, hill rule).** In sub-areas AR-C1, AR-D and AR-E of Annex 2A, on the hill rim of AR-A and AR-A1, and on any natural slope steeper than 10° anywhere, no deliberate infiltration practice (soakaway, soak or percolation pit, recharge pit, shaft or well, infiltration trench, unlined bioretention, or permeable paving with an exfiltrating base) shall be built or credited on natural ground sloping more than 10°; on Siwalik shale, at any slope; on colluvium, slope debris or fill; in a mapped landslide zone or above a landslide scarp; or upslope of a cut slope or retaining wall within twice its height, unless a geotechnical certificate by a qualified geotechnical engineer or engineering geologist shows that the added water will not destabilise the slope. On such sites roof runoff goes to storage sized under Clause 4.11 (25 L per m² of roof), with its overflow, and all other runoff, by a lined, stepped drain through a silt trap and an energy dissipator to a stable natural channel, never onto an unprotected slope; the exception for roof water in Clause 8.11.3(c) does not apply, and no infiltration is credited toward retention or the WQv. The CGWB describes Papum Pare as "underlain mostly by Siwalik group of rocks", with hill slopes "covered by residual soil or slope debris", and the older formations "overthrusted over the Younger Tertiary Siwaliks"; the Master Plan of Itanagar Capital Region-2031 places the capital in Earthquake Zone V with "5 fault lines in the city"; and the landslide at Laptap on 11 July 2017 followed three days of rain (as reported). The bye-laws refuse earth-cutting permission "if the average slope of the topography is more than 30%" and declare such a site "not fit for construction except for plantation" (APBBL 2019, clause 4.39(14)); that is a limit on earth cutting, not on infiltration. The 10° threshold (about 18%) and the shale condition are this Manual's: no Arunachal Pradesh rule sets a slope limit for infiltration. **(ii) No infiltration on the floodplain or where the water is high (Clause 4.11, floodplain rule).** In sub-areas AR-A (the valley floor), AR-B and AR-C, no deliberate infiltration practice shall be built or credited on land below the 1% AEP flood level of the Dikrong, the Pachin, the Senki, the Siang, the Lohit, the Dibang or the Noa-Dihing or of a nallah; on the palaeochannels and swampy land of the Pachin and Dikrong flood plains; on the margins of a pond (its Zone 1 and Zone 2 under Chapter 7); on flood-plain silts and swamps; or wherever the seasonal high water table is less than 2.0 m below ground. The last condition alone may be set aside where a piezometer record of a full April–November season shows the water table at least 2.0 m below ground and at least 1.0 m below the base of the practice; the others may not. The CGWB gives 1 to 5 m below ground in the semi-consolidated formations of Papum Pare and 2 to 4 m before the monsoon and 2 to 5 m after it in the Dikrong valley, 1.50 to 11.13 m in East Siang, 3.58 m and 3.52 m in Lohit (2008) and 2.62 to 5.50 m in the dug wells of Bhalukpong in the lean period; and 15 of the 27 Arunachal Pradesh stations of its North Eastern Region bulletin stood at 0 to 2 m below ground in August 2025 (as summarised). On such land roof runoff goes to storage for use, the exception for roof water in Clause 8.11.3(c) does not apply, retention is met by storage for use and by surface measures that do not infiltrate below ground, and detention under Chapter 4 is lined and checked for flotation. **(iii) Recharge only on tested ground outside both rules (Clause 4.11, recharge rule).** Recharge is allowed, with pretreatment, the field test of Clause 8.8.3 and the separation of this Clause, with the seasonal high water table at least 2.0 m below ground, only on the sandy terrace and valley-fill soils of the Naharlagun–Nirjuli–Doimukh valley (NERIST's test at Doimukh found 95.19% sand and a double-ring infiltration rate falling from 12 cm/h to a basic rate of 1 cm/h after 250 to 300 minutes; Dabral et al., 2016) and on the coarse boulder fan heads of the foothills above the water table ("Siwalik group is the recharge zone" and the piedmont plain "is highly permeable", CGWB, East Siang; "The Bhabar is mostly composed of boulders", CGWB, Lohit), away from scarps and avulsion channels. Recharge is a choice, not a duty: the State's stage of groundwater extraction is 0.39% (CGWB, 2024, as summarised). **(iv) Springs and their recharge areas.** Arunachal Pradesh has no statute that keeps building or drains away from a spring; the Arunachal Pradesh Municipal Corporation Act, 2019 vests "all public streams, springs and works for the supply … of water" in the Corporation. The springs of Papum Pare discharge 0.43 to 2 L/s before the monsoon and 0.02 to 2.4 L/s after it, and "most of the springs become dry during dry season"; in the northern hills of East Siang springs are the only source (CGWB). Within the recharge area of a spring above a town's or village's drinking-water intake, as a hydrogeologist maps it, no paving is laid except for access, no road runoff is led into the ground, and no infiltration facility, soak pit or septic tank is placed; no drain, cut or fill intercepts the flow to a spring, crosses its outlet or buries it; and no infiltration facility, soak pit or septic tank lies

within Zone 1 of the spring (Clause 7.4). These rules are set by this Manual; springs were not researched for this Manual, and no spring inventory was found [TBC]. (v) Quality and wells. Iron is the main quality issue: the CGWB found 0.14 to 0.78 mg/L in the springs of Papum Pare and flags iron in East Siang and Changlang, and a shallow well or spring is the first water a recharge structure reaches. No recharge pit, trench, shaft or well shall be placed within 30 m of a dug well or spring used for drinking water; no runoff from roads with heavy traffic, fuel stations, workshops, industrial yards or solid-waste sites is led to any recharge structure; and a recharge structure on a valley floor or fan takes only roof water or runoff that has passed a filtering BMP. (vi) Septic dispersion. Clause 4.16.1 of the APBBL 2019 places a septic tank's dispersion system at least 18 m from any source of drinking water and at least 6 m from buildings; on a slope this puts water into the ground that the hill rule protects. This Manual does not override the bye-law: it recommends that a dispersion trench or soak pit on a slope steeper than 10° or on shale be sited by a geotechnical engineer, downslope of buildings and cuts, and outside the recharge area of any spring, and it refers sewage to Clause 8.9. The 10° trigger, the shale condition, the distance of twice the wall height, the 2.0 m limit, the 30 m distance and the conditions of items (iv) to (vi) are set by this Manual; no Arunachal Pradesh rule on infiltration, soak pits, springs or recharge near wells was found. The seasonal high groundwater table shall be determined under Clause 3.10.2.

8.8.2 Other separation. The base of an infiltration facility shall also be at least 1.0 m above bedrock or any impermeable layer, unless the facility is designed to recharge a fractured or weathered rock aquifer under Clause 8.8.10.

8.8.3 Infiltration tests. The infiltration rate shall be measured at the proposed base level of the facility:

- (a) by a double-ring infiltrometer test (ASTM D3385) for basins, bioretention and permeable pavement;
- (b) by a falling-head borehole or trial-pit soakage test (for example BRE Digest 365) for trenches, soakaways, recharge pits and recharge wells;
- (c) with at least **2 tests per facility**, and at least 1 test per 100 m² of infiltration base area or per 50 m of trench length; and
- (d) by a person competent in geotechnical testing, with the results reported on the Infiltration Test Record (Form 8-2).

Tests made in the dry season shall be reported with the groundwater level at the time of test and the seasonal high level of Clause 8.8.1.

8.8.4 Design infiltration rate. The design infiltration rate is the measured rate divided by a safety factor:

- (a) **2.0** where the tests meet Clause 8.8.3(c) and the results vary by no more than a factor of 2; and
- (b) **3.0** otherwise.

8.8.5 Minimum rates.

- (a) Full infiltration (no underdrain) only where the design rate is at least **13 mm/h**.
- (b) Partial infiltration, with an underdrain, where the design rate is 3 mm/h to 13 mm/h. Only the volume that infiltrates within 72 hours is credited as retention.
- (c) No infiltration credit where the design rate is below 3 mm/h.

8.8.6 Setbacks for infiltration facilities. Infiltration facilities receiving runoff from roads, parking or other paved surfaces shall be at least:

- (a) **3 m** from building foundations, and **5 m** from a basement;
- (b) **1.5 m** from a property boundary, unless the neighbour agrees in writing;
- (c) **30 m** from a drinking-water well or borewell;
- (d) **15 m** from a septic tank or soak pit; and
- (e) **6 m** from the crest of a slope steeper than 1V:3H, unless a geotechnical report shows the slope remains stable.

Roof-only runoff to recharge structures is subject to (a) and (b) only, and to Clause 8.11.3.

8.8.7 **Drawdown and verification.** Every infiltration facility shall empty within **72 hours** at the design rate (Chapter 4), and shall be tested after construction (Clause 10.9.3).

8.8.8 **Hotspots.** Runoff from the following shall not be infiltrated without treatment, and shall not be infiltrated at all where (d) or (e) applies:

- (a) fuel stations;
- (b) vehicle workshops, washing bays, and bus and truck depots;
- (c) industrial yards and loading areas where hazardous materials are handled or stored;
- (d) solid waste transfer stations and landfill areas; and
- (e) land known or suspected to be contaminated.

Treatment for (a) to (c) shall include an oil-grit separator and a lined filtering BMP before any infiltration.

8.8.9 **Sandy coastal aquifers.** This Clause applies only to coastal sand aquifers. Arunachal Pradesh has none, so the Clause has no effect in the State; it is kept only so that the clause numbers stay unchanged. The sandy terrace and valley-fill soils of the Naharlagun–Nirjuli–Doimukh valley, the boulder fans of the foothills and the alluvium along the Dikrong, the Siang, the Lohit and the Noa-Dihing are not coastal sand areas: Clause 8.8.1 applies there in full, with the floodplain rule and the recharge rule of Clause 4.11, and the reduced separation of item (d) does not. In coastal sand areas:

- (a) infiltration is the preferred means of meeting retention and the WQv wherever Clause 8.8.1 is met;
- (b) storm drains shall not be designed to lower the groundwater table: inverts below the seasonal high groundwater table shall be watertight, with no weep holes or subsoil drains that discharge groundwater to the outfall, unless a hydrogeological report shows no harm to the freshwater aquifer;
- (c) no long-term pumping of groundwater into storm drains shall be approved (for example basement dewatering); and
- (d) in notified coastal sand areas, **roof-only runoff** may be infiltrated with a separation of not less than **0.5 m** to the seasonal high groundwater table, provided a groundwater mounding check shows that the mound stays at least 0.3 m below the facility base and does not reach adjacent foundations or basements. No other runoff may use this reduced separation;
- (e) where neither the 1.0 m separation nor clause (d) can be met, the site shall use surface retention that does not infiltrate below ground (for example shallow vegetated depressions, disconnection of roofs onto lawns, and reuse), and detention under Chapter 4.

8.8.10 **Laterite and hard-rock areas.** In laterite and hard-rock terrain (for example the gneiss and schist of the Bomdila Group and the higher ranges round Bomdila, Dirang, Tawang and Anini, with thin soils over rock and snow in winter, and the Siwalik sandstones, shales and boulder beds of the foothills round Itanagar, which are not hard rock in the usual sense but whose hill slopes are "covered by residual soil or slope debris" (CGWB, Papum Pare), and the Gondwana group that "acts as a run off zone" (CGWB, East Siang); on any slope steeper than 10° and on Siwalik shale at any slope the hill rule of Clause 4.11 applies first under Clause 8.8.1, and no recharge into rock is credited (Clause 4.11, recharge rule)):

- (a) tests shall be made at the facility base, below any surface crust or hardpan;
- (b) recharge into weathered or fractured rock is permitted only for roof runoff, or for runoff that has passed through a filtering BMP, because fractures give little treatment; and
- (c) infiltration on or above slopes shall be checked for slope stability.

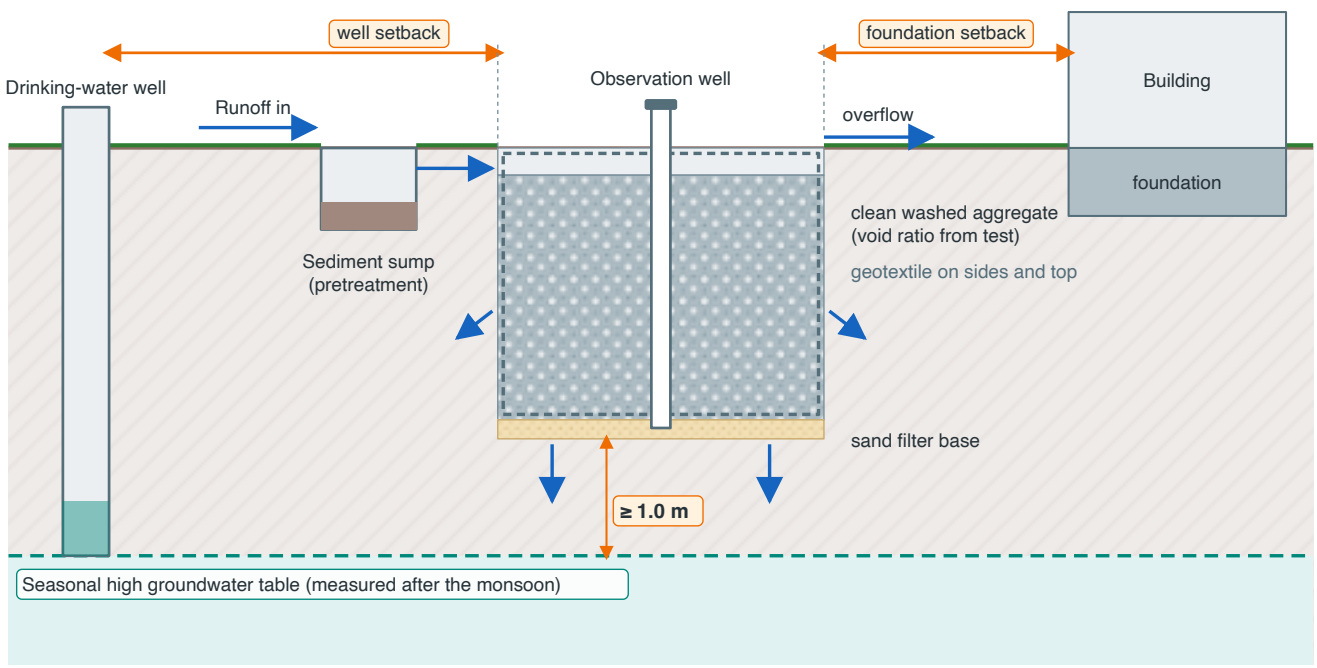
8.8.11 **Delta clays and black cotton soils.** In the flood-plain silts and swamps of the Dikrong, the Pachin, the Siang, the Lohit and the Noa-Dihing, the palaeochannels and swampy land of the Pachin and Dikrong flood plains (CGWB; the Master Plan of Itanagar Capital Region-2031), the silted beds of ponds and the margins of reservoirs, and the clayey residual soil, colluvium, fill and slide debris of the hills, and in expansive black cotton soils:

- (a) infiltration facilities will usually fail Clause 8.8.5 and need not be tested where the soil survey (Chapter 3) shows HSG D; and

- (b) where infiltration is used near buildings on expansive soils, the setback of Clause 8.8.6(a) shall be doubled.

Commentary. The 1.0 m groundwater separation is a core requirement of this Manual. The other values in this Clause (the 1.0 m bedrock separation, test numbers, safety factors, minimum rates and setbacks) are typical of US and UK practice and have no Arunachal Pradesh precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. Arunachal Pradesh RWH practice routes roof water into open wells and recharge wells, and Clause 8.11 keeps that practice.

No map of hydrologic soil groups for Arunachal Pradesh and no soil series of the National Bureau of Soil Survey and Land Use Planning were found [TBC], and the only measured infiltration rate in the State found for this Manual is NERIST's double-ring test at Doimukh: a soil of 95.19% sand, whose rate fell from 12 cm/h to a basic rate of 1 cm/h after 250 to 300 minutes (Dabral et al., 2016). Every other infiltration design needs the tests of Clause 8.8.3. The ground is of four kinds. In the foothills round Itanagar, Papum Pare is "underlain mostly by Siwalik group of rocks", "the Siwalik Hills form hogback topography", hill slopes are covered by residual soil or slope debris, and the older metamorphic formations are "overthrusted over the Younger Tertiary Siwaliks" (CGWB, Papum Pare). In the valleys there are "Quaternary alluvium and terrace deposits", an intermontane valley between Naharlagun and Nirjuli, and an alluvial plain "along the wide flood plain areas of Pachin and Dikrong rivers" with palaeochannels, swampy land, terraces and bars; "The soils in the valley areas are sandy loamy in texture with high acidic content" (CGWB). On the eastern fans "Siwalik group is the recharge zone" and the piedmont plain "is highly permeable" (CGWB, East Siang), and "The Bhabar is mostly composed of boulders while flood plain is composed of fine sand and silt" (CGWB, Lohit). In the high ranges the gneiss and schist of the Bomdila Group carry thin soils, and the upper reaches of Tawang are "mostly devoid of vegetation, due to heavy snowfall" (CGWB). The water is shallow on the valley floors: 1 to 5 m below ground in the semi-consolidated formations of Papum Pare and 2 to 4 m before the monsoon and 2 to 5 m after it in the Dikrong valley; 1.50 to 11.13 m in East Siang; 3.58 m and 3.52 m in Lohit (2008); 2.62 to 5.50 m in the dug wells of Bhalukpong (CGWB); and 15 of the 27 Arunachal Pradesh stations of the CGWB's North Eastern Region bulletin at 0 to 2 m below ground in August 2025 (as summarised). Iron is the main quality issue (0.14 to 0.78 mg/L in the springs of Papum Pare; flagged in East Siang and Changlang, CGWB). Groundwater is not short: the State's stage of extraction is 0.39% (CGWB, 2024, as summarised). Water put into the ground is a hazard as well as a resource: on the Siwalik slopes it raises the pore pressure in slopes that slide (NEER reading), and the landslide at Laptap on 11 July 2017, after three days of rain, killed 14 people (some reports give up to 16; as reported); on the valley floors it reaches the shallow wells and springs first. The CWC report for subzone 2(a) uses a loss rate of 0.24 cm/h, about a quarter of the basic rate at Doimukh, which is consistent with catchment-scale saturation in the monsoon (NEER reading; Chapter 3). This Manual's interim soil groups follow from these: Siwalik slopes with residual soil and slope debris C (D on cut slopes, fills and shale); the terrace and valley sands of the Naharlagun–Nirjuli–Doimukh valley A to B by texture, with the water-table limit; the boulder fans A; flood-plain silts and swamps C to D (D where waterlogged); the gneiss and schist of the high ranges C to D; and urban fill C (D if clayey or compacted) (Chapter 3). **The State therefore needs three rules, not one** (Clause 4.11). On the tested terrace sands of the capital's valley and the coarse fan heads above the water table, recharge is allowed, with pretreatment, as a choice rather than a duty. On hill slopes, on shale, on colluvium, slope debris and fill and in landslide zones, no water is put into the ground on purpose, under the hill rule. On the floodplain, round ponds and wherever the water table is within 2.0 m, no infiltration is built or credited, under the floodplain rule. Everywhere, runoff from roads and open land goes to surface systems and never directly to a recharge well, borewell or shaft (Clause 8.11.3(b)). Clause 8.8.9 has no effect in Arunachal Pradesh, which has no coast.



Test infiltration at the proposed base level. Design rate = measured rate ÷ safety factor. Empty within 72 h.
Setback distances and test methods: Clauses 8.8.3 to 8.8.6. Road and parking runoff is never piped into a well.
Sandy coastal soils: high rates, shallow groundwater. Laterite, hard rock: low rates. Delta clay: usually unsuitable.

Figure 8.3 — Infiltration trench in section: pretreatment sump, aggregate-filled trench in geotextile, observation well, overflow, the 1.0 m minimum separation to the seasonal high groundwater table, and setbacks to wells and foundations. Original drawing for this Manual, adapted from the Georgia Stormwater Management Manual, 2016 (Vol 2), and CIRIA, The SuDS Manual (C753), 2015.

8.9 Sewage cross-connections and dry-weather flow

8.9.1 **No sewage in storm drains.** No sewage or sullage (grey water from kitchens, bathrooms and laundries), septic tank effluent, or trade effluent shall be connected to, or discharged into, any storm drain, by any pipe, channel or opening.

8.9.2 **Condition of approval.** Before the completion certificate, the Applicant shall show, by a dye or smoke test witnessed by the Authority or the sewerage agency, that every sewage and sullage outlet on the site discharges to a sewer or to an approved on-site system, and that none discharges to a storm drain. Any existing cross-connection on the site shall be removed as a condition of approval, including on redevelopment and on additions to existing buildings.

8.9.3 **Where no sewer exists.** Where no sewer is available, sewage and sullage shall go to an approved on-site or decentralised treatment system. The treated effluent of such a system may be discharged to a storm drain only with the written consent of the Arunachal Pradesh State Pollution Control Board (APSPCB) and the drain owner.

8.9.4 **Public drains: DWF survey.** Every ULB in a Tier A area shall survey its storm drain outfalls to waterbodies for dry-weather flow at least once a year, before the monsoon, and record:

- (a) the outfalls with DWF;
- (b) the estimated DWF rate; and
- (c) the upstream sources found by tracing, CCTV, dye or smoke testing.

The results shall be published in the register of Clause 10.17.

8.9.5 **DWF interception.** Until the sources are removed, every outfall to a waterbody that carries DWF shall have a DWF interceptor that:

- (a) diverts the DWF to a sewer or a treatment plant;
- (b) does not reduce the capacity of the storm drain for the minor or major event (Chapter 6), with its weir or diversion head losses included in the hydraulic design (Chapter 9);
- (c) has a screen ahead of the diversion; and
- (d) is not a substitute for removing the source connections.

8.9.6 **Sewage overflows.** No new sewage overflow, emergency bypass or pumping station overflow shall be designed to discharge into a storm drain or waterbody, except where the sewerage agency shows that no alternative exists, and then only with screening and with the overflow frequency stated.

> **Commentary.** The prohibition of sewage connections and the removal of existing cross-connections as a condition of approval are core requirements of this Manual, and Clause 1.10.3 allows no variance from them. Sewage in storm drains is the single largest water quality problem of urban drainage in Arunachal Pradesh. It defeats every other measure in this chapter: BMPs designed for stormwater are overloaded, GPTs fill with sludge, and the receiving tanks and channels become sewage lagoons. CPHEEO (2019) notes that Indian drains carry night soil and urine (Part A §9.5). DWF interception (Clause 8.9.5) is an interim measure. It protects the waterbody while the sources are traced and removed, but it can become permanent if the source work is not done, which is why the annual survey and publication of Clause 8.9.4 are required. The annual survey frequency is set by this Manual.
>
> In Arunachal Pradesh no town treats its sewage, and this Clause is the normal case everywhere. "No ULB is treating sewage. Even the state capital, Itanagar-Naharlagun, lacks a sewage treatment facility" (observations on the State's report of 10 February 2025, quoted in its affidavit-cum-six-monthly report to the National Green Tribunal in O.A. 606/2018). The Master Plan of Itanagar Capital Region-2031 records the "Absence of a sewerage network, resulting in the sewerage being drained to open or vacant land as well as into ponds"; that "Most of the surface water and sewerage gets mixed up resulting in storm water drains being used as sewers"; that "There is no sewage treatment plant present in the city"; and that "City sewerage is discharged into open drains. The hilly terrain means limited scope for u/g sewer network"; industrial effluents are discharged untreated "into artificial ponds". The State's affidavit reports detailed project reports for "all 27 ULBs", sewage treatment plants for 15 census towns and faecal sludge treatment plants for 12, and 19.89 MLD of sewage in 15 towns against 4.20 MLD of existing treatment capacity (17.30 MLD proposed) and 0.19 MLD of septage against 0.14 MLD; the minutes of 11 April 2025 record that the Naharlagun plant "may be converted into a Septage Plant, and liquid waste may be collected using trucks and tankers"; the observations call it a "skewed strategy", with "3 MLD STP at Itanagar-Naharlagun against an estimated sewage generation of 14.4 MLD and having 4 MLD STP against sewage generation of only 1.2 MLD at Pasighat"; and the amicus curiae found on 20 March 2026 a "complete absence of functional sewage treatment systems" in Itanagar–Naharlagun, with a shortfall of about 16 MLD. The Naharlagun plant, under AMRUT and due in 2020, was still under construction in 2025 (as reported). Three rules already bar what this Clause bars. Clause 4.16.2(c) of the APBBL 2019 says: "Under no circumstances shall effluent from a septic tank be allowed into an open channel drain or body of water without adequate treatment." Section 203 of the Arunachal Pradesh Municipal Corporation Act, 2019 forbids discharging "foul water into a drain provided for surface water" where separate drains exist, and surface water into a foul drain without the Commissioner's permission, and any connection "directly with a storm water overflow drain". Section 194 of the Arunachal Pradesh Municipal Act, 2007 makes a municipality construct drains and sewers and "provide a safe and sufficient outfall" for storm water and sewage "in such manner as may not cause any nuisance, whether by flooding", with a proviso that "no sewage shall be discharged into any watercourse until it has been so treated" from a date the State appoints. And in O.A. 94/2020/EZ, S. D. Loda v. Union of India & Ors., on the Senki, the Pachin and the Dikrong, the National Green Tribunal directed on 5 January 2023 that "no untreated sewage or treated sewage be allowed to enter into the waterbody", with quarterly monitoring by the APSPCB, and on 8 April 2025 asked the

State and IMC to file counter-affidavits on the adequacy of the faecal sludge plants (as summarised by the India Environment Portal). The gap is therefore enforcement and the absence of a sewer or septage service, not the rule. The CPCB's list of 2025 places four Arunachal Pradesh stretches in Priority V, all first listed in 2025 "as previously these sanctioned locations were not monitored by the State": the Namchik at Kharsang (BOD 3.2 mg/L), the Senki at Chandranagar, Itanagar, upstream of the Pachin (3.2 mg/L), the Dibang at Roing, upstream (3.6 mg/L) and the Subansiri at Gerukamukh (3.1 mg/L); the Pachin itself is not listed, although the master plan says that rivers "like Pachin flowing through densely populated areas had become a waste disposal site". In Arunachal Pradesh, therefore: **(i)** every storm-drain and nallah outfall to the Senki, the Pachin or the Dikrong, every outfall to the Siang at Pasighat, the Lohit at Tezu, the Noa-Dihing at Namsai and the Dibang at Roing, and every inflow to a pond used as storage is taken to carry dry-weather flow until the survey of Clause 8.9.4 shows that it does not, and has a DWF interceptor and a screen under Clause 8.9.5 before it reaches the river or pond; **(ii)** no septic tank or soak-pit overflow is connected to a storm drain or nallah on any site approved under this Manual, with clause 4.16.2(c) of the APBBL 2019 as the local hook; **(iii)** in the IMC area, every connection approved under section 203 keeps foul water and surface water apart, and where no foul drain exists the Applicant shows on the drawings which route the sullage takes, to a septic tank and dispersion system under clause 4.16, a sewer or a decentralised treatment unit, never to the storm drain; **(iv)** until sewers exist, a nallah, and a hill-town drain that receives sullage, is designed as a combined channel under Clause 6.3.6(d): for velocities that keep sludge moving in dry weather as well as for the storm flow, with access for cleaning along it, and with covers or screens where it passes homes, because of the smell and the risk to health; and **(v)** where no sewer or treatment plant exists to receive the intercepted flow, the interceptor delivers it to an interim treatment unit that the APSPCB approves, never to a pond, a spring or a stream. Every interceptor is sized from the measured dry-weather flow of its drain, does not reduce the drain's capacity for the minor and major events (Clause 8.9.5(b)), and passes the storm flow above its capacity on down the drain; at an outfall that the Dikrong or a main stem backs up, it and its chamber are placed above the 1% AEP level or made watertight and work with any gate shut (Clause 5.8.5(a) and (c)); and on a hill stream or nallah that carries boulders, slide debris and garbage in flood, they are placed above its 1% AEP level or protected against its scour and debris (Clause 5.8.5(b); Chapter 9). These conditions are set by this Manual.

8.10 Outfalls to waterbodies: first flush, gross pollutant traps and screens

8.10.1 **Requirement.** Every new storm drain outfall to a waterbody, and every existing outfall on a drain that is rebuilt, widened or extended, shall have:

- (a) a GPT designed under Clause 8.7.10; and
- (b) first-flush treatment: treatment of the WQv (or Q_wq) of the contributing catchment by the BMPs of Clause 8.7, either on the contributing sites or at the outfall.

8.10.2 **Where treatment at the outfall is impracticable.** Where land is not available at a public outfall, first-flush treatment may be provided by:

- (a) a proprietary first-flush or hydrodynamic device sized for Q_wq; or
- (b) a treatment wetland or forebay within the waterbody setback (Clause 7.5.1(b)), outside the waterspread.

8.10.3 **Screens and trash racks.** Screens at outfalls, culvert inlets and pump sumps shall:

- (a) be designed with **50% blockage** for hydraulic capacity;
- (b) have an overflow or bypass path so that a fully blocked screen does not flood property;
- (c) have bar spacing chosen for the hazard: closer spacing for litter capture, wider spacing where blockage would cause flooding; and
- (d) be cleanable from a safe platform, with vehicle access.

8.10.4 **Existing outfalls.** Each ULB shall prepare a programme to fit GPTs and DWF interceptors to its existing outfalls to waterbodies, starting with outfalls to tanks used for drinking water supply and to notified wetlands (Clause 7.12), and shall report progress in the register of Clause 10.17.

> Commentary. This Manual requires first-flush treatment and gross pollutant traps at outfalls to waterbodies. Gross pollutants are the most visible form of pollution in Arunachal Pradesh waterbodies, and plastics also block drains and culverts, which links water quality to flooding. The 50% screen blockage matches the grate clogging factor of Chapter 6. Clause 8.10.3(c) warns against fine screens on large drains, which block in the first hour of a storm and cause the flooding they were meant to prevent.

8.11 Rainwater harvesting integration

8.11.1 **RWH mandate continues.** The rainwater harvesting required by the Arunachal Pradesh Building Bye-Laws, 2019 (clause 9.1: "All buildings having a plot size of 100 sqm while submitting the building plans for sanction shall mandatorily include the complete proposal of rainwater harvesting"; Table 9.1 by building type; clause 9.6, under which public open spaces of more than 500 m² "shall have arrangements for complete utilization and capture of storm water"; clause 9.7, which makes recharge mandatory for all buildings of 500 m² or more and for parks, parking and plazas; clause 9.8's Rainwater Harvesting Cell and inspection before the completion certificate; and Annexure E, whose item 1.7 lets the Authority impose a levy for a failure to provide or maintain it; none sets a storage volume, a release rate or a design storm) continues to apply, subject to the limits of Clause 8.8.1: where clause 9.7's mandatory recharge falls on a site where Clause 4.11 bars infiltration, this Manual states the conflict, requires storage for use in its place, and leaves the Applicant to seek the Authority's relaxation of the bye-law, which this Manual does not override (Chapter 1). This Clause sets how RWH structures are counted under this Manual.

8.11.2 **Three different functions.** The designer shall keep apart, on the drawings and in the calculations:

- (a) **harvesting**: storage for use (sumps and tanks);
- (b) **recharge**: recharge pits, trenches, shafts and wells that put water into the ground; and
- (c) **detention**: storage with an orifice outlet that is empty at the start of a storm (Chapter 4).

8.11.3 **Recharge structures.**

- (a) Roof runoff may be led to recharge wells, open wells, recharge pits and shafts after a filter or settling chamber.
- (b) Runoff from roads, parking and other paved areas shall not be led directly into any well, borewell or recharge shaft. It may be recharged only through an infiltration facility that meets Clause 8.8, with pretreatment.
- (c) Recharge structures shall meet the groundwater separation of Clause 8.8.1, measured from the base of the pit or the bottom of the filter media, except recharge wells that receive filtered roof water only.

8.11.4 **Credit toward retention and WQv.** A recharge structure counts toward the retention volume of Chapter 4 and the WQv only where:

- (a) its infiltration rate has been tested under Clause 8.8.3;
- (b) it empties within 72 hours at the design rate; and
- (c) it has pretreatment.

A harvesting sump counts toward retention only where its contents are used, by a demand stated in the drainage report, within 72 hours (Chapter 4).

8.11.5 **No credit as detention.** RWH storage does not count as detention unless it is a dedicated volume that is empty when a storm arrives, with an outlet. RWH sumps are assumed **full** at the start of every monsoon (April–October) design storm (Chapter 4).

8.11.6 **Overflow.** Every RWH structure shall have an overflow that discharges at grade to the site drainage, never onto a neighbouring plot or into a sewer.

8.11.7 **Surface-runoff recharge in public spaces.** Recharge trenches, shafts and percolation pits in roads, medians, parks and other public spaces shall meet Clause 8.8 in full, including the hotspot rules for roads with heavy traffic, and shall have a GPT or silt trap at each inlet.

> **Commentary.** The rule that RWH storage does not count as detention is set in Chapter 4. Arunachal Pradesh's building rules make rainwater harvesting compulsory, but they set no storage volume and no detention rule. Clause 9.1 of the APBBL 2019 says: "All buildings having a plot size of 100 sqm while submitting the building plans for sanction shall mandatorily include the complete proposal of rainwater harvesting"; Table 9.1 sets the requirement by building type, and for group housing "Concrete paving to be avoided and permeable materials are to be used for all open parking spaces"; clause 9.6 asks public open spaces of more than 500 m² for "complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites"; clause 9.7 makes recharge mandatory for all buildings of 500 m² or more and for parks, parking and plazas; and clause 9.8 sets up a "Rainwater Harvesting Cell", with inspection before the completion certificate, 100% monitoring above 1,000 m² with annual verification and a 10% random survey below it. Annexure E makes harvesting mandatory from 100 m² (item 1.1) and not below it (item 1.4) and lets the Authority impose a levy for a failure to provide or maintain it (item 1.7). The bye-laws state that "Rainwater can be harvested to the extent of 55,000 liters per 100sq. meters area per year from rooftops", and the Master Plan of Itanagar Capital Region-2031 says that harvesting "should be mandatory for all new buildings". None of these gives litres of storage per m² of roof, a release rate, a design storm, a test of a recharge pit or a limit on recharge on slopes, and no audit of what has been built was found. In Arunachal Pradesh harvesting is **storage and reuse**: springs fail in the dry season in Papum Pare (CGWB), and groundwater is not short (stage of extraction 0.39%, CGWB, 2024, as summarised), so recharge is not a design objective. This Manual credits storage of at least 25 L per m² of roof (Clause 4.11), the value of the North-East editions of this series, as retention only through its reuse, and assumes it full at the start of every monsoon design storm; it is never counted as detention. On the tested terrace sands of the Naharlagun–Nirjuli–Doimukh valley and the coarse fan heads above the water table, recharge may be one function of harvesting where Clause 8.8.1 allows it (Clause 8.11.2(b)); on hill slopes, on shale, on colluvium, slope debris and fill, in landslide zones and on land under the floodplain rule, harvesting is for storage and use only, and its overflow goes to a lined drain; where clause 9.7's mandatory recharge falls on such a site, this Manual states the conflict and requires storage in its place, and the Applicant seeks the Authority's relaxation of the bye-law (Clause 8.11.1). RWH serves water supply and recharge. It is usually full, or its soil saturated, by the time a July to September monsoon storm in the foothills, such as those of 11 July 2017 at Laptap and September 2018 at Itanagar, arrives after weeks of rain, which is why it cannot be counted as detention.
>
> Clause 8.11.3(b) has no direct precedent; this Manual sets it because road runoff carries oil, metals and pathogens. A recharge shaft or borewell bypasses the soil that would otherwise filter it and delivers it straight to the aquifer that supplies wells nearby. The CGWB *Manual on Artificial Recharge of Ground Water* (2007) gives recharge structure types and filter designs; this Manual adds the source-water restrictions.

8.12 Construction-stage erosion and sediment control

8.12.1 **ESC plan.** Every development with land disturbance of **0.1 ha** or more, and every public drainage or road work, shall have an Erosion and Sediment Control (ESC) plan, approved with the drainage report. It shall show:

- (a) the sequence of clearing, earthworks and stabilisation;
- (b) the area exposed at each stage;
- (c) the measures of Clause 8.12.3, with their locations and sizes;
- (d) the protection of infiltration and retention areas (Chapter 10);

- (e) stockpile, concrete washout and fuel storage locations; and
- (f) the inspection and maintenance schedule.

8.12.2 **Monsoon timing.** Earthworks shall be planned so that:

- (a) the area exposed during the monsoon (April to October) is as small as practicable;
- (b) all completed earthworks are stabilised by vegetation, mulch, matting or paving by **31 March**; and
- (c) any area exposed between 1 April and 31 October has sediment controls in place before it is cleared.

8.12.3 **Measures.**

- (a) **Silt fences** along the downslope edge of disturbed areas receiving sheet flow, with the area draining to each fence limited as set in Annex 8E.
- (b) **Sediment traps** for concentrated flow from disturbed areas of up to 2 ha.
- (c) **Sediment basins** for disturbed areas of more than 2 ha. The storage volume below the outlet shall be at least the greater of the runoff from the 50% AEP (2-yr) 24-hour storm and **250 m³ per hectare** of drainage area, with a dewatering outlet that draws water from the surface.
- (d) **Inlet protection** at every existing drain inlet that receives runoff from the site.
- (e) **Stabilised construction exits**, with wheel washing where vehicles enter public roads.
- (f) **Stockpiles** outside Zone 1 of any waterbody setback (Chapter 7), at least 10 m from any drain, and covered during the monsoon.
- (g) **Dewatering** discharges passed through a sediment basin, settling tank or filter bag, never pumped directly into a drain or waterbody.
- (h) **Concrete washout** in a lined pit, never into a drain.

8.12.4 **Design storm for temporary works.** Temporary ESC measures use the rainfall of Chapter 2 with a climate factor of 1.0 (Clause 2.8.2).

8.12.5 **Inspection.** ESC measures shall be inspected weekly and within 24 hours after every heavy-rainfall event (as defined in Chapter 10), repaired within 48 hours, and cleaned when half full of sediment.

8.12.6 **Removal.** Temporary measures shall be removed only after the area draining to them is stabilised. Sediment shall be removed from any permanent facility used for sediment control before its as-built survey (Chapter 10).

> Commentary. The 0.1 ha threshold is the applicability threshold of Chapter 1. The sediment basin volume of 250 m³/ha is the US EPA Construction General Permit minimum of 3,600 ft³ per acre drained, converted to SI (US EPA, 2022 CGP); the CGP allows the alternative of the 2-year, 24-hour runoff. This Manual requires the greater of the two, because Arunachal Pradesh's 2-year 24-hour depths are high and construction sites are commonly left exposed through the monsoon. The 2 ha division between traps and basins, the 31 March stabilisation date, the 10 m stockpile distance and the inspection frequency have no direct precedent and are set by this Manual. The 31 March date matches the pre-monsoon deadline of Chapter 10. Construction sediment is a direct flood hazard as well as a pollutant: it fills drains, culverts and tanks, and in Arunachal Pradesh cutting debris, slide material and garbage travel with the sediment: the drains along the Bage Tinali–Naharlagun road are reported to be clogged by debris from earth cutting, with an inspection recommending de-silting "upto the Dikrong river" (as reported); the Master Plan of Itanagar Capital Region-2031 finds the drains "chocked with the solid wastes" and records "heavy silting"; in September 2018 a landslide was reported from "the dumping area of NH 415" during the Modirijo and Donyi Polo floods (as reported); and illegal earth cutting along NH-415 was blamed for a mudslide near the Donyi Polo airport (as reported). The APBBL 2019 already give the hooks for sediment control on cut sites, though they set no basin size or inspection, which Clause 8.12 supplies: earth-cutting permission is refused where the average slope exceeds 30% (clause 4.39(14)); a cut is not higher than 3 m (4.39(4)); "It is duty of plot owner to clear/dispose-of soil/debris from site or drain to suitable/safer place" (4.39(8)); and a retaining or breast wall is built "immediately" on completion of the cut (4.39(11)). The stabilisation date of 31 March is set by this Manual, before its season begins on 1 April, because the pre-monsoon months are wet (May at Doimukh brings 505.9 mm, NERIST series) and cut slopes must be stable and walled before the April storms; it is the same date as the

desilting and the declaration of Chapter 10, and clause 4.39(11)'s "immediately" applies to every cut whatever its date. The reason given above for the larger basin volume, that the 2-year 24-hour depths are high, holds across Arunachal Pradesh: the capital-region table of Clause 2.3.6(c)(ii) gives 135 mm at 50% AEP (NERIST's Doimukh fit, 115.9 mm in one day, multiplied by 1.13); the interim 50% AEP depths of Clause 2.3.6(d), at 0.42 of the 2% AEP depth, are about 101 mm where that depth is 240 mm (AR-E and the floor of AR-C1) and about 118 mm in AR-D, and more on the wetter foothill plates; and the fifteen NIH-DHAARA cells give 52.5 to 288.6 mm (comparison values only, not design values; Chapter 2), with AMC III through most of the season (Chapter 3); the rule of Clause 8.12.3(c) is kept unchanged everywhere. In Arunachal Pradesh the outlet of a sediment basin or trap under Clause 8.12 discharges to a lined drain or a stable channel and never onto an unprotected slope; no sediment basin or trap is designed to infiltrate where Clause 4.11 bars infiltration, which includes every slope steeper than 10°, all shale and slope debris and all land under the floodplain rule; no spoil, debris or garbage from a site is placed in a stream, hill stream, nallah or pond, within its Zone 1, or on the recharge area of a spring; and a construction site above a spring or in the catchment of a pond or lake keeps its sediment out of every drain that reaches the water.

8.13 Monitoring

8.13.1 **Outfall monitoring.** Each Tier A authority shall monitor water quality at a representative set of its outfalls to waterbodies, including every outfall to a drinking-water tank or notified wetland. Monitoring shall include:

- (a) dry-weather sampling (Clause 8.9.4), at least once a year before the monsoon; and
- (b) wet-weather sampling of at least three events each monsoon at a set of index outfalls.

8.13.2 **Parameters.** At minimum: TSS, BOD, COD, faecal coliform, total nitrogen, total phosphorus, oil and grease, and, for industrial catchments, heavy metals. Results shall be compared with the CPCB water quality criteria for the designated best use of the receiving waterbody.

8.13.3 **Gross pollutant records.** The mass or volume of material removed from each GPT and screen at each cleaning shall be recorded in the O&M records (Chapter 10).

8.13.4 **BMP performance monitoring.** The State Stormwater Technical Committee shall run a BMP performance calibration programme and shall revise Table 8.3 and Annex 8C from its results.

8.13.5 **Publication.** Monitoring results shall be published in the register of Clause 10.17.

> Commentary. No Arunachal Pradesh programme of stormwater quality monitoring was found during research for this Manual, and CPHEEO (2019) sets no Indian targets. The monitoring in Clause 8.13 is the minimum needed to calibrate Table 8.3 and to show whether DWF interception and source removal are working. The parameter list follows the key pollutants named in CPHEEO's WSUD procedure (TSS, nitrogen, phosphorus and gross pollutants), with BOD and faecal coliform added because of sewage contamination. The monitoring frequencies are set by this Manual.

8.14 Submittal requirements

Every drainage report under this chapter shall include:

1. the **Water Quality Sheet (Form 8-1)**: P_ret, P_3m and P_wq; the WQv and Q_wq for each drainage area; the volume retained under Chapter 4; and the BMP serving each area;
2. for Tier A: the LoS calculation (ΔCN, required LoS) and the composite VR (Clause 8.6);

3. the design of each BMP to Clause 8.7 and Annex 8D, with pretreatment;
4. for infiltration and recharge: the **Infiltration Test Record (Form 8-2)**, the seasonal high groundwater level and its source, the design rate, the drawdown time, and the setbacks of Clause 8.8.6;
5. the sewage and sullage connection plan and the dye or smoke test record of Clause 8.9.2;
6. the GPT and first-flush design for any outfall to a waterbody (Clause 8.10);
7. the RWH layout, separating harvesting, recharge and detention (Clause 8.11); and
8. the ESC plan (Clause 8.12).

8.15 Review and update

8.15.1 This chapter shall be reviewed with the rest of the Manual (Chapter 1). Table 8.3 shall also be reviewed when the calibration programme of Clause 8.13.4 reports, and in any case within 5 years of notification.

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- Central Ground Water Board, North Eastern Region. Ground Water Information Booklets, Papum Pare, East Siang, Lohit, West Kameng, Tawang and Changlang districts (Wayback Machine captures of cgwb.gov.in); the North Eastern Region water-level bulletin of August 2025 and the dynamic groundwater resources of 2024 (as summarised).
- Dabral, P. P., Kumar, A. and Tana, G. (2016). Determination of surface drainage coefficient – a case study of Doimukh (Arunachal Pradesh), India. *Agricultural Engineering International: CIGR Journal* 18(4): 1–10 (Chapter 2 references).
- Government of Arunachal Pradesh. *Arunachal Pradesh State Action Plan on Climate Change* (draft, 2011) (Chapter 2 references); NIH-DHAARA (Chapter 2 references).
- Central Water Commission (1991). *Flood Estimation Report for North Brahmaputra Subzone 2(a)*, Report No. NB/18/1991 (Chapter 2 references).
- Reports of the Naharlagun sewage treatment plant and the Chimpu septage plant (secondary).

- Parliament reply AU1419 on AMRUT 2.0 admissible components. https://eparlib.sansad.in/bitstream/123456789/2988692/1/AU1419_tzClvw.pdf

Annexes and forms

Annex / Form	Content
8A	3-month ARI 24-hour depth and IDF by zone
8B	Redevelopment LoS table and treatment-train composite VR
8C	Arunachal Pradesh BMP performance calibration
8D	BMP design sheets, media specification, plant lists
8E	Erosion and sediment control standard details
Form 8-1	Water Quality Sheet
Form 8-2	Infiltration Test Record

CHAPTER 9

Hydraulic Design of Structures

9.1 Purpose and scope

9.1.1 This chapter sets the hydraulic design methods for the structures used in the minor and major systems (Chapter 6), in retention and detention facilities (Chapter 4), at outfalls (Chapter 5) and at waterbodies (Chapter 7). It covers:

- (a) pipes and box drains (Clause 9.3);
- (b) culverts (Clause 9.4);
- (c) open channels (Clause 9.5);
- (d) energy dissipators, outlet protection and drop structures (Clause 9.6);
- (e) detention outlet structures (Clause 9.7);
- (f) trash racks and screens (Clause 9.8);
- (g) pumps and sumps (Clause 9.9);
- (h) tide gates, flap gates and non-return valves (Clause 9.10);
- (i) inlets and gratings (Clause 9.11);
- (j) manholes, junction chambers and access (Clause 9.12); and
- (k) materials and durability, including coastal and saline exposure (Clause 9.13).

9.1.2 **Structural design is outside the scope of this Manual.** Structures shall be designed structurally to the applicable Indian Standards and IRC codes, for example IS 456 (plain and reinforced concrete), IS 458 (concrete pipes), IRC:SP:13 (small bridges and culverts) and the IRC bridge codes. Where this chapter refers to a structural standard, it does so only for durability (Clause 9.13) or hydraulic performance.

9.1.3 Design flows, design AEPs and level-of-service limits come from Chapters 2 to 7. This chapter does not change them.

> **Commentary.** APWA Section 5600 places most structure hydraulics in its sections on inlets and manholes (5604), enclosed pipe systems (5606), engineered channels (5607) and detention (5608). CPHEEO (2019) spreads them across Chapters 5, 6, 8 and 11. This chapter gathers them in one place and points to the US Federal Highway Administration (FHWA) hydraulic circulars for methods that Indian codes do not cover in enough detail: HDS-5 for culverts, HEC-14 for energy dissipators, HEC-22 for inlets and access holes, and HEC-24 for pump stations. The FHWA editions cited are those listed in the FHWA hydraulics library as of October 2026.

9.2 General requirements

9.2.1 **Tailwater.** Every structure that discharges to a river, stream, nallah, pond or reservoir whose level can rise above the outfall invert shall be analysed with the tailwater conditions of Chapter 5: the non-tidal tailwater of Clause 5.6 for minor- and major-system design; the riverine backwater of Clause 5.8, including the releases of the Pare dam of NEEPCO and the tailrace of its Ranganadi project in the Dikrong below Doimukh, and the releases of the Ranganadi, Kameng and Lower Subansiri projects on the reaches below them; the outfall-closed check of Clause 5.10 wherever the

receiving water can rise above the outfall invert, which is the case for the nallahs and drains of Naharlagun, Nirjuli and Doimukh that outfall to the Dikrong and for the lower Pachin and Senki where the Dikrong backs up into them (Clause 5.8.5(a)), for the town drains of Pasighat, Tezu, Namsai and Roing that outfall to the Siang, the Lohit, the Noa-Dihing and the Dibang (Clause 5.8.5(c)), for outfalls on a reservoir release reach (Clause 5.8.5(d)) and for drains that end in a pond kept as storage (Clause 5.8.5(g)); for an outfall to the Dikrong, until a gauge with a named datum exists, the interim design tailwater of Clause 5.8.5(a), the higher of the 1% AEP level at the outfall from a hydraulic model run with the largest recorded release of the Pare dam and the Ranganadi tailrace, and the Dikrong at its surveyed flood mark of that release (31 May 2025), with the check case at the surveyed mark of the 1999 flood, the local benchmark (as reported), or the highest later mark, if higher, on a datum still to be fixed [TBC], because no CWC site on the Senki, the Pachin or the Dikrong in the capital was found; for an outfall to a main stem, the interim design tailwater of Clause 5.8.5(c), the CWC danger level at the nearest site as the design case and the CWC highest flood level (HFL) as the check case, transferred to the outfall by survey: on the Siang at Pasighat 153.96 m and 157.54 m, an HFL set on 11 June 2000 by the outburst of the Yigong landslide dam in Tibet, 3.58 m above the danger level; on the Noa-Dihing at Namsai 145.8 m and 146.6 m; and on the Lohit at Tezu the HFL of 192.14 m as both the design and the check level, since no danger level was transcribed [TBC] (all CWC levels as transcribed by SANDRP, as reported, on a datum not stated [TBC]); at Roing, on the Dibang, which has no CWC site, the 1% AEP level from a hydraulic model and the surveyed flood marks, as for the Dikrong; and wherever a model gives a higher level, the model; for an outfall on a release reach, the level of the largest recorded release or, until the operator gives one, of the spillway capacity, which was not found for any project [TBC] (Clause 5.8.5(d)); for an outfall to a stream that has no gauge, which is nearly every stream of the hill towns and of the hill rim of the capital, the level of the 1% AEP flood in the reach, computed with the sediment, debris, bulking and blockage allowances of Chapter 6 (Clause 6.3.6(f)–(h) and (m)) and checked against surveyed flood marks, with the outfall invert at least 0.5 m above the highest surveyed bed (Clause 5.8.5(b)); on the main stems of the Siang, Dibang, Lohit, Subansiri, Kameng and Tawang Chu, the outburst screening of Clause 2.3.6(i), whose stages govern siting and floor levels rather than the size of a drain (Clause 5.8.5(e)); for an outfall to a pond, its surveyed spill level; the level held in a drain by any gate, weir or pumping station downstream of the outfall, taken as a fixed control at its gate-closed level, its weir crest or the start level of its pumps; and the joint case of Clause 2.12. The CWC levels on the reaches downstream across the State border, on the Lohit, the Subansiri, the Ranganadi and the Jia Bharali, are tens of kilometres away, where the Assam edition governs those reaches, and are not tailwater for any Arunachal Pradesh town; readings of a gauge published in the press are never mixed with CWC levels. No document found sets a design river, reservoir, pond or stream level at any outfall in Arunachal Pradesh, and no floodplain zoning law or flood zone exists; until one is set, the levels of Chapter 5 apply.

9.2.2 **Climate factor.** Design flows shall include the climate factor of Clause 2.8.

9.2.3 **Maintenance access.** Every structure shall be accessible for inspection and cleaning by the methods in Clause 9.12 and Chapter 10, without manual entry into confined spaces wherever practicable.

9.2.4 **Design life.** Structures shall be designed for a service life of at least 50 years for concrete and masonry works, and at least 25 years for mechanical and electrical equipment, unless the approving authority agrees otherwise.

9.2.5 **Blockage.** Where a structure can be blocked by debris, it shall be checked in the blocked condition set out in this chapter, and a safe overflow route shall exist for that condition (Chapter 6, Clause 6.3.2).

> Commentary. The design-life values in Clause 9.2.4 have no direct precedent; this Manual sets them because they are needed to decide when the climate factor applies (Clause 2.8.2 applies it to elements with a design life over 25 years).

9.3 Pipes and box drains

9.3.1 **Capacity and roughness.** Pipe and box-drain capacity shall be computed by Manning's equation with the design n of Chapter 6, Table 6.6. For precast or cast-in-situ RCC box drains, the design n shall be at least 0.015.

9.3.2 **Partly full flow.** Depth, velocity and discharge in partly full circular pipes shall be computed from the hydraulic-element relationships for circular sections (for example CPHEEO 2019, Table 5.5). The minimum velocity of Clause 6.7.3 applies at the design flow.

9.3.3 **Pressure flow.** Where a pipe runs full or surcharged, the HGL shall be computed under Chapter 6, Clause 6.8, with friction and structure losses.

9.3.4 **Steep pipes.** Where the design flow in a pipe is supercritical (Froude number above 1), the designer shall:

- (a) locate any hydraulic jump and show that it occurs in a structure designed to contain it, not in a pipe run;
- (b) provide air venting where the jump can seal the pipe; and
- (c) meet the maximum velocity of Clause 6.7.3(b).

9.3.5 **Changes of size and direction.**

- (a) Pipe size shall not decrease downstream.
- (b) Pipes shall join only at manholes or junction chambers, except that inlet connections may join pipes of 1,200 mm or more through a factory-made junction.
- (c) Changes of direction greater than 90° in a single structure are not permitted.

9.3.6 **Flotation.** Pipes and box drains in high groundwater shall be checked for flotation (Chapter 6, Clause 6.7.7).

> Commentary. The design n of 0.015 for box drains is set by this Manual to match the "fair" concrete value in Table 6.6. Clauses 9.3.4 and 9.3.5 follow common practice in FHWA HEC-22 and other manuals. A jump inside a pipe run causes pressure surges and can blow off manhole covers.

9.4 Culverts

9.4.1 **Method.** Culverts shall be designed by the methods of FHWA *Hydraulic Design of Highway Culverts*, HDS-5, 3rd edition (2012), or by software that implements them (for example FHWA HY-8). The design headwater is the **greater** of the headwater under inlet control (HWi) and the headwater under outlet control (HWo).

9.4.2 **Inlet control.** HWi shall be computed from the HDS-5 inlet-control equations or nomographs for the barrel shape, material and inlet edge condition actually built.

9.4.3 **Outlet control.** HWo shall be computed as:

> $HWo = h_o + H - L \cdot S$

> $H = [1 + k_e + (19.63\, n^2\, L) / R^{1.33}] \cdot V^2 / 2g$ (SI units, full barrel)

> ho = the greater of TW and (dc + D)/2

where ho is the outlet water depth used for control (m), H is the total head loss through the barrel (m), L is the barrel length (m), S is the barrel slope (m/m), ke is the entrance loss coefficient (Table 9.1), n is the barrel roughness, R is the hydraulic radius (m), V is the barrel velocity (m/s), TW is the tailwater depth above the outlet invert (m), dc is the critical depth (m) and D is the barrel rise (m). Part-full barrels under outlet control shall be analysed by backwater calculation as set out in HDS-5.

Table 9.1 — Entrance loss coefficients ke (outlet control, full or partly full)

Barrel and inlet	ke
Concrete pipe, projecting from fill, socket (groove) end	0.2
Concrete pipe, projecting from fill, square-cut end	0.5
Concrete pipe, headwall or headwall with wingwalls, socket end	0.2
Concrete pipe, headwall or headwall with wingwalls, square edge	0.5
Concrete pipe, headwall, rounded entrance (radius = D/12)	0.2
Concrete pipe, mitred to conform to fill slope	0.7
Concrete pipe, bevelled edges	0.2
Corrugated metal pipe, projecting from fill	0.9
RCC box, headwall parallel to embankment, square edge on three sides	0.5
RCC box, headwall parallel to embankment, three edges rounded or bevelled	0.2
RCC box, wingwalls at 30°–75° to barrel, square-edged crown	0.4
RCC box, wingwalls at 10°–25° to barrel, square-edged crown	0.5
RCC box, wingwalls parallel (extension of sides), square-edged crown	0.7

Source: FHWA HDS-5 (2012), entrance loss coefficient table (Appendix C).

9.4.4 **Tailwater.** TW shall be the higher of:

- (a) the normal or backwater depth in the downstream channel at the design flow; and
- (b) the tailwater level of Clause 9.2.1, for culverts within tidal or river backwater reach.

9.4.5 **Headwater limits.** At the design AEP of Chapter 6, Table 6.1:

- (a) HW/D shall not exceed 1.2;
- (b) the headwater shall be at least 0.3 m below the edge of the road shoulder at the upstream face; and
- (c) the headwater shall not raise water levels at any upstream building or property boundary above the limits of Chapter 6, Clause 6.12.2(d).

9.4.6 **Road overtopping.** Flow over the road in the check and 1% AEP events shall be computed with the broad-crested weir equation:

> Qr = Cd · L · h^1.5

where Qr is the overtopping flow (m³/s), L is the length of the overtopping section (m) and h is the depth of the headwater above the road crest (m). Cd shall be taken from HDS-5 for the road surface and the ratio of h to road width, and shall not exceed 1.66 (SI). The culvert and overtopping flows shall be balanced at a common headwater. The overtopping depths and hazard shall meet Chapter 6, Clause 6.12.

9.4.7 **Outlet velocity.** The outlet velocity at the design AEP and at the 1% AEP shall be computed and the outlet protected under Clause 9.6.

9.4.8 **Barrels and debris.**

- (a) Multi-barrel culverts shall be avoided in debris-prone urban drains. Where they are used, one barrel shall carry the dry-weather flow, and the inlet shall have a debris fin or deflector.
- (b) Culverts shall meet the minimum size and blockage checks of Chapter 6, Clauses 6.12.4 and 6.12.5.
- (c) Culvert inverts shall match the bed of the drain. They shall not be set above the bed, which traps silt and water upstream.

9.4.9 **Headwalls and cut-offs.** Inlets and outlets shall have headwalls, wingwalls and cut-off walls designed to prevent piping and undermining.

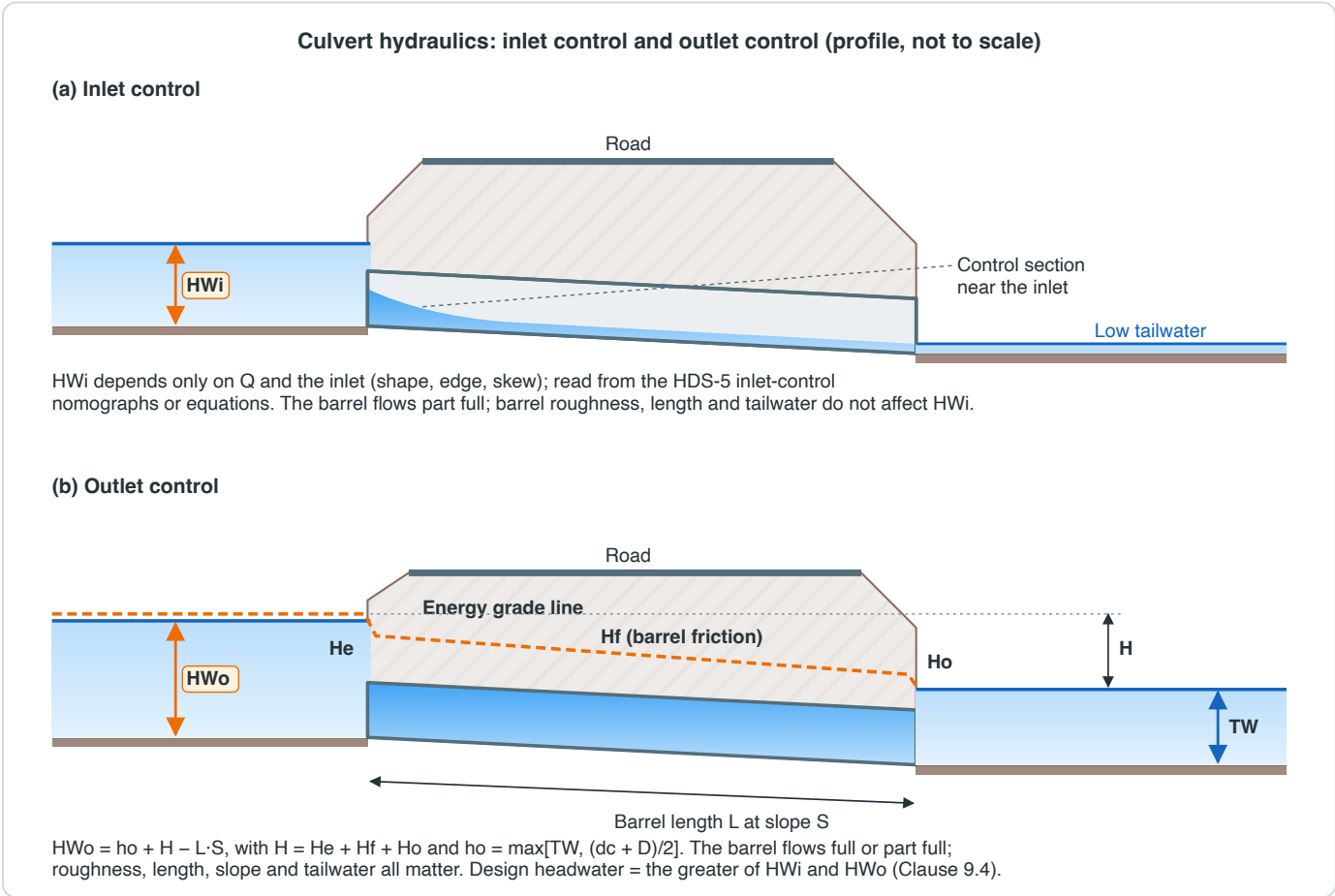


Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

> **Commentary.** HDS-5 (3rd ed., FHWA-HIF-12-026, April 2012) merged the culvert design material of HEC-5, HEC-10 and HEC-13 and is the current FHWA culvert manual. The outlet-control equation in Clause 9.4.3 is the HDS-5 energy equation in SI units: the friction coefficient 19.63 equals 2g. The ke values in Table 9.1 are reproduced from HDS-5. The weir coefficient cap of 1.66 (SI) is the conversion of the APWA 5600 (2006) limit of C ≤ 3.0 (US units) for overtopping calculations. The headwater limits of Clause 9.4.5 are set by this Manual: HW/D ≤ 1.2 keeps

the inlet from operating far into submerged-orifice flow at the design event, where small increases in flow give large increases in headwater. Clause 9.4.8(c) has no direct precedent; it is included because raised culvert inverts are common in Arunachal Pradesh where a road is rebuilt on top of an old culvert, and they hold standing water and silt upstream.

9.5 Open channels

9.5.1 **Flow computation.** Open channels shall be designed by Manning's equation for uniform flow, with the n of Table 6.6. Water levels shall be computed by gradually varied flow (standard step) analysis where tailwater, bridges, culverts, bends or changes of section affect them, which on the nallahs and drains of Naharlagun, Nirjuli and Doimukh and on the lower Pachin and Senki under the backwater of the Dikrong, on the town drains of Pasighat, Tezu, Namsai and Roing under the backwater of the Siang, the Lohit, the Noa-Dihing and the Dibang, on drains that end in ponds kept as storage, on the release reaches below the Pare, Ranganadi, Kameng and Lower Subansiri projects, and on the steep drains, nallahs and streets of the hill rim of Itanagar and of Ziro, Bomdila, Tawang, Seppa, Daporijo, Aalo, Khonsa and the other hill towns, stepped by drop structures and chutes and passing through critical depth at every step, is the normal case.

9.5.2 **Flow regime.** At the design flow, the Froude number shall not exceed 0.8 (CPHEEO 2019, §5.3), unless the channel is designed as a supercritical chute. Flows with a Froude number between 0.8 and 1.2 are not permitted at the design flow in any channel.

9.5.3 **Permissible velocities.** Mean velocity at the design flow shall not exceed the limits of Table 9.2.

Table 9.2 — Maximum permissible mean velocities in channels

Lining or soil	Maximum velocity (m/s)	Source
Concrete lining	3.0	CPHEEO 2019 Table 5.11
Riprap lining	1.8	CPHEEO 2019 Table 5.11
Grassed lining	1.2	CPHEEO 2019 Table 5.11
Stabilised earthen channel (modified natural channel)	2.0, or the critical velocity if less	CPHEEO 2019 §5.10.3
Unlined, fine sand	0.46	Fortier and Scobey (1926), clear water
Unlined, sandy loam	0.53	As above
Unlined, silt loam	0.61	As above
Unlined, firm loam	0.76	As above
Unlined, stiff clay	1.14	As above
Unlined, fine gravel	0.76	As above
Unlined, coarse gravel	1.22	As above

Flexible linings (vegetation, riprap, geosynthetics) may instead be designed by the permissible shear stress method of FHWA HEC-15, *Design of Roadside Channels with Flexible Linings*, 3rd edition (2005).

9.5.4 **Longitudinal slope.** In engineered channels, the longitudinal slope shall not exceed 0.4% for natural linings and 0.2% for concrete linings, unless drop structures (Clause 9.6.6) or a chute are provided (CPHEEO 2019, Table 5.11).

9.5.5 **Freeboard and bends.** Freeboard shall meet Chapter 6, Table 6.7, measured above the water level that includes superelevation at bends. Bend radii shall meet Chapter 6, Clause 6.7.10.

9.5.6 **Side slopes.** Unless a structural or geotechnical design supports a steeper slope:

- (a) unlined earth channels shall have side slopes no steeper than 1V:2H; and
- (b) grassed channels that are mown shall have side slopes no steeper than 1V:3H.

9.5.7 **Low-flow channel.** Channels with a bed width of 3 m or more shall have a defined low-flow channel that carries the dry-weather flow at the self-cleansing velocity of Clause 6.7.3.

9.5.8 **Transitions.** Changes of section shall use gradual transitions. Abrupt expansions and contractions are not permitted in supercritical flow.

9.5.9 **Linings in high groundwater.** Lined channels in areas of high groundwater or tidal influence shall have weep holes with filters, or shall be designed to resist uplift with the channel empty.

9.5.10 **Natural channels.** Natural channels shall be preserved where possible (CPHEEO 2019, §5.10.3 note; Chapter 7). Where a natural channel must be modified, its capacity shall meet the design AEP of Chapter 6 and its velocities shall meet Table 9.2.

> Commentary. The lined-channel velocities and slopes are CPHEEO (2019) Table 5.11 values. The unlined-soil values are the classic Fortier and Scobey (1926) permissible velocities for clear water, as reproduced in Chow (1959). They are given for soils common in Arunachal Pradesh (the residual soils and slope debris over the Siwalik sandstones, shales and boulder beds of the foothills, the sandy terrace and valley-fill soils of the Naharlagun–Nirjuli–Doimukh valley, about 95% sand where NERIST tested them at Doimukh (Dabral et al., 2016), the bhabar boulder fans and flood-plain silts of the Siang, Dibang, Lohit and Noa-Dihing, the thin soils over gneiss and schist of the high ranges, and the cut-and-fill ground of the hill towns, on which the gravel, boulders, slide debris and garbage a flow carries, rather than the soil itself, decide what a channel bed must withstand (this Manual's reading)). The ban on Froude numbers between 0.8 and 1.2 extends CPHEEO's advice to avoid critical flow, where the water surface "becomes unstable and wavy" (§5.3). This extension is made by this Manual. The side slopes and the low-flow channel are also set by this Manual, because many Arunachal Pradesh urban channels carry sewage-mixed dry-weather flow until the cross-connections of Chapter 8 are removed. A wide flat bed then deposits sludge across its whole width, and a low-flow channel keeps the dry-weather flow concentrated.

9.6 Energy dissipators, outlet protection and drop structures

9.6.1 **When required.** Outlet protection or an energy dissipator shall be provided at every pipe, culvert and channel outlet where the outlet velocity at the design AEP or the 1% AEP exceeds the permissible velocity of the receiving channel in Table 9.2, and at every outlet to an unlined channel, tank or waterbody.

9.6.2 **Method.** Energy dissipators and outlet protection shall be designed by the methods of FHWA HEC-14, *Hydraulic Design of Energy Dissipators for Culverts and Channels*, 3rd edition (2006), selecting the dissipator type by its range of application.

9.6.3 **Riprap aprons.** For a circular outlet discharging to a flat apron, the median riprap size shall be computed with the HEC-14 apron equation:

> D50 = 0.2 · D · [Q / (g^0.5 · D^2.5)]^(4/3) · (D / TW)

where D50 is the median stone size (m), D is the culvert diameter or rise (m), Q is the design discharge (m³/s), g = 9.81 m/s² and TW is the tailwater depth (m). Where TW is not known, it shall be taken as 0.4D.

Apron length and thickness shall follow the HEC-14 riprap-class table (Table 9.3). The apron width at the outlet shall be at least 3D and shall flare to the downstream channel.

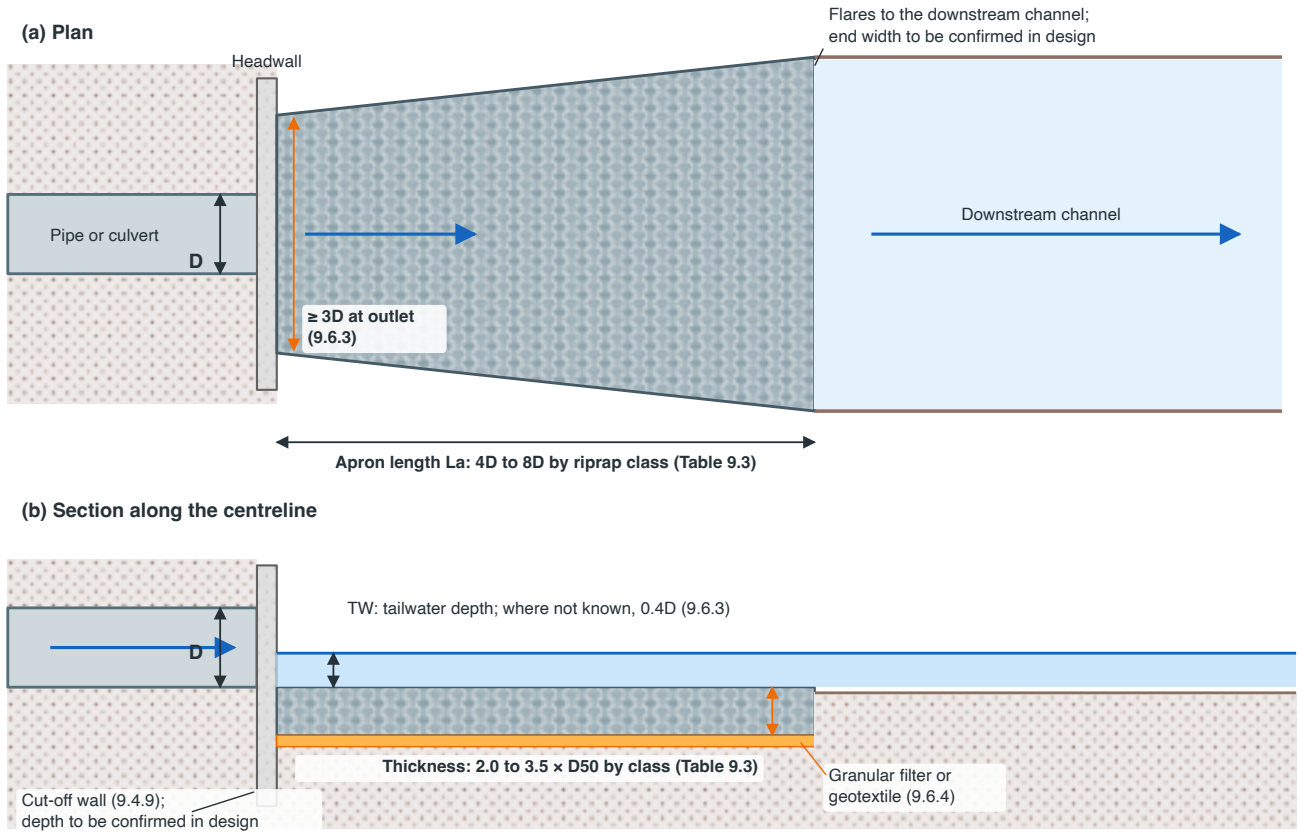
Table 9.3 — Riprap classes and apron dimensions (HEC-14)

Class	D50 (mm)	Apron length	Apron thickness
1	125	4D	3.5 D50
2	150	4D	3.3 D50
3	250	5D	2.4 D50
4	350	6D	2.2 D50
5	500	7D	2.0 D50
6	550	8D	2.0 D50

Source: FHWA HEC-14 (2006), §10.2 and Table 10.1, as reproduced in state-agency design worksheets. Where the computed D50 exceeds Class 6, a riprap basin or a structural stilling basin shall be used.

9.6.4 **Riprap filter and grading.** Riprap shall be placed on a granular filter or a geotextile. Stone shall be angular, durable and graded so that the D50 of Clause 9.6.3 is met.

Riprap apron at a pipe or culvert outlet (plan and section, schematic, not to scale)



D50 = 0.2 · D · [Q / (g^0.5 · D^2.5)]^(4/3) · (D / TW) (9.6.3)
D50 above Class 6 (550 mm): riprap basin or stilling basin

Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Energy Dissipators for Culverts and Channels, HEC-14 (3rd ed., 2006), §10.2.

9.6.5 **Stilling basins.** Where velocities or Froude numbers are above the range of riprap aprons and basins, a structural stilling basin or impact basin shall be designed from HEC-14 or from the US Bureau of Reclamation basin types it describes.

9.6.6 **Drop structures.** Drop structures shall be used where the channel slope would otherwise exceed Clause 9.5.4 or the velocity limit of Table 9.2.

- (a) For a straight vertical drop, the drop number $D = q^2 / (g\,h^3)$ shall be computed, where q is the unit discharge (m^2/s) and h is the drop height (m). The pool geometry shall be set from the Rand (1955) relationships: drop length Ld/h = 4.30 D^0.27; pool depth Yp/h = 1.00 D^0.22; sequent depths y1/h = 0.54 D^0.425 and y2/h = 1.66 D^0.27.
- (b) Baffled chutes and stepped drops shall be designed by HEC-14 or US Bureau of Reclamation methods.
- (c) The height of a single vertical drop in a public drain shall not exceed 1.5 m. Drops shall have edge protection under Chapter 6, Clause 6.13.8.

9.6.7 **Coastal and beach outfalls.** Outfalls onto beaches or into estuaries shall be protected against wave action and scour. Where littoral sand can close the outfall, the outfall shall be designed so that it can be reopened by machine, and the drainage system shall be checked with the outfall closed under Chapter 5.

> **Commentary.** HEC-14 (3rd ed., FHWA-NHI-06-086, July 2006) is the current FHWA energy-dissipator manual. The apron equation and the class table are from HEC-14 §10.2 (Equation 10.4 and Table 10.1). The equation and table are given here as reproduced in secondary design documents (a Tennessee handbook and a state-agency riprap worksheet). The 3D apron width is from the same sources. A Purdue study (JTRP) found the HEC-14 apron method somewhat conservative within its range of application. The Rand (1955) drop relationships are standard and are reproduced in Chow (1959). The 1.5 m limit on a single vertical drop has no direct precedent; this Manual sets it for public safety in urban drains.

9.7 Detention outlet structures

9.7.1 **Primary outlet.** The primary outlet of a detention facility shall:

- (a) produce the release rates and drawdown times of Chapter 4;
- (b) work without mechanical parts or operator action, except in pumped facilities (Clause 9.9);
- (c) have no orifice smaller than **50 mm**, and every orifice shall be protected by a trash screen (Clause 9.8.5); and
- (d) be accessible for cleaning from the surface.

9.7.2 **Orifices.** Orifice flow shall be computed as:

> $Q = Cd \cdot A \cdot (2\,g\,h)^{0.5}$

where A is the orifice area (m^2) and h is the head (m) on the centroid of the orifice, or the difference between the upstream and downstream water levels where the orifice is submerged. Cd shall be 0.60 for a sharp-edged orifice in a thin plate. Other edge conditions shall use published tested values.

9.7.3 **Weirs.** Weir flow shall be computed as Q = Cw · L · H^1.5, with:

- (a) sharp-crested rectangular weirs: Cw = 1.84 (SI), with the effective length reduced by 0.1 H for each end contraction;
- (b) V-notch weirs: Q = 1.38 · tan(θ/2) · H^2.5 (SI), where θ is the notch angle; and
- (c) broad-crested weirs and spillway crests: Cw = 1.44 to 1.70 (SI), selected from published tables for the crest shape and head.

Submerged weirs shall be corrected for submergence from published relationships.

9.7.4 **Stage–discharge rating.** For multi-stage outlets (orifices and weirs in a riser, with an outlet pipe), the designer shall compute, at each stage, the discharge under every possible control (each orifice, each weir, riser crest, and the outlet pipe under inlet and outlet control) and use the **smallest** combined value. The rating shall be tabulated from the outlet invert to the emergency spillway crest plus the design head.

9.7.5 **Tailwater.** Ratings shall be computed with the tailwater of Clause 9.2.1. Where the receiving water can rise above the outlet, the outlet shall have a flap gate or non-return valve under Clause 9.10, and the storage shall meet the outfall-closed check of Chapter 5.

9.7.6 **Emergency spillway.** The emergency spillway shall pass the 1% AEP inflow with the primary outlet assumed blocked and the basin full at the start, with **0.3 m** freeboard to the embankment crest. High-hazard basins shall also be checked for the 0.2% AEP inflow (Chapter 4).

9.7.7 **Outlet pipes through embankments.** Outlet pipes through embankments shall have a filter diaphragm or seepage collars to prevent piping along the pipe, and a flared or headwalled inlet.

9.7.8 **Anti-vortex.** Riser outlets with a design head above the riser crest greater than the riser diameter shall have an anti-vortex plate.

> Commentary. The 50 mm minimum orifice with a trash screen, the emergency-spillway criterion and the drawdown times are core criteria of this Manual (Chapter 4). The minimum orifice is smaller than the APWA 5600 (2006, 5608.4) minimum of 3 in (about 75 mm). It allows the low release rates of the Chapter 4 mixed-frequency rule on small sites, and it relies on a good screen (Clause 9.8.5). The "no mechanical parts" rule follows APWA 5600 (2006, 5608.4), which requires the primary outlet to function unattended. The orifice and weir coefficients are standard textbook values (for example Brater and King, *Handbook of Hydraulics*; Chow 1959). The 1.84 sharp-crested coefficient and the 0.1H end-contraction correction are the Francis formula in SI units. The broad-crested range 1.44–1.70 is the SI equivalent of the US range 2.6–3.1 commonly tabulated. Clauses 9.7.7 and 9.7.8 follow common dam and detention practice.

9.8 Trash racks and screens

9.8.1 **Where required.** Trash racks or screens shall be provided:

- (a) where an open drain enters a pipe, covered drain or culvert longer than 30 m (Chapter 6, Clause 6.13.4);
- (b) at every detention outlet orifice (Clause 9.7.1);
- (c) at the inlet of every pump sump (Clause 9.9); and
- (d) at outfalls to waterbodies, as part of the gross pollutant trap of Chapter 8.

9.8.2 **Conduit-entrance racks.** Racks at the entrance to conduits and culverts shall have:

- (a) clear bar spacing not less than 75 mm and not more than half the smallest internal dimension of the conduit;
- (b) a gross area at least 4 times the conduit's cross-sectional area;

- (c) a mean velocity through the rack at the design flow, with 50% of the rack blocked, of not more than 1.0 m/s; and
- (d) an inclination no steeper than 1V:2H where the rack is to be raked by hand, with a working platform and handrail.

9.8.3 **Head loss.** Head loss through a clean rack shall be computed with the Kirschmer equation:

$$h_r = \beta \cdot (t / b)^{(4/3)} \cdot (V^2 / 2g) \cdot \sin\theta$$

where t is the bar thickness, b is the clear bar spacing, V is the approach velocity, θ is the angle of the rack from the horizontal, and β is the bar shape factor (2.42 for sharp-edged rectangular bars; 1.79 for circular bars). The HGL and headwater shall be checked with the rack **50% blocked** (head loss computed with half the open area).

9.8.4 **Overflow when blocked.** Every rack shall have an overflow route so that a fully blocked rack does not flood buildings or exceed the limits of Chapter 6.

9.8.5 **Detention outlet screens.** Screens over detention orifices shall have openings smaller than the orifice they protect, and an open area at least 10 times the orifice area.

9.8.6 **Pump sump screens.** Bar screens at pump-station inlets shall have a clear spacing smaller than the largest solid the pumps can pass, as stated by the pump manufacturer. Screens shall be built in removable modules, and a mechanically raked screen shall be used where the design inflow exceeds 1 m³/s.

9.8.7 **Safety.** Racks at the entrance to long conduits shall prevent people from being drawn in. They shall be designed for the hydrostatic load of a fully blocked rack.

> Commentary. CPHEEO (2019, §8.3.1.3) describes pump-station bar screens with a spacing of "approximately 58 mm", built in modules, with an emergency overflow in case of clogging. Clause 9.8.6 follows that approach but links the spacing to the pump's solids-passing size, which varies by pump. The 50% blockage check matches the grate clogging factor of Chapter 6. The Kirschmer equation and its shape factors are standard (Kirschmer 1926, as reproduced in hydraulic handbooks). The rack spacing, area ratio, through-velocity, the 30 m conduit length trigger, the 10× screen area for orifices and the 1 m³/s trigger for mechanical raking have no direct precedent and are set by this Manual.

9.9 Pumps and sumps

9.9.1 **When pumping is used.** Pumping shall be used only where gravity drainage cannot meet the requirements of Chapters 5 and 6, for example at road underpasses (Chapter 6, Clause 6.10.5), basements, low-lying areas and outfalls that are tide-locked under the outfall-closed check of Chapter 5.

9.9.2 **Design inflow and storage.** The station shall be designed with the inflow hydrograph routed through the catchment and any upstream storage. Pump capacity and storage shall be chosen together:

- (a) the station shall meet the design AEP of the element it serves (for underpasses, the 2% AEP with a 1% AEP check);
- (b) where the station serves a tidal outfall, storage plus pumps shall hold the 48 h design volume with the outfall throttled for the tidal-lock duration (default: two consecutive high tides of 6 h each), as required by Chapter 5; and
- (c) the pumps shall be selected for the full range of static head between the lowest sump level against the lowest tailwater, and the highest tailwater (HAT plus surge plus 0.3 m).

9.9.3 **Wet-well volume.** The effective wet-well volume (between the pump-stop and the lowest pump-start level) shall be the greatest of:

- (a) where variable-speed drives and automatic controls are installed, 5 minutes of the minimum inflow (CPHEEO 2019, §8.3.3);
- (b) otherwise, 10 to 15 minutes of the peak inflow, or the volume needed for the pump manufacturer's minimum cycle time, from $V = Q \cdot t$ (CPHEEO 2019, Eq. 8.1); and
- (c) for constant-speed pumps, the volume $V = \Theta \cdot q / 4$ for each pump, where Θ is the minimum cycle time recommended by the motor manufacturer and q is the pump capacity (FHWA HEC-24, 2001).

9.9.4 **Duty and standby.**

- (a) Duty pumps shall be of the same size where practicable (CPHEEO 2019, §8.3.3).
- (b) Standby capacity shall be at least equal to the largest duty pump, and not less than 50% of the number of duty pumps.
- (c) Duty and standby roles shall alternate automatically.

9.9.5 **Pump type.** Pumps shall be solids-handling (non-clog) types suited to stormwater with sand and debris. Axial-flow pumps shall be used only behind a screen that meets Clause 9.8.6, because they cannot handle debris (CPHEEO 2019, §8.3.2).

9.9.6 **Sump and intake design.** Sump geometry, pump spacing, minimum submergence and approach flow conditions shall follow the pump manufacturer's requirements and ANSI/HI 9.8 (Rotodynamic Pumps for Pump Intake Design). A physical hydraulic model study shall be carried out where any pump exceeds 1 m^3/s, or where the sump does not follow standard ANSI/HI 9.8 geometry. The minimum clear space between adjacent pumps or motors is 0.6 m for small and medium units and 1.0 m for large units (CPHEEO 2019, §8.2.5).

9.9.7 **Silt and screens.** A silt trap and a bar screen shall be provided upstream of the wet well (Clause 9.8.6; Chapter 6, Clause 6.13.3).

9.9.8 **Controls and monitoring.**

- (a) Pumps shall be controlled by a primary level sensor (ultrasonic, radar or pressure) with an independent float-switch back-up.
- (b) High-level and pump-fault alarms shall be sent by telemetry to the local body's control room.
- (c) Sump levels, pump run hours and power status shall be logged and kept for at least 5 years.

9.9.9 **Power supply.**

- (a) The station shall have two independent power sources: the grid supply and a standby generator (or a second independent grid feeder) able to run all duty pumps at once (CPHEEO 2019, §2.4.2.3(j)).
- (b) Fuel for at least **72 hours** of continuous operation of all duty pumps shall be stored on site, above the flood level of Clause 9.9.10.
- (c) Changeover to standby power shall be automatic.

9.9.10 **Flood protection of the station.** The floor of the electrical and control room, the generator and the transformer shall be at least 0.5 m above the 1% AEP flood level at the station (Chapter 6, Clause 6.11). Access to the station for maintenance vehicles shall remain usable in the 1% AEP event.

9.9.11 **Discharge.** Each pump shall have its own rising main, or a non-return valve and an isolating valve where mains combine. Rising mains shall discharge into a delivery chamber or outfall fitted with a flap gate or non-return valve under Clause 9.10. Discharge piping shall be sized by a recognised friction formula (CPHEEO 2019, §8.3.9).

9.9.12 **Emergency connections.** Every station shall have a hard-standing area and a quick-coupling connection for mobile pumps to discharge into the delivery chamber.

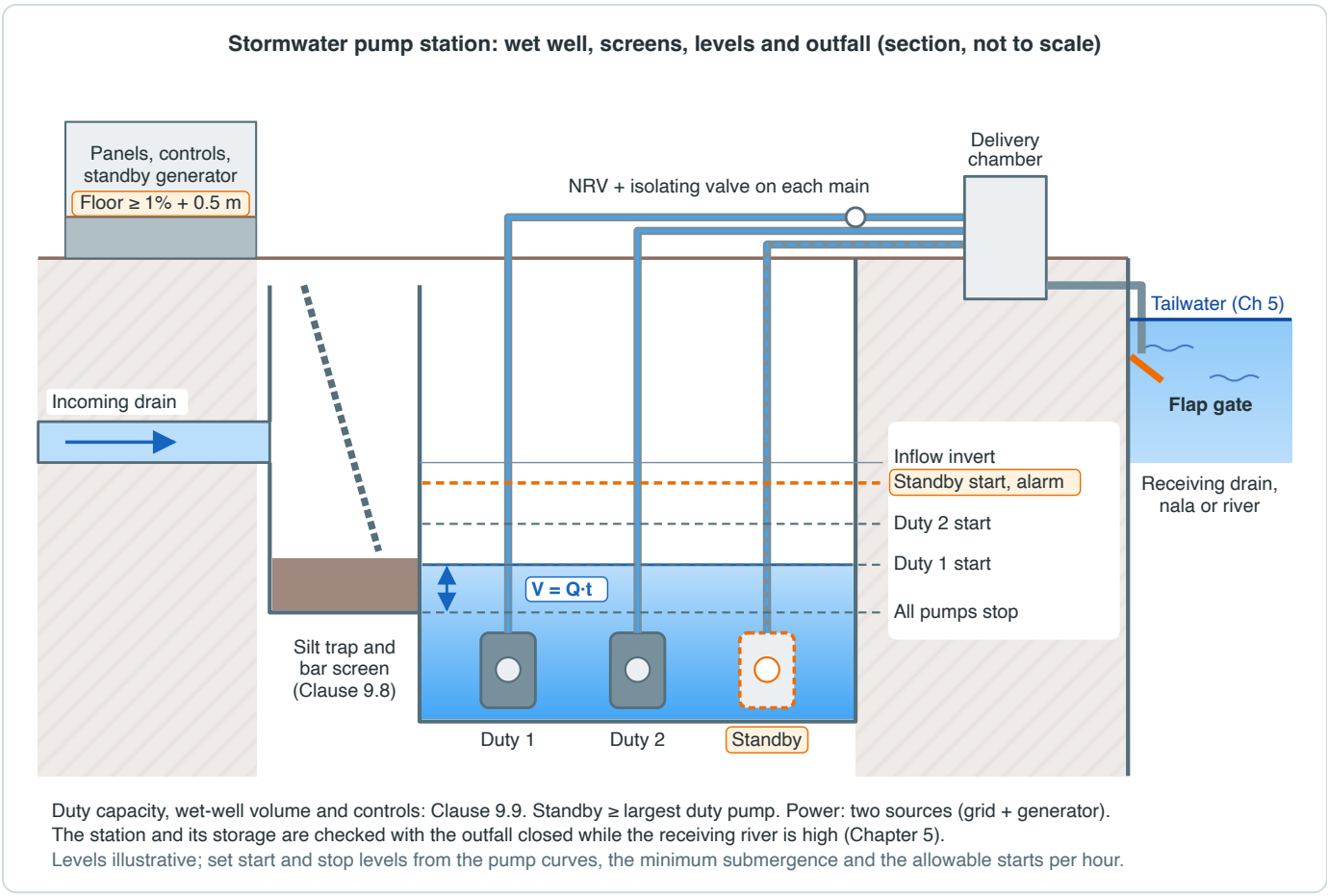


Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).

> **Commentary.** CPHEEO (2019) Chapter 8 covers stormwater pumping: wet-well sizing (§8.3.3), pump types (§8.3.2), trash screens (§8.3.1.3), space requirements (§8.2.5) and the need for generator sets "as standby for emergency operation during failure of electricity" (§2.4.2.3). It recommends standby units of "minimum 50% of the duty pump units". Clause 9.9.4(b) is stricter: the standby must at least equal the largest duty pump, so the station still meets its design duty with its largest pump out of service. This stricter rule is set by this Manual. FHWA HEC-24 (*Highway Stormwater Pump Station Design*, FHWA-NHI-01-007, 2001) is the FHWA pump-station manual. The 72 h fuel storage is set by this Manual to match the 72 h design storm of Chapter 2. The model-study trigger, the telemetry and data-retention requirements, and the emergency connection have no direct precedent and are set by this Manual.

9.10 Tide gates, flap gates and non-return valves

9.10.1 **Where required.** Flap gates, tide gates or non-return valves shall be provided on every outfall whose invert is below the 1% AEP still-water level of the receiving water (Chapter 5).

9.10.2 **Types.** Acceptable devices are:

- (a) hinged flap gates (cast iron, ductile iron, stainless steel, HDPE or composite);
- (b) elastomeric in-line or end-of-pipe check valves (duckbill type); and
- (c) penstocks or sluice gates, manual or motorised, as a secondary closure.

9.10.3 **Secondary closure.** Outfalls of 900 mm or more, and every outfall serving a pumped or storage system, shall have a penstock or stop-log slot upstream of the flap gate so that the gate can be maintained, and as a back-up if the gate jams open.

9.10.4 **Hydraulics.** The head loss through the device in the open position shall be taken from the manufacturer's tested data and included in the HGL (Chapter 6, Clause 6.8.7). Flap gates shall open at a small head difference (CPHEEO 2019, §6.3.10.1).

9.10.5 **Sand and debris.** At beach, estuary and creek outfalls where sand or debris can hold a gate open or shut:

- (a) the gate shall be housed in a chamber with surface access, or elastomeric check valves shall be used; and
- (b) the gate shall be inspected after every high-tide or surge event during the monsoon season (Chapter 10).

9.10.6 **Materials.** Hinges, pins, links and fixings shall be of corrosion-resistant material (CPHEEO 2019, §6.3.10.1). In coastal and tidal locations this means stainless steel grade 316, bronze or a non-metallic material (Clause 9.13).

9.10.7 **Storage behind gates.** Where gates close during a storm, the storage or pumping behind them shall meet the outfall-closed check of Chapter 5.

> Commentary. CPHEEO (2019, §6.3.10.1) describes flap gates and flood gates at outfalls to tidal waters. It notes that "adequate storage may be necessary if pumping is to be avoided during the closure of the gate" and that hinge pins and links "should be of corrosion-resistant materials". Arunachal Pradesh has no coast, so no outfall in the State is closed by the tide, and the beach, estuary, tidal and coastal provisions of Clauses 9.6.7, 9.9.2(b), 9.10.5 and 9.13.6, and the coastal and tidal rows of Table 9.5, do not arise; in Clause 9.9.2(c) the highest tailwater is the highest river, stream, nallah, pond or reservoir level of Chapter 5. No pumping station or gated outfall on a storm drain was found anywhere in the State [TBC], and most outfalls in the hills fall freely to steep streams and nallahs, so pumps and sumps under Clause 9.9, and gates under this clause, are needed only where the outfall-closed check of Chapter 5 shows that gravity cannot drain a site. Two cases need them. The first is the valley floor of the capital. Itanagar's drains run to nallahs and to the Senki and the Pachin, Naharlagun's to the Dikrong, and the existing drains "end up mostly into the Nallah and in some cases, into local ponds or open fields" (Master Plan of Itanagar Capital Region-2031, report); the Dikrong below Doimukh carries the releases of NEEPCO's Pare dam and the tailrace of its Ranganadi project, about 160 m³/s against an observed Dikrong flood flow of about 2,500 m³/s (a 1994 study of the Central Water and Power Research Station, as reported), and no CWC site on the Senki, the Pachin or the Dikrong was found. The second is the main stems of the eastern foothills, where the town drains of Pasighat, Tezu, Namsai and Roing outfall to the Siang, the Lohit, the Noa-Dihing and the Dibang, whose stage is set far upstream: the CWC highest flood level of the Siang at Pasighat, 157.54 m on 11 June 2000, 3.58 m above the danger level of 153.96 m, was the outburst of the Yigong landslide dam in Tibet (CWC levels as transcribed by SANDRP, as reported). A nallah or drain whose invert lies below the river's design level of Clause 5.8.5(a) or (c) therefore needs a flap gate (Clause 9.10.1), a penstock behind it (Clause 9.10.3), and storage behind the gate for the outfall-closed durations that Chapter 5 sets, not less than 72 hours with pump-down within 48 hours (Clause 5.8.5(a) and (c)); pumps are added only where storage alone cannot meet that check. The sill and the gate-closing level are tied to the CWC danger level and highest flood level transferred by survey at Pasighat, Namsai and Tezu, and to the surveyed flood marks on the Dikrong, until a gauge with a named datum exists (Clause 5.8.5(a) and (c)); a gate on the Siang at Pasighat is not designed to hold back an outburst, whose stage governs siting and floor levels (Clause 2.3.6(i); Clause 5.8.5(e)).
>
> The reservoirs set the other gated case. NEEPCO issues monsoon advisories on controlled releases through the Pare dam's radial gates, and the dam passed a peak of 1,310 m³/s on 31 May 2025, when the plant was credited with easing floods from Jampa village to Doimukh; the flood of 1999 is the local benchmark on that reach (all as reported). The Ranganadi project released 1,412.57 m³/s into the lower Ranganadi on 9 July 2017 (a study prepared for the disaster management authority downstream, as summarised); the Lower Subansiri project of NHPC on the State border put its first unit into commercial operation on 23 December 2025 (as reported); no release or flood data were found for the Kameng project [TBC], and the Dibang project is under construction. No

operator's release protocol or warning threshold was found for any of them [TBC]. An outfall to a release reach is checked against the largest recorded release or, until the operator gives one, the spillway capacity, and below that level needs a flap gate and storage for the lock of Clause 5.8.5(d). The dams are works of NEEPCO and NHPC, designed to dam-safety standards and not to this chapter, but their reservoir levels and releases are this chapter's boundary conditions.

Most of the State drains steeply. Papum Pare "is underlain mostly by Siwalik group of rocks", "the Siwalik Hills form hogback topography", and the hill slopes are covered by residual soil or slope debris (CGWB, Papum Pare district booklet); the capital lies in Earthquake Zone V with "5 fault lines in the city" (Master Plan of Itanagar Capital Region-2031, report); and no slope classification of any town was found [TBC]. The bye-laws refuse earth-cutting permission where "the average slope of the topography is more than 30%" and limit a cut to 3 m (APBBL 2019, 4.39(4) and (14)), but they set no rule for a drain on a slope, so drop structures (Clause 9.6.6), stepped channels, baffled chutes and stilling basins (Clauses 9.6.5 and 9.6.6(b)) and supercritical chutes designed under Clause 9.5.2 are the normal case in the hills, far beyond the 0.4% and 0.2% of Clause 9.5.4. In Arunachal Pradesh the following are set by this Manual, as in the mountain editions of this series, for a structure on a drain whose catchment includes an undeveloped hill slope, a cut slope, a nallah or a stream from the hills, in sub-areas AR-C1, AR-D and AR-E, on the hill rim of AR-A and AR-A1, and where the hill streams cross the bhabar fans of AR-B and AR-C: (a) a drop or stepped channel shall have each pool shaped to drain dry and reachable by machine, and no single vertical drop shall exceed the 1.5 m of Clause 9.6.6(c); (b) where such a drain enters a pipe, covered drain or culvert, with the debris rack, bulking and blockage provisions of Chapter 6 (Clause 6.3.6(f)–(h)), a debris rack, inclined so that the flow lifts debris onto it, shall stand upstream of the inlet, with a clear bar spacing chosen from a survey of the gravel, boulders and garbage in the bed and not less than that of Clause 9.8.2(a), and a debris basin or silt trap upstream of the rack, at the foot of the hills where a stream reaches a valley floor or a fan (Clause 6.3.6(m)); the basin volume shall be estimated from the debris and garbage deposited at the site in past floods and a stated debris-yield method, counting every slide scar, road cut, earth-cutting site, spoil heap, building site and garbage dump in the catchment as a source, because no Indian or Arunachal Pradesh guidance on sizing debris basins and no Arunachal Pradesh debris or bulking allowance was found [TBC]; its spillway shall pass the 1% AEP inflow with the basin full of debris, as for Clause 9.7.6, and it shall have a ramp for the machines that empty it; (c) a culvert on a stream or nallah shall have a single barrel where possible (Clause 9.4.8(a)), an armoured headwall and apron at the inlet with a deflector against boulders, an invert that follows the bed (Clause 9.4.8(c)), and an outlet protected under Clause 9.6 and led to a stable natural channel, never onto an unprotected slope (Clause 6.3.6(k)); (d) every lined drain that receives runoff from unpaved slopes, cut slopes, hill roads or building sites shall have a silt trap before it joins a public drain, a nallah, a stream, a pond or a reservoir, and every drain outfall to the Senki, the Pachin and the Dikrong in the capital and to the main stems at Pasighat, Tezu, Namsai and Roing, and every nallah mouth, a screen against garbage (Clause 6.3.6(e) and (m)); and (e) a lining in a steep drain shall be designed for the abrasion of the gravel and boulders it carries as well as for the velocity of Table 9.2. No structure of this chapter is built to exfiltrate, that is, as a soakaway, exfiltrating chamber, perforated pipe or open-jointed drain, on natural ground sloping more than 10°, on Siwalik shale, on colluvium, slope debris or fill, in a mapped landslide zone, above a landslide scarp or within twice the height of a cut slope or retaining wall upslope of it, unless a geotechnical certificate allows it (Clause 4.11, hill rule), or below the 1% AEP flood level of the Dikrong, the Pachin, the Senki, the Siang, the Lohit, the Dibang, the Noa-Dihing or a nallah, on the palaeochannels and swampy land of the Pachin and Dikrong flood plains, on pond margins or where the seasonal high water table is less than 2.0 m below ground (Clause 4.11, floodplain rule).

The need is shown by the record. In the Modirijo and Donyi Polo floods of September 2018 in Itanagar–Naharlagun the Senki View culvert and the Press Colony bridge were washed away, and a landslide from "the dumping area of NH 415" was reported (as reported; the tolls of 3 and up to 7 dead conflict). In 2017 the flash floods badly damaged the "land protection wall of several nallahs and rivulets" and closed NH-415, with traffic diverted via Papu Nallah and Jullang Road, and landslides along NH-52A follow the undercutting of its toe by the Dikrong (Master Plan of Itanagar Capital Region-2031, report). The drains along the Bage Tinali–Naharlagun road are reported "too shallow and narrow" and clogged by earth-cutting debris, an inspection recommended de-silting "upto the Dikrong river" and three culverts between the police station and the NERIST gate, a protection wall collapsed at Niti Vihar with 4 dead (date not found), and illegal earth cutting along NH-415 was blamed for a

mudslide near Donyi Polo airport (all as reported). In the rural roads the audit found three PMGSY projects taken up "without provision of drain", although "It is mandatory under PMGSY to have a drainage plan prepared for each rural road project", and "₹46.15 crore on construction of 49 Km roads wherein no drains were constructed" (CAG, Audit Report for the year ended 31 March 2023). On 24 June a debris-blocked channel above the Poosa / NEEPCO colony at Yazali breached, with 1 dead and 4 missing and about 18 quarters, or about 50 houses, washed away, from a side catchment of about 17 km² while "the main river stayed in its channel"; one report dates the flood to 2026 and another dates its photographs to 2025, a conflict this Manual does not resolve (as reported). A road drain or culvert of PWD or PWD (Highways) therefore never discharges onto an unprotected slope (Clause 6.3.6(k)), and the earth-cutting conditions of Clause 6.3.6(l) apply on every sloping site. No structure of this chapter is designed to pass a debris flow, a landslide or an outburst flood: on the hazard-first sites of Clause 2.3.6(i), which include the landslide ground on Siwalik sandstone, shale and boulder beds, colluvium, slope debris and fill, the earth-cutting sites, the bhabar fans and avulsion corridors at Pasighat, Ruksin, Roing, Tezu, Namsai, Bhalukpong and Banderdewa, the main stems fed from Tibet and glaciers, the glacial lakes and the release reaches below the dams, the screening of that clause comes first, and a structure is sited out of the hazard; the landslide at Laptap in Papum Pare on 11 July 2017, after three days of rain, which killed 14 people (14 to 16 in different reports, as reported), shows what a site on such ground risks.

Screens matter as much as gates, because the drains carry sewage. "Most of the surface water and sewerage gets mixed up resulting in storm water drains being used as sewers", "City sewerage is discharged into open drains" and "There is no sewage treatment plant present in the city" (Master Plan of Itanagar Capital Region-2031, report); the bye-laws bar septic effluent from "an open channel drain or body of water without adequate treatment" (APBBL 2019, 4.16.2(c)), but the State's own report to the National Green Tribunal quotes the observation that "no ULB is treating sewage" (affidavit in O.A. No. 606 of 2018, 2025); the Senki at Chandranagar, Itanagar, upstream of the Pachin, is in Priority V of CPCB's polluted river stretches (2025); and in O.A. No. 94/2020/EZ the Tribunal directed on 5 January 2023 that "no untreated sewage or treated sewage be allowed to enter into the waterbody" of the Senki, the Pachin and the Dikrong (as summarised). A rack or screen on an Arunachal Pradesh drain is therefore checked in the blocked case of Clause 9.8.4 and placed with the interception of dry-weather flow before every outfall to the Senki, the Pachin and the Dikrong and to the main stems at Pasighat, Tezu, Namsai and Roing, and before any pond used as storage (Clause 6.3.6(e); Chapter 8, Clause 8.9.5). No inventory of the flap gates, debris racks, screens, silt traps and culverts on the drains of any Arunachal Pradesh town, with their sizes and operating rules, no release protocol for any dam linked to the towns below it, and no design river, reservoir, pond or stream level at any outfall was found in the public domain. Clauses 9.10.3 and 9.10.5 are set by this Manual because a flap gate or penstock that fails, or is jammed open by silt, gravel, slide debris, garbage or woody debris, lets the Dikrong or a main stem in flood back into a nallah, and one jammed shut blocks it. The drains carry the towns' sewage and garbage as well as their storm water: "Most of the surface water and sewerage gets mixed up resulting in storm water drains being used as sewers", the drains are "chocked with the solid wastes" and "Regular cleaning of drains is not taking place and hence heavy silting happens" (Master Plan of Itanagar Capital Region-2031, report); observations quoted in the State's affidavit to the National Green Tribunal in O.A. No. 606 of 2018 (2025) record that "no ULB is treating sewage"; and earth cutting on the hill slopes sends its spoil to the drains, which the bye-laws recognise by making it the "duty of plot owner to clear/dispose-of soil/debris from site or drain to suitable/safer place" (APBBL 2019, 4.39(8)); so a gate, its screen and the debris rack above it are exposed to the same load and must be kept clear together; and because NEEPCO passes the Pare dam's floods through its radial gates under monsoon advisories, with a peak of 1,310 m³/s on 31 May 2025 (both as reported), and no operator's release protocol or warning threshold was found for the Pare, Ranganadi, Kameng or Lower Subansiri projects [TBC], a gate on an outfall to a release reach can be exposed for days at a time.

9.11 Inlets and gratings

9.11.1 **Hydraulics.** Inlet capacity, spacing and clogging shall follow Chapter 6, Clause 6.6.

9.11.2 **Load class.** Gratings, covers and frames shall be rated for the traffic at their location. Load classes shall be those of IS 1726 (cast iron manhole covers and frames) or EN 124 (gully tops and manhole tops), at least:

- (a) carriageways and medians: EN 124 class D400 or the equivalent heavy-duty IS class;
- (b) kerb-side channel inlets within 0.5 m of the kerb: class C250 or equivalent; and
- (c) footpaths and cycle tracks: class B125 or equivalent.

9.11.3 **Grate pattern.**

- (a) Grates in carriageways, cycle tracks and footpaths shall not have openings parallel to the direction of travel wider than 25 mm.
- (b) Grate types without tested capacity data shall be rated by the weir and orifice methods of FHWA HEC-22 (2024), with the clogging factors of Chapter 6.

9.11.4 **Kerb openings.** Kerb-opening inlets shall have a clear opening height of at least 100 mm and a length of at least 1.0 m. Where a kerb inlet discharges through the wall of a covered drain (Chapter 6, Clause 6.13.1), the opening shall be at road level.

9.11.5 **Security.** Gratings and covers on public land shall be hinged or locked to their frames, so that they cannot be removed without a tool.

9.11.6 **Inlet chambers.** Inlet chambers shall have the silt sump of Chapter 6, Clause 6.6.7, and shall be sized so that the sump can be emptied by a suction or grab machine.

> Commentary. NDMA (2010, §4.13) cites IS 5961 for cast-iron gratings for drainage inlets. The load classes are based on the EN 124 classes used internationally. The 25 mm limit on parallel openings is set for cyclist and pedestrian safety. APWA 5600 (2006, 5604.2) requires kerb openings of at least 4 ft (about 1.2 m) long and 6 in (about 150 mm) clear height. Clause 9.11.4 sets smaller minimums suited to the narrower roads and lower kerbs common in Arunachal Pradesh towns.

9.12 Manholes, junction chambers and access

9.12.1 **Location and spacing.** Manholes shall be provided at the locations and spacings of Chapter 6, Clause 6.7.11 and Table 6.8. Where pipes are too large for a standard manhole, a junction chamber with a riser to the surface shall be used (CPHEEO 2019, §11.3.7.3).

9.12.2 **Minimum internal size.** Manholes shall have at least the internal dimensions of Table 9.4 (CPHEEO 2019, §11.3.7.6):

Table 9.4 — Minimum internal size of manholes

Shape and depth	Minimum internal size
Rectangular, depth below 0.9 m	900 mm × 800 mm
Rectangular, depth 0.9–2.5 m	1,200 mm × 900 mm
Circular, depth above 0.9 m and up to 1.65 m	900 mm diameter
Circular, depth above 1.65 m and up to 2.30 m	1,200 mm diameter
Circular, depth above 2.30 m and up to 6.0 m	1,500 mm diameter
Circular, depth above 6.0 m and up to 9.0 m	1,800 mm diameter

The manhole shall also be large enough to fit the largest pipe connected plus the benching on each side.

9.12.3 **Access openings.** The clear access opening of manholes and access chambers on public drains shall be at least 600 mm, so that cleaning equipment can be lowered.

9.12.4 **Drops.** Where the difference between incoming and outgoing inverts exceeds 0.6 m, a drop connection shall be provided. Below 0.6 m, the difference shall be taken up by adjusting the slope of the incoming pipe or the benching (CPHEEO 2019, §11.3.7.5). The invert drop across a manhole where pipe size changes shall be at least the following fraction of the difference in diameters (CPHEEO 2019, Table 11.6):

- conduits below 400 mm: one-half;
- 400 mm to 900 mm: two-thirds;
- above 900 mm: four-fifths.

9.12.5 **Benching.** Manhole floors shall be benched to at least the crown of the outgoing pipe, with channels shaped to guide flow from each incoming pipe.

9.12.6 **Surcharge.** Manholes on mains where the 1% AEP HGL can rise above the cover (Chapter 6, Clause 6.8.4) shall have bolted, locked or hinged covers designed for that pressure.

9.12.7 **Mechanical cleaning.** Manholes, chambers and covered drains shall be designed for cleaning by machine (suction, jetting, grab or robotic equipment) from the surface. Fixed ladders shall be of corrosion-resistant, encapsulated material where provided.

> Commentary. The size and drop requirements are from CPHEEO (2019) Chapter 11. The 600 mm access opening, the benching rule and the bolted covers are set by this Manual. Designing for mechanical cleaning supports the prohibition on hazardous manual cleaning under *The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013*.

9.13 Materials and durability

9.13.1 **Exposure classes.** Concrete structures shall be designed for the exposure class of IS 456: 2000, Table 3. In Arunachal Pradesh the minimum classes of Table 9.5 apply unless a site investigation shows a more severe condition:

Table 9.5 — Minimum IS 456 exposure classes for Arunachal Pradesh locations

Location	Minimum IS 456 exposure class
Inland drains and structures	Moderate
Drains and structures in the coastal environment, and any drain that carries or may carry sewage-mixed flow	Severe
Structures exposed to sea-water spray, or in contact with saline or aggressive groundwater	Very severe
Structures in the tidal zone	Extreme

9.13.2 **Concrete.** Minimum concrete grade, maximum water–cement ratio, minimum cement content and nominal cover to reinforcement shall be those of IS 456 for the exposure class. For the reader's convenience, IS 456 sets the minimum reinforced-concrete grades as M25 (moderate), M30 (severe), M35 (very severe) and M40 (extreme), and the nominal covers as 30, 45, 50 and 75 mm respectively.

9.13.3 **Aggressive ground.** Groundwater and soil at every structure in coastal and delta areas shall be tested for chlorides and sulphates. Cement type and concrete mix shall be chosen to suit the results under IS 456.

9.13.4 **Sewage-mixed flow.** Pipes and covered drains that carry, or may carry, sewage-mixed flow shall be protected against sulphide (crown) corrosion, by a sacrificial concrete thickness, a corrosion-resistant lining or a non-concrete pipe material.

9.13.5 **Pipes.** Concrete pipes shall comply with IS 458, with the class selected by structural design. Other pipe materials (for example ductile iron, HDPE or structured-wall plastic pipes) shall comply with the applicable Indian Standard and be approved by the approving authority.

9.13.6 **Metalwork.** Within 5 km of the coast, and in all tidal and saline locations:

- (a) fixings, hinges, ladders, handrails and screen frames shall be stainless steel grade 316, or hot-dip galvanised steel with a protective coating, or a non-metallic material; and
- (b) dissimilar metals shall be isolated from each other.

9.13.7 **Masonry.** New public drains in Tier A bodies shall be in reinforced or plain concrete. Brick or stone masonry may be used for drains in Tier B bodies only if it is plastered on the wetted face and meets the n value of Table 6.6.

> Commentary. The IS 456 exposure classes and the grade and cover values are quoted from IS 456: 2000 (Tables 3, 5 and 16) for convenience. The standard governs, and designers shall use its current amendment. Assigning Arunachal Pradesh locations to exposure classes, the sulphide-corrosion requirement and the ban on new masonry drains in Tier A bodies have no direct precedent and are set by this Manual. Drains that receive sewage cross-connections (a common condition, Chapter 8) generate hydrogen sulphide, which attacks unprotected concrete above the water line.

9.14 Submittal requirements

Every structure design shall be submitted with a **Hydraulic Structures Report** (Form 9-1) containing, as applicable:

1. culvert calculations (HDS-5 or HY-8 output) with HWi, HWo, outlet velocity, tailwater, overtopping and the blockage check;
2. channel water-surface profiles, velocities, Froude numbers and freeboard;
3. outlet protection and dissipator design, with riprap sizing;
4. detention outlet stage–discharge tables and the emergency spillway check;
5. screen and rack design with the 50% blocked check;
6. a pump station design report: inflow hydrograph, storage, pump curves and system curves, wet-well volume, controls, power supply and the Chapter 5 outfall-closed check;
7. gate and valve selection with head-loss data;
8. inlet, grate and cover load classes; and
9. an exposure class and materials statement (Clause 9.13).

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Annexes and forms

Annex / Form	Content
9A	HDS-5 inlet-control coefficients and worked culvert example in SI units
9B	Standard drawings: headwalls, riprap aprons, drop structures, trash racks, detention risers
9C	Pump station design checklist and standard control philosophy

Annex / Form	Content
Form 9-1	Hydraulic Structures Report checklist

CHAPTER 10

Submittals, Review, Operation & Maintenance and Enforcement

10.1 Purpose and scope

10.1.1 This chapter sets out how compliance with this Manual is shown, checked, built, kept working and enforced. It covers:

- (a) the submittal stages and their contents (Clauses 10.3–10.4);
- (b) the compliance calculator (Clause 10.5);
- (c) professional certification and review (Clauses 10.6–10.7);
- (d) construction inspection and as-built certification (Clauses 10.8–10.9);
- (e) maintenance declarations, O&M plans, inspection and access (Clauses 10.10–10.13);
- (f) handover of public assets (Clause 10.14);
- (g) enforcement (Clause 10.15); and
- (h) monitoring, post-event review and data publication (Clauses 10.16–10.17).

10.1.2 This chapter applies to every development and public work to which Chapters 4 and 5 apply under Clause 1.5.2. Clauses 10.3.1 (Stage 0), 10.15 and 10.17 also apply to development that is subject only to Clause 1.5.4.

> Commentary. A criterion that is not checked at approval, built as approved, and maintained afterwards has no effect. In Arunachal Pradesh the failure is one of missing criteria, not of a missing building rule, and of land that no permission reaches. No document stating a design return period, intensity or runoff coefficient for the storm drains of any town was found. The building rule is the Arunachal Pradesh Building Bye-Laws, 2019 (Department of Town Planning and ULBs, Government of Arunachal Pradesh), now under the Department of Urban Affairs (Town Planning wing); their notification number, date and gazette reference are not in the copy read, whose "Gazette Notification" page is blank [TBC]. They "extent to whole of Arunachal Pradesh" (2.1), apply for five years and stay in force until reviewed bye-laws are notified (2.2), and are named as the State's building bye-laws by section 2(c) of the Arunachal Pradesh Fire and Emergency Services Act, 2026 (Act No. 12 of 2026); no amendment was found, and whether the review due from 2024 has begun is not known [TBC]. Their "Authority" is the Director/Chief Town Planner of Town Planning and Urban Local Bodies "till an executing authority is notified" (definition 12), and the "Act" under which they work is the Arunachal Pradesh Municipal Act, 2007 (Act No. 4 of 2008) and the Arunachal Pradesh Urban and Country Planning Act, 2007 (Act No. 3 of 2008). An "Arunachal Pradesh Building Bye-Law 2010" is listed as notified on the Town Planning portal (as summarised) but was not read and is not cited here as the current rule, and the hill-site clause of the 2009 final draft of the bye-laws, which asked for "location of landslide prone areas" and the "diversion of the natural flow of water coming from uphill side" on the site plan, is not in the 2019 text, although the Itanagar master plan's report reproduces it. The Online Building Permission System, launched on 30 July 2025, was "customised" to the bye-laws and processes all permits online (as reported), so the drainage checklist of Form 10-1 would have to be built into it. The bye-laws already ask for much of what a drainage submittal needs, and this chapter hooks into them. The site plan shows "Any existing physical features such as well, drains, trees" (2.10.1(j)), the "Distance from Nallah/Stream as per the notified rules/norms" and the "Distance from Disaster Prone Area as per norms set by Disaster Management Authority" (2.10.1(e) and (f)), and no such rules or norms were found: the drainage sheet of Stage 2 goes with the site plan, and the corridor

of Chapter 7, which this Manual offers as the norms that 2.10.1(e) refers to and which the State could notify, is drawn on it. A "certificate of supervision and execution of drainage/sanitary works" in Appendix 'A-3' accompanies the notice (2.10.10): the as-built certificate of Stage 4 (Form 10-5) goes with it. The Authority grants planning permission within 30 days of an application (2.14.1(a)) and, for residential schemes, a completion is "deemed to approved by the Authority for occupation" if nothing is communicated within 30 days of the notice of completion (2.17), so the drainage review must fit inside those periods: the 5 working days of the completeness check and the 15 of the first review (Clause 10.7) come to about four calendar weeks, which fit only if the drainage report is complete and lodged with the building application, and the Stage 4 inspection must be made inside the 30 days of 2.17 (this Manual's reading of Clause 10.7.6). Earth cutting needs its own permission, valid for six months, with written notice before work starts (4.39(1)–(2)); a cut may not exceed 3 m, a clear 2.5 m is kept from the property line on the upper terrace, the owner must clear "soil/debris from site or drain", a retaining or breast wall follows "immediately", and no permission is given where "the average slope of the topography is more than 30%" (4.39(4), (5), (8), (11) and (14)): the slope-drainage conditions of this Manual (catch drains, toe drains, silt traps and no infiltration above a cut, Clause 4.11, hill rule) are attached to that permission. Rainwater harvesting is required on plots of 100 m² and more (9.1), and recharge "should be made mandatory" on plots of 500 m² and more (9.7), its structures are inspected before the completion certificate by the Authority's Rainwater Harvesting Cell (9.8), and a levy may be imposed for failing to provide or maintain them (Annexure E, 1.7): the storage of Clause 4.11 is shown on the same plans and inspected at the same visit. The Building Permission Committee recommends the cancellation of a land allotment for unapproved cutting (4.39(14)). The bye-laws do register professionals: "Registration of Professionals" (6.3.6) refers to Appendix 'E', "Registration: Qualifications and Competence of Professionals", and every professional's qualifications are as given there (2.14.5), so the "APBBL 2019 registration" of Clause 10.6.1's commentary and the "APBBL 2019 registration number" of Form 10-3 read as written. A layout is approved under the Urban and Country Planning Act (2.10.3), whose Local Planning Authority, the Itanagar Planning Authority in the Itanagar Capital Region, grants permission for development (s.29), and Ordinance No. 5 of 2025 adds Town Planning Schemes whose contents include "drainage, inclusive of sewerage, surface or sub-soil drainage and sewage disposal" and "the filling-up or reclamation of low-lying, swampy or unhealthy area"; an amending Bill was reported passed on 9 March 2026 (as reported), and its Act number and final text were not found [TBC]. In the Pasighat municipal area a building is sanctioned by the Municipal Building Committee (Arunachal Pradesh Municipal Act, 2007, ss.340–343), and in the area of the Itanagar Municipal Corporation (IMC) a private drain is connected to a drain of the Corporation on application, with no "foul water into a drain provided for surface water" where separate drains exist (Arunachal Pradesh Municipal Corporation Act, 2019, s.203). Land is the other hook. The State has no Sixth Schedule area, and Article 371H gives the Governor a special responsibility for law and order without protecting customary law or land (as quoted); the Arunachal Pradesh (Land Settlement and Records) Act, 2000 (Act No. 10 of 2000) incorporates "customary rights on the land", defines a "community" to include "a clan, sub-clan, kindred", and vests the beds of rivers, streams, nallahs, lakes and tanks in the Government only where they "are not the property of any person or community" (s.9(1)); individual titles came with an amendment of 2018 (s.1A, as reported), and much land near the towns is held by communities, clans and individuals. So the land that a drain, corridor, storage or outfall needs is secured by agreement with the owners or the community, by donation, by purchase, or by reservation in a master plan, layout or Town Planning Scheme, and never taken by this Manual; where the State decides that land must be obtained compulsorily, the Municipal Act routes it through the "Land of Acquisition Act, 1894" (as printed) and allows "other methods of land assembly including the use of transferable development rights" (s.104), and this Manual states that route and does not invoke it. On community or clan land outside any permission this chapter is guidance for the owners or the community. One field of the forms reads differently here: the "survey numbers, village, circle" of Form 10-6, because much customary land has no survey number in any State record, so the village, the circle and the description of the land in the owner's or community's record, or the title issued under s.1A where one exists, are entered (this Manual's reading). Every stormwater item in this chapter is therefore written so that the registered professional can certify it on Forms 1-1, 2-1, 10-2 and 10-3, and the Authority can check it with the site plan of 2.10.1, the earth-cutting permission of 4.39, the supervision certificate of 2.10.10 and the rainwater harvesting plans of Chapter 9, within the 30 days of 2.14.1 and 2.17, and at completion. This chapter is the process.

10.2 Definitions

Term	Meaning in this chapter
Submittal	A set of documents lodged with the Authority at one of the stages of Clause 10.3.
Drainage report	The preliminary (Stage 1) or final (Stage 2) report required by Clause 10.4.
Stormwater facility	Any retention, detention, water quality, conveyance, pumping, gate or outfall element required by this Manual, public or private.
Hold point	A construction stage at which work shall not proceed until the Authority or the certifying professional has inspected it (Clause 10.8).
As-built certificate	The certificate of Clause 10.9 that the facility was built as approved and performs as designed.
Owner	The person or body responsible for a facility under its maintenance declaration, or the ULB for a handed-over asset.
O&M plan	The operation and maintenance plan of Clause 10.11.
Facility register	The public register of facilities of Clause 10.17.

Other terms are defined in Clause 1.4.

10.3 Submittal stages

10.3.1 Submittals shall be made in the following stages, linked to the approval steps of the Arunachal Pradesh Building Bye-Laws, 2019 (Table 10.1):

Table 10.1 — Submittal stages and linked approvals

Stage	Submittal	When	Linked approval
0	**Pre-application** meeting and **Form 1-1** (Applicability Determination)	Before the planning permission or layout application	None (advisory record)
1	**Preliminary drainage report**	With the planning permission or layout application	Planning permission / layout approval
2	**Final drainage design**	Before building permit, or before commencement where the permit is issued with the planning permission	Building permit / commencement
3	**Construction inspections** at hold points	During construction	None (records filed)
4	**As-built certificate** and verification tests	Before the completion certificate	Completion / occupancy certificate
5	**Maintenance declaration** registered, or **handover** of public assets	Before or with the completion certificate	Completion certificate; asset acceptance
6	**Annual declarations** and inspection reports	Every year after completion	Continuing compliance

10.3.2 **Stage 0 is mandatory** for:

- (a) sites of 2 ha or more;

- (b) sites in a flood-sensitive catchment;
- (c) sites proposing a variance, waiver, regional facility or fee-in-lieu; and
- (d) sites draining to a tidal outfall or adjoining a waterbody.

For other sites, Stage 0 is optional, and Form 1-1 is lodged with Stage 1.

10.3.3 **Combined stages.** For sites of less than 1 ha outside flood-sensitive catchments, the Authority may accept Stages 1 and 2 as one submittal.

10.3.4 **Public works.** For a public work, Stage 1 is the drainage section of the DPR and Stage 2 is the drainage section of the tender drawings. The sanctioning authority shall not sanction or tender the work until the relevant stage has been reviewed under Clause 10.7.

10.3.5 **Changes after approval.** Any change that alters impervious area, levels, storage, outlet or outfall after Stage 2 shall be resubmitted, with the compliance calculator re-run, before the change is built.

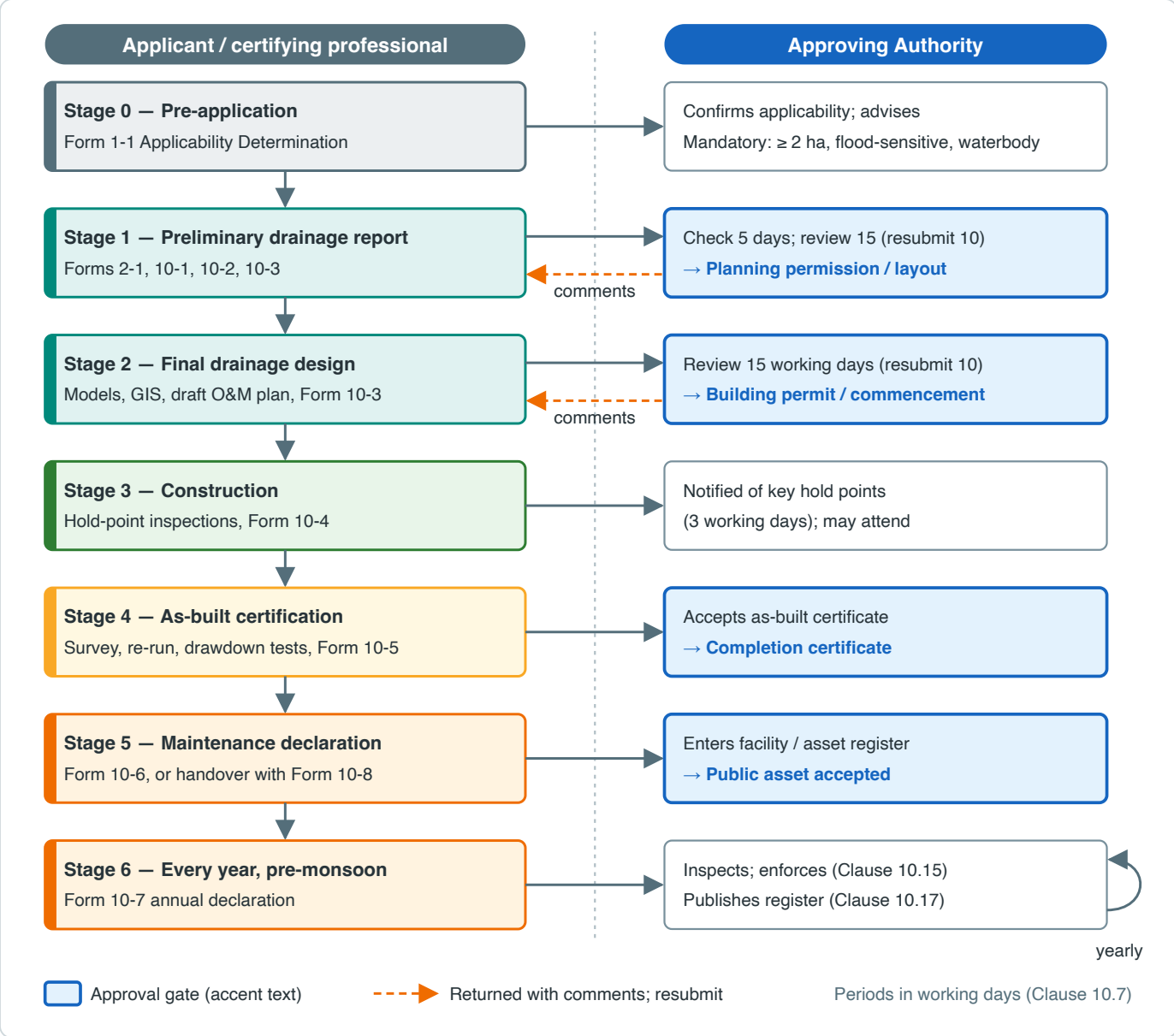

Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.

> **Commentary.** The stages follow the APWA 5600 sequence of preliminary and final stormwater studies, construction inspection and maintenance agreements (APWA 5600, 2006, §5608 and §5609), mapped onto the APBBL 2019 steps an Arunachal Pradesh applicant already follows. Linking Stage 4 to the completion certificate copies the MBBL 2016 RWH model, which requires inspection before the completion certificate (MBBL 2016, §9.6). The 2 ha and 1 ha limits in Clauses 10.3.2 and 10.3.3 have no direct precedent and are set by this Manual.

10.4 Required contents and checklists

10.4.1 **Preliminary drainage report (Stage 1).** The report shall contain at least:

- (a) Form 1-1 and, where applicable, Form 1-2 (Variance / Waiver Request);
- (b) a site plan with existing and proposed levels, impervious areas, and the catchment boundaries draining to and through the site;
- (c) soils (HSG), the seasonal high groundwater table, and infiltration test results or a test plan (Chapter 3);
- (d) the **Design Rainfall Sheet (Form 2-1)**, completed as Clause 2.13 requires;
- (e) the pre-development condition and hydrologic method (Chapter 3);
- (f) how the hierarchy of Clause 1.2 has been applied: areas preserved, retention method, detention concept and conveyance;
- (g) preliminary retention, water quality and detention volumes, and release rates, from the compliance calculator (Clause 10.5);
- (h) the downstream extent and tailwater case (Chapter 5);
- (i) waterbodies, setbacks and the 1% AEP level (Chapters 6 and 7); and
- (j) the land reserved for facilities and maintenance access (Clause 10.13).

10.4.2 **Final drainage design (Stage 2).** The final design shall contain, in addition to updated Stage 1 contents:

- (a) the final calculations for every storage duration of Clause 2.5.2 and every AEP required by Chapter 4, including the outfall-closed check of Chapter 5;
- (b) stage–storage–discharge tables for each facility, and the emergency spillway design (Chapter 4);
- (c) hydraulic design of conveyance elements, inlets and structures (Chapters 6 and 9);
- (d) the water quality design and the first-flush or gross pollutant trap where required (Chapter 8);
- (e) construction drawings, details and specifications of every facility;
- (f) the construction sequence, including protection of retention and infiltration areas from sediment and compaction (Clause 10.8.3);
- (g) the hold-point schedule (Clause 10.8);
- (h) the draft O&M plan (Clause 10.11) and draft maintenance declaration (Clause 10.10);
- (i) the model input files and the GIS data of Clause 10.4.4; and
- (j) the certificates of Clause 10.6.

10.4.3 **Checklist.** Each submittal shall include the **Drainage Report Checklist (Form 10-1)**, showing for each item of Clauses 10.4.1–10.4.2 the page or sheet where it is addressed, or the reason it does not apply. The Authority shall not start technical review of a submittal without a completed Form 10-1.

10.4.4 **Digital submittal.**

- (a) Reports and drawings shall be submitted as searchable PDF.
- (b) Hydrologic and hydraulic models shall be submitted in their native, runnable format (for example SWMM .inp, HEC-HMS or HEC-RAS project files), with the version of the software used.
- (c) Facilities, outfalls, flow paths and catchment boundaries shall be submitted as GIS data (GeoPackage or shapefile) in WGS 84 (EPSG:4326) or the applicable UTM zone (46N for a project area west of 96° E, which is most of the State, including Itanagar, Pasighat, Roing, Namsai and Anini, and 47N for a project area wholly east of

96° E, which includes Tezu (about 96.16° E), Miao, Wakro, Hayuliang (about 96.54° E) and Anjaw district; a project area uses one zone, and one that crosses 96° E uses the zone that holds most of it and states the conversion (set by this Manual); the State's eastern limit is given as about 96°30' E in some sources and 97°30' E in others (as reported), a conflict to be confirmed against Survey of India maps [TBC], and Namsai, Roing and Anini lie within about 15 km of 96° E (this Manual's reading)), with attributes as listed in Annex 10B.

- (d) Levels shall be stated relative to a named vertical datum. The relationship to the river datums of the CWC sites on the Siang at Pasighat, the Noa-Dihing at Namsai and the Lohit at Tezu (levels as transcribed by SANDRP, on a datum not stated [TBC]), of any gauge or staff gauge on the Senki, the Pachin and the Dikrong in the capital and on the Dibang at Roing (none with a published datum was found [TBC]), of the reservoir and release levels of the Pare, Ranganadi, Kameng and Lower Subansiri projects (not found on a named datum [TBC]), and of the flood marks surveyed on ungauged streams, nallahs and ponds used in Chapter 5 shall be stated.

10.4.5 **Summary of forms used in submittals** (Table 10.2):

Table 10.2 — Forms used in submittals

Form	Title	Stage
1-1	Applicability Determination	0 or 1
1-2	Variance / Waiver Request	1
2-1	Design Rainfall Sheet	1, 2
10-1	Drainage Report Checklist	1, 2
10-2	Compliance Calculator Summary	1, 2, 4
10-3	Professional Design Certificate	1, 2
10-4	Hold-Point Inspection Record	3
10-5	As-built Certificate	4
10-6	Maintenance Declaration	5
10-7	Annual Maintenance Declaration and Inspection Report	6
10-8	Asset Handover Certificate	5

Commentary. Runnable models and GIS data cost the applicant little and let the Authority check the work, and later build a city-wide picture of private storage. Arunachal Pradesh has no design return period, design storm, runoff coefficient, time-of-concentration rule or drain standard for the storm drains of any town, and none was found in any document of the Department of Urban Affairs, the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Smart City companies, PWD or the Water Resources Department. The APBBL 2019 refer to Part 9 of the National Building Code (2005) for plumbing and drainage (4.19.1.3 and 4.33.1); road drains follow the practice of the Indian Roads Congress, which this Manual did not research. The Master Plan of Itanagar Capital Region-2031 proposes a "new drainage network … in the Itanagar and Naharlagun regions taking into consideration of the topography of the region and flow gradient" (Maps 28–30), with no design storm, return period or runoff coefficient; the expression of interest of 31 October 2017 for a "GIS based Integrated Drainage Master Plan and DPR for Itanagar Capital City" (65 km², horizon year 2038) states no return period; a GIS-based drainage plan for the capital prepared by En-Geo Consultancy and Research Centre was reviewed by the Chief Minister in June 2021, the foundation stone of a storm-water drainage and seepage-management project for Itanagar was laid in June 2018, and a SWMM 5.2 study of Itanagar's C-Sector has been posted as a preprint (all as reported or as summarised), and the design basis of none of them was seen. The State Action Plan on Climate Change (draft, 2011) budgets "Storm water draining in twenty six urban settlements" at Rs 15,000.0 million without criteria. The rainfall studies do not supply a design storm either. No intensity–duration–frequency relation with constants was found for any Arunachal Pradesh station; IMD's national study (Das et al., 2022) has no

Arunachal Pradesh panel; IMD's *Extremes* lists Pasighat, Tezu, Ziro and Hayuliang and no gauge in the capital, and its Pasighat record of 652.2 mm on 5 October 1988 is 1.37 times the station's next day and is to be confirmed by IMD [TBC]; NERIST's daily gauge at Doimukh (1988–2012) gives 210.39 mm in a day at 25 years (Dabral et al., 2016), about one contour above Plate 8 of the CWC Flood Estimation Report for subzone 2(a) at Itanagar; and the 2(a) plates draw their isopluvials only along the foothills, so that every hill and high-range town lies inside the subzone but beyond its last contour. The State's design values are therefore those of Chapter 2: the capital-region table from the Doimukh gauge in sub-area AR-A (Clause 2.3.6(c)(ii)), the 2(a) or 2(b) plates, the higher where both draw a contour, with floors, in AR-A1, AR-B, AR-C and AR-C1 (Clause 2.3.6(c)(i)), the floors of Clause 2.3.6(c)(iii) in the middle hills and high ranges of AR-D and AR-E, the Pasighat and Tezu records as floors within 25 km of their gauges (Clause 2.3.6(h)), and site-specific values with an outburst screening in snow-fed and glaciated catchments (Clause 2.3.6(i)); NIH-DHAARA is reported for comparison only; and each submission must state its own design basis. Form 2-1 and Form 10-2 ensure that every design states its inputs.

10.5 Compliance calculator

10.5.1 The State Stormwater Technical Committee shall issue and maintain a **compliance calculator**: a version-controlled spreadsheet or web tool that, for a given site:

- (a) applies the applicability tests of Clause 1.5;
- (b) computes the retention volume from the Annex 2E depth, and the water quality volume (Chapter 8);
- (c) applies the credits for preserved areas and retained volume against detention (Chapter 4);
- (d) on the design-aid route (Clause 1.7, S-1), gives retention and detention volumes from the unit-storage tables;
- (e) on alternative S-2, gives the permissible site discharge for each AEP; and
- (f) produces the **Compliance Calculator Summary (Form 10-2)**.

10.5.2 **Use.**

- (a) Every Stage 1, 2 and 4 submittal shall include Form 10-2 from the current version of the calculator.
- (b) On the design-aid route, the calculator may be the only storage calculation.
- (c) Outside the design-aid route, the calculator is a summary and a screening check. It does not replace the hydrograph analysis of Chapter 3. Where a model result differs from the calculator screen by more than the tolerance stated in the calculator guide, the report shall explain why.

10.5.3 **Version control.** The calculator shall record its version in every output. A new version applies to new submittals 6 months after release, in line with Clause 2.14.2. A submittal shall use one version throughout Stages 1 to 4, unless the Applicant elects a later one.

10.5.4 **Openness.** The calculator, its user guide, and the source of every table in it shall be published free of charge.

Commentary. The Mid-America Regional Council issued a Compliance Calculator (.xlsm) and a Calculator Start-Up Guide with APWA 5600 Version 2025.01, together with a site activity plan template and the Policy Supplement (MARC stormwater management page, 2025). The calculator turns a layered standard with credits into one consistent set of numbers that a reviewer can check quickly. Singapore achieves a similar effect with a much simpler rule: a single allowable C value of 0.55 for 10-yr storms up to 4 h, applied by formula (PUB Code of Practice, cl. 7.1.5). An Arunachal Pradesh calculator serves Tier B authorities in particular, where it may be the whole calculation.

10.6 Professional certification

10.6.1 **Who may sign.** Drainage reports and designs shall be prepared and signed by a registered professional (Clause 1.4) competent in hydrology and hydraulics. For any of the following, the signatory shall be a civil engineer **empanelled as a Stormwater Design Professional** by the Authority or Urban Affairs:

- (a) Tier A sites of 1 ha or more;
- (b) any site in a flood-sensitive catchment;
- (c) any facility with an embankment, or a high-hazard basin checked for the 0.2% AEP (Chapter 4); and
- (d) any pumped facility, tide gate or regional facility.

10.6.2 **Empanelment criteria** shall be issued by Urban Affairs and shall include a civil engineering degree, relevant experience in drainage design, and completion of a training course on this Manual.

10.6.3 **Certificate.** The signatory shall complete the **Professional Design Certificate (Form 10-3)**, certifying that:

- (a) the design complies with this Manual, except for variances listed and approved;
- (b) the rainfall, soils and tailwater inputs are as recorded in Forms 2-1 and 10-2; and
- (c) the models submitted reproduce the results reported.

10.6.4 **Independent check.** Facilities under Clause 10.6.1(c) and (d) shall be checked by a second empanelled professional who is independent of the designer. That professional shall sign Form 10-3 as checker.

10.6.5 **False certification.** A false or negligent certificate is an offence under Clause 10.15.

> Commentary. Singapore requires that its ABC Waters design features used for peak control be endorsed by an ABC Waters Professional who is also a Professional Engineer (Civil) (PUB Detention Tank Guide, 2024). India has no statutory register of professional engineers comparable to Singapore's, so this clause uses the APBBL 2019 registration and adds empanelment for the higher-risk cases. The 1 ha limit is set by this Manual.

10.7 Review procedure and timelines

10.7.1 **Completeness check.** The Authority shall check each submittal against Form 10-1 within **5 working days** and either accept it for review or return it with a list of missing items.

10.7.2 **Technical review.** The Authority shall complete technical review and issue approval, conditional approval or a single consolidated list of comments within:

- (a) **15 working days** of acceptance for a first submittal; and
- (b) **10 working days** of acceptance for a resubmittal.

10.7.3 **No new comments.** On resubmittal, the Authority shall not raise new comments on matters that were unchanged and not commented on in the earlier review, unless the matter affects safety.

10.7.4 **Review capacity.** A Tier B authority, or a Tier A authority for overflow work, may use an empanelled reviewer from the Urban Affairs list. The empanelled reviewer shall not have worked on the same site. The Authority remains the decision-maker.

10.7.5 **Concurrent clearances.** Where the approval of the Water Resources Department (WRD) for a work in or on a river, or for an outfall to a river or an anti-erosion work in its charge, among them the Dikrong, the Siang, the Lohit and the Noa-Dihing, the permission of the Itanagar Municipal Corporation (IMC) to connect a drain to a drain of the Corporation (Arunachal Pradesh Municipal Corporation Act, 2019, s.203) or the consent of the Pasighat Municipal Council for a

drain vested in it (Arunachal Pradesh Municipal Act, 2007, ss.102 and 196), the agreement of the owner, the community or the clan for a drain, corridor, storage or outfall on its land, the consent of PWD or PWD (Highways) for a discharge to a side drain, catch-water drain or culvert of one of their roads, NH-415 among them, the consent of the Arunachal Pradesh State Pollution Control Board (APSPCB) for a discharge that carries effluent, and the consent of the body that owns or runs the receiving drain where that body is not the Authority (for example the Department of Urban Affairs or a Smart City company for a drain it has built and not yet handed over to the ULB), or another agency's concurrence is required (Chapter 7), the Authority shall forward the submittal on the day it is accepted for review, and the review periods shall run concurrently.

10.7.6 **Fit with permit timelines.** The periods in Clauses 10.7.1–10.7.2 run within, and do not extend, the overall time limits for planning permission and building permits set by the Government.

10.7.7 **Reasons.** Every refusal or condition shall state the clause of this Manual on which it is based.

> Commentary. The review periods have no direct precedent and are set by this Manual. A single consolidated comment list and the "no new comments" rule follow common good practice for engineering review.

10.8 Construction inspection

10.8.1 **Hold points.** The approved hold-point schedule (Form 10-4) shall include at least:

- (a) the excavated base of each retention, infiltration and detention facility, before any media, liner or structure is placed;
- (b) the outlet structure, orifice and trash screen, before backfill or before the facility is first allowed to fill;
- (c) the infiltration tests of Clause 10.9.3;
- (d) the outfall, flap or tide gate and non-return valve, before the downstream connection is made; and
- (e) pumps and controls, at commissioning.

10.8.2 Each hold point shall be inspected by the certifying professional and recorded on Form 10-4 with dated, geotagged photographs. For sites under Clause 10.6.1, the Authority shall be given at least 3 working days' notice of hold points (a) and (b), and may attend.

10.8.3 **Protection during construction.**

- (a) Retention and infiltration areas shall be fenced off from construction traffic and stockpiles.
- (b) Infiltration facilities shall not be brought into service until the area draining to them is stabilised.
- (c) Sediment shall be removed from any facility used for temporary sediment control before the as-built survey.

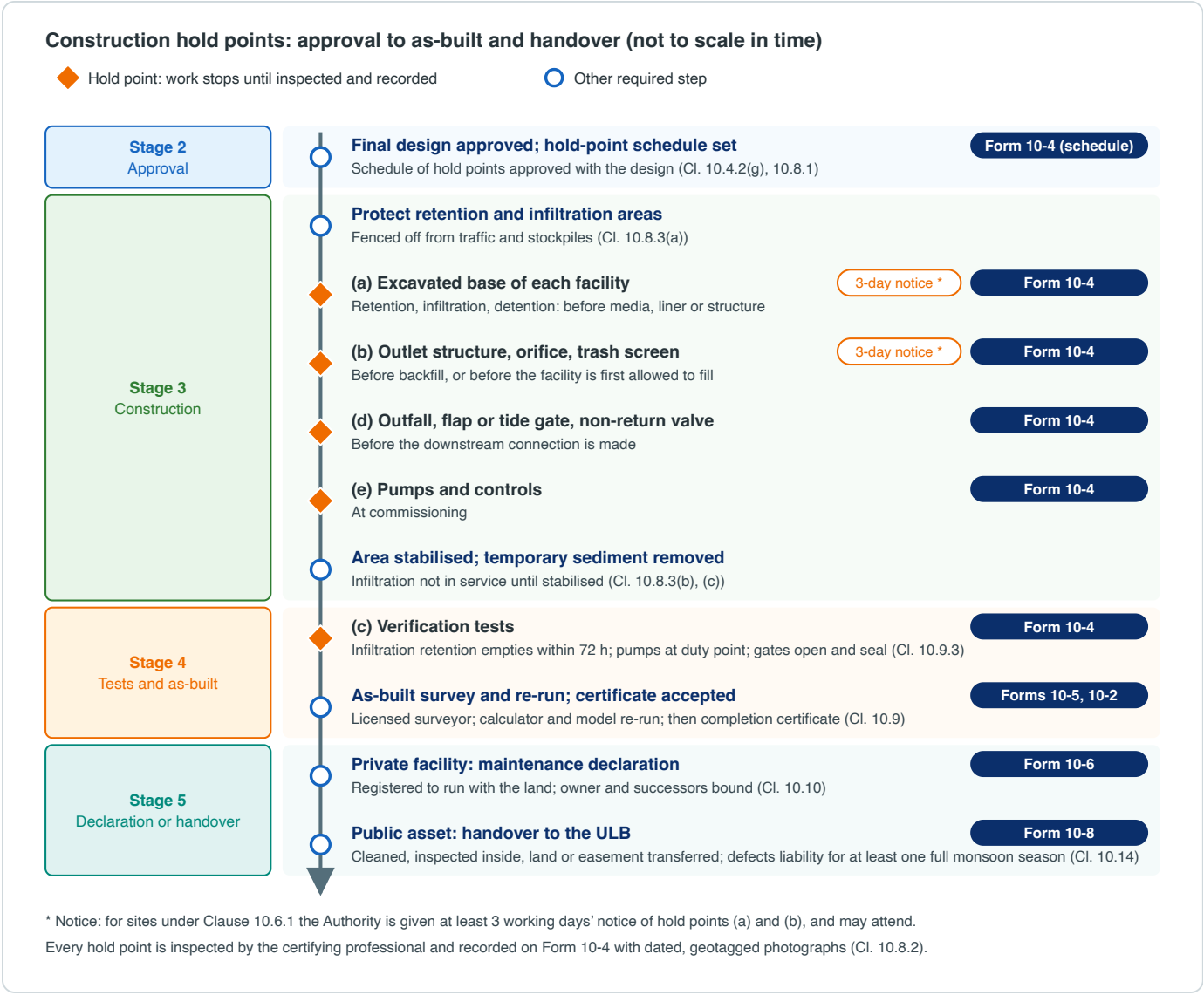

Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement sequence of APWA Section 5600 (2006), §5608.

> **Commentary.** Infiltration facilities fail most often in construction, when they are compacted or filled with silt before they ever operate. Hold points (a) and (c) target that failure. The 3-day notice is set by this Manual.

10.9 As-built certification

10.9.1 Before the completion certificate is issued, the certifying professional shall submit the **As-built Certificate (Form 10-5)** with:

- (a) an as-built survey by a licensed surveyor of each facility's levels, storage volume, outlet dimensions and inverts, and the outfall;
- (b) a re-run of the compliance calculator, and of the model where one was used, with as-built values;
- (c) the completed hold-point records (Form 10-4); and

- (d) the final O&M plan and the executed maintenance declaration or handover documents (Clauses 10.10 and 10.14).

10.9.2 **Acceptance.** The as-built facility is accepted where:

- (a) the as-built storage volume at each design level is not less than the volume required by Chapter 4;
- (b) the outlet dimensions and inverts match the approved design; and
- (c) the re-run shows compliance with every criterion of Chapters 4 and 5.

Any deviation shall be corrected, or re-certified as compliant under Clause 10.3.5.

10.9.3 **Verification tests.** Every retention facility that relies on infiltration shall be tested after construction to show that it empties within **72 hours**, as Chapter 4 requires. Pumped facilities shall be tested at their design duty point. Tide gates and non-return valves shall be shown to open and seal.

10.9.4 The Authority shall not issue the completion certificate until Form 10-5 is accepted.

> Commentary. The 72-hour retention drawdown is the criterion of Chapter 4. This Manual requires it to be tested after construction, rather than relying on pre-construction tests alone, because compaction during construction can cut infiltration rates far below the design values.

10.10 Maintenance declarations and covenants

10.10.1 **Declaration.** The owner of every private stormwater facility shall execute a **Maintenance Declaration (Form 10-6)** before the completion certificate is issued. The declaration shall:

- (a) identify each facility, its location and the approved O&M plan;
- (b) bind the owner and successors in title to operate, inspect and maintain the facility under the O&M plan;
- (c) grant the Authority a right of entry to inspect, and to carry out works in default under Clause 10.15;
- (d) prohibit removal, filling, covering, reduction or change of use of the facility without the Authority's approval; and
- (e) be registered so that it runs with the land and is disclosed to purchasers.

10.10.2 **Multi-owner developments.** For apartments, layouts and gated communities, the declaration shall name the association or body responsible after handover by the developer. The developer remains responsible until that body is legally constituted and has accepted the declaration in writing.

10.10.3 **Annual declaration.** Every owner of a facility in a Tier A area, and of any pumped facility, tide gate or regional facility anywhere, shall submit an **Annual Maintenance Declaration and Inspection Report (Form 10-7)** by **31 March** each year. The report shall be signed by the owner and, for facilities under Clause 10.6.1(c) and (d), by an empanelled professional. It shall state that the pre-monsoon inspection of Clause 10.12 has been done and any defects corrected.

10.10.4 **Transfer.** On sale or transfer, the seller shall disclose the declaration and the latest Form 10-7. The purchaser takes on the obligations from the date of transfer.

> Commentary. Singapore requires owners of pumped detention systems to file yearly declarations and documents with PUB (PUB Detention Tank Guide, citing Code of Practice §13.2). Addendum No. 3 to the Code of Practice (16 Apr 2025) introduced annual maintenance declarations for flood barriers and pumped detention tanks, following amendments to the Sewerage and Drainage Act. APWA 5600 (2006, §5608) required easements and maintenance provisions for detention facilities. A registered declaration matters in Arunachal Pradesh because

detention tanks under podiums and in basements are easy to convert to parking or storage once the building is occupied. The 31 March date is set by this Manual to fall before the monsoon season (April–October), when most Arunachal Pradesh extreme rainfall occurs.

10.11 O&M plans

10.11.1 Every stormwater facility shall have an O&M plan, approved at Stage 2 and finalised at Stage 4. The plan shall include:

- (a) an inventory and a plan drawing of each facility, with design levels, volumes and outlet details;
- (b) routine tasks and their frequency: inspection, debris and sediment removal, vegetation care, screen cleaning;
- (c) the trigger for sediment removal, stated as a depth or a percentage of design volume;
- (d) inspection checklists matching Form 10-7;
- (e) for pumped systems, gates and valves: the operating rules, test schedule, standby power, and actions on a cyclone or heavy-rainfall warning;
- (f) actions to prevent standing water and mosquito breeding, consistent with the drawdown times of Chapter 4;
- (g) safety measures for confined spaces, deep water and public access;
- (h) access routes and equipment needed (Clause 10.13);
- (i) an annual cost estimate and who pays it; and
- (j) the records to be kept, and for how long.

10.11.2 **Public facilities.** For facilities owned by a ULB or department, the O&M plan shall be included in the asset register (Clause 10.14.3) and funded in the annual maintenance budget.

Commentary. Arunachal Pradesh has no dated State or municipal order fixing pre-monsoon desilting, and none was found for the capital; the Department of Disaster Management's daily situation reports run through the season (as reported). The Master Plan of Itanagar Capital Region-2031 finds that "Regular cleaning of drains is not taking place and hence heavy silting happens" and that the drains are "chocked with the solid wastes", and an inspection of the Bage Tinali–Naharlagun road found its drains clogged by earth-cutting debris and recommended de-silting "upto the Dikrong river" (as reported). The drains are run by many hands, and no notification divides them (this Manual's reading): the Itanagar Municipal Corporation for the public drains, sewers, culverts and watercourses in or under its streets and the public streams and springs vested in it (Arunachal Pradesh Municipal Corporation Act, 2019, s.200, with the obligatory "maintenance and cleaning of drains and drainage works" of s.60(a)); the Pasighat Municipal Council for the drains vested in it (Arunachal Pradesh Municipal Act, 2007, ss.102, 194 and 196); the Department of Urban Affairs, a works department with a Chief Engineer and 28 divisions, and the Itanagar and Pasighat Smart City companies for the storm drains, sewerage and septage works they build, until they hand them over; PWD and PWD (Highways) for the drains and culverts of State roads and of NH-415, the spine from Itanagar to Naharlagun (as reported); WRD for the rivers and anti-erosion works, among them the Siang schemes at Mebo (as reported); PHED for water supply, which this Manual did not research [TBC]; and, on community or clan land outside a ULB, the community itself, with no statutory owner. The Pasighat Smart City company's "Storm Water Drainage Project" was criticised by the local Member of Parliament for "improperly constructed drainage systems" (as reported). The septage plant at Chimpu, reported as 100 KLD in one account and "1 MLD" in another (a conflict), and the Naharlagun sewage treatment plant, still under construction in 2025 and possibly to be converted into a septage plant (minutes of 11 April 2025 in the State's affidavit to the National Green Tribunal), need their own maintenance, and their screens trap the same garbage as the storm drains. The large gated structures are run by rules made for another purpose: NEEPCO operates the Pare, Ranganadi and Kameng projects and NHPC the Lower Subansiri project for power, NEEPCO issues monsoon advisories on releases from the Pare dam (as reported), and no release protocol or warning

threshold was found for any of them [TBC]. No operating rule for any gate or pumping station in an Arunachal Pradesh town, linking it to a river level, a dam release or a rainfall warning, was found in the public domain. Every gate and pump in this Manual needs a written rule for what happens when a warning is issued.

10.12 Inspection frequencies

10.12.1 **Owner inspections.** Owners shall inspect facilities at least as set out in Table 10.3:

Table 10.3 — Minimum owner inspection frequencies

Facility type	Routine	Pre-monsoon (by 31 March)	After a heavy-rainfall event
Retention / infiltration (soakaways, trenches, bioretention, permeable paving)	Every 6 months	Yes	Yes
Surface detention basin or multi-use open space area	Every 6 months	Yes	Yes
Underground or podium detention tank, gravity outlet	Every 6 months	Yes	Yes
Pumped detention, pumps and controls	Monthly test run	Yes, with full duty test	Yes
Flap / tide gate, non-return valve	Every 3 months	Yes, with seal test	Yes
Gross pollutant trap / first-flush device	Every 3 months	Yes	Yes
Private drains and inlets	Every 6 months	Yes	—

A heavy-rainfall event, for this Clause, is a day on which the nearest approved gauge records rainfall at or above the IMD "heavy rainfall" category, or a day for which a red alert is issued for the district. In Arunachal Pradesh, the pre-monsoon inspection of flap gates, penstocks, non-return valves, debris racks, screens, silt traps, debris basins, culvert inlets and any pumped facility, including the gates, where any exist, on the outfalls of the nallahs and drains of Naharlagun, Nirjuli and Doimukh to the Dikrong, on the outfalls of the town drains of Pasighat, Tezu, Namsai and Roing to the Siang, the Lohit, the Noa-Dihing and the Dibang, and on outfalls to a reservoir or its release reach, with the desilting of every drain, nallah and channel, the clearance of inlets, culverts, racks, silt traps and slide debris, and the pump duty and gate seal tests, shall be completed by **31 March**, with earthworks and cut slopes stabilised and their retaining or breast walls built (APBBL 2019, 4.39(11)) by the same date; gates, flap gates and any pumped facilities, with their standby power, shall be certified ready on the same date, with every gate on an outfall to a river or reservoir operated through its full travel, because the season of this Manual begins on 1 April and the April storms of the east and the May rain of the foothills follow at once. Gates, pumps, their standby power and racks shall then be kept on standby, with the monthly test run, from **1 April to 31 October**, and at an outfall on a release reach until the operator's releases have ended, if that is later. Inlets, culverts, debris racks, silt traps and the mouths of the nallahs shall be cleared again by **15 May**, of the silt, slide debris and garbage of the April and early-May storms, before the storms of the last ten days of May, and every public drain, nallah, inlet, rack, trap, basin and culvert in every town shall be cleared of the silt, slide debris and garbage of the season by **15 November**, after the October storms of the east. In the towns of the high ranges where snow lies in winter, inlets, culverts and racks shall be kept clear of snow and ice from December to March; where snow or frozen ground prevents the desilting before 31 March, it shall be done in the 15 November clearance and a snowmelt clearance of inlets, culverts and racks shall follow by **30 April**, and the declaration of 31 March shall state what was done and what waits for the snowmelt. WRD's own works on rivers and anti-erosion works keep WRD's calendar.

10.12.2 **Authority inspections.** The Authority shall inspect:

- (a) every facility on a site of 1,000 m² or more, or under Clause 10.6.1(c) or (d), at least once every 2 years, and every year in a flood-sensitive catchment; and
- (b) a random sample of at least 10% of other facilities each year.

10.12.3 The results of Authority inspections shall be entered in the facility register (Clause 10.17).

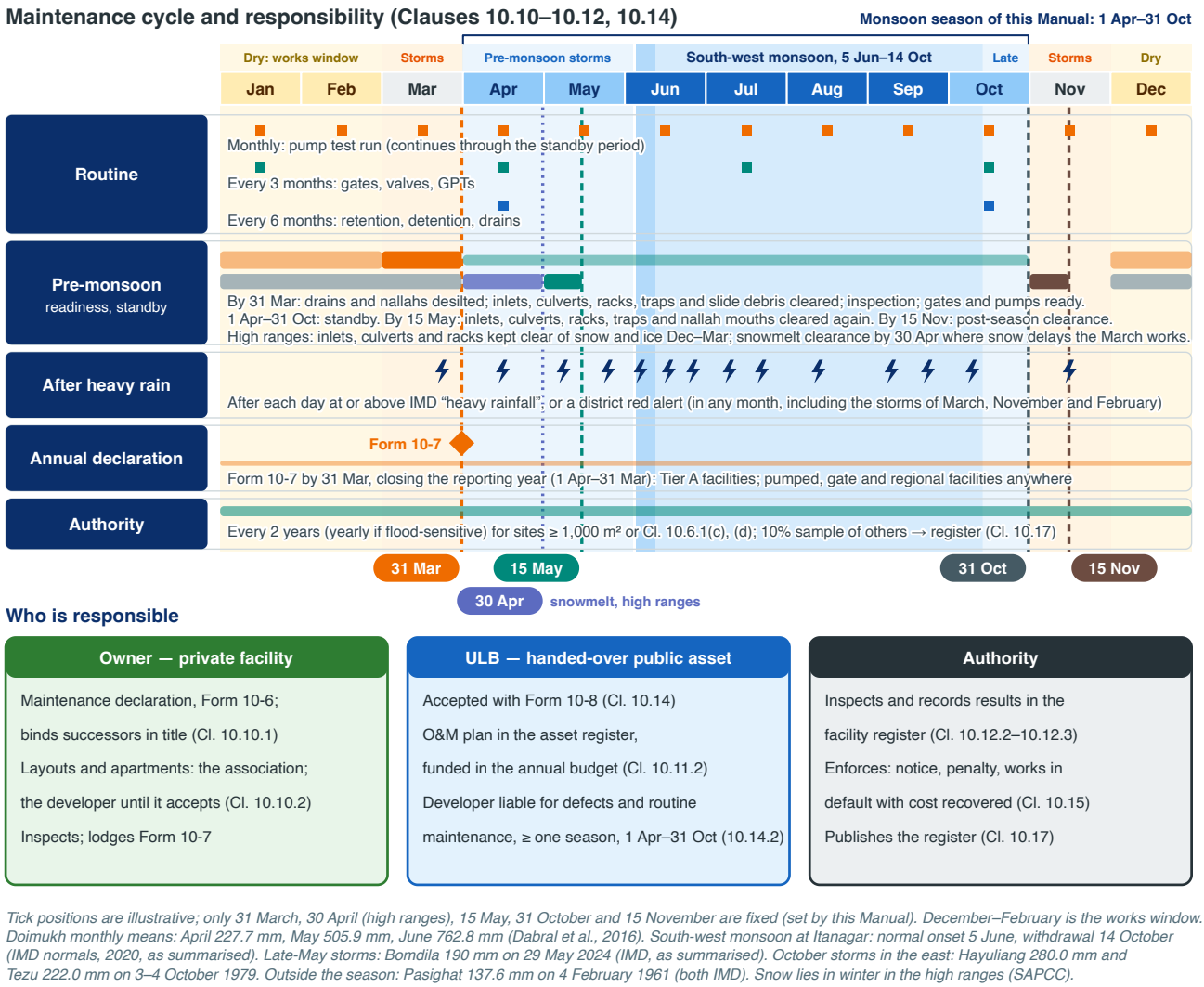

Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 31 March) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the monsoon season (April–October); tick positions within the year are illustrative.

> **Commentary.** The split in Clause 10.12.2 follows the MBBL 2016 inspection regime for RWH, which requires 100% monitoring of buildings over 1,000 m² and a 10% random check below that (MBBL 2016, §9.6). The inspection intervals in Table 10.3 are set by this Manual. The 31 March deadline is set by this Manual for a wet season that begins before the south-west monsoon. In this Manual the monsoon season runs from 1 April to 31 October: the pre-monsoon months of April and May, and the south-west monsoon from its normal onset at Itanagar on 5 June (4 June before) to its withdrawal on 14 October (IMD, new normal dates of onset and withdrawal, 2020, as summarised; no Pasighat date was found). The monsoon in IMD's sense does not begin in April; the season of this Manual does, for four reasons. First, the pre-monsoon months are wet: at Doimukh the monthly means are 227.7 mm in April, 505.9 mm in May and 762.8 mm in June, the wettest month, and March to May bring 846.5

mm, 24.0% of the year's 3,531.8 mm (NERIST series, Dabral et al., 2016, citing Dabral et al., 2006); over the State, March to May bring 23.4% of 2,818 mm (IMD gridded data for 1971–2005, as given in the State Action Plan on Climate Change, draft, 2011), which notes that "The state receives rainfall over a period of 8 to 9 months excepting in winter"; and in West Kameng the "rainy season starts from April and continues up to November" (CGWB). Second, the east has large April and May falls: 278.5 mm at Hayuliang on 24 April 1980, 234.4 mm at Pasighat on 29 May 1948 and 181.4 mm at Tezu on 21 May 1978, with monthly totals of 1,087.9 mm at Tezu in April 2010 and 1,367.0 mm at Hayuliang in April 1975 (IMD, *Extremes*). Third, cut slopes and earthworks must be finished and stabilised before that rain, since the bye-laws ask for a retaining or breast wall "immediately" after earth cutting (APBBL 2019, 4.39(11)). And NDMA (2010) sets 31 March for pre-monsoon desilting nationally; this Manual keeps that date, as the other North-East editions of this series do. No Arunachal Pradesh order fixing a date for desilting was found. The research suggested tiered dates, 31 March in the foothill towns, 15 April in the mid-hill towns and 31 May in the high towns, with a post-monsoon check by 30 September; they are not used, because one calendar keeps the North East on one date, because 31 May falls inside the storms of the last ten days of May, and because 30 September falls before the October storms of the east. December to February is the works window. This Manual therefore takes 31 March for the desilting of drains, nallahs and channels, the clearance of inlets, culverts, racks, silt traps and slide debris, the pre-monsoon inspection, the annual declaration, the BSMP annual report, the stabilisation of completed earthworks and cut slopes, and the readiness of gates, flap gates and any pumps, with no later readiness date. WRD's own works on rivers and anti-erosion works keep WRD's calendar. The damaging pre-monsoon storms come in the last ten days of May: the remnants of cyclone Remal brought 190 mm at Bomdila, 120 mm at Miao and 70 mm at Namsai in the 24 hours to 29 May 2024 (IMD bulletin, as summarised); on 30 May 2025 a landslide swept a vehicle off NH-13 between Bana and Seppa, killing seven people, and the Pare dam passed a peak of 1,310 m³/s on 31 May 2025 (both as reported). A second clearance due by 31 May, the date of the Assam edition and of the plateau edition to the west, would fall inside those storms, so inlets, culverts, racks, silt traps and the mouths of the nallahs are cleared again by 15 May, as in the adjoining edition to the south and the edition to its south, after the April storms and before the late-May cluster. Storms continue after the withdrawal, and the largest come in the east: 280.0 mm at Hayuliang on 3 October 1979 and 222.0 mm at Tezu on 4 October 1979, Pasighat's October monthly record of 1,207.9 mm in 1979, and its 652.2 mm of 5 October 1988, a record this Manual keeps under Clause 2.3.6(h) until IMD confirms or withdraws it (IMD, *Extremes*); gates, pumps and racks are therefore kept on standby to 31 October (Figure 10.3), and every town clears its drains a second time by 15 November. Storms also come outside the season, 137.6 mm at Pasighat on 4 February 1961 and 122.6 mm at Hayuliang on 16 February 1973 (IMD, *Extremes*), and Ziro's record of 150.7 mm on 4 February 1974, which this Manual treats as suspect (Chapter 2), while November to February bring 142.68 mm, 4.0% of the year, at Doimukh (Dabral et al., 2016); design statistics use annual maxima from all months, and the post-event inspections of Table 10.3 cover storms at any time of year. In the high ranges "Higher regions experience snow fall during winter" (State Action Plan on Climate Change, draft, 2011), and Tawang has "occasional rainfall/snowfall during winter" (CGWB), with snow in Tawang, upper West Kameng, the upper Subansiri, Mechuka and the Dibang and Lohit ranges; the calendar is not split, as the mountain editions of this series kept one statewide date: in the towns where snow lies, inlets, culverts and racks are kept clear of snow and ice from December to March, the desilting that snow or frozen ground prevents before 31 March is done in the 15 November clearance, and a snowmelt clearance of inlets, culverts and racks follows by 30 April. The research's 31 May for the high towns is not used, because the late-May storms reach the high ranges too, as at Bomdila on 29 May 2024. The reporting year runs from 1 April to 31 March, so that the annual declaration of 31 March closes it.

10.13 Maintenance access

10.13.1 Every facility shall have permanent access for inspection and maintenance, shown on the approved drawings and protected by the maintenance declaration or, for public facilities, by an easement or land transfer.

10.13.2 **Surface facilities.** Basins, ponds and open channels shall have a vehicle access route to the inlet, the outlet and the base, and a maintenance strip along at least one side. Ramps into basins shall be suitable for the plant needed to remove sediment.

10.13.3 **Underground facilities.** Tanks shall have:

- (a) an access opening over the inlet, the outlet and each chamber;
- (b) fixed ladders or steps, and ventilation for confined-space entry;
- (c) a sump or low point for sediment removal; and
- (d) headroom sufficient for manual cleaning.

10.13.4 **Outlets.** Orifices and screens shall be reachable for cleaning without entering a full facility.

10.13.5 Access routes shall not be built over, fenced off or used for parking in a way that prevents access.

> Commentary. APWA 5600 (2006, §5608) required a 15-ft (about 4.5 m) maintenance access strip for detention facilities. Plot sizes in Arunachal Pradesh cities make a fixed width hard to apply to every site, so this Manual sets functional requirements. Annex 10C covers maintenance access dimensions.

10.14 Handover of public assets to the ULB

10.14.1 Drains, roads, open space facilities, regional facilities and other stormwater assets that a developer builds for transfer to a ULB shall be handed over only when:

- (a) the as-built certificate (Clause 10.9) has been accepted;
- (b) the facility has been cleaned, and pipes and culverts have been inspected internally (for example by CCTV or manual entry), with the record handed over;
- (c) the land, or an easement over it, has been transferred to the ULB;
- (d) the O&M plan, drawings, GIS data and warranties have been handed over; and
- (e) the **Asset Handover Certificate (Form 10-8)** has been signed by both parties.

10.14.2 **Defects liability.** The developer shall remain responsible for defects and for routine maintenance for a defects liability period that includes at least **one full monsoon season, from 1 April to 31 October,** after handover. The ULB may hold a security deposit for this period.

10.14.3 **Asset register.** On acceptance, the ULB shall enter the asset in its GIS drainage asset register and in the facility register of Clause 10.17.

10.14.4 **Private facilities.** A private facility remains the owner's responsibility under its maintenance declaration unless the ULB formally accepts it under this Clause.

> Commentary. NDMA (2010) calls for a GIS inventory of drains. Requiring the developer's GIS data at handover builds that inventory as the city grows, at no cost to the ULB. The defects period spans one monsoon because many defects in Arunachal Pradesh drainage show up only in the first monsoon.

10.15 Enforcement

10.15.1 **Offences.** The following are contraventions of this Manual:

- (a) building without an approved drainage design where one is required;
- (b) building a facility other than as approved;
- (c) removing, filling, covering, reducing or changing the use of a facility without approval;
- (d) failing to maintain a facility, or to submit Form 10-7;
- (e) a sewage connection to a storm drain;
- (f) building or filling in a waterbody setback or no-fill zone (Chapter 7);
- (g) obstructing a natural drainage path or major-system flow path; and
- (h) false or negligent certification.

10.15.2 **Graduated response.** The Authority shall respond in the following order, moving to a later step where an earlier one fails or where the contravention is serious (Table 10.4):

Table 10.4 — Graduated enforcement response

Step	Action
1	Written notice stating the contravention, the clause breached, the remedy and a compliance period.
2	Stop-work order, or withholding of the completion certificate, for development not yet complete.
3	Penalty under the applicable Act or rules.
4	Works in default by the Authority, with the cost recovered from the owner.
5	Disconnection of the private drain connection to the public system, where this causes no hazard to others.
6	Report of the certifying professional to the registering authority, and suspension from the empanelled list.

10.15.3 **Immediate action.** Where a contravention puts life or property at risk during a monsoon, the Authority may carry out works in default at once and recover the cost later.

10.15.4 **Security deposits.** For sites under Clause 10.6.1, the Authority may require a security deposit or bank guarantee, released after the as-built certificate is accepted, to cover works in default.

10.15.5 **Record.** Every notice and action under this Clause shall be entered in the facility register.

> **Commentary.** Penalties are referred to generically. This Manual cannot itself create offences or fines, and the powers come from the Acts under which the Arunachal Pradesh Building Bye-Laws, 2019 were issued and from the municipal Acts. The graduated steps are set by this Manual. In Arunachal Pradesh the bye-laws carry real penalties for slopes and for rainwater harvesting, the municipal Acts give the local bodies a duty over their drains, and the National Green Tribunal has begun to act on the rivers; nothing yet acts on a drain that is built too small. The APBBL 2019 refuse earth-cutting permission where "the average slope of the topography is more than 30%", and "If formation cutting is under taken without obtaining approval … an amount of One Lakh shall be charged as penalty further, Building Permission Committee shall recommend to the Govt. of AP for cancellation of land allotment" (4.39(14)); they require the Authority to "constitute a Rainwater Harvesting Cell which will be responsible for enforcement and monitoring" and to inspect rainwater harvesting structures "before issuing Completion Certificates" (9.8(a)–(b)), let it "impose a levy for the failure of the owner … to provide or to maintain" them (Annexure E, 1.7), make it punishable "as per section 35" of the Urban and Country Planning Act to let polluted or waste water into a recharge pit, and withhold occupancy certificates without "satisfactory proof of compliance" (Annexure E, 8, 9.1 and 9.2); they let the Authority revoke a permit for false statements or for building against the bye-laws or the sanctioned plan (2.14.4), take action against unauthorised development "which may include demolition of unauthorized works, sealing of premises, prosecution and criminal proceeding" (2.14.7), and

debar or blacklist an architect, engineer, supervisor or plumber who has deviated from professional conduct or made a false statement, after a show-cause notice (2.14.6; 17.8). Under the Arunachal Pradesh Urban and Country Planning Act, 2007, development without permission or against its conditions is punishable "with a fine which may extend to twenty thousand rupees" and up to five hundred rupees a day while it continues (s.35), the Local Planning Authority may within four years require unauthorised development to be removed or brought into conformity (s.36), and an applicant aggrieved by a refusal or a condition may appeal to the State Government or the State Urban and Country Planning Board (s.30), the section to which the bye-laws send appeals against debarment (17.8(iii)); they send appeals against a refused occupancy certificate to "section 34 (1)" (17.11(iii)), which in the Act read is the power to revoke or modify a permission, so that cross-reference is to be confirmed [TBC]. The Arunachal Pradesh Municipal Corporation Act, 2019 makes "the maintenance and cleaning of drains and drainage works" an obligatory function of the Corporation (s.60(a)), vests its public drains in it (s.200) and forbids foul water in a drain provided for surface water where separate drains exist (s.203); the Arunachal Pradesh Municipal Act, 2007 requires a Municipality to "construct and maintain drains and sewers, and provide a safe and sufficient outfall" for storm water "in such manner as may not cause any nuisance, whether by flooding" (s.194), although a Municipality may "decide not to take up, or postpone" a core function (s.47(2)). The audits show what happens without enforcement: three PMGSY road projects costing ₹47.70 crore were taken up "without provision of drain", and "₹46.15 crore on construction of 49 Km roads wherein no drains were constructed" was spent, against the scheme's rule that a drainage plan be prepared for each rural road project, findings the Government accepted at the exit conference in June 2023 (CAG, Audit Report for the year ended 31 March 2023); no CAG audit of the Smart Cities, of drainage by the urban local bodies, of AMRUT storm drains or of the State's disaster management authority was found. The Tribunal and the court supervise what the rules leave open: in O.A. No. 94/2020/EZ, on the Senki, the Pachin and the Dikrong, the National Green Tribunal directed on 5 January 2023 that "no untreated sewage or treated sewage be allowed to enter into the waterbody", with quarterly monitoring by the Arunachal Pradesh State Pollution Control Board, and on 8 April 2025 asked the State and the Itanagar Municipal Corporation to file counter-affidavits on faecal sludge treatment (as summarised); in O.A. No. 606 of 2018 the amicus curiae recorded on 20 March 2026 the "complete absence of functional sewage treatment systems" in Itanagar–Naharlagun; and the Gauhati High Court, Itanagar Bench, directed the Corporation to fine littering in PIL 21/2021 and PWD (Highways) to repair the Itanagar–Jullang–Naharlagun–Nirjuli road in 2024 (both as reported). No order on the capital's drains, earth cutting or landslides was found. On community or clan land outside any permission, the owners or the community decide; this Manual does not bind them unless a permission or a plan carries it. This shows that a rule without routine enforcement does little, and that the step that acts on the professional who signs, which the bye-laws already provide for, is the one most likely to work. Professional accountability (step 6) is often more effective than fines on owners, because it acts on the person who signs the design.

10.16 Monitoring and post-event review

10.16.1 **Monitoring network.** Tier A authorities shall maintain, or have access to, recording rain gauges and water-level gauges at their main outfalls and regional facilities. Data shall be archived at intervals of 15 minutes or less.

10.16.2 **Event reports.** After any event that floods buildings within a ULB area, the ULB shall prepare a short event report within **3 months**, recording:

- (a) rainfall at the nearest approved gauges, by duration, compared with the design depths of Chapter 2;
- (b) the level of the receiving river at the nearest gauge with a named datum, which for the Siang at Pasighat, the Noa-Dihing at Namsai and the Lohit at Tezu means the CWC site, with CWC's datum stated [TBC], and for the Senki, the Pachin and the Dikrong in the capital and the Dibang at Roing a staff gauge set up and levelled for the purpose, since none with a published datum was found [TBC], or the level of the receiving pond, with any reading published in the press kept apart and never mixed with CWC levels; for an ungauged stream or nallah, which includes the streams that flooded Modirijo and Donyi Polo in September 2018 and Papu Nallah, the flood marks

surveyed after the event and the gravel, slide debris and garbage deposited at crossings, racks and culverts; the state of every flap gate, penstock, debris rack, screen, silt trap, debris basin and pumping station on the outfall and on the drain upstream of it, with the volume of debris and garbage removed from each, the hours each pump ran and any loss of power; and the gate openings, inflows and releases of the Pare, Ranganadi, Kameng or Lower Subansiri project where they set the receiving level, with the times of any warning the operator gave;
- (c) flooded locations, depths and durations, with flood marks surveyed where possible;
- (d) the performance of public and inspected private facilities, including any blocked outlets, failed pumps or closed gates; and
- (e) recommended actions.

10.16.3 **Post-event review.** Where an event exceeds the 1% AEP 24-hour or 72-hour design depth at two or more approved gauges in the State (Clause 2.14.1), APSDMA, with the State Stormwater Technical Committee, shall lead a post-event review within **12 months**. It shall assess whether the criteria of this Manual were adequate, and shall feed into the review of Clause 1.12.

10.16.4 **Facility performance sampling.** The Authority shall, at least every 5 years, monitor a sample of private retention and detention facilities through a monsoon, to test whether they perform as designed.

> Commentary. The post-event trigger is the review trigger already set in Clause 2.14.1. Arunachal Pradesh's floods and landslides have been counted more often than they have been reviewed, and the counts conflict. The Modirijo and Donyi Polo floods of about 14 September 2018 killed 3 people with at least 4 missing in early reports and up to 7 in later ones, and damaged more than 90 houses (as reported). The landslide at Laptap in Papum Pare on 11 July 2017 killed 14 people by one count and 14 to 16 by others, at about 13:30 or about 15:30 in different reports (as reported). In Itanagar the storm of 23 June 2024 inundated at least 66 houses, while the reported "cloudburst" of about 28 July 2024 submerged NH-415 and led to seven relief camps; the two are separate events, and the date of the second is in conflict between its dateline and its publication (as reported). The statewide floods and landslides from late May to 7 June 2025 killed 12 people with one missing and affected 33,200 people in 215 villages of 24 districts by the count of the State Emergency Operation Centre, against 9, 10 and 11 dead and 156 villages in other reports (as reported). The Poosa / NEEPCO colony flood at Yazali on 24 June is dated 2026 by one report and 2025 by another (as reported). The Department of Disaster Management counted 173 landslides, 104 floods, 80 heavy-rainfall events and 8 flash floods in the 2026 season to 20 July, with 15 deaths, 4 of them in flash floods (as quoted). The Yigong outburst of June 2000 is said to have killed 30 people in one account and more than 100, counting the reaches downstream, in others (as reported). The official tolls of the State's disaster management authority for these events were not found [TBC]. For most of these events no gauge value was published: no IMD rainfall series for any of them is in the research, only an IMD bulletin as summarised (190 mm at Bomdila on 29 May 2024), values quoted by officials (40 mm between 10:30 and 12:30 on 23 June 2024) and press values (73 mm in 24 hours at the Poosa colony); no rainfall was published for Laptap. No review of any flood in an Arunachal Pradesh town, and no record of flood extents, depths or durations kept by the Itanagar Municipal Corporation, the Pasighat Municipal Council or any District Disaster Management Authority, was found. NDMA (2010) called for automatic rain gauges at "1 in every 4 sq km" in Class I, II and III cities. Clause 10.16.1 asks only for gauges where they serve design and review. The report and sampling intervals are set by this Manual.

10.17 Data publication

10.17.1 Each Authority shall publish, on a public website, and update at least quarterly:

- (a) a **facility register**: location, type, design volume, release rate, owner, date of as-built acceptance, and the latest inspection result for every facility approved under this Manual;
- (b) a summary of each approved drainage report, with Forms 2-1 and 10-2;

- (c) the register of variances and waivers (Clause 1.10);
- (d) the alternatives adopted under the Policy Supplement (Clause 1.7);
- (e) enforcement actions (Clause 10.15.5); and
- (f) event reports and post-event reviews (Clause 10.16).

10.17.2 The State Stormwater Technical Committee shall publish the compliance calculator, all Annexes, the flood-sensitive catchment maps and the State-level summary of facility registers as open data.

10.17.3 Personal data other than the name of a corporate owner or association shall not be published. Security-sensitive details of critical infrastructure may be withheld, with the reason recorded.

10.17.4 Published data shall be machine-readable (for example CSV and GeoPackage) and released under the Government Open Data Licence – India or an equivalent open licence.

> Commentary. Transparency is a design criterion in its own right here. Some of Arunachal Pradesh's drainage record is public: the APBBL 2019, the Urban and Country Planning Act, 2007, the Municipal Act, 2007, the municipal-area notifications of Itanagar and Pasighat, the Master Plan of Itanagar Capital Region-2031 with its notice of approval, and the drainage expression of interest of 2017, all through archived copies of the Town Planning portal; the Municipal Corporation Act, 2019, the Fire and Emergency Services Act, 2026 and Ordinance No. 5 of 2025 through PRS; the Land Settlement and Records Act, 2000 through FAOLEX; the State's affidavit to the National Green Tribunal and the amicus curiae's observations; CPCB's list of polluted river stretches (2025); the CAG's audit of PMGSY roads; the Forest Department's report on the truthing of wetlands; the CGWB district booklets; NERIST's Doimukh rainfall study; and IMD's station extremes. Much else could not be found in the public domain: the notification of the APBBL 2019 and the "notified rules/norms" for the distance from a nallah or stream to which they refer; the notification constituting the Itanagar Municipal Corporation; the final text of the amendment to the Urban and Country Planning Act; the integrated drainage master plan for the capital and its design basis; the design basis of the AMRUT and Smart City drains; any gauge level or datum on the Senki, the Pachin or the Dikrong; CWC's datum for its Arunachal Pradesh sites; the release protocols and levels of the Pare, Ranganadi, Kameng and Lower Subansiri projects on a named datum; the station list and hourly archive of the Meteorological Centre Itanagar; IMD's ruling on the Pasighat record of 1988; the official tolls of the State's disaster management authority; a master plan or drainage plan for Pasighat; and an inventory of the gates, racks, screens and culverts of any town. Publishing inputs and facility records lets the public, researchers and other agencies check that the city's growing stock of private storage actually exists. The open-format requirement is set by this Manual.

10.18 Review of this chapter

10.18.1 This chapter shall be reviewed with the Manual under Clause 1.12. The forms and the compliance calculator may be revised by the State Stormwater Technical Committee between reviews, under Clause 10.5.3.

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Annexes and forms

Annex / Form	Content
10A	Compliance calculator and user guide
10B	GIS data specification and attribute schema
10C	Maintenance access dimensions
10D	Model O&M plans by facility type
10E	Empanelment criteria for Stormwater Design Professionals and reviewers
Form 10-1	Drainage Report Checklist
Form 10-2	Compliance Calculator Summary
Form 10-3	Professional Design Certificate
Form 10-4	Hold-Point Inspection Record

Annex / Form	Content
Form 10-5	As-built Certificate
Form 10-6	Maintenance Declaration
Form 10-7	Annual Maintenance Declaration and Inspection Report
Form 10-8	Asset Handover Certificate
Form 2-1	Design Rainfall Sheet (Chapter 2)

CHAPTER 11

Basin and City Stormwater Master Plans

11.1 Purpose and scope

11.1.1 Chapters 2 to 10 control one project at a time. This chapter sets the requirements for the plan that ties those projects together: the **Basin Stormwater Master Plan (BSMP)**. A BSMP is prepared for each drainage basin of a city or urban area. A city's set of BSMPs makes up its **City Stormwater Master Plan**.

11.1.2 A BSMP shall:

- (a) map flood hazard for the basin under existing and future conditions;
- (b) set the level of service each part of the drainage system must achieve (Clause 11.6);
- (c) identify the works, storage and land needed to reach that level of service, and rank them (Clauses 11.7 and 11.8);
- (d) reserve land for regional storage, pond and tank restoration, and major flow paths in the statutory land-use plan (Clause 11.9);
- (e) set the basin-specific inputs that site designs under Chapter 4 depend on: regional facilities, the fee-in-lieu unit rate, and any basin release rate stricter than Chapter 4 (Clause 11.8.3); and
- (f) recommend catchments for notification as flood-sensitive (Clause 4.5.4).

11.1.3 **Relationship to site design.** Site criteria (Chapters 4 to 8) apply whether or not a BSMP exists. A BSMP may make the site criteria **stricter** for its basin. It shall not relax them, except through the regional detention and fee-in-lieu routes of Clauses 4.13 and 4.5.6.

> Commentary. Arunachal Pradesh has a statutory master plan for its capital, a drainage master plan tendered and drafted but not found adopted, and no storm-drainage master plan with a design storm anywhere. The Master Plan of Itanagar Capital Region-2031, covering Itanagar, Naharlagun, Nirjuli, Doimukh and Banderdewa, was approved under section 24 of the Arunachal Pradesh Urban and Country Planning Act, 2007 on 3 June 2022 (notice of approval of 30 June 2022), and is described as the "first city of the country to be notified as GIS-based master plan of AMRUT Mission" (a Union official, as quoted); the report read is titled "Draft", and whether the approved text differs was not checked [TBC]. Its diagnosis is plain: "the storm water drainage system consists of natural drainage system (Nallah) and major drains", "no scheme or work for storm water drains is under execution", "There is no proper storm water network for the overall town area", the drains are "not engineered … open drains or kutcha drains without any flow gradient", "With only 3.7% storm drains along main roads, drainage was marked as a key area of focus", and "rivers like Pachin flowing through densely populated areas had become a waste disposal site". It proposes a "new drainage network … in the Itanagar and Naharlagun regions taking into consideration of the topography of the region and flow gradient" (Maps 28–30) and one sewage treatment plant of 4 MLD, also given as 3.9 MLD, near the Dikrong, but states no design storm, return period or runoff coefficient (this Manual's reading of the text). Its "2289 mm" of annual rain and "170 rainy days" are the plan's own words, with no source given. The Department of Town Planning and ULBs invited expressions of interest on 31 October 2017 for a "GIS based Integrated Drainage Master Plan and DPR for Itanagar Capital City" over 65 km², with a horizon year of 2038 and no return period stated; a plan prepared by En-Geo Consultancy and Research Centre was reviewed by the Chief Minister in June 2021, who asked for "a GIS-based and scientifically approved drainage master plan" with trial sectors in Itanagar and Naharlagun; the Itanagar Municipal Corporation (IMC) sought

central funds for a 64 km integrated drainage system; and a master plan for the twin capital cities was announced in August 2024, its relation to the plan of 2022 unclear (all as reported). The adoption of none of these drainage plans was found. No master plan or drainage plan for Pasighat was found [TBC]. The State Action Plan on Climate Change (draft, 2011) budgets Rs 15,000.0 million for "Storm water draining in twenty six urban settlements" without criteria. Ordinance No. 5 of 2025 adds Town Planning Schemes to the Urban and Country Planning Act, whose contents include "drainage, inclusive of sewerage, surface or sub-soil drainage and sewage disposal" and "the filling-up or reclamation of low-lying, swampy or unhealthy area, or levelling-up of land"; the Cabinet approved schemes for 47 urban centres and the Assembly passed an amending Bill on 9 March 2026 (as reported), whose Act number and final text were not found [TBC]. The reclamation clause is the main statutory risk to ponds, swamps and low land kept as storage in Itanagar–Naharlagun and Pasighat (this Manual's reading), and the compensatory storage of Clause 7.6.4 applies to such reclamation. No published document sets a design return period for the storm-drain network of any Arunachal Pradesh town. This chapter supplies the design storm, levels of service, storage and buffer criteria that such a plan needs, with the design storms of Chapter 2 and the levels of service of Clause 11.6; it has not been adopted by the Department of Urban Affairs, the Itanagar Planning Authority, IMC, the Pasighat Municipal Council, any village authority or community, the Water Resources Department (WRD), the Arunachal Pradesh State Disaster Management Authority (APSDMA), NEEPCO, NHPC or any other body. A site-level manual cannot fix basin-level problems: lost tank storage, nallahs narrowed by encroachment and earth-cutting spoil and choked with garbage, which flood the colonies of Itanagar and Naharlagun both when they block and when the Dikrong backs up into them, slopes that rain, open drains and blocked culverts saturate until they slide, culverts that debris washes out, as at Senki View in September 2018 (as reported), drains that carry untreated sewage to the Senki, the Pachin and the Dikrong, reaches below the Pare and Ranganadi projects whose level the releases set, main-stem outfalls at Pasighat, Tezu and Namsai whose level is set upstream, at Pasighat by outbursts in Tibet, and single streams split between a Municipal Corporation or Council, PWD, WRD and the communities and clans whose land they cross, and drains that are adequate on their own but overload the next reach. Comparable manuals pair site criteria with basin planning:

- Denver's Mile High Flood District prepares major drainageway master plans that set regional facilities and release rates.
- The Kansas City APWA criteria rest on regional watershed studies (MARC).
- England's Surface Water Management Plans (Defra, Surface Water Management Plan Technical Guidance, 2010) set a phased method of preparation, risk assessment, options and implementation.
- Malaysia's MSMA requires drainage master plans for urban areas.

This chapter adapts that method to Arunachal Pradesh, the seventh North-East edition of this series and its first State with neither a Sixth Schedule area nor constitutional protection of land: to a foothill capital on Siwalik sandstone and shale that slides, whose hill rim drains through steep nallahs to the Senki and the Pachin and whose valley floor at Naharlagun, Nirjuli and Doimukh drains to a Dikrong that carries the releases of the Pare dam; to foothill towns, Pasighat, Tezu, Namsai and Roing, on bhabar fans and flood plains of main stems whose level is set upstream, at Pasighat by outbursts in Tibet; to hill and high-range towns, Ziro, Bomdila, Tawang, Seppa, Daporijo and Aalo among them, where water put into the slope moves the ground and snow lies in winter; to glacial lakes that NDMA lists as high-risk; to rainfall that the national products barely cover, a CWC subzone whose isopluvials stop at the foothills, a capital whose only frequency analysis, from NERIST's gauge at Doimukh, reads about one contour above the plate, and a gridded product that doubles the foothill values; to drains that carry the towns' untreated sewage; to a statewide building rule, the APBBL 2019, with the strongest slope rule of the North-East editions but no number for the distance from a nallah; to a statutory GIS master plan for the capital that diagnoses the drains but sets no design storm; to land held largely by communities, clans and individuals, so that land for a drain or a corridor is secured by agreement, donation, purchase or reservation in a plan, never taken; to a planning law being rewritten around Town Planning Schemes and a "sponge city"; and to a wet season that begins with the April storms of the east and the May rain of the foothills, so that on landslide ground, on the outburst reaches and below the dams a BSMP begins with the hazard, not the storm (Clause 11.3.3).

11.2 Definitions

Term	Meaning in this Manual
Basin	The land draining to one outfall to the sea, a river, or a major waterbody, as delineated under Clause 11.3.
Basin Stormwater Master Plan (BSMP)	The plan for one basin prepared under this chapter.
Lead Authority	The body responsible for preparing a BSMP (Clause 11.4).
Level of service (LoS)	The flood performance a part of the drainage system must achieve, expressed as an AEP and an outcome (Clause 11.6).
Flood hazard map	A map of flood extent, depth, velocity and hazard class (H1–H6, Chapter 6) for a stated AEP and scenario.
Regional facility	A storage, conveyance or outfall work serving more than one development, identified in a BSMP.
Capital Improvement Programme (CIP)	The ranked, costed list of works in a BSMP (Clause 11.8.4).

11.3 Planning unit: the basin, not the ward

11.3.1 BSMPs shall be prepared **by hydrological basin**, not by ward, zone or local-body boundary. Where a basin crosses local-body boundaries, one BSMP shall cover the whole basin.

11.3.2 Basin boundaries shall be delineated from the digital elevation model of Clause 11.5.2, checked against the drain network, road embankments, canals and tank supply channels. Diversions between basins, whether by canal, drain or surplus course, shall be mapped and represented in the model.

11.3.3 No basin delineation has been published for any Arunachal Pradesh town. For the urban areas where the evidence identifies them, the basins are at least the following, in the order of the flood-sensitive catchments of Clause 4.5.3.2:

- **Itanagar, Senki:** the catchment of the **Senki** through Itanagar to its confluence with the Pachin, with the lift intake of the town's supply, CPCB's monitored stretch at Chandranagar and the Senki View culvert washed away in September 2018 shown, the drain register marking the reaches that carry sewage and the reaches on community, clan or private land, and surveyed flood marks and the 1% AEP level with its sediment, debris and bulking as the boundary, since the river has no gauge;
- **Itanagar and Naharlagun, Pachin:** the catchment of the **Pachin** through Itanagar and Naharlagun to the Dikrong near Nirjuli, with its palaeochannels and swampy land mapped and the Dikrong's level at the confluence, from the model of the Dikrong reach below, as the boundary;
- **Naharlagun, Nirjuli and Doimukh, Dikrong and Papu Nallah:** the catchments that drain to the **Dikrong** below the Pare dam, **Papu Nallah** among them, with the outfalls as outfall-closed cases under the interim design tailwater of Clause 5.8.5(a), both failure cases modelled (the river low with the nallahs blocked, and the river high with the Pare release and the Ranganadi tailrace backing up the outfalls), and the surveyed flood marks of 1999, 2017, September 2018, 2024 and May–June 2025;
- **NH-415, Itanagar to Naharlagun:** the catchments that cross NH-415, with Energy Park, Bank Tinali, Niti Vihar, Abo Tani Colony and the drains of the Bage Tinali–Naharlagun road (as reported), the closures of 2017 and the slides and earth-cutting sites along the road mapped;
- **Modirijo and Donyi Polo:** the catchments of the streams that flooded Modirijo and Donyi Polo in September 2018, within the basins of the Senki and the Pachin (this Manual's reading [TBC]), with the Press Colony bridge and the landslide from "the dumping area of NH 415" (as reported) mapped, under the hazard-first rule below;

- **Pasighat, Siang:** the catchments of the town that drain to the **Siang** and its side channels, with the CWC danger level (153.96 m) as the design boundary and the highest flood level (157.54 m, 11 June 2000) as the check (Clause 5.8.5(c)), the erosion at Jarkong and the Mebo villages (as reported) and the bhabar fan and its avulsion channels mapped;
- **Tezu, Lohit:** the catchments of the town that drain to the **Lohit**, with the CWC highest flood level at Tezu (192.14 m, 16 July 1996) as the boundary until a danger level is given [TBC], and the fan and its channels mapped;
- **Namsai and Miao, Noa-Dihing:** the catchments of the two towns that drain to the **Noa-Dihing**, with the CWC levels at Namsai (danger level 145.8 m, highest flood level 146.6 m) and Miao (highest flood level 241.57 m) as the boundaries (Clause 5.8.5(c));
- **Roing, Dibang:** the catchments of the town that drain to the **Dibang**, which has no CWC site, with the 1% AEP level from a hydraulic model and the surveyed flood marks as the boundary;
- **Yazali, Ranganadi:** the catchments of Yazali and the NEEPCO colony at Poosa on the reach of the **Ranganadi** at Yazali, where the flood of 24 June (2025 or 2026, a conflict) came from a side stream of about 17 km² while the main river stayed in its channel (as reported), so the side streams are modelled as hill streams (Clause 5.8.5(b)) and the Ranganadi's release as the boundary (Clause 5.8.5(d)); and
- **Tawang and Dibang Valley, glacial-lake and outburst reaches:** the town catchments below the glacial lakes that NDMA lists as high-risk, 6 in Tawang and 16 in Dibang Valley among the State's 27 (as reported), under the hazard-first rule below.

Hazard first on landslide ground, the outburst reaches and the release reaches (set by this Manual). On the hazard-first sites of Clause 2.3.6(i), which include the landslide ground on Siwalik sandstone, shale and boulder beds, colluvium, slope debris and fill, the earth-cutting sites along NH-415, the bhabar fans and avulsion corridors at Pasighat, Ruksin, Roing, Tezu, Namsai, Bhalukpong and Banderdewa, the main stems of the Siang, Dibang, Lohit, Subansiri, Kameng and Tawang Chu, the glacial lakes and the release reaches below the Pare, Ranganadi, Kameng and Lower Subansiri projects, and in every basin below one of them, the BSMP begins with a hazard screening for landslides, debris flows, flash floods, outbursts and dam releases, made with NDMA's list of glacial lakes, CWC's monitoring of glacial lakes and the hazard maps of APSDMA and the District Disaster Management Authorities where they exist [TBC], and the operators' release reaches [TBC], and in snow-fed and glaciated catchments uses site-specific hydrology in place of a CWC report, which neither report supplies (Clause 2.3.6(b) and (i)). The outburst of the Yigong landslide dam in Tibet on 10–11 June 2000 is the check event for Pasighat: it gave the CWC highest flood level of 157.54 m, 3.58 m above the danger level (as reported), and "a recorded rise of 5.5 m at the Pasighat gauge, 462 km downstream" (a peer-reviewed analysis, as summarised); it lies outside the design storm, and its stage governs siting, floor levels and the screening, not the size of a drain. The ground moves more than the design storm here: 14 people died at Laptap on 11 July 2017 (14 to 16 by other counts) and at least 3 in the Modirijo and Donyi Polo floods of September 2018, and the Siang ran turbid at 425 NTU at Pasighat on 27 November 2017 after landslide dams formed in Tibet (all as reported). The hazard zones are shown on the 1% AEP map, no drain, storage or pumping station is sited in them, and no work in the CIP is sized to carry a debris flow, a landslide or an outburst. Other Tier A bodies and the Tier B local bodies define their basins in the first BSMP that covers them. Where a master plan, a Town Planning Scheme, NEEPCO, NHPC, WRD, CWC or a court has a flood level, a reservoir level, a line or an operating rule for a dam or gate, the BSMP shall take its boundary conditions from it and show those levels against its own 1% AEP map.

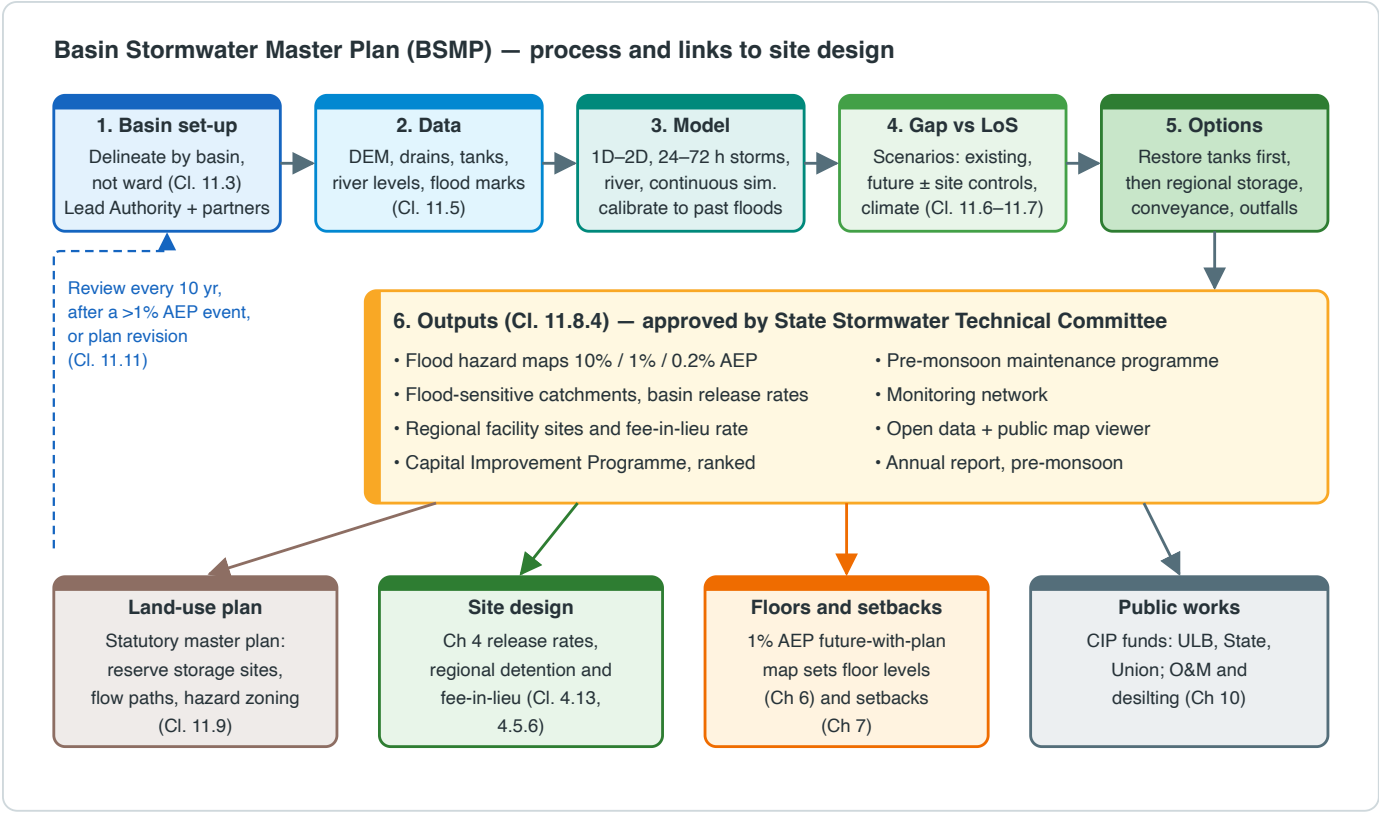

Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.

Commentary. Water does not follow ward boundaries. A ward-by-ward drain plan can pass the problem to the next ward, and to the next local body. In Arunachal Pradesh a single stream passes through many hands, and through land held in several ways, on its way to a river. In the capital the Senki runs through Itanagar to the Pachin, and supplies 7 MLD of the town's water by lift (Master Plan of Itanagar Capital Region-2031, report); the Pachin "passes through most of the area before it debouches to Dikrang river near Nirjuli" (a CGWB document, as summarised); Naharlagun drains to the Dikrong, whose flood plain, with the Pachin's, carries palaeochannels and swampy land (CGWB, Papum Pare district booklet), and Papu Nallah is a named channel of Naharlagun; and below Doimukh the Dikrong carries the releases of the Pare dam and the tailrace of the Ranganadi project. The three rivers are at once storm drains and sewers: the master plan finds "storm water drains being used as sewers", the Senki at Chandranagar, upstream of the Pachin, is in CPCB's Priority V (2025), and the National Green Tribunal has kept O.A. No. 94/2020/EZ on the Senki, the Pachin and the Dikrong open since November 2020, asking whether two sewage treatment plants would suffice "across the entire stretch of 145 Kms" (as reported). The capital's land is held in several ways at once. The municipal area of the Itanagar Municipal Corporation (Itanagar, Naharlagun, Nirjuli and Banderdewa) and the Itanagar Capital Region of the master plan, which adds Doimukh, are not the Deputy Commissioner's district of the Itanagar Capital Complex; much land near the towns is held by communities, clans and individuals, and the beds of rivers, streams, nallahs, lakes and tanks are the Government's only where they "are not the property of any person or community" (Arunachal Pradesh (Land Settlement and Records) Act, 2000, s.9(1)); so a stream that crosses the capital crosses municipal land, community and clan land, private land and Government land. In Pasighat the town drains to the Siang and its side channels, on whose banks erosion has reached Jarkong near the airfield and the villages of Mebo (as reported), and Tezu, Namsai and Roing drain to the Lohit, the Noa-Dihing and the Dibang. The drains vest in IMC and in the Pasighat Municipal Council (Arunachal Pradesh Municipal Corporation Act, 2019, s.200; Arunachal Pradesh Municipal Act, 2007, s.102), the road drains are PWD's or PWD (Highways)'s, the rivers WRD's, the reservoirs and release reaches NEEPCO's and NHPC's to operate, and the drains on community land outside a ULB the community's. Below them the main stems leave the State: the Siang, the Lohit, the Subansiri, the Ranganadi and

> the Kameng flow on across the State border, where other plans govern. No rule divides the natural streams from the municipal drains, and no notification divides the drains among their owners (this Manual's reading). This clause makes the basin the planning unit, so that one model carries each stream and nallah from its head on the ridge to the river or reservoir whoever owns each reach, so that a drain register gives every reach an owner, a land status (community, clan, individual, municipal or Government land) and an outfall, and so that the sewage it carries is separated before it reaches the river or a pond (Chapter 8, Clause 8.9.5).

11.4 Who prepares, and when

11.4.1 **Lead Authority.**

- For the basins of the Itanagar Capital Region (Itanagar, Naharlagun, Nirjuli, Doimukh and Banderdewa): the **Itanagar Municipal Corporation (IMC)**, in which the public drains, streams and springs within its limits vest (Arunachal Pradesh Municipal Corporation Act, 2019, s.200), jointly with the **Department of Urban Affairs** (Town Planning wing), which issues the building bye-laws and prepared the master plan, and the **Itanagar Planning Authority**, the Local Planning Authority for the region under the Arunachal Pradesh Urban and Country Planning Act, 2007, into whose master plan, layouts and Town Planning Schemes the BSMP is taken (Clause 11.9). Each role is the one the body would have if the Manual were adopted. The **Smart City company** is a partner for its works until they are handed over. For the basins of Pasighat: the **Pasighat Municipal Council**, in which the public drains vest (Arunachal Pradesh Municipal Act, 2007, ss.102, 194 and 196), with the **Department of Urban Affairs**. Where a basin extends beyond a local body's limits, the communities and clans whose land it crosses and the other local bodies and Local Planning Authorities in the basin are partners, and one BSMP covers the whole basin (Clause 11.3.1); on community or clan land the BSMP is guidance unless the owners or the community agree to it or a permission or plan carries it.
- No notification dividing the natural streams from the municipal drains, or the drains among their owners, was found; until one is made, this Manual assigns the reaches within each BSMP as follows, each body being Lead Authority for the reaches and works it owns or runs and for the parts of the CIP on them: the **Water Resources Department (WRD)** for the rivers, their beds and banks, and the anti-erosion works, among them the Dikrong, the Siang, the Lohit, the Noa-Dihing and the Dibang; **IMC** and the **Pasighat Municipal Council** for the public drains, streams and springs vested in them; the **Department of Urban Affairs** and the **Smart City companies** for the storm drains, sewerage and septage works they have built, until handed over in writing; **PWD** and **PWD (Highways)** for the side drains, catch-water drains and culverts of State roads and of NH-415 and the other national highways, with the slide debris and spoil of their works; **PHED** for water supply [TBC]; **NEEPCO** and **NHPC** as the operators of the Pare, Ranganadi, Kameng and Lower Subansiri projects, whose levels and releases a BSMP needs as data, not as approving authorities; the **community** for the drains on community or clan land outside a ULB, if it adopts the Manual; and the **Arunachal Pradesh State Disaster Management Authority (APSDMA)**, with the District Disaster Management Authorities, for the mapping of landslide, flood, debris and outburst hazards that a BSMP must show.
- In the other towns, which are Tier B: the Lead Authority is named by the Department of Urban Affairs, if the Manual is adopted. Basins draining to a common river reach or reservoir may be grouped into one district-level plan.

APSDMA and the Deputy Commissioner shall be consulted on every BSMP; NEEPCO or NHPC on every BSMP whose basin drains to one of their reservoirs or to the reach below its dam; the Arunachal Pradesh State Pollution Control Board (APSPCB) on every BSMP that proposes works on a drain or stream that carries sewage, among them the Senki, the Pachin and the Dikrong; the owners, communities and clans on every BSMP that crosses their land or needs it for a corridor, storage or outfall, which is secured by agreement, donation, purchase or reservation in a plan, never taken; and, for a basin whose outfall lies on a river that flows on across the State border, the water resources department downstream, through WRD.

The Water Resources Department (WRD) shall be a partner in every BSMP that includes a river, canal or tank under its control.

11.4.2 **When a BSMP is required.**

- (a) Every Tier A body shall approve BSMPs covering its whole area within **3 years** of this Manual taking effect.
- (b) A BSMP is required before:
  - any regional detention or fee-in-lieu is accepted under Clause 4.13;
  - a fee held under Clause 4.5.6.3 is spent; and
  - a basin-specific release rate is applied under Clause 11.8.3.
- (c) A Tier B body shall prepare a BSMP where its Lead Authority, or the State Stormwater Technical Committee, finds recurrent flooding of buildings or arterial roads.

11.4.3 **Preparation.** BSMPs shall be prepared by, or under the direction of, an engineer empanelled as a Stormwater Design Professional (Chapter 10) with experience in basin-scale modelling.

11.5 Data and surveys

11.5.1 Each BSMP shall assemble and publish (Clause 11.10) the data in Table 11.1:

Table 11.1 — Minimum data and surveys for a BSMP

Data	Minimum requirement
Terrain	Digital elevation model from LiDAR or photogrammetry, with vertical accuracy of 0.15 m RMSE or better in urban areas, tied to the Survey of India datum
Drain network	Inventory of all public drains, culverts and outfalls with invert levels, sizes, condition and silt depth; private drains above 600 mm
Waterbodies	Survey of every tank, pond, pond and marsh under Chapter 7: FTL, MWL, bund level, stage–storage, sluices, surplus weirs, supply channels, encroachment
Rivers and canals	Cross-sections at no more than 200 m spacing and at every structure
Outfalls, rivers, streams, nallahs, ponds and reservoirs	The datum of every level named; outfall invert levels against a surveyed level of the receiving river at the outfall; for the Siang at Pasighat, the Noa-Dihing at Namsai and the Lohit at Tezu, the CWC danger level and highest flood level (as transcribed by SANDRP, as reported) on CWC's datum once stated [TBC], with the Pasighat HFL of 11 June 2000 marked as an outburst stage from Tibet; for the Senki, the Pachin and the Dikrong in the capital and the Dibang at Roing, which have no CWC site, surveyed flood marks (on the Dikrong those of 1999, 2017, September 2018, 2024 and May–June 2025) and any local gauge kept as a separate series; for the hill streams and nallahs, surveyed flood marks, the debris and garbage lines of past floods and the 1% AEP flood level with its sediment, debris and bulking; for outfalls on the release reaches of the Pare, Ranganadi, Kameng and Lower Subansiri projects, the levels, spillway and gate data and release records of NEEPCO and NHPC on a named datum, naming which is used [TBC]; ponds at their surveyed spill levels; the glacial lakes, landslide dams and debris fans above the basin, from NDMA's list and CWC's monitoring, and the landslide and flood hazards from the inventories of APSDMA and the District Disaster Management Authorities where they exist [TBC]; and the flap gates, penstocks, debris racks, screens, silt traps, debris basins and any pumping stations on the outfalls, with their capacities and operating rules

Data	Minimum requirement
Rainfall and levels	All available rain gauges (IMD, including the network reported by the Meteorological Centre Itanagar, whose automatic weather stations and rain gauges were not listed in any source found [TBC], and the IMD stations at Pasighat (42220), Tezu (01203), Ziro (42312, printed "Zero") and Hayuliang (01212, rain records 1971–1985); the daily gauge of NERIST at Doimukh (1988–2012); the State ordinary gauges used in the CWC Flood Estimation Report for subzone 2(a), which are not named on the pages read [TBC]; the CWC sites on the Siang, the Noa-Dihing, the Lohit, the Subansiri and the Ranganadi; the rain and reservoir records of NEEPCO and NHPC at the Pare, Ranganadi, Kameng and Lower Subansiri projects [TBC]; and any gauges or sensors kept by the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Smart City companies, WRD and the Arunachal Pradesh State Disaster Management Authority (APSDMA) [TBC]) and water-level records, including those for the September 2018 (the Modirijo and Donyi Polo floods in Itanagar–Naharlagun on or about 14 September, with 3 dead and at least 4 missing in early reports and up to 7 dead in later ones, a conflict, the Senki View culvert and the Press Colony bridge washed away, as reported, and no rainfall value found), 23 June 2024 (Itanagar and Naharlagun, with 66 houses inundated, as reported, and 40 mm between 10:30 and 12:30 "As per IMD", as quoted from the secretary of the State's disaster management authority, who said that IMD "confirmed there was no incident of cloudburst"), July 2024 (the reported Itanagar "cloudburst" of about 28 July, with NH-415 submerged and homes near Energy Park and Bank Tinali flooded, as reported, its date in conflict between dateline and publication and kept apart from 23 June, and no rainfall value found), late May to 7 June 2025 (the statewide floods and landslides, with 12 dead by one count and 9 to 11 by others, a conflict, and a peak release of 1,310 m³/s from the Pare dam on 31 May, all as reported, with only press values of rain), 24 June 2025 or 2026 (the Poosa / NEEPCO colony flood at Yazali, dated 2026 by one report and 2025 by another, a conflict, with 73 mm in 24 hours, mostly in 3 hours, as reported) and the 2017 monsoon (the capital's floods that damaged the protection walls of nallahs and closed NH-415, recorded in the Master Plan of Itanagar Capital Region-2031, with no rainfall value found) events
Flood evidence	Surveyed flood marks and mapped flood extents from past events, including public reports
Land use	Existing land use and imperviousness; future land use from the statutory master plan
Soils and groundwater	HSG map (Annex 3A); seasonal high groundwater; aquifer and recharge zones
Sewer interaction	Known sewage cross-connections, dry-weather flow in drains, and solid-waste hotspots

Commentary. The 0.15 m accuracy has no direct precedent; this Manual sets it because on the valley floor of Naharlagun, Nirjuli and Doimukh along the Dikrong and the Pachin, with their palaeochannels and swampy land, on the bhabar fans and flood plains of Pasighat, Ruksin, Roing, Tezu and Namsai, where the rivers back up into the drains and the channels can shift, on the release reaches below the dams, and on pond margins and the few flat benches of the hill towns, where a raised road, a dumped fill or a low wall can turn an overflow from one side of a valley floor to the other, a small error in ground level moves the flood edge a long way, and the 1% extent from the BSMP sets floor levels (Chapter 6) and setbacks (Chapter 7). Past flood marks matter as much as models. The September 2018 (the Modirijo and Donyi Polo floods in Itanagar–Naharlagun on or about 14 September, with 3 dead and at least 4 missing in early reports and up to 7 dead in later ones, a conflict, the Senki View culvert and the Press Colony bridge washed away, as reported, and no rainfall value found), 23 June 2024 (Itanagar and Naharlagun, with 66 houses inundated, as reported, and 40 mm between 10:30 and 12:30 "As per IMD", as quoted from the secretary of the State's disaster management authority, who said that IMD "confirmed there was no incident of cloudburst"), July 2024 (the reported Itanagar "cloudburst" of about 28 July, with NH-415 submerged and homes near Energy Park and Bank Tinali flooded, as reported, its date in conflict between dateline and publication and kept apart from 23 June, and no rainfall value found), late May to 7 June 2025 (the statewide floods and landslides, with 12 dead by one count and 9 to 11 by others, a conflict, and a peak release of 1,310 m³/s from the Pare dam on 31 May, all as reported, with only press values of rain), 24 June 2025 or 2026 (the Poosa / NEEPCO colony flood at Yazali, dated 2026 by one report and 2025 by another, a conflict, with 73 mm in 24 hours, mostly in 3 hours, as reported) and the 2017 monsoon (the capital's floods that damaged the protection walls of nallahs and closed NH-415, recorded in the Master Plan of Itanagar Capital Region-2031, with no rainfall value found) events are the best calibration data Arunachal Pradesh has, and much of the evidence is held in photographs, news reports and residents' records that should be collected before it is lost.

11.6 Levels of service

11.6.1 Each BSMP shall adopt the following minimum levels of service. A BSMP may adopt stricter levels.

Table 11.2 — Minimum levels of service

Element	Minimum level of service
Minor system	The design AEP of Chapter 6 (Table 6.1)
Habitable buildings	No flooding above floor level in the 1% AEP (100-yr) event
Critical facilities (hospitals, emergency services, substations, water and sewage plants)	No flooding of the facility in the 0.2% AEP (500-yr) event; access road passable in the 1% AEP event
Evacuation routes and arterial roads	Passable (hazard class H2 or better, Chapter 6) in the 1% AEP event
Ponding drain time	Surface water cleared from roads within **6 hours** after rain ends in the 10% AEP (10-yr) event
Tank and pond storage	No net loss of flood storage below the MWL in the basin, measured against the earliest available survey
Outfalls	Functioning under the joint and outfall-closed cases of Chapter 5

Commentary. The building and road levels repeat Chapter 6, so that the basin plan and the site designs aim at the same outcome. The 0.2% AEP for critical facilities, the 6-hour ponding drain time and the no-net-loss rule for tank storage have no direct precedent and are set by this Manual. The drain time reflects what residents notice most after a storm. The no-net-loss rule reflects a loss of storage that has been reported but not measured. Arunachal Pradesh's storage is in its ponds, swamps and low land on the valley floors, its lakes and its reservoirs more than in tanks; it has no irrigation tank cascades, so the tank clauses of this chapter apply to ponds, lakes and any impounded water. The Forest Department's truthing lists 1,127 wetlands of 2.25 ha or more in 19 districts, 944 of them high-altitude lakes, 24 aquaculture ponds, 12 ox-bow lakes, 8 waterlogged areas, 3 lakes, 2 tanks or ponds, 1 reservoir and 1 paddy field, with 130 entries found to be shadows and boundaries demarcated for 997; only 6 are in Papum Pare. The first census of water bodies counted 993 in the State, 893 rural and 100 urban, with none reported encroached (a Rajya Sabha answer, as summarised). Ganga Lake (Gyakar Sinyi), in the Itanagar Wildlife Sanctuary about 6 km from Itanagar, faces encroachment and earth-cutting pressure (as reported); it is a lake in a sanctuary, not storage, and is never counted as detention. Glaw Lake in Lohit district was announced as the State's first Ramsar site on 3 August 2026 (as reported). No wetland notified under Rule 4 of the Wetlands Rules, 2017 was found. The master plan records that sewage is "drained to open or vacant land as well as into ponds" and that "The natural water bodies such as ponds and streams are getting polluted", and the bye-laws ask every urban local body and planning authority to "identify, demarcate, protect and maintain the water bodies that come under their jurisdiction" and prepare a list (APBBL 2019, Annexure E, 1.8), but no such list was found. Town Planning Schemes may provide for "the filling-up or reclamation of low-lying, swampy or unhealthy area, or levelling-up of land" (Ordinance No. 5 of 2025), the main statutory risk to ponds, swamps and paddy-field storage in Itanagar–Naharlagun and Pasighat, to which the compensatory storage of Clause 7.6.4 applies. No survey of the storage of any pond, or of the low land and flood plain inside any town, was found.

11.7 Modelling and scenarios

11.7.1 **Model.** Each BSMP shall use a coupled 1D–2D hydraulic model of:

- the minor system;
- the major (overland) system;
- rivers, canals and tanks; and
- the outfalls.

Methods shall follow Chapter 3. Tidal and river boundaries shall follow Chapter 5.

11.7.2 **Design storms.** The model shall be run for the design storms of Chapter 2, including the 24-, 48- and 72-hour storms, for at least the 50%, 10%, 1% and 0.2% AEPs. Areal reduction shall be applied under Clause 2.7.3.

11.7.3 **Continuous simulation.** Basins with tank cascades shall also be run by continuous simulation (Clause 3.13), using the full IMD gridded daily record where available and at least 30 years, disaggregated by the temporal patterns of Annex 2D. This shows how full the tanks are when the design storms arrive, and how often heavy rain coincides with a closed outfall. The two-step approach of Clause 3.13.5 may be used: a simplified storage model is run for the whole record, and the coupled 1D–2D model of Clause 11.7.1 is run only for the design storms, starting from the tank levels the continuous run gives. A continuous run of the full 1D–2D model is not required.

11.7.4 **Scenarios.** Each BSMP shall model at least:

- (a) **Existing:** existing land use, network, tanks and outfalls;
- (b) **Future, uncontrolled:** future land use under the statutory master plan, with no site controls;
- (c) **Future, controlled:** future land use with the site controls of Chapter 4;
- (d) **Future, with plan:** scenario (c) plus the works of the CIP; and
- (e) **Climate:** scenarios (a) and (d), with the climate factors of Clause 2.8, used unchanged: no projection of heavy rainfall for Arunachal Pradesh has been adopted with a design factor; the State Action Plan on Climate Change (draft, July 2011) projects annual rainfall 5% to 15% lower in the 2030s and 25% to 35% higher by the 2080s, with the pre-monsoon the exception to the decrease of the 2030s, and gives no factor for extreme rainfall or for intensity–duration–frequency relations (a press summary places the decrease in the 2050s, a conflict); the plan reports "spatial variability in rainfall trend (increasing as well as decreasing trend)"; a researcher is reported to find declining totals with more frequent high-intensity events (as reported; no paper seen), which is a reason to keep the factors, not to reduce them, while the Meteorological Centre Itanagar is reported to say that one season is not enough to show a trend (as reported); NIH-DHAARA's projected depths are not used; and on the hazard-first sites of Clause 2.3.6(i), the outburst reaches of the main stems among them, the hazard screening of Clause 11.3.3 is made in every scenario.

11.7.5 **Calibration.** The model shall be calibrated and validated under Clause 3.15, using at least two of the September 2018 (the Modirijo and Donyi Polo floods in Itanagar–Naharlagun on or about 14 September, with 3 dead and at least 4 missing in early reports and up to 7 dead in later ones, a conflict, the Senki View culvert and the Press Colony bridge washed away, as reported, and no rainfall value found), 23 June 2024 (Itanagar and Naharlagun, with 66 houses inundated, as reported, and 40 mm between 10:30 and 12:30 "As per IMD", as quoted from the secretary of the State's disaster management authority, who said that IMD "confirmed there was no incident of cloudburst"), July 2024 (the reported Itanagar "cloudburst" of about 28 July, with NH-415 submerged and homes near Energy Park and Bank Tinali flooded, as reported, its date in conflict between dateline and publication and kept apart from 23 June, and no rainfall value found), late May to 7 June 2025 (the statewide floods and landslides, with 12 dead by one count and 9 to 11 by others, a conflict, and a peak release of 1,310 m³/s from the Pare dam on 31 May, all as reported, with only press values of rain), 24 June 2025 or 2026 (the Poosa / NEEPCO colony flood at Yazali, dated 2026 by one report and 2025 by another, a conflict, with 73 mm in 24 hours, mostly in 3 hours, as reported) and the 2017 monsoon (the capital's floods that damaged the protection walls of nallahs and closed NH-415, recorded in the Master Plan of Itanagar Capital Region-2031, with no rainfall value found) events where data exist.

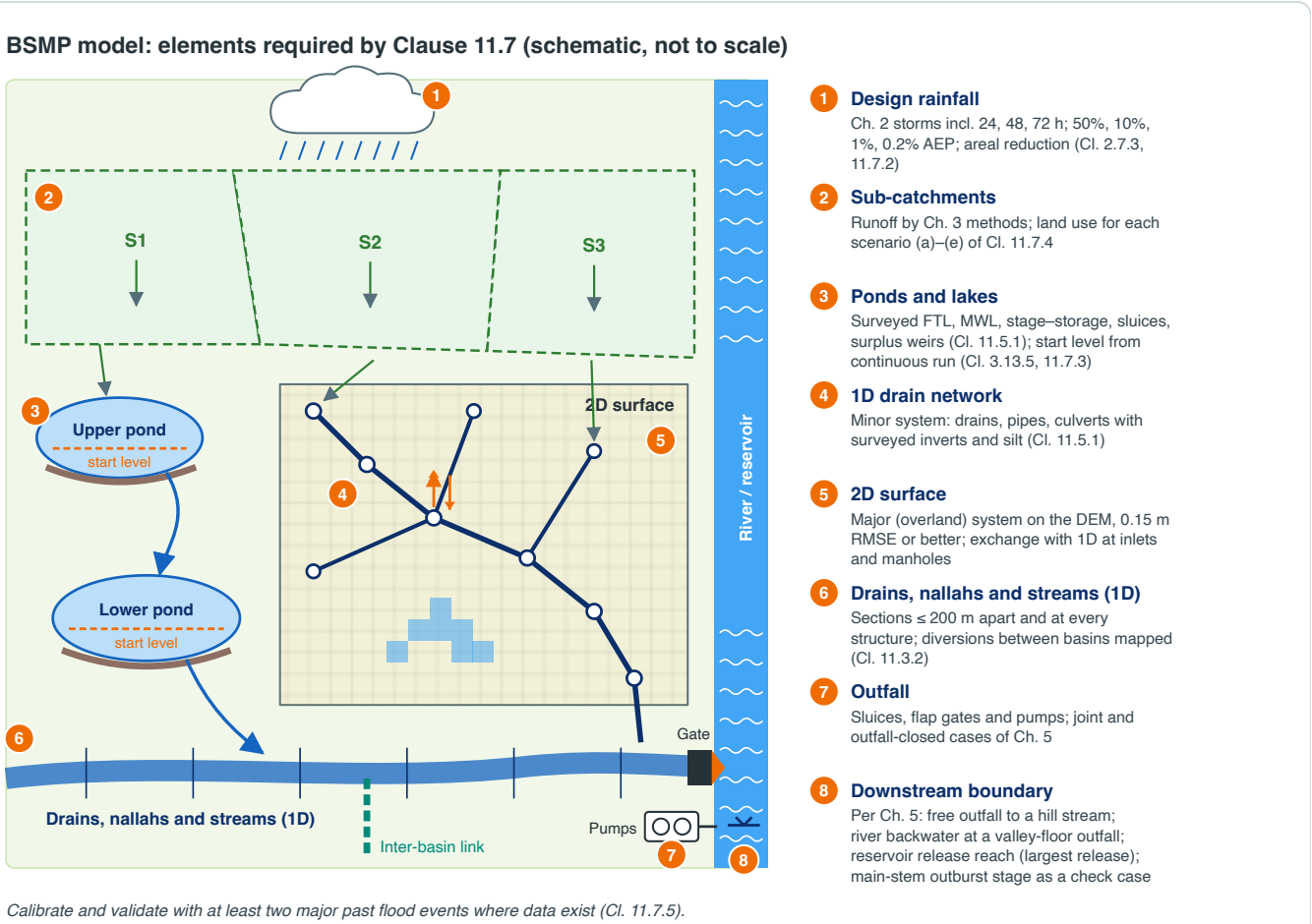

Figure 11.2 — Elements of the BSMP model required by Clause 11.7: sub-catchments, the 1D drain and channel network, the 2D surface, tanks and ponds with starting levels from continuous simulation, and the tidal or river boundary at the outfall (schematic, not to scale). Original drawing for this Manual, adapted from common coupled 1D–2D urban flood modelling practice.

> **Commentary.** Scenario (b) against scenario (c) shows what the site rules achieve on their own. Scenario (d) shows what the public works add. This comparison is also the evidence base for notifying flood-sensitive catchments (Clause 4.5.4) and for setting a stricter basin release rate (Clause 11.8.3).

11.8 Options, outputs and the Capital Improvement Programme

11.8.1 **Options hierarchy.** Options shall be considered in the following order, the basin-scale form of the hierarchy in Clause 1.2:

1. **Protect and restore storage:** ponds, tanks, marshes and floodplains, including desilting to the original bed and recovering encroached area (Chapter 7);
2. **Regional retention and detention**, sited by modelling so that releases do not coincide with the main-stem peak (Clause 4.13);
3. **Conveyance** upgrades to drains, canals and culverts;
4. **Outfall works:** flap gates on the outfalls of the nallahs and drains of Naharlagun, Nirjuli and Doimukh to the Dikrong and of the town drains of Pasighat, Tezu, Namsai and Roing to the main stems, where a river in flood can close an outfall, with storage behind them, and pumping only where the outfall-closed check of Chapter 5 shows that storage alone cannot serve, since no pumping station on a storm drain was found in the State [TBC];

screens, debris racks and silt traps at the mouths of the nallahs and where the hill streams leave the hills for a valley floor or a fan; debris racks, silt traps and debris basins above the culverts of the hill rim of the capital, of NH-415 and of the other hill roads, with ramps for the machines that empty them; drop structures, chutes, energy dissipators and protected outfalls where steep drains reach a stream or nallah, never an unprotected slope; the interception and screening of dry-weather flow before the outfalls to the Senki, the Pachin and the Dikrong and to the main stems at Pasighat, Tezu, Namsai and Roing, and before any pond used as storage (Chapter 8, Clause 8.9); and release scenarios, agreed with NEEPCO and NHPC, for the drains on the reaches below the Pare, Ranganadi, Kameng and Lower Subansiri projects;

5. **Property-level protection** where works cannot reach the level of service; and
6. **Non-structural measures:** flood warning (for example IMD district rainfall warnings and nowcasts issued by the Meteorological Centre Itanagar, CWC level forecasts for the Siang at Pasighat and the Noa-Dihing at Namsai, warnings of releases from the Pare, Ranganadi, Kameng and Lower Subansiri projects under protocols agreed with NEEPCO and NHPC [TBC], level gauges with alarms on the Senki, the Pachin and the Dikrong in the capital, which have no published gauge today, alerts of outbursts on the Siang from upstream in Tibet and from the glacial lakes that NDMA lists, and the alerts of APSDMA and the District Disaster Management Authorities), flood-hazard zoning, emergency planning and public information.

11.8.2 **Option assessment.** Each option shall be assessed for:

- reduction in flood risk (buildings and people flooded; expected annual damage);
- capital and 30-year maintenance cost;
- land required;
- effect on the springs and streams that supply the hill towns and villages, which in Papum Pare discharge 0.43–2 litres a second before the monsoon and of which "most of the springs become dry during dry season" (CGWB), and their recharge areas above the intakes, which this Manual keeps free of paving and of infiltrated road runoff, the stability of hill slopes on Siwalik shale, colluvium, slope debris and fill, where water put into the ground raises the pore pressure, recharge on the tested sandy terrace and valley-fill soils of the Naharlagun–Nirjuli–Doimukh valley and on the coarse bhabar fan heads, the only ground where it is allowed, and not within 30 m of a dug well or spring used for drinking water (Clause 4.11, recharge rule), although groundwater is not short (stage of extraction 0.39%, CGWB 2024, as summarised), the shallow water table of the valley floors and flood plains, and the quality of the groundwater, which carries iron (0.14–0.78 mg/L in the springs of Papum Pare, CGWB), and of the streams, nallahs, ponds and reservoirs that the runoff reaches (Chapter 8);
- effect on downstream basins and the receiving river, stream, nallah, pond or reservoir; and
- who benefits.

11.8.3 **Basin release rates.** Where scenario (c) does not meet the level of service, the BSMP may set a basin-specific **permissible site discharge** (m³/s/ha) stricter than Chapter 4, by AEP and sub-catchment. The rate takes effect under the notification procedure of Clause 4.5.4.

11.8.4 **Outputs.** Each BSMP shall produce:

- (a) flood hazard maps (extent, depth, velocity, hazard class) for the 10%, 1% and 0.2% AEPs, existing and future-with-plan. The **1% AEP future-with-plan map** becomes the reference map for floor levels (Chapter 6) and setbacks (Chapter 7);
- (b) recommended flood-sensitive catchments and any basin release rates (Clauses 4.5.4 and 11.8.3);
- (c) regional facility sites, with storage volumes, land needs and the sites they serve;
- (d) the fee-in-lieu unit rate for the basin (Clause 4.13.3);
- (e) the **Capital Improvement Programme**: works ranked by risk reduction per rupee, with cost, phasing and agency;
- (f) a pre-monsoon **maintenance programme**: desilting, gate and pump testing, and tank operating rules (Chapter 10); and
- (g) monitoring needs: new rain gauges, level sensors and flood-mark survey points.

Commentary. Restoring storage comes first because the outfalls of the capital's valley floor and of the main-stem towns are closed or limited in the wettest hours, and because the storage left is in ponds, swamps and low land that a Town Planning Scheme may reclaim (Ordinance No. 5 of 2025). The State's planning law is itself being rewritten around storage: Ordinance No. 5 of 2025 defines a "sponge city" as "an area that acts like a sponge, soaking up and retaining water during rain and storms and releasing it slowly" and lets the Government "prepare policy documents for … Sponge City … Risk Informed master Plan" (new s.71(2)(za)); an amending Bill was reported passed on 9 March 2026 (as reported), and its Act number and final text were not found [TBC], so whether that power stands in the amended Act is not known; and no policy document under it was found. The bye-laws already ask for "Artificial or natural Storage of storm water runoff from larger sites" (APBBL 2019, 9.6) and an unpaved area of at least 20% of the recreational open spaces of large projects (Table 14.1). The Master Plan of Itanagar Capital Region-2031, by contrast, proposes a drainage network designed on the "topography of the region and flow gradient", that is, conveyance. This Manual's storage-first rules, on-site detention, ponds and low land kept as storage, and release at pre-development rates (Chapters 4, 7 and 11), are an engineering form of the Ordinance's definition, and the Manual could be offered as technical input to such a policy document; it is not one, and it does not criticise the master plan, which was written for land use. Storage matters here for three reasons. First, the capital's outfalls back up when the Dikrong carries the Pare releases and the Ranganadi tailrace, so removing water faster fills the nallahs sooner when the river is high (Clause 5.8.5(a)). Second, the drains of Pasighat, Tezu and Namsai back up from the Siang, the Lohit and the Noa-Dihing, whose level is set upstream (Clause 5.8.5(c)). Third, water sent downstream faster reaches the reaches across the State border, on the Ranganadi and the Subansiri below the projects, where other plans govern. In the hills storage means a lined tank or a terrace, never a pond that soaks into the ground (Clause 4.11, hill rule); the rainwater storage of at least 25 litres per m² of roof that Clause 4.11 sets, where the bye-laws require harvesting without a volume (APBBL 2019, 9.1), is the first of it, and it also serves the towns when the springs run low in the dry months. Conveyance upgrades on their own move water faster to a nallah outfall that the Dikrong may close when it carries the Pare releases, to a main-stem outfall at Pasighat, Tezu or Namsai whose level is set upstream, to a hill stream whose bed and banks shift with the gravel, slide debris and garbage it carries, to a release reach whose level the dam's releases set, or to the villages and the reaches downstream across the State border. Groundwater in Arunachal Pradesh calls for storage and restraint, not recharge. The State draws little of what it has, with a stage of extraction of 0.39% (CGWB, 2024, as summarised), although the State Action Plan on Climate Change (draft, 2011) reports growing demand on groundwater in the foothill districts as surface sources decline; no State observation-well network was found, and the wells reported are CGWB's [TBC]. In the hills water put into the ground can do harm: Papum Pare "is underlain mostly by Siwalik group of rocks", its hill slopes are covered by residual soil or slope debris, and "The entire older metamorphic formation of Paleozoic is overthrusted over the Younger Tertiary Siwaliks" (CGWB, Papum Pare district booklet), so on Siwalik shale, colluvium, slope debris and fill infiltration raises the pore pressure on slopes that slide. On the valley floors and fans the ground is different but the water is near the surface: the Dikrong valley's water stood 2–4 m below ground before the monsoon and 2–5 m after it, the semi-consolidated formations of Papum Pare 1–5 m, East Siang 1.50–11.13 m, Lohit about 3.5 m (2008) and the dug wells of Bhalukpong 2.62–5.50 m in the lean period (CGWB district booklets), and 15 of the State's 27 stations stood within 2 m of the surface in August 2025 (CGWB, as summarised). In East Siang the "Gondwana group acts as a run off zone while Siwalik group is the recharge zone" and the piedmont plain "is highly permeable", and in Lohit "The Bhabar is mostly composed of boulders while flood plain is composed of fine sand and silt" (CGWB); at Doimukh NERIST measured infiltration falling from 12 cm/h to a basic rate of 1 cm/h after 250–300 minutes on a soil of 95.19% sand (Dabral et al., 2016). Iron is the main quality issue, 0.14–0.78 mg/L in the springs of Papum Pare and flagged in East Siang and Changlang (CGWB). The springs matter more than the wells: in Papum Pare they discharge 0.43–2 litres a second before the monsoon and 0.02–2.4 after it, and "most of the springs become dry during dry season", while in the northern hills of East Siang springs are the only source (CGWB); the Municipal Corporation Act vests "all public streams, springs and works for the supply … of water" in the Corporation, but no spring inventory was found and springs were not researched for this Manual [TBC]. The capital's supply comes from the Senki by lift (7 MLD) and from the Poma (11 MLD) and the Niorch (7 MLD) by gravity (Master Plan of Itanagar Capital Region-2031, report), and the Poma pipeline broke in the floods of June 2025 (as reported). This is why springs and their recharge areas, slope stability, recharge only on the

tested sandy terrace soils of the Naharlagun–Nirjuli–Doimukh valley and the coarse bhabar fan heads (Clause 4.11, recharge rule), the shallow water table and groundwater quality are all assessment criteria, and why rainwater harvesting here means storage and reuse. This Manual ranks projects by risk reduction per rupee so that limited budgets go first where most people are protected.

11.9 Integration with land-use planning

11.9.1 An approved BSMP shall be incorporated into the statutory land-use plan: the Master Plan of Itanagar Capital Region-2031, approved under section 24 of the Arunachal Pradesh Urban and Country Planning Act, 2007, and the master plans of the other Local Planning Areas once any is approved; the layouts approved under that Act (APBBL 2019, 2.10.3); the Town Planning Schemes that Ordinance No. 5 of 2025 provides for, in whatever form the amending Act takes [TBC]; the APBBL 2019, which apply to the whole State; and the buildings permitted under them; on community or clan land outside any of these, the BSMP is guidance for the owners or the community unless they take it up. In particular:

- (a) regional facility sites, restored tank flood storage, and major flow paths shall be **reserved** in the plan;
- (b) the 1% AEP hazard map shall be shown, and Chapter 7 setbacks applied to it;
- (c) land in hazard classes H5–H6 in the 1% AEP event shall not be zoned for new habitable development; and
- (d) the open space of layouts within a basin should be located, where possible, to form part of the major flow paths or regional storage shown in the BSMP.

11.9.2 Where a land-use plan is revised before a BSMP is approved, the planning authority shall use the best available flood mapping and record the BSMP as pending.

Commentary. Arunachal Pradesh draws no water line in law. No statute or bye-law found sets a numerical setback from a stream, nallah, spring, pond or drain, and no floodplain zoning law or Bill was found (this Manual's reading). What exists is a reference without a number: the site plan must show the "Distance from Nallah/Stream as per the notified rules/norms" and the "Distance from Disaster Prone Area as per norms set by Disaster Management Authority" (APBBL 2019, 2.10.1(e) and (f)), and no such rules or norms were found. The bye-laws also define a *Jhot*, "A strip of land permanently left open for drainage purposes", which "is not to be used as an access way or a street and is not to be included as a part of setbacks" (definition 69), without a width; ask large projects to keep "The inlet and outlet point of natural drain system … with adequate size of channel for ensuring unrestricted flow of water" (Table 14.1); list "sacred groves, hills, hillocks, water bodies (and the areas adjoining the same)" as natural features to be "listed in notification(s) … / identified in Master Plan" (Chapter 12); and count as flood-prone the areas "flooded under conditions of heavy intensity rains, inundation in depressions, back flow in drains, inadequate drainage, etc. as identified through local surveys in the development plan of the area" (definition of a natural hazard prone area). The plinth is "not less than 300 mm" above the surrounding ground (4.2.1.1), and no high flood level fixed by any local authority was found for any town [TBC]. The master plan's 30 m green buffers line its new 30, 45 and 60 m roads, not its streams (Master Plan of Itanagar Capital Region-2031, report). Town Planning Schemes may provide for "the filling-up or reclamation of low-lying, swampy or unhealthy area, or levelling-up of land" (Ordinance No. 5 of 2025), which can remove the storage this chapter relies on. Much land near the towns is held by communities, clans and individuals, and stream and nallah beds on it are not the Government's (Arunachal Pradesh (Land Settlement and Records) Act, 2000, s.9(1)). Where a master-plan line or a Town Planning Scheme governs, it applies; elsewhere the hydraulic corridor and setback zones of Chapter 7 apply as this Manual's proposal, with a Zone 1 of at least 15 m from the top of bank on every channel draining 8 ha or more, including the capital's nallahs, the Senki, the Pachin and the Dikrong, and round every pond and spring the Manual covers, and a Zone 2 to the 1% AEP extent plus 10 m, whichever is wider; the 15 m is offered as the "norms" to which 2.10.1(e) refers, which the State could notify, and it applies to new development and redevelopment approved under this Manual, not to existing buildings. The corridor is a condition of building permission and layout approval wherever the bye-laws apply, which is the whole State (2.1), and a

recommendation for works on community land outside any permission; Zone 1 land that is community, clan or private land is secured by agreement with the owners or the community, by donation, by purchase, or by reservation in a master plan, layout or Town Planning Scheme, never taken by this Manual; where the State decides that land must be obtained compulsorily, the Arunachal Pradesh Municipal Act, 2007 routes it through the "Land of Acquisition Act, 1894" (as printed) and allows "other methods of land assembly including the use of transferable development rights" (s.104), and this Manual states that route and does not invoke it. A BSMP gives the master plans, the Town Planning Schemes and the local surveys of the bye-laws' flood-prone definition the 1% AEP drainage-flood map and the buffer widths of Chapter 7 that they need. Using open space land as storage or flow path has no direct precedent; this Manual adopts it because the APBBL 2019 already require public open spaces of more than 500 m² to have "arrangements for complete utilization and capture of storm water", including "Artificial or natural Storage of storm water runoff from larger sites" (9.6), require on large projects an unpaved area of at least 20% of the recreational open spaces and the inlet and outlet of the natural drain system "maintained with adequate size of channel for ensuring unrestricted flow of water" (Table 14.1), and define a *Jhot*, "A strip of land permanently left open for drainage purposes" (definition 69), and Ordinance No. 5 of 2025 defines a "sponge city" as "an area that acts like a sponge, soaking up and retaining water during rain and storms and releasing it slowly", but no rule sets a detention volume or a peak-runoff limit; storage placed in a layout's open space builds on these, and because that land still serves as open space, the storage must stay usable as one, and on a hill slope or on shale it is a lined tank or a shallow terrace, never an infiltration basin (Clause 4.11, hill rule). Placing it on the flow path costs the developer nothing extra and gives the basin storage it would otherwise have to buy.

11.10 Consultation and publication

11.10.1 A draft BSMP shall be published for public comment for at least **60 days**, with public meetings in each affected local body.

11.10.2 After approval, the following shall be published as open data:

- the model files;
- the flood hazard maps;
- the data of Clause 11.5.1, except security-sensitive asset details; and
- the CIP.

They shall also be shown on a public map viewer.

> Commentary. Publishing the maps lets buyers, lenders, insurers and residents see flood hazard before they build or buy. Publishing the model lets designers use the same boundary conditions as the Authority, so site designs and the basin plan stay consistent. This matches the publication approach of Chapter 10.

11.11 Approval, review and reporting

11.11.1 **Approval.** BSMPs shall be approved by the State Stormwater Technical Committee (Chapter 1), after review of the model and of the public comments.

11.11.2 **Review.** Each BSMP shall be reviewed:

- every **10 years**;
- within **2 years** of an event exceeding the 1% AEP design depth in the basin (Clause 2.14); and

- when the statutory land-use plan is revised.

11.11.3 **Annual report.** The Lead Authority shall publish an annual implementation report before each monsoon (by 31 March). The report shall show:

- CIP progress;
- the fee-in-lieu ledger (Clause 4.13.4);
- maintenance completed; and
- any flooding against the levels of service.

11.12 Interim arrangements

11.12.1 Until a BSMP is approved for a basin:

- (a) all site criteria of Chapters 4 to 8 apply in full;
- (b) regional detention and fee-in-lieu under Clause 4.13 are not available, except the holding of fees under Clause 4.5.6.3;
- (c) floor levels and setbacks use the best available mapping, and the methods of Chapters 6 and 7 where no mapping exists; and
- (d) public drain projects shall include a basin-level check that their outfall and downstream reaches can take the design flow under the Chapter 5 tailwater cases.

References (chapter)

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Annexes and forms

Annex / Form	Content
11A	BSMP terms of reference template
11B	Basin lists and boundaries for Tier A bodies
11C	Depth–damage curves for Arunachal Pradesh building types
11D	BSMP data and model publication standard
Form 11-1	Annual implementation report

ANNEXES TO CHAPTER 1

Policy, Applicability and Adoption

These annexes support Chapter 1. They hold the lists and maps that define where the Manual applies, the model text of the Policy Supplement and of the legal instruments that would give the Manual effect, and the two forms an Applicant files under Chapter 1. The Manual is a draft; it is not adopted by any government or agency: model legal text is offered for consideration by a competent authority and is not in force, and the forms are draft forms. An annex marked "To be prepared" states the data it needs and the rule to use until it is published (Clause 1.11.5).

Annex 1A — List of Tier A authorities, with the boundaries of the Itanagar Municipal Corporation area and of the Master Plan of Itanagar Capital Region-2031

Supports Clauses 1.6.1 to 1.6.5 of Chapter 1.

1A.1 Clause 1.6.1 defines Tier A by class of authority. Table 1A.1 sets out the classes, and the authorities named in the clause, as Chapter 1 defines them. Every authority not in Table 1A.1 is Tier B (Clause 1.6.2).

Table 1A.1 — Tier A authorities as defined in Clause 1.6.1

Item	Tier A authority	Clause
(a)	The Itanagar Municipal Corporation (IMC)	1.6.1(a)
(b)	Every approving authority within the area of the Master Plan of Itanagar Capital Region-2031 (Itanagar, Naharlagun, Nirjuli, Doimukh and Banderdewa): the Itanagar Planning Authority for layouts and the Authority under the APBBL 2019 for building permits, whichever has jurisdiction over a site	1.6.1(b)
—	A Tier B authority that opts into Tier A by council resolution, or that the Government notifies as Tier A	1.6.4

1A.2 Whatever the tier, the design-aid route and the alternatives of Clause 1.7 are not available in a flood-sensitive catchment (Clause 1.6.5; Annex 1B).

To be prepared. This annex will contain the full list, by name, of every Approving Authority within the area of the Itanagar Municipal Corporation and of the Master Plan of Itanagar Capital Region-2031, with the date from which each is Tier A, and the boundaries of those areas as a map and as a GIS layer. It needs the limits of the Itanagar Municipal Corporation, whose constituting notification under the 2019 Act was not found and whose extension to Jullang, Chimpu and nearby villages was proposed in March 2026 (as reported) [TBC], and of the Pasighat municipal area (the Department of Urban Affairs, the urban local bodies); the planning area of the Itanagar Planning Authority and the Local Planning Areas notified elsewhere, with any Town Planning Schemes (the Department of Urban Affairs, Town Planning wing); the limits of community and clan land inside and beside the towns, shown as the communities state them, without this Manual deciding them; and the district and circle boundaries (land revenue offices of the Deputy Commissioners, Survey of India). Until it is published, the tier is decided by the classes in Clause 1.6.1 and recorded on Form 1-1, and the Authority confirms it at the pre-application stage (Clause 1.5.9).

Table 1A.2 — Register of Tier A authorities (layout)

No.	Authority	Class (Municipal Corporation / Municipal Council / Local Planning Authority / Authority under the bye-laws / other)	District	Basis (Clause 1.6.1(a), (b), (c) or 1.6.4)	Tier A from (date)	Notification or resolution reference
1						
2						
3						

1A.3 The Itanagar Capital Region and Itanagar Municipal Corporation boundary map shall be published as open data in a machine-readable format (Clause 10.17.4), with the date of the notification it shows.

Annex 1B — Maps of flood-sensitive catchments

Supports Clauses 1.4, 1.6.5 and 1.10.3(d) of Chapter 1, and Clauses 4.5.3 and 4.5.4 of Chapter 4.

1B.1 The flood-sensitive catchments are listed in Clause 4.5.3.2. Table 1B.1 repeats that list. The maps of this annex and the boundaries of Annex 4A are the same data set and shall be issued together.

Table 1B.1 — Flood-sensitive catchments listed in Clause 4.5.3.2

Item	Catchment	Extent as described in Chapter 4
(a)	The Senki through Itanagar	The land of Itanagar that drains to the Senki down to its confluence with the Pachin, where the Senki View culvert was washed away in September 2018 (as reported); CPCB lists the Senki at Chandranagar, upstream of the Pachin, as a polluted stretch (Priority V; CPCB, 2025), and Itanagar's lift supply draws 7 MLD from it (master plan)
(b)	The Pachin through Itanagar–Naharlagun	The land of Itanagar and Naharlagun that drains to the Pachin, which "passes through most of the area before it debouches to Dikrang river near Nirjuli" (CGWB, as summarised) and, "flowing through densely populated areas", had "become a waste disposal site" (master plan); its flood plain has palaeochannels and swampy land (CGWB)
(c)	The Dikrong at Naharlagun, Nirjuli and Doimukh, with Papu Nallah	The land of Naharlagun, Nirjuli and Doimukh that drains to the Dikrong, with Papu Nallah, on the reach that carries the releases of the Pare dam (peak 1,310 m³/s on 31 May 2025) and the tailrace of the Ranganadi project (as reported); the 1999 flood is the local benchmark (as reported); no CWC gauge on the reach; NEEPCO's release protocol was not found [TBC]
(d)	The NH-415 corridor from Itanagar to Naharlagun	The land draining to and across NH-415 between Itanagar and Naharlagun, which the 2017 floods closed, with traffic diverted via Papu Nallah and Jullang Road (master plan), and where Energy Park, Bank Tinali, Niti Vihar and Abo Tani Colony flooded or slid in June and July 2024 and the drains of the Bage Tinali–Naharlagun road were found "too shallow and narrow" and clogged with earth-cutting debris (as reported)
(e)	The Modirijo and Donyi Polo catchments	The land of Itanagar and Naharlagun that drains through Modirijo and Donyi Polo, where cloudburst floods about 14 September 2018 killed 3 people with at least 4 missing (up to 7 dead in later reports), washed away the Press Colony bridge and brought a landslide from "the dumping area of NH 415" (as reported)
(f)	Pasighat on the Siang	The land of Pasighat that drains to the Siang and its side channels, on the reach whose CWC highest flood level, 157.54 m on 11 June 2000, is the outburst stage of the Yigong landslide dam in Tibet, 3.58 m above the danger level of 153.96 m (CWC data as transcribed by SANDRP, as reported); with the erosion at Jarkong near the airfield and in the Mebo villages (as reported)
(g)	Tezu on the Lohit	The land of Tezu that drains to the Lohit, whose CWC highest flood level at Tezu is 192.14 m (16 July 1996; no danger level transcribed [TBC]) (as reported), on the bhabar fan of the river

Item	Catchment	Extent as described in Chapter 4
(h)	Namsai and Miao on the Noa-Dihing	The land of Namsai and Miao that drains to the Noa-Dihing, whose CWC levels are a danger level of 145.8 m and a highest flood level of 146.6 m at Namsai and a highest flood level of 241.57 m at Miao (as reported; SANDRP notes that the Namsai values "changed without explanation")
(i)	Roing on the Dibang	The land of Roing that drains to the Dibang and its fans, where no CWC site exists; CPCB lists the Dibang at Roing (upstream) as a polluted stretch (Priority V; CPCB, 2025); NHPC's Dibang project is under construction (status not researched [TBC])
(j)	The Ranganadi reach at Yazali	The land at Yazali that drains to the Ranganadi below the Ranganadi (Panyor) project and its side streams, where the flash flood of 24 June (2025 or 2026; year in conflict) from a side catchment of about 17 km² struck the Poosa / NEEPCO colony while "the main river stayed in its channel" (as reported); CWC's highest flood level at Yazali is 623.1 m (14 June 2008, as reported)
(k)	The glacial-lake and outburst reaches of Tawang and Dibang Valley	The land along the streams below the glacial lakes that NDMA lists as high-risk, 6 in Tawang district and 16 in Dibang Valley district (as reported), and any town reach on their path, screened under Clause 2.3.6(i)
(l)	Notified catchments	Any catchment notified under Clause 4.5.4

To be prepared. This annex will contain a map of each catchment in Table 1B.1 at a scale fit for deciding whether a plot lies inside it, and the same boundaries as a GIS layer. It needs catchment boundaries drawn from a digital elevation model and the drain and nallah network (IMC, the Pasighat Municipal Council, the Department of Urban Affairs, the communities for community and clan land, Survey of India); the nallahs and drains with their outfalls, the dry-weather interceptions on them and the gates where any exist [TBC], with levels on a stated datum (the urban local bodies, the Department of Urban Affairs); the flood marks of 1999, 2017, September 2018, June and July 2024 and May–June 2025 in the capital region and the localities that flooded (the Deputy Commissioners, the District Disaster Management Authorities, APSDMA and the Department of Disaster Management); the CWC levels of the Siang at Pasighat, the Lohit at Tezu and the Noa-Dihing at Namsai and Miao, with their datum, which the transcriptions do not state [TBC] (CWC); the release records and release protocols of the Pare, Ranganadi, Kameng and Lower Subansiri projects (NEEPCO, NHPC) [TBC]; the landslide inventories of the capital region and the NH-415 and NH-13 corridors [TBC]; and NDMA's list of the high-risk glacial lakes by name, with CWC's glacial-lake monitoring [TBC]. Ziro, Bomdila, Seppa, Daporijo, Aalo and the other hill towns are candidates for notification under Clause 4.5.4 once their catchment boundaries and flood record are documented [TBC]. The corridors of Chapter 7 are governed by Chapter 7 rather than by this list. Until it is published, the Authority decides at the pre-application stage whether a site lies in a listed catchment, from the best boundary available, and the decision and its basis are recorded on Form 1-1 and in the drainage report (Clauses 1.5.9 and 1.11.5).

Table 1B.2 — Attributes of the flood-sensitive catchment layer (layout)

Field	Content	Unit or format
catchment_id	Unique identifier	text
name	Catchment name	text
basis	Clause 4.5.3.2 item (a) to (k), or the notification under Clause 4.5.4	text
notification_ref	Gazette notification number, where notified	text
notified_on	Date of notification	date
applies_from	Date from which the rule applies to applications (Clause 4.5.4.2, step 5)	date
boundary_source	Source and date of the boundary	text

Field	Content	Unit or format
area_km2	Catchment area	km²

Annex 1C — Policy Supplement: text of alternatives S-1 to S-5 and model council resolution

Supports Clauses 1.6.3, 1.6.5 and 1.7.1 to 1.7.3 of Chapter 1.

> **Model text for consideration by a competent authority. Not in force.** The text below shows how the Policy Supplement of Clause 1.7 could be written. It has no effect unless and until it is issued by the Government and adopted by an Approving Authority under Clause 1.7.3.

Part 1 — General provisions

P1.1 **Scope.** This Supplement sets out alternatives S-1 to S-5 to the requirements of the Arunachal Pradesh Stormwater Design Manual (the Manual) named in each alternative. An alternative applies within the area of an Approving Authority (the Authority) only from the date on which the Authority adopts it under P1.3.

P1.2 **No lower criterion.** No alternative lowers any criterion of the Manual. S-1 and S-2 are simplified methods for meeting the same criterion (Clause 1.7.3(a)).

P1.3 **Adoption.**

- (a) A Tier B authority adopts an alternative by council resolution in the form of Part 3, and sends a copy to the State Stormwater Technical Committee (the Committee) within 30 days of the resolution.
- (b) A Tier A authority adopts an alternative only after the Committee has concurred in writing.
- (c) The Authority publishes the alternatives it has adopted on its website and in the register of Clause 10.17.

P1.4 **Retention.** No alternative replaces the retention requirement (Annex 2E depth), except where fee-in-lieu under S-5 funds equivalent retention in the same basin (Clause 1.7.3(d)).

P1.5 **Tables.** The tables used by S-1, S-2 and S-3 are those issued by the Committee, and are reviewed with Chapter 2 of the Manual (Clauses 1.7.3(e) and 2.14). An alternative that depends on a table cannot be used until that table is issued.

P1.6 **Record.** An Applicant who uses an alternative states it on Form 1-1 and in the drainage report, with the resolution or concurrence under which it was adopted.

Part 2 — The alternatives

S-1 — Design-aid route for storage

S-1.1 *Replaces:* storage sized by a hydrograph method under Chapter 3.

S-1.2 *Alternative:* retention and detention volumes may be taken from the unit-storage tables issued for Annex 4B (m³ per ha, by rainfall zone, hydrologic soil group and impervious fraction) and the compliance calculator, by the method of Clause 4.14.2.

S-1.3 *Eligibility:* sites of 2 ha or less outside flood-sensitive catchments, and of 0.5 ha or less within them (Table 1.2; Clause 4.14.1).

S-1.4 *Conditions:* the post-development imperviousness used shall be that shown on the approved plans; the outlet, spillway, RWH accounting and safety provisions of Clause 4.14.2 apply; the compliance calculator may be the sole calculation (Table 1.1).

S-2 — Permissible site discharge (PSD)

S-2.1 *Replaces:* the release rate Q_post(T) ≤ 0.9 × Q_pre(T) computed for the site (Clause 2.11.2).

S-2.2 *Alternative:* the release rate for each AEP may be taken as the tabulated unit-area release rate for the site's zone and AEP, multiplied by the site area. The tabulated rates are derived from the 0.9 × Q_pre rule (Table 1.2).

S-2.3 *Eligibility:* any site outside a flood-sensitive catchment.

S-2.4 *Conditions:* storage is then sized to hold every duration of Clause 2.5.2 at the PSD; drawdown, minimum orifice and spillway rules of Chapter 4 apply unchanged.

S-3 — Fixed-width waterbody setback

S-3.1 *Replaces:* the waterbody setback extended to the mapped 1% AEP flood extent plus margin (Chapter 7).

S-3.2 *Alternative:* where no 1% AEP extent is mapped, the setback shall be the fixed width for the class of waterbody in the table of Clause 7.4.6 (and Annex 7B), measured as in Clause 7.4.3.

S-3.3 *Eligibility:* waterbodies with no mapped 1% AEP extent.

S-3.4 *Conditions:* no setback under this alternative is less than the Zone 1 minimum of Clause 7.4.7 (Clause 1.10.3(c)); the no-fill zone of Chapter 7 applies; where a 1% AEP extent is later mapped and adopted, the mapped setback applies to new applications.

S-4 — Downstream screening checklist

S-4.1 *Replaces:* downstream analysis by hydraulic model under Chapter 5.

S-4.2 *Alternative:* the Applicant completes a screening checklist of downstream capacity and known flooding, covering at least the conditions of Clause 5.3.4: that the receiving public drain has documented capacity for its minor-system design flow (Chapter 6), and that no flood-prone location is recorded within 500 m downstream. A hydraulic model under Chapter 5 is required only where the screen fails.

S-4.3 *Eligibility:* sites of less than 1 ha, outside flood-sensitive catchments, not discharging to a tidal outfall.

S-4.4 *Conditions:* the checklist is signed by the registered professional who signs the drainage report (Clause 10.6); flood-prone locations are those recorded by the local body, the Deputy Commissioner and the District Disaster Management Authority, the Arunachal Pradesh State Disaster Management Authority (APSDMA) and the Department of Disaster Management, WRD, or the community (Clause 5.3.3(d)).

S-5 — Fee-in-lieu toward regional storage

S-5.1 *Replaces:* on-site detention under Chapter 4.

S-5.2 *Alternative:* all or part of the detention requirement may be met by a fee-in-lieu toward a regional detention facility or restored pond or tank storage identified in the basin plan (Clause 4.13.1).

S-5.3 *Eligibility:* sites in a basin for which a basin plan has been notified (Table 1.2).

S-5.4 *Conditions:*

- (a) the conditions of Clause 4.13.2 apply, including interim on-site detention until the regional facility or restored tank is operational, and retention and WQv treatment on site;
- (b) the fee is computed under Clause 4.13.3 and held in the ring-fenced basin account;

- (c) the volume credited and the fee are entered in the public ledger of Clause 4.13.4; and
- (d) in a flood-sensitive catchment, fee-in-lieu is available only as allowed by Clause 1.10.3(d).

Part 3 — Model council resolution

> **Model text for consideration by a competent authority. Not in force.**

Resolution No. _____ of _____ (name of Municipal Corporation / Municipal Council), dated _____

Subject: Adoption of alternatives under the Policy Supplement to the Arunachal Pradesh Stormwater Design Manual.

The Council, having considered the report of the Commissioner / Executive Officer dated _____, and noting that:

- (i) the Arunachal Pradesh Stormwater Design Manual and its Policy Supplement have been given effect by _____ (instrument and date);
- (ii) this local body is a Tier B / Tier A authority under Clause 1.6 of the Manual; and
- (iii) for a Tier A authority, the State Stormwater Technical Committee concurred on _____ (reference _____),

resolves:

1. to adopt the following alternatives of the Policy Supplement within its area, under the conditions of Clause 1.7.3 of the Manual:

Table 1C.1 — Alternatives adopted by this resolution

Alternative	Adopted (Yes / No)	Area to which it applies (whole area, or wards / zones)	Applies from (date)
S-1 Design-aid route			
S-2 Permissible site discharge			
S-3 Fixed-width setback			
S-4 Downstream screening checklist			
S-5 Fee-in-lieu			

2. that no adopted alternative shall apply within a flood-sensitive catchment except as the Manual allows (Clause 1.6.5);
3. that a copy of this resolution be sent to the State Stormwater Technical Committee within 30 days;
4. that the adopted alternatives be published on the local body's website and entered in the register of Clause 10.17; and
5. that this resolution be reviewed when the tables of Clause 1.7.3(e) are revised.

Mayor / Chairperson: _____ Commissioner / Executive Officer: _____ Date: _____

Annex 1D — Model APBBL 2019 amendment and model ULB bye-law

Supports Clauses 1.3.1, 1.3.4, 1.11 and 1.12 of Chapter 1.

Model text for consideration by a competent authority. Not in force. The text shows one way the instruments of Clause 1.3.1 could be drafted. Rule and section numbers are left blank.

Drafting note D1D.1. The rule numbers of the Arunachal Pradesh Building Bye-Laws, 2019 at which the new rule and the conditions would be inserted, and the enabling sections of the Arunachal Pradesh Urban and Country Planning Act, 2007 and the municipal and panchayat Acts, are to be confirmed by the Government's legal advisers. None is stated here.

Part A — Model amendment to the Arunachal Pradesh Building Bye-Laws, 2019

A.1 **Short title and commencement.**

- (1) These rules may be called the Arunachal Pradesh Building (Stormwater Management) (Amendment) Bye-Laws, _____.
- (2) They shall come into force on the date six months after their publication in the Arunachal Pradesh Gazette (Clause 1.11.1).

A.2 **Insertion of a new rule.** After rule [_____] of the building bye-laws issued by the Department of Town Planning and ULBs, Government of Arunachal Pradesh, which extend to the whole State, the following rule shall be inserted:

Rule [_____]. Stormwater management.

(1) *Definitions.* In this rule, "the Manual" means the Arunachal Pradesh Stormwater Design Manual as notified by the Government, with its annexes and amendments; other words have the meanings given in Clause 1.4 of the Manual.

(2) *Application.* This rule applies to every development for which planning permission, building permit or layout approval is required under these rules.

(3) *Runoff control.* Where a development, over its common plan of development, involves land disturbance of 0.1 ha or more, or new or replaced impervious area of 500 m² or more, the development shall comply with Chapters 4 and 5 of the Manual (retention, detention, downstream and tailwater analysis).

(4) *Provisions for every development.* Every development, whatever its size, shall comply with Clause 1.5.4 of the Manual: no sewage connection to a storm drain; floor levels; waterbody setbacks and the no-fill zone; and no obstruction of a drainage path.

(5) *Exemptions.* A single dwelling on its own plot below the thresholds of sub-rule (3), and linear road resurfacing that adds no impervious area, are exempt from sub-rule (3) but not from sub-rule (4) or the rainwater harvesting provisions of these rules.

(6) *Conditions of approval.* The competent authority shall not grant:

- (a) planning permission or layout approval, unless a preliminary drainage report under the Manual has been accepted;
- (b) a building permit, or permission to commence, unless the final drainage design has been accepted; or
- (c) a completion certificate, unless the as-built certificate has been accepted and the maintenance declaration has been registered, or the public assets have been handed over,

for a development to which sub-rule (3) applies (Manual, Clause 10.3).

(7) *Certification.* Drainage reports and designs shall be signed by a registered professional, and, where Clause 10.6.1 of the Manual so requires, by an empanelled Stormwater Design Professional.

(8) *Rainwater harvesting.* Nothing in this rule alters the rainwater harvesting provisions of these rules.

(9) *Variances and waivers.* The competent authority may grant a variance or waiver only on the grounds and by the procedure of Clause 1.10 of the Manual, and shall publish each decision.

(10) *Transition.* Applications filed complete before the commencement of this rule, and Tier B authorities, are governed by Clause 1.11 of the Manual.

Part B — Model ULB bye-law

B.1 **Title and commencement.** These bye-laws may be called the _____ (name of local body) Stormwater Management Bye-laws, _____. They come into force on _____.

B.2 **Adoption of the Manual.** The Arunachal Pradesh Stormwater Design Manual, as notified by the Government, applies to:

- (a) every development approved by the local body; and
- (b) every drainage, road, culvert, waterbody and flood-mitigation work executed by the local body, including its own drains and roads (Clause 1.3.1(b)).

B.3 **Public works.** Every detailed project report and contract for a work under B.2(b) shall require compliance with the Manual, from the dates in Clause 1.11 (Clause 1.3.4).

B.4 **Tier and alternatives.** The local body is a Tier _____ authority under Clause 1.6 of the Manual. The alternatives of the Policy Supplement adopted by the local body are listed in the Schedule, with the resolution under which each was adopted.

B.5 **Submittals and review.** Submittals shall be made in the stages of Clause 10.3 of the Manual and reviewed within the periods of Clause 10.7.

B.6 **Maintenance, inspection and enforcement.** Maintenance declarations, inspections, handover of public assets and enforcement shall follow Clauses 10.10 to 10.15 of the Manual.

B.7 **Publication.** The local body shall publish the registers and reports of Clause 10.17 of the Manual.

B.8 **Review.** These bye-laws shall be reviewed whenever the Manual is amended under Clause 1.12.

Table 1D.1 — Schedule: alternatives adopted (layout)

Alternative	Resolution number and date	Committee concurrence (Tier A only)	Applies from	Area

Form 1-1 — Applicability Determination

Supports Clauses 1.5.1 to 1.5.9 and 1.6 of Chapter 1, and Clause 10.3 of Chapter 10.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Lodged at the pre-application meeting (Stage 0) or with the preliminary drainage report (Stage 1), as Clause 10.3.2 requires.

Table 1F.1 — Form 1-1: Applicability Determination

No.	Item (clause)	Entry
	A. Applicant and site	
A1	Applicant (owner, developer or department)	_____
A2	Site address and survey numbers	_____
A3	Site coordinates (latitude, longitude)	_____
A4	Approving Authority (Clause 1.4)	_____
A5	Tier of the Authority: A / B (Clause 1.6; Annex 1A)	_____
A6	Approval sought: planning permission / building permit / layout approval / public work (DPR)	_____
A7	Type of development: building / layout / sub-division / road / paving / land-use change / other (Clause 1.4)	_____
A8	Stage at which this form is lodged: Stage 0 / Stage 1 (Clause 10.3)	_____
	B. Coverage (Clause 1.5.1)	
B1	Development requiring approval under the Arunachal Pradesh Building Bye-Laws, 2019 — 1.5.1(a): Yes / No	_____
B2	Public work by a ULB, State department, board or State undertaking — 1.5.1(b): Yes / No	_____
B3	Work by a Central agency needing the Authority's approval or no-objection — 1.5.1(c): Yes / No	_____
	C. Areas over the common plan of development (Clauses 1.4, 1.5.5)	
C1	Phases, plots and sub-divisions included (one layout approval or one ownership)	_____
C2	Total site area (ha)	_____
C3	Land disturbance (ha)	_____
C4	Existing impervious area (m²)	_____
C5	New impervious area (m²)	_____
C6	Replaced impervious area, removed to subgrade and rebuilt (m²)	_____
C7	New plus replaced impervious area, C5 + C6 (m²)	_____
C8	Plot area for the RWH mandate (m²) (Clause 1.5.3)	_____
	D. Thresholds and exemptions	
D1	Land disturbance 0.1 ha or more — 1.5.2(a): Yes / No	_____
D2	New or replaced impervious area 500 m² or more — 1.5.2(b): Yes / No	_____
D3	Redevelopment (existing impervious cover on the site) — 1.5.6: Yes / No	_____
D4	Constrained redevelopment route of Clause 4.5.6 proposed: Yes / No	_____

No.	Item (clause)	Entry
D5	Linear public work: added impervious area per drainage catchment crossed given in Table 1F.2 — 1.5.7: Yes / No / not applicable	_____
D6	Exemption claimed — 1.5.8(a) single dwelling below the thresholds / 1.5.8(b) resurfacing with no added impervious area / none	_____
D7	RWH mandate applies (APBBL 2019, 9.1 and Annexure E 1.1: buildings on plots of 100 m² and more; 9.7: recharge for buildings of 500 m² and more and for parks, parking and plazas; 9.6: public open spaces of more than 500 m²) — 1.5.3: Yes / No	_____
	E. Site conditions	
E1	Site in a flood-sensitive catchment (Annex 1B; Clause 4.5.3): No / Yes — name	_____
E2	Source of the catchment boundary used	_____
E3	1% AEP level mapped or determinable for the site (Clause 1.5.4(b)): Yes / No; source	_____
E4	Waterbody on or adjoining the site (Clause 1.5.4(c); Chapter 7): No / Yes — name	_____
E5	Natural drainage path or major-system flow path crossing the site (Clause 1.5.4(d)): No / Yes	_____
E6	Site drains to a tidal outfall (Clause 10.3.2(d)): Yes / No	_____
E7	Variance, waiver, regional facility or fee-in-lieu proposed (Clause 10.3.2(c)): No / Yes — Form 1-2 attached	_____
	F. Determination	
F1	Result: (i) Chapters 4 and 5 apply, with Clause 1.5.4 and the RWH mandate; (ii) Clause 1.5.4 and the RWH mandate only (below thresholds); (iii) exempt under 1.5.8, Clause 1.5.4 and the RWH mandate still apply	_____
F2	Stage 0 mandatory under Clause 10.3.2: Yes (state item (a) to (d)) / No	_____
F3	Storage method: hydrograph method (Chapter 3) / design-aid route S-1 (Clause 1.7, where adopted and eligible)	_____
F4	Other Policy Supplement alternatives relied on (S-2 to S-5), with the adopting resolution	_____
F5	Tier B phased start applies (Clause 1.11.3): Yes / No	_____
	G. Declaration	
G1	I declare that the information above is correct and covers the whole common plan of development. Applicant: name, signature, date	_____
G2	Prepared by (registered professional, Clause 1.4): name, registration number, signature, date	_____
	H. For the Authority (Clause 1.5.9)	
H1	Determination confirmed / corrected	_____
H2	Corrections and reasons	_____
H3	Officer: name, designation, signature, date	_____

Table 1F.2 — Form 1-1: added impervious area by drainage catchment, linear works (Clause 1.5.7)

Drainage catchment crossed	Chainage from – to	Added impervious area (m²)	500 m² or more (Yes / No)	Storage location: right of way / regional facility

Form 1-2 — Variance / Waiver Request

Supports Clause 1.10 of Chapter 1.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Lodged with the preliminary drainage report (Clause 1.10.4(a)), with one form for each requirement concerned.

Table 1F.3 — Form 1-2: Variance / Waiver Request

No.	Item (clause)	Entry
	A. Applicant and site	
A1	Applicant	_____
A2	Site address and coordinates	_____
A3	Form 1-1 reference and date	_____
A4	Tier of the Authority: A / B	_____
A5	Site area (ha)	_____
A6	Site in a flood-sensitive catchment: Yes / No	_____
	B. Request	
B1	Type: variance from a numeric requirement (1.10.1) / waiver of Chapter 4 detention (1.10.2)	_____
B2	Clause of the Manual concerned	_____
B3	Value required by the Manual	_____
B4	Value or arrangement proposed	_____
	C. Matters that cannot be varied or waived (Clause 1.10.3) — confirm that the request does not concern any of them	
C1	(a) a sewage connection to a storm drain	Not concerned: _____
C2	(b) the lowest habitable floor level of Chapter 6	Not concerned: _____
C3	(c) a waterbody setback below the Zone 1 minimum of Clause 7.4.7, or fill or construction in the no-fill zone of Chapter 7	Not concerned: _____
C4	(d) retention in a flood-sensitive catchment, except by fee-in-lieu under Clause 1.7	Not concerned: _____
	D. Variance: grounds (Clause 1.10.1(a))	
D1	Site condition: high groundwater table / contaminated soil / rock / site too small for the required facility / other	_____
D2	Evidence (tests, surveys, plans), with references	_____
D3	Options assessed and why each is impracticable	_____
	E. Variance: equal performance or make-up (Clause 1.10.1(b))	
E1	Downstream point used (Chapter 5)	_____
E2	Performance at that point with full compliance and with the variance (peak flows, water levels)	_____

No.	Item (clause)	Entry
E3	Or: shortfall made up by fee-in-lieu or off-site works in the same catchment — volume (m³), works or fee	_____
	F. Waiver of detention: grounds (Clause 1.10.2)	
F1	Site discharges directly to the sea / to a tidal reach with no flood-prone property downstream	_____
F2	Analysis showing that undetained flow does not worsen the outfall-closed condition of Chapter 5 — reference	_____
F3	Retention still provided in full: Yes	_____
	G. Attachments (Clause 1.10.4(a))	
G1	Report certified under Clause 10.6	_____
G2	Preliminary drainage report	_____
	H. Certification and declaration	
H1	Certified by (registered professional; empanelled professional where Clause 10.6.1 applies): name, registration or empanelment number, signature, date	_____
H2	Applicant: name, signature, date	_____
	I. For the Authority (Clause 1.10.4)	
I1	Referred to the State Stormwater Technical Committee (Tier B, site 1 ha or more): Yes / No; date	_____
I2	Decision: granted / granted with conditions / refused	_____
I3	Reasons and conditions	_____
I4	Entry number in the public register (Clause 10.17)	_____
I5	Note: a variance runs with the approval and lapses if the approval lapses (Clause 1.10.4(d))	—
I6	Officer: name, designation, signature, date	_____

ANNEXES TO CHAPTER 2

Design Rainfall and Design Storms

These annexes support Chapter 2. Annexes 2A to 2E will hold the statewide rainfall tables that Chapter 2 refers to: the benchmark checks and zone map, sub-daily ratios, grid-to-point factors, temporal patterns and retention depths. Each needs analysis of NIH-DHAARA and IMD records that has not yet been done for this Manual, so each is marked "To be prepared" and gives its intended layout and the rule to use until it is published (Clause 1.11.5). Form 2-1 is a draft form for the Design Rainfall Sheet that every hydrologic submittal must include (Clause 2.13). The Manual is a draft; it is not adopted by any government or agency.

Annex 2A — NIH-DHAARA vs IMD station and IMD gridded checks at benchmark points; zone map

Supports Clauses 2.3.1 to 2.3.5 of Chapter 2.

To be prepared. This annex will compare, at benchmark points across the State, the NIH-DHAARA design depths with frequency analyses of long IMD daily station records and of IMD gridded daily data (converted to point values with Annex 2C), for 24 hours and longer and for the AEPs of Table 2.1. It will also contain the map of rainfall zones used by Annexes 2B, 2C and 2E and by the Tier B tables of Chapter 4. It needs NIH-DHAARA values at the benchmark coordinates (NIH), IMD daily and recording-gauge station records and IMD gridded rainfall (IMD), State rain-gauge records (the IMD stations of IMD's *Extremes* in the State, Pasighat (A) (42220, rainfall data 1916–2012), Tezu (01203, 1969–2012), Ziro ("Zero", 42312, 1965–2012 as printed) and Hayuliang (01212, 1971–1985), the automatic weather stations and automatic rain gauges of the Meteorological Centre Itanagar, whose list and archive were not obtained, the daily gauge of the NERIST meteorological laboratory at Doimukh, 1988–2012, and any gauges of APSDMA, the Department of Disaster Management or the Smart City companies [TBC]), and district and basin boundaries (Survey of India, WRD). Until it is published, design depths are taken from NIH-DHAARA under Clause 2.3.1, the cross-checks of Clause 2.3.3 are reported on Form 2-1, and the zone of a site is the one agreed with the Authority and recorded on Form 2-1.

Table 2A.1 — Benchmark comparison of design depths (layout)

Benchmark point	IMD station ID	Latitude, longitude	Years of record	Duration (h)	AEP	NIH-DHAARA (mm)	IMD station analysis (mm)	IMD gridded, point value (mm)	NIH-DHAARA / IMD station	Remarks
				24						
				48						
				72						

2A.1 The zone names below are the working names used in the Tier B table template of Chapter 4 (Clause 4.14.2). Their boundaries, and whether further zones are needed, are to be set by the analysis of this annex.

Table 2A.2 — Rainfall zones (layout)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
AR-Z1 Western foothills	The Siwalik foothills and valleys of the Dikrong, Pare, Ranganadi, Pakke and Kameng (Jia Bharali) and the Lower Subansiri foothills, from the State border to the last contour of the plates, in CWC subzone 2(a), North Brahmaputra, contoured (Clause 2.3.6(b)); part of the foothill domain of the record check (Clause 2.3.6(h)); catchments that cross a zone line take the higher zone value	NERIST meteorological laboratory, Doimukh (daily, 1988–2012); the automatic stations of the Meteorological Centre Itanagar (list and record lengths [TBC]); North Lakhimpur (A) / Lilabari (42309) across the border, for context	AR-A: the capital-region table of Clause 2.3.6(c)(ii); AR-A1: the plates, not below that table. Arunachal Pradesh interim ratios (Clause 2.3.6(f)) and the short-storm floors of Clause 2.3.6(g); 72-h = 24-h × 2.05. Siwalik sandstone, shale and boulder beds with residual soil and slope debris; intermontane valley sands; hill rule of Clause 4.11 on the slopes, floodplain and recharge rules on the valley floors
AR-Z1 Western foothills: AR-A Itanagar capital region (Itanagar–Naharlagun–Nirjuli–Doimukh–Banderdewa)	The area of the Master Plan of Itanagar Capital Region-2031 and of the Itanagar Municipal Corporation: the Senki, the Pachin, Papu Nallah and the Dikrong, the hill slopes round the valley and the Dikrong reach below the Pare dam; boundaries [TBC]	NERIST Doimukh (27°08'39" N, 93°45'05" E, 118 m; daily, 1988–2012); MC Itanagar automatic stations (first data request of Clause 2.3.6(a))	24-h 135 / 175 / 205 / 240 / 265 / 290 mm at 50% / 20% / 10% / 4% / 2% / 1% AEP (Clause 2.3.6(c)(ii); NERIST lognormal 1-day × 1.13, rounded up to 5 mm). FER 2(a) plates at Itanagar about 180 / 200 / 240 mm (Plates 8 / 9 / 10), in an open "<200" cell with no contour north of the town (NEER reading; recorded, not used). NIH-DHAARA 472 / 528 mm at Itanagar and 409 / 458 mm at Naharlagun (50 / 100-yr), flagged, not used. 1-h at 2% / 1% AEP 95 / 105 mm after the floors of Clause 2.3.6(g). Annual normals in conflict: Itanagar 3,942.44 mm (CGWB, as summarised) and "2289 mm" (master plan, no source); Doimukh 3,531.8 mm (NERIST) and 3,251.67 mm (CGWB, as summarised). Records: NERIST 185 mm (1990; not an IMD gauge); IMD 40 mm in 2 h (23 Jun 2024, as quoted) and 52.0 mm "till 12:30" (27 Jun 2024, as summarised), flags only. Doimukh field soil 95.19% sand, basic infiltration 1 cm/h (Dabral et al., 2016); Dikrong valley water table 2–4 m below ground before the monsoon and 2–5 m after it (CGWB). Receiving waters: the Senki, the Pachin and the Dikrong, with the Pare releases and the Ranganadi tailrace; no CWC gauge
AR-Z1 Western foothills: AR-A1 Western foothills (Bhalukpong–Seijosa–Kimin–Yazali)	The Kameng (Jia Bharali), Pakke and Ranganadi foothills and the Lower Subansiri foothills on the State border; the Ranganadi reach at Yazali; boundaries [TBC]; Seijosa and Yazali lie near zone lines, and the site's coordinates decide [TBC]	No IMD station; MC Itanagar automatic stations [TBC]	FER 2(a) 2% / 1% AEP 24-h: Bhalukpong 240 / 280 mm and Kimin 240 / 280 mm, at the open ends of the 240 and 280 lines (NEER reading, low confidence); Seijosa and Yazali not read [TBC]; not less than the AR-A table at every AEP (Clause 2.3.6(c)(i)), which therefore governs at both towns read. NIH-DHAARA 464 mm at Bhalukpong (50-yr), flagged. 72-h = 24-h × 2.05. Receiving waters: the Kameng at Bhalukpong (no gauge in the State); the Ranganadi below the Ranganadi project (CWC highest flood level 623.1 m at Yazali, 14 Jun 2008, as reported)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
AR-Z2 Eastern foothills	The bhabar fans and flood plains of the Siang, Dibang and Lohit north of the 2(a)/2(b) boundary, which leaves the Lohit at about Tezu, in subzone 2(a) at its edge, where the 2(b) contours also reach (Clause 2.3.6(b)); part of the foothill domain of the record check; catchments that cross a zone line take the higher zone value	Pasighat (A) (IMD 42220, rainfall data 1916–2012); Tezu (IMD 01203, 1969–2012)	The higher of the 2(a) and 2(b) plates (Clause 2.3.6(c)); Arunachal Pradesh interim ratios with the short-storm floors; 72-h = 24-h × 1.95. Bhabar boulder fans and flood-plain silts; floodplain rule of Clause 4.11; main stems whose stage is set upstream
AR-Z2 Eastern foothills: AR-B Siang–Dibang–Lohit foothills (Pasighat–Ruksin–Likabali–Roing–Tezu)	Pasighat, Ruksin, Likabali, Roing and Tezu, the fans and flood plains of the Siang, Dibang and Lohit north of the 2(a)/2(b) boundary; boundaries [TBC]	Pasighat (A) (IMD 42220); Tezu (IMD 01203)	2% / 1% AEP 24-h (NEER reading, low confidence): Likabali 440 / 520 mm (2(a) ">400" and ">480" cells); Pasighat 320 / 400 mm (2(a) blank; 2(b) at the open ends of the 320 and 400 lines); Roing 320 / 400 mm (2(a); 2(b) 280 / 320); Tezu 280 / 320 mm (2(a); 2(b) 240 / 280). Plate 8: Likabali 360, Pasighat 320, Roing 280, Tezu 240 mm. Record check (Clause 2.3.6(h)): within 25 km of the Pasighat gauge, not less than 652.2 / 612.2 mm at 1% / 2% AEP until IMD rules on the record (476.7 / 436.7 mm if it is withdrawn); within 25 km of the Tezu gauge, not less than 338.4 / 298.4 mm. NIH-DHAARA 657 mm at Pasighat, 726 mm at Roing and 515 mm at Tezu (50-yr), flagged. Records: Pasighat 652.2 mm (5 Oct 1988) [U], 476.7 mm (22 Aug 1988), 467.9 mm (11 Jul 1948; 467.0 mm in FER 2(a) Table 7); Tezu 338.4 mm (2 Jul 1974) (IMD). Annual normals: East Siang 2,910.18 mm, Lohit 5,179 mm (CGWB). East Siang water table 1.50–11.13 m below ground; Lohit 3.58 / 3.52 m (2008) (CGWB). Receiving waters: the Siang at Pasighat (CWC danger level 153.96 m, highest flood level 157.54 m, 11 Jun 2000, an outburst stage); the Lohit at Tezu (highest flood level 192.14 m, 16 Jul 1996); the Dibang at Roing (no CWC site) (CWC data as transcribed by SANDRP)
AR-Z3 South-east	The Noa-Dihing and Burhidihing plain south of the Lohit and the Patkai hills of Changlang, Tirap and Longding districts, in subzone 2(b), South Brahmaputra (Clause 2.3.6(b)); the plain is part of the foothill domain of the record check and the hills part of the hill domain; catchments that cross a zone line take the higher zone value	No IMD station in the State in IMD's *Extremes*; MC Itanagar automatic stations [TBC]	FER 2(b) plates; the 2(b) ratios on the plain and the Arunachal Pradesh interim ratios in the hills (Clause 2.3.6(f)). Recent alluvium on the Bordumsa–Miao plain and older alluvium in the foothills (CGWB)

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
AR-Z3 South-east: AR-C Noa-Dihing plain (Namsai–Chowkham–Bordumsa–Miao)	Namsai, Chowkham, Bordumsa and Miao, the plain south of the Lohit and the Noa-Dihing and Burhidihing flood plains; boundaries [TBC]	No IMD station; MC Itanagar automatic stations [TBC]	FER 2(b) 2% / 1% AEP 24-h: Namsai 280 / 320 mm (between the 240 and 280 lines on both Plates 9 and 10, so 1% = 2% + 40 mm); Miao 240 / 280 mm (NEER reading, low confidence); Plate 8 240 and 200 mm. 2(b) ratios: on Namsai's 280 mm about 134 mm in 1 hour at 2% AEP, against 92 mm in NIH-DHAARA's Namsai cell. 72-h = 24-h × 1.70. NIH-DHAARA 461 mm at Namsai (50-yr), flagged. Remal storm: Namsai 70 mm and Miao 120 mm in 24 hours to 29 May 2024 (IMD bulletin, as summarised; flags only). Receiving waters: the Noa-Dihing (CWC Namsai danger level 145.8 m, highest flood level 146.6 m; Miao highest flood level 241.57 m; as reported)
AR-Z3 South-east: AR-C1 Patkai hills (Changlang–Jairampur–Deomali–Khonsa–Longding)	Changlang, Tirap and Longding districts above the plain; the Tirap and Burhidihing headwaters; the Myanmar and Nagaland borders; boundaries [TBC]; Jairampur and Deomali lie near zone lines [TBC]	No IMD station; MC Itanagar automatic stations [TBC]	Not less than 240 / 280 mm at 2% / 1% AEP (Clause 2.3.6(c)(i)); plate readings Jairampur 240 / 280, Changlang and Deomali 200 / 240 (in the closed "<200" pocket), Khonsa 240 / 280 (on its edge) and Longding 240 / 280 mm (NEER reading, low confidence). The adjoining Nagaland edition reads one contour higher across the Longding border; the plate governs on each side. NIH-DHAARA 233 / 260 mm at Khonsa and 261 / 293 mm at Changlang (50 / 100-yr), within about 10% of the floor. Arunachal Pradesh interim ratios; no short-storm floor; 72-h = 24-h × 1.75. Changlang annual normal 2,913.8 mm (3,800–4,866 mm in parts) (CGWB); hill rule of Clause 4.11
AR-Z4 Hills and high ranges	The middle hills and high ranges of the Subansiri, Siang, Kameng, Dibang and Lohit basins and of Tawang, inside subzone 2(a) but beyond its last contour, where the plates are blank (Clause 2.3.6(b)); the hill domain of the record check; catchments that cross a zone line take the higher zone value	Ziro ("Zero", IMD 42312; rainfall data 1965–2012 as printed, with large gaps); Hayuliang (IMD 01212, 1971–1985)	No contour: floors of Clause 2.3.6(c)(iii). Arunachal Pradesh interim ratios; no short-storm floor. Gneiss and schist of the Bomdila Group and the higher ranges, thin soils, slope debris; rain-shadow valleys beside large single days; hill rule of Clause 4.11
AR-Z4 Hills and high ranges: AR-D Middle hills (Ziro–Daporijo–Aalo–Seppa–Basar–Yingkiong)	Lower and Upper Subansiri, Kra Daadi, Kurung Kumey, Kamle, West Siang, Leparada, Siang, Upper Siang below the snow, East Kameng and Pakke-Kessang above the foothills; the NH-13 landslide corridor (district names as reported for 2024, not verified); boundaries [TBC]	Ziro (IMD 42312)	Not less than 280 / 320 mm at 2% / 1% AEP; at Ziro, at the open ends of the 2(a) 320 and 400 lines on the plateau edge, 320 / 400 mm (NEER reading, very low confidence), which governs there (Clause 2.3.6(c)(iii)). 72-h = 24-h × 1.90. NIH-DHAARA 308 mm at Ziro, 288 mm at Daporijo, 513 mm at Aalo and 351 mm at Seppa (50-yr), a bracket only. Ziro 150.7 mm (4 Feb 1974) excluded [U]. Receiving waters: the Subansiri at Daporijo (CWC highest flood level 213.9 m, 15 Oct 1987, as reported); the Siang at Yingkiong (danger level 304.0 m, as reported); steep streams and nallahs to free outfalls

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
AR-Z4 Hills and high ranges: AR-E High ranges (Tawang–Bomdila–Dirang–Mechuka–Anini–Hayuliang)	Tawang, West Kameng above the foothills, Shi Yomi, Upper Siang above Tuting, Dibang Valley and Anjaw; snow in winter, glaciers and glacial lakes; boundaries [TBC]; Tuting and Hayuliang lie near zone lines [TBC]	Hayuliang (IMD 01212, 1971–1985)	Not less than 240 / 280 mm at 2% / 1% AEP (Clause 2.3.6(c)(iii)); snow-fed and glaciated catchments site-specific, with the outburst screening of Clause 2.3.6(i). 72-h = 24-h × 1.80. NIH-DHAARA 328 mm at Bomdila and 129 mm at Tawang (50-yr), a bracket only; Tawang's cell is not a safe minimum. Records: Hayuliang 280.0 mm (3 Oct 1979) and 278.5 mm (24 Apr 1980) (IMD; under 20 years of data, flags only); Bomdila 190 mm (29 May 2024, as summarised). Annual normals: Tawang about 1,600 mm, West Kameng 1,607 mm (CGWB). Glaciers: 52 (66 km²) in the Kameng basin, 91 (146 km²) in the Subansiri and 14 (11 km²) in the Dibang (State Action Plan on Climate Change); NDMA's high-risk glacial lakes: Tawang 6, Kurung Kumey 1, Shi Yomi 1, Dibang Valley 16, Anjaw 3 (as reported). Receiving waters: the Tawang Chu (to Bhutan), the Kameng, the Siang at Tuting (CWC highest flood level 420.43 m) and the Lohit at Kibithu (1,229.8 m) (as reported)

Annex 2B — Sub-daily ratios P(t)/P(24h) by zone: NIH-DHAARA (hourly-based) vs the one-third rule

Supports Clauses 2.6.1 to 2.6.4 of Chapter 2.

To be prepared. This annex will tabulate, for each zone of Annex 2A, the ratios of the t-hour to the 24-hour design depth from NIH-DHAARA, which are derived from hourly records, against the ratios implied by IMD Das et al. (2022) and by the one-third rule. It needs NIH-DHAARA depths for each duration at representative points in each zone (NIH), IMD recording-gauge data and the IDF values of Das et al. (2022) (IMD). Until it is published, sub-daily depths are read directly from NIH-DHAARA or an approved station IDF (Clause 2.6.1). Where only daily depths are available, the ratios used are those agreed with the Authority, which in Arunachal Pradesh are those of Clause 2.3.6 for the site's sub-area in Table 2B.1 (the 2(b) ratios in AR-C; the Arunachal Pradesh interim ratios in AR-A, AR-A1, AR-B, AR-C1, AR-D and AR-E), applied to the 24-hour depth of Clause 2.3.6(c) or (d) before the record check of Clause 2.3.6(h), with the short-storm floors of Clause 2.3.6(g) in AR-A, AR-A1, AR-B and AR-C and its 1-hour limits where a station fit replaces them (Clause 2.6.2), and are recorded on Form 2-1. The one-third rule is not used (Clause 2.6.4).

2B.1 The first row of Table 2B.1 gives the ratios of the one-third rule P(t) = P(24)·(t/24)^(1/3), for comparison only. The 1, 3, 6 and 12 h values are those stated in the commentary to Clause 2.6; the 2 h value is computed from the same formula. The rule shall not be used for design unless this annex confirms it for the zone concerned (Clause 2.6.4).

Table 2B.1 — Ratios P(t)/P(24h) by zone (layout)

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
All (reference only, not for design)	One-third rule	0.35	0.44	0.50	0.63	0.79	1.00

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
AR-Z3 (AR-C Noa-Dihing plain)	CWC FER 2(b), §4.3.2 and Table 4.1, p. 20, 10-yr basis, six recording gauges (interim design ratios, Clause 2.3.6(f); 2-h value interpolated on logarithmic axes; 9 h 0.81, 15 h 0.91, 18 h 0.95). Applied to the 24-h depth of Clause 2.3.6(c) or (d) before the check of Clause 2.3.6(h), with the short-storm floors of Clause 2.3.6(g); 72-h = 24-h × 1.70 (Clause 2.3.6(e))	0.48		0.62	0.74	0.87	1.00
AR-Z1 (AR-A Itanagar capital region; AR-A1 Western foothills), AR-Z2 (AR-B Siang–Dibang–Lohit foothills), AR-Z3 (AR-C1 Patkai hills) and AR-Z4 (AR-D Middle hills; AR-E High ranges)	Arunachal Pradesh interim ratios, set by this Manual: the upper envelope, rounded up to 0.01, of the fifteen Arunachal Pradesh NIH-DHAARA cells (50-yr), the CWC FER 2(a) ratios (NB/18/1991, §3.1.2, p. 24) and the adjoining Nagaland edition's interim ratios, which it equals (Clause 2.3.6(f); 9 h 0.84, 15 h 0.92, 18 h 0.95). Applied before the check of Clause 2.3.6(h); short-storm floors of Clause 2.3.6(g) in AR-A, AR-A1 and AR-B. 72-h = 24-h × 2.05 in AR-A and AR-A1, × 1.95 in AR-B, × 1.75 in AR-C1, × 1.90 in AR-D and × 1.80 in AR-E (Clause 2.3.6(e))	0.33	0.52	0.61	0.76	0.88	1.00
AR-A, 24-h depths	The capital-region table of Clause 2.3.6(c)(ii), set by this Manual from the NERIST Doimukh series (Dabral et al., 2016, Table 8, lognormal 1-day, × 1.13, rounded up to 5 mm): 135, 175, 205, 240, 265 and 290 mm at 50%, 20%, 10%, 4%, 2% and 1% AEP; also the minimum in AR-A1 at every AEP; not ratios of duration						
AR-A1, AR-B, AR-C, AR-C1, AR-D and AR-E, every 24-h depth below 2% AEP	Growth factors of Clause 2.3.6(d), set by this Manual: the 50%, 20%, 10% and 4% AEP 24-h depths = the 2% AEP depth of Clause 2.3.6(c), before the check of Clause 2.3.6(h), × 0.42, 0.61, 0.73 and 0.89 (upper envelope of the NIH-DHAARA growth curves), with the 4% AEP depth not below Plate 8 where a contour reaches the site; not ratios of duration						
AR-C1, AR-D and AR-E, 24-h depths at 2% / 1% AEP	Floors of Clause 2.3.6(c), set by this Manual: AR-C1 not less than 240 / 280 mm; AR-D not less than 280 / 320 mm (Ziro 320 / 400 mm where the 2(a) lines reach it); AR-E not less than 240 / 280 mm; not ratios of duration						
AR-A, AR-A1, AR-B and AR-C, 1-, 3- and 6-h depths at 10% AEP and rarer	Short-storm floors of Clause 2.3.6(g), set by this Manual (the adjoining Assam edition's floors): 1 h 70 / 85 / 95 / 105 mm, 3 h 120 / 145 / 165 / 185 mm and 6 h 130 / 160 / 180 / 200 mm at 10% / 4% / 2% / 1% AEP; none in AR-C1, AR-D and AR-E						
Every sub-area, where a station fit replaces Clause 2.3.6(f)	1-hour limit of Clause 2.3.6(g), set by this Manual: 1-h ratio not below 0.33, or 0.48 in AR-C, until Annex 2B is published						
AR-Z1 (AR-A): Itanagar and Naharlagun cells	NIH-DHAARA, IMDAA, 50-yr (queried 14 Nov 2026; comparison only)	0.17 / 0.21	0.28 / 0.34	0.37 / 0.43	0.55 / 0.61	0.75 / 0.78	1.00
AR-Z2 (AR-B): Pasighat and Tezu cells	NIH-DHAARA, IMDAA, 50-yr (comparison only)	0.13 / 0.18	0.22 / 0.32	0.30 / 0.40	0.48 / 0.57	0.72 / 0.77	1.00
AR-Z3: Namsai (AR-C) and Changlang (AR-C1) cells	NIH-DHAARA, IMDAA, 50-yr (comparison only; Changlang gives the 1-h and 2-h maxima of the fifteen cells)	0.20 / 0.29	0.34 / 0.48	0.44 / 0.57	0.63 / 0.72	0.82 / 0.84	1.00

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
AR-Z4: Ziro (AR-D) and Tawang (AR-E) cells	NIH-DHAARA, IMDAA, 50-yr (comparison only)	0.23 / 0.13	0.35 / 0.23	0.41 / 0.31	0.55 / 0.49	0.74 / 0.73	1.00

2B.2 Depths from fixed observation windows are converted to true-interval depths with the factors of Clause 2.6.3, repeated in Table 2B.2. They are the standard WMO (Hershfield) values and are not provisional.

Table 2B.2 — Fixed-interval adjustment factors (Clause 2.6.3)

Number of fixed observation intervals in the duration	Factor
1	1.13
2	1.04
3–4	1.02

Annex 2C — Grid-to-point factors

Supports Clauses 2.7.1 and 2.7.4 of Chapter 2.

To be prepared. This annex will give the factors that convert grid-average design depths (for example from 0.25° cells) to point depths, by zone, duration and AEP. It needs paired frequency analyses of IMD gridded rainfall and of the IMD and State gauges inside each cell (IMD, the automatic weather stations and automatic rain gauges of the Meteorological Centre Itanagar, the NERIST meteorological laboratory at Doimukh and any gauges of APSDMA, the Department of Disaster Management or the Smart City companies [TBC]), the benchmark points of Annex 2A, and a stated method for deriving the factors. Until it is published, design depths are taken as point values from NIH-DHAARA or an approved station IDF (Clauses 2.3.1 and 2.3.2). Grid-average values are not used as design depths unless a conversion agreed with the Authority is recorded on Form 2-1 (Clause 1.11.5).

2C.1 The commentary to Clause 2.7 shows why the factors matter. In Arunachal Pradesh NIH-DHAARA was queried at fifteen points for this Manual. In the foothills, where it can be checked, its reanalysis cells give 1.7 to 2.4 times the CWC plates and about 1.5 times the NERIST gauge at Doimukh: 472 mm at 50 years in 24 hours over Itanagar, against 265 mm from the gauge and about 200 mm on the plate; in the south-east its Khonsa and Changlang cells lie within one contour of the plates; and in the interior its Tawang cell gives 129 mm, below the 190 mm that Bomdila received on 29 May 2024 (NIH-DHAARA, queried 14 Nov 2026; Dabral et al., 2016; IMD bulletin, as summarised). Values of this kind are grid- or area-average values and need these factors before any use as point depths; under Clause 2.3.6 NIH-DHAARA is never a design value in Arunachal Pradesh, and is reported in every sub-area for comparison only (Clause 2.3.6(m)).

Table 2C.1 — Grid-to-point factors (layout)

Zone	Grid product and cell size	Duration (h)	AEP	Factor (point / grid)	Stations used	Years of record
		24				
		48				
		72				

Annex 2D — Arunachal Pradesh temporal patterns (Huff curves)

Supports Clauses 2.9.3 and 2.9.4 of Chapter 2, and Clause 11.7.3 of Chapter 11.

To be prepared. This annex will give dimensionless time-distribution (mass) curves of Arunachal Pradesh storms, in the form introduced by Huff (1967), by zone, storm-duration class and quartile, at stated probability levels. It needs storm hyetographs from recording gauges and automatic weather stations (IMD, its automatic weather stations and automatic rain gauges in the State under the Meteorological Centre Itanagar, whose hourly archive is the first data request of Clause 2.3.6(a), and any hourly record of the NERIST meteorological laboratory at Doimukh [TBC]), separated into independent storms by a stated rule, and the Modirijo and Donyi Polo storm of about 14 September 2018 at Itanagar, the Remal storm of 28–29 May 2024, with 190 mm at Bomdila, the Itanagar storm of 23 June 2024, with 40 mm between 10:30 and 12:30 as quoted from IMD, the reported Itanagar cloudburst of July 2024, the storms of late May and June 2025, and the Poosa storm at Yazali of 24 June 2025 or 2026 among them. Until it is published, design storms use the alternating-block pattern of Clause 2.9.1 and the 48- and 72-hour pattern of Clause 2.9.2; for catchments of 25–5,000 km², the CWC Flood Estimation Report curves may be used with a sensitivity run under Clause 2.9.1 (Clause 2.9.4). SCS Type distributions are not used (Clause 2.9.3). For the disaggregation of daily records in continuous simulation (Clause 11.7.3), the method is agreed with the Authority and recorded (Clause 1.11.5).

Table 2D.1 — Cumulative fraction of storm depth against cumulative fraction of storm time (layout, one table per zone, duration class and quartile)

Fraction of storm time	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
10% probability curve	0										1.0
50% probability curve	0										1.0
90% probability curve	0										1.0

2D.1 Each table shall state the zone, the duration class, the quartile (the quarter of the storm in which most rain fell), the number of storms analysed and the period of record.

Reference: Huff, F.A. (1967). Time distribution of rainfall in heavy storms. *Water Resources Research* 3(4), 1007–1019.

Annex 2E — Retention percentile depths by zone

Supports Clauses 2.8.3 and 2.10.1 to 2.10.2 of Chapter 2, Clause 4.4 of Chapter 4 and Chapter 8.

To be prepared. This annex will give, for each zone of Annex 2A, the retention design depth P_R: the 24-hour rainfall depth not exceeded on 90% of days with rain (≥ 2.5 mm) in the long-term record (Clause 2.10.1). It needs long daily records at stations in each zone (IMD, the automatic weather stations and automatic rain gauges of the Meteorological Centre Itanagar, the NERIST meteorological laboratory at Doimukh and any gauges of APSDMA, the Department of Disaster Management or the Smart City companies [TBC]) and IMD gridded data with the factors of Annex 2C where stations are sparse. Until it is published, P_R is computed by the definition of Clause 2.10.1 from the long-term daily record of a station agreed with the Authority, by the steps in 2E.1, and recorded on Form 2-1 (Clause 1.11.5).

2E.1 **Computing P_R from a daily record.**

1. Take the daily (24-hour) rainfall series of the station for its full record.
2. Keep only the days with rain of 2.5 mm or more (wet days).
3. Rank the wet-day depths and take the depth not exceeded on 90% of them (the 90th percentile).
4. Do not apply the climate factor (Clause 2.8.3) or the fixed-interval factor; P_R is a statistic of everyday rainfall, not an AEP design depth.
5. Record the station, the period of record, the number of wet days and P_R on Form 2-1.

Table 2E.1 — Retention depth P_R by zone (layout)

Zone	Stations or grid cells used	Period of record	Number of wet days (≥ 2.5 mm)	P_R, 90th percentile (mm)	Issued on
AR-Z1 Western foothills					
AR-Z2 Eastern foothills					
AR-Z3 South-east					
AR-Z4 Hills and high ranges					

Form 2-1 — Design Rainfall Sheet

Supports Clauses 2.3 to 2.13 of Chapter 2, and Clause 10.4.1(d) of Chapter 10.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. One sheet for each hydrologic submittal. The steps follow Figure 2.3 of Chapter 2.

Table 2F.1 — Form 2-1: site, source and storms

No.	Item (clause)	Entry
	A. Site (Clause 2.13, item 1)	
A1	Project and site	_____
A2	Site coordinates (latitude, longitude, decimal degrees)	_____
A3	Rainfall zone (Annex 2A, or as agreed with the Authority)	_____
A4	Contributing catchment area (km²) (Clause 2.7)	_____
A5	Design life: more than 25 years / temporary works, 5 years or less (Clause 2.8.2)	_____
A6	Outfall under tidal or river backwater influence: Yes / No (Clauses 2.5.3, 2.12)	_____
	B. Source (Clauses 2.3, 2.3.5; item 2)	
B1	NIH-DHAARA: version or access date	_____
B2	Coordinates queried	_____
B3	Screenshot or export of the values extracted attached: reference	_____
B4	Station IDF used (Clause 2.3.2): No / Yes — station, ID, distance from site (km)	_____
B5	Station IDF: years of recording-gauge data (30 or more); published or approved by	_____
B6	Station IDF: change of terrain or coastal exposure between gauge and site: None / describe	_____
	C. AEPs and durations (Clauses 2.4, 2.5)	
C1	Elements designed and their AEPs (Table 2.1)	_____
C2	Conveyance: Tc and design duration (not less than 10 min) (Clause 2.5.1)	_____
C3	Storage: durations checked from {1, 2, 3, 6, 12, 24, 48, 72 h}; 24, 48 and 72 h included (Clause 2.5.2)	_____
C4	Critical duration found for each storage element	_____
	D. Conversions	
D1	Sub-daily depths: read directly / from Annex 2B ratios / from ratios agreed with the Authority (Clauses 2.6.1, 2.6.2)	_____
D2	Fixed-interval factor applied: none (true-interval source) / 1.13 / 1.04 / 1.02 (Clause 2.6.3)	_____
D3	Grid-to-point factor: not needed (point source) / Annex 2C / agreed value (Clause 2.7.1)	_____
D4	ARF: 1.0 (10 km² or less; single-site storage) / CWC curve / interpolated (Clauses 2.7.2–2.7.4)	_____
D5	Climate factor: 1.20 (≤ 6 h) and 1.10 (> 6–72 h) / 1.0 temporary works / projected depths under Clause 2.8.4	_____
	E. Cross-checks (Clause 2.3.3; item 4)	
E1	IMD Das et al. (2022) values for 1–24 h: reported in Table 2F.2	_____

No.	Item (clause)	Entry
E2	CWC subzone 2(a) or 2(b) (in AR-D and AR-E enter "none: beyond the last 2(a) contour") 24-hour point value, catchments of 25–5,000 km²: subzone used	_____
E3	CWC floor governs for any AEP: No / Yes — AEPs	_____
	F. Retention depth (Clause 2.10)	
F1	P_R (mm) and source: Annex 2E zone value / computed under Annex 2E, 2E.1 — station and period	_____
F2	No climate factor applied to P_R (Clause 2.8.3): confirmed	_____
	G. Design storms (Clauses 2.9, 2.11, 2.12; items 5 and 6)	
G1	Storms up to 24 h: alternating block, peak at 50%; time step (≤ Tc/3 and ≤ 15 min)	_____
G2	48 and 72 h storms: built under Clause 2.9.2 (Table 2F.3)	_____
G3	Other pattern used: none / Annex 2D / CWC FER with sensitivity run (Clauses 2.9.3, 2.9.4)	_____
G4	Hyetographs attached as a table and a plot for each design storm: reference	_____
G5	AMC: III for every design storm of 1 May–15 October in sub-areas AR-A, AR-A1, AR-C and AR-C1, of 1 April–31 October in AR-B and of 1 June–15 October in AR-D and AR-E, whatever its duration; III for every design storm of 1 April–31 October on land below the 1% AEP level of a river, stream or nallah, on the Pachin and Dikrong palaeochannels and swamps, on pond margins and where the seasonal high water table is within 2 m of ground; III at any time in catchments draining to a reservoir, its backwater or a release reach (Pare, Ranganadi, Kameng, Lower Subansiri); at any other site or time, III for a storm that follows or contains a 5-day total of more than 53 mm; II otherwise (Clause 2.11.4)	_____
G6	Pre-development condition: greenfield, open land in good condition for the mapped HSG (Clause 2.11.5)	_____
G7	Release criterion: standard, Q_post ≤ 0.9 × Q_pre (Clause 2.11.2) / flood-sensitive, mixed-frequency rule (Clause 2.11.3)	_____
G8	Tailwater joint cases run (Clause 2.12): case (a) MHWS + sea-level allowance; case (b) 10% AEP 48 h storm with 1% AEP still-water level + sea-level allowance; governing case	_____
	H. Prepared by	
H1	I confirm that the values above are those extracted and used in the submittal. Name, registration number, signature, date	_____

Design depth = source depth × fixed-interval factor × grid-to-point factor × ARF × climate factor. Where the design depth is lower than the CWC floor for the same AEP, the floor is adopted (Clause 2.3.3).

Table 2F.2 — Form 2-1: depth table (Clause 2.13, item 3)

AEP (T-yr)	Duration	Source depth (mm)	Fixed-interval factor	Grid-to-point factor	ARF	Climate factor	Design depth (mm)	IMD Das et al. (2022) (mm)	CWC floor (mm)	Adopted depth (mm)

Table 2F.3 — Form 2-1: 48- and 72-hour storm construction (Clause 2.9.2)

AEP (T-yr)	Duration (h)	Total design depth (mm)	24 h design depth, final 24 h (mm)	Remainder (mm)	Hours before the final 24 h	Uniform intensity before the final 24 h (mm/h)
	48				24	

AEP (T-yr)	Duration (h)	Total design depth (mm)	24 h design depth, final 24 h (mm)	Remainder (mm)	Hours before the final 24 h	Uniform intensity before the final 24 h (mm/h)
	72				48	

ANNEXES TO CHAPTER 3

Hydrologic Methods

These annexes support Chapter 3. Annex 3C sets out benchmark test problems for software acceptance, and Forms 3-1 and 3-2 are the submittal forms required by Clause 3.17. Annexes 3A, 3B, 3D and 3E need survey, gauging or published report data that this draft does not yet contain; each gives the intended layout and the interim rule of Chapter 3 that applies until it is published. The forms are draft forms and have no statutory status.

Annex 3A — Arunachal Pradesh soil series to HSG lookup; seasonal high water table map

Supports Clauses 3.7 and 3.10 of Chapter 3.

To be prepared. This annex will contain (a) a lookup from each soil series mapped in Arunachal Pradesh to its hydrologic soil group (HSG), in both the drained and the undrained state, and (b) a map of the depth to the seasonal high groundwater table in the monsoon season (April–October). It needs NBSS&LUP and State soil survey agency [TBC] series maps with their scales, measured saturated hydraulic conductivity and depth to an impermeable layer for each series, and observation-well records from the Central Ground Water Board and the WRD, supplemented by piezometers in the valley floor of the capital region, where the CGWB records 2–4 m below ground before the monsoon and 2–5 m after it in the Dikrong valley and 1–5 m in the semi-consolidated formations of Papum Pare (Papum Pare district booklet), above all the Pachin and Dikrong flood plains with their palaeochannels and swampy land; the flood plains and fan toes of the Siang at Pasighat (1.50–11.13 m, East Siang district booklet), the Lohit at Tezu (3.58 m before and 3.52 m after the monsoon of 2008, Lohit district booklet), the Dibang at Roing and the Noa-Dihing at Namsai and Miao; the dug-well ground of Bhalukpong (2.62–5.50 m in the lean period, West Kameng district booklet); the land beside the capital's nallahs; the margins of ponds, swamps and reservoirs; and hill sites with perched water or springs. Until it is published, use the interim rules of Chapter 3: assign HSG from measured saturated hydraulic conductivity and depth to an impermeable layer or water table by the criteria of NEH Part 630, Ch. 7 (Clause 3.7.2); verify it by site infiltration tests wherever retention relies on infiltration (Clause 3.7.3); take the seasonal high water table from site piezometers, trial pits or the nearest observation well (Clause 3.10.2); and assign HSG D wherever that level is within 0.6 m of the ground surface (Clause 3.10.1).

Table 3A.1 — Soil series to HSG lookup (layout)

Soil series	District(s)	Taxonomic class	Surface texture	Saturated hydraulic conductivity (mm/h)	Depth to impermeable layer (m)	HSG, drained	HSG, undrained	Source map and scale

Table 3A.2 — Seasonal high water table, by mapping unit (layout)

Mapping unit or grid cell	Observation wells used	Years of April–October record	Highest April–October level below ground (m)	Within 0.6 m of ground (Clause 3.10.1)?	Data source

Annex 3B — Arunachal Pradesh CN calibration and supplementary land covers (forest and scrub of the hills, valley and flood-plain fields, landslide scars, earth cuts and hill-road fills, boulder-bed streams and bhabar fans, snow and bare rock of the high ranges, and pond, swamp and reservoir beds)

Supports Clauses 3.8 and 3.15 of Chapter 3.

To be prepared. This annex will contain (a) curve numbers calibrated against observed rainfall and runoff in Arunachal Pradesh catchments, compared with the TR-55 values of Table 3.5, and (b) curve numbers for land covers that Table 3.5 does not list: the forest and scrub that cover most of the hills and ranges; the fields of the valley floors and flood plains, with their bunds recorded; the fresh scars, slope debris and fills of landslides, earth cutting and hill-road cuts, such as those along NH-415 between Itanagar and Naharlagun and on NH-13 between Bana and Seppa (as reported); the boulder beds of the hill streams and the bhabar fans of Pasighat, Ruksin, Roing, Tezu, Namsai and Bhalukpong, of which the CGWB writes that "The Bhabar is mostly composed of boulders" (Lohit district booklet); the snow, ice and bare rock of the high ranges, where the upper reaches of Tawang are "mostly devoid of vegetation, due to heavy snowfall" (Tawang district booklet); and the beds and margins of ponds and swamps, and of the reservoirs above the Pare, Ranganadi and Kameng dams, that are exposed at the start of a storm. It needs paired rainfall–runoff records for small gauged catchments of known cover and soil, from WRD gauging sites, agricultural research stations and tank gauges, analysed by event and by antecedent moisture. Until it is published: the pre-development reference stays open space in good condition for every site (Clause 3.3.2), so these covers do not enter the pre-development run; for off-site existing conditions, use the nearest Table 3.5 or TR-55 cover row, including the cultivated rows (Clause 3.8.3(c)), and state the row chosen and the reason on Form 3-1; land under standing water at the start of the design storm is modelled as water surface with no losses (Table 3.5; Clause 3.10.4(b)). Any departure from these defaults requires calibration under Clause 3.15 (Clause 3.15.1(d)).

Table 3B.1 — Supplementary land covers, AMC II (layout)

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Forest and scrub of the hills and ranges, with the litter and the depth of soil over rock recorded						
Fields of the valley floors and flood plains, with the bunds and the depth to water recorded						
Fresh landslide scar, slope debris or earth cut; hill-road cut slope or fill (NH-415 between Itanagar and Naharlagun, NH-13 between Bana and Seppa and the like)						
Boulder bed of a hill stream, dry at the start of the storm						

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Bhabar boulder fan (Pasighat, Ruksin, Roing, Tezu, Namsai, Bhalukpong and the like), with the depth to water recorded						
Snow, ice or bare rock of the high ranges, with the snow cover at the start of the storm recorded						
Pond or swamp bed or margin, or reservoir margin (Pare, Ranganadi, Kameng), exposed at the start of the storm						
Other (state)						

Table 3B.2 — CN calibration catchments (layout)

Catchment	District	Area (km²)	Dominant HSG and cover	Events used	Table 3.5 CN	Calibrated CN	Calibrated ÷ Table 3.5

Annex 3C — Benchmark test problems for software acceptance

Supports Clauses 3.5, 3.6, 3.8, 3.9, 3.11, 3.12 and 3.16 of Chapter 3.

Purpose. Software not listed in Clause 3.16.1 shall reproduce the results of the five problems below (Clause 3.16.3). Each problem is fully specified and uses only the methods and tables of Chapter 3, so every answer can be checked by hand. The acceptance tolerance is ±5% on each tabulated result, the equivalence threshold of Clause 3.16.2; for closed-form results (Problems 3C-1 to 3C-4), software should agree to the rounding shown. The submittal shall report the software result next to each answer below.

Illustrative — not design values. The inputs (areas, intensities, rainfall depths, slopes and the basin) are chosen for testing only. They are not design data for any site.

Problem 3C-1 — Rational Method peak (Clause 3.5)

Inputs. A 2.0 ha catchment draining to one inlet: 1.2 ha concrete paving and roofs, C = 0.90 (Table 3.2, upper half of 0.80–0.95); 0.8 ha lawns on sandy soil, average slope, C = 0.15 (Table 3.2, upper half of 0.10–0.15). Design AEP 1% (100-yr). Rainfall intensity at Tc, including the climate factor: i = 120 mm/h.

Part (b): a separate 0.5 ha fully paved catchment, C = 0.90, design AEP 1%, i = 150 mm/h.

Table 3C.1 — Problem 3C-1 solution

Step	Calculation	Result
Composite C (Clause 3.5.4)	(1.2 × 0.90 + 0.8 × 0.15) / 2.0	0.60
Frequency factor (Table 3.3)	1% AEP	Cf = 1.25
C · Cf (≤ 1.0)	0.60 × 1.25	0.75
Peak flow (Clause 3.5.1)	0.75 × 120 × 2.0 / 360	**Q = 0.500 m³/s**
Part (b): C · Cf	0.90 × 1.25 = 1.125, capped at 1.0 (Clause 3.5.3)	1.00
Part (b): peak flow	1.00 × 150 × 0.5 / 360	**Q = 0.208 m³/s**

Problem 3C-2 — Time of concentration by the segment method (Clause 3.6)

Inputs. Pre-development flow path: sheet flow over greenfield, n = 0.15 (Clause 3.6.3), L = 30 m, S = 0.01; P2 (50% AEP 24-hour rainfall, no climate factor) = 80 mm. Shallow concentrated flow, unpaved, L = 200 m, S = 0.01. Channel flow, L = 400 m, bank-full velocity V = 1.0 m/s (given).

Table 3C.2 — Problem 3C-2 solution

Segment	Calculation	Travel time
Sheet flow (Clause 3.6.2(a))	0.091 × (0.15 × 30)^0.8 / (80^0.5 × 0.01^0.4) = 0.2138 h	12.83 min
Shallow concentrated (Clause 3.6.2(c))	V = 4.918 × 0.01^0.5 = 0.4918 m/s; 200 / (3,600 × 0.4918) = 0.1130 h	6.78 min
Channel (Clause 3.6.2(d))	400 / (3,600 × 1.0) = 0.1111 h	6.67 min
Tc (Clause 3.6.1; ≥ 10 min)	12.83 + 6.78 + 6.67	**26.27 min**
Lag (Clause 3.6.5)	0.6 × 26.27	15.76 min

Problem 3C-3 — SCS-CN runoff depth, AMC and Ia sensitivity (Clause 3.8)

Inputs. Pre-development reference on HSG C: CN = 74 at AMC II (Table 3.5), all pervious. Cumulative rainfall P = 100 mm; second case P = 25 mm.

Table 3C.3 — Problem 3C-3 solution

Case	S (mm)	Ia (mm)	Runoff Q (mm), P = 100 mm	Runoff Q (mm), P = 25 mm
(a) AMC II, Ia = 0.2S: S = 25,400 / 74 − 254	89.24	17.85	**39.38**	**0.53**
(b) AMC III, Ia = 0.2S: CN(III) = 23 × 74 / (10 + 0.13 × 74) = 86.75	38.80	7.76	**64.93**	—
(c) AMC II, Ia = 0.05S: S0.05 = 25.4 × 1.33 × (89.24 / 25.4)^1.15	143.31	7.17	**36.49**	**1.97**

Runoff is Q = (P − Ia)² / (P − Ia + S). Case (c) gives less runoff than case (a) at 100 mm but more at 25 mm, as Clause 3.8.5 and Figure 3.3 describe.

Problem 3C-4 — Separate vs composite impervious representation, and SCS unit hydrograph peak (Clauses 3.9 and 3.11.2)

Inputs, part (a). A site that is 50% directly connected impervious (CN 98) and 50% open space on HSG B (CNp = 61), AMC II, Ia = 0.2S, P = 25 mm.

Inputs, part (b). A sub-area of A = 2.5 km² with Tc = 1.0 h and computation interval Δt = 0.1 h.

Table 3C.4 — Problem 3C-4 solution

Step	Calculation	Result
(a) Impervious half (Clause 3.9.2)	S = 5.18 mm, Ia = 1.04 mm; Q = 23.96² / (23.96 + 5.18)	19.70 mm
(a) Pervious half	S = 162.39 mm, Ia = 32.48 mm > P	0 mm
(a) Area-weighted runoff, separate sub-areas	0.5 × 19.70 + 0.5 × 0	**9.85 mm**

Step	Calculation	Result
(a) Composite CN (Clause 3.9.4)	61 + 0.50 × (98 − 61)	79.5
(a) Runoff with composite CN	S = 65.50 mm, Ia = 13.10 mm; Q = 11.90² / (11.90 + 65.50)	**1.83 mm**
(b) Interval check (Clause 3.11.3(a))	0.133 × 1.0 = 0.133 h ≥ Δt = 0.1 h	satisfied
(b) Lag and time to peak (Clause 3.11.2)	tL = 0.6 × 1.0 = 0.60 h; tp = 0.1 / 2 + 0.60	tp = 0.65 h
(b) Unit hydrograph peak, Q = 1 mm	0.208 × 2.5 × 1 / 0.65	**qp = 0.800 m³/s per mm**

Part (a) reproduces the comparison in the commentary to Clause 3.9 (about 9.9 mm vs 1.8 mm).

Problem 3C-5 — Level-pool (modified Puls) storage routing (Clause 3.12.1)

Inputs. A detention basin with vertical sides and plan area 500 m², with the stage–storage–discharge relationship of Table 3C.5. Triangular inflow hydrograph: 0 at t = 0, rising linearly to 0.50 m³/s at t = 30 min, falling linearly to 0 at t = 90 min. Basin empty at t = 0. Routing interval Δt = 10 min (600 s). No tailwater.

Table 3C.5 — Problem 3C-5 stage–storage–discharge relationship

Stage (m)	Storage S (m³)	Outflow O (m³/s)
0.0	0	0.00
0.5	250	0.05
1.0	500	0.10
1.5	750	0.15
2.0	1,000	0.20
2.5	1,250	0.25

Method. The storage-indication equation is (I1 + I2) + (2S1/Δt − O1) = (2S2/Δt + O2). The table gives O = S / 5,000 (S in m³, O in m³/s), so 2S/Δt + O = 17.667 O and 2S/Δt − O = 15.667 O, and each step is O2 = [(I1 + I2) + 15.667 O1] / 17.667. Software interpolating linearly in Table 3C.5 shall give the same result.

Table 3C.6 — Problem 3C-5 routed outflow

Time (min)	Inflow I (m³/s)	Outflow O (m³/s)	Storage (m³)	Stage (m)
0	0.0000	0.0000	0.0	0.000
10	0.1667	0.0094	47.2	0.094
20	0.3333	0.0367	183.3	0.367
30	0.5000	0.0797	398.4	0.797
40	0.4167	0.1226	612.8	1.226
50	0.3333	0.1511	755.7	1.511
60	0.2500	0.1670	835.2	1.670
70	0.1667	**0.1717**	**858.6**	**1.717**
80	0.0833	0.1664	832.1	1.664
90	0.0000	0.1523	761.5	1.523

Time (min)	Inflow I (m³/s)	Outflow O (m³/s)	Storage (m³)	Stage (m)
120	0.0000	0.1062	531.1	1.062
180	0.0000	0.0517	258.3	0.517

Results. Peak outflow 0.172 m³/s at 70 min; peak storage 859 m³; peak stage 1.72 m. The inflow peak of 0.50 m³/s is reduced to 34% of its value.

Table 3C.7 — Benchmark results to be reported by the applicant

Problem	Result	Benchmark	Software result	Difference (%)	Within ±5%?
3C-1	Q, main case (m³/s)	0.500			
3C-1	Q, part (b) (m³/s)	0.208			
3C-2	Tc (min)	26.27			
3C-3	Q, case (a), P = 100 mm (mm)	39.38			
3C-3	Q, case (b), P = 100 mm (mm)	64.93			
3C-3	Q, case (c), P = 100 mm (mm)	36.49			
3C-3	Q, case (c), P = 25 mm (mm)	1.97			
3C-4	Runoff, separate sub-areas (mm)	9.85			
3C-4	Runoff, composite CN (mm)	1.83			
3C-4	qp (m³/s per mm)	0.800			
3C-5	Peak outflow (m³/s)	0.172			
3C-5	Peak storage (m³)	859			

Annex 3D — Peak rate factor study for flat coastal land

Supports Clauses 3.11.5 and 3.15 of Chapter 3.

> **Not required in Arunachal Pradesh.** Arunachal Pradesh is landlocked and mostly hilly, so no land in the State meets Clause 3.11.5(a), and the standard factor 484 (PRF' = 0.208) applies to all land (Clause 3.11.5). The valley floor of the capital region and the plains round Pasighat, Tezu and Namsai are flat in places and slow to drain when the Dikrong, the Siang, the Lohit or the Noa-Dihing is high, but they are not coastal plain; their slow response is represented by storage and backwater (Clauses 3.10.4 and 3.12.4) and by the outfall-closed check of Chapter 5, not by a lower peak rate factor, while the hills respond fast. The annex and the layout of Table 3D.1 are kept only so that the annex numbering is unchanged.

Table 3D.1 — Calibrated peak rate factors (layout)

Catchment	Area (km²)	Mean slope (m/m)	Drainage condition	Events used	Calibrated PRF (US customary)	PRF' (SI)	Range of applicability

Annex 3E — CWC SUH parameters for subzones 2(a) and 2(b), with worked example

Supports Clauses 3.4.3 and 3.11.4 of Chapter 3.

To be prepared. This annex will tabulate, for CWC subzones 2(a) (North Brahmaputra) and 2(b) (South Brahmaputra), other than snow-fed and glaciated catchments, to which neither report applies, the regression relationships for the synthetic unit hydrograph parameters, the design storm duration, loss rate, base flow, areal reduction and time distribution, each with its reference to the Flood Estimation Report, and a worked example for one catchment. It needs the two CWC Flood Estimation Reports that cover Arunachal Pradesh: the North Brahmaputra subzone 2(a) report (No. NB/18/1991), whose Plates 8, 9 and 10 draw isopluvials only along the foothills (Bhalukpong, Kimin, Itanagar–Naharlagun–Doimukh, the plateau edge at Ziro, Likabali, Roing and Tezu) and leave the middle hills and high ranges blank, and whose areal reduction table (Table 6), time distribution (Fig. 12 and Table 7-2) and simplified formulae were not transcribed for this draft [TBC]; the South Brahmaputra subzone 2(b) report (Revised; Design Office Report No. SB-2(b)/R-4/44/99, March 2000), whose plates cover the south-east (Namsai, Miao, Jairampur, Changlang, Deomali, Khonsa and Longding) and also draw contours north of the Lohit to Pasighat, Roing and Tezu, where they overlap the 2(a) plates, and whose Fig. 11 and Annex 4.4 were not read and Annex 4.3 was read only by optical character recognition [TBC]; written confirmation from CWC of whether any revision of the 2(a) report extends its isopluvials into the hills [TBC]; the position of the 2(a)/2(b) boundary between Tezu and the Myanmar border, read by eye to within about 0.03–0.1° [TBC]; and, for the snow-fed and glaciated catchments of the high ranges, which neither report covers, a basis for site studies agreed with WRD [TBC], transcribed and checked against the published reports, and a catchment with physiographic parameters measured from survey or a DEM. Until it is published, take all SUH inputs directly from the applicable Flood Estimation Report (Clause 3.11.4(a)), apply the 24-hour design rainfall of Clauses 2.3.3(b) and 2.7.3 with the climate factor of Clause 2.8 (Clause 3.11.4(b)), report the SUH result alongside the HEC-HMS or SWMM result for the existing natural condition (Clause 3.11.4(c)), and, where the hydrograph model gives a lower 1% AEP peak, either justify it by calibration under Clause 3.15 or adopt the SUH peak (Clause 3.11.4(d)).

Table 3E.1 — SUH relationships by subzone (layout)

Parameter	Symbol	Unit	Subzone 2(a) (North Brahmaputra) relationship	Subzone 2(b) (South Brahmaputra) relationship
Peak discharge per unit area	qp	m³/s per km²	qp = 2.272 (L·Lc/S)^−0.409, with S as printed (not √S)	qp = Qp / A
Peak discharge of the 1-hour unit hydrograph	Qp	m³/s	Qp = qp · A	Qp = 0.905 A^0.758 (Eq. 3.4.3.2); the peak depends on the catchment area alone
Time from centre of unit rainfall to peak	tp	h	tp = 2.164 qp^−0.940	tp = 2.87 qp^−0.839
Width of UH at 50% of peak	W50	h	W50 = 2.084 qp^−1.065	W50 = 2.304 qp^−1.035
Width of UH at 75% of peak	W75	h	W75 = 1.028 qp^−1.071	W75 = 1.339 qp^−0.978
Width of rising limb at 50% of peak	WR50	h	WR50 = 0.856 qp^−0.865	WR50 = 0.814 qp^−1.018

Parameter	Symbol	Unit	Subzone 2(a) (North Brahmaputra) relationship	Subzone 2(b) (South Brahmaputra) relationship
Width of rising limb at 75% of peak	WR75	h	WR75 = 0.440 qp^−0.918	WR75 = 0.494 qp^−0.966 (confirmed by the errata)
Base width of UH	TB	h	TB = 5.428 tp^0.852	TB = 2.447 tp^1.157
Time to peak from start of rise	Tm	h	Tm = tp + tr/2	Tm = tp + tr/2
Unit duration	tr	h	1	1
Design storm duration	TD	h	TD = TB (it gave the higher peak on 16 of the 21 catchments)	TD = 1.1 tp, "rounded off to nearest full hour", or any value that gives the maximum discharge
Design loss rate	—	mm/h	2.4 (printed "0.24 cm/hr", the modal value of 233 flood events on 21 catchments; "The designer can however modify this value as per the local site conditions"); for rural SUH runs only	3.5 (printed "0.35 cm/hr", the modal value of 100 flood events, kept from the report of 1984); for rural SUH runs only
Design base flow	—	m³/s per km²	0.05	0.05 (68 of 100 events in the range 0.01–0.09)
Ratio of t-hour to 24-hour rainfall	—	—	50-yr, 12 self-recording gauges, none of them in Arunachal Pradesh: 1 h 0.260; 3 h 0.457; 6 h 0.615; 9 h 0.720; 12 h 0.805; 15 h 0.875; 18 h 0.930; 24 h 1.000. Not used on its own in this Manual: it is one of the three sets whose upper envelope gives the Arunachal Pradesh interim ratios of Clause 2.3.6(f)	10-yr, partial duration, mean of the six self-recording gauges of the report, none of them in Arunachal Pradesh: 1 h 0.48; 3 h 0.62; 6 h 0.74; 9 h 0.81; 12 h 0.87; 15 h 0.91; 18 h 0.95; 24 h 1.00 (Table 4.1). Used in this Manual only in sub-area AR-C (Clause 2.3.6(f))
Time distribution of rainfall	—	cumulative fraction by hour	2,207 storms from 147 station-years in five duration classes (2–3, 4–6, 7–12, 13–18 and 19–24 h) (Fig. 12, Table 7-2); coefficients not transcribed [TBC]	1,040 storms in five duration groups (2–3 h: 229; 4–6 h: 286; 7–12 h: 322; 13–18 h: 116; 19–24 h: 87); for a 13-hour storm 0.26, 0.43, 0.56, 0.64, 0.70, 0.76, 0.82, 0.87, 0.90, 0.94, 0.96, 0.98, 1.00 (worked example); Fig. 11 and the tables of Annex 4.4 not read [TBC]
Conversion of 1-day to 24-hour rainfall	—	factor	1.15	1.15 (§4.3.1)
Areal reduction factor	ARF	% of point rainfall	Table 6, from the short-duration rainfall "of only 8 bridge catchments"; not transcribed [TBC]. Also the curves for sub-areas AR-D and AR-E, which lie inside the subzone beyond its last contour (Clause 2.7.3)	Annex 4.3, read by optical character recognition only [TBC]: at 50 km², 93.75 (1 h), 94.25 (3 h), 95.50 (6 h), 97.00 (12 h), 98.00 (24 h); at 100 km², 88.00, 90.00, 91.75, 94.50, 96.50; at 200 km², 78.50, 82.00, 85.50, 90.00, 94.00; at 300 km², 71.00, 75.50, 80.00, 87.50, 92.00; at 500 km², 64.50 (3 h), 71.25, 83.00, 88.50; at 1,000 km², 76.00 (12 h), 83.00; at 2,000 km², 77.50 (24 h); the errata correct the 24-hour value at 1,500 km² from 79.50 to 79.00

Parameter	Symbol	Unit	Subzone 2(a) (North Brahmaputra) relationship	Subzone 2(b) (South Brahmaputra) relationship
Simplified formulae	—	m³/s	Given in the report, within ±15% of the detailed method; not transcribed for this draft [TBC]	A km², S m/km, L and Lc km, R the 24-hour point rainfall in cm: Q25 = 1.9194 A^0.4240 S^0.0917 L^0.9965 Lc^−0.5092 R25^0.3789; Q50 = 1.1368 A^0.4846 S^0.0540 L^0.8915 Lc^−0.5012 R50^0.6107; Q100 = 0.5160 A^0.5226 S^0.0552 L^0.7010 Lc^+0.3961 R100^0.9286, with the Lc exponent printed positive, unlike Q25 and Q50, probably a sign error [TBC]; not used for design in this Manual
50-yr 24-hour point rainfall at Arunachal Pradesh towns (Plate 9)	—	mm	Read by eye within about one contour (NEER reading): Itanagar about 200, in an open "<200" cell with no contour north of the town; Naharlagun and Doimukh about 200; Kimin and Bhalukpong about 240; Ziro about 320 at the open end of the line on the plateau edge; Likabali in a ">400" cell; Roing about 320; Tezu about 280; Pasighat, Seppa, Bomdila, Dirang, Tawang, Daporijo, Aalo, Mechuka, Yingkiong and Anini in blank map space, with no contour. The design depths are those of Clause 2.3.6(c), not these readings	Read by eye within about one contour (NEER reading): Namsai between 240 and 280; Pasighat at the open end of the 320 line; Roing between 240 and 280; Tezu about 240; Miao, Jairampur and Longding about 240; Khonsa on the southern edge of a closed "<200" pocket, and Changlang and Deomali inside it. The design depths are those of Clause 2.3.6(c), not these readings
Gauged catchments in or near Arunachal Pradesh	—	—	None in the State: the 21 gauged catchments are railway bridges on the plains, outside the State	None in the State: the 14 gauged catchments are railway and highway bridges in the valley below the hills, outside the State
Catchment area for which the relationships apply	A	km²	25–2,500; up to 5,000 with judgement	more than 50 to 1,500; up to 5,000 "judiciously"
Report reference	—	—	NB/18/1991: the unit hydrograph relationships, the loss rate, the ratio table (p. 24), Table 7 and Plates 8–10	SB-2(b)/R-4/44/99: §§3.4–3.7, Table 3.3, the simplified formulae (p. 17), Table 4.1 (p. 20), §4.3, Annexes 3.1, 3.2, 4.1–4.3, the errata, the worked example and Plates 8–10

Note: relationships as printed in the two CWC reports that cover Arunachal Pradesh (References of Chapter 3), read from scanned copies; Table 3.3 of the 2(b) report, its simplified formulae, its ratio table and its errata, and the 2(a) relationships and ratios, were checked against the page images for the Assam edition of this series, which uses the same two reports. A is the catchment area in km², L the length of the main stream in km, Lc the length to the point nearest the catchment centroid in km and S the equivalent slope in m/km. **Coverage.** Subzone 2(a), North Brahmaputra, lies "between 88° and 97°-20' longitudes (East) and 26° and 29°-25' latitudes (North)", "mostly bounded by international boundaries", and names "Itanagar … and Anini in Arunachal Pradesh" among its towns; its rivers include the Kameng (10,766.97 km²), the Subansiri (17,427.47 km²), the "Dinag", probably the Dihang or Siang (15,724.79 km²), and the Dibang (12,369.59 km²) (areas as read by optical character recognition). It covers the State north and west of the Lohit, but its Plates 8–10 draw isopluvials only along the foothills, roughly 10–40 km north of the State's southern border (Bhalukpong, Kimin, Itanagar–Naharlagun–Doimukh, Ziro, where the lines end at the plateau edge, Likabali, Roing and Tezu); north of them the plates are blank and the base map is schematic, so they are not read there (NEER reading). Subzone 2(b), South Brahmaputra, covers the south-east, the Noa-Dihing plain and the Patkai hills (sub-areas AR-C and AR-C1: Namsai south of the Lohit, Miao, Jairampur, Changlang, Deomali, Khonsa and Longding); the 2(a)/2(b) boundary leaves the Lohit at about Tezu and runs east-south-east to the Myanmar border (NEER reading, about 0.03–0.1°) [TBC].

The 2(b) plates also draw contours north of the Lohit at Pasighat, Roing and Tezu, where they overlap the 2(a) plates and read about one contour lower; Clause 2.3.6(c) takes the higher reading. The Western Himalayas zone 7 report covers 73°–81° E and does not apply. Where a catchment drains across the 2(a)/2(b) boundary, the SUH is computed with the parameters of each subzone and the higher 1% AEP peak is adopted, unless calibration under Clause 3.15 supports the other (set by this Manual, as in the Assam edition); the subzone is chosen by the catchment's outfall, not by its district. **Basis.** The 2(a) relationships rest on 21 gauged catchments and 233 flood events, and the 2(b) relationships on 14 catchments with 100 bridge-years of record; every gauged site is a railway or road bridge on a rural river of the plains, none of them in Arunachal Pradesh, and the steepest 2(b) catchments are outliers in its own validation, while the hill streams of the State fall far more steeply than any of them (NEER reading). **Neither SUH rests on an urban, embanked or hill catchment, and neither is tested on Arunachal Pradesh slopes. Area only.** The 2(b) peak depends on A alone, while the 2(a) peak uses L·Lc/S; at the same catchment the two can differ greatly, and that difference is a property of the reports, not of the river. **Use in the State.** The SUHs apply only to the rural rivers of more than 25 km² (2(a)) or 50 km² (2(b)) below the snow that enter or pass the towns, such as the Dikrong at Doimukh, the Pachin and the Senki where they exceed 25 km², and the foothill reaches of the Pare, the Kameng, the Ranganadi and the Siyom in subzone 2(a), and the Noa-Dihing, the Tirap and the Burhidihing headwaters in subzone 2(b); they are computed only as the benchmark of the natural condition (Clause 3.11.4), the SUH result is reported beside the hydrograph model, and the reason for any large difference is stated. In sub-areas AR-D and AR-E the 2(a) SUH is run with the design rainfall of Clause 2.3.6, because no CWC point rainfall exists there. For 2(b) catchments of 25–50 km², below the report's range, the SUH is computed and reported as outside that range. Clause 3.11.4(d) applies as written in every case. The urban catchments of Itanagar, Naharlagun, Pasighat, Tezu, Namsai and the hill towns are far smaller than 25 km² and, in the hills, far steeper than the gauged catchments; they are designed by the Rational Method or SWMM under Clause 3.4, with Tc by the segment method and the rules for steep ground and valley floors of the Commentary to Clause 3.7. Below a dam the flood is set by releases (Chapter 5), and the reaches downstream of the State are outside it (the Assam edition governs those reaches). **No SUH in snow-fed or glaciated catchments.** Neither report mentions snow or glaciers for these ranges, and the 2(a) catchments are all on the plains, so in catchments with permanent snow or a glacier, in sub-area AR-E or elsewhere (the upper Kameng, the upper Subansiri, the Siang above Tuting, the Dibang and the Lohit above Hayuliang), no CWC unit hydrograph applies: every cross-drainage structure and outfall of more than 1 km² there needs a site-specific hydrology study, agreed with the Authority and WRD and recorded on Form 2-1, with the design rainfall of Clause 2.3.6 on the part below the snow and the outburst screening of Clause 2.3.6(i) (Commentary to Clause 3.7). The design loss rates of 2.4 and 3.5 mm/h are φ-indices fitted to floods of rural catchments on the plains; the 2(a) rate is about a quarter of the basic infiltration rate measured at Doimukh (10 mm/h; Dabral et al., 2016), which suggests catchment-scale saturation in the monsoon season (NEER reading); each is used only in rural SUH runs within its own subzone, is not a soil infiltration capacity and is not used to assign HSG (Clause 3.7), in urban SCS-CN or SWMM models, or to size infiltration practices (Chapter 4). The 2(b) ratios are not used north of the Lohit or in the hills: applied to the capital-region 2% AEP depth of 265 mm, the 1-hour ratio of 0.48 would give 127 mm in an hour, against 87 mm from the Arunachal Pradesh interim ratios, 78 mm from NIH-DHAARA's Itanagar cell at 50 years and 69 mm from the 2(a) ratio (NEER's computation; tool output); Clause 2.3.6(f) deals with the difference.

Table 3E.2 — Worked example outline (layout)

Step	Content	Clause
1	Catchment area, main stream length, length to centroid and equivalent slope, from survey or DEM	3.11.4(a)
2	SUH parameters from Table 3E.1 and the plotted unit hydrograph	3.11.4(a)
3	Design storm duration, point and areal 24-hour rainfall with climate factor, time distribution	3.11.4(a), (b)
4	Effective rainfall after the design loss rate; convolution with the SUH; base flow added	3.11.4(a)
5	1% AEP peak compared with the HEC-HMS or SWMM peak for the existing natural condition	3.11.4(c), (d)

Form 3-1 — Hydrologic Calculation Summary

Supports Clauses 3.4, 3.6, 3.7, 3.8, 3.10–3.13, 3.15–3.17 of Chapter 3.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. One form per submittal. Attach the documents listed in Section H.

A. Project

Table 3F.1 — Form 3-1: project

Field	Entry
A1. Project name and applicant	
A2. Location (village or ward, survey numbers, district)	
A3. Site area (ha) and number of points of comparison (POCs)	
A4. Catchment class: standard (Clause 2.11.2) or flood-sensitive (Clause 2.11.3)	
A5. Design Rainfall Sheet reference (Form 2-1)	

B. Method and software (Clauses 3.4, 3.11, 3.12, 3.16)

Table 3F.2 — Form 3-1: method and software

Field	Entry
B1. Purpose of each calculation (conveyance, storage, comparison, catchment study)	
B2. Contributing area for each purpose (ha or km²)	
B3. Method used and the row of Table 3.1 that permits it	
B4. Reason for the choice of method	
B5. Software and version; engine and version for packages built on SWMM or HEC (Clause 3.16.1, 3.16.2)	
B6. For other software: benchmark results of Annex 3C attached (Table 3C.7) and the 5% comparison of Clause 3.16.2	
B7. Runoff transform (Clause 3.11.1)	
B8. Computation interval Δt (h), with 0.133 Tc of the smallest sub-area and the hyetograph time step (Clause 3.11.3(a))	
B9. Storage routing and channel routing methods (Clauses 3.12.1, 3.12.2)	
B10. Dynamic-wave routing required? If yes, which condition of Clause 3.12.4	
B11. CWC SUH benchmark required (25–5,000 km², Clause 3.11.4)? Result reference	
B12. Continuous simulation required (Clause 3.13.1)? Record used and starting tank levels (Clause 3.13.5)	
B13. Calibration required (Clause 3.15.1)? Calibration report reference	

C. Soils and groundwater (Clauses 3.3.3(b), 3.7, 3.10)

Table 3F.3 — Form 3-1: soils and groundwater

Field	Entry
C1. HSG source map, scale and lookup used (Clause 3.7.1, Annex 3A) or NEH Part 630, Ch. 7 assignment (Clause 3.7.2)	
C2. Infiltration tests: number, locations, depths, results (Clause 3.7.3)	
C3. Seasonal high water table: depth below ground and source (Clause 3.10.2)	
C4. Areas within 0.6 m assigned HSG D (Clause 3.10.1)	
C5. Disturbed pervious areas and HSG downgrade applied (Clause 3.3.3(b))	

D. Parameters by sub-area and condition (Clauses 3.3, 3.5, 3.8, 3.9; Clause 3.17 item 4)

Table 3F.4 — Form 3-1: parameters by sub-area and condition

Sub-area	Condition (pre / post)	Area (ha)	Impervious: roofs / paved / roads (ha)	DCIA (ha)	Disconnected (ha)	HSG	CN, AMC II	CN, AMC III (pervious part)	C and Cf (if Rational)	Tc (min)

E. Time of concentration worksheet (Clause 3.6)

One worksheet per sub-area and condition.

Table 3F.5 — Form 3-1: time of concentration worksheet

Segment	Flow type	Surface and n (Table 3.4)	L (m)	S (m/m)	P2 (mm)	V (m/s)	Tt (min)
1	Sheet					—	
2	Shallow concentrated				—		
3	Channel or pipe				—		
	Tc (not less than 10 min)						

E1. Is the post-development Tc shorter than the pre-development Tc? If not, explain (Clause 3.6.6): _____

F. Rainfall and losses (Clauses 3.8.4, 3.8.5, 3.11.5, 3.12, 3.3.5)

Table 3F.6 — Form 3-1: rainfall, losses and starting levels

Field	Entry
F1. AEPs and durations run; climate factor applied (Chapter 2)	
F2. AMC used for each duration (Clause 3.8.4)	
F3. Ia ratio for design runs; Ia = 0.05S sensitivity run made (Clause 3.8.5)	
F4. Peak rate factor used; if lower than 484, the Annex 3D value and the land it applies to (Clause 3.11.5)	
F5. Starting water level of each tank or waterbody, and its basis (Clauses 3.12.5, 3.13.5)	

Field	Entry
F6. Off-site run-on: land use assumed for conveyance and for the comparison (Clause 3.3.5)	
F7. Incidental storage counted? If yes, the authority's acceptance (Clause 3.12.3)	

G. Departures

Table 3F.7 — Form 3-1: departures from Chapter 3

No.	Clause departed from	Value used in place of the Chapter 3 value	Justification
1			
2			

H. Attachments (Clause 3.17)

Table 3F.8 — Form 3-1: attachments

Item	Attached (yes / no / not applicable)	Reference
H1. Catchment maps, pre- and post-development, with sub-areas, Tc flow paths, POCs and off-site run-on		
H2. HSG map, water-table data and infiltration test results		
H3. Parameter tables (Section D) and Tc worksheets (Section E)		
H4. Design Rainfall Sheet (Form 2-1) and hyetographs		
H5. Hydrograph tables and plots; stage–storage and stage–discharge tables; routed outflows; peak water levels		
H6. Form 3-2 for each POC		
H7. Calibration report (Clause 3.15)		
H8. Native model input and output files (Clause 3.16.4)		

I. Statement by the responsible engineer (Clause 3.17 item 10)

I state that the methods and parameters of Chapter 3 of the Arunachal Pradesh Stormwater Design Manual (Draft v1.0) have been used in this submittal, and that every departure is listed and justified in Section G.

Table 3F.9 — Form 3-1: statement by the responsible engineer

Field	Entry
Name	
Qualification and registration number	
Organisation	
Signature	
Date	

Form 3-2 — Pre- vs Post-Development Comparison

Supports Clauses 3.8.5, 3.11.5 and 3.14 of Chapter 3.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. One form for each point of comparison (POC). Flows in m³/s, volumes in m³.

A. Point of comparison (Clause 3.14.2)

Table 3F.10 — Form 3-2: point of comparison

Field	Entry
A1. POC identifier and location	
A2. Area draining to the POC: site (ha) and off-site run-on (ha)	
A3. Off-site run-on passes through site storage? (Clause 3.14.2(c))	
A4. Catchment class: standard (Clause 2.11.2) or flood-sensitive (Clause 2.11.3)	
A5. Tailwater applied, including joint cases of Clause 2.12 (Clause 3.14.9(c))	
A6. Flood-sensitive only: largest 10% AEP pre-development peak over all durations, the cap of Clause 2.11.3 (Clause 3.14.7)	
A7. Flood-sensitive only: 50% AEP pre-development peak at the pre-development critical duration (Clause 2.11.3)	

B. Peak flows (Clauses 3.14.7–3.14.10)

Limit: standard catchments 0.9 × Q_pre for the same AEP and duration (Clause 3.14.10(a)); flood-sensitive catchments the caps A6 (for 1% AEP) and A7 (for 50% AEP) (Clause 3.14.10(b)).

Table 3F.11 — Form 3-2: peak flows by AEP and duration

AEP	Duration (h)	AMC	Q_pre	Q_post, uncontrolled	Q_post, routed	Limit	Met?
50% (2-yr)	1	II					
50% (2-yr)	2	II					
50% (2-yr)	3	II					
50% (2-yr)	6	II					
50% (2-yr)	12	III					
50% (2-yr)	24	III					
50% (2-yr)	48	III					
50% (2-yr)	72	III					
10% (10-yr)	1	II					
10% (10-yr)	2	II					
10% (10-yr)	3	II					
10% (10-yr)	6	II					

AEP	Duration (h)	AMC	Q_pre	Q_post, uncontrolled	Q_post, routed	Limit	Met?
10% (10-yr)	12	III					
10% (10-yr)	24	III					
10% (10-yr)	48	III					
10% (10-yr)	72	III					
1% (100-yr)	1	II					
1% (100-yr)	2	II					
1% (100-yr)	3	II					
1% (100-yr)	6	II					
1% (100-yr)	12	III					
1% (100-yr)	24	III					
1% (100-yr)	48	III					
1% (100-yr)	72	III					

C. Volumes and storage (Clauses 3.14.8–3.14.10)

Table 3F.12 — Form 3-2: volumes and storage

AEP	Governing duration (h)	Runoff volume, pre	Runoff volume, post uncontrolled	Retention volume	Detention storage required	Peak water level in storage (m)
50% (2-yr)						
10% (10-yr)						
1% (100-yr)						

C1. Governing duration for storage, and the 24, 48 and 72 h results (Clause 3.14.10): _____

D. Sensitivity runs (Clauses 3.8.5, 3.14.11)

Table 3F.13 — Form 3-2: sensitivity runs

Run	Governing storm (AEP, duration)	Change in Q_post, routed (%)	Change in required storage (%)	Retention volume or WQv governing (Clause 3.8.5(c))
Ia = 0.05S				
Standard peak rate factor (only where a lower factor is used)				—

E. Associated checks (Clause 3.14.12)

Table 3F.14 — Form 3-2: associated checks

Check	Result	Reference in submittal
Drawdown times (Chapter 4)		
Minimum orifice and trash screen (Chapter 4)		
Emergency spillway (Chapter 4)		
Outfall-closed storage check (Chapter 5)		
Downstream analysis (Chapter 5)		

F. Statement by the responsible engineer

I state that this comparison has been made by the procedure of Clause 3.14, with the same design storms in the pre- and post-development runs, and that no runoff has been diverted from one natural catchment to another to meet the criterion (Clause 3.14.2(b)).

Table 3F.15 — Form 3-2: statement by the responsible engineer

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 4

Site Runoff Control: Retention and Detention

These annexes support Chapter 4. Annex 4C is a complete Tier A worked example with routing tables, built on the illustrative example of Clause 4.6.7. Annex 4B sets out the structure of the Tier B tables, the provisional fixed release coefficients and a standard orifice table computed from the Chapter 4 orifice equation; the values that need NIH-DHAARA depths are still to be derived. Annex 4A needs GIS and groundwater data that this draft does not yet contain; it gives the intended layout and the interim rules of Chapter 4. Forms 4-1 to 4-3 are the submittal forms required by Clause 4.17. They are draft forms and have no statutory status.

Annex 4A — Flood-sensitive catchment boundaries (GIS); shallow-groundwater zone map

Supports Clauses 4.5.3, 4.5.4 and 4.12 of Chapter 4.

4A.1 **Flood-sensitive catchment boundaries.** The catchments are those listed in Clause 4.5.3.2, with any catchment notified under Clause 4.5.4. Their maps and GIS layer are the same data set as Annex 1B, which lists the catchments and gives the attribute layout of the layer. The two annexes shall be issued together.

4A.2 **Shallow-groundwater zone map.** This map shows the areas where Clause 4.12 applies: the valley floor of the capital region, where the CGWB records water levels of 2–4 m below ground before the monsoon and 2–5 m after it in the Dikrong valley and 1–5 m in the semi-consolidated formations of Papum Pare (Papum Pare district booklet), with the palaeochannels and swampy land of the Pachin and Dikrong flood plains; the flood plains and fan toes of the Siang at Pasighat (1.50–11.13 m, East Siang district booklet), the Lohit at Tezu (3.58 m before and 3.52 m after the monsoon of 2008, Lohit district booklet), the Dibang at Roing and the Noa-Dihing at Namsai and Miao; the dug-well ground of Bhalukpong (2.62–5.50 m in the lean period, West Kameng district booklet); the land beside the capital's nallahs; the margins of ponds, swamps and reservoirs; and hill sites with perched water or springs, and any area where the groundwater table lies within 3 m of the surface at any time of year (Clause 4.12.1).

To be prepared. This annex will contain (a) the boundaries of the flood-sensitive catchments as a GIS layer and as maps at a scale fit for deciding whether a plot lies inside them, and (b) a map of the shallow-groundwater zone of Clause 4.12.1, with the seasonal high groundwater depth during and after the monsoon. It needs basin and sub-basin boundaries from a digital elevation model and the drainage network (WRD, NRSC, Survey of India), the river and anti-erosion works of WRD, with their design levels [TBC], the CWC levels at Passighat, Namsai, Tezu, Miao and Yazali (as transcribed by SANDRP), surveyed flood marks of the Dikrong flood of 1999 and of the floods of 2017, September 2018, 2024 and May–June 2025, with the localities named in the reports, the reservoir and release records of NEEPCO and NHPC, NDMA's list of high-risk glacial lakes and CWC's glacial-lake monitoring, the returns of the Water Bodies Census and the Forest Department's wetland truthing, the list of water bodies that urban local bodies and Planning Authorities are to prepare under Annexure E 1.8 of the APBBL 2019, and any landslide inventory or hazard map of the Arunachal Pradesh State Disaster Management Authority (APSDMA), a District Disaster Management Authority, GSI or NRSC [TBC], town boundaries (the Department of Urban Affairs (Town Planning wing) for the municipal areas of Itanagar and Pasighat (notified in August and September 2010; the High Court records later notifications of 2012, and the dates conflict), the area of the ICR Master Plan 2031 and the Local Planning Areas; IMC and the Pasighat Municipal Council themselves; and the Deputy Commissioners for the circles and villages, with the communities and clans for the land they hold), flood maps held by APSDMA, observation-well records of the CGWB and the WRD, and the extent of the sandy terrace and valley-fill soils of the Naharlagun–Nirjuli–Doimukh valley, the palaeochannels, swamps and flood-plain silts of the Pachin and the Dikrong and of the Siang, the Dibang, the Lohit and the Noa-Dihing, the bhabar boulder fans of Pasighat, Ruksin, Roing, Tezu, Namsai, Bhalukpong and Banderdewa, the residual soils and slope debris over the Siwalik sandstones and shales, the thin soils over the gneiss and schist of the high ranges and urban fill, with the slopes of more than 10° and the shale ground to which the hill rule of Clause 4.11 applies and the flood-plain land to which its floodplain rule applies from soil survey maps (NBSS&LUP, the State soil survey agency [TBC]). Until it is published: (a) the catchments named in Clause 4.5.3.2 apply, and whether a site lies in one is decided and recorded as set out in Annex 1B; and (b) every site to which Clause 4.12.1 may apply establishes its design groundwater level from site piezometer readings over one April–November season or, failing that, from the nearest CGWB or State observation well plus 0.5 m and the design flood level of any adjacent river, stream, nallah, pond or reservoir, including the backwater of the Dikrong below the Pare dam in a Naharlagun or Doimukh nallah and of the Siang, Lohit or Noa-Dihing at a Pasighat, Tezu or Namsai outfall (Clause 4.12.1(b)). For the flotation check in the Dikrong and Pachin flood plains of the capital region, with their palaeochannels and swamps, the Siang, Lohit and Noa-Dihing flood plains at Pasighat, Tezu and Namsai, land below the 1% AEP flood level of those rivers, and the pond and swamp margins without piezometer readings, the design groundwater level is existing ground level (Clause 4.12.1).

Table 4A.1 — Attributes of the shallow-groundwater zone layer (layout)

Field	Content	Unit or format
zone_id	Unique identifier	text
zone_class	Capital-region valley floor (Pachin or Dikrong flood plain, palaeochannel or swampy land, terrace sands, or other); main-stem flood plain or fan toe (Siang at Pasighat, Lohit at Tezu, Dibang at Roing, Noa-Dihing at Namsai or Miao, or other); nallah flood plain (Senki, Pachin, Papu Nallah or other); pond or swamp margin; reservoir margin or release reach (Pare, Ranganadi, Kameng, Lower Subansiri or other); perched water or spring on a hill slope; other area with groundwater within 3 m of the surface (Clause 4.12.1)	text
shgw_depth_m	Seasonal high groundwater depth below ground, monsoon season	m
shgw_basis	Wells or piezometers used, and period of record	text
tidal_influence	Whether the groundwater level follows an adjacent tidal water body (Clause 4.12.1(b))	yes / no
source	Source agency and date of the data	text

Field	Content	Unit or format
geometry	Zone boundary	polygon

Annex 4B — Tier B tables: PSD and SSR (Table 4.3), retention credit factor C_R, standard outlet sizes; confirmed fixed release coefficients (Table 4.3A)

Supports Clauses 4.4.6.3, 4.14.1, 4.14.2 and 4.14.4 to 4.14.6 of Chapter 4.

4B.1 This annex will hold four tables. Their status in this draft is:

Table 4B.1 — Contents of Annex 4B and their status

Table	Content	Clause	Status in this draft
4B.2	Tier B permissible site discharge (PSD) and site storage requirement (SSR), the values of Table 4.3	4.14.2	To be prepared
4B.3	Retention credit factor C_R	4.4.6.3	To be prepared; C_R = 0 until published
4B.4	Standard outlet sizes	4.14.2 step 4, 4.14.6	Computed in this annex from the orifice equation of Clause 4.6.5.2
4B.5	Fixed release coefficients C_10 and C_2 (Table 4.3A)	4.14.4	Provisional values of Table 4.3A; confirmed values to be prepared

4B.2 PSD and SSR (Table 4.3)

To be prepared. This table will give, for each rainfall zone, hydrologic soil group and post-development imperviousness, the PSD for the 2-yr and 100-yr stages and the SSR, for standard and flood-sensitive catchments, in the layout of Table 4.3. It needs NIH-DHAARA design depths with the climate factor for each zone (Chapter 2, Annex 2A), the sub-daily ratios of Annex 2B, and routing of a set of standard sites by the full method of Clause 4.6 for every AEP and duration of Table 4.1. Each PSD shall be the governing release cap and each SSR the governing storage per hectare, with a margin so that the simplified method is never cheaper than routing. Until it is published, Tier B sites use Clause 4.6, or the fixed-coefficient route of Clause 4.14.3 where the site is 1 ha or less (Clauses 4.14.1 and 4.14.3).

Table 4B.2 — Tier B PSD and SSR (layout of Table 4.3)

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
AR-Z1 Western foothills: AR-A Itanagar capital region (Itanagar–Naharlagun–Nirjuli–Doimukh–Banderdewa)	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
AR-Z1 Western foothills: AR-A1 Western foothills (Bhalukpong–Seijosa–Kimin–Yazali)	A / B / C / D	50% / 70% / 90%	—	—	—	—	—

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
AR-Z2 Eastern foothills: AR-B Siang–Dibang–Lohit foothills (Pasighat–Ruksin–Likabali–Roing–Tezu)	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
AR-Z3 South-east: AR-C Noa-Dihing plain (Namsai–Chowkham–Bordumsa–Miao)	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
AR-Z3 South-east: AR-C1 Patkai hills (Changlang–Jairampur–Deomali–Khonsa–Longding)	C / D	50% / 70% / 90%	—	—	—	—	—
AR-Z4 Hills and high ranges: AR-D Middle hills (Ziro–Daporijo–Aalo–Seppa–Basar–Yingkiong)	C / D	50% / 70% / 90%	—	—	—	—	—
AR-Z4 Hills and high ranges: AR-E High ranges (Tawang–Bomdila–Dirang–Mechuka–Anini–Hayuliang)	C / D	50% / 70% / 90%	—	—	—	—	—

4B.3 Retention credit factor C_R

To be prepared. This table will give C_R for each rainfall zone, hydrologic soil group and design infiltration or drawdown rate of the retention practice (Clauses 4.4.3 and 4.4.6.3). It needs routing of the full duration set of Clause 2.5.2 with NIH-DHAARA depths, with the retention practice modelled as in Clause 4.4.6.2, and the credit expressed as the reduction in governing storage per cubic metre of retention provided. Until it is published, **C_R = 0** (Clause 4.4.6.3).

Table 4B.3 — Retention credit factor C_R (layout)

Zone (Annex 2A)	HSG	Design infiltration or drawdown rate (mm/h)	C_R (–)

4B.4 Standard outlet sizes

4B.4.1 Table 4B.4 gives the largest circular orifice, in 5 mm steps, whose discharge does not exceed a stated permissible discharge at a stated head. It is computed from the orifice equation with the discharge coefficient of Clause 4.6.5.2:

$$Q = 0.60 \times (\pi d^2 / 4) \times \sqrt{(2 g H)}$$

where Q is the discharge (m³/s), d the orifice diameter (m), g = 9.81 m/s² and H the head from the water level to the centre of the orifice (m). Sizes are rounded **down**, so that the orifice never passes more than the permissible discharge. Where the computed size is below 50 mm, the 50 mm minimum of Clause 4.8.2 is shown; it is deemed to comply under Clause 4.5.5.1.

4B.4.2 The table assumes free discharge. Where the tailwater can rise above the orifice (Clause 4.6.6), H is the difference between the upstream and downstream water levels and the orifice shall be checked by routing. The State Stormwater Technical Committee may replace this table when it issues Annex 4B.

Table 4B.4 — Largest orifice diameter (mm) for a permissible discharge at a given head (Cd = 0.60, free discharge)

Permissible discharge (L/s)	H = 0.5 m	H = 1.0 m	H = 1.5 m	H = 2.0 m
5	55	50	50	50
10	80	65	60	55
15	100	80	75	70
20	115	95	85	80
30	140	115	105	100
50	180	150	135	130
75	225	185	170	155
100	260	215	195	180
150	315	265	240	225
200	365	305	275	260
300	450	375	340	315

Check: for 50 L/s at H = 1.0 m, the area is 0.050 / (0.60 × √(2 × 9.81 × 1.0)) = 0.0188 m², so d = √(4 × 0.0188 / π) = 0.155 m, rounded down to 150 mm.

4B.5 Fixed release coefficients (Table 4.3A)

4B.5.1 Table 4B.5 repeats the provisional coefficients of Table 4.3A. They may be used now under the fixed-coefficient route (Clause 4.14.4).

Table 4B.5 — Fixed release coefficients C_10 and C_2 (provisional, Table 4.3A)

Hydrologic soil group	C_10	C_2	Clause	Status
A (sandy, well drained)	0.05	0.02	4.14.4	Provisional
B	0.08	0.03	4.14.4	Provisional
C	0.15	0.08	4.14.4	Provisional
D (clay, poorly drained)	0.25	0.15	4.14.4	Provisional

To be prepared. The confirmed coefficients will replace Table 4B.5. They need NIH-DHAARA depths for each zone and the greenfield curve numbers of Clause 3.3, as described in the commentary to Clause 4.14. Until they are published, the provisional values of Table 4.3A apply.

Annex 4C — Worked example (Tier A) with full routing tables

Supports Clauses 4.4 to 4.9, 4.15 and 4.17 of Chapter 4.

Illustrative — not design values. This example continues the illustrative example of Clause 4.6.7. Its inputs are invented to be plausible for a hillside colony in Itanagar draining to the Senki; they are not NIH-DHAARA values and must not be used for design. Part 1 sets out the inputs, hydrographs and routing step by step, for a trial outlet. Part 2 finds that the trial outlet fails the drawdown check with the blockage of Clause 4.8.3, and revises it to the outlet reported in Table 4.2. Part 3 completes the spillway, outlet, safety and retention checks. The outfall-closed check of Chapter 5 for the same facility on an outfall to the Senki below a hillside colony in Itanagar is in Annex 5C.

Part 1 — Inputs, hydrographs and routing (Clauses 4.6.1 to 4.6.4)

4C.1 **Inputs.**

Table 4C.1 — Inputs (Illustrative — not design values)

Item	Value	Basis
Site area A	2.0 ha (0.02 km²), one outfall	Clause 4.6.7
Catchment class	Flood-sensitive (Clause 4.5.3)	Clause 4.6.7
Land cover and curve numbers, AMC II	Pre-development: all pervious, CN 70. Post-development, as two sub-areas: directly connected impervious 1.57 ha at CN 98, and pervious open space 0.43 ha at CN 70 (same soil as pre-development). Impervious fraction f = (92 − 70) / (98 − 70) = 0.786, so the area-weighted CN is 92	Clauses 3.9.2, 4.6.7
AMC III conversion	Pervious areas only, for storms of 12 h and longer: CN_III = 23·CN / (10 + 0.13·CN) = 84.3. The impervious CN 98 is not converted	Clause 3.8.4
Initial abstraction	Ia = 0.2S; Ia = 0.05S as a sensitivity run	Clause 3.8.5
Time of concentration Tc	45 min pre-development; 15 min post-development, used for both sub-areas, because the open space is small and drains through the same site system	Clause 4.6.7
Unit hydrograph	SCS triangular; tL = 0.6 Tc; tp = Δt/2 + tL; base 2.67 tp	Clauses 3.6.5, 3.11.2
Time step Δt	5 min (= Tc/3 of the post-development site)	Clause 4.6.2, step 8
24-h depths, 2-, 10-, 100-yr	110, 200, 350 mm, taken as including the climate factor	Clause 4.6.7
Shorter durations	P(t) = P24 · (t/24)^0.40 (assumed ratio set, not Annex 2B)	Clause 4.6.7
48-h and 72-h depths	1.25 and 1.40 × P24, with the 24-h depth on the last day	Clauses 4.6.7, 2.9.2
Storage	Open, vertical-walled, 2,500 m² plan area, excavated, no embankment, not publicly accessible	Clause 4.6.7
Trial outlet	Stage 1: 120 mm orifice at the floor. Stage 2: 470 mm orifice, invert 0.533 m above the floor. No Stage 3	Trial for this annex; Part 2 revises it
Outfall	Free outfall to a receiving drain whose level stays below the outlet invert	Illustrative input

The example follows Clauses 3.8.4 and 3.9.2: the runoff of each sub-area is computed separately and the two are added before routing.

4C.2 **Design rainfall.** Table 4C.2 gives the depths. For example, the 100-yr 6-hour depth is 350 × (6/24)^0.40 = 350 × 0.574 = 201.0 mm.

Table 4C.2 — Design rainfall depths, mm (Illustrative — not design values)

Duration (h)	1	2	3	6	12	24	48	72
50% AEP (2-yr)	30.9	40.7	47.9	63.2	83.4	110.0	137.5	154.0
10% AEP (10-yr)	56.1	74.0	87.1	114.9	151.6	200.0	250.0	280.0
1% AEP (100-yr)	98.2	129.5	152.3	201.0	265.3	350.0	437.5	490.0

4C.3 **Hyetographs.** Storms up to 24 h use the alternating-block method in 5-minute blocks with the peak block at mid-storm (Clause 2.9.1). The 48- and 72-hour storms spread the depth in excess of the 24-hour depth uniformly over the first 24 or 48 h and place the 24-hour alternating-block storm on the last day (Clause 2.9.2). For the 100-yr 72-hour storm: (490.0 − 350.0) / 576 blocks = 0.243 mm per 5 minutes for the first 48 h; the peak 5-minute block on the last day is 350 × (5/1440)^0.40 = 36.3 mm, at 60:00–60:05 h.

4C.4 **Losses.** Table 4C.3 gives S = 25,400/CN − 254 (mm) and Ia = 0.2S. The runoff depth for a rainfall depth P is Q = (P − Ia)² / (P − Ia + S) for P > Ia, and zero otherwise.

Table 4C.3 — Curve numbers and abstractions (Illustrative — not design values)

Condition	AMC	CN	S (mm)	Ia = 0.2S (mm)
Pre-development	II (durations ≤ 6 h)	70	108.9	21.8
Pre-development	III (durations ≥ 12 h)	84.3	47.3	9.5
Post-development pervious open space (0.43 ha)	II (durations ≤ 6 h)	70	108.9	21.8
Post-development pervious open space (0.43 ha)	III (durations ≥ 12 h)	84.3	47.3	9.5
Post-development directly connected impervious (1.57 ha)	All durations (not converted)	98	5.2	1.0

Check: 100-yr 24 h, post-development. Impervious: Q = (350.0 − 1.0)² / (350.0 − 1.0 + 5.2) = 343.9 mm. Pervious, AMC III: Q = (350.0 − 9.5)² / (350.0 − 9.5 + 47.3) = 299.0 mm. Site: 0.786 × 343.9 + 0.214 × 299.0 = 334.2 mm. The post-development columns of Table 4C.4 are these area-weighted site depths.

Table 4C.4 — Storm runoff depth Q, mm (Illustrative — not design values)

Duration (h)	AMC	2-yr pre	2-yr post	10-yr pre	10-yr post	100-yr post
1	II	0.7	20.1	8.2	41.3	79.2
2	II	2.8	28.2	16.9	57.2	108.5
3	II	5.1	34.2	24.5	69.0	130.2
6	II	11.4	47.5	42.9	94.7	177.1
12	III	45.0	70.5	106.6	137.2	249.9
24	III	68.4	96.4	152.6	185.1	334.2
48	III	93.5	123.3	201.0	234.7	421.5
72	III	108.9	139.6	230.3	264.5	473.9

The runoff volume is 10 × Q × A = 20 × Q m³ for this 2.0 ha site: for example 9,478 m³ for the 100-yr 72-hour storm. The routed hydrographs carry up to 0.5% less, because the 5-minute alternating-block storm places 349.5 mm rather than 350.0 mm on the last day.

4C.5 **Unit hydrographs.** The runoff in each 5-minute block (for the post-development site, the sum of the two sub-areas) is convolved with the triangular unit hydrograph of Table 4C.5. The peak is qp = 0.208 × A × Q / tp, with A in km² and Q = 1 mm (Clause 3.11.2).

Table 4C.5 — Unit hydrograph parameters (Illustrative — not design values)

Condition	Tc (h)	tL = 0.6 Tc (h)	tp = Δt/2 + tL (h)	Base 2.67 tp (h)	qp (L/s per mm of runoff)
Pre-development	0.75	0.45	0.492	1.313	8.5
Post-development	0.25	0.15	0.192	0.512	21.7

4C.6 **Release caps (Clause 4.5.3).** The site is flood-sensitive, so the mixed-frequency rule applies. The 100-yr cap is the largest pre-development 10-yr peak over all durations: **356 L/s** (72 h; Table 4.2). The 2-yr cap is the largest pre-development 2-yr peak: **180 L/s** (72 h). Each cap applies to every post-development duration (Clause 4.5.3.1).

4C.7 **Stage–storage–discharge.** The basin is vertical-walled, so storage S = 2,500 × h (m³), where h is the stage above the floor (m). Outlet discharge follows Clause 4.6.5.2 with Cd = 0.60:

- Stage 1, for h ≥ d: Q1 = 0.60 × A1 × √(2g (h − d/2)). For h < d (orifice part-full), the head is taken as d/2 and the result is multiplied by h/d.
- Stage 2 is counted once the water is above its centre: Q2 = 0.60 × A2 × √(2g (h − z2 − d2/2)), where z2 is its invert. Below its centre its flow is ignored, which slightly over-states storage.

Table 4C.6 — Stage–storage–discharge, trial outlet (Illustrative — not design values)

Stage h (m)	Storage (m³)	Stage 1, 120 mm (L/s)	Stage 2, 470 mm (L/s)	Total (L/s)
0.00	0	0.0	0.0	0.0
0.06	150	3.7	0.0	3.7
0.12	300	7.4	0.0	7.4
0.20	500	11.2	0.0	11.2
0.30	750	14.7	0.0	14.7
0.40	1,000	17.5	0.0	17.5
0.50	1,250	19.9	0.0	19.9
0.60	1,500	22.1	0.0	22.1
0.70	1,750	24.0	0.0	24.0
0.80	2,000	25.9	83.0	108.9
0.90	2,250	27.5	167.8	195.3
1.00	2,500	29.1	222.3	251.4
1.10	2,750	30.7	265.8	296.5
1.20	3,000	32.1	303.2	335.3
1.30	3,250	33.5	336.4	369.9
1.40	3,500	34.8	366.7	401.5

Check at h = 1.00 m: Q1 = 0.60 × 0.01131 × √(19.62 × 0.94) = 0.0291 m³/s; Q2 = 0.60 × 0.1735 × √(19.62 × (1.00 − 0.533 − 0.235)) = 0.2223 m³/s.

4C.8 **Routing.** Each storm is routed by level-pool continuity (Clause 4.6.1): over each 5-minute step, the change in storage equals inflow volume minus outflow volume. The computation used six 50-second sub-steps per 5-minute step. Each row of Table 4C.7 can be checked by hand as ΔS ≈ (I − Ō) × 300 s, where I is the mean inflow over the 5-minute step ending at the time shown and Ō is the mean of the outflows at the start and end of the step. For example, between 60:15 and 60:20: ΔS = 2,853.0 − 2,613.3 = 239.7 m³, and (1.0891 − (0.2655 + 0.3069)/2) × 300 = 240.9 m³.

Table 4C.7 — Routing of the 100-yr 72-hour storm through the trial outlet, around the peak (Illustrative — not design values)

Time (h:min)	Rainfall in step (mm)	Inflow I (L/s)	Outflow O (L/s)	Storage S (m³)	Stage h (m)
60:00	8.44	286.3	169.5	2,164.0	0.866
60:05	36.33	354.2	184.1	2,216.9	0.887
60:10	11.61	703.3	218.0	2,367.1	0.947
60:15	6.88	1,066.0	265.5	2,613.3	1.045
60:20	5.23	1,089.1	306.9	2,853.0	1.141
60:25	4.34	897.5	334.8	3,025.0	1.210
60:30	3.77	653.2	349.9	3,117.6	1.247
60:35	3.36	403.6	353.8	**3,132.9**	**1.253**
60:40	3.05	301.5	352.3	3,117.3	1.247
60:45	2.81	254.8	348.6	3,088.7	1.235
60:50	2.61	224.9	343.7	3,052.4	1.221
60:55	2.45	203.3	337.9	3,011.3	1.205

Storage is greatest at the end of the step ending at 60:35. In the next step the mean inflow (302 L/s) is below the outflow (about 352 L/s), so storage falls.

Table 4C.8 — Routing of the 100-yr 72-hour storm through the trial outlet, hourly (Illustrative — not design values)

Time (h)	Cumulative rainfall (mm)	Inflow (L/s)	Outflow (L/s)	Stage (m)	Storage (m³)
12	35.0	14	8	0.130	325
24	70.0	15	12	0.215	536
36	105.0	16	14	0.264	660
48	140.0	16	15	0.294	736
54	181.7	47	19	0.469	1,172
57	213.5	69	23	0.623	1,559
59	248.5	120	91	0.789	1,971
60	293.3	286	170	0.866	2,164
61	378.0	187	332	1.187	2,967
62	399.3	106	237	0.968	2,421

Time (h)	Cumulative rainfall (mm)	Inflow (L/s)	Outflow (L/s)	Stage (m)	Storage (m³)
63	414.5	80	142	0.829	2,072
66	446.9	51	52	0.771	1,927
72	489.5	33	33	0.768	1,920
84	489.5	0	18	0.405	1,012
96	489.5	0	10	0.167	418
108	489.5	0	4	0.058	146

The routed outflow volume equals the inflow volume (about 9,470 m³): detention delays the volume but does not remove it.

4C.9 **Results, trial outlet.** Table 4C.9 gives the peaks, maximum stages and drawdown times for the trial outlet.

Table 4C.9 — Results for the trial outlet (120 mm and 470 mm orifices) (Illustrative — not design values)

Duration (h)	2-yr detained (L/s)	2-yr max stage (m)	10-yr detained (L/s)	10-yr max stage (m)	100-yr detained (L/s)	100-yr max stage (m)	100-yr storage (m³)	10-yr 90% drawdown, clean (h)	10-yr 90% drawdown, 50% blocked (h)
1	9	0.15	15	0.30	22	0.59	1,468	27.2	54.2
2	11	0.20	18	0.42	89	0.79	1,966	28.3	57.0
3	13	0.24	20	0.50	135	0.82	2,058	29.3	59.1
6	15	0.31	23	0.64	190	0.89	2,229	31.1	63.4
12	17	0.40	49	0.77	279	1.06	2,647	36.2	69.2
24	19	0.45	87	0.79	334	1.20	2,991	42.8	75.4
48	20	0.51	144	0.83	353	1.25	3,129	42.5	72.7
72	20	0.52	147	0.84	354	1.25	**3,133**	42.5	71.9

The drawdown time is measured from the time of maximum 10-yr storage until 90% of that storage has been released (Clause 4.7.1).

Part 2 — Checks and revision of the outlet (Clauses 4.5, 4.7 and 4.8)

4C.10 **Release caps.** Every 100-yr detained peak is at or below 356 L/s, and every 2-yr detained peak is far below the 2-yr cap of 180 L/s. Both caps are met. The 2-yr peaks are not compared duration by duration with the pre-development peaks: for a flood-sensitive site the 2-yr cap is the single largest pre-development 2-yr peak (Clause 4.5.3.1).

4C.11 **Drawdown.** Clause 4.8.3 requires the low-flow orifice to be assumed **50% blocked** when drawdown is checked. With the 120 mm orifice at half its area, 90% of the 10-yr storage takes 54 to 75 h to drain (Table 4C.9), against the 48-hour limit of Clause 4.7.1. **The trial outlet fails.** With a clean orifice it would drain in about 42 h.

4C.12 **Revised outlet.** The low-flow orifice was increased in 10 mm steps until the blocked drawdown met 48 h for every duration, and Stage 2 was then re-sized so that the 100-yr cap was still met. The result:

- Stage 1: **170 mm** orifice at the floor;
- Stage 2: **460 mm** orifice, invert 0.53 m above the floor (centre at 0.76 m);
- no Stage 3.

The larger low-flow orifice releases more in frequent storms. That is acceptable here because the 2-yr cap of a flood-sensitive site is the largest pre-development 2-yr peak (Clause 4.5.3.1). The WQv is assumed to be treated in a separate practice upstream (Chapter 8), so Stage 1 is not required to hold the WQv for 24–48 h (Clause 4.6.5.1); where Stage 1 also releases the WQv, Clause 4.7.2 must be checked as well.

Table 4C.10 — Stage–storage–discharge, revised outlet (Illustrative — not design values)

Stage h (m)	Storage (m³)	Stage 1, 170 mm (L/s)	Stage 2, 460 mm (L/s)	Total (L/s)
0.00	0	0.0	0.0	0.0
0.085	213	8.8	0.0	8.8
0.17	425	17.6	0.0	17.6
0.30	750	28.0	0.0	28.0
0.40	1,000	33.9	0.0	33.9
0.50	1,250	38.9	0.0	38.9
0.60	1,500	43.3	0.0	43.3
0.70	1,750	47.3	0.0	47.3
0.76	1,900	49.6	0.0	49.6
0.80	2,000	51.0	88.3	139.3
0.90	2,250	54.5	165.3	219.7
1.00	2,500	57.7	216.4	274.1
1.10	2,750	60.8	257.5	318.3
1.17	2,925	62.8	282.8	345.6
1.20	3,000	63.7	293.0	356.7
1.30	3,250	66.5	324.6	391.1

Table 4C.11 — Results for the revised outlet (170 mm and 460 mm orifices) (Illustrative — not design values)

Duration (h)	2-yr detained (L/s)	2-yr max stage (m)	10-yr detained (L/s)	10-yr max stage (m)	10-yr storage (m³)	100-yr detained (L/s)	100-yr max stage (m)	100-yr storage (m³)	10-yr 90% drawdown, 50% blocked (h)
1	15	0.14	28	0.29	734	42	0.57	1,426	31.3
2	20	0.19	34	0.40	990	79	0.76	1,911	32.1
3	22	0.22	37	0.46	1,147	139	0.80	1,999	32.8
6	25	0.26	41	0.56	1,386	194	0.86	2,154	34.2
12	30	0.33	46	0.68	1,692	276	1.01	2,512	39.0
24	32	0.37	49	0.75	1,870	320	1.11	2,766	45.3
48	34	0.40	82	0.77	1,913	343	1.17	**2,913**	44.8
72	34	0.41	84	0.77	1,915	343	1.16	2,911	44.7

Findings:

- **100-yr cap:** largest detained peak 343 L/s ≤ 356 L/s. Met.
- **2-yr cap:** largest detained peak 34 L/s ≤ 180 L/s. Met.
- **Drawdown:** longest blocked drawdown 45.3 h ≤ 48 h (Clause 4.7.1). Met.
- **Governing storage: 2,913 m³** (100-yr, 48 h), at a maximum stage of **1.17 m**. The larger low-flow orifice releases more water early in the long storms, so the revised outlet needs about 220 m³ less storage than the trial outlet. Table 4.2 in Clause 4.6.7 reports this revised design.
- **Governing storms (Clause 4.6.2, step 12):** storage, the 100-yr 48-hour storm; Stage 1, the 10-yr 24-hour storm (drawdown); Stage 2, the 100-yr 48-hour storm (cap).

Part 3 — Sensitivity, retention, spillway, outlet details and safety

4C.13 **Ia = 0.05S sensitivity (Clause 3.8.5).** With S converted as S0.05 = 25.4 × 1.33 × (S0.20 / 25.4)^1.15, the governing 100-yr 48-hour run gives 2,898 m³ of storage and a 341 L/s peak, slightly below the default run. The pre-development 10-yr peak, and so the 100-yr cap, falls to 344 L/s. The design is based on the default run (Clause 3.8.5(c)); the sensitivity results are reported on Form 3-2.

4C.14 **Retention and retention credit (Clauses 4.4.2 and 4.4.6).** With an illustrative retention depth P_R = 40 mm, Q_R is computed for each sub-area at AMC II, because a composite CN is not used for retention (Clause 3.9.4). Impervious, CN 98: S = 5.2 mm, Ia = 1.0 mm, Q_R = (40 − 1.0)² / (40 − 1.0 + 5.2) = 34.4 mm. Pervious, CN 70: S = 108.9 mm, Ia = 21.8 mm, Q_R = (40 − 21.8)² / (40 − 21.8 + 108.9) = 2.6 mm. RRV = 10 × (34.4 × 1.571 + 2.6 × 0.429) = **552 m³**. The retention is modelled as a store that is empty at the start of the storm and captures all runoff until full, with no infiltration during the storm (Clause 4.4.6.2).

Table 4C.12 — Retention credit by routing, revised outlet (Illustrative — not design values)

100-yr storm	Storage without retention (m³)	Storage with retention (m³)	Reduction (m³)
24 h	2,766	2,628	138
48 h	2,913	2,906	7
72 h	2,911	2,911	0

The governing storage falls from 2,913 to 2,906 m³, so the retention credit is 7 m³, about 1% of the RRV. The retention is still required in full for its own purposes (Clause 4.4.1, Chapter 8).

4C.15 **Emergency spillway (Clause 4.9).** The facility is excavated, with no embankment, so Clause 4.9.7 applies: the overflow route is treated as the spillway and must meet Clause 4.9.1.

- Design flow: the 1% AEP peak inflow, 1,089 L/s, with the outlet blocked and the basin full to the crest.
- Crest: the 1% AEP maximum water level with the outlet working is 1.17 m; with the recommended 0.15 m clearance (Clause 4.9.3) the crest is set at **1.35 m**.
- Crest length: a broad-crested weir with Q = C × L × H^1.5, C = 1.7 (an illustrative coefficient for a broad-crested weir in SI units; Clause 4.6.5.2 requires a coefficient suited to the shape). With L = 4.0 m: H = (1.089 / (1.7 × 4.0))^(2/3) = 0.295 ≈ **0.30 m**.
- Maximum level with the spillway flowing: 1.35 + 0.30 = 1.65 m. With 0.3 m freeboard (Clause 4.9.1), the top of the walls is at least **1.95 m** above the floor.
- The spillway discharges to the 1% AEP overland flow path, away from buildings (Clause 4.9.4).

4C.16 **Outlet details (Clause 4.8).**

Table 4C.13 — Outlet checks, revised outlet (Illustrative — not design values)

Item	Requirement	Value	Result
Minimum orifice	≥ 50 mm (Clause 4.8.2)	170 mm	Met
Rack bar spacing	≤ half the smallest opening and ≥ 25 mm (Clause 4.8.3)	≤ 85 mm	Set at 75 mm
Rack open area	≥ 10 × area protected (Clause 4.8.3)	10 × (0.0227 + 0.1662) m² = 1.89 m² for one rack around both orifices	Provide ≥ 1.89 m²
Anti-vortex, Stage 1	Needed if head > 1.5 d (Clause 4.8.4)	Head up to 1.08 m > 0.26 m	Required
Anti-vortex, Stage 2	Needed if head > 1.5 d (Clause 4.8.4)	Head above centre up to 0.41 m < 0.69 m	Not required
Isolation	Facility serving > 1 ha (Clause 4.8.6)	Serves 2.0 ha	Stop-log slot or penstock, normally open
Outlet barrel	≥ 300 mm (Clause 4.8.5)	Sized under Chapter 9 for 343 L/s	To be designed

4C.17 **Safety (Clause 4.15).** The 10-yr depth (0.77 m) exceeds the 0.45 m limit for publicly accessible storage (Clause 4.15.1(a)), so the facility is not open to the public. It has vertical walls higher than 0.6 m and a depth of more than 1.2 m when the spillway flows, so a non-climbable fence at least 1.2 m high with a lockable gate is required (Clause 4.15.3). Signs and a depth marker are provided (Clause 4.15.5).

4C.18 **Summary of the design (Illustrative — not design values).**

Table 4C.14 — Summary of the revised design (Illustrative — not design values)

Item	Value
Storage	2,500 m² plan area; 2,913 m³ at the 1% AEP maximum level of 1.17 m
Stage 1	170 mm orifice at the floor, with trash rack and anti-vortex plate
Stage 2	460 mm orifice, invert 0.53 m
Spillway	Crest 1.35 m, length 4.0 m, maximum level 1.65 m
Top of walls	≥ 1.95 m above the floor
100-yr peak release	343 L/s (cap 356 L/s)
2-yr peak release	34 L/s (cap 180 L/s)
10-yr drawdown, 50% blocked	45.3 h (limit 48 h)
Retention	RRV 552 m³ provided in addition; credit 7 m³
Still to be checked	Outfall-closed check on an outfall to the Senki below a hillside colony in Itanagar (Annex 5C); downstream analysis (Chapter 5); groundwater and flotation (Clause 4.12); WQv (Chapter 8)

Form 4-1 — Site Runoff Control Report

Supports Clauses 4.3 to 4.17 of Chapter 4.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. One form for each site. Where the site drains to more than one outfall, complete Sections E to J for each outfall (Clause 4.5.1.3). Tier B sites using Clause 4.14.2 attach Form 4-2 in place of Sections F and G; sites using the fixed-coefficient route attach Form 4-3 in place of Sections F and G (Clause 4.17).

A. Site and route

Table 4F.1 — Form 4-1: site and route

Field	Entry
A1. Project name and applicant	
A2. Location (village or ward, survey numbers, district)	
A3. Approving Authority and tier (Tier A / Tier B)	
A4. Site area, land disturbance and new or replaced impervious area (ha, ha, m²) (Clause 4.1.2)	
A5. Number of outfalls (Clause 4.5.1.3)	
A6. Sizing route: full method (Clause 4.6) / Tier B tables (Clause 4.14.2) / fixed-coefficient route (Clause 4.14.3)	
A7. Constrained redevelopment route used (Clause 4.5.6)? If yes, attach the Constraint Statement, the existing-condition model and the shortfall and fee computation	

B. Inputs (Clause 4.17, item 1)

Table 4F.2 — Form 4-1: inputs

Field	Entry
B1. Design Rainfall Sheet reference (Form 2-1)	
B2. Hydrologic Calculation Summary reference (Form 3-1)	
B3. HSG of each sub-area and the tests that confirm it (Clause 4.6.2, step 1)	
B4. Pre-development condition and CN (Clause 4.5.1.2)	
B5. Post-development CN of each sub-area, and Tc pre and post	
B6. Routing method and software, with version; time step (Clauses 4.6.1, 4.6.2)	

C. Order of measures (Clause 4.3.1; Clause 4.17, item 2)

Table 4F.3 — Form 4-1: order of measures

Step	What the design does	Why this step cannot do more
1. Preserve		
2. Retain		

Step	What the design does	Why this step cannot do more
3. Detain		
4. Convey		

D. Retention (Clause 4.4; Clause 4.17, items 3 and 4)

Table 4F.4 — Form 4-1: retention

Field	Entry
D1. Retention depth P_R (mm) and zone (Annex 2E)	
D2. Runoff depth Q_R (mm) by sub-area and RRV (m³) (Clause 4.4.2)	
D3. Retention practices and volume provided (m³)	
D4. Infiltration tests: number, locations and depths, measured rates (mm/h) (Clause 4.4.3(a))	
D5. Design infiltration rate (mm/h), not more than half the measured rate (Clause 4.4.3(b))	
D6. Seasonal high groundwater depth below the base of each practice (m), at least 1.0 m (Clause 4.4.3(c))	
D7. Reuse demand calculation, where retention is by reuse (Clause 4.4.3)	
D8. Retention drawdown time (h), not more than 72 h (Clause 4.4.5)	
D9. Shortfall in RRV (m³), if any, treated as WQv (Clause 4.4.4.2)	
D10. Governing storage without and with retention, and the retention credit (m³) (Clause 4.4.6)	
D11. Preservation credit areas and covenant reference (Clause 4.4.7)	

E. Release criteria (Clause 4.5; Clause 4.17, item 5)

Table 4F.5 — Form 4-1: release criteria

Field	Entry
E1. Catchment class: standard (Clause 4.5.2) or flood-sensitive (Clause 4.5.3), with the Annex 4A map extract	
E2. Release caps by AEP (L/s), and the duration that sets each cap	
E3. Clause 4.5.5 used (50 mm orifice deemed to comply, or the short-duration 2-yr relief)? Report any 2-yr exceedance	

F. Results (Clause 4.6; Clause 4.17, item 6)

Complete one row for each duration, in the format of Table 4.2. Mark the governing case for storage, for each outlet stage and for the spillway (Clause 4.6.2, step 12).

Table 4F.6 — Form 4-1: results by duration (L/s; m³)

Duration (h)	2-yr pre	2-yr post, detained	10-yr pre	10-yr post, detained	100-yr post, uncontrolled	100-yr post, detained	100-yr storage used
1							
2							

Duration (h)	2-yr pre	2-yr post, detained	10-yr pre	10-yr post, detained	100-yr post, uncontrolled	100-yr post, detained	100-yr storage used
3							
6							
12							
24							
48							
72							

G. Facility, drawdown and outlet (Clauses 4.7, 4.8, 4.10; Clause 4.17, items 7 to 9)

Table 4F.7 — Form 4-1: facility, drawdown and outlet

Field	Entry
G1. Facility type (Clause 4.10) and storage provided (m^3)	
G2. Stage–storage and stage–discharge tables and plots; inflow and outflow hydrographs for the governing cases (attach)	
G3. 10-yr drawdown: time to release 90% of the maximum stored volume (h), with the low-flow orifice 50% blocked (Clauses 4.7.1, 4.8.3)	
G4. WQv release time (h), 24 to 48 h (Clause 4.7.2)	
G5. Tidal outfall: drawdown with the tidal tailwater, and any pumped drawdown (Clause 4.7.4)	
G6. Each outlet stage: type, size (mm), invert level (m)	
G7. Trash racks: clear bar spacing (mm) and open area (m^2) (Clause 4.8.3)	
G8. Anti-vortex devices (Clause 4.8.4); outlet barrel diameter and seepage control (Clause 4.8.5); isolation (Clause 4.8.6)	
G9. Proprietary devices: certified head–discharge curve and minimum clear opening (Clause 4.6.5.3)	

H. Spillway, freeboard and embankment (Clause 4.9; Clause 4.17, item 10)

Table 4F.8 — Form 4-1: spillway and freeboard

Field	Entry
H1. Hazard classification, with reasons (Clause 4.9.2)	
H2. 1% AEP peak inflow (L/s); 0.2% AEP peak inflow for high-hazard facilities (L/s)	
H3. 1% AEP maximum water level with the outlet working (m); spillway crest level (m) (Clause 4.9.3)	
H4. Spillway or overflow route: type, dimensions, maximum level with the outlet blocked (m)	
H5. Freeboard to the embankment crest or wall top (m), at least 0.3 m (Clause 4.9.1)	
H6. Spillway location and discharge path (Clause 4.9.4)	
H7. Embankment height (m); geotechnical report where more than 2 m (Clause 4.9.6)	

I. RWH accounting, groundwater and flotation (Clauses 4.11, 4.12; Clause 4.17, items 11 and 12)

Table 4F.9 — Form 4-1: RWH, groundwater and flotation

Field	Entry
I1. RWH storage provided (m³), assumed full at the start of every storm (Clause 4.11.2)	
I2. Combined RWH and detention tanks: zone levels and the detention orifice level (Clause 4.11.3); attach tank sections	
I3. Design groundwater level and its basis (Clause 4.12.1)	
I4. Lined or unlined storage; volume below the design groundwater level not counted (Clause 4.12.2)	
I5. Flotation factor of safety, at least 1.2 (Clause 4.12.3)	

J. Downstream, tailwater, safety and maintenance (Clause 4.17, items 13 and 14)

Table 4F.10 — Form 4-1: downstream, tailwater, safety and maintenance

Field	Entry
J1. Downstream and Tailwater Report (Form 5-1) or Simplified Downstream Statement (Form 5-2) reference	
J2. Tailwater used in routing, and flap gate where tailwater governs (Clause 4.6.6)	
J3. Public access, depths in the 10% and 1% AEP storms, slopes, fencing, grates, signs and depth markers (Clause 4.15)	
J4. Draft maintenance declaration reference (Chapter 10)	

K. Statement by the registered professional (Clause 10.6)

I state that this report has been prepared under Chapter 4 of the Arunachal Pradesh Stormwater Design Manual (Draft v1.0), that the results reported are reproduced by the models submitted, and that every departure from Chapter 4 is listed with its reason. The Professional Design Certificate (Form 10-3) is attached.

Table 4F.11 — Form 4-1: statement by the registered professional

Field	Entry
Name	
Qualification and registration number	
Empanelment number, where Clause 10.6.1 requires it	
Organisation	
Signature	
Date	

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0.

Form 4-2 — Tier B Site Sheet

Supports Clauses 4.4.6.3, 4.14.1 and 4.14.2 of Chapter 4.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. This sheet replaces items 6 and 7 of the Site Runoff Control Report (Form 4-1) for Tier B sites using Clause 4.14.2. It can be used only after Table 4.3 is published in Annex 4B; until then, Tier B sites use Clause 4.6 or, for sites of 1 ha or less, the fixed-coefficient route (Clauses 4.14.1 and 4.14.3).

A. Eligibility (Clause 4.14.1)

Table 4F.12 — Form 4-2: eligibility

Field	Entry
A1. Local body (Tier B)	
A2. Site area A (ha): 2 ha or less outside flood-sensitive catchments; 0.5 ha or less inside them	
A3. Catchment class: standard or flood-sensitive (Annex 4A)	

B. Table 4.3 values (Clause 4.14.2, step 1)

Table 4F.13 — Form 4-2: values read from Table 4.3

Field	Entry
B1. Rainfall zone (Annex 2A)	
B2. Hydrologic soil group	
B3. Post-development imperviousness (%)	
B4. PSD 2-yr (L/s/ha)	
B5. PSD 100-yr (L/s/ha), for the catchment class	
B6. SSR (m³/ha), for the catchment class	

C. Storage and release (Clause 4.14.2, steps 2 and 3)

Table 4F.14 — Form 4-2: storage and release

Line	Quantity	Computation	Value
C1	RRV provided (m³)	Clause 4.4	
C2	C_R	Annex 4B; 0 until published	
C3	V_credit (m³)	C2 × C1 (Clause 4.4.6.3)	
C4	Required storage V (m³)	B6 × A − C3	
C5	Storage provided (m³)	From drawings	
C6	Q_PSD,2 (L/s)	B4 × A	

Line	Quantity	Computation	Value
C7	Q_PSD,100 (L/s)	B5 × A	

D. Outlet and other provisions (Clause 4.14.2, steps 4 and 5)

Table 4F.15 — Form 4-2: outlet and other provisions

Field	Entry
D1. Low-flow orifice: diameter (mm) from the Annex 4B outlet table, head (m), at least 50 mm	
D2. Upper control: type, size and level	
D3. Spillway or overflow (Clause 4.9)	
D4. RWH accounting (Clause 4.11)	
D5. Safety provisions (Clause 4.15)	

E. Statement

I state that the values above are taken from Annex 4B for the site's zone, soil group, imperviousness and catchment class, and that the storage and outlets shown on the drawings match them.

Table 4F.16 — Form 4-2: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0.

Form 4-3 — Fixed-coefficient Route Sheet (Clauses 4.14.3 to 4.14.7)

Supports Clauses 4.14.3 to 4.14.7 of Chapter 4.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. This sheet replaces items 6 and 7 of the Site Runoff Control Report (Form 4-1) for sites using the fixed-coefficient route. Complete it for each point where runoff leaves the site (Clause 4.14.4). Figure 4.3 shows the method.

A. Eligibility (Clause 4.14.3)

Table 4F.17 — Form 4-3: eligibility

Check	Yes / No
A1. Site area 1 ha or less	
A2. The design does not count tank or waterbody storage (Clause 4.14.3(a))	
A3. No part of the site lies within a waterbody setback (Clause 4.14.3(b))	
A4. The site does not drain to a tank cascade whose storage is counted in a downstream design (Clause 4.14.3(c))	

B. Release caps (Clause 4.14.4)

Table 4F.18 — Form 4-3: release caps

Line	Quantity	Source or computation	Value
B1	Site area A (ha)	Survey	
B2	Area of each hydrologic soil group (ha)	Clause 3.7	
B3	C_10 and C_2, area-weighted	Table 4.3A	
B4	i_10 and i_2 (mm/h), 15-minute duration, with the climate factor	Form 2-1; Clause 2.8	
B5	Q_cap,10 (L/s)	2.78 × C_10 × i_10 × A	
B6	Q_cap,2 (L/s)	2.78 × C_2 × i_2 × A	
B7	Discharge of a 50 mm orifice at the corresponding stage (L/s), where a cap is smaller (Clause 4.5.5.1)	Orifice equation, Clause 4.6.5.2	

C. Volumetric coefficient (Clause 4.14.5)

Table 4F.19 — Form 4-3: volumetric coefficient C_v

Line	Quantity	Value
C1	Composite C of Table 3.2 (upper half of each range)	
C2	Cf of Table 3.3 for the 1% AEP	
C3	C_v for durations below 12 h (C1 × C2)	
C4	C_v for durations of 12 h or more, with C for every pervious surface not less than 0.50	

D. Storage (Clause 4.14.5)

For each duration: inflow = 10 × C_v × P(d) × A (m³); release = 1.8 × Q_cap × d (m³); difference = inflow − release. V_100 and V_2 are the largest differences; V is the larger of the two.

Table 4F.20 — Form 4-3: storage by duration

d (h)	P_100(d) (mm)	100-yr inflow (m³)	1.8 × Q_cap,10 × d (m³)	100-yr difference (m³)	P_2(d) (mm)	2-yr inflow (m³)	1.8 × Q_cap,2 × d (m³)	2-yr difference (m³)
1								
2								
3								
6								
12								
24								
48								
72								

Table 4F.21 — Form 4-3: storage required and provided

Line	Quantity	Value
D1	V_100 (m³) and governing duration	
D2	V_2 (m³) and governing duration	
D3	V = larger of D1 and D2 (m³)	
D4	Storage provided (m³)	

E. Outlet, retention and other checks (Clauses 4.14.3, 4.14.6, 4.14.7)

Table 4F.22 — Form 4-3: outlet, retention and other checks

Field	Entry
E1. Low-flow orifice: diameter (mm) and invert; discharge (L/s) with the storage holding V_2 full, not more than Q_cap,2	
E2. Upper orifice or weir: size and level; total release (L/s) at the top of V, not more than Q_cap,10	
E3. Retention volume of Clause 4.4 provided in addition to V (m³); no retention credit taken	
E4. Drawdown (Clause 4.7), trash racks (Clause 4.8), spillway (Clause 4.9): reference to Form 4-1 Sections G and H	
E5. Downstream and tailwater checks (Chapter 5) and water quality (Chapter 8): references	

F. Statement

I state that the site meets the eligibility conditions of Clause 4.14.3 and that the caps, storage and outlets above have been computed by Clauses 4.14.4 to 4.14.7.

Table 4F.23 — Form 4-3: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 5

Downstream and Tailwater Analysis

These annexes support Chapter 5. Annex 5C is a worked example of the outfall-closed check of Clause 5.10, for the illustrative facility of Annex 4C. Annexes 5A and 5B need tidal, surge, survey and river data that this draft does not yet contain; each lists what the chapter already sets, gives the intended layout and states the interim rule of Chapter 5 that applies until it is published. Forms 5-1 and 5-2 are the submittal forms required by Clause 5.14. They are draft forms and have no statutory status.

Annex 5A — Tidal datums (MSL, MHWS, HAT vs CD and Survey of India datum), surge allowances and 1% still-water levels by coastal segment

Supports Clauses 5.7, 5.9, 5.10, 5.11 and 5.12 of Chapter 5.

5A.1 Table 5A.1 shows how the values of this annex enter the design tailwater levels of Table 5.1. The sea-level allowance is set by Clause 5.7.4 and does not depend on this annex.

Table 5A.1 — Use of the Annex 5A values in the design tailwater (Table 5.1)

Design case	Tailwater	Annex 5A values used	Chapter value
Minor-system design	MHWS + SLA	MHWS	SLA ≥ +0.3 m (Clause 5.7.4)
Major-system and storage design	HAT + surge + SLA	HAT; 10% AEP surge (Clause 5.7.3(a))	SLA ≥ +0.3 m
Joint case (Clause 2.12(b))	1% AEP still-water level + SLA	1% AEP still-water level (Clause 5.7.3(b))	SLA ≥ +0.3 m
Datum conversion	Chart datum to project datum	Offset from chart datum to the Survey of India datum (Clause 5.7.2(b))	—

Not prepared for Arunachal Pradesh. Arunachal Pradesh has no coast, so no outfall in the State has a tidal tailwater, and this annex has no Arunachal Pradesh content (Clause 5.1.4). Its tables are kept, empty, so that the annex and table numbers match the other editions of this Manual. Rows F1 to F7 of Form 5-1 are entered as "not applicable", and the tailwater is derived under rows F8 to F10; for an outfall to a nallah of the capital region or to the Senki, the Pachin or the Dikrong, row F10 records the model, the release and the flood marks of Clause 5.8.5(a), each with its datum; for a hill stream, the study, the flood marks and the bed survey of Clause 5.8.5(b); for a main stem, the CWC levels and their transfer to the outfall under Clause 5.8.5(c); and for a reservoir or a release reach, the operator's levels and release records, or the interim values of Clause 5.8.5(d), with their source and datum.

Table 5A.2 — Tidal datums, surge and still-water levels by coastal segment (layout)

Coastal segment	Reference port and tide-table edition	MSL (m CD)	MHWS (m CD)	HAT (m CD)	CD to Survey of India datum (m)	10% AEP surge (m)	1% AEP still-water level (m CD)	Wave set-up (m), open-sea outfalls	Sources

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Annex 5B — Major drains, riverine outfall reaches, and river mouths subject to sand-bar closure; map

Supports Clauses 5.2, 5.3, 5.8 and 5.13 of Chapter 5.

5B.1 Table 5B.1 lists the water bodies that Chapter 5 already names. It is not complete: the annex will add the extents of each reach, the other rivers, canals and mouths of the State, and a map.

Table 5B.1 — Water bodies named in Chapter 5

Water body	Region	Listed as	Clause
Senki, Itanagar	Itanagar capital region (sub-area AR-A)	Major drain and riverine outfall reach; runs through Itanagar to the Pachin; no gauge or published level [TBC]; source of Itanagar's lift supply (7 MLD, Master Plan); stretch at Chandranagar (u/s of Pachin) in Priority V (CPCB, 2025); Senki View culvert washed away in September 2018 (as reported); design tailwater the higher of the 1% AEP model level (with the Dikrong at its design level at the Pachin confluence as the boundary) and the highest surveyed flood mark	5.2, 5.8.1, 5.8.5
Pachin, Itanagar to Nirjuli	Itanagar capital region	Major drain and riverine outfall reach; "passes through most of the area before it debouches to Dikrang river near Nirjuli" (CGWB, as cited); wide flood plain with palaeochannels and swampy land (Master Plan); "a waste disposal site" (Master Plan); no gauge or published level [TBC]; dumped waste not counted as channel	5.2, 5.8.1, 5.8.5
Dikrong (Dikrang) at Naharlagun, Nirjuli and Doimukh	Itanagar capital region	Riverine outfall reach and release reach; no CWC site; below the Pare dam (peak release 1,310 m³/s, 31 May 2025, as reported) and the Ranganadi tailrace (160 m³/s, as reported); master channel in the alluvial terrain "about 48 km" (CGWB); design tailwater the higher of the 1% AEP model level and the surveyed flood mark of the largest recorded release, checked at the 1999 flood mark and the 2017–2025 marks; no mark surveyed or tied [TBC]; lock not less than 72 hours; pump-down within 48 hours; landslides along the highway from undercutting (Master Plan)	5.8.1, 5.8.3, 5.8.5
Papu Nallah, Naharlagun	Itanagar capital region	Major drain to the Dikrong, and a place name; traffic was diverted "via Papu Nallah and Jullang Road" when NH-415 closed in the 2017 floods (Master Plan); as for the capital's nallahs	5.2, 5.8.5
Nallahs of the Modirijo and Donyi Polo catchments, Itanagar	Hill rim of the capital region	Hill streams and major drains to the Senki; ungauged; flash floods of September 2018 (as reported); 1% AEP study with bulking and blockage and surveyed flood marks; outfall at least 0.5 m above the highest surveyed bed level; lock the storm and the recession, not less than 24 hours	5.2, 5.8.1, 5.8.5

Water body	Region	Listed as	Clause
Streams of the other hill towns: Ziro, Bomdila, Tawang, Seppa, Daporijo, Aalo, Khonsa, Changlang, Yingkiong, Anini	Sub-areas AR-A1, AR-C1, AR-D and AR-E	Hill streams; ungauged; as for the Modirijo and Donyi Polo nallahs; snow on inlets in the high ranges (Chapter 10)	5.2, 5.8.1, 5.8.5
Side stream at Poosa and the NEEPCO colony, Yazali	Western foothills (sub-area AR-A1), Keyi Panyor	Hill stream of about 17 km²; flash flood of 24 June 2026 or 2025 (year in conflict, as reported) while the main river stayed in its channel; governs the colony's outfalls; the Ranganadi checked as well	5.8.5
Siang (Dihang) at Pasighat and its side channels	Siang–Dibang–Lohit foothills (sub-area AR-B)	Main stem; CWC Passighat warning level 152.96 m, danger level 153.96 m, highest flood level 157.54 m (11 June 2000, the Yigong outburst; SANDRP transcription, as reported; datum [TBC]); design tailwater the danger level, check the highest flood level, transferred by survey; flap gate and storage between them; outburst screening; bank erosion at Jarkong and the Mebo villages (as reported); upstream sites at Yingkiong (danger level 304.0 m) and Tuting (highest flood level 420.43 m)	5.8.1, 5.8.5
Lohit at Tezu	Siang–Dibang–Lohit foothills	Main stem; CWC Tezu highest flood level 192.14 m (16 July 1996, as reported; datum [TBC]); no danger level transcribed [TBC], so the highest flood level is the design and check level; upstream site at Kibithu (1,229.8 m)	5.8.1, 5.8.5
Noa-Dihing at Namsai and Miao	Noa-Dihing plain (sub-area AR-C)	Main stem; CWC Namsai warning level 144.8 m, danger level 145.8 m, highest flood level 146.6 m (31 August 1974; values "changed without explanation", SANDRP, as reported); Miao highest flood level 241.57 m (9 July 2004, as reported); datum [TBC]	5.8.1, 5.8.5
Dibang at Roing	Siang–Dibang–Lohit foothills	Main stem; no CWC site; 1% AEP model and surveyed flood marks; outburst screening (16 of NDMA's high-risk glacial lakes in Dibang Valley, as reported); stretch upstream of Roing in Priority V (CPCB, 2025); Dibang Multipurpose Project upstream, under construction [TBC]	5.8.1, 5.8.5
Ranganadi at Yazali and below	Western foothills (sub-area AR-A1)	Release reach below the Ranganadi (Panyor) project; release 1,412.57 m³/s (9 July 2017, as summarised); CWC Yazali highest flood level 623.1 m (14 June 2008, as reported); lock not less than 72 hours	5.8.1, 5.8.3, 5.8.5
Kameng (Jia Bharali) at Bhalukpong and below the Bichom and Tenga dams	Western foothills and the Kameng hills	Main stem and release reach; no CWC site in the State; no release or flood data [TBC]; spillway capacity in the operator's writing required; outburst screening	5.8.1, 5.8.3, 5.8.5
Subansiri at Daporijo and below the Lower Subansiri dam	Middle hills; the Assam border at Gerukamukh	Main stem and release reach; CWC Daporijo highest flood level 213.9 m (15 October 1987) and Lemeking 1,107.16 m (as reported); release rules not found [TBC]; spillway capacity in the operator's writing required; stretch at Gerukamukh in Priority V (CPCB, 2025)	5.8.1, 5.8.3, 5.8.5
Tawang Chu	High ranges (sub-area AR-E)	Main stem; flows on into Bhutan; no level found [TBC]; outburst screening (6 of NDMA's high-risk glacial lakes in Tawang, as reported)	5.8.5
Lohit at Dholabazar; Burhidihing at Naharkatia and Margherita; Subansiri at Chouldhowaghat and Badatighat; Ranganadi and Jia Bharali at their NT Road crossings	Assam, downstream of the State	CWC sites, all in Assam (SANDRP's transcription, as reported; datum [TBC]); the Assam edition governs those reaches; a lower bound on a model's downstream boundary only	5.8.1, 5.8.5

Water body	Region	Listed as	Clause
Ponds of the capital region and other towns	Statewide	Ponds as receiving storage; full to the outlet at the start of every storm; stage–storage [TBC]; the owner's or community's consent; dry-weather-flow interception before them (Clause 8.9); not detention ponds; listing by the local body under APBBL 2019 Annexure E 1.8 not found [TBC]	5.8.5
Ganga Lake (Gyakar Sinyi), Itanagar Wildlife Sanctuary	Near Itanagar	Lake in a sanctuary; not storage or detention for any project; encroachment and earth-cutting pressure (as reported); Chapter 7 applies to any outfall	5.8.5
Glaw Lake, Kamlang Tiger Reserve	Lohit district	Ramsar site announced on 3 August 2026, the State's first (as reported); area not confirmed; no town outfall to it found; Chapter 7 applies	5.8.5
Drains of the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Department of Urban Affairs, the Smart City companies, PWD and PWD (Highways) 1.0 m wide or more; drains and streams on community or clan land	Arunachal Pradesh	Major drains; owner's written consent (IMC under ss.200 and 203 of the 2019 Act; the Pasighat Municipal Council under ss.102, 194 and 196 of the 2007 Act; the community on its own land), design water level and flap gate	5.2, 5.8.5
River mouths subject to sand-bar closure	None in Arunachal Pradesh	Not applicable (Clause 5.1.4)	5.13.1

To be prepared. This annex will list and map (a) the major drains of each basin plan, (b) the riverine outfall reaches where backwater shall be modelled, with their upstream and downstream limits and the source of their design flood levels, and (c) the river mouths and creek inlets subject to seasonal sand-bar closure, with the most recent pre-monsoon bar crest levels and any WRD mouth-maintenance programme. It needs WRD river and canal records, design and recorded flood levels, reservoir operating rules, mouth-condition, dredging and bar-cutting records and pre-monsoon bar surveys (WRD), the drain inventories of IMC and other local bodies, basin stormwater master plans (Chapter 11), and base mapping from the Survey of India and NRSC. Until it is published: every river, WRD canal, the Senki, the Pachin and the Dikrong in the Itanagar capital region, Papu Nallah and the nallahs of the Modirijo and Donyi Polo catchments, the Dikrong below the Pare dam and the Ranganadi below Yazali, any drain built or held by the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Department of Urban Affairs, a Smart City company, PWD or PWD (Highways) with an internal width of 1.0 m or more, and every stream, nallah or other natural channel that drains 8 ha or more, whether or not it is lined, piped or covered and every tidal creek is a major drain (Clause 5.2); the water bodies of Table 5B.1 are riverine outfall reaches (Clause 5.8.1); and the mouths of the coastal States' rivers (there is none in Arunachal Pradesh) are assumed closed at the start of the monsoon unless the Water Resources Department certifies otherwise (Clause 5.13.2).

Table 5B.2 — Attributes of the Annex 5B layers (layout)

Field	Content	Unit or format
feature_id	Unique identifier	text
name	Name of the drain, river, canal, creek or mouth	text
category	Major drain; riverine outfall reach; mouth subject to sand-bar closure	text
clause	Clause of Chapter 5 under which it is listed	text

Field	Content	Unit or format
reach_limits	Upstream and downstream limits of the reach	text
design_flood_level_source	WRD design or highest recorded flood level, or hydraulic model (Clause 5.8.2)	text
reservoir_release	Upstream reservoir or tank and its operating rule, where any (Clause 5.8.3)	text
bar_crest_level	Most recent pre-monsoon bar crest level, for mouths	m (Survey of India datum)
mouth_programme	WRD mouth-maintenance programme and certification (Clause 5.13.2)	text
source	Source agency and date	text
geometry	Line (drains and reaches) or point (mouths)	line / point

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Annex 5C — Worked example: outfall-closed check for a hillside colony in Itanagar draining to the Senki

Supports Clauses 5.9, 5.10, 5.11 and 5.12 of Chapter 5 and Clause 4.6.6 of Chapter 4.

Illustrative — not design values. This example applies the outfall-closed check of Clause 5.10 to the revised detention facility of Annex 4C. The site, its levels and its receiving drain are invented to show the method. No tidal level is used: the tide enters only through the illustrative statements in Table 5C.1 about whether the receiving drain is above or below the site outlet.

Inputs

5C.1 The site is the 2.0 ha flood-sensitive site of Annex 4C. It discharges through its own outlet chamber and a flap gate to a public storm drain that runs down a nallah to the Senki in Itanagar, which runs through the town to the Pachin and whose stretch at Chandranagar, upstream of the Pachin, CPCB lists as polluted (CPCB, 2025); the Senki's level rises when it runs full in a monsoon storm, and its bed and crossings collect gravel, slide debris and garbage, as the floods of September 2018 showed when the Senki View culvert was washed away (as reported), so Clause 5.10.1 applies to the facility. To show the method, this example uses the two 6-hour lock windows of Clause 5.10.3, as the coastal editions of this Manual do. In Arunachal Pradesh an outfall to a hill stream or to the Senki above the reach where the Dikrong backs it up, whose invert is below its design level, is closed for the design storm and the stream's recession, and for not less than 24 hours, and for the whole storm where no hydrograph of the stream has been computed; an outfall backed up by the Dikrong at Naharlagun, Nirjuli or Doimukh, or by a main stem at Pasighat, Tezu, Namsai or Roing, and an outfall to a release reach, has a single lock of at least 72 hours, and on a release reach for as long as the release lasts; and an outfall below the design level of a reservoir or a pond, or a main-stem outfall checked at the highest flood level, is closed for the whole storm, under Clause 5.8.5. In each of those cases that lasts longer than the windows used here, the facility must store or pump the volume of the longer closure, up to the whole storm volume (Clause 5.9.4); that needs more storage, or pumping, than this example shows. The routing, the volume balance of Clause 5.10.4 and the assessment are the same. The public drain's own outfall to the Senki would also need the debris rack, the bulking factor and the solid-waste trap of Clause 6.3.6 and an invert above the range of bed movement of Clause 5.8.5(b); the public drain, like most in the capital, may carry sewage ("storm water drains being used as sewers", Master Plan of Itanagar Capital Region-2031, report), so the site's connection has the non-return valve of Clause 6.3.6(c); and on a hillside in Itanagar the facility itself would be a lined tank, not an infiltrating basin (Clause 4.11 (hill rule)).

Table 5C.1 — Inputs (Illustrative — not design values)

Item	Value	Basis
Facility	Revised facility of Annex 4C: 2,500 m² plan area, vertical walls; 170 mm orifice at the floor; 460 mm orifice, invert 0.53 m	Annex 4C, Table 4C.14
Storm	1% AEP, 48 h, peak day last, AMC III; 72 h also run	Clause 5.10.2
Inflow	Post-development 1% AEP hydrographs of Annex 4C (48 h: 8,420 m³; 72 h: 9,468 m³)	Annex 4C
Receiving drain levels at the connection, J1, J2 and J3	Below the site outlet invert (from the drain owner's model)	Illustrative input
Receiving drain during each lock window	Backs up above the site outlet invert, so the site cannot discharge	Illustrative input; Clause 5.10.3(b)
Flap gate on the site outlet	Set 0.15 m below the orifice inverts in the outlet chamber, so that outside the lock windows its opening head and head loss do not affect the orifice control	Illustrative input; to be confirmed from the certified curve (Clause 5.11.2)
Lock windows	Two of 6 h each, starts 12.4 h apart (semi-diurnal tide)	Clause 5.10.3(a)
Pumps	None	—

5C.2 **Cases of Table 5.2.** Because the receiving drain stays below the site outlet in J1, J2 and J3 (Table 5C.1), those cases give the free-outfall results of Annex 4C: in J2 the 1% AEP maximum water level is **1.17 m** (2,913 m³), and in J3 (10% AEP, 48 h) it is 0.77 m. R1 and R2 do not apply, because the site does not drain to a river. J4, the outfall-closed check, is worked below.

Lock windows (Clause 5.10.3)

5C.3 The peak 1-hour block of the final 24 hours of the 48-hour storm is 35:35–36:35 h, with 98.2 mm (the 1-hour depth of Table 4C.2). Two runs are made:

- **Run A:** the first window is centred on that block: 33:05–39:05 h; the second starts 12.4 h later: 45:29–51:29 h.
- **Run B:** the first window starts at that block: 35:35–41:35 h; the second: 47:59–53:59 h.

For the 72-hour storm, every time is 24 h later.

5C.4 Gravity discharge is zero inside each window. Outside the windows the outlet discharges through the orifices of Table 4C.10. The routing is the same level-pool routing as in Annex 4C.

Results

Table 5C.2 — Outfall-closed check results (Illustrative — not design values)

Storm	Run	Lock windows (h:min)	Maximum stage (m)	Maximum storage (m³)	Time of maximum (h:min)	Largest release after a window (L/s)
1% AEP, 48 h	A	33:05–39:05; 45:29–51:29	2.01	5,019	39:05	566
1% AEP, 48 h	B	35:35–41:35; 47:59–53:59	**2.10**	**5,238**	41:35	584
1% AEP, 72 h	A	57:05–63:05; 69:29–75:29	2.00	5,012	63:05	565
1% AEP, 72 h	B	59:35–65:35; 71:59–77:59	2.09	5,233	65:35	584

Run B of the 48-hour storm governs. The first window closes the outlet just as the storm peak arrives, so the whole peak is stored. The second window arrives when the facility has drained to about 0.7 m, below the Stage 2 orifice, and adds little.

5C.5 **Volume balance (Clause 5.10.4).** Table 5C.3 gives the balance for Run B. The outflow in each period is found by continuity: outflow = storage at start + inflow − storage at end.

Table 5C.3 — Volume balance, 1% AEP 48-hour storm, Run B (Illustrative — not design values)

Period (h:min)	Inflow (m³)	Gravity outflow (m³)	Pumped (m³)	Storage at start (m³)	Storage at end (m³)
0:00–35:35, before window 1	3,817	2,213	0	0	1,604
35:35–41:35, window 1	3,634	0	0	1,604	5,238
41:35–47:59, between windows	941	4,423	0	5,238	1,756
47:59–53:59, window 2	28	0	0	1,756	1,784
After 53:59	0	1,784	0	1,784	0
Total	8,420	8,420	0	—	—

Check for window 1: V_inflow = 3,634 m³ ≤ V_storage available + V_pumped + V_gravity = (5,238 − 1,604) + 0 + 0 = 3,634 m³. The facility therefore needs **5,238 m³** of storage, which the routing confirms.

Table 5C.4 — Stage hydrograph, 1% AEP 48-hour storm, Run B (Illustrative — not design values)

Time (h)	Inflow (L/s)	Outlet	Outflow (L/s)	Stage (m)	Storage (m³)
24	20	Open	18	0.18	445
28	39	Open	24	0.25	621
32	59	Open	32	0.36	906
34	85	Open	37	0.47	1,166
36	286	Closed	0	0.78	1,944
38	106	Closed	0	1.73	4,321
40	66	Closed	0	1.96	4,904
42	51	Open	529	1.79	4,472
44	42	Open	204	0.87	2,181
46	37	Open	49	0.74	1,854
48	33	Open	47	0.70	1,756
50	0	Closed	0	0.71	1,784
54	0	Closed	0	0.71	1,784
56	0	Open	43	0.58	1,459
60	0	Open	32	0.37	921
66	0	Open	16	0.16	397
72	0	Open	7	0.06	162

Assessment

5C.6 **Clause 5.10.4(a).** The facility of Annex 4C reaches 1.17 m in J2, and its spillway crest is at 1.35 m (Annex 4C). In the outfall-closed check the stage reaches 2.10 m, so the spillway would operate. **The facility of Annex 4C fails the check.**

5C.7 **Remedy.** Pumping (Clause 5.12) does not help here: during the lock windows the receiving drain is itself closed, and pumping into it would raise its level, which Clause 5.12.3 does not permit. The remedy is more storage. Keeping the plan area of 2,500 m² and the outlets of Annex 4C:

- the facility must hold 5,238 m³, to a stage of **2.10 m**;
- the spillway crest is set above that stage, with the 0.15 m clearance recommended in Clause 4.9.3: **2.25 m**;
- with the 4.0 m spillway of Annex 4C (head 0.30 m), the maximum level with the spillway flowing is 2.55 m, and with 0.3 m freeboard the top of the walls is at least **2.85 m** above the floor.

The outfall-closed check therefore governs the storage: 5,238 m³ against 2,913 m³ from the release-rate checks, about 80% more. A larger plan area would make the facility shallower; the outlet, caps and drawdown would then have to be re-checked, because the stage–discharge relationship changes.

5C.8 **Release after the lock.** When the first window ends, the stored water is released under a head of about 2 m, at up to 584 L/s. This is above the 100-yr cap of 356 L/s. Clause 5.10.4 allows this, because the release reaches a drain that has itself just reopened, and requires it to be included in the J4 run of the downstream analysis (Clauses 5.4 and 5.9) and reported on Form 5-1, Section H.

5C.9 **Drawdown after the storm (Clause 5.10.5).** The J1 tidal curve stays below the site outlet (Table 5C.1), so the drawdown of Annex 4C applies: 45.3 h for 90% of the 10-yr storage with the low-flow orifice 50% blocked, within the 48-hour limit of Clause 4.7. In Run B, 90% of the maximum J4 storage is released 22.6 h after the maximum.

5C.10 **Other requirements.**

- The flap gate on the site outlet is inspected and operated before 31 March each year and after every event in which it closed against a storm flow (Clause 5.11.5).
- The deeper facility is checked for flotation with groundwater at the design groundwater level; in the Dikrong and Pachin flood plains of the capital region, with their palaeochannels and swamps, the Siang, Lohit and Noa-Dihing flood plains at Pasighat, Tezu and Namsai, land below the 1% AEP flood level of those rivers, and the pond and swamp margins without piezometer readings that level is existing ground level (Clauses 4.12.1 and 4.12.3).
- The fence and signs of Annex 4C apply to the deeper facility (Clause 4.15).

Table 5C.5 — Summary (Illustrative — not design values)

Item	Value
Governing case	J4, 1% AEP 48-hour storm, Run B (first window starting at the peak 1-hour block)
Storage required	5,238 m³ (Annex 4C release-rate design: 2,913 m³)
Maximum stage	2.10 m, with 2,500 m² plan area
Spillway crest	2.25 m
Top of walls	≥ 2.85 m above the floor
Largest release after a lock window	584 L/s, to be included in the downstream J4 run
Drawdown	Annex 4C result applies: 45.3 h with the low-flow orifice 50% blocked

Form 5-1 — Downstream and Tailwater Report

Supports Clauses 5.3 to 5.14 of Chapter 5.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. One report for each project. Sites of less than 0.5 ha that meet Clause 5.3.4 may submit Form 5-2 instead, where the Authority accepts it. Attach the plans, model files and hydrographs referred to.

A. Project

Table 5F.1 — Form 5-1: project

Field	Entry
A1. Project name, applicant and location	
A2. Project type: site under Chapter 4; drainage project under Chapter 6; regional detention or tank restoration (Clause 5.1.2)	
A3. Site or project area (ha) and outfalls	
A4. Site Runoff Control Report reference (Form 4-1), where applicable	

B. Extent of the analysis (Clause 5.3; Clause 5.14, item 1)

Table 5F.2 — Form 5-1: analysis points

Point	Location	Type (Clause 5.3.3 (a) to (e))	Contributing catchment (ha)	Project area as % of it

Table 5F.3 — Form 5-1: end point

Field	Entry
B1. End point and reason: 10% point, tank or pond, or major drain or the sea (Clause 5.3.1 (a) to (c))	
B2. Where the end point is a tank or pond: change in maximum water level (m) and in surplus-weir discharge (m^3/s); continuation below the weir if the level rises (Clause 5.3.2)	
B3. Plan of the analysis extent, showing the site, each point with its contributing area and percentage, and the end point (attach)	

C. Model (Clause 5.4.4; Clause 5.14, item 2)

Table 5F.4 — Form 5-1: model

Field	Entry
C1. Software and version; hydrologic and hydraulic methods (Clause 5.4.4)	
C2. Network schematic, with the survey sources for drains and crossings (attach)	
C3. Land use and CN of off-site areas (present land use)	

Field	Entry
C4. Upstream detention included, with evidence that it is built, maintained and documented	
C5. Calibration or validation evidence, where available	
C6. Scenarios run: existing, with project, and future where the Authority requires it (Clause 5.4.1)	
C7. Storms run: AEPs and durations, AMC and areal reduction (Clause 5.4.3)	

D. Results at each analysis point (Clause 5.4.2; Clause 5.14, item 3)

Complete one row for each analysis point, AEP and duration. E = existing; P = with project.

Table 5F.5 — Form 5-1: results by analysis point

Point	AEP	Duration (h)	Peak flow E / P (m^3/s)	Time to peak E / P (h)	Maximum water level E / P (m)	Peak velocity E / P (m/s)	Duration of inundation E / P (h)

E. Acceptance (Clause 5.5; Clause 5.14, item 4)

Table 5F.6 — Form 5-1: acceptance criteria

Criterion	Met at every point?	Where not met, the remedy adopted (Clause 5.5.3)
E1. 1% AEP water level rise ≤ 10 mm at buildings, lowest openings and carriageways (Clause 5.5.1(a))		
E2. No building newly flooded; no building or road newly failing the Chapter 6 limits (Clause 5.5.1(b))		
E3. Peak flow not above existing at the minor-system AEP of each element or at 1% AEP (Clause 5.5.1(c))		
E4. Velocity in lined channels within the lining limit, 3.0 m/s maximum (Clause 5.5.1(d))		
E5. Velocity in unlined channels, 50% and 10% AEP, not increased by more than 10% (Clause 5.5.1(e))		
E6. Change in duration of road closure on arterial or emergency routes (Clause 5.5.2)		
E7. Timing exception requested (Clause 5.5.4)? Give the conditions met		

F. Tailwater derivation (Clauses 5.6 to 5.8; Clause 5.14, item 5)

Table 5F.7 — Form 5-1: tailwater derivation

Field	Entry
F1. Tide-table edition and port, or port authority source (Clause 5.7.2(a))	

Field	Entry
F2. MHWS, HAT and MSL (m above chart datum)	
F3. Connection from chart datum to the Survey of India benchmark and the project datum: offset (m) and source (Clause 5.7.2(b))	
F4. Estuary, creek or canal outfall: levels used and any evidence for a departure from open-coast levels (Clause 5.7.2(c))	
F5. 10% AEP surge and 1% AEP still-water level: values, source, method and record length (Clause 5.7.3)	
F6. Wave set-up, for outfalls facing the open sea (Clause 5.7.3(d))	
F7. SLA (m), at least +0.3 m; design life; sensitivity run at twice the SLA for design lives over 50 years (Clause 5.7.4)	
F8. Non-tidal tailwater: receiving-system level and source (Clauses 5.6.2, 5.6.3)	
F9. River levels and sources; reservoir or tank releases included (Clauses 5.8.2, 5.8.3)	
F10. The capital's nallahs and the Dikrong, hill-town streams, the main stems, reservoirs and release reaches, outburst reaches, the Assam reaches, ponds, and drains of other bodies: for an outfall in the capital region, the nallah and the river it reaches (Senki, Pachin or Dikrong, or Papu Nallah), a statement that no CWC or other gauge exists, the 1% AEP model with the rainfall of Clause 2.3.6, AMC, the Pare release (1,310 m³/s, or a larger recorded release) with the Ranganadi tailrace (160 m³/s) and the channel as surveyed net of encroachment, silt, waste and vegetation; the surveyed flood mark of the largest recorded release (31 May 2025), the check marks (1999; 2017, 2018, 2024, 2025 or later) and their sources, each tied to a Survey of India benchmark, or a statement that none has been surveyed; the low-river case with the drains blocked and the high-river case with the outfalls backed up; the operator of each gate, flap gate and pumping station, sills, bank or wall crest, installed capacity, operating levels and gate-closing level, or a statement that none exists; drain behind the gate routed with its whole catchment and present storage, pumping confirmed available (permanent pumps only, not more than installed capacity less the largest pump), pumps operable at the design level; the lock (the whole 72-hour storm, not less than 72 hours with no gravity discharge where a gate would shut, or longer from a stage record) and the pump-down within 48 hours; gate-failure check; for a hill stream, the 1% AEP study with the bulking, blockage and solid-waste rules of Clause 6.3.6, the surveyed flood marks and their sources, the side stream checked as its own case, the receiving system confirmed by survey, the bed survey and range of bed movement, the invert at least 0.5 m above the highest surveyed bed level, the scour depth of the foundation, the energy dissipator, confirmation that no outfall discharges onto an unprotected slope, to a spring or above a supply intake, and the lock (storm plus recession, not less than 24 hours); for a main stem (Siang, Lohit, Noa-Dihing, Dibang, Kameng or Subansiri), the CWC site, its danger level and highest flood level as transcribed, the datum and the survey that transfers them to the outfall, or the model and flood marks where no site exists (Roing, Bhalukpong), the flap gate and storage for stages between the danger level and the highest flood level, the check at the highest flood level with the outfall closed for the whole storm, the lock and pump-down as for the capital's nallahs, and the bank-erosion and channel-shift check; for a reservoir, the operator's written MWL or FRL and datum, or FRL + 0.5 m [TBC], outfall below the tailwater treated as closed for the whole of the 72-hour storm, no gate operation, drawdown, notice or attenuation credited; for a release reach, the design storm and the 72-hour storm with the largest recorded release (Pare 1,310 m³/s with the Ranganadi tailrace; Ranganadi 1,412.57 m³/s) or the spillway capacity in the operator's writing (Kameng, Lower Subansiri, Dibang), placed before, during and after the storm, and the lock (not less than 72 hours, and for the release's duration where the operator gives it); for a main stem or a stream below a glacial lake, moraine or landslide dam or a debris fan, the outburst screening of Clause 2.3.6(i), the siting decision and the floor level against the highest recorded outburst level (Pasighat 157.54 m transferred); for a river leaving the State, the Assam-site level used only as the model's downstream boundary; for a pond, the owner's or community's consent, the outlet level surveyed, the stage–storage relation, the routed level and the dry-weather interception before it (Ganga Lake not counted as storage); WRD's consent for work in or on a river or an anti-erosion work; owner's consent for a drain of another body (IMC under ss.200 and 203 of the 2019 Act; the Pasighat Municipal Council under ss.102, 194 and 196 of the 2007 Act; PWD or PWD (Highways); the Department of Urban Affairs or a Smart City company; the community), the owner's or community's written agreement for a drain across another's land, permitted rate, design water level or computed channel level, and flap gate; and the lines checked (APBBL 2019 2.10.1(e): no notified norms found; *Jhot*: no width; the corridor of Clause 7.4) (Clause 5.8.5)	

G. Joint cases (Clause 5.9; Clause 5.14, item 6)

Table 5F.8 — Form 5-1: joint-case results

Case	Rainfall	Tailwater used (m, project datum)	Applies?	Governing result (storage, level, pipe size or pump capacity)
J1				
J2				

Case	Rainfall	Tailwater used (m, project datum)	Applies?	Governing result (storage, level, pipe size or pump capacity)
J3				
J4				
R1				
R2				

H. Outfall-closed check (Clause 5.10; Clause 5.14, item 7)

Table 5F.9 — Form 5-1: outfall-closed check

Field	Entry
H1. Reason the check applies (Clause 5.10.1)	
H2. Storm: AEP, 48 h and 72 h, AMC III (Clause 5.10.2)	
H3. Lock duration and basis: default of two 6-hour windows, or site study (Clause 5.10.6); extension for sand-bar closure (Clause 5.13.5)	
H4. Lock windows of the two runs (start and end times) (Clause 5.10.3(d))	
H5. Maximum stage in each facility, against its 1% AEP maximum water level (Clause 5.10.4(a))	
H6. Maximum stage in the minor and major systems, against the Chapter 6 limits (Clause 5.10.4(b))	
H7. Property connections: surcharge level, or non-return valves fitted (Clause 5.10.4(c))	
H8. Stage hydrographs (attach)	
H9. Drawdown after the storm under the J1 tidal curve, and pumping where needed (Clause 5.10.5)	

Table 5F.10 — Form 5-1: volume balance for each lock window (Clause 5.10.4)

Period	Inflow (m^3)	Gravity outflow (m^3)	Pumped (m^3)	Storage at start (m^3)	Storage at end (m^3)
Before window 1					
Window 1					
Between windows					
Window 2					
After window 2					

I. Gates and valves (Clause 5.11; Clause 5.14, item 8)

Table 5F.11 — Form 5-1: schedule of flap gates, tide gates and non-return valves

Location	Type	Size (mm)	Invert (m, project datum)	Certified head–discharge data (reference)	Stop-log or penstock (outfalls > 600 mm)

J. Pumped outfalls (Clause 5.12; Clause 5.14, item 9)

Table 5F.12 — Form 5-1: pumped outfalls

Field	Entry
J1. Reason pumping is needed (Clause 5.12.1)	
J2. Duty capacity (m^3/s) at the static head for the J2 tailwater; standby capacity (Clause 5.12.2)	
J3. Effect on the receiving water level (Clause 5.12.3)	
J4. Power supply: two independent supplies, or standby generation with 72 h of fuel; automatic changeover (Clause 5.12.4)	
J5. Level of electrical panels, controls, generators and fuel, against the higher of the 1% AEP flood level + 0.5 m and HAT + surge + SLA + 0.5 m (Clause 5.12.5)	
J6. Discharge arrangement (Clause 5.12.6); controls, alarms and logging (Clause 5.12.7); screens (Clause 5.12.8)	

K. Sand bar (Clause 5.13; Clause 5.14, item 10)

Table 5F.13 — Form 5-1: sand-bar assumption

Field	Entry
K1. River mouth or creek inlet concerned	
K2. Mouth assumed closed, or open with WRD certification attached (Clause 5.13.2)	
K3. Bar crest level from the most recent pre-monsoon survey (m) and the closed-mouth tailwater (Clause 5.13.3)	
K4. Extension of the lock duration, where required (Clause 5.13.5)	

L. Inspection and maintenance (Clause 5.14, item 11)

Table 5F.14 — Form 5-1: inspection and maintenance

Field	Entry
L1. Gate and valve inspection before 31 March and after closure events (Clause 5.11.5)	
L2. Pump test runs before 31 March (Clause 5.12.9)	
L3. Other requirements for the maintenance plan (Chapter 10)	

M. Statement by the registered professional (Clause 10.6)

I state that this report has been prepared under Chapter 5 of the Arunachal Pradesh Stormwater Design Manual (Draft v1.0), that the results reported are reproduced by the models submitted, and that every departure from Chapter 5 is listed with its reason. The Professional Design Certificate (Form 10-3) is attached.

Table 5F.15 — Form 5-1: statement by the registered professional

Field	Entry
Name	
Qualification and registration number	

Field	Entry
Empanelment number, where Clause 10.6.1 requires it	
Organisation	
Signature	
Date	

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0.

Form 5-2 — Simplified Downstream Statement (small sites)

Supports Clause 5.3.4 of Chapter 5.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. For sites of less than 0.5 ha. The Authority may accept this statement in place of the full analysis only where every answer in Section B is "Yes". Otherwise submit Form 5-1.

A. Site

Table 5F.16 — Form 5-2: site

Field	Entry
A1. Project name, applicant and location	
A2. Site area (ha), less than 0.5 ha	
A3. Receiving public drain: name or reference, type and size	
A4. Site Runoff Control Report reference (Form 4-1)	

B. Conditions (Clause 5.3.4)

Table 5F.17 — Form 5-2: conditions

Condition	Yes / No	Evidence
B1. The receiving public drain has documented capacity for its minor-system design flow (Chapter 6)		
B2. No flood-prone location is recorded within 500 m downstream of the site outfall. Records checked: local body, IMC, APSDMA, WRD (Clause 5.3.3(d))		
B3. The site does not drain to a tidal or backwater-affected outfall		

C. Route plan

Table 5F.18 — Form 5-2: attachments

Attachment	Attached?
C1. Plan of the drainage route from the site outfall for 500 m downstream, with the receiving drain and any recorded flood-prone locations	
C2. Copy or reference of the drain capacity record	

D. Statement

I state that the site meets the conditions of Clause 5.3.4 as shown above, and that the records listed have been checked.

Table 5F.19 — Form 5-2: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 6

Minor and Major Drainage Systems

These annexes support Chapter 6. Annex 6A (standard inlets and their capacity curves) and Annex 6B (sediment yield) need test and survey data that are not yet available; each states what it will contain and the interim rule to use until it is published. Annex 6C gives standard drawings that carry only the dimensions Chapter 6 and Chapter 9 already set; every other dimension is marked "to be confirmed in design". Form 6-1 is a draft form: it lists what Clause 6.15 requires and does not add to it.

Annex 6A — Standard inlet types for Arunachal Pradesh with capacity curves (on grade and sag)

Supports Clauses 6.6.1 to 6.6.7 of Chapter 6 and Clause 9.11 of Chapter 9.

To be prepared. This annex will contain a short list of standard inlet types for Arunachal Pradesh streets (kerb-opening, grate and combination inlets, including the road-level wall opening into a covered drain) and, for each type, capacity curves on grade and in a sag. It needs a fixed set of standard inlet geometries agreed with the road-owning agencies, and rating tests of those geometries (laboratory or full-scale), or HEC-22 calculations for each geometry checked against tests (data and likely sources: Public Works Department (PWD), PWD (Highways) and Itanagar Municipal Corporation standard details, the engineering institutions of the State and the region, among them NERIST at Nirjuli, none of whose hydraulic testing capability was identified during research [TBC], or other hydraulic laboratories, manufacturers' tested ratings). Until it is published, compute the clean capacity of the inlet actually proposed by the methods of FHWA HEC-22 (4th edition, 2024) or from the manufacturer's tested rating for that exact geometry (Clause 6.6.2), reduce it by the clogging factors of Table 6.5 (Clause 6.6.3), and meet the interim requirements of Table 6A.1.

Table 6A.1 — Interim requirements for inlets until Annex 6A is published (from Chapters 6 and 9)

Item	Requirement	Clause
Inlet type on public streets	Kerb-opening or combination inlets, unless the Approving Authority accepts grate-only inlets for a location	6.6.1(a)
Inlet level	Openings at road level; gutter depression where practicable	6.6.1(b)
Clean capacity	FHWA HEC-22 (4th ed., 2024) or the manufacturer's tested rating for the exact geometry; CPHEEO §5.6.2 equations as a cross-check only	6.6.2
Clogging, on grade	Grate 50%; kerb opening 10%	6.6.3, Table 6.5
Clogging, in a sag	Grate 50%; kerb opening 20%	6.6.3, Table 6.5
Spacing	By sequential calculation from the top of each gutter run; not more than 30 m on kerbed roads	6.6.4

Item	Requirement	Clause
Kerb opening size	Clear height at least 100 mm; length at least 1.0 m	9.11.4
Grate pattern	Openings parallel to the direction of travel not wider than 25 mm	9.11.3(a)
Load class	D400 in carriageways and medians; C250 within 0.5 m of the kerb; B125 in footpaths and cycle tracks (or the equivalent IS class)	9.11.2
Connection pipe	At least 300 mm diameter; gradient giving at least 0.9 m/s at the inlet's design flow	6.6.6
Silt sump	At least 300 mm deep below the outlet pipe invert, cleanable from the surface	6.6.7, 9.11.6

The intended layout of the annex is given in Tables 6A.2 to 6A.4.

Table 6A.2 — Register of standard inlet types (layout)

Type code	Description	Grate size or kerb opening (mm)	Gutter depression (mm)	Load class	Standard drawing
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Table 6A.3 — Capacity on grade (layout; one table per inlet type)

Cross slope Sx (m/m)	Longitudinal slope SL (m/m)	Gutter flow Q (L/s)	Spread T (m)	Clean intercepted flow (L/s)	Design intercepted flow after clogging (L/s)	Bypass flow (L/s)
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

Table 6A.4 — Capacity in a sag (layout; one table per inlet type)

Ponded depth at the inlet (mm)	Clean capacity (L/s)	Clogging factor (Table 6.5)	Design capacity (L/s)	Flow regime (weir, orifice or transition)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Annex 6B — Sediment yield for silt-trap sizing and calibration of the sediment allowance

Supports Clauses 6.7.4, 6.7.8, 6.13.3 and 6.13.10 of Chapter 6.

To be prepared. This annex will contain sediment yields for urban drains in Arunachal Pradesh, by land use and drain type, for sizing the silt traps of Clause 6.13.3, and a calibration of the sediment allowance of Clause 6.7.8 against measured silt depths. It needs desilting records (volume or mass removed per drain length and per catchment area, with dates), silt-depth surveys before and after the monsoon season, and catchment land-use and soil data (data and likely sources: desilting records of Itanagar Municipal Corporation and other urban local bodies, WRD records for channels, land cover from NRSC, soils from the Arunachal Pradesh soil survey and NBSS&LUP, rainfall from IMD). Until it is published, size each silt trap from the designer's stated estimate of the sediment expected between scheduled cleanings, based on the desilting records of the same drain or of similar drains in the same local body, and state the cleaning interval assumed; the interval shall not be longer than the yearly pre-monsoon desilting of Clause 6.13.10. Inlet silt sumps remain at least 300 mm deep (Clause 6.6.7), and the sediment allowance of Clause 6.7.8 applies unchanged.

The intended method is a simple volume balance, with every term to be stated in the design:

$$V_{trap} = Y \cdot A \cdot t_c$$

where V_{trap} is the sediment storage volume of the trap below its outlet invert (m^3), Y is the sediment yield for the catchment's land use and drain type (m^3/ha per year, from Table 6B.2 once published), A is the catchment area draining to the trap (ha), and t_c is the scheduled cleaning interval (years). The annex will state whether a safety margin is added.

Table 6B.1 — Sediment allowances already set by Chapter 6 (provisional, to be calibrated)

Element	Sediment allowance at the invert	Clause
Open and covered drains	Greater of 75 mm and 10% of the clear internal depth	6.7.8(a)
Pipes of 600 mm diameter or more	5% of the internal diameter	6.7.8(b)
Pipes below 600 mm	No allowance; minimum velocity of Clause 6.7.3(a) applies	6.7.8(c)
Drains and pipes that cannot reach the minimum velocity	Allowance doubled; mechanical desilting access provided	6.7.4(b), (c)
Inlet silt sumps	At least 300 mm below the outlet pipe invert	6.6.7

Table 6B.2 — Sediment yield by land use and drain type (layout)

Land use or catchment type	Drain type	Sediment yield Y (m^3/ha per year)	Bulk density (t/m^3)	Local body and records used	Years of record
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Table 6B.3 — Calibration of the sediment allowance (layout)

Drain or pipe ID	Clear internal depth or diameter (mm)	Allowance under Clause 6.7.8 (mm)	Measured silt depth before pre-monsoon desilting (mm)	Measured silt depth at the end of the monsoon (mm)	Ratio of measured to allowance
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Annex 6C — Standard drawings: covered roadside drain with removable covers, access chamber, inlet with silt sump

Supports Clauses 6.6, 6.7.6 to 6.7.10 and 6.13 of Chapter 6, and Clauses 9.11 and 9.12 of Chapter 9.

The drawings below are schematic standard drawings. They show only the dimensions that Chapter 6 and Chapter 9 set. Wall and slab thicknesses, reinforcement, concrete grade and cover, chamber plan sizes and frame details are to be confirmed in design: they come from the structural design (Clause 9.1.2) and the exposure class of Clause 9.13. Table 6C.1 lists the dimensions shown and their source clauses.

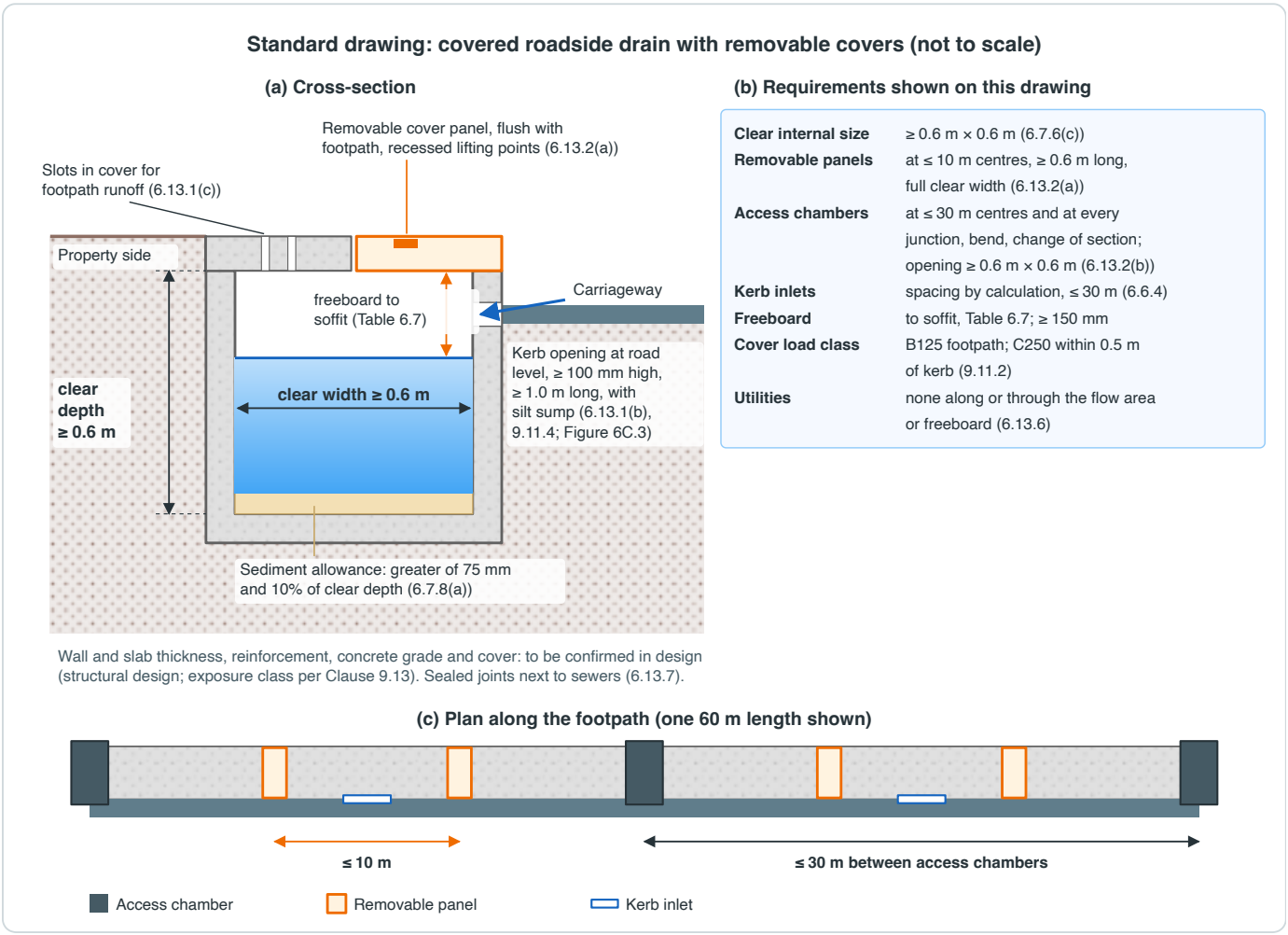


Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 5, and IRC:SP:50-2013.

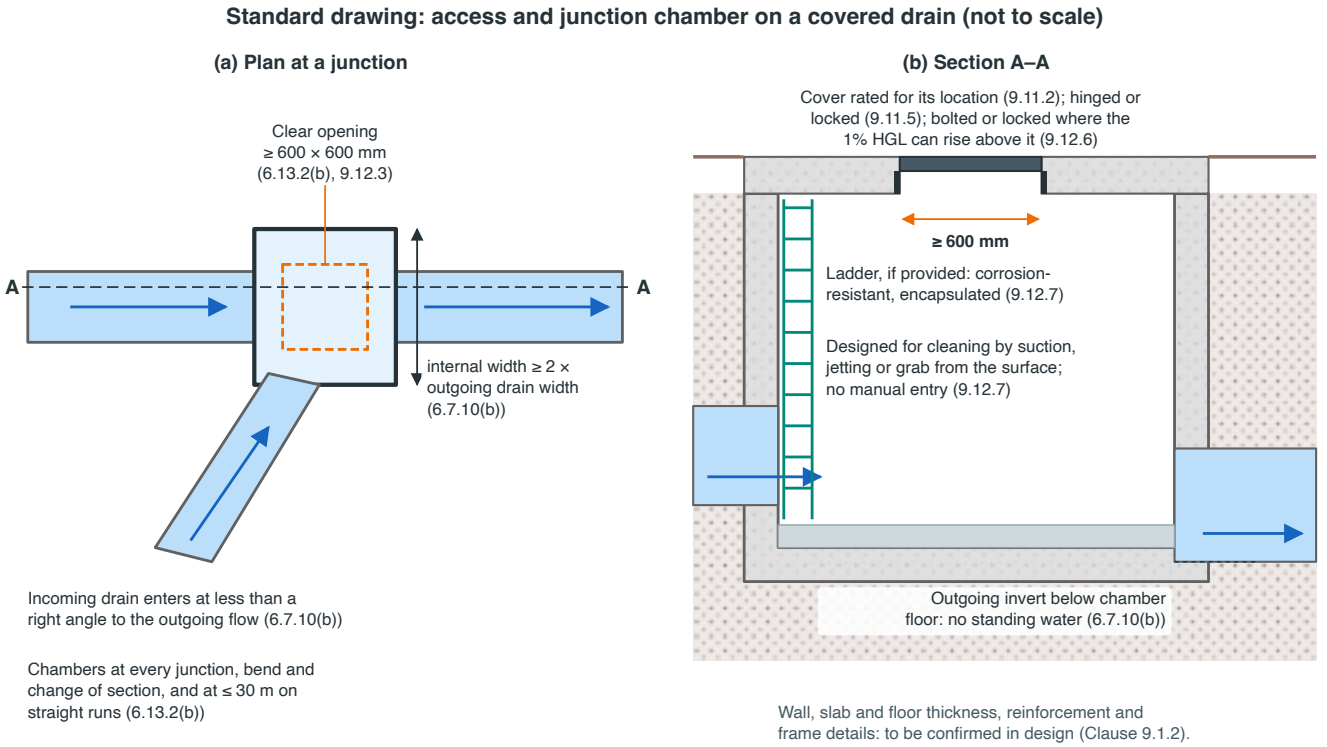


Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), §5.3.4 and Chapter 11.

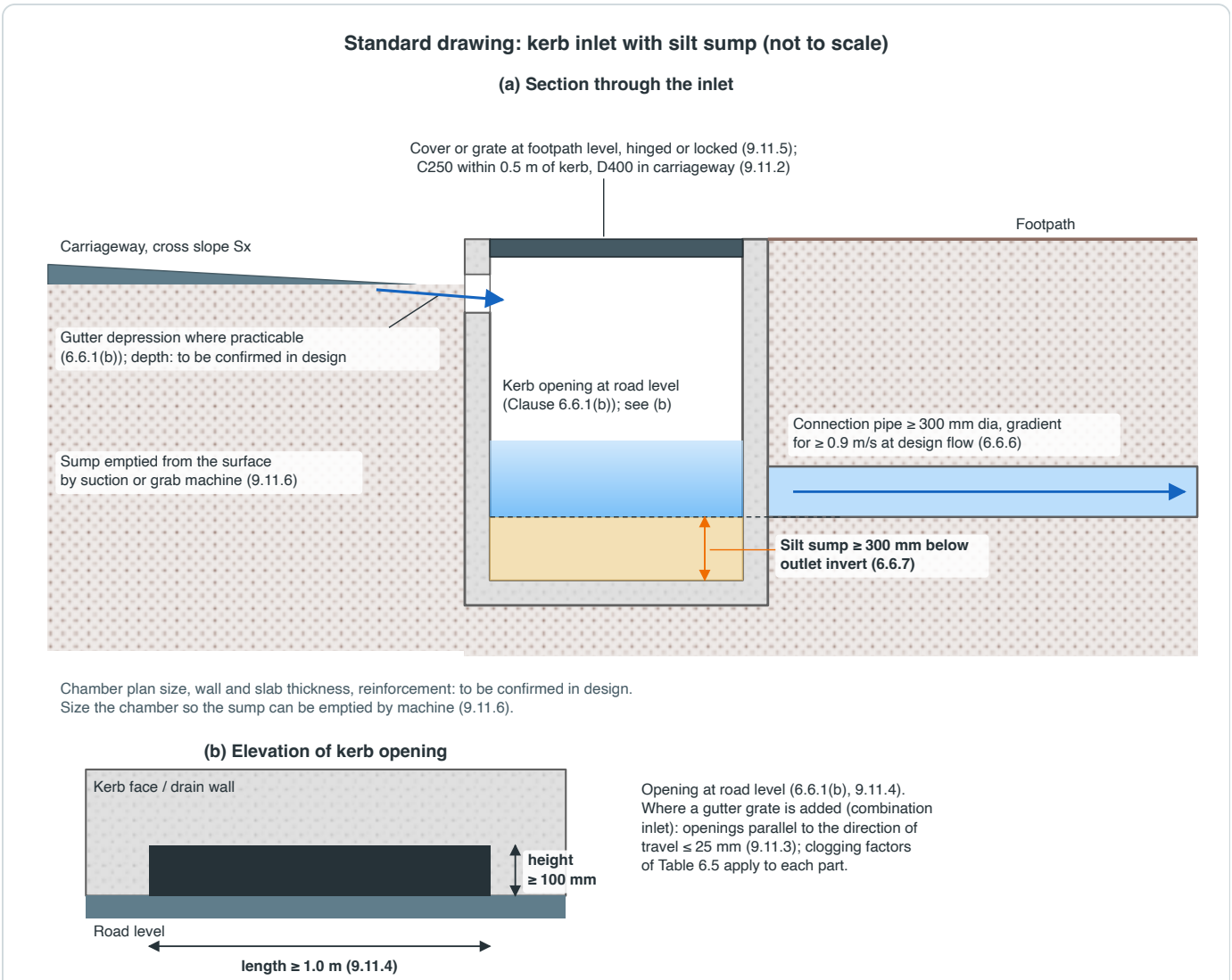


Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

Table 6C.1 — Dimensions on the standard drawings and their source clauses

Drawing	Item	Dimension or rule	Clause
6C.1	Clear internal size of a covered public drain	At least 0.6 m wide and 0.6 m deep	6.7.6(c)
6C.1	Freeboard to the cover soffit	Table 6.7; not less than 150 mm for any roadside drain	6.7.9, 6.13.1(a)
6C.1	Sediment allowance	Greater of 75 mm and 10% of clear depth	6.7.8(a)
6C.1	Removable cover panels	At not more than 10 m centres; each at least 0.6 m long and spanning the full clear width; recessed lifting points; flush with the footpath	6.13.2(a)
6C.1	Footpath runoff	Through slots or grated openings in the cover	6.13.1(c)
6C.1	Kerb inlets	Openings in the drain wall at road level, each with a silt sump; spacing by calculation, not more than 30 m	6.13.1(b), 6.6.4
6C.1, 6C.2	Access chambers	At every junction, bend and change of section, and at not more than 30 m centres on straight runs	6.13.2(b)

Drawing	Item	Dimension or rule	Clause
6C.2	Clear access opening	At least 0.6 m × 0.6 m (600 mm)	6.13.2(b), 9.12.3
6C.2	Junction chamber	Internal width at least twice the outgoing drain width; incoming drains at less than a right angle; outgoing invert below the chamber floor	6.7.10(b)
6C.2	Covers	Load class for the location; hinged or locked; bolted or locked where the 1% AEP HGL can rise above the cover	9.11.2, 9.11.5, 9.12.6
6C.2	Cleaning	By machine from the surface; ladders, where provided, corrosion-resistant and encapsulated	9.12.7
6C.3	Kerb opening	At road level; clear height at least 100 mm; length at least 1.0 m	6.6.1(b), 9.11.4
6C.3	Silt sump	At least 300 mm below the outlet pipe invert; emptied by suction or grab machine	6.6.7, 9.11.6
6C.3	Connection pipe	At least 300 mm diameter; at least 0.9 m/s at the design flow	6.6.6
6C.3	Grate in a combination inlet	Openings parallel to travel not wider than 25 mm; Table 6.5 clogging on each part	9.11.3, 6.6.3
All	Wall and slab thickness, reinforcement, concrete grade and cover, chamber plan size, gutter depression depth	To be confirmed in design	9.1.2, 9.13

Form 6-1 — Conveyance Design Report checklist

Supports Clause 6.15 of Chapter 6.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Not for statutory use.

Attach this checklist to the front of the Conveyance Design Report. For each item, enter Yes, No or Not applicable, and the drawing or page where it is shown.

Section A — Project

Table 6F.1 — Form 6-1, Section A: project

Field	Entry
Project name and location	_____
Local body, and Tier A or Tier B (Chapter 1)	_____
Applicant	_____
Designer (name and registration)	_____
Total catchment area served (ha)	_____
High-density area status for the 10% AEP minor system (Clause 6.4.4)	_____
Within the coastal band of Clause 6.11.6 (Yes / No)	_____
Date and revision	_____

Section B — Contents required by Clause 6.15

Table 6F.2 — Form 6-1, Section B: contents required by Clause 6.15

No.	Item	Clause	Provided (Yes / No / NA)	Drawing or page
1	Catchment plan: sub-catchments, minor system, inlet locations and the 1% AEP major-system overland flow paths	6.3.2		
2	Land-use and road-class AEP adopted for each element, and the high-density area status	Table 6.1, 6.4.4		
3	Design flows, with the rainfall sheet of Chapter 2 and the method of Chapter 3	6.3.4		
4	Gutter spread, depth and D·V checks for the minor, check and 1% events	Tables 6.2, 6.3		
5	Inlet schedule: clean capacity, clogging factor, design capacity and bypass flow	6.6		
6	Pipe and drain design tables: n, velocity, sediment allowance and freeboard	6.7		
7	HGL profiles for the minor and check events, with the tailwater used	6.8		
8	Sag ponding levels, including the fully-blocked check	6.10		
9	Floor-level schedule for every building	6.11		
10	Culvert and crossing calculations (with Form 9-1)	6.12, Chapter 9		

No.	Item	Clause	Provided (Yes / No / NA)	Drawing or page
11	Utilities-crossing schedule and access-opening layout for covered drains	6.13		

Section C — Design basis

Table 6F.3 — Form 6-1, Section C: design basis

Field	Entry	Clause
Minor-system design AEP adopted	_____	Table 6.1
Road class(es) and design / check AEPs for road drainage and crossings	_____	Table 6.1, 6.4.2
Rainfall source and climate factor applied	_____	6.3.4, Chapter 2
Method: Rational Method (catchment ≤ 16 ha, single element) or hydrograph method with routing	_____	6.3.4(a), (b)
Minimum time of concentration used (not less than 10 min)	_____	6.3.4(c)
Tailwater at the outfall for the HGL (MHWS + 0.3 m at tidal outfalls, or the receiving level)	_____	6.8.2
Any transfer of flow between natural catchments (none unless accepted under 6.3.5)	_____	6.3.5

Section D — Compliance checks

Table 6F.4 — Form 6-1, Section D: compliance checks

No.	Check	Limit	Clause	Complies (Yes / No / NA)
D1	Every inlet, sag, pipe, drain, culvert and storage element has a 1% AEP overland path	Shown on plan	6.3.2	
D2	Major-system flow = 1% AEP peak less the clogged minor-system capacity	Computed at each point	6.3.3	
D3	Spread in the minor event	Table 6.2	6.5.2	
D4	Depth in the check and 1% events	≤ 150 mm at the crown; ≤ 350 mm at the deepest point	Table 6.2	
D5	Flow hazard (D·V) by location	Table 6.3	6.5.3	
D6	Inlet clogging factors applied	Table 6.5	6.6.3	
D7	Inlet spacing on kerbed roads	≤ 30 m	6.6.4(a)	
D8	Sag inlet design capacity ≥ minor design flow arriving; flanking inlets where required	—	6.6.5	
D9	Inlet connection pipes and silt sumps	≥ 300 mm dia, ≥ 0.9 m/s; sump ≥ 300 mm	6.6.6, 6.6.7	
D10	Manning's n not less than the minimum design values	Table 6.6	6.7.2	
D11	Minimum velocity at the minor design flow	0.6 m/s drains; 0.9 m/s pipes	6.7.3(a)	
D12	Maximum velocity and Froude number	3.0 m/s lined drains and pipes; Fr ≤ 0.8	6.7.3(b), (d)	

No.	Check	Limit	Clause	Complies (Yes / No / NA)
D13	Where minimum velocity cannot be met: velocity reported, sediment allowance doubled, desilting access provided	—	6.7.4	
D14	Pipes sized for pipe-full capacity, not the 0.95-depth peak	—	6.7.5	
D15	Minimum sizes	Pipes 300 mm (450 mm public mains); open drain bed 0.3 m; covered public drains 0.6 m × 0.6 m	6.7.6	
D16	Cover to pipes; flotation check where groundwater is within 1 m of the crown	≥ 0.6 m; ≥ 0.9 m under carriageways	6.7.7	
D17	Sediment allowance in capacity	6.7.8 values	6.7.8	
D18	Freeboard, including superelevation at bends	Table 6.7	6.7.9	
D19	Bend radii and junction sumps	6.7.10	6.7.10	
D20	Manhole spacing on straight runs	Table 6.8	6.7.11	
D21	HGL below inlet rims and manhole covers in the minor event	≥ 0.3 m	6.8.3	
D22	Manholes that can surcharge above ground: bolted or locked covers	—	6.8.4	
D23	Soffits matched or outgoing soffit lower; outgoing invert not above the lowest incoming invert	—	6.8.6	
D24	Gate and valve losses included in the HGL; non-return valves on private connections where required	—	6.8.7, 6.8.8	
D25	Overland flow paths outside streets: width, tenure, no obstruction, continuous fall	≥ 1% top width + 0.5 m each side, ≥ 3.0 m	6.9.2	
D26	Compound walls across mapped flow paths: openings pass the 1% flow at 50% blockage	—	6.9.3	
D27	Access strip along open drains with top width ≥ 2 m	≥ 3.5 m, linked to a road at ≤ 500 m	6.9.4	
D28	Drainage reserve where required: width, separate plot, no structures, markers, services, 2 m stability check	Table 6.9	6.9.6–6.9.8	
D29	Sag ponding in the 1% event, overflow route, and fully-blocked check	≤ 350 mm at the deepest point	6.10.2, 6.10.3	
D30	Trapped sags and road underpasses	6.10.4, 6.10.5	6.10.4, 6.10.5	
D31	Floor levels	≥ 1% AEP level + 0.5 m; defaults of 6.11.3 where no level is computed	6.11.1–6.11.3	
D32	Basements and building services	6.11.4, 6.11.5	6.11.4, 6.11.5	
D33	Coastal band: floor ≥ 1% still-water level + 2 × SLA (+ wave set-up where applicable) + 0.5 m; no basement rooms or plant	—	6.11.6	
D34	Culverts: design AEP, overtopping, 50% / 20% blockage check, minimum size	≥ 900 mm	6.12	

No.	Check	Limit	Clause	Complies (Yes / No / NA)
D35	Covered drains: removable panels and access chambers	≤ 10 m; ≤ 30 m	6.13.1, 6.13.2	
D36	Silt traps, screens with bypass and 50% blockage check	—	6.13.3, 6.13.4	
D37	No building over drains; no utilities in the flow area or freeboard; existing crossings deducted with 50% blockage	—	6.13.5, 6.13.6	
D38	No sewage connections; sealed joints next to sewers; edge protection on open drains deeper than 1.0 m	—	6.13.7, 6.13.8	
D39	Outfalls: tailwater, flap gates or non-return valves below the 1% still-water level, outlet protection	—	6.14	

Section E — Variances

Table 6F.5 — Form 6-1, Section E: variances

Clause	Requirement not met	Reason and proposed alternative	Approved by and date
_____	_____	_____	_____

Section F — Signatures

The report shall be prepared and signed by a registered professional, and the Professional Design Certificate (Form 10-3) attached (Clauses 10.6.1 and 10.6.3 of Chapter 10). Where a structure stands within 2 m of the edge of a drainage reserve, the stability design shall also be signed by a qualified structural engineer (Clause 6.9.8(f)).

Table 6F.6 — Form 6-1, Section F: signatures

Role	Name	Registration or empanelment no.	Signature	Date
Designer	_____	_____	_____	_____
Structural engineer (Clause 6.9.8(f), where applicable)	_____	_____	_____	_____

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 7

Waterbodies, Ponds, Lakes and Setbacks

These annexes support Chapter 7. They give the inventory field specification, the fixed-width setback table, a template operating rule, the desilting and restoration specification, a glossary of Nyishi waterbody terms, and the three forms that Clause 7.15 requires. Where an annex cannot yet be completed it says so and gives the rule to use in the meantime. The forms are draft forms; the template and model text are for consideration by a competent authority and are not in force.

Annex 7A — Statewide waterbody GIS layer and inventory fields

Supports Clauses 7.3.1, 7.3.3 and 7.3.5 of Chapter 7.

To be prepared. This annex will contain the statewide GIS layer of waterbodies required by Clause 7.3.1, prepared by each Authority with the Water Resources Department and the land revenue offices of the Deputy Commissioners. It needs the records of the land revenue offices of the Deputy Commissioners under the Arunachal Pradesh (Land Settlement and Records) Act, 2000, which are thin, because much land near the towns is held by communities, clans and individuals under the customary rights that the Act incorporates and is in no State register: individual titles came only with the 2018 amendment (section 1A, as reported), and the beds of rivers, streams, nallahs, lakes and tanks are Government property only where they are "not the property of any person or community" (section 9(1)), so that the records of the communities, clans and owners are also needed (none was read for this Manual [TBC]); the public streams, springs, drains and water courses that vest in the Itanagar Municipal Corporation under the Arunachal Pradesh Municipal Corporation Act, 2019, and the public tanks, streams, reservoirs, wells and drains that vest in a municipality under section 102 of the Arunachal Pradesh Municipal Act, 2007; the list of the water bodies in its jurisdiction that every urban local body and planning authority is to prepare under Annexure E 1.8 of the APBBL 2019 (none was found [TBC]); the maps of the Master Plan of Itanagar Capital Region-2031, with its "natural drainage system (Nallah)" and the flood plains of the Pachin and the Dikrong; the first Water Bodies Census (993 water bodies, 893 rural and 100 urban, none encroached, as summarised from a Rajya Sabha answer); the Forest Department's truthing and boundary demarcation of 1,127 wetlands, of which 997 have been demarcated; NDMA's list of high-risk glacial lakes (as reported); NEEPCO's and NHPC's records of the levels and land of their reservoirs; and each town's drain register (Chapter 6); the NEEPCO and village authority tank registers with FTL and MWL; surveyed levels on a common datum; the ISRO National Wetland Inventory and Assessment (NRSC); Survey of India topographic maps; and any list of waterbodies published under court directions. Until it is published, each Applicant identifies waterbodies from all the sources of Clause 7.3.3, with the larger extent governing, and records them on the Waterbody Sheet (Form 7-1).

The field specification below is complete. It is written so that every field the chapter asks for (Clause 7.3.1(a) to (g)) has a defined name, type and source, and so that the same fields can be filled from a project's Form 7-1.

7A.1 Layers

- **WB_POLY** — one polygon per waterbody: the Revenue record boundary (Clause 7.3.1(c)).

- **WB_FTL** — the surveyed FTL contour (tanks, lakes, ponds) or top of bank (channels), as a polygon or line.
- **WB_MWL** — the MWL contour of each tank, as a polygon.
- **WB_FLOOD** — the 1% AEP flood extent, where mapped (Clause 7.3.1(f)), with the floodway where delineated (Clause 7.6.1).
- **WB_STRUCT** — points for surplus weirs, sluices, regulators, inlets and drain outfalls.
- **WB_LINK** — lines for supply channels, surplus courses and the links between tanks in a cascade (Clause 7.3.1(e)).
- **WB_ENCR** — polygons of known encroachments, each with the date recorded (Clause 7.3.1(g)).
- **WB_SETBACK** — Zone 1 and Zone 2 polygons (Clause 7.4), derived from the layers above.

All layers shall carry the waterbody identifier (WB_ID) so that they can be joined. All levels shall be stated to one datum (Clause 7.3.5), named in the layer metadata.

Table 7A.1 — Attribute fields of the waterbody inventory (WB_POLY)

Field	Type	Unit / domain	Required	Content	Clause
WB_ID	Text	District code + serial	Yes	Unique identifier, never reused	7.3.1
WB_NAME	Text	—	Yes	Name as in Revenue and NEEPCO records, with local name	7.3.1(a)
WB_NAME_LOC	Text	the local language script	Yes	Name in the local language	7.3.1(a)
WB_TYPE	Code	Table 7A.2	Yes	Waterbody type	7.2, 7.3.1(a)
SURVEY_NOS	Text	Village, survey and subdivision numbers	Yes	Revenue survey numbers of the waterbody	7.3.1(a)
VILLAGE	Text	—	Yes	Revenue village, circle and district	7.3.1(a)
CUSTODIAN	Code	Table 7A.2	Yes	Custodian body	7.3.1(b)
AREA_REC	Number	ha	Yes	Area within the Revenue record boundary	7.3.1(c)
AREA_FTL	Number	ha	Tanks	Waterspread at FTL, surveyed	7.2, 7.3.1(d)
FTL	Number	m (datum)	Tanks	Full tank level	7.3.1(d)
MWL	Number	m (datum)	Tanks	Maximum water level (Clause 7.2 definition)	7.3.1(d)
MWL_BASIS	Code	NEEPCO record / 1% AEP computed	Tanks	Which value governs MWL	7.2
TBL	Number	m (datum)	Tanks	Top bund level, lowest point	7.3.1(d)
WEIR_CREST	Number	m (datum)	Tanks	Surplus weir crest level	7.3.1(d)
WEIR_LEN	Number	m	Tanks	Surplus weir crest length	7.3.1(d)
WEIR_TYPE	Text	—	Tanks	Surplus weir type (for example fixed crest, with shutters or falling boards)	7.3.1(d)
SLUICE_N	Integer	—	Tanks	Number of sluices; details in WB_STRUCT	7.3.1(d)
SUPPLY_CH	Text	WB_ID(s)	Tanks	Supply channel(s) feeding the tank	7.3.1(d)
SURPLUS_CS	Text	WB_ID(s)	Tanks	Surplus course(s) leaving the tank	7.3.1(d)
UPSTR_WB	Text	WB_ID(s)	Cascades	Upstream tank(s) in the cascade	7.3.1(e)
DNSTR_WB	Text	WB_ID	Cascades	Downstream tank, river, drain or sea outfall	7.3.1(e)

Field	Type	Unit / domain	Required	Content	Clause
CATCH_AREA	Number	ha	Channels	Drainage area at the downstream end of the reach (for the 8 ha trigger of Clause 7.4.1(b) and Table 7.1)	7.4.1
DATUM	Text	—	Yes	Datum of all levels; conversion from any older NEEPCO datum	7.3.5
LEVEL_DATE	Date	—	Tanks	Date of the level survey	7.7.1(a)
SSC_DATE	Date	—	Tanks	Date of the latest stage–storage survey	7.7.1(b)
FLOOD_SRC	Code	Adopted map / site study / none	Yes	Source of the 1% AEP extent	7.3.4
FLOODWAY	Code	Delineated / whole 1% extent / below MWL	Yes	Basis of the floodway	7.6.1
ENCR_KNOWN	Code	Yes / No	Yes	Known encroachment; details in WB_ENCR	7.3.1(g)
CREDITED	Code	Yes / No	Tanks	Storage counted under Clause 7.7, with the scheme reference	7.7.1
WETLAND	Code	Notified / listed / other	Wetlands	Status under Clause 7.12.1	7.12.1
SOURCES	Text	—	Yes	Sources used, from the list in Clause 7.3.3(a) to (e)	7.3.3
UPDATED	Date	—	Yes	Date of the last edit, and by whom	7.3.1

Table 7A.2 — Code lists

Code list	Values	Clause
WB_TYPE	River or stream; hill stream (small steep stream into which a hill town's drains fall); nallah (natural or open urban channel; selam); drain; pond (natural or dug; private, community or public); lake or wetland (sinyi); glacial or moraine-dammed lake (hazard, never storage); reservoir (with its drawdown zone); spring and its recharge area; supply channel; surplus course	7.2
CUSTODIAN	IMC (Municipal Corporation Act, 2019, s.200); Pasighat Municipal Council or other municipality (Municipal Act, 2007, s.102); Department of Urban Affairs or Smart City company (until handed over); PWD or PWD (Highways) (road drains and culverts); Water Resources Department (rivers, anti-erosion works); PHED (water-supply source or intake); NEEPCO or NHPC (reservoir and release reach); Forest Department (truthed wetland; sanctuary lake); State Wetland Authority (notified wetland); community or clan (customary land; Land Act, s.9(1)); private owner; village authority; developer (until handed over); other (name)	7.3.1(b)
Structure (WB_STRUCT)	Surplus weir; sluice; regulator; inlet; drain outfall; gross pollutant trap; crossing	7.3.1(d), 7.10
Encroachment (WB_ENCR)	Building; fill; road; wall; dumping; cultivation; other — each with date recorded, area (m²) and source	7.3.1(g), 7.13

Table 7A.3 — Attribute fields of structures (WB_STRUCT)

Field	Type	Unit	Content	Clause
STR_ID	Text	—	Unique identifier	7.3.1(d)
WB_ID	Text	—	Waterbody served	7.3.1(d)
STR_TYPE	Code	Table 7A.2	Structure type	7.3.1(d)
CREST_SILL	Number	m (datum)	Weir crest or sluice sill level	7.7.1(a)
LENGTH_SIZE	Text	m	Weir crest length, or sluice opening size	7.7.1(a)

Field	Type	Unit	Content	Clause
GATED	Code	Yes / No	Controllable outlet (needed for a flood cushion, Clause 7.8.2(a))	7.8.2
CONDITION	Code	Serviceable / defective	Result of the latest pre-monsoon inspection, with date	7.7.1(d), 7.14.4

Annex 7B — Fixed-width setback table (alternative S-3, with Annex 1C)

Supports Clauses 7.3.4, 7.4.3, 7.4.6 and 7.4.7 of Chapter 7, and alternative S-3 of the Policy Supplement (Annex 1C).

7B.1 When the table may be used

The fixed-width setback may be used only where all of the following apply:

- (a) the Authority has not adopted a 1% AEP flood extent map for the waterbody (Clause 7.3.4);
- (b) Clause 7.3.4 does not require the Applicant to determine the 1% AEP extent by a hydraulic study: the site is not in a flood-sensitive catchment, is not a site of 1 ha or more adjoining a waterbody, and the Authority has not asked for a study; and
- (c) the waterbody is one to which setbacks apply (Clause 7.4.1): any recorded or found waterbody, and any natural channel draining 8 ha or more at the site.

Where an Authority adopts alternative S-3 under Clause 1.7, the table below is the S-3 table. Clause 1.7.3(e) provides for the S-3 table to be issued by the State Stormwater Technical Committee. Until it is issued, the values are those of Clause 7.4.6, repeated here without change.

Table 7B.1 — Fixed-width setback by waterbody class (alternative S-3)

Waterbody class	Drainage area at the site	Total setback (Zone 1 + Zone 2)	Of which Zone 1	Measured from
Channel, small	8 ha to 65 ha	25 m	15 m	Top of bank (Clause 7.4.3)
Channel, medium	65 ha to 20 km²	40 m	15 m	Top of bank
Channel, large, and rivers	More than 20 km²	50 m	20 m	Top of bank
Tank, lake or pond	Any	MWL contour + 25 m	To the MWL contour, and not less than 15 m from FTL	FTL contour (Zone 1); MWL contour (total)
Marsh, estuary or backwater	Any	As notified by the Authority, and not less than 50 m	15 m	The waterbody boundary of Clause 7.13.1

Values from Clause 7.4.6 (Table 7.1). Zone 2 is the total setback less Zone 1.

7B.2 Rules of application

- (a) **Measurement.** Measure horizontally on plan, outward from the boundary of Clause 7.13.1: the larger of the Revenue record boundary and the surveyed FTL (or top of bank). Where FTL and top of bank both apply, use whichever gives the wider zone (Clause 7.4.3).
- (b) **Drainage area.** For a channel, use the drainage area at the downstream end of the reach that adjoins the site. Where a reach crosses a class limit within the site, apply the wider setback to the whole reach within the site.
- (c) **Both banks.** The setback applies on each bank of a channel and all round a tank, lake, pond or marsh.
- (d) **Minimum set by this Manual.** Zone 1 is never less than 15 m (Clause 7.4.7). A wider statutory or approval setback governs for the uses it restricts (Clause 7.4.5).

- (e) **Stricter of the two.** Where a hydraulic study is made voluntarily, the setback is the wider of Table 7B.1 and Clauses 7.4.3 and 7.4.4.
- (f) **Record.** The basis of the setback (fixed width) shall be stated on the Waterbody Sheet (Form 7-1) and in the approval (Clause 7.4, Disclosure).
- (g) **Review.** The table shall be reviewed within 2 years of the Authority adopting 1% AEP flood maps (Clause 7.16.1).

7B.3 Source of the channel widths

The channel widths were set by this Manual with reference to the 2006 Kansas City APWA default stream buffers, rounded up and floored at the 15 m minimum (Clause 7.4.6, commentary). The source values, as cited in the chapter, are:

Table 7B.2 — Source buffers cited in Clause 7.4.6 (KC APWA 5600, 2006, §5605.3)

Drainage area (source, acres)	Approximate SI equivalent	Source buffer
Less than 40 ac	Less than 16 ha	40 ft (12 m)
40–160 ac	16–65 ha	60 ft (18 m)
160–5,000 ac	65 ha – 20 km²	100 ft (30 m)
More than 5,000 ac	More than 20 km²	120 ft (37 m)

The 65 ha and 20 km² class limits in Table 7B.1 are the SI equivalents of 160 ac and 5,000 ac. The 8 ha lower limit is the 20-acre trigger of APWA 2025.01 (Clause 7.4.1(b)).

Annex 7C — Template tank operating rule, with flood cushion

Supports Clauses 7.7.1(c), 7.7.3, 7.8 and 7.14.4 of Chapter 7.

Model text for consideration by a competent authority. Not in force. For tanks under NEEPCO control, the operating rule is NEEPCO's rule (Clause 7.8.4); this template sets out the content that Clause 7.8 asks for, so that the custodian's rule can be checked against it. Text in square brackets is to be completed for each tank.

7C.1 Identification

1. Tank: [name, WB_ID of Annex 7A, village, circle, district].
2. Custodian: [NEEPCO division / ULB / village authority / other].
3. Cascade position: upstream tank(s) [ ]; downstream tank, river or drain [ ].
4. Datum: [ ]. Surveyed levels (Clause 7.7.1(a)), date of survey [ ]: FTL [ ] m; MWL [ ] m; TBL (lowest point) [ ] m; surplus weir crest [ ] m, length [ ] m; sluice sills [ ] m.
5. Stage–storage curve (Clause 7.7.1(b)): survey date [ ]; attached as Schedule 1.
6. Controllable outlets (Clause 7.8.2(a)): [gated sluice / regulator / none]; capacity at FTL [ ] m³/s.

7C.2 Purposes and priority

7. The tank serves [irrigation of a command area of [ ] ha / drinking water supply / recharge / flood storage]. Irrigation and water supply remain primary unless the custodian records otherwise (Clause 7.8.2(d)).

7C.3 Levels and dates through the year (Clause 7.8.1(a))

8. The tank shall be operated to the levels in Table 7C.1.

Table 7C.1 — Rule levels by period (to be completed for each tank)

Period	Target level (m)	Upper limit (m)	Lower limit (m)	Purpose
[1 Jan – date]	[ ]	FTL	[ ]	Holding for irrigation / supply
[date – start of cushion period]	[ ]	FTL	[ ]	Holding
[Flood-cushion period, if any]	Cushion level [ ]	Cushion level [ ]	[ ]	Flood cushion (Clause 7.8.2)
[End of cushion period – 31 Dec]	[ ]	FTL	[ ]	Refilling

9. Where no flood cushion is adopted, the starting level for design is FTL (Clause 7.7.3) and the row for the cushion period is deleted.

7C.4 Flood cushion (Clause 7.8.2)

10. Cushion level: [ ] m, which is [ ] m below FTL, giving a cushion volume of [ ] m³ from Schedule 1.
11. Dates: the cushion applies from [ ] to [ ].
12. Drawdown: the tank can be drawn down from FTL to the cushion level through [outlet] in [ ] hours, with a release not exceeding the maximum release rate of paragraph 18.
13. Reliability: continuous simulation (Clause 3.13) over the record [years] shows that the cushion is available at the start of a design storm in [ ]% of monsoon seasons, which shall be at least 90%. The simulation report is Schedule 2.
14. Yield: the custodian accepts the loss of irrigation or supply yield stated in Schedule 3 [and the compensation recorded there].
15. Where the tank has no controllable outlet, this section does not apply and no flood cushion is assumed (Clause 7.8.3).

7C.5 Releases (Clause 7.8.1(b) to (d))

16. Sluice and regulator settings at each level: Table 7C.2.
17. Operator: the sluices and regulators are operated by [post]. A release above [ ] m³/s may be ordered only by [post], or, in an emergency, by [post].
18. Maximum release rate: [ ] m³/s. This rate, added to the flow from the downstream catchment, does not flood buildings downstream (Schedule 4 gives the downstream check).
19. No person shall cut, lower or breach the bund or surplus weir except under the custodian's emergency procedure (Clause 7.14.5).

Table 7C.2 — Outlet settings by level (to be completed for each tank)

Tank level (m)	Sluice 1	Sluice 2	Regulator	Expected outflow (m³/s)	Notes
Below cushion level	[ ]	[ ]	[ ]	[ ]	
Cushion level to FTL	[ ]	[ ]	[ ]	[ ]	
FTL (weir begins to spill)	[ ]	[ ]	[ ]	[ ]	
Above FTL to MWL	[ ]	[ ]	[ ]	[ ]	Check freeboard to TBL (Clause 7.7.4(b))

7C.6 Forecasts, warnings and communication (Clause 7.8.1(e) and (f))

20. The triggers and actions are in Table 7C.3.
21. Before any release under this rule, the operator shall inform the ULBs and the district administration downstream, and residents by the means stated in Schedule 5, at least [ ] hours before the release where the forecast allows.

Table 7C.3 — Triggers and actions (to be completed for each tank)

Trigger	Source	Action	By whom
IMD district heavy-rainfall warning for the catchment	IMD	Read gauges [ ] hourly; check outlets are free; confirm the tank is at or below its rule level	[ ]
IMD or APSDMA red alert	IMD, APSDMA	Begin releases needed to reach the rule level, within the maximum release rate; notify downstream bodies (paragraph 21)	[ ]
City forecast system warning, where available	[ ]	[ ]	[ ]
Tank level reaches FTL	Gauge	Record outflow hourly; inspect bund and weir	[ ]
Tank level reaches [MWL − [ ] m]	Gauge	Emergency procedure; warning to the breach area of any emergency action plan (Clause 7.14.3(c))	[ ]

7C.7 Records and review (Clause 7.8.1(g))

22. During the monsoon (1 April to 31 October) the operator shall record daily: the tank level, every release (time, rate and duration), and every gate setting. Outside the monsoon, records shall be kept [weekly].
23. Records shall be kept with the O&M plan (Chapter 10) and given to the Authority on request.
24. The tank shall be inspected before the monsoon (by 31 March) and after every heavy-rainfall event (Clause 7.14.4).
25. This rule shall be reviewed after any event in which the tank surplused at a level above [ ] m, after any change to the weir, sluices or bund (Clause 7.7.6), and in any case with the review of the Manual.

Schedules: 1 stage–storage curve; 2 continuous simulation report; 3 yield and compensation; 4 downstream check of the maximum release; 5 communication list.

Annex 7D — Desilting and restoration specification

Supports Clauses 7.7.1(b), 7.9 and 7.14.4 of Chapter 7.

This specification applies to every desilting, restoration or deepening of a tank, pond or other waterbody under Clause 7.9. Values are those of Chapter 7. Where the chapter does not set a value, it is marked "to be confirmed in design" and shall be stated in the works design.

7D.1 Pre-works survey (Clause 7.9.1)

- (a) **Topographic and bathymetric survey** of the waterspread, foreshore (to the MWL contour), bund, surplus weir and sluices, levelled to the datum of Clause 7.3.5. Survey grid and point density: to be confirmed in design.
- (b) **Original bed level** found by test pits or augering on a grid (grid spacing to be confirmed in design), and from historical records where available. Each pit log shall show the silt thickness, the level of the original bed, and any clay or silt layer below it.

- (c) **Silt testing** where the tank receives urban runoff or sewage: samples from the pits of (b), tested for heavy metals and other contaminants before disposal is planned. The parameters and limits shall be those the Arunachal Pradesh State Pollution Control Board (APSPCB) directs.
- (d) **Structures:** condition of the bund (seepage, slips, cracks, animal burrows, trees), surplus weir and sluices, as in Clause 7.14.4.
- (e) **Existing stage–storage curve** from the survey of (a).

7D.2 Limits of excavation (Clauses 7.9.2 and 7.9.3)

- (a) Desilting removes accumulated sediment down to the original bed level of 7D.1(b), and no deeper.
- (b) Deepening below the original bed only with a hydrogeological report showing each of Clause 7.9.3(a) to (c).
- (c) Storage created below the lowest sluice sill is not flood storage, and shall not be shown as such in the revised stage–storage curve.
- (d) Excavation shall stay clear of the bund toe by a distance to be confirmed in design, so that the bund's stability is not reduced.

7D.3 Edges and safety (Clause 7.9.4)

Where the public has access to the edge:

- (a) side slopes no steeper than **1V:4H** from **0.5 m above FTL** down to **1.2 m below FTL**; or
- (b) a level safety bench at least **3 m** wide, between **0.3 m and 0.5 m below FTL**; and
- (c) no isolated deep pit or vertical cut left in the bed. Borrow pits shall be regraded to the bed.

7D.4 Storage not reduced (Clause 7.9.5)

- (a) Islands, walkways, bund widening into the waterspread, ring roads, parking, buildings and lake-front platforms within the waterspread or foreshore are lost storage.
- (b) Lost storage shall be offset by compensatory storage at equivalent levels, band by band, using Form 7-3.

7D.5 Silt handling and disposal (Clause 7.9.6)

- (a) Desilted material shall not be placed within the setback, on the bund (except approved bund strengthening), or on any flood path.
- (b) Contaminated silt shall be disposed of as the Arunachal Pradesh State Pollution Control Board (APSPCB) directs.
- (c) Haul routes and temporary stockpiles shall meet the construction erosion and sediment control rules of Clause 8.12, including stockpiles outside Zone 1.

7D.6 Inlets (Clause 7.9.7)

Every inlet that brings urban runoff shall have a sediment forebay, a constructed wetland inlet zone or a gross pollutant trap, designed under Chapter 8 (Annex 8D).

7D.7 Timing (Clause 7.9.8)

Desilting shall be complete, and the waterbody made safe, by **31 March**. No excavation shall be left open, and no sluice or weir left dismantled, during the monsoon.

7D.8 Completion records

- (a) As-built survey and revised stage–storage curve. The curve is the one that Clause 7.7.1(b) requires "after the last desilting".
- (b) Volume removed, its disposal site, and the silt test results.
- (c) Photographs of the bund, weir, sluices and inlet works.
- (d) Update of the inventory record (Annex 7A: SSC_DATE, LEVEL_DATE, CONDITION).

Table 7D.1 — Hold points for desilting and restoration works

Hold point	Check	Clause
1. Before excavation	Pre-works survey, pit logs, silt tests, and hydrogeological report if deepening	7.9.1, 7.9.3
2. Original bed reached	Levels checked against pit logs; no excavation below the original bed unless approved	7.9.2
3. Edges formed	Side slopes or safety bench as 7D.3	7.9.4
4. Inlet works	Forebay, wetland inlet zone or GPT built	7.9.7
5. Completion (by 31 March)	As-built survey, stage–storage curve, silt disposal record	7.9.8, 7.7.1(b)

Annex 7E — Glossary of Nyishi waterbody terms and regional variants

Supports Clause 7.2 and Clause 7.3 of Chapter 7.

The terms below are the Nyishi words for water, lakes and channels that were found, with the working words of this Manual. English is the working language of Arunachal Pradesh and the language of this Manual (as reported); the State has many tribal languages, among them Nyishi, Adi, Galo, Apatani, Monpa, Mishmi and Tangsa (NEER reading), and no single local language. The Nyishi terms are given here, and in the glosses of the definitions after Clause 7.2, only as glosses, with their language, source and page; they are not the Manual's working words, and running text uses only "pond", "lake", "nallah", "spring" and "stream". A meaning is given only where it was found in one vocabulary, read as the OCR text of the Internet Archive copy: R. C. Hamilton, *An Outline Grammar of the Dafla Language as Spoken by the Tribes Immediately South of the Apa Tanang Country* (1900). "Dafla" is the colonial name for Nyishi (renamed, as a 2005 Parliament question is titled), so the language is written here as **Nyishi (called "Dafla" in the source)**. **Two cautions apply.** The page numbers are approximate, because the pages were read from OCR text, not page images; and the spellings and diacritics are those of a vocabulary of 1900, read by OCR, and may differ from modern usage. No Adi, Galo, Apatani, Monpa, Mishmi or Tangsa source was read (Table 7E.4). The list is to be extended by the State Stormwater Technical Committee, with the names the urban local bodies, the village authorities and the land revenue offices use.

The Manual's term for a pond in Arunachal Pradesh is the plain English **pond** (plural **ponds**). No single local word is used: no tribal language is shared across the State; the one word found, Nyishi *sinyi*, means "Lake" and "Tank" (Hamilton 1900, c. pp. 104 and 118), a larger water than a small urban pond, and is the second word of *Gyakar Sinyi*, the local name of Ganga Lake (NEER reading); and the statutes, the Master Plan of Itanagar Capital Region-2031, the Water Bodies Census and the Forest Department's wetland truthing already count "ponds" and "tanks" in English. A **lake** is a lake in plain English, such as Ganga Lake (Gyakar Sinyi) and Glaw Lake. The natural and open urban channels are **nallahs**, as the APBBL 2019 ("Distance from Nallah/Stream"), the Arunachal Pradesh (Land Settlement and Records) Act, 2000 ("nallahs") and the master plan ("natural drainage system (Nallah)") write the word, and as in Papu Nallah; the Manual spells it "nallah" always. The *Jhot* is the bye-laws' "strip of land permanently left open for drainage purposes" (APBBL 2019, definition 69), an English-text term of the bye-laws used for that strip only. An engineered detention basin is a **detention pond**, never a natural or community pond, a lake, a spring pool or a reservoir; natural waters keep their own names and descriptions.

Table 7E.1 — Lakes, tanks and ponds

Term	Language	Meaning (source, page)	Manual term (Clause 7.2)
sinyi	Nyishi (called "Dafla" in the source)	"Lake" (Hamilton 1900, c. p. 104) and "Tank" (c. p. 118); the second word of *Gyakar Sinyi*, Ganga Lake (NEER reading)	Lake (gloss only); not used for a pond
—	Nyishi	No separate word for a small pond was found (Hamilton, 1900)	—

Table 7E.2 — Water, channels and springs

Term	Language	Meaning (source, page)	Manual term (Clause 7.2)
issi	Nyishi (called "Dafla" in the source)	"Water" (Hamilton 1900, c. p. 122; the OCR reads "issh")	Not a defined term
selam	Nyishi (called "Dafla" in the source)	"Channel" (Hamilton 1900, c. p. 96)	Nallah or channel (gloss only)
lol	Nyishi (called "Dafla" in the source)	"Spring … (of water) … But the word is rarely used" (Hamilton 1900, c. p. 118)	Not used
pödöng; nyadang	Nyishi (called "Dafla" in the source)	"Rain" (Hamilton 1900, c. p. 110; the OCR diacritics are uncertain)	Not used

Table 7E.3 — The Manual's working words

Term	Meaning in this Manual	Defined in
pond	A pond, natural or dug, private, community or public (plain English)	Definitions after Clause 7.2
lake	A lake in plain English, such as Ganga Lake (Gyakar Sinyi); never storage for a development	Definitions after Clause 7.2
detention pond	Engineered storage built under this Manual; never a natural pond, a lake, a spring pool or a reservoir	Definitions after Clause 7.2
nallah	A natural or open urban channel, as the bye-laws, the Land Act and the master plan use the word	Definitions after Clause 7.2
hill stream	A small, steep stream into which the drains of a hill town fall	Definitions after Clause 7.2
Jhot	"A strip of land permanently left open for drainage purposes" (APBBL 2019, definition 69); no width	Definitions after Clause 7.2
spring; spring recharge area	Groundwater coming out at the surface; the area upslope that feeds it	Definitions after Clause 7.2; Clause 8.8.1
glacial or moraine-dammed lake	A lake held by a glacier, moraine or landslide dam; a hazard, never storage or an outfall	Definitions after Clause 7.2; Clause 2.3.6(i)
community land; landholder	Land held by a community, clan or individual under customary rights; its community, clan or owner	Definitions after Clause 7.2; Chapter 1

Table 7E.4 — Terms not found or not yet verified

These terms were not found, or were not confirmed in a dictionary, during research for this Manual. They shall not be used in a record or a drawing as defined terms until verified.

Term	Reported meaning or use	Status
Adi terms for pond, drain, stream and spring	—	Lorrain's Abor-Miri dictionary was not located [TBC]
Galo, Apatani, Monpa, Mishmi and Tangsa terms	—	Not found [TBC]
Shaiyang Miri terms	—	Needham's grammar of 1886 has no usable entries for pond or drain
A Nyishi word for a small pond	—	None found in Hamilton (1900)
Modern spellings of the Nyishi terms	Spellings in present use	Not checked beyond the vocabulary of 1900
The spoken link language of the State	—	Not researched; no word from it is used

Notes for the Annex 7A fields. Three fields of Table 7A.1 read as follows in Arunachal Pradesh. **WB_NAME_LOC** holds the waterbody's name in the local language: the language in local use in the ward or village, as the urban local body or the village authority uses it for its own public notices. The scripts in which the State's languages are written were not researched for this Manual, so "the local language script" in that row means the spelling the local body uses for the name, recorded as the local body writes it [TBC]. **VILLAGE**: "Revenue village" means, in Arunachal Pradesh, the village of the circle (the State's administrative circles, as in "Toru circle"); inside a town the field records both the village, where one exists, and the ward of the urban local body. **SURVEY_NOS**: much land is held by communities, clans and individuals under the customary rights that the Arunachal Pradesh (Land Settlement and Records) Act, 2000 incorporates, and customary land often has no survey number in any State record; where none exists, the field records the community, clan or owner as the village authority or the land revenue office records them, and "none" [TBC]. The custodian of every pond, spring and lake (CUSTODIAN) shall be confirmed with the urban local body, the village authority or the owners.

Form 7-1 — Waterbody Sheet

Supports Clauses 7.3.2, 7.4 and 7.15(1) of Chapter 7.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. One sheet per waterbody. Attach the plan of Clause 7.3.2 at 1:1,000 or larger.

Table 7F.1 — Form 7-1, Section A: Project and waterbody

No.	Field	Entry	Clause
A1	Project name and Authority file number	_____	—
A2	Waterbody name (English and the local language) and inventory ID (Annex 7A), if any	_____	7.3.1
A3	Waterbody type (Clause 7.2)	_____	7.2
A4	Position: within the site / within 100 m of the site boundary / downstream within the Chapter 5 extent	_____	7.3.2
A5	Survey numbers and village	_____	7.3.1(a)
A6	Custodian	_____	7.3.1(b)
A7	Sources checked (tick): Land revenue office, community, clan and owner records; IMC (s.200) and municipal (s.102) records; APBBL 2019 Annexure E 1.8 water-body lists; ICR Master Plan 2031 maps; Water Bodies Census; Forest Department wetland truthing; NDMA glacial-lake list; NEEPCO and NHPC records; drain register □; NEEPCO / village authority registers □; Authority inventory or court list □; historical maps and imagery, including NWIA □; site survey □	_____	7.3.3
A8	Where sources conflict: which extent governs (the larger)	_____	7.3.3
A9	Datum of all levels, and conversion from any NEEPCO datum	_____	7.3.5

Table 7F.2 — Form 7-1, Section B: Levels and features

No.	Field	Entry	Clause
B1	FTL (tanks, lakes, ponds) or top of bank (channels), m	_____	7.2
B2	MWL (tanks), m, and basis (NEEPCO record or 1% AEP computed)	_____	7.2
B3	TBL, lowest point (tanks), m	_____	7.3.1(d)
B4	1% AEP flood level, m, and source (adopted map / hydraulic study / not available)	_____	7.3.4
B5	Drainage area at the site (channels), ha	_____	7.4.1(b)
B6	Supply channels, surplus courses, sluices and surplus weirs shown on plan (yes / no)	_____	7.3.2
B7	Known encroachments, with date recorded	_____	7.3.1(g)

Table 7F.3 — Form 7-1, Section C: Setback

No.	Field	Entry	Clause
C1	Basis of setback: mapped extent / hydraulic study / fixed width (Annex 7B)	_____	7.15(1)
C2	Is a hydraulic study required under Clause 7.3.4 (a) / (b) / (c)?	_____	7.3.4
C3	Floodway outer edge, m from FTL or top of bank, and how delineated	_____	7.6.1
C4	Zone 1 width, m (greatest of 15 m, floodway edge, MWL contour)	_____	7.4.3

No.	Field	Entry	Clause
C5	Zone 2 width, m (to 1% AEP extent + 10 m, or 10 m)	_____	7.4.4
C6	Wider statutory or approval setback, if any, and its source	_____	7.4.5
C7	Setback applied: Manual standard / a wider line of a plan, permission or order (no statutory distance from water exists in Arunachal Pradesh): a line of the Master Plan of Itanagar Capital Region-2031 or another master plan, layout or Town Planning Scheme; a condition of the building or earth-cutting permission under the APBBL 2019 (a "Distance from Nallah/Stream" under clause 2.10.1(e) once norms are notified; a Jhot under definition 69; clause 4.39); a Water Resources Department line at a river or anti-erosion work; a NEEPCO or NHPC line at a reservoir or release reach; an agreement with the owners or the community on customary land; a court or Tribunal line; or other (state which)	_____	7.4, Disclosure
C8	Uses proposed in Zone 1 and Zone 2, and the custodian's NOC for any work in Zone 1	_____	7.5, 7.15(5)
C9	Fill proposed in the flood fringe (yes / no); if yes, Form 7-3 attached	_____	7.6.3
C10	Zone 1 marker positions shown (not more than 30 m apart)	_____	7.13.4

Table 7F.4 — Form 7-1, Section D: Prepared by

Field	Entry
Name, registration and empanelment number (Clause 10.6)	_____
Signature and date	_____
Licensed surveyor for the levels (name, licence number)	_____

Form 7-2 — Tank Storage Credit Sheet

Supports Clauses 7.7, 7.8, 7.11, 7.14 and 7.15(4) of Chapter 7.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. One sheet per tank whose storage is counted. Storage that fails any item in Section B shall not be counted (Clause 7.7.1).

Table 7F.5 — Form 7-2, Section A: Tank and scheme

No.	Field	Entry	Clause
A1	Tank name and inventory ID (Annex 7A); custodian	_____	7.3.1
A2	Scheme in which storage is counted: basin plan / regional facility / fee-in-lieu (S-5)	_____	7.7.1, 7.11
A3	Cascade modelled: uppermost tank _____ to outfall _____	_____	7.7.2
A4	Datum	_____	7.3.5

Table 7F.6 — Form 7-2, Section B: Conditions for counting storage

No.	Condition	Date / reference	Met (yes / no)	Clause
B1	FTL, MWL, TBL, weir crest and length, sluice sills surveyed within the previous 5 years	_____	_____	7.7.1(a)
B2	Stage–storage curve from a bathymetric and topographic survey within 5 years or after the last desilting, whichever is later	_____	_____	7.7.1(b)
B3	Documented operating rule agreed with the custodian (Annex 7C)	_____	_____	7.7.1(c), 7.8
B4	Weir, sluices and bund under an O&M plan; latest pre-monsoon inspection found them serviceable	_____	_____	7.7.1(d), 7.14.4
B5	Custodian's written concurrence	_____	_____	7.7.1(e)

Table 7F.7 — Form 7-2, Section C: Levels and creditable volume

No.	Item	Value	Clause
C1	Starting level: FTL, or cushion level under a rule meeting Clause 7.8.2, m	_____	7.7.3
C2	If a cushion is used: controllable outlet (type) and drawdown time, h	_____	7.8.2(a)
C3	If a cushion is used: reliability from continuous simulation, % of monsoon seasons (≥ 90%)	_____	7.8.2(c)
C4	Computed maximum level, 1% AEP inflow with climate factor routed through the cascade, m	_____	7.7.4
C5	MWL, m; is C4 ≤ MWL?	_____	7.7.4(a)
C6	Freeboard C4 to TBL, m; NEEPCO freeboard standard, m; met?	_____	7.7.4(b)
C7	Storage between C1 and C4, from the stage–storage curve, m^3	_____	7.7.5
C8	Volume already committed to another facility or scheme, m^3	_____	7.7.5
C9	Creditable volume = C7 − C8, m^3	_____	7.7.5
C10	Register entry under Clause 10.17 (fee-in-lieu storage)	_____	7.11.2(d)

Table 7F.8 — Form 7-2, Section D: Bund safety

No.	Item	Entry	Clause
D1	Specified dam under the Dam Safety Act, 2021? Height, crest length, capacity, maximum flood discharge	_____	7.14.1
D2	Hazard class: high / low	_____	7.14.2
D3	High hazard: weir passes 1% AEP at MWL with freeboard; 0.2% AEP check without overtopping	_____	7.14.3(a)
D4	High hazard: breach analysis and emergency action plan (references)	_____	7.14.3(b), (c)
D5	High hazard: independent check under Clause 10.6 (name)	_____	7.14.3(d)

Table 7F.9 — Form 7-2, Section E: Signatures

Role	Name and designation	Signature and date
Designer (Clause 10.6)	_____	_____
Independent checker, where Clause 7.14.3(d) applies	_____	_____
Custodian's concurrence (Clause 7.7.1(e))	_____	_____

Form 7-3 — Compensatory Storage Calculation (by elevation band)

Supports Clauses 7.6.3 to 7.6.5, 7.9.5 and 7.15(3) of Chapter 7.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0.

Method

1. Fix the **lower limit**: the normal water level of the waterbody, or the 50% AEP (2-yr) level where higher (Clause 7.6.4(b)).
2. Fix the **upper limit**: the 1% AEP flood level (with the climate factor).
3. Divide the range into **bands of not more than 0.3 m**. The top band may be thinner.
4. For each level z at a band boundary, measure on plan:
    - A_fill(z): the area of the fill footprint where existing ground is below z; and
    - A_cut(z): the area of the excavation where finished ground is below z and existing ground was above z (new flooded area).
5. For each band, by the average end-area method: V = (A(z_bottom) + A(z_top)) / 2 × band thickness. Do this for fill (volume lost) and for excavation (volume gained).
6. **Check each band:** volume gained ≥ volume lost. A surplus in one band does not make up a shortfall in another (Clause 7.6.4(b)).
7. Check the other conditions of Clause 7.6.4(c) to (f) in Section C.

Figure 7.2 in Chapter 7 shows the method.

Table 7F.10 — Form 7-3, Section A: Levels

No.	Field	Entry	Clause
A1	Waterbody, reach, and inventory ID	_____	7.6.4(c)
A2	Normal water level, m; 50% AEP level, m; lower limit (the higher), m	_____	7.6.4(b)
A3	1% AEP flood level with climate factor, m (upper limit)	_____	7.6.4(b)
A4	Band thickness, m (≤ 0.3) and number of bands	_____	7.6.4(b)
A5	Datum	_____	7.3.5

Table 7F.11 — Form 7-3, Section B: Band-by-band balance

Band	From (m)	To (m)	A_fill bottom (m²)	A_fill top (m²)	Volume lost (m³)	A_cut bottom (m²)	A_cut top (m²)	Volume gained (m³)	Gained ≥ lost?
1	_____	_____	_____	_____	_____	_____	_____	_____	_____
2	_____	_____	_____	_____	_____	_____	_____	_____	_____
3	_____	_____	_____	_____	_____	_____	_____	_____	_____
4	_____	_____	_____	_____	_____	_____	_____	_____	_____
Total					_____			_____	

Add rows as needed.

Table 7F.12 — Form 7-3, Section C: Other conditions

No.	Condition	Met (yes / no) and evidence	Clause
C1	Fill is in the flood fringe, not the floodway, and for a permitted use	_____	7.6.2, 7.6.3
C2	Excavation is in the same reach of the same waterbody, hydraulically connected, and not further downstream than the fill	_____	7.6.4(c)
C3	Excavation drains by gravity as the flood recedes; no pumping; no permanent pool below normal water level	_____	7.6.4(d)
C4	Excavation built before, or at the same time as, the fill	_____	7.6.4(e)
C5	Covenant or handover so that it is never filled (reference)	_____	7.6.4(f)
C6	Not counted as detention or retention under Chapter 4	_____	7.6.5
C7	Signature of designer (Clause 10.6) and date	_____	10.6

Worked example

Illustrative — not design values. A site in the flood fringe of a channel needs a fill pad for a permitted Zone 2 use (Clause 7.5.2). The inputs are assumed.

- Normal water level 10.00 m; 50% AEP level 9.80 m. Lower limit = 10.00 m (the higher).
- 1% AEP flood level 11.20 m. Range 1.20 m, so four bands of 0.30 m.
- The fill footprint is 1,600 m². Existing ground across the footprint rises evenly from 10.00 m to 11.20 m, so the area of footprint below each level is: 0 m² at 10.00 m; 400 m² at 10.30 m; 800 m² at 10.60 m; 1,200 m² at 10.90 m; 1,600 m² at 11.20 m.
- The excavation is a graded cut beside the channel, with its floor at 10.00 m. The new flooded area below each level (first trial) is: 300 m² at 10.00 m; 900 m² at 10.30 m; 1,100 m² at 10.60 m; 1,500 m² at 10.90 m; 1,500 m² at 11.20 m.

Step 1 — volume lost, band by band (V = average area × 0.3 m):

- Band 1: (0 + 400) / 2 × 0.3 = 60 m³
- Band 2: (400 + 800) / 2 × 0.3 = 180 m³
- Band 3: (800 + 1,200) / 2 × 0.3 = 300 m³
- Band 4: (1,200 + 1,600) / 2 × 0.3 = 420 m³
- Total: 960 m³

Step 2 — volume gained, first trial:

Table 7F.13 — Worked example: first trial (illustrative)

Band	From (m)	To (m)	Volume lost (m³)	A_cut bottom (m²)	A_cut top (m²)	Volume gained (m³)	Gained ≥ lost?
1	10.00	10.30	60	300	900	180	Yes
2	10.30	10.60	180	900	1,100	300	Yes
3	10.60	10.90	300	1,100	1,500	390	Yes
4	10.90	11.20	420	1,500	1,500	450	Yes
Total			960			1,320	

Every band passes. Note that a simple total balance would hide a failure if, for example, the cut were made deeper and narrower: suppose the designer instead offers a cut with new flooded areas of 1,400 m² at 10.00 m, 1,400 m² at 10.30 m, 1,000 m² at 10.60 m, 600 m² at 10.90 m and 200 m² at 11.20 m.

Table 7F.14 — Worked example: deeper, narrower cut (illustrative)

Band	From (m)	To (m)	Volume lost (m³)	A_cut bottom (m²)	A_cut top (m²)	Volume gained (m³)	Gained ≥ lost?
1	10.00	10.30	60	1,400	1,400	420	Yes
2	10.30	10.60	180	1,400	1,000	360	Yes
3	10.60	10.90	300	1,000	600	240	**No**
4	10.90	11.20	420	600	200	120	**No**
Total			960			1,140	

The total gained (1,140 m³) exceeds the total lost (960 m³), but bands 3 and 4 are short by 60 m³ and 300 m³. The surplus low down cannot be counted against them: the low storage fills early in every flood and is not available when the fill takes away storage near the peak. This design fails Clause 7.6.4(b) and must be regraded so that the upper bands gain at least as much as they lose, as in the first trial.

ANNEXES TO CHAPTER 8

Water Quality and Recharge

These annexes support Chapter 8. They give the layout of the water quality rainfall tables, the Level of Service and Value Rating method in detail, the layout of the BMP calibration programme, design sheets for each BMP, standard details for construction erosion and sediment control, and the two forms that Clause 8.14 requires. Annexes 8A and 8C need data that are not yet available; they say so and give the rule to use in the meantime. The forms are draft forms.

Annex 8A — 3-month ARI 24-hour depth and IDF by zone

Supports Clauses 8.2, 8.4.1 and 8.4.5 of Chapter 8.

To be prepared. This annex will contain, for each rainfall zone of Chapter 2, the 24-hour 3-month ARI depth P_3m and the 3-month ARI intensity–duration relationship used for Q_wq. It needs long-term daily and sub-daily rainfall records (IMD station and gridded data, with NIH as the Chapter 2 primary source), analysed as a partial-duration series. Until it is published, the designer shall compute P_3m from the longest available daily record for the site's zone, as the 24-hour depth equalled or exceeded on average four times a year (Clause 8.2), state the record, its length and the method on the Water Quality Sheet (Form 8-1), and use P_wq = max (P_ret, P_3m) (Clause 8.4.1). The climate factor is not applied (Clause 8.4.3).

8A.1 Method to be used in preparing the annex

- (a) Use daily records of at least 30 years where available (as for station IDF in Chapter 2).
- (b) Form the partial-duration series of 24-hour depths, with independent events separated by at least one dry day.
- (c) Choose the threshold so that the number of events above it averages four per year; P_3m is that threshold.
- (d) Derive the 3-month ARI intensities for durations from 10 minutes to 24 hours from sub-daily records, or by the Chapter 2 method of scaling from the daily value, stating which.
- (e) Do not apply the climate factor (Clause 8.4.3).

Table 8A.1 — Water quality rainfall depths by zone (layout)

Zone (Chapter 2)	Representative stations or grid	Record (years)	P_ret, Annex 2E (mm)	P_3m (mm)	P_wq = max (mm)
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Table 8A.2 — 3-month ARI intensity by duration (layout)

Zone	10 min (mm/h)	15 min (mm/h)	30 min (mm/h)	1 h (mm/h)	2 h (mm/h)	6 h (mm/h)	24 h (mm/h)
_____	_____	_____	_____	_____	_____	_____	_____

Zone	10 min (mm/h)	15 min (mm/h)	30 min (mm/h)	1 h (mm/h)	2 h (mm/h)	6 h (mm/h)	24 h (mm/h)
_____	_____	_____	_____	_____	_____	_____	_____

Annex 8B — Redevelopment LoS table and treatment-train composite VR

Supports Clauses 8.6.2 to 8.6.5 of Chapter 8.

8B.1 Required Level of Service for redevelopment

To be prepared. This part will give the required Level of Service for redevelopment sites (existing impervious cover of 20% or more of the site, Clause 8.6.2). The MARC/APWA BMP Manual (2012, Table 4.3) sets the redevelopment LoS from the percentage of impervious cover within the disturbed area; the Arunachal Pradesh values need to be set by the State Stormwater Technical Committee and checked against local redevelopment cases. Until it is published, the required LoS for a redevelopment site is **6** for the disturbed area. Where Table 8.2, applied to the change in CN from the existing condition to post-development, gives a higher LoS, that higher LoS applies. This interim value is set by this Manual. A redevelopment site that retains its whole WQv on site under Chapter 4 needs no further treatment for that area, apart from pretreatment, hotspot controls and the outfall requirements (Clause 8.4.4).

Table 8B.1 — Required LoS for redevelopment (layout)

Existing impervious cover within the disturbed area (%)	Change in impervious cover	Required LoS
_____	_____	_____
_____	_____	_____
_____	_____	_____

8B.2 Composite Value Rating: area-weighted method

The composite VR of a site is the area-weighted average of the VRs of the BMPs serving each part of the site (Clause 8.6.3):

$$VR_{site} = \Sigma (A_i \times VR_i) / \Sigma A_i + VR_{signage}$$

where:

- A_i = the area of part i of the site, ha;
- VR_i = the Value Rating (Table 8.3) of the BMP serving part i, which counts only if the BMP meets Clause 8.6.4 for the whole of A_i;
- ΣA_i = the whole site area: every part of the site is assigned to one BMP, or to preserved native vegetation; a part served by no BMP is entered with $VR_i = 0$; and
- $VR_{signage} = 0.25$ where public education signage is provided (Table 8.3), otherwise 0.

The site complies where $VR_{site} \geq$ required LoS (Clause 8.6.3).

Illustrative — not design values. A 1.0 ha site that is not redevelopment, with ΔCN = 18. Required LoS = 8 (Table 8.2).

Table 8B.2 — Worked example: composite VR (illustrative)

Part	Area A_i (ha)	BMP	VR_i (Table 8.3)	A_i × VR_i
Roofs and paving draining to bioretention	0.60	Bioretention	8.5	5.100
Car park	0.25	Permeable pavement	7.5	1.875
Preserved strip along boundary	0.15	Native vegetation (preserved)	9.25	1.388
Total	1.00			8.363

- Area-weighted VR = 8.363 / 1.00 = 8.36
- Signage provided: + 0.25
- VR_site = 8.61 ≥ 8. The site complies.

Without the permeable pavement (car park draining untreated, VR = 0): (5.100 + 0 + 1.388) / 1.00 + 0.25 = 6.74 < 8. The site would not comply.

8B.3 Treatment trains

To be prepared. This part will give the composite VR of BMPs in series (a treatment train), following the approach of the MARC/APWA BMP Manual (2012, Table 4.6), with values to be confirmed for Arunachal Pradesh by the calibration programme of Clause 8.13.4 (Annex 8C). Until it is published, each part of the site is credited with the VR of one BMP in the train that meets Clause 8.6.4 for that part, normally the last BMP before discharge, and no extra credit is given for BMPs in series. Pretreatment devices, silt traps and oil-grit separators upstream of the credited BMP earn no VR of their own (Clauses 8.6.4(c), 8.7.11(c) and 8.7.12(c)).

Table 8B.3 — Composite VR of treatment trains (layout)

First BMP	Second BMP	Composite VR	Conditions
_____	_____	_____	_____
_____	_____	_____	_____

Annex 8C — Arunachal Pradesh BMP performance calibration

Supports Clauses 8.6.3, 8.13 and 8.15.1 of Chapter 8.

To be prepared. This annex will report the BMP performance calibration programme of the State Stormwater Technical Committee (Clause 8.13.4): measured inflow and outflow concentrations and volumes for BMPs built in Arunachal Pradesh, and the revised Value Ratings that follow from them. It needs wet-weather monitoring of BMPs over several monsoon seasons, with laboratory analysis to the CPCB methods, and the outfall monitoring of Clause 8.13.1 published under Clause 10.17. Until it is published, the Value Ratings of Table 8.3 (MARC/APWA 2012) apply, and a proprietary device earns a VR only from verified test data (Table 8.3).

The layouts below set the minimum records the programme shall keep, so that results from different authorities can be pooled.

Table 8C.1 — Monitoring site register (layout)

Site ID	BMP type (Table 8.3)	Location and authority	Catchment area (ha)	Impervious (%)	Soil and groundwater setting	Date commissioned	Pretreatment
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Table 8C.2 — Event record (layout; parameters of Clause 8.13.2)

Site ID	Event date	Rainfall (mm)	Inflow volume (m^3)	Outflow volume (m^3)	TSS in / out (mg/L)	BOD in / out (mg/L)	COD in / out (mg/L)	Faecal coliform in / out (MPN/100 mL)	TN in / out (mg/L)	TP in / out (mg/L)	Oil and grease in / out (mg/L)	Heavy metals (industrial catchments)
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Table 8C.3 — Performance summary and proposed VR (layout)

BMP type	Sites	Events	Volume reduction (%)	Median effluent TSS (mg/L)	Other findings	VR in Table 8.3	Proposed VR
_____	_____	_____	_____	_____	_____	_____	_____

Annex 8D — BMP design sheets, media specification, plant lists

Supports Clauses 8.5, 8.7, 8.8 and 8.11 of Chapter 8.

Each design sheet collects the requirements of Chapter 8 for one BMP. Values marked "recommended starting value" in Clause 8.7.1 may be departed from with justification. Values that the Manual does not set are marked "to be confirmed in design"; the designer shall state and justify them. Every BMP also needs: sizing for the WQv or Q_wq (Clause 8.6.4(a)), pretreatment (Clause 8.5.3), a safe bypass for flows above Q_wq (Clause 8.4.6) and maintenance access (Chapter 10).

8D.1 Design sheets

Table 8D.1 — Pretreatment (all BMPs)

Item	Requirement	Clause
Where needed	Every bioretention cell, infiltration facility, permeable pavement receiving run-on, wet pond and constructed wetland, at each concentrated inflow	8.5.3
Types	Sediment forebay, grass filter strip, silt trap or proprietary device	8.5.3
Size	Holds at least 10% of the WQv of its contributing area; or sized for Q_wq (flow-through devices)	8.5.3
Access	Cleanable without entering or disturbing the main BMP	8.5.4
Silt traps and catch pits	At every inlet receiving runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody; sump at least 300 mm below the outlet invert; earn no VR	8.7.12

Table 8D.2 — Bioretention and rain gardens (Figure 8.2)

Item	Requirement	Clause
Ponding depth	≤ 300 mm above the mulch, with an overflow at maximum ponding level	8.7.2(a)
Ponding drawdown	Within 48 h	8.7.2(b)
Filter media	600–900 mm engineered sandy loam, low fines, low phosphorus (Table 8D.12)	8.7.2(c)
Mulch	50–75 mm	8.7.2(c)
Transition (choker) and gravel drainage layers	Required; thickness and grading to be confirmed in design	8.7.2(d)
Underdrain	Perforated; required where the design infiltration rate cannot meet the 48 h drawdown, or where lined; diameter to be confirmed in design	8.7.2(e)
Lining	Required where Clause 8.8 cannot be met, and at hotspots	8.7.2(f)
Plants	Native or naturalised, tolerant of waterlogging and long dry spells (Tables 8D.13 and 8D.14)	8.7.2(g)
VR	8.5 (rain garden / infiltration 9.0)	Table 8.3

Table 8D.3 — Vegetated swales

Item	Requirement	Clause
Section	Trapezoidal or parabolic; side slopes no steeper than 1V:3H	8.7.3(a)
Longitudinal slope	0.5% to 4%; check dams where steeper	8.7.3(b)
Flow at Q_wq	Depth not more than grass height; velocity ≤ 0.3 m/s	8.7.3(c)
1% AEP or bypass flow	No erosion (Chapter 9 permissible velocities)	8.7.3(d)
Underdrained ("dry") swale	Where slope < 1% or subsoil is poorly drained; filter media as Table 8D.12	8.7.3(e)
VR	4.0 (native vegetation swale)	Table 8.3

Table 8D.4 — Vegetated filter strips

Item	Requirement	Clause
Inflow	Sheet flow only; level spreader where flow arrives concentrated	8.7.4(a)
Length in flow direction	≥ 5 m	8.7.4(b)
Slope	1% to 8%	8.7.4(b)
Use	Mainly pretreatment for bioretention, infiltration and swales	8.7.4(c)
VR	5.0	Table 8.3

Table 8D.5 — Permeable pavement

Item	Requirement	Clause
Run-on	Impervious run-on area ≤ 2 × permeable area; none from unpaved or eroding areas	8.7.5(a)
Base reservoir	Clean open-graded aggregate holding its share of the WQv in its voids; void ratio confirmed by test	8.7.5(b)
Open (infiltrating) base	Only where Clause 8.8 is met; otherwise lined with underdrain and counted as filtration only	8.7.5(c)

Item	Requirement	Clause
Structure	Designed for traffic loading to the road authority's standards	8.7.5(d)
Exclusions	Not at hotspots; not where it will be resurfaced with impermeable material	8.7.5(e)
VR	7.5	Table 8.3

Table 8D.6 — Infiltration trenches and basins (Figure 8.3)

Item	Requirement	Clause
Pretreatment	Always (Table 8D.1)	8.7.6(a)
Fill	Clean washed aggregate, void ratio confirmed by test; geotextile on sides and top; sand base	8.7.6(b)
Observation well	To the base of each trench	8.7.6(c)
Storage	WQv (or Chapter 4 retention volume, if greater) held in the voids	8.7.6(d)
Drawdown	Empty within 72 h at the design infiltration rate	8.7.6(d), 8.8.7
Overflow	At grade, to the minor or major system	8.7.6(e)
Commissioning	Not in service until the contributing area is stabilised	8.7.6(f)
Criteria	All of Clause 8.8 (Table 8D.11)	8.8

Table 8D.7 — Wet ponds (extended wet detention)

Item	Requirement	Clause
Permanent pool	≥ WQv	8.7.7(a)
Extended detention	WQv above the pool, released over 24–48 h	8.7.7(a), 8.4.7
Forebay	At each inlet	8.7.7(b)
Flow path	Length-to-width ≥ 3:1; no short-circuiting	8.7.7(c)
Pool depth	1.0–2.5 m, with safety bench (Clause 7.9.4)	8.7.7(d)
Water balance	Monthly balance with IMD rainfall and pan evaporation: ≥ 50% of pool volume kept through the driest year in 10; no top-up with groundwater, potable water or sewage	8.7.8
Flood detention	Chapter 4 detention may sit above the extended detention level	8.7.7(f)
VR	5.0	Table 8.3

Table 8D.8 — Constructed wetlands

Item	Requirement	Clause
Layout	Inlet sedimentation pond (forebay), then shallow macrophyte zone	8.7.9(a)
Extended detention	WQv above normal water level, released over 24–48 h; depth ≤ 0.5 m	8.7.9(b)
Flow path	Length-to-width ≥ 3:1; deep zones across the flow path	8.7.9(c)
Bypass	High-flow bypass so that floods do not scour the macrophyte zone	8.7.9(d)
At a tank inlet	Within the tank's setback, outside its waterspread; not counted as tank storage	8.7.9(e)
Water balance	As wet ponds (minimum wetland depth kept)	8.7.8

Item	Requirement	Clause
VR	7.0 (extended detention wetland)	Table 8.3

Table 8D.9 — Gross pollutant traps and outfall screens

Item	Requirement	Clause
Treatment flow	Q_wq; all flows up to 1% AEP pass without washing out captured material	8.7.10(a)
Capture size	Down to about 5 mm	8.7.10(b)
Head loss	In the drain HGL (Chapter 9), screen 50% blocked	8.7.10(c), 8.10.3(a)
Storage	For the O&M cleaning interval; not less than 3-monthly cleaning	8.7.10(d)
Access	Vehicle access for suction or grab cleaning; safe cleaning platform	8.7.10(e), 8.10.3(d)
Blocked screen	Overflow or bypass path so that a fully blocked screen does not flood property	8.10.3(b)
Bar spacing	Chosen for the hazard: closer for litter capture, wider where blockage would cause flooding; to be confirmed in design	8.10.3(c)

Table 8D.10 — Oil-grit separators

Item	Requirement	Clause
Where	Fuel stations; vehicle workshops and washing bays; bus and truck depots; parking areas of more than 50 spaces	8.7.11(a)
Sizing	Q_wq, with high-flow bypass	8.7.11(b)
Not alone	Followed by a filtering BMP where the site needs a VR above 5; lined filtering BMP before any infiltration at hotspots	8.7.11(c), 8.8.8

Table 8D.11 — Infiltration and recharge criteria (all infiltrating BMPs)

Item	Requirement	Clause
Groundwater separation	Seasonal high groundwater ≥ 1.0 m below base (roof-only runoff in notified coastal sand: ≥ 0.5 m with mounding check, mound ≥ 0.3 m below base)	8.8.1, 8.8.9(d)
Bedrock or impermeable layer	Base ≥ 1.0 m above, unless designed for rock-aquifer recharge under Clause 8.8.10	8.8.2
Tests	Double-ring (ASTM D3385) for basins, bioretention, permeable pavement; falling-head borehole or trial-pit soakage (e.g. BRE Digest 365) for trenches, soakaways, pits, wells; ≥ 2 per facility and ≥ 1 per 100 m² of base or per 50 m of trench; Form 8-2	8.8.3
Design rate	Measured rate ÷ 2.0 (tests meet 8.8.3(c) and vary by no more than a factor of 2), otherwise ÷ 3.0	8.8.4
Minimum rates	≥ 13 mm/h full infiltration; 3–13 mm/h partial, with underdrain, credit only for volume infiltrated within 72 h; < 3 mm/h no credit	8.8.5
Setbacks (runoff from paved surfaces)	Foundations 3 m, basements 5 m; property boundary 1.5 m; drinking-water well or borewell 30 m; septic tank or soak pit 15 m; crest of slope steeper than 1V:3H 6 m	8.8.6
Expansive soils	Foundation setback doubled	8.8.11(b)

Item	Requirement	Clause
Drawdown	Empty within 72 h at design rate; tested after construction	8.8.7
Hotspots	No infiltration without treatment; none at all for waste sites and contaminated land	8.8.8
Road runoff	Never led directly into a well, borewell or recharge shaft	8.11.3(b)

8D.2 Bioretention drawdown check

The 48-hour ponding drawdown (Clause 8.7.2(b)) and the minimum rates of Clause 8.8.5 together decide whether a cell needs an underdrain.

- Rate needed to drain the maximum ponding depth in 48 h = 300 mm / 48 h = 6.25 mm/h.
- Design rate ≥ 13 mm/h: full infiltration, no underdrain, provided Clause 8.8 is met.
- Design rate from 6.25 mm/h to 13 mm/h: the ponding drains in time, but Clause 8.8.5(b) applies, so an underdrain is required.
- Design rate below 6.25 mm/h: the ponding cannot drain in 48 h by infiltration; an underdrain is required (Clause 8.7.2(e)), and below 3 mm/h no infiltration credit is given.

Illustrative — not design values. Two tests at the base of a proposed cell give 30 mm/h and 22 mm/h. The two results differ by a factor of 30 / 22 = 1.36, which is not more than 2, and the number of tests meets Clause 8.8.3(c), so the safety factor is 2.0. Taking the lower result, the design rate = 22 / 2.0 = 11 mm/h. This is above 6.25 mm/h, so the ponding drains in 300 / 11 = 27 h, within 48 h. It is below 13 mm/h, so the cell is a partial-infiltration design with an underdrain (Clause 8.8.5(b)).

8D.3 Filter media specification

Table 8D.12 — Bioretention filter media and layers

Layer	Requirement from Chapter 8	Values to be confirmed in design
Mulch	50–75 mm (Clause 8.7.2(c)); shredded hardwood or similar organic mulch that does not float away at the ponding depth	Material and source
Filter media	600–900 mm engineered sandy loam with low fines and low phosphorus content (Clause 8.7.2(c))	Particle size grading; fines (silt + clay) limit; organic matter content; phosphorus limit; saturated hydraulic conductivity of the compacted media; source and test certificate for each batch
Transition (choker) layer	Between media and gravel, to stop media washing into the gravel (Clause 8.7.2(d))	Thickness and grading, matched to the media and gravel
Gravel drainage layer	Below the transition layer, surrounding the underdrain (Clause 8.7.2(d))	Thickness, grading, washed
Underdrain	Perforated pipe where Clause 8.7.2(e) applies, with cleanouts	Diameter, slope, perforation, outlet level
Liner	Where Clause 8.7.2(f) applies (cannot meet Clause 8.8; hotspots)	Liner type and protection

Media shall be tested before placing, and placed in lifts without heavy compaction. The State Stormwater Technical Committee should set numeric limits for grading, fines, organic matter and phosphorus, with local sources of sand and compost, when it reviews this annex.

8D.4 Plant lists

No Arunachal Pradesh source on planting for stormwater BMPs was found during research for this Manual, and none of the sources read names the native species to be used in bioretention, swales, filter strips or constructed wetlands in the State. This annex therefore lists **no species** for Arunachal Pradesh, and gives no plant names in any local language, rather than carry over lists drawn up for other States or invent local names. Until the State Stormwater Technical Committee issues lists, the species for each BMP shall be chosen, and recorded on the BMP design sheet, by a horticulturist or the Department of Environment, Forest and Climate Change for the site's sub-area of Annex 2A, its altitude, its soil and its water table, under the following rules (set by this Manual):

- (a) **Native or long naturalised species only**, as the Department of Environment, Forest and Climate Change confirms for the site; no species named in Table 8D.15 or otherwise known to be invasive in the State.
- (b) **Wet and dry ground.** Species that stand saturated ground through the season of 1 April to 31 October, and survive the drier months of November to March without irrigation once established; in the high ranges, species that survive snow and frost.
- (c) **Slopes.** In the hills, species chosen first to bind soil on banks, cut slopes and the margins of nallahs and hill streams; bioretention on a slope is lined (Clause 8.8.1).
- (d) **Not in the waterway.** No planting in the bed or on the banks of a stream, hill stream or nallah, or on an embankment or anti-erosion work, without the consent of its custodian (IMC, the municipality, the Water Resources Department, or the owners or the community, as the case may be), and none that would obstruct the flow of a channel or the outlet of a pond.
- (e) **Not in the waterbodies or the springs.** No planting under this annex in a pond, lake or spring or on its recharge area, or in a wetland the Forest Department has demarcated or a sanctuary or reserve, whose vegetation is managed by its custodian under Chapter 7.

Table 8D.13 — Indicative plants for bioretention, swales and filter strips

Use	Botanical name	Local name	Notes
All BMPs of Clause 8.7	None listed for Arunachal Pradesh in this draft	—	Chosen under rules (a) to (e) above and recorded on the BMP design sheet (Annex 8D)

Table 8D.14 — Indicative plants for constructed wetlands and wet ponds

Zone	Botanical name	Local name	Notes
All zones	None listed for Arunachal Pradesh in this draft	—	Chosen under rules (a) to (e) above; constructed wetlands are built outside the waterspread of any natural waterbody (Clause 8.7.9(e))

Table 8D.15 — Species not to be planted

Botanical name	Local name	Reason
Any species the Department of Environment, Forest and Climate Change lists as invasive in Arunachal Pradesh	—	No list of invasive species for Arunachal Pradesh was read for this Manual [TBC]

Annex 8E — Erosion and sediment control standard details

Supports Clause 8.12 of Chapter 8.

The details below show the arrangement of each measure. Dimensions set by the Manual are given. Dimensions the Manual does not set are labelled "to be confirmed in design" and shall be shown on the ESC plan (Clause 8.12.1). Temporary measures are designed with the rainfall of Chapter 2 and a climate factor of 1.0 (Clause 8.12.4).

Table 8E.1 — Selection of measures (Clause 8.12.3)

Situation	Measure	Detail
Sheet flow leaving a disturbed area, along its downslope edge	Silt fence	Figure 8E.1
Concentrated flow from a disturbed area of up to 2 ha	Sediment trap	Figure 8E.2
Disturbed area of more than 2 ha	Sediment basin with surface dewatering outlet	Figure 8E.2
Existing drain inlet receiving site runoff	Inlet protection	Figure 8E.4
Vehicle exit to a public road	Stabilised construction exit, with wheel washing	Figure 8E.3
Stockpiles	Outside Zone 1 of any waterbody setback; ≥ 10 m from any drain; covered in the monsoon	Notes to Figure 8E.1
Dewatering	Through a sediment basin, settling tank or filter bag; never pumped directly to a drain or waterbody	Notes to Figure 8E.2
Concrete washout	Lined pit; never into a drain	Notes to Figure 8E.3

8E.1 Silt fence

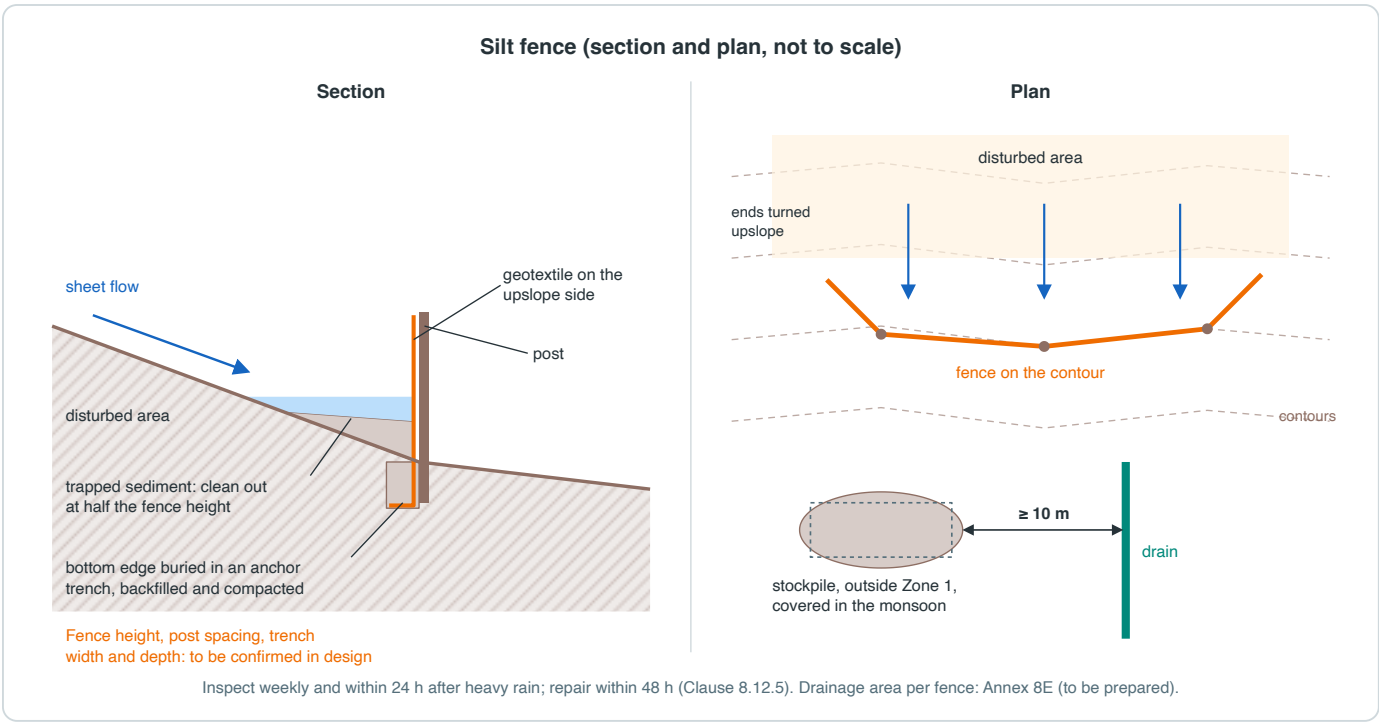


Figure 8E.1 — Silt fence: section showing geotextile on posts with the bottom edge buried in an anchor trench on the upslope side, and plan showing the fence on the contour with returns at the ends. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (C753), 2015.

To be prepared. Clause 8.12.3(a) refers to this annex for the limit on the area draining to each silt fence. That limit, and the maximum slope length above a fence, need to be set by the State Stormwater Technical Committee for Arunachal Pradesh rainfall. Until they are published, the following interim limits apply, taken from common US practice (US EPA, Stormwater Best Management Practice fact sheet: Silt Fence):

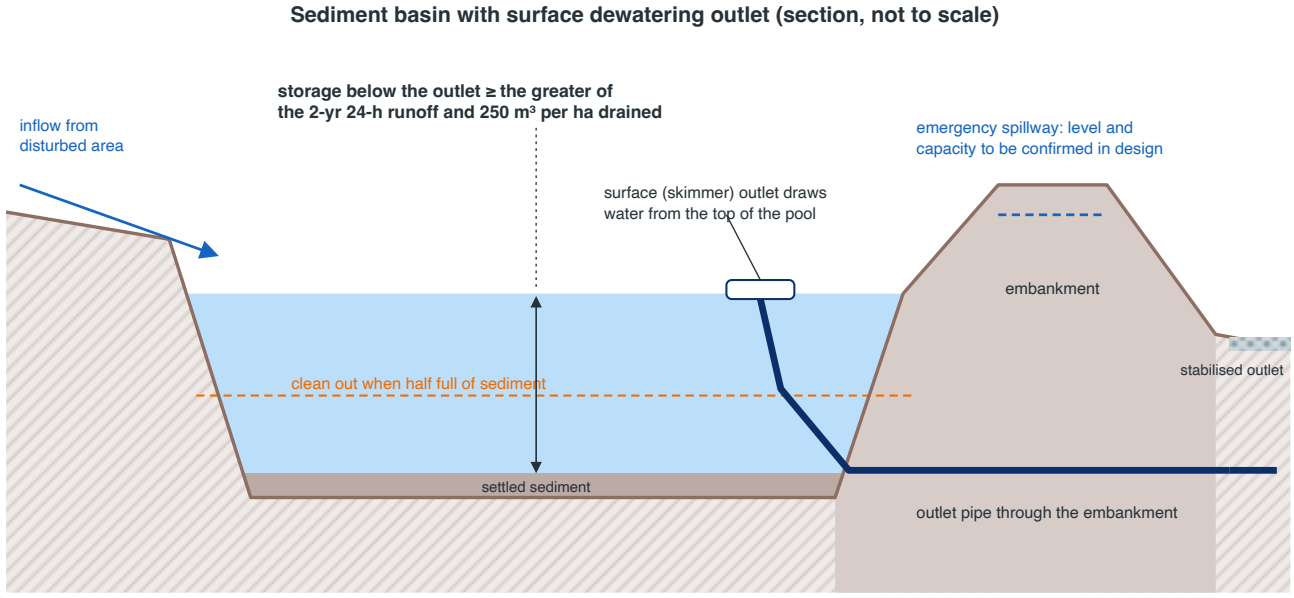
- drainage area: not more than **0.1 ha per 30 m** of fence;
- slope length above the fence: not more than 30 m on slopes under 2%, 23 m at 2–5%, 15 m at 5–10%, 8 m at 10–20% and 5 m steeper than 20%;
- wherever flow arrives concentrated, or a limit cannot be met, a sediment trap (Figure 8E.2) is used instead.

The designer shall show the drainage area and slope length served by each fence on the ESC plan.

Notes:

1. Place along the contour at the downslope edge of the disturbed area, never across a concentrated flow path.
2. Turn the ends upslope so that water cannot run round them.
3. Inspect weekly and within 24 hours after every heavy-rainfall event; repair within 48 hours; remove sediment when the deposit reaches half the fence height (Clause 8.12.5).
4. Remove only after the area draining to it is stabilised (Clause 8.12.6).
5. Stockpiles: outside Zone 1, at least 10 m from any drain, and covered during the monsoon (Clause 8.12.3(f)).

8E.2 Sediment trap and sediment basin



Sediment trap: disturbed area up to 2 ha. Sediment basin: more than 2 ha (Clause 8.12.3(b), (c)).
Design rainfall from Chapter 2 with climate factor 1.0 (Clause 8.12.4). Dewatering of excavations passes through the basin, a settling tank or a filter bag.

Figure 8E.2 — Sediment trap or basin in section: inflow, storage volume below the outlet, surface dewatering outlet (skimmer) drawing water from the top of the pool, emergency spillway, and sediment cleanout level at half the storage. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022).

Notes:

1. **Sediment trap:** for concentrated flow from disturbed areas of up to 2 ha (Clause 8.12.3(b)). Storage volume, depth and outlet: to be confirmed in design.

2. **Sediment basin:** for disturbed areas of more than 2 ha. Storage below the outlet ≥ the greater of (a) the runoff from the 50% AEP (2-yr) 24-hour storm and (b) 250 m³ per hectare of drainage area (Clause 8.12.3(c)).
3. The dewatering outlet draws water from the surface (Clause 8.12.3(c)).
4. An emergency spillway and its capacity: to be confirmed in design. Where the basin is also a permanent detention facility, the Chapter 4 spillway rules apply.
5. Clean out when half full of sediment (Clause 8.12.5). Remove sediment from any permanent facility before its as-built survey (Clause 8.12.6).
6. Dewatering of excavations shall pass through a sediment basin, settling tank or filter bag (Clause 8.12.3(g)).

Illustrative — not design values. A sediment basin serves 3.0 ha of disturbed land. Assume a 2-yr 24-hour rainfall of 100 mm (climate factor 1.0, Clause 8.12.4) and a curve number of 86 for bare compacted ground under the antecedent moisture condition of Chapter 2.

- $S = 25{,}400 / 86 - 254 = 41.35$ mm; $I_a = 0.2S = 8.27$ mm
- $Q = (P - I_a)^2 / (P - I_a + S) = (100 - 8.27)^2 / (100 - 8.27 + 41.35) = 8{,}414 / 133.08 = 63.2$ mm
- (a) Runoff volume = $10 \times Q \times A = 10 \times 63.2 \times 3.0 = 1{,}896$ m³
- (b) 250 m³/ha × 3.0 ha = 750 m³
- Required storage below the outlet = max (1,896, 750) = 1,896 m³. Here the 2-yr runoff governs.

8E.3 Stabilised construction exit and concrete washout

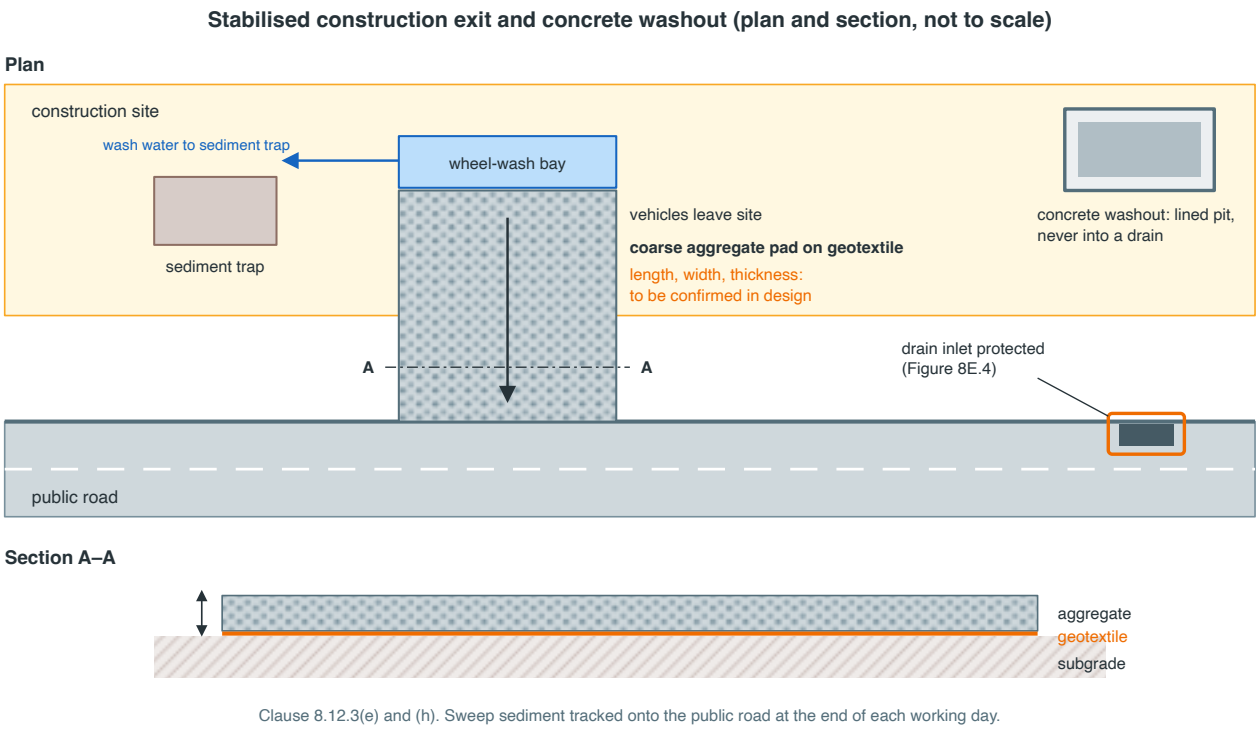


Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022).

Notes:

1. Provide at every point where vehicles leave the site onto a public road, with wheel washing (Clause 8.12.3(e)).
2. Pad length, width, thickness and aggregate size: to be confirmed in design.
3. Wash water drains to a sediment trap or basin, never to a drain.
4. Concrete washout in a lined pit, never into a drain (Clause 8.12.3(h)).

5. Sweep any sediment tracked onto the public road at the end of each working day.

8E.4 Inlet protection

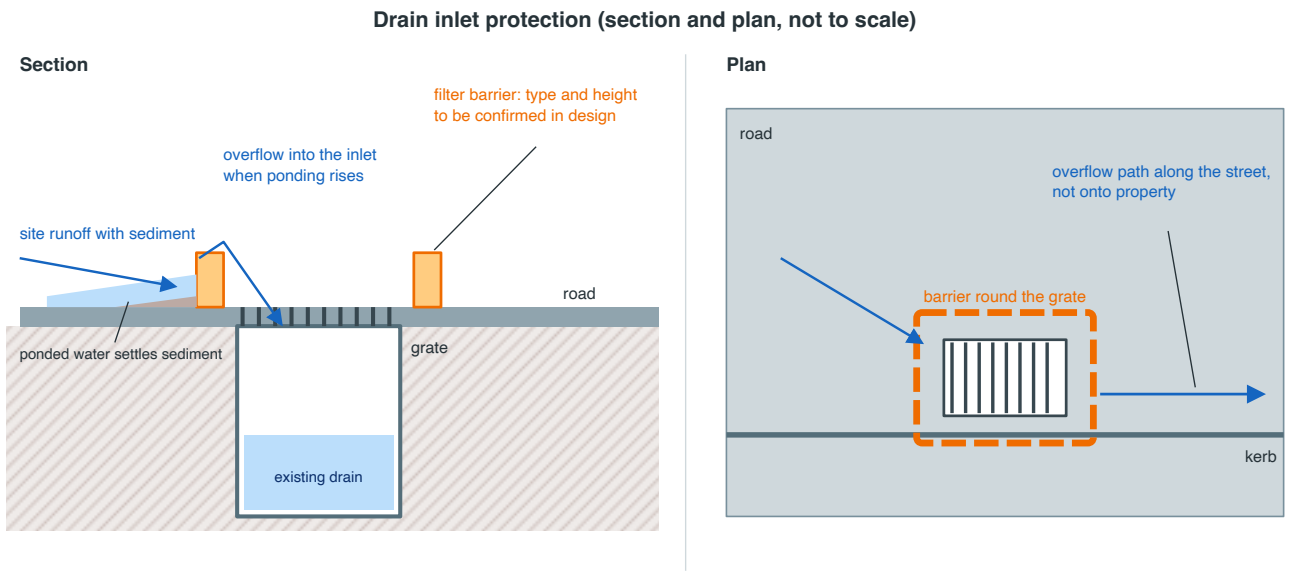


Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (C753), 2015.

Notes:

1. At every existing drain inlet that receives runoff from the site (Clause 8.12.3(d)).
2. The protection must not block the inlet: water ponding behind it must be able to overflow into the inlet or along the street.
3. Barrier type and height: to be confirmed in design.
4. Remove sediment after each heavy-rainfall event (Clause 8.12.5).

8E.5 Timing and inspection

Table 8E.2 — ESC timing and inspection (Clauses 8.12.2 and 8.12.5)

Item	Requirement
Completed earthworks	Stabilised by vegetation, mulch, matting or paving by 31 March
Area cleared between 1 April and 31 October	Sediment controls in place before clearing
Area exposed in the monsoon	As small as practicable
Inspection	Weekly, and within 24 h after every heavy-rainfall event (Chapter 10)
Repair	Within 48 h
Cleaning	When half full of sediment
Removal	Only after the area draining to the measure is stabilised

Form 8-1 — Water Quality Sheet

Supports Clauses 8.4, 8.6 and 8.14 of Chapter 8.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0.

Table 8F.1 — Form 8-1, Section A: Site and rainfall

No.	Field	Entry	Clause
A1	Project name and Authority file number	_____	—
A2	Tier (A / B) and site area, ha	_____	8.6.1
A3	Rainfall zone (Chapter 2)	_____	8.4.1
A4	P_ret, mm (Annex 2E)	_____	8.4.1
A5	P_3m, mm (Annex 8A, or the interim calculation: record, years, method)	_____	8.4.1
A6	P_wq = max (P_ret, P_3m), mm (no climate factor)	_____	8.4.1, 8.4.3
A7	WQv method: SCS-CN, or Rv (sites < 0.5 ha and Tier B simplified method only)	_____	8.4.2
A8	Redevelopment (existing impervious ≥ 20%)?	_____	8.6.2

Table 8F.2 — Form 8-1, Section B: Water quality volume and flow by drainage area

Area ID	Area (ha)	Impervious I (%)	Q_wq runoff depth (mm) or Rv	WQv (m^3)	Q_wq (m^3/s)	Volume retained, Chapter 4 (m^3)	WQv not retained (m^3)	BMP serving the area	Pretreatment
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Total	_____			_____		_____	_____		

Table 8F.3 — Form 8-1, Section C: Level of Service and Value Rating (Tier A)

No.	Field	Entry	Clause
C1	CN pre-development; CN post-development; ΔCN	_____	8.6.2
C2	Required LoS (Table 8.2, or Annex 8B for redevelopment)	_____	8.6.2
C3	Composite VR (Annex 8B calculation attached)	_____	8.6.3
C4	Composite VR ≥ required LoS?	_____	8.6.3
C5	Tier B: route used under Clause 8.6.5 (a) retained on site / (b) bioretention, rain garden or infiltration	_____	8.6.5

Table 8F.4 — Form 8-1, Section D: Other submittals (Clause 8.14)

No.	Item	Attached (yes / no / not applicable)	Clause
D1	BMP designs to Clause 8.7 and Annex 8D, with pretreatment	_____	8.14(3)

No.	Item	Attached (yes / no / not applicable)	Clause
D2	Infiltration Test Record (Form 8-2), seasonal high groundwater level and source, design rate, drawdown time, setbacks	_____	8.14(4)
D3	Sewage and sullage connection plan; dye or smoke test record	_____	8.9.2, 8.14(5)
D4	GPT and first-flush design for any outfall to a waterbody	_____	8.10, 8.14(6)
D5	RWH layout separating harvesting, recharge and detention	_____	8.11, 8.14(7)
D6	ESC plan	_____	8.12, 8.14(8)
D7	Hotspot controls, where Clause 8.8.8 applies	_____	8.8.8

Table 8F.5 — Form 8-1, Section E: Prepared by

Field	Entry
Name, registration and empanelment number (Clause 10.6)	_____
Signature and date	_____

Form 8-2 — Infiltration Test Record

Supports Clauses 8.8.1 to 8.8.7 and 8.11.4 of Chapter 8.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. One record per facility. Attach a plan showing the test locations, and the readings for each test.

Table 8F.6 — Form 8-2, Section A: Facility

No.	Field	Entry	Clause
A1	Project and facility ID; facility type	_____	8.8.3
A2	Infiltration base area (m²) or trench length (m)	_____	8.8.3(c)
A3	Proposed base level of the facility, m (datum)	_____	8.8.3
A4	Runoff source: roof only / paved surfaces / mixed; hotspot (yes / no)	_____	8.8.6, 8.8.8
A5	Ground setting: sandy coastal / laterite or hard rock / delta clay or black cotton / other	_____	8.8.9–8.8.11

Table 8F.7 — Form 8-2, Section B: Tests

Test no.	Location (grid ref.)	Date	Method: double-ring (ASTM D3385) / falling-head borehole or trial-pit soakage (e.g. BRE Digest 365)	Test level, m	Groundwater level at time of test, m	Measured rate (mm/h)
1	_____	_____	_____	_____	_____	_____
2	_____	_____	_____	_____	_____	_____
3	_____	_____	_____	_____	_____	_____

Minimum number of tests: 2 per facility, and 1 per 100 m² of base area or per 50 m of trench (Clause 8.8.3(c)).

Table 8F.8 — Form 8-2, Section C: Design rate and drawdown

No.	Item	Entry	Clause
C1	Number of tests made; number required	_____	8.8.3(c)
C2	Highest and lowest measured rates; ratio (highest ÷ lowest)	_____	8.8.4
C3	Safety factor: 2.0 (tests meet 8.8.3(c) and ratio ≤ 2) or 3.0	_____	8.8.4
C4	Design rate = measured rate used ÷ safety factor, mm/h (state which measured rate was used)	_____	8.8.4
C5	Category: ≥ 13 mm/h full infiltration / 3–13 mm/h partial with underdrain / < 3 mm/h no credit	_____	8.8.5
C6	Depth of water to infiltrate, mm; drawdown time = depth ÷ design rate, h (≤ 72 h)	_____	8.8.7

Table 8F.9 — Form 8-2, Section D: Separation and setbacks

No.	Item	Entry	Clause
D1	Seasonal high groundwater level, m, and its source (Clause 3.10.2)	_____	8.8.1
D2	Separation from facility base to seasonal high groundwater, m (≥ 1.0; ≥ 0.5 for roof-only runoff in notified coastal sand with mounding check)	_____	8.8.1, 8.8.9(d)

No.	Item	Entry	Clause
D3	Depth to bedrock or impermeable layer below base, m (≥ 1.0 unless Clause 8.8.10)	_____	8.8.2
D4	Distances to: foundations / basement / property boundary / drinking-water well or borewell / septic tank or soak pit / crest of slope steeper than 1V:3H, m	_____	8.8.6
D5	Expansive soils: foundation setback doubled?	_____	8.8.11(b)

Table 8F.10 — Form 8-2, Section E: Declaration

Field	Entry
Tester: name, qualification in geotechnical testing, organisation	_____
I certify that the tests were made at the stated locations and levels, by the stated methods, and that the readings attached are complete. Signature and date	_____
Designer (Clause 10.6): name and signature	_____

ANNEXES TO CHAPTER 9

Hydraulic Design of Structures

These annexes support Chapter 9. Annex 9A gives the FHWA HDS-5 inlet-control equations in SI units, with published coefficients for common inlets, and a full worked culvert example. Annex 9B gives standard drawings that carry only the dimensions Chapter 9 and Chapter 6 already set; every other dimension is marked "to be confirmed in design". Annex 9C is a pump station design checklist with a standard control philosophy drawn from Clause 9.9. Form 9-1 is a draft form: it lists what Clause 9.14 requires and does not add to it.

Annex 9A — HDS-5 inlet-control coefficients and worked culvert example in SI units

Supports Clauses 9.4.1 to 9.4.7 of Chapter 9 and Clause 6.12 of Chapter 6.

9A.1 Inlet-control equations

FHWA *Hydraulic Design of Highway Culverts*, HDS-5, 3rd edition (2012), Appendix A, gives three inlet-control equations. In SI units:

> Unsubmerged, Form 1: HWi/D = Hc/D + K · [Ku · Q / (A · D^0.5)]^M + Ks · S

> Unsubmerged, Form 2: HWi/D = K · [Ku · Q / (A · D^0.5)]^M

> Submerged: HWi/D = c · [Ku · Q / (A · D^0.5)]² + Y + Ks · S

where HWi is the headwater depth above the inlet invert under inlet control (m), D is the interior height (rise) of the barrel (m), Hc is the specific head at critical depth, dc + Vc²/2g (m), Q is the discharge (m³/s), A is the full cross-sectional area of the barrel (m²), S is the barrel slope (m/m), K, M, c and Y are the constants of Table 9A.1, Ku = 1.811 in SI units (1.0 in US units), and Ks is the slope correction: −0.5, or +0.7 for mitred inlets.

Which equation applies depends on X = Ku · Q / (A · D^0.5):

- X ≤ 3.5: unsubmerged equation (Form 1 or Form 2 as listed in Table 9A.1);
- X ≥ 4.0: submerged equation;
- 3.5 < X < 4.0 (transition): use FHWA HY-8, which implements the HDS-5 transition. Where a hand calculation is used, take the higher of the unsubmerged and submerged results. This is a conservative simplification made by this annex, not an HDS-5 rule.

Table 9A.1 — HDS-5 inlet-control coefficients for common inlets

Barrel	Inlet edge	Form	K	M	c	Y
Circular concrete	Square edge with headwall	1	0.0098	2.0	0.0398	0.67
Circular concrete	Groove (socket) end with headwall	1	0.0018	2.0	0.0292	0.74
Circular concrete	Groove (socket) end projecting	1	0.0045	2.0	0.0317	0.69
Circular corrugated metal	Headwall	1	0.0078	2.0	0.0379	0.69
Circular corrugated metal	Mitred to slope	1	0.0210	1.33	0.0463	0.75
Circular corrugated metal	Projecting	1	0.0340	1.50	0.0553	0.54
Rectangular box	Wingwalls flared 30° to 75°	1	0.026	1.0	0.0347	0.81
Rectangular box	Wingwalls flared 90° and 15°	1	0.061	0.75	0.0400	0.80
Rectangular box	Wingwalls at 0° (extensions of the sides)	1	0.061	0.75	0.0423	0.82
Rectangular box	90° headwall with 19 mm (3/4 in) chamfers	2	0.515	0.667	0.0375	0.79
Rectangular box	90° headwall with 45° bevels	2	0.495	0.667	0.0314	0.82
Rectangular box	90° headwall with 33.7° bevels	2	0.486	0.667	0.0252	0.865

Source: FHWA HDS-5 (2012), Appendix A, Table A.1 (the coefficients are dimensionless and apply in SI units with Ku = 1.811). The values were checked against HIF-12-026, Table A.1 (chart and scale numbers 1/1–1/3, 2/1–2/3, 8/1–8/3 and 10/1–10/3). Where a later edition of HDS-5 differs, the later table governs. Entrance loss coefficients for outlet control are in Table 9.1 of Chapter 9.

9A.2 Worked example: pipe culvert under a collector road

Illustrative — not design values. The inputs below are invented to show the method; the results are not design values for any site.

Inputs.

Table 9A.2 — Inputs for the worked example

Item	Value	Source
Road class	Collector; design AEP 4% (25-yr), check event 2% (50-yr), and the 1% AEP check	Table 6.1, Clause 6.12.2
Design flow, 4% AEP	1.80 m³/s (including the climate factor)	Illustrative
Check flow, 2% AEP	2.20 m³/s	Illustrative
1% AEP flow	3.00 m³/s	Illustrative
Barrel	One 1,200 mm RCC pipe with collar joints, n = 0.015	Table 6.6
Inlet	Square edge with headwall: ke = 0.5; K = 0.0098, M = 2.0, c = 0.0398, Y = 0.67, Form 1	Tables 9.1 and 9A.1
Length and slope	L = 20.0 m; S = 0.005 (inlet invert 20.00 m, outlet invert 19.90 m, local datum)	Illustrative
Road levels at the inlet	Shoulder edge 22.00 m; lowest point of the road crest 22.10 m	Illustrative
Tailwater above the outlet invert, TW	0.60 m at 1.80 m³/s; 0.70 m at 2.20 m³/s; 0.85 m at 3.00 m³/s (normal depth in the downstream channel)	Illustrative; Clause 9.4.4
Receiving channel	Unlined sandy loam	Table 9.2

Minimum size: 1,200 mm ≥ 900 mm (Clause 6.12.5). The span is below 1.5 m, so the blockage check uses 50% of the inlet area blocked (Clause 6.12.4(a)).

Step 1 — Barrel properties. A = π · 1.2² / 4 = 1.131 m²; full-barrel hydraulic radius R = D/4 = 0.300 m; D^0.5 = 1.095.

Step 2 — Critical depth. For each flow, dc is found by trial from the critical-flow condition for a circular section, $Q^2 \cdot T / (g \cdot Ac^3) = 1$, where Ac and T are the flow area and top width at depth dc.

Table 9A.3 — Critical depth and specific head (D = 1.2 m)

Q (m³/s)	dc (m)	Ac (m²)	T (m)	Vc = Q/Ac (m/s)	Hc = dc + Vc²/2g (m)	Hc/D
1.80	0.737	0.728	1.168	2.471	1.048	0.873
2.20	0.817	0.820	1.119	2.683	1.184	0.987
3.00	0.952	0.962	0.972	3.118	1.447	1.206

Step 3 — Headwater under inlet control. X = 1.811 · Q / (1.131 × 1.095) = 1.462 · Q.

Table 9A.4 — Inlet-control headwater

Q (m³/s)	X	Equation	HWi/D	HWi (m)
1.80	2.631	Unsubmerged, Form 1: 0.873 + 0.0098 × 2.631² − 0.5 × 0.005 = 0.873 + 0.068 − 0.003	0.939	1.127
2.20	3.216	Unsubmerged, Form 1: 0.987 + 0.0098 × 3.216² − 0.003 = 0.987 + 0.101 − 0.003	1.085	1.302
3.00	4.385	Submerged: 0.0398 × 4.385² + 0.67 − 0.003 = 0.765 + 0.67 − 0.003	1.433	1.719

Step 4 — Headwater under outlet control (Clause 9.4.3). The friction term is 19.63 · n² · L / R^1.33 = 19.63 × 0.015² × 20.0 / 0.300^1.33 = 0.0883 / 0.2016 = 0.438, so H = (1 + 0.5 + 0.438) · V²/2g = 1.938 · V²/2g. L · S = 20.0 × 0.005 = 0.100 m.

Table 9A.5 — Outlet-control headwater

Q (m³/s)	V = Q/A (m/s)	V²/2g (m)	H (m)	(dc + D)/2 (m)	TW (m)	ho (m)	HWo = ho + H − L·S (m)
1.80	1.592	0.129	0.250	0.969	0.60	0.969	1.119
2.20	1.945	0.193	0.374	1.009	0.70	1.009	1.283
3.00	2.653	0.359	0.695	1.076	0.85	1.076	1.671

Step 5 — Governing headwater (Clause 9.4.1): the greater of HWi and HWo.

Table 9A.6 — Governing headwater and checks

Event	Q (m³/s)	HWi (m)	HWo (m)	Control	HW (m)	HW level (m)	HW/D
Design, 4% AEP	1.80	1.127	1.119	Inlet	1.127	21.13	0.94
Check, 2% AEP	2.20	1.302	1.283	Inlet	1.302	21.30	1.09
1% AEP	3.00	1.719	1.671	Inlet	1.719	21.72	1.43

Step 6 — Headwater limits at the design AEP (Clause 9.4.5):

- (a) HW/D = 0.94 ≤ 1.2. Complies.
- (b) HW level 21.13 m ≤ shoulder edge 22.00 m − 0.30 m = 21.70 m. Complies.

- (c) Water levels at upstream buildings and property boundaries are compared with the existing condition under Clause 6.12.2(d). This needs the upstream survey and is not shown here.

Step 7 — Road overtopping (Clauses 6.12.2, 6.12.3 and 9.4.6). The 1% AEP headwater level, 21.72 m, is below the lowest road crest, 22.10 m, so the road is not overtopped in the check or 1% AEP events. Had the headwater exceeded the crest, the overtopping flow Qr = Cd · L · h^1.5 (Cd ≤ 1.66) would be balanced with the culvert flow at a common headwater, and the overtopping depth checked against Clause 6.12.2(a).

Step 8 — Outlet velocity (Clause 9.4.7). Under inlet control, the outlet velocity is the velocity at normal depth in the barrel. The barrel's full-flow capacity is (1/n) · A · R^(2/3) · S^0.5 = (1/0.015) × 1.131 × 0.448 × 0.0707 = 2.39 m³/s.

- 1.80 m³/s: normal depth 0.778 m, outlet velocity 2.32 m/s.
- 2.20 m³/s: normal depth 0.908 m, outlet velocity 2.40 m/s.
- 3.00 m³/s: above the full-flow capacity, so the barrel flows full at the outlet; velocity = Q/A = 2.65 m/s.

The receiving channel is unlined sandy loam, with a permissible velocity of 0.53 m/s (Table 9.2), so outlet protection is required (Clause 9.6.1). All barrel velocities are below 3.0 m/s (Clause 6.7.3(b)).

Step 9 — Riprap apron (Clause 9.6.3; Figure 9.2). D50 = 0.2 · D · [Q / (g^0.5 · D^2.5)]^(4/3) · (D/TW), with g^0.5 · D^2.5 = 3.132 × 1.577 = 4.941.

Table 9A.7 — Riprap apron sizing

Q (m³/s)	TW (m)	Q / (g^0.5 · D^2.5)	[ ]^(4/3)	D50 (m)
1.80	0.60	0.364	0.260	0.2 × 1.2 × 0.260 × 2.00 = 0.125
2.20	0.70	0.445	0.340	0.2 × 1.2 × 0.340 × 1.71 = 0.140
3.00	0.85	0.607	0.514	0.2 × 1.2 × 0.514 × 1.41 = 0.174

Clause 9.4.7 requires the outlet to be protected for the design AEP and the 1% AEP, so the apron is sized here for the largest D50, 0.174 m. From Table 9.3, Class 2 (D50 = 150 mm) is too small, so **Class 3** (D50 = 250 mm) is used:

- apron length 5D = 5 × 1.2 = 6.0 m;
- apron thickness 2.4 × D50 = 2.4 × 0.25 = 0.60 m;
- apron width at the outlet at least 3D = 3.6 m, flaring to the downstream channel;
- stone placed on a granular filter or geotextile (Clause 9.6.4).

Step 10 — Blockage check (Clause 6.12.4(a)). Steps 3 to 7 are repeated for the 1% AEP flow with 50% of the inlet area blocked, and the results must meet Clause 6.12.2(a) and (d). This Manual does not yet set a standard way of representing a partly blocked inlet, so this check is carried out in HY-8 or by a method agreed with the Approving Authority. It is not worked here.

Table 9A.8 — Summary of the worked example (Illustrative — not design values)

Check	Result	Clause
Minimum size	1,200 mm ≥ 900 mm	6.12.5
Design HW/D	0.94 ≤ 1.2	9.4.5(a)
Design HW below shoulder edge	21.13 m ≤ 21.70 m	9.4.5(b)
Overtopping in the check and 1% events	None (21.72 m < 22.10 m)	6.12.2, 9.4.6
Outlet protection	Class 3 riprap apron, 6.0 m long, 0.60 m thick, 3.6 m wide at the outlet	9.6.1, 9.6.3
Blockage check	To be run in HY-8 or by an agreed method	6.12.4

Annex 9B — Standard drawings: headwalls, riprap aprons, drop structures, trash racks, detention risers

Supports Clauses 9.4, 9.6, 9.7 and 9.8 of Chapter 9.

The drawings below are schematic standard drawings. They show only the dimensions and rules that Chapter 9 and Chapter 6 set. Structural dimensions, reinforcement, foundations and fixings are to be confirmed in design (Clause 9.1.2). The riprap apron standard drawing is Figure 9.2 of Chapter 9, with dimensions from Table 9.3; it is not repeated here. Table 9B.1 lists the dimensions shown and their source clauses.

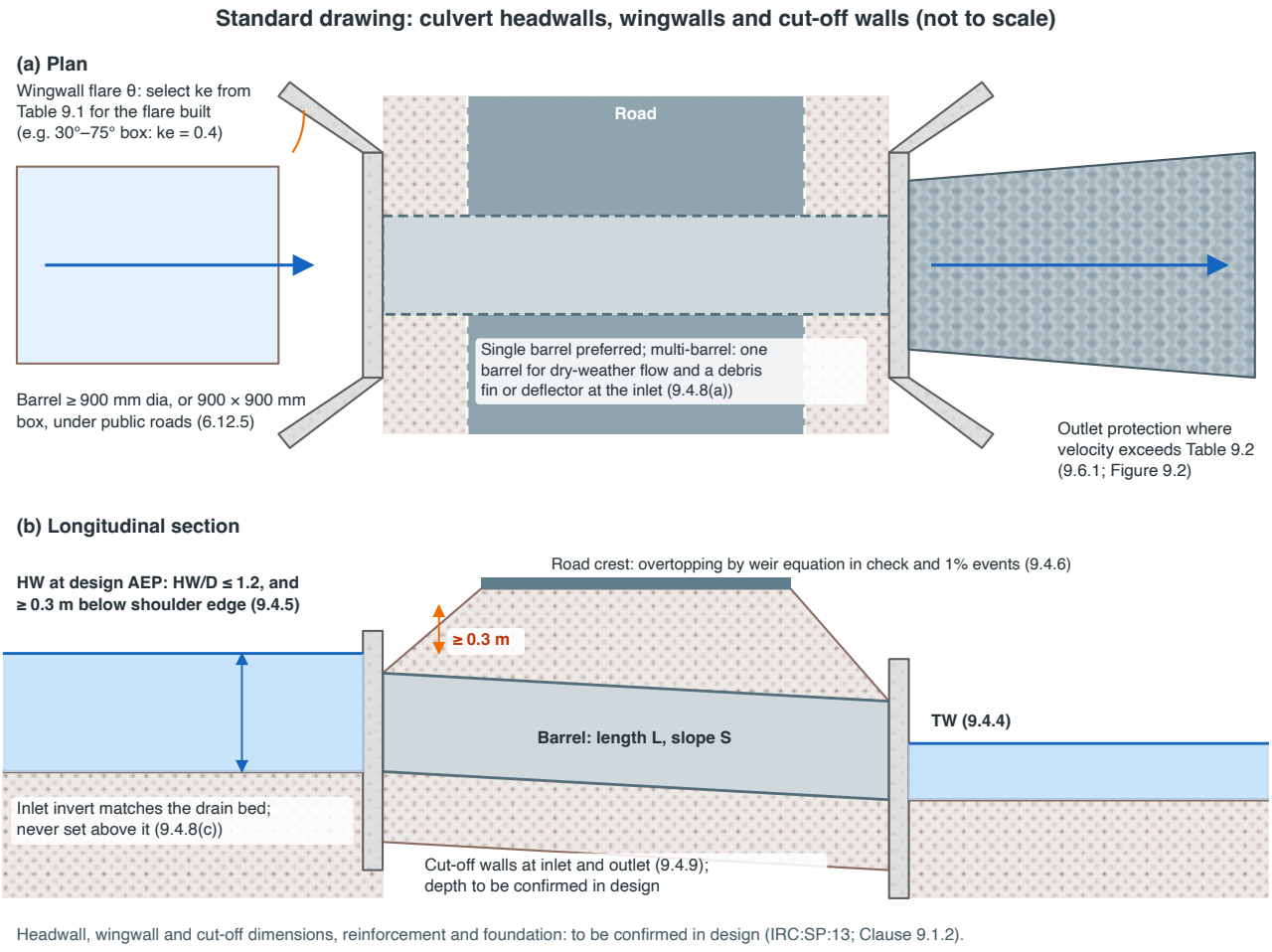


Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

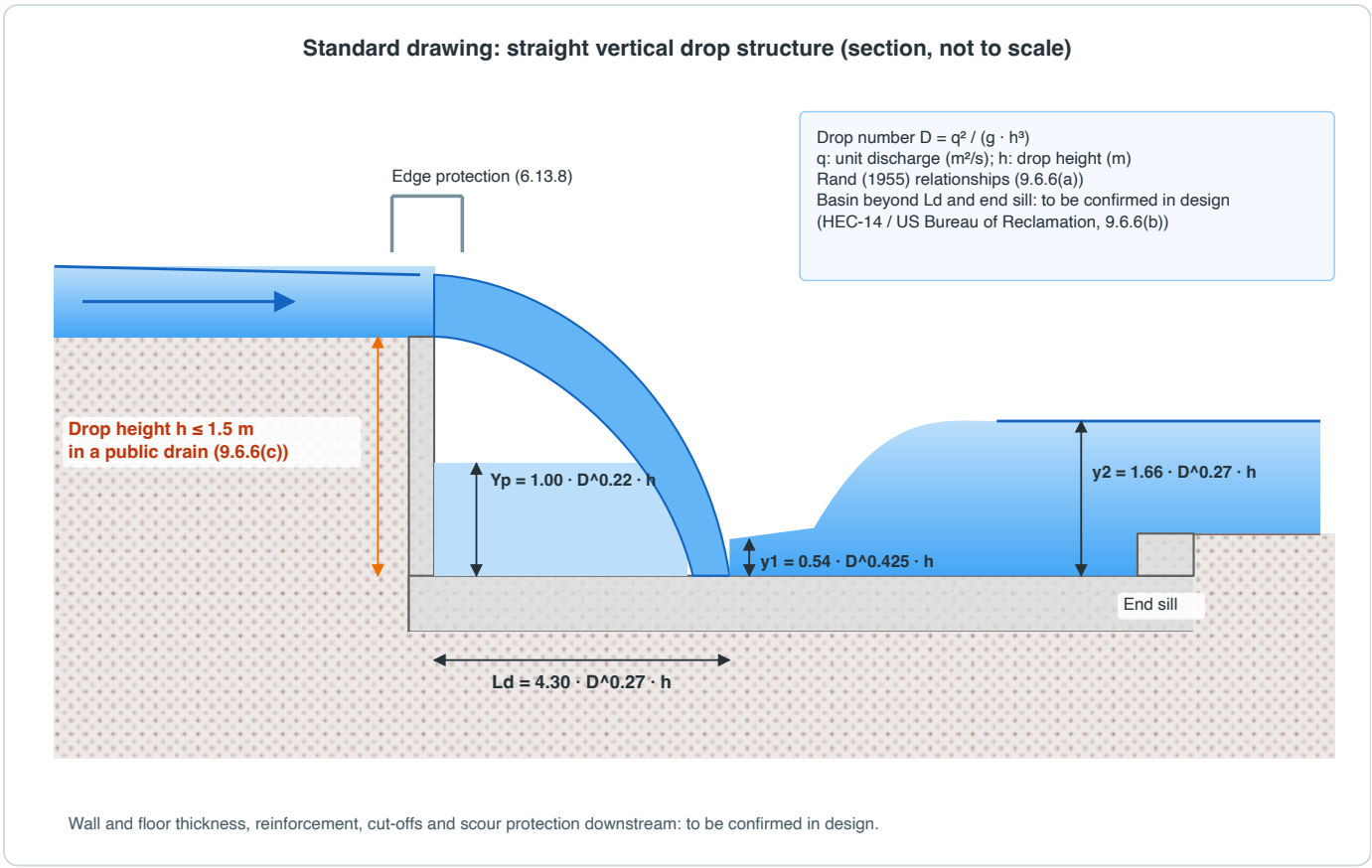


Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).

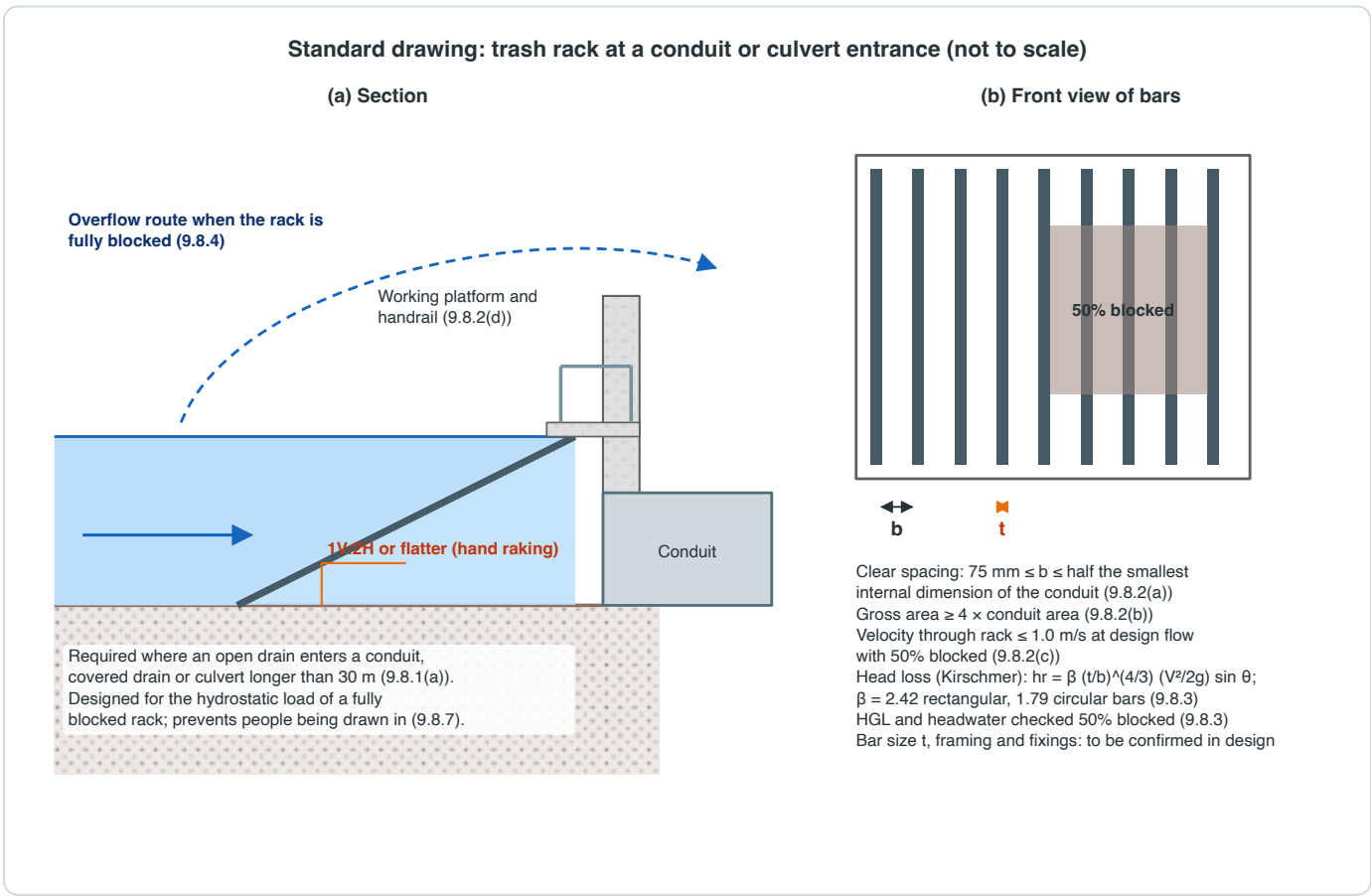


Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm Water Drainage Systems (2019), §8.3.1.3.

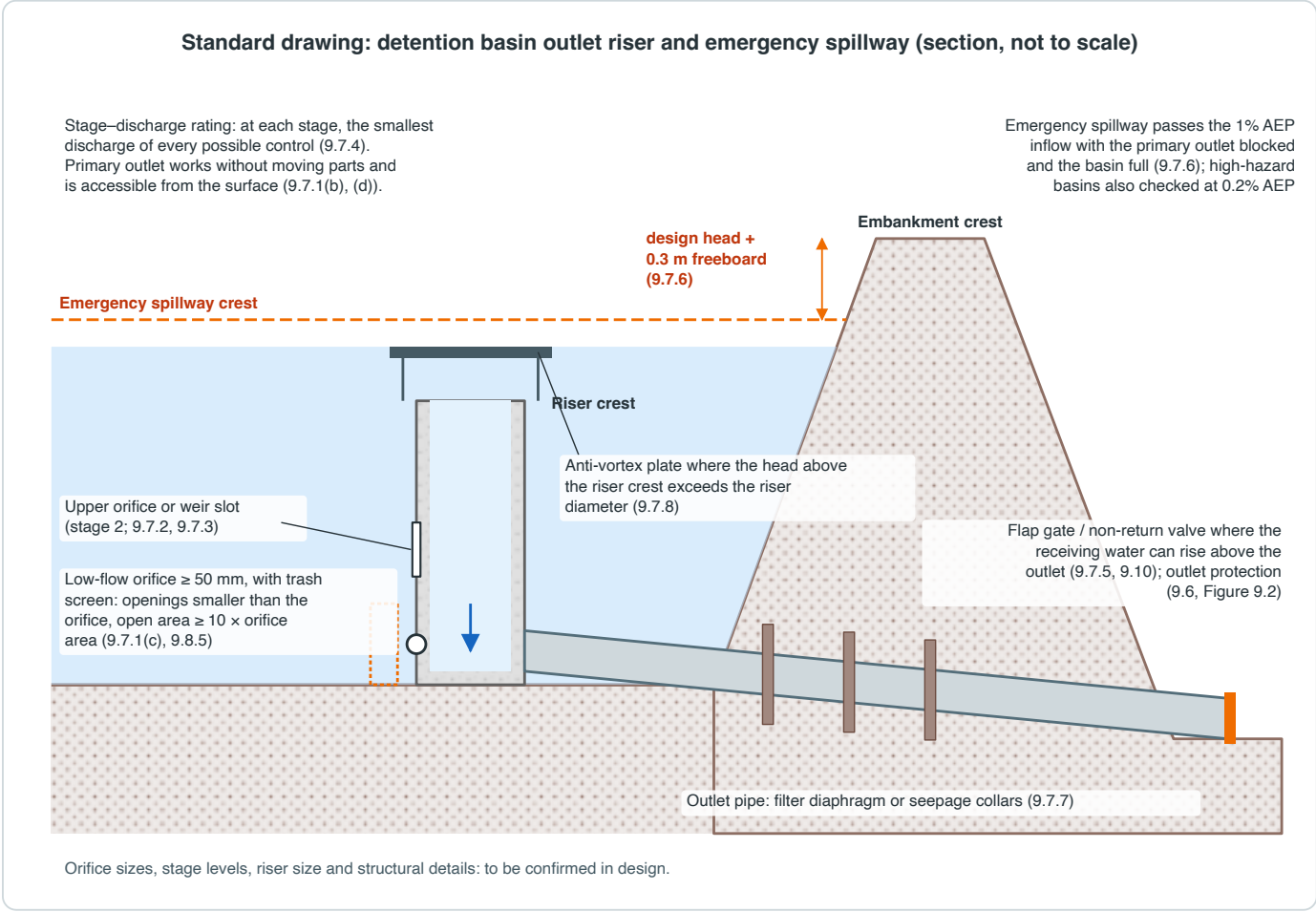


Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).

Table 9B.1 — Dimensions and rules on the standard drawings and their source clauses

Drawing	Item	Dimension or rule	Clause
9B.1	Minimum culvert size under public roads	900 mm diameter, or 900 mm × 900 mm box	6.12.5
9B.1	Headwater at the design AEP	HW/D ≤ 1.2; at least 0.3 m below the shoulder edge at the upstream face	9.4.5
9B.1	Entrance loss coefficient	From Table 9.1 for the inlet built (for example 0.4 for a box with wingwalls at 30°–75°)	9.4.3
9B.1	Inverts	Match the drain bed; never above it	9.4.8(c)
9B.1	Multi-barrel culverts	Avoided in debris-prone drains; where used, one barrel for dry-weather flow and a debris fin or deflector	9.4.8(a)
9B.1	Headwalls, wingwalls, cut-off walls	Required; dimensions to be confirmed in design	9.4.9
9B.1	Road overtopping	Qr = Cd · L · h^1.5, Cd ≤ 1.66	9.4.6
Figure 9.2	Riprap apron	Width at the outlet ≥ 3D, flaring to the channel; length and thickness from Table 9.3; filter or geotextile	9.6.3, 9.6.4

Drawing	Item	Dimension or rule	Clause
9B.2	Single vertical drop in a public drain	Height h ≤ 1.5 m; edge protection	9.6.6(c), 6.13.8
9B.2	Pool geometry	D = q²/(g h³); Ld/h = 4.30 D^0.27; Yp/h = 1.00 D^0.22; y1/h = 0.54 D^0.425; y2/h = 1.66 D^0.27	9.6.6(a)
9B.2	Basin beyond Ld, end sill	To be confirmed in design (HEC-14 or US Bureau of Reclamation)	9.6.6(b)
9B.3	Where required	Where an open drain enters a conduit, covered drain or culvert longer than 30 m	9.8.1(a)
9B.3	Clear bar spacing b	Not less than 75 mm and not more than half the smallest internal dimension of the conduit	9.8.2(a)
9B.3	Gross rack area	At least 4 times the conduit area	9.8.2(b)
9B.3	Velocity through the rack	Not more than 1.0 m/s at the design flow with 50% blocked	9.8.2(c)
9B.3	Inclination	No steeper than 1V:2H where raked by hand; working platform and handrail	9.8.2(d)
9B.3	Head loss and blocked check	Kirschmer equation; HGL and headwater checked with 50% blocked	9.8.3
9B.3	Overflow and safety	Overflow route for a fully blocked rack; designed for the full hydrostatic load	9.8.4, 9.8.7
9B.4	Low-flow orifice	Not smaller than 50 mm; trash screen with openings smaller than the orifice and open area at least 10 times the orifice area	9.7.1(c), 9.8.5
9B.4	Orifice and weir flow	Q = Cd · A · (2gh)^0.5, Cd = 0.60 sharp-edged; weir coefficients of Clause 9.7.3	9.7.2, 9.7.3
9B.4	Stage–discharge rating	Smallest discharge of every possible control at each stage	9.7.4
9B.4	Anti-vortex plate	Where the design head above the riser crest exceeds the riser diameter	9.7.8
9B.4	Outlet pipe through the embankment	Filter diaphragm or seepage collars; flared or headwalled inlet	9.7.7
9B.4	Flap gate or non-return valve	Where the receiving water can rise above the outlet	9.7.5, 9.10
9B.4	Emergency spillway	Passes the 1% AEP inflow with the primary outlet blocked and the basin full, with 0.3 m freeboard to the embankment crest; 0.2% AEP check for high-hazard basins	9.7.6
All	Structural dimensions, reinforcement, foundations, bar sizes, orifice sizes and stage levels	To be confirmed in design	9.1.2

Annex 9C — Pump station design checklist and standard control philosophy

Supports Clauses 9.8.6, 9.9 and 9.10 of Chapter 9, with Clause 6.10.5 of Chapter 6 and the outfall-closed check of Chapter 5.

9C.1 Design checklist

Submit this checklist with the pump station design report of Clause 9.14, item 6.

Table 9C.1 — Pump station design checklist

No.	Item	Requirement	Clause	Provided (Yes / No / NA)
1	Need for pumping	Gravity drainage cannot meet Chapters 5 and 6; reason stated	9.9.1	
2	Inflow	Inflow hydrograph routed through the catchment and any upstream storage	9.9.2	
3	Design standard	Design AEP of the element served; for underpasses, 2% AEP with a 1% AEP check	9.9.2(a), 6.10.5(a)	
4	Tidal outfall	Storage plus pumps hold the 48 h design volume with the outfall throttled for the tidal-lock duration (default two high tides of 6 h each)	9.9.2(b), Chapter 5	
5	Head range	Pumps selected from the lowest sump level against the lowest tailwater to the highest tailwater (HAT + surge + 0.3 m); pump and system curves submitted	9.9.2(c), 9.14	
6	Wet-well volume	Greatest of: 5 min of minimum inflow (variable speed and automatic control); 10 to 15 min of peak inflow, or the manufacturer's minimum cycle volume; $V = \Theta \cdot q / 4$ for each constant-speed pump	9.9.3	
7	Duty pumps	Same size where practicable	9.9.4(a)	
8	Standby	At least equal to the largest duty pump, and not less than 50% of the number of duty pumps	9.9.4(b)	
9	Alternation	Duty and standby roles alternate automatically	9.9.4(c)	
10	Pump type	Solids-handling (non-clog); axial-flow only behind a screen meeting Clause 9.8.6	9.9.5	
11	Sump and intake	Manufacturer's requirements and ANSI/HI 9.8; clear space 0.6 m (small and medium) or 1.0 m (large units)	9.9.6	
12	Model study	Physical model where any pump exceeds 1 m^3/s or the sump departs from ANSI/HI 9.8 geometry	9.9.6	
13	Silt trap and screen	Upstream of the wet well; screen spacing smaller than the pumps' solids size; removable modules; mechanical raking where inflow exceeds 1 m^3/s	9.9.7, 9.8.6	
14	Screen overflow	Overflow route when the screen is fully blocked	9.8.4	
15	Level control	Primary level sensor (ultrasonic, radar or pressure) with an independent float-switch back-up	9.9.8(a)	
16	Alarms	High-level and pump-fault alarms by telemetry to the local body's control room	9.9.8(b)	
17	Records	Sump levels, pump run hours and power status logged and kept at least 5 years	9.9.8(c)	
18	Power sources	Grid supply plus a standby generator or second independent feeder able to run all duty pumps at once	9.9.9(a)	
19	Fuel	At least 72 h of all duty pumps, stored above the flood level of Clause 9.9.10	9.9.9(b)	
20	Changeover	Automatic changeover to standby power	9.9.9(c)	
21	Flood protection	Electrical and control room floor, generator and transformer at least 0.5 m above the 1% AEP flood level; vehicle access usable in the 1% AEP event	9.9.10	
22	Discharge	Separate rising mains, or a non-return and an isolating valve where mains combine; delivery chamber or outfall with a flap gate or non-return valve; mains sized by a recognised friction formula	9.9.11	

No.	Item	Requirement	Clause	Provided (Yes / No / NA)
23	Gates	Flap or tide gate on outfalls below the 1% AEP still-water level; penstock or stop-log slot upstream for outfalls of 900 mm or more and every pumped outfall; head loss from tested data	9.10.1, 9.10.3, 9.10.4	
24	Sand and debris at the outfall	Gate in a chamber with surface access, or elastomeric check valves, at beach, estuary and creek outfalls	9.10.5	
25	Emergency connection	Hard-standing and quick-coupling connection for mobile pumps into the delivery chamber	9.9.12	
26	Materials	Exposure class of Clause 9.13; stainless steel grade 316, galvanised and coated steel, or non-metallic fixings within 5 km of the coast	9.13	
27	Design life	At least 50 years for civil works and 25 years for mechanical and electrical equipment	9.2.4	
28	Underpass stations	Depth markers and automatic warning or closure signals at 150 mm depth on the carriageway	6.10.5(d)	
29	Certification	Designed by an empanelled professional and checked by an independent empanelled professional	10.6.1(d), 10.6.4	

9C.2 Standard control philosophy

This is the standard control philosophy for a stormwater pump station designed under Clause 9.9. The designer adapts it to the station and submits it with the design report. Items marked "recommended" are good practice that Chapter 9 does not require; all others restate a clause.

Table 9C.2 — Control levels (values to be set in design)

Level	Rule for setting it	Clause
Pump stop	Not below the minimum submergence required by the pump manufacturer and ANSI/HI 9.8	9.9.6
Duty pump 1 start	Above the pump-stop level by at least the effective wet-well volume of Clause 9.9.3	9.9.3
Duty pumps 2, 3 … start	Staged above duty pump 1 start; spacing to be confirmed in design	9.9.2
High-level alarm	Above the highest duty-pump start level; to be confirmed in design	9.9.8(b)
Float back-up high	Independent float; starts the duty pumps	9.9.8(a)
Float back-up low	Independent float; stops the pumps	9.9.8(a)

1. **Normal (automatic) operation.** As the wet-well level rises to the duty pump 1 start level, the lead pump starts. If the level keeps rising, each further duty pump starts at its start level. The pumps stop when the level falls to the pump-stop level. The primary level sensor controls this sequence (Clause 9.9.8(a)).
2. **Duty rotation.** The lead pump changes automatically, after each pump-down cycle or by run hours as set in the design, so that duty and standby roles alternate and wear is shared (Clause 9.9.4(c)).
3. **Pump fault.** A pump that trips or fails to start is locked out. The next available pump, including the standby pump, takes its place, and a pump-fault alarm is sent by telemetry (Clauses 9.9.4(b) and 9.9.8(b)).
4. **Level-sensor failure.** If the primary sensor fails, or disagrees with the float switches, control passes to the independent float back-up: at the float-high level the duty pumps run, and at the float-low level they stop. An alarm is sent (Clause 9.9.8(a), (b)).
5. **Power failure.** Supply changes over automatically to the standby generator or second feeder (Clause 9.9.9(c)). Recommended: pumps restart one at a time after changeover, to limit the starting load on the generator.

6. **High level.** At the high-level alarm level an alarm is sent by telemetry to the local body's control room (Clause 9.9.8(b)). At an underpass, the warning or closure signals operate at 150 mm depth on the carriageway (Clause 6.10.5(d)).
7. **Outfall and gates.** Rising mains discharge to a delivery chamber or outfall fitted with a flap gate or non-return valve (Clause 9.9.11). Flap gates open and close under head difference without control action. The upstream penstock or stop logs are closed only for maintenance, or if the flap gate jams open (Clause 9.10.3). Recommended: penstock position is shown at the control panel and logged.
8. **Tide-locked operation.** Where the outfall is tide-locked, storage and pumping together hold the 48 h design volume for the tidal-lock duration (Clause 9.9.2(b) and Chapter 5). Where the station also has a gravity outfall, gravity discharge resumes through the flap gate when the tide falls.
9. **Screens.** Mechanically raked screens (required where inflow exceeds 1 m³/s, Clause 9.8.6) are run automatically. Recommended: raking is started by a timer and by the level difference across the screen, with an alarm when the difference stays high.
10. **Manual operation.** Recommended: each pump has a hand–off–auto selector at the panel, and the float back-up high-level start remains active in hand mode.
11. **Mobile pumps.** When fixed pumps are out of service or overwhelmed, mobile pumps discharge into the delivery chamber through the quick-coupling connection (Clause 9.9.12).
12. **Records.** Sump levels, pump run hours and power status are logged and kept for at least 5 years (Clause 9.9.8(c)). Recommended: alarms, pump starts and stops, and changeovers are logged as well.
13. **Testing.** The controls, floats, alarms, telemetry, changeover and generator are tested in the pre-monsoon inspection of Chapter 10 (Clause 10.12), and the results reported in the Annual Maintenance Declaration (Form 10-7; Clause 10.10.3).

Form 9-1 — Hydraulic Structures Report checklist

Supports Clause 9.14 of Chapter 9.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Not for statutory use.

Attach this checklist to the front of the Hydraulic Structures Report. For each item, enter Yes, No or Not applicable, and the drawing or page where it is shown.

Section A — Project

Table 9F.1 — Form 9-1, Section A: project

Field	Entry
Project name and location	_____
Local body, and Tier A or Tier B (Chapter 1)	_____
Applicant	_____
Designer (name and registration)	_____
Structures covered (culverts, channels, dissipators, outlets, screens, pumps, gates, inlets, manholes)	_____
Tailwater conditions used: MHWS, HAT + surge, sea-level allowance, joint case (Clause 9.2.1)	_____
Date and revision	_____

Section B — Contents required by Clause 9.14

Table 9F.2 — Form 9-1, Section B: contents required by Clause 9.14

No.	Item	Clause	Provided (Yes / No / NA)	Drawing or page
1	Culvert calculations (HDS-5 or HY-8 output) with HWi, HWo, outlet velocity, tailwater, overtopping and the blockage check	9.4, 6.12		
2	Channel water-surface profiles, velocities, Froude numbers and freeboard	9.5		
3	Outlet protection and dissipator design, with riprap sizing	9.6		
4	Detention outlet stage–discharge tables and the emergency spillway check	9.7		
5	Screen and rack design with the 50% blocked check	9.8		
6	Pump station design report: inflow hydrograph, storage, pump and system curves, wet-well volume, controls, power supply and the Chapter 5 outfall-closed check (with Annex 9C)	9.9		
7	Gate and valve selection with head-loss data	9.10		
8	Inlet, grate and cover load classes	9.11		
9	Exposure class and materials statement	9.13		

Section C — Compliance checks

Table 9F.3 — Form 9-1, Section C: compliance checks

No.	Check	Limit	Clause	Complies (Yes / No / NA)
C1	Climate factor included in design flows	Clause 2.8	9.2.2	
C2	Blocked condition checked where debris can block; safe overflow route	—	9.2.5	
C3	Pipes and box drains: design n (box drains ≥ 0.015); supercritical pipes: jump located in a structure, air venting	—	9.3.1, 9.3.4	
C4	Pipe size does not decrease downstream; joins only at manholes or junction chambers; no change of direction over 90°	—	9.3.5	
C5	Culvert design headwater = greater of HWi and HWo	—	9.4.1	
C6	Culvert headwater at the design AEP	HW/D ≤ 1.2; ≥ 0.3 m below shoulder edge	9.4.5	
C7	Road overtopping weir coefficient	Cd ≤ 1.66	9.4.6	
C8	Culvert inverts match the drain bed; headwalls, wingwalls and cut-off walls	—	9.4.8(c), 9.4.9	
C9	Channel Froude number at the design flow	≤ 0.8; none between 0.8 and 1.2	9.5.2	
C10	Channel velocity	Table 9.2	9.5.3	
C11	Channel slope in engineered channels	≤ 0.4% natural, ≤ 0.2% concrete, or drops / chute	9.5.4	
C12	Side slopes; low-flow channel where bed width ≥ 3 m; uplift or weep holes	—	9.5.6, 9.5.7, 9.5.9	
C13	Outlet protection where outlet velocity exceeds Table 9.2	Table 9.3 apron, or basin	9.6.1, 9.6.3	
C14	Single vertical drop height	≤ 1.5 m	9.6.6(c)	
C15	Detention primary outlet: no moving parts; minimum orifice	≥ 50 mm with screen	9.7.1	
C16	Emergency spillway	1% AEP, outlet blocked, basin full, 0.3 m freeboard; 0.2% AEP for high-hazard basins	9.7.6	
C17	Outlet pipe through embankment; anti-vortex plate where needed	—	9.7.7, 9.7.8	
C18	Conduit-entrance racks	Spacing 75 mm to half the smallest conduit dimension; area ≥ 4×; ≤ 1.0 m/s at 50% blocked	9.8.2	
C19	Detention orifice screens	Openings smaller than the orifice; open area ≥ 10×	9.8.5	
C20	Pump station	Annex 9C checklist complete	9.9	
C21	Gates on outfalls below the 1% AEP still-water level; secondary closure; corrosion-resistant fittings	—	9.10	
C22	Grate load classes, parallel openings ≤ 25 mm, kerb openings ≥ 100 mm × 1.0 m, locked covers	—	9.11	
C23	Manhole sizes (Table 9.4), 600 mm access openings, drops, benching, surcharge covers	—	9.12	

No.	Check	Limit	Clause	Complies (Yes / No / NA)
C24	Exposure class (Table 9.5); chloride and sulphate tests in coastal and delta areas; sulphide protection; metalwork within 5 km of the coast	—	9.13	

Section D — Variances

Table 9F.4 — Form 9-1, Section D: variances

Clause	Requirement not met	Reason and proposed alternative	Approved by and date
_____	_____	_____	_____

Section E — Signatures

The report shall be prepared and signed by a registered professional, and the Professional Design Certificate (Form 10-3) attached (Clauses 10.6.1 and 10.6.3 of Chapter 10). For a facility with an embankment, a high-hazard basin, a pumped facility, a tide gate or a regional facility, the signatory shall be an empanelled Stormwater Design Professional, and a second, independent empanelled professional shall sign as checker (Clauses 10.6.1(c), (d) and 10.6.4).

Table 9F.5 — Form 9-1, Section E: signatures

Role	Name	Registration or empanelment no.	Signature	Date
Designer	_____	_____	_____	_____
Independent checker (Clause 10.6.4, where applicable)	_____	_____	_____	_____

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 10

Submittals, Review, Operation & Maintenance and Enforcement

These annexes support Chapter 10. They give the specification and user-guide outline of the compliance calculator, the GIS data specification, the maintenance access dimensions that the Manual sets, model O&M plans for each facility type, model empanelment criteria, and the eight forms that Chapter 10 requires. The Design Rainfall Sheet (Form 2-1) is in the annexes to Chapter 2. The forms are draft forms. The model texts are for consideration by a competent authority and are not in force.

Annex 10A — Compliance calculator and user guide

Supports Clauses 10.4.1(g), 10.5 and 10.9.1(b) of Chapter 10.

> **Status.** The compliance calculator does not exist yet. Clause 10.5.1 requires the State Stormwater Technical Committee to issue and maintain it. This annex is the specification the calculator shall meet and the outline of its user guide. Until the calculator is issued, the designer completes Form 10-2 by hand from the calculations of Chapters 4, 5 and 8, enters "not issued" as the calculator version, and attaches the calculations.

10A.1 General requirements

The calculator shall:

- (a) be a spreadsheet or web tool, published free of charge with its user guide and the source of every table in it (Clause 10.5.4);
- (b) print its version number and release date on every output page and every exported file (Clause 10.5.3);
- (c) keep a public version log. A new version applies to new submittals 6 months after release; a submittal keeps one version from Stage 1 to Stage 4 unless the Applicant elects a later one (Clause 10.5.3);
- (d) work for one site at a time, with one or more drainage areas, each draining to its own outfall (Clause 4.5.1.3);
- (e) never apply a value that the Manual has not published. Where a table it needs has not been issued (for example Table 4.3 of Annex 4B, or the S-2 discharge tables of Annex 1C), the calculator shall show that route as "not available" rather than estimate the value; and
- (f) export its inputs and results as a machine-readable file (CSV or JSON) as well as Form 10-2, so that the Authority can load them into the facility register (Clause 10.17.1(b)).

10A.2 Inputs

Table 10A.1 — Calculator inputs

No.	Input	Unit	Source
I1	Authority, tier (A or B) and file number	—	Clause 1.6

No.	Input	Unit	Source
I2	Site area; land disturbance area	ha	Clause 1.5.2
I3	New impervious area; replaced impervious area; existing impervious area before demolition	m²	Clauses 1.5.2, 1.5.6, 4.5.6.1
I4	Development type: new, redevelopment, linear public work, single dwelling	—	Clauses 1.5.6–1.5.8
I5	Flood-sensitive catchment (yes / no), and basin with an approved BSMP (yes / no)	—	Clauses 4.5.3, 4.13, 11.12
I6	Rainfall zone	—	Annex 2A
I7	Retention depth P_R; 3-month ARI 24-hour depth P_3m	mm	Annexes 2E, 8A
I8	Design rainfall depths by duration (1–72 h) and AEP, with the climate factor, as recorded on Form 2-1	mm	Clauses 2.5, 2.8, 2.13
I9	15-minute intensities i_10 and i_2, with the climate factor (fixed-coefficient route only)	mm/h	Clause 4.14.4
I10	Drainage areas: for each, area, land cover, impervious percentage, HSG and curve number, pre- and post-development	ha, %, —	Clauses 3.3, 3.7, 3.9
I11	Areas preserved under a registered covenant	ha	Clause 4.4.7
I12	Seasonal high groundwater depth below the base of each retention practice	m	Clauses 4.4.3(c), 8.8
I13	Measured infiltration rate at each practice	mm/h	Clause 4.4.3
I14	Retention volume provided, by practice; reuse demand where retention is by reuse	m³, m³/d	Clauses 4.4.3, 4.4.5
I15	Route: full hydrograph method (Clause 4.6); design-aid S-1 (Clause 4.14.2); PSD S-2 (Clause 1.7); fixed-coefficient (Clause 4.14.3); constrained redevelopment (Clause 4.5.6)	—	Clauses 1.7, 4.5.6, 4.6, 4.14
I16	For the full method: model results for each AEP and duration — pre- and post-development peaks, storage used, retention credit found by routing	m³/s, m³	Clauses 4.4.6.2, 4.6
I17	Outlet: low-flow orifice diameter or least slot dimension; drawdown times from routing	mm, h	Clauses 4.7, 4.8.2
I18	Outfall: tidal or non-tidal; outfall-closed check result	—	Chapter 5
I19	Fee-in-lieu unit rate notified for the basin, where the route applies	₹/m³	Clause 4.13.3
I20	Stage of submittal (1, 2 or 4) and, at Stage 4, the as-built values of I14, I16 and I17	—	Clauses 10.5.2, 10.9.1(b)

10A.3 Calculations, by clause

Table 10A.2 — Calculations the calculator shall perform

Step	Calculation	Clause
C1	**Applicability.** Chapters 4 and 5 apply where land disturbance ≥ 0.1 ha or new plus replaced impervious area ≥ 500 m², over the common plan of development. Report exemptions. Flag that the universal provisions apply at every size, and that RWH applies under Chapter 9 and Annexure E of the APBBL 2019 to buildings on plots of 100 m² and more (9.1; Annexure E, 1.1), with recharge to be made mandatory on plots of 500 m² and more (9.7) and the capture of storm water on open spaces of more than 500 m² (9.6), as storage of at least 25 litres per m² of roof (Clause 4.11, set by this Manual, since the bye-laws set no volume), credited as retention only through reuse; recharge is credited only where Clause 4.11 (recharge rule) allows it, which is on tested sandy terrace and valley-fill soils of the Naharlagun–Nirjuli–Doimukh valley and on the coarse bhabar fan heads, with the seasonal high water table at least 2.0 m below ground and not within 30 m of a dug well or spring used for drinking water; never, unless a geotechnical certificate allows it, on natural ground sloping more than 10°, on Siwalik shale, on colluvium, slope debris or fill, in a mapped landslide zone, above a landslide scarp or within twice the height of a cut or retaining wall upslope of it (Clause 4.11, hill rule); and never below the 1% AEP flood level of the Dikrong, the Pachin, the Senki, the Siang, the Lohit, the Dibang, the Noa-Dihing or a nallah, on the palaeochannels and swampy land of the Pachin and Dikrong flood plains, on the margins of a pond or where the seasonal high water table is less than 2.0 m below ground (Clause 4.11, floodplain rule); where the bye-laws' recharge requirement falls on such ground, storage is provided instead and the Authority's relaxation is sought.	1.5.2–1.5.8
C2	**Process flags.** Stage 0 mandatory (≥ 2 ha, flood-sensitive, variance or regional route, tidal outfall or waterbody); Stages 1 and 2 may be combined (< 1 ha, not flood-sensitive); empanelled signatory required; independent check required.	10.3.2, 10.3.3, 10.6.1, 10.6.4
C3	**Route eligibility.** Tier B simplified method: ≤ 2 ha, or ≤ 0.5 ha in a flood-sensitive catchment, and only once Table 4.3 is published. Fixed-coefficient route: ≤ 1 ha and none of the exclusions of Clause 4.14.3. Constrained redevelopment: existing ≥ 60% impervious and ≤ 1 ha. Regional detention or fee-in-lieu: only in a basin with an approved BSMP.	4.5.6.1, 4.13.1, 4.14.1, 4.14.3, 11.12.1(b)
C4	**Retention volume.** RRV = 10 × Q_R × A, with Q_R the SCS-CN runoff from P_R for each sub-area at AMC II, summed over sub-areas. The larger of the Ia = 0.2S and Ia = 0.05S results governs. The Rv form (RRV = 10 × P_R × Rv × A, Rv = 0.05 + 0.009 × I) is offered only for sites < 0.5 ha and the Tier B method. No climate factor.	4.4.2, 3.8.5(c), 2.8.3
C5	**Preservation credit.** Preserved areas are modelled at their pre-development CN in the post-development condition.	4.4.7
C6	**Retention checks.** Design infiltration rate ≤ half the measured rate; groundwater ≥ 1.0 m below the base; drawdown of the retained volume within 72 h at the design rate (or by the stated reuse demand). A practice that fails any check gets no credit; any shortfall is reported and treated as WQv.	4.4.3–4.4.5, 4.4.6.4
C7	**Water quality volume.** P_wq = max(P_ret, P_3m); WQv = 10 × Q_wq × A by SCS-CN, or (P_wq / 1000) × Rv × A (A in m²) for sites < 0.5 ha and the Tier B method. The retained volume counts toward the WQv in full. No climate factor.	8.4.1–8.4.4, 3.8.5(c)
C8	**Retention credit.** Tier A: the credit found by routing is entered (I16); the calculator does not compute it. Tier B: V_credit = C_R × RRV provided, with C_R = 0 until Annex 4B is published.	4.4.6
C9	**Design-aid route (S-1).** V = SSR × A − V_credit; Q_PSD,T = PSD_T × A for the 2-yr and 100-yr stages, from Table 4.3. Shown as "not available" until Table 4.3 is published.	1.7.2, 4.14.2
C10	**Permissible site discharge (S-2).** Q = PSD (m³/s/ha) × A for each AEP, from the S-2 tables. Shown as "not available" until they are issued.	1.7.2, 1.7.3(e)
C11	**Fixed-coefficient route.** Q_cap,10 = 2.78 × C_10 × i_10 × A and Q_cap,2 = 2.78 × C_2 × i_2 × A (L/s); V_100 and V_2 = max over d of [10 × C_v × P(d) × A − 1.8 × Q_cap × d] for d = 1 to 72 h, with pervious C ≥ 0.50 for d ≥ 12 h; V = max(V_100, V_2); retention added without credit. Coefficients from Table 4.3A (provisional).	4.14.4–4.14.7
C12	**Release-rate screen (full method).** For each AEP and duration: Q_post ≤ 0.9 × Q_pre (standard), or the two mixed-frequency caps (flood-sensitive). Report the governing duration and margin.	4.5.2, 4.5.3
C13	**Constrained redevelopment.** Q_post ≤ 0.5 × Q_existing for 2-, 10- and 100-yr at each duration; shortfall volume = greenfield storage − storage provided; fee = shortfall × unit rate.	4.5.6.2, 4.5.6.3
C14	**Minimum orifice.** Flag any orifice < 50 mm. Where a cap is below the discharge of a 50 mm orifice at the corresponding stage, report "50 mm orifice deemed to comply".	4.5.5.1, 4.8.2

Step	Calculation	Clause
C15	**Drawdown.** Report the detention drawdown (90% of the 10-yr stored volume within 48 h), the WQv release time (24–48 h) and the retention emptying time (≤ 72 h).	4.7
C16	**Fee-in-lieu.** Fee = detention volume required on site × notified unit rate.	4.13.3
C17	**Model screen.** Where the full method is used, compare the model results (I16) with the calculator's screen values (C9 to C11, where available) and flag a difference above the tolerance stated in the user guide.	10.5.2(c)
C18	**As-built re-run.** At Stage 4, repeat C4 to C17 with the as-built values and report each change from Stage 2.	10.9.1(b), 10.9.2

10A.4 Outputs

The calculator produces:

- (a) **Form 10-2**, filled in, with the calculator version and release date on every page;
- (b) a machine-readable export of every input and result of Tables 10A.1 and 10A.2; and
- (c) a list of the flags raised (C1 to C3, C6, C14, C17), each with the clause on which it is based (Clause 10.7.7).

10A.5 Testing before release

Before each release the State Stormwater Technical Committee shall check that the calculator reproduces, within rounding, the worked examples of the Manual that use the same method, including the illustrative examples of Clauses 4.6.7 and 4.14, and the benchmark problems of Annex 3C where they apply. The test results shall be published with the version log.

10A.6 Outline of the user guide

The user guide shall contain at least:

1. Purpose, status and limits of the calculator: a summary and screening check outside the design-aid route (Clause 10.5.2(c)).
2. How to obtain the current version, and the version rule of Clause 10.5.3.
3. Each input of Table 10A.1, with where to find it in the Manual and its annexes.
4. Each calculation of Table 10A.2, with its equation and clause.
5. The tolerance used in step C17, and what the drainage report must explain where it is exceeded (Clause 10.5.2(c)).
6. How to read and sign Form 10-2, and what to attach.
7. At least one worked example for each route, labelled "Illustrative — not design values".
8. The sources of every table in the calculator (Clause 10.5.4), and the version log.

Annex 10B — GIS data specification and attribute schema

Supports Clauses 10.4.4, 10.14.1(d), 10.14.3 and 10.17 of Chapter 10.

10B.1 Format and reference systems

- (a) **Format.** One OGC GeoPackage (.gpkg) per submittal is preferred. Shapefiles are accepted, one per layer, zipped with all component files. Field names shall be as in Tables 10B.2 to 10B.6; shapefile names are limited to 10 characters, and the names below meet that limit.

- (b) **Horizontal reference.** WGS 84 geographic (EPSG:4326), or WGS 84 / UTM zone 46N (EPSG:32646) for a project area west of 96° E, which is most of the State, or 47N (EPSG:32647) for a project area wholly east of 96° E (Tezu, Miao, Wakro, Hayuliang and Anjaw); a project uses one zone for all its layers, whichever contains the site (Clause 10.4.4(c)). One system shall be used for all layers.
- (c) **Vertical reference.** All levels shall be in metres relative to a named vertical datum, stated in the metadata. The metadata shall also state the relationship between that datum and the river datums of the CWC sites on the Siang at Pasighat, the Noa-Dihing at Namsai and the Lohit at Tezu (levels as transcribed by SANDRP, on a datum not stated [TBC]), of any gauge or staff gauge on the Senki, the Pachin and the Dikrong in the capital and on the Dibang at Roing (none with a published datum was found [TBC]), of the reservoir and release levels of the Pare, Ranganadi, Kameng and Lower Subansiri projects (not found on a named datum [TBC]), and of the flood marks surveyed on ungauged streams, nallahs and ponds used in Chapter 5 (Clause 10.4.4(d)).
- (d) **Accuracy.** Positions shall come from the site survey or the approved drawings. At Stage 4 and at handover, positions and levels shall come from the as-built survey (Clause 10.9.1(a)).
- (e) **File name.** `<Authority file number>_<stage>_<yyyymmdd>.gpkg`, for example `TP–BP–2026–0123_S2_20261015.gpkg`.
- (f) **Identifiers.** Every feature has an identifier unique within the submittal (FAC_ID, OUT_ID, CAT_ID, FLP_ID). The Authority replaces them with register identifiers on acceptance and returns the mapping to the Applicant.

10B.2 Layers

Table 10B.1 — Layers

Layer	Geometry	Content	Required at
SW_SITE	Polygon	Site boundary	Stages 1, 2, 4
SW_CATCH	Polygon	Catchment boundaries draining to and through the site, pre- and post-development (Clause 10.4.1(b))	Stages 1, 2, 4
SW_FAC	Polygon (point for buried items smaller than 5 m across)	Every stormwater facility: retention, detention, water quality, pumping, gate, conveyance element designed under this Manual	Stages 2, 4; handover
SW_OUTF	Point	Every outfall from the site, and every public outfall	Stages 1, 2, 4; handover
SW_FLOW	Line	Major-system flow paths through and from the site, and natural drainage paths (Clause 10.15.1(g))	Stages 1, 2, 4
SW_CONV	Line	Drains and pipes designed under Chapter 6	Stage 4 for public works; handover
SW_META	Table (no geometry)	Metadata of Table 10B.6	Every stage

10B.3 Attribute schema

Types: T = text, I = integer, R = real, D = date (ISO 8601, yyyy-mm-dd). "Req." marks fields that shall not be empty; other fields are filled where they apply.

Table 10B.2 — Attributes of SW_FAC (facilities)

Field	Type	Unit	Req.	Content	Source
FAC_ID	T	—	Yes	Facility identifier	10B.1(f)
FAC_TYPE	T	—	Yes	Code from Table 10B.7	Clause 4.10, Table 10.3
FAC_NAME	T	—		Name on the drawings	—

Field	Type	Unit	Req.	Content	Source
OWNER_TYP	T	—	Yes	PRIVATE / ASSOC / DEVELOPER / ULB / DEPT	Clauses 10.10, 10.14
OWNER_NM	T	—	Yes	Name of a corporate owner or association only; for an individual, "private individual" (Clause 10.17.3)	Clause 10.17.3
CTRL_AREA	R	ha	Yes	Area draining to the facility	Clause 4.5.1.3
V_RET	R	m³		Retention volume provided	Clause 4.4
V_WQ	R	m³		Water quality volume provided	Clause 8.4
V_DET	R	m³		Detention volume at the top design level	Clause 4.6
Q_2	R	L/s		Release at the 50% AEP (2-yr) design level	Clause 4.5
Q_10	R	L/s		Release at the 10% AEP (10-yr) design level	Clause 4.5
Q_100	R	L/s		Release at the 1% AEP (100-yr) design level	Clause 4.5
ORIF_MM	R	mm		Low-flow orifice diameter or least slot dimension	Clause 4.8.2
INV_OUT	R	m		Outlet invert level	Clause 10.9.1(a)
TWL_DES	R	m		Top design water level	Clause 10.9.2(a)
SPILL_LV	R	m		Spillway or overflow crest level	Clause 4.9
PUMPED	T	—	Yes	Y / N	Clause 10.10.3
REGIONAL	T	—	Yes	Y / N	Clause 4.13
EMPANEL	T	—	Yes	Y / N: facility under Clause 10.6.1(c) or (d)	Clause 10.6.1
STATUS	T	—	Yes	Code from Table 10B.8	Clause 10.17.1(a)
APPR_DATE	D	—		Date of Stage 2 approval	Clause 10.3
ASB_DATE	D	—		Date the as-built certificate was accepted	Clause 10.9
DECL_REF	T	—		Registration reference of the Maintenance Declaration (Form 10-6)	Clause 10.10.1(e)
HAND_DATE	D	—		Date of the Asset Handover Certificate (Form 10-8)	Clause 10.14
LAST_INSP	D	—		Date of the latest inspection	Clause 10.12
INSP_RES	T	—		Code from Table 10B.9	Clause 10.17.1(a)
OUT_ID	T	—	Yes	Outfall to which the facility discharges	—

Table 10B.3 — Attributes of SW_OUTF (outfalls)

Field	Type	Unit	Req.	Content	Source
OUT_ID	T	—	Yes	Outfall identifier	10B.1(f)
RECEIVER	T	—	Yes	Receiving drain, channel, waterbody or sea, by name	Clause 4.5.1.3
RECV_TYPE	T	—	Yes	PUBLIC_DRAIN / CANAL / RIVER / TANK / SEA / OTHER	Chapter 5
INV_LEVEL	R	m	Yes	Outfall invert level	Clause 10.9.1(a)
SIZE_MM	R	mm	Yes	Diameter, or width × height written in the drawing	Chapter 6
TIDAL	T	—	Yes	Y / N	Chapter 5

Field	Type	Unit	Req.	Content	Source
GATE_TYPE	T	—		NONE / FLAP / TIDE / DUCKBILL / PENSTOCK / NRV	Clauses 5.11, 9.10
GATE_REQ	T	—	Yes	Y / N: invert below the 1% AEP still-water level	Clause 5.11.1
GPT	T	—		Y / N: gross pollutant trap fitted	Clause 8.10.1
Q_100	R	L/s		Design 1% AEP discharge	Chapter 5

Table 10B.4 — Attributes of SW_CATCH (catchments)

Field	Type	Unit	Req.	Content	Source
CAT_ID	T	—	Yes	Catchment identifier	10B.1(f)
CONDITION	T	—	Yes	PRE / POST / EXTERNAL (land outside the site draining through it)	Clause 10.4.1(b)
AREA_HA	R	ha	Yes	Area	—
IMPERV_PC	R	%	Yes	Impervious percentage	Clause 3.9
HSG	T	—	Yes	A / B / C / D, or mixed with area shares in NOTES	Clause 3.7
CN	R	—		Curve number, AMC II	Chapter 3
OUT_ID	T	—	Yes	Outfall to which it drains	Clause 4.5.1.3
FLOODSENS	T	—	Yes	Y / N	Clause 4.5.3
NOTES	T	—		Free text	—

Table 10B.5 — Attributes of SW_FLOW and SW_CONV (flow paths and conveyance)

Field	Type	Unit	Req.	Content	Source
FLP_ID	T	—	Yes	Line identifier	10B.1(f)
LINE_TYPE	T	—	Yes	OVERLAND / NATURAL / OPEN_DRAIN / COVERED_DRAIN / PIPE / CULVERT	Chapter 6
US_LEVEL	R	m		Upstream invert or ground level	Chapter 6
DS_LEVEL	R	m		Downstream invert or ground level	Chapter 6
SIZE_MM	R	mm		Pipe diameter, or drain width (depth in NOTES)	Clause 6.7.6
Q_DES	R	L/s		Design discharge	Chapter 6
AEP_DES	T	—		Design AEP, for example "10%" or "1%"	Clause 6.4
RESERVE_M	R	m		Drainage reserve width, where one applies	Clause 6.9.7
NOTES	T	—		Free text	—

Table 10B.6 — Metadata (SW_META)

Field	Content
FILE_NO	Authority file number
STAGE	1, 2, 4 or HANDOVER
H_CRS	EPSG code of the horizontal reference system
V_DATUM	Name of the vertical datum

Field	Content
TIDE_REL	Relationship of the vertical datum to the Chapter 5 river datums of the CWC sites on the Siang at Pasighat, the Noa-Dihing at Namsai and the Lohit at Tezu (levels as transcribed by SANDRP, on a datum not stated [TBC]), of any gauge or staff gauge on the Senki, the Pachin and the Dikrong in the capital and on the Dibang at Roing (none with a published datum was found [TBC]), of the reservoir and release levels of the Pare, Ranganadi, Kameng and Lower Subansiri projects (not found on a named datum [TBC]), and of the flood marks surveyed on ungauged streams, nallahs and ponds (for example, MSL = x.xx m on the site datum)
SURVEYOR	Name and licence number of the surveyor
SURV_DATE	Date of the survey
PREP_BY	Name and registration number of the certifying professional
CALC_VER	Compliance calculator version (Annex 10A), or "not issued"
DATE	Date the file was prepared

10B.4 Code lists

Table 10B.7 — Facility type codes (FAC_TYPE)

Code	Facility	Inspection row of Table 10.3
RET_SOAK	Soakaway, recharge pit or shaft	Retention / infiltration
RET_TRENCH	Infiltration trench or basin	Retention / infiltration
RET_BIO	Bioretention or rain garden	Retention / infiltration
RET_PERM	Permeable pavement	Retention / infiltration
RET_REUSE	Retention by reuse (tank with demand)	Underground or podium detention tank, gravity outlet
DET_BASIN	Surface detention basin	Surface detention basin or multi-use open space area
DET_OSR	Multi-use detention in open space, park or playfield	Surface detention basin or multi-use open space area
DET_ROOF	Rooftop detention	Underground or podium detention tank, gravity outlet
DET_PODIUM	Podium or landscape-deck detention	Underground or podium detention tank, gravity outlet
DET_PARK	Parking-lot detention	Surface detention basin or multi-use open space area
DET_TANK	Underground tank or vault, gravity outlet	Underground or podium detention tank, gravity outlet
DET_PUMP	Pumped detention or pump station	Pumped detention, pumps and controls
WQ_POND	Wet pond or constructed wetland	Surface detention basin or multi-use open space area
WQ_SWALE	Swale or filter strip	Private drains and inlets
WQ_GPT	Gross pollutant trap, first-flush device or oil-grit separator	Gross pollutant trap / first-flush device
GATE	Flap or tide gate, non-return valve	Flap / tide gate, non-return valve
CONV	Private drain, inlet or culvert	Private drains and inlets

Table 10B.8 — Status codes (STATUS)

Code	Meaning
PROPOSED	In a Stage 1 or Stage 2 submittal

Code	Meaning
APPROVED	Stage 2 approved; not yet built
ASBUILT	As-built certificate accepted (Clause 10.9)
HANDEDOVER	Accepted by the ULB (Clause 10.14)
ALTERED	Changed with the Authority's approval (Clause 10.3.5)
REMOVED	Removed with the Authority's approval

Table 10B.9 — Inspection result codes (INSP_RES)

Code	Meaning
OK	Working as designed; no defect
MINOR	Defect found and corrected; date in the inspection record
MAJOR	Defect affecting storage, outlet or safety; notice issued (Clause 10.15.2, step 1)
NOACCESS	Inspection could not be made
NOTFOUND	Facility missing, filled, covered or changed in use (Clause 10.15.1(c))

10B.5 Facility register extract

The public facility register of Clause 10.17.1(a) is an extract of SW_FAC: FAC_ID, FAC_TYPE, location (centroid), V_DET (and V_RET, V_WQ), Q_100 (and Q_2, Q_10), OWNER_NM, ASB_DATE, LAST_INSP and INSP_RES. It is published as CSV and GeoPackage under the licence of Clause 10.17.4. Personal data are not published (Clause 10.17.3).

Annex 10C — Maintenance access dimensions

Supports Clause 10.13 of Chapter 10.

Clause 10.13 sets access by function. This annex collects the access dimensions that the Manual already sets in other chapters, and lists the dimensions that it does not set. Where a dimension is not set by the Manual, the designer shall state it on the drawings, show that it suits the plant and equipment named in the O&M plan (Clause 10.11.1(h)), and mark it "to be confirmed in design".

Table 10C.1 — Access dimensions set by the Manual

Element	Requirement	Clause
Open drains with a top width of 2 m or more	Maintenance access strip at least 3.5 m wide along one bank, connected to a public road at intervals of not more than 500 m	6.9.4
Drainage reserves	Width not less than Table 6.9, based on the required drain size; where the access strip of Clause 6.9.4 is wider, the wider governs	6.9.7
Covered drains, minimum section	0.6 m × 0.6 m clear	6.7.6
Covered drains, removable covers	Panels at not more than 10 m centres, each at least 0.6 m long and spanning the full clear width, liftable by two workers or a hand-operated device	6.13.2(a)
Covered drains, access chambers	Clear opening at least 0.6 m × 0.6 m at every junction, bend and change of section, and at not more than 30 m centres on straight runs	6.13.2(b)

Element	Requirement	Clause
Manholes and access chambers on public drains	Clear access opening at least 600 mm	9.12.3
Inlet chambers on public roads	Silt sump at least 300 mm deep below the outlet pipe invert, cleanable from the surface	6.6.7
Underground tanks and vaults	Access openings over the outlet chamber and over every inlet; in tanks over 500 m², not more than 30 m apart; floor falling at least 1% to a sump at the outlet	4.10.2(b), (c)
Detention outlets serving more than 1 ha	A means of isolating the outlet (stop-log slot or penstock)	4.8.6
Outfall gates	Stop-log slot or penstock upstream on outfalls larger than 600 mm (Chapter 5) and on outfalls of 900 mm or more or serving a pumped or storage system (Chapter 9); the gate chamber accessible at all tides, with its access above HAT + surge + sea-level allowance	5.11.3(d), (e); 9.10.3
Pump stations	Maintenance vehicle access usable in the 1% AEP event; hard standing and a quick-coupling connection for mobile pumps; clear space between adjacent pumps or motors of 0.6 m (small and medium units) or 1.0 m (large units)	9.9.6, 9.9.10, 9.9.12
Pretreatment devices	Cleanable without entering or disturbing the main BMP	8.5.4
Screens at outfalls, culvert inlets and pump sumps	Cleanable from a safe platform, with vehicle access	8.10.3(d)
Infiltration trenches	Observation well to the base of each trench	8.7.6(c)
Publicly accessible storage	Side slopes no steeper than 4H:1V, with at least a quarter of the perimeter at 6H:1V or flatter	4.15.1(c)
Wet basins	Safety bench at least 3 m wide, no more than 0.3 m below normal water level	4.15.2
Fencing	At least 1.2 m high, non-climbable, with a lockable gate, where Clause 4.15.3 requires it	4.15.3

Table 10C.2 — Access dimensions not set by the Manual (to be confirmed in design)

Element	What the designer shall state	Clause setting the function
Vehicle access route to the inlet, outlet and base of a basin, pond or open channel	Width, gradient, turning space and design load for the plant in the O&M plan	10.13.2
Maintenance strip beside a basin or pond	Width along at least one side	10.13.2
Ramp into a basin	Width, gradient and surface for the sediment-removal plant	10.13.2
Access openings of private tanks	Clear size of each opening over the inlet, outlet and each chamber	10.13.3(a)
Ladders and steps	Type and spacing; ventilation for confined-space entry	10.13.3(b)
Headroom in underground tanks	Clear height for manual cleaning	10.13.3(d)
Reach to orifices and screens	How the outlet is cleaned without entering a full facility	10.13.4

> **Commentary.** APWA 5600 (2006, §5608) required a maintenance access strip of 15 ft (about 4.5 m) for detention facilities. The Manual did not adopt a fixed width for private sites, because plot sizes in Arunachal Pradesh cities vary widely (Clause 10.13, Commentary). The State Stormwater Technical Committee may add standard values to Table 10C.2 when it issues the standard drawings of Annexes 6C and 9B.

Annex 10D — Model O&M plans by facility type

Supports Clauses 10.11, 10.12 and 10.13 of Chapter 10.

The model plans below are starting points. The designer adapts them to each facility and completes the items marked "_____". Inspection frequencies are the minimum frequencies of Table 10.3; a plan may set more frequent inspection, never less. Where this annex leaves a value to the designer, the Manual does not set it.

10D.1 Contents of every O&M plan

Every plan shall contain the items of Clause 10.11.1:

Table 10D.1 — Contents of an O&M plan

Item	Content	Clause
1	Inventory and plan drawing of each facility, with design levels, volumes and outlet details (from SW_FAC, Annex 10B)	10.11.1(a)
2	Routine tasks and their frequency (Tables 10D.2 to 10D.8)	10.11.1(b)
3	Trigger for sediment removal, as a depth (mm) or a percentage of design volume: _____	10.11.1(c)
4	Inspection checklist matching Form 10-7	10.11.1(d)
5	For pumps, gates and valves: operating rules, test schedule, standby power, and actions on a cyclone or heavy-rainfall warning	10.11.1(e)
6	Actions against standing water and mosquito breeding, consistent with the drawdown times of Clause 4.7	10.11.1(f)
7	Safety: confined spaces, deep water, public access	10.11.1(g)
8	Access routes and equipment (Annex 10C)	10.11.1(h)
9	Annual cost estimate (₹ _____ per year) and who pays it	10.11.1(i)
10	Records to be kept, and for how long: _____ years (pump records at least 5 years, Clause 9.9.8(c))	10.11.1(j)

10D.2 Model plans

Table 10D.2 — Retention and infiltration (soakaways, trenches, bioretention, permeable paving)

Task	Frequency	Standard or trigger	Clause
Inspect surface, inlets, pretreatment and overflow	Every 6 months; before 31 March; after each heavy-rainfall day	No blockage; overflow clear	Table 10.3
Check drawdown at the observation well or surface	At each inspection after rain	Empties within 72 h of the end of rain; if not, investigate clogging	4.4.5, 8.7.6(c)
Clean pretreatment (forebay, filter strip, silt trap)	When the sediment trigger (item 3) is reached	Pretreatment cleaned without disturbing the main BMP	8.5.3, 8.5.4

Task	Frequency	Standard or trigger	Clause
Bioretention: mulch, plants, ponding	Every 6 months	Ponding drains within 48 h; dead plants replaced; mulch 50–75 mm	8.7.2
Permeable paving: surface	Every 6 months	Sweep or vacuum; no resurfacing with impermeable material	8.7.5(e)
Keep the contributing area stable	Each inspection	Bare soil stabilised; no sediment washing in	10.8.3(b)
Keep the facility in place and in use	Each inspection	Not filled, covered, paved or built over without approval	10.10.1(d)

Table 10D.3 — Surface detention basin or multi-use open space area

Task	Frequency	Standard or trigger	Clause
Inspect inlets, outlet, orifice, trash rack and spillway	Every 6 months; before 31 March; after each heavy-rainfall day	Orifice and rack clear; spillway unobstructed	Table 10.3, 4.8, 4.9
Remove debris and sediment	When the sediment trigger is reached, and after events	Design volume restored	10.11.1(c)
Check that the basin drains	After rain	No low point ponds for more than 72 h	4.15.7
Vegetation	As set in the plan	Grass cut; no woody growth on embankments or in the outlet zone	10.11.1(b)
Safety features	Every 6 months	Signs in the local language and English and a depth marker in place; fences and gates sound where required	4.15.3, 4.15.5
Embankment (if any)	Every 6 months and after events	No cracks, slips, seepage or animal burrows	4.9.6

Table 10D.4 — Underground or podium detention tank, gravity outlet

Task	Frequency	Standard or trigger	Clause
Inspect from the access openings: inlets, outlet, orifice, screen, sump, vents	Every 6 months; before 31 March; after each heavy-rainfall day	Clear; vents open	Table 10.3, 4.10.2
Clean the sump and floor	When the sediment trigger is reached	Floor falls freely to the sump	4.10.2(c)
Inlet silt trap or GPT	Every 3 months (Table 10.3 row for GPTs)	Cleaned	4.10.2(e)
Overflow route	Each inspection	Operates when the outlet is blocked; route to the overland path unobstructed	4.9.5
Confined-space entry	Each entry	Entry procedure stated in the maintenance declaration followed; covers locked after	4.15.6
Use of the space	Each inspection	Not used for parking or storage; volume not reduced	10.10.1(d)

Table 10D.5 — Pumped detention, pumps and controls

Task	Frequency	Standard or trigger	Clause
Test run of each pump, duty and standby	Monthly	Each pump starts on level control; roles alternate	Table 10.3, 9.9.4(c)
Full duty test	Before 31 March	Station meets its design duty point	Table 10.3, 10.9.3
Standby power	Monthly with the test run; full test before 31 March	Automatic changeover works; fuel for at least 72 h of all duty pumps on site	9.9.9
Level sensors, float back-up, alarms, telemetry	Monthly	High-level and fault alarms reach the control room	9.9.8
Screens and silt trap	Every 3 months and after events	Clean	9.9.7
Records	Continuous	Sump levels, run hours and power status logged; kept at least 5 years	9.9.8(c)
Warning actions	On an IMD heavy-rainfall or cyclone warning	Actions written in the plan: _____ (for example staff on site, fuel topped up, mobile pump connection checked)	10.11.1(e), 9.9.12

Table 10D.6 — Flap or tide gate, non-return valve

Task	Frequency	Standard or trigger	Clause
Inspect and operate	Every 3 months; after each heavy-rainfall day	Opens at a small head; no debris, sand or growth holding it	Table 10.3, 9.10.4
Seal test	Before 31 March	Seals against the receiving water	Table 10.3, 10.9.3
Beach, estuary and creek outfalls	After every high-tide or surge event in the monsoon season	Sand and debris cleared	9.10.5(b)
Isolation	Before 31 March	Stop-log slot or penstock operable	9.10.3
Hinges, pins and fixings	Before 31 March	No corrosion that would stop the gate working	9.10.6
Property non-return valves	Every 3 months	Cleaning eye accessible; valve seals	5.11.4

Table 10D.7 — Gross pollutant trap or first-flush device

Task	Frequency	Standard or trigger	Clause
Inspect and empty	Every 3 months; before 31 March; after each heavy-rainfall day	Emptied before the capture chamber is full; bypass clear	Table 10.3, 8.4.6
Screens	Each inspection	Clean; overflow path clear	8.10.3(b)
Disposal	Each cleaning	Material taken to an authorised solid-waste facility	—

Table 10D.8 — Private drains and inlets

Task	Frequency	Standard or trigger	Clause
Inspect and clean drains, inlets and silt sumps	Every 6 months; before 31 March	Free of silt and debris	Table 10.3

Task	Frequency	Standard or trigger	Clause
Check for sewage connections	Each inspection	None; any cross-connection removed	1.5.4, 8.9
Overland flow paths	Each inspection	Not obstructed by walls, fill or stored material	6.9.2, 10.15.1(g)

Annex 10E — Empanelment criteria for Stormwater Design Professionals and reviewers

Supports Clauses 10.6, 10.7.4 and 11.4.3 of Chapter 10.

> *Model text for consideration by a competent authority. Not in force.* Clause 10.6.2 assigns the issue of empanelment criteria to Urban Affairs. The text below is a model. Values shown as "[ ]" are for the competent authority to set; the Manual does not set them.

10E.1 Model criteria

1. **Lists.** The competent authority shall keep three public lists:
    - (a) **Stormwater Design Professionals**, who may sign designs under Clause 10.6.1 and act as independent checkers under Clause 10.6.4;
    - (b) **Empanelled Reviewers**, who may review submittals for an Authority under Clause 10.7.4; and
    - (c) a **basin modelling endorsement**, held by a Stormwater Design Professional who may prepare or direct a BSMP under Clause 11.4.3.
2. **Eligibility for list (a).** An applicant shall:
    - (a) hold a degree in civil engineering, or an equivalent qualification recognised by the competent authority (Clause 10.6.2);
    - (b) be registered as a professional under the Arunachal Pradesh Building Bye-Laws, 2019 (Clause 1.4);
    - (c) have at least [ ] years of experience in drainage design after graduation, shown by a list of at least [ ] projects with the applicant's role in each (Clause 10.6.2); and
    - (d) have completed a training course on this Manual, with an assessment, within the [ ] years before application (Clause 10.6.2).
3. **Eligibility for list (b).** As for list (a), with at least [ ] years of experience, of which at least [ ] years in the design or review of drainage under this Manual or an equivalent standard.
4. **Basin modelling endorsement (c).** A Stormwater Design Professional who shows experience in basin-scale 1D–2D modelling, including calibration, on at least [ ] studies (Clause 11.4.3).
5. **Independence of a checker.** A checker under Clause 10.6.4 shall not be employed by, or a partner of, the designer's firm or the Applicant, and shall not have worked on the design.
6. **Conflict of interest of a reviewer.** An Empanelled Reviewer shall not review a site on which the reviewer, or the reviewer's firm, has worked in any capacity (Clause 10.7.4), and shall declare any other interest before accepting a review. The Authority remains the decision-maker (Clause 10.7.4).
7. **Application.** The application shall include proof of degree and registration, the project list with references, the training certificate, and a signed declaration that the information is true.
8. **Term and renewal.** Empanelment is valid for [ ] years. Renewal requires evidence of continuing practice and of any refresher training issued after a revision of the Manual (Clause 1.12).
9. **Suspension and removal.** The competent authority may suspend or remove an empanelled person after a false or negligent certificate (Clause 10.6.5), on a report under step 6 of Table 10.4, or on loss of registration. The person shall be given notice and an opportunity to be heard. Every suspension and removal shall be published on the list.
10. **Publication.** The lists shall be published and kept current, with each person's name, registration number, list, endorsement and validity date.

Form 10-1 — Drainage Report Checklist

Supports Clauses 10.4.1 to 10.4.4 and 10.7.1 of Chapter 10.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Lodge with every Stage 1 and Stage 2 submittal. For each item give the page or sheet where it is addressed, or the reason it does not apply. The Authority does not start technical review without a completed Form 10-1 (Clause 10.4.3).

Table 10F.1 — Form 10-1, Section A: Submittal

No.	Field	Entry
A1	Authority and file number	_____
A2	Site name and address; survey numbers	_____
A3	Stage: 1 / 2 / combined 1 and 2 (Clause 10.3.3) / public work DPR or tender (Clause 10.3.4)	_____
A4	Applicant	_____
A5	Certifying professional (name, registration and empanelment number)	_____

Table 10F.2 — Form 10-1, Section B: Stage 1 contents (Clause 10.4.1)

No.	Item	Clause	Page / sheet	Not applicable: reason
B1	Form 1-1; Form 1-2 where a variance or waiver is sought	10.4.1(a)	_____	_____
B2	Site plan: existing and proposed levels, impervious areas, catchment boundaries to and through the site	10.4.1(b)	_____	_____
B3	Soils (HSG), seasonal high groundwater, infiltration tests or test plan	10.4.1(c)	_____	_____
B4	Design Rainfall Sheet (Form 2-1)	10.4.1(d)	_____	_____
B5	Pre-development condition and hydrologic method	10.4.1(e)	_____	_____
B6	Order of measures: areas preserved, retention method, detention concept, conveyance	10.4.1(f)	_____	_____
B7	Preliminary retention, WQ and detention volumes and release rates, with Form 10-2	10.4.1(g)	_____	_____
B8	Downstream extent and tailwater case	10.4.1(h)	_____	_____
B9	Waterbodies, setbacks and the 1% AEP level	10.4.1(i)	_____	_____
B10	Land reserved for facilities and maintenance access	10.4.1(j)	_____	_____
B11	Professional Design Certificate (Form 10-3)	10.4.5	_____	_____

Table 10F.3 — Form 10-1, Section C: Stage 2 contents (Clause 10.4.2)

No.	Item	Clause	Page / sheet	Not applicable: reason
C1	Updated Stage 1 contents (Section B)	10.4.2	_____	_____
C2	Final calculations for every storage duration and AEP, with the outfall-closed check	10.4.2(a)	_____	_____

No.	Item	Clause	Page / sheet	Not applicable: reason
C3	Stage–storage–discharge tables; emergency spillway design	10.4.2(b)	_____	_____
C4	Hydraulic design of conveyance, inlets and structures	10.4.2(c)	_____	_____
C5	Water quality design; first-flush device or GPT where required	10.4.2(d)	_____	_____
C6	Construction drawings, details and specifications of every facility	10.4.2(e)	_____	_____
C7	Construction sequence, with protection of retention and infiltration areas	10.4.2(f)	_____	_____
C8	Hold-point schedule (Form 10-4, Section A)	10.4.2(g)	_____	_____
C9	Draft O&M plan and draft Maintenance Declaration (Form 10-6)	10.4.2(h)	_____	_____
C10	Model input files and GIS data	10.4.2(i)	_____	_____
C11	Certificates (Form 10-3, signed by designer and, where required, checker)	10.4.2(j)	_____	_____

Table 10F.4 — Form 10-1, Section D: Digital submittal (Clause 10.4.4)

No.	Item	Clause	Provided (yes / no)	Detail
D1	Reports and drawings as searchable PDF	10.4.4(a)	_____	_____
D2	Models in native, runnable format; software name and version	10.4.4(b)	_____	_____
D3	GIS data to Annex 10B; horizontal reference system (EPSG code)	10.4.4(c)	_____	_____
D4	Vertical datum named; relationship to the Chapter 5 river datums of the CWC sites on the Siang at Pasighat, the Noa-Dihing at Namsai and the Lohit at Tezu (levels as transcribed by SANDRP, on a datum not stated [TBC]), of any gauge or staff gauge on the Senki, the Pachin and the Dikrong in the capital and on the Dibang at Roing (none with a published datum was found [TBC]), of the reservoir and release levels of the Pare, Ranganadi, Kameng and Lower Subansiri projects (not found on a named datum [TBC]), and of the flood marks surveyed on ungauged streams, nallahs and ponds	10.4.4(d)	_____	_____

Table 10F.5 — Form 10-1, Section E: Declaration and completeness check

Field	Entry
I confirm that this checklist is complete and correct. Certifying professional: name, signature, date	_____
For the Authority: date received	_____
Date of completeness check (within 5 working days, Clause 10.7.1)	_____
Result: accepted for review / returned	_____
Missing items, if returned	_____
Officer: name, designation, signature	_____

Form 10-2 — Compliance Calculator Summary

Supports Clauses 10.4.1(g), 10.5 and 10.9.1(b) of Chapter 10.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Produced by the compliance calculator (Annex 10A) with Stage 1, 2 and 4 submittals. Until the calculator is issued, complete it by hand and enter "not issued" in A3. One column per drainage area where the site has more than one outfall.

Table 10F.6 — Form 10-2, Section A: Site and route

No.	Field	Entry	Clause
A1	Authority, file number, stage (1 / 2 / 4)	_____	10.5.2(a)
A2	Site area, ha; land disturbance, ha; new + replaced impervious area, m²	_____	1.5.2
A3	Calculator version and release date	_____	10.5.3
A4	Tier (A / B); flood-sensitive (yes / no); approved BSMP for the basin (yes / no)	_____	1.6, 4.5.3, 11.12
A5	Route: full method / S-1 / S-2 / fixed-coefficient / constrained redevelopment / regional or fee-in-lieu	_____	1.7, 4.5.6, 4.13, 4.14
A6	Flags raised by the calculator (list)	_____	Annex 10A.4

Table 10F.7 — Form 10-2, Section B: Rainfall and soils

No.	Field	Entry	Clause
B1	Rainfall zone; Form 2-1 reference	_____	2.13
B2	Retention depth P_R, mm; 3-month ARI depth P_3m, mm	_____	2.10, 8.4.1
B3	Climate factor applied (≤ 6 h; > 6–72 h)	_____	2.8
B4	HSG by sub-area; seasonal high groundwater, m below base	_____	3.7, 4.4.3
B5	Measured and design infiltration rates, mm/h	_____	4.4.3

Table 10F.8 — Form 10-2, Section C: Volumes

No.	Quantity	Required (m³)	Provided (m³)	Clause
C1	Retention volume (RRV)	_____	_____	4.4.2
C2	Water quality volume (WQv)	_____	_____	8.4.2
C3	Retention credit against detention	_____	—	4.4.6
C4	Detention volume	_____	_____	4.6, 4.14
C5	Fee-in-lieu or regional volume, and fee (₹)	_____	_____	4.5.6.3, 4.13.3

Table 10F.9 — Form 10-2, Section D: Release rates (each outfall)

AEP	Q_pre or cap (L/s)	Q_post (L/s)	Governing duration (h)	Meets criterion (yes / no)	Clause
50% (2-yr)	_____	_____	_____	_____	4.5
10% (10-yr)	_____	_____	_____	_____	4.5

AEP	Q_pre or cap (L/s)	Q_post (L/s)	Governing duration (h)	Meets criterion (yes / no)	Clause
1% (100-yr)	_____	_____	_____	_____	4.5

Table 10F.10 — Form 10-2, Section E: Outlets, drawdown and stage comparison

No.	Field	Entry	Clause
E1	Low-flow orifice, mm (minimum 50 mm)	_____	4.8.2
E2	Detention: time to release 90% of the 10-yr stored volume, h (≤ 48 h)	_____	4.7.1
E3	WQv release time, h (24–48 h)	_____	4.7.2
E4	Retention emptying time, h (≤ 72 h)	_____	4.7.3
E5	Model result differs from the calculator screen by more than the guide tolerance? If yes, report section that explains it	_____	10.5.2(c)
E6	Stage 4 only: changes from the Stage 2 values (list), and whether every criterion is still met	_____	10.9.2
E7	Prepared by (name, registration number), signature, date	_____	10.6.3(b)

Form 10-3 — Professional Design Certificate

Supports Clauses 10.6.1 to 10.6.5 of Chapter 10.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Signed by the designer with every Stage 1 and Stage 2 submittal, and by an independent checker for facilities under Clause 10.6.1(c) and (d).

Table 10F.11 — Form 10-3, Section A: Project and signatory

No.	Field	Entry	Clause
A1	Authority, file number, stage	_____	—
A2	Site and facilities covered by this certificate	_____	—
A3	Designer: name, qualification, APBBL 2019 registration number	_____	10.6.1
A4	Empanelment number, where required, and the reason: Tier A ≥ 1 ha / flood-sensitive / embankment or high-hazard basin / pumped, tide gate or regional facility	_____	10.6.1(a)–(d)
A5	Variances or waivers approved (Form 1-2 references), or "none"	_____	10.6.3(a)

Table 10F.12 — Form 10-3, Section B: Certificate of the designer

No.	I certify that:	Initials
B1	the design complies with the Arunachal Pradesh Stormwater Design Manual, except for the variances listed at A5, which have been approved	_____
B2	the rainfall, soils and tailwater inputs are as recorded on Form 2-1 and Form 10-2	_____
B3	the models submitted reproduce the results reported	_____
B4	I understand that a false or negligent certificate is a contravention under Clause 10.15	_____

Table 10F.13 — Form 10-3, Section C: Certificate of the independent checker (Clause 10.6.4)

No.	Field or statement	Entry
C1	Checker: name, registration and empanelment number	_____
C2	I am independent of the designer and the Applicant and have not worked on this design	_____
C3	I have checked the facilities listed: _____, and agree with the certificate in Section B	_____
C4	Matters on which I do not agree, if any	_____

Table 10F.14 — Form 10-3, Section D: Signatures

Role	Name	Signature	Date
Designer	_____	_____	_____
Independent checker (where required)	_____	_____	_____

Form 10-4 — Hold-Point Inspection Record

Supports Clauses 10.4.2(g), 10.8 and 10.9.3 of Chapter 10.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Section A is the hold-point schedule, approved at Stage 2. Section B is completed at each hold point, with dated, geotagged photographs (Clause 10.8.2). Work shall not proceed past a hold point until Section B is signed. See Figure 10.2.

Table 10F.15 — Form 10-4, Section A: Hold-point schedule

Hold point	Facility (FAC_ID)	Stage of work	Planned date	Notice to Authority sent (date)*	Authority attended (yes / no)
(a) Excavated base, before media, liner or structure	_____	_____	_____	_____	_____
(b) Outlet structure, orifice and trash screen, before backfill or first filling	_____	_____	_____	_____	_____
(c) Infiltration and verification tests (Clause 10.9.3)	_____	_____	_____	–	_____
(d) Outfall, flap or tide gate and non-return valve, before downstream connection	_____	_____	_____	–	_____
(e) Pumps and controls, at commissioning	_____	_____	_____	–	_____
Other hold points added by the Authority	_____	_____	_____	_____	_____

* For sites under Clause 10.6.1, at least 3 working days' notice of hold points (a) and (b) (Clause 10.8.2).

Table 10F.16 — Form 10-4, Section B: Inspection record (one per hold point)

No.	Field	Entry
B1	Hold point and facility	_____
B2	Date and time of inspection; weather	_____
B3	Inspected by (certifying professional); others present	_____
B4	Approved drawing and revision checked against	_____
B5	Levels, dimensions and materials found, against approved values	_____
B6	For (a): retention and infiltration areas protected from traffic and stockpiles (Clause 10.8.3(a))	_____
B7	For (b): orifice size and invert; screen in place	_____
B8	For (c): infiltration test result and emptying time (≤ 72 h); pump duty point; gate opening and sealing	_____
B9	For (d) and (e): gate type, seating and test; pump commissioning record	_____
B10	Photograph references (dated, geotagged)	_____
B11	Result: released / not released; corrective work required	_____
B12	Corrective work checked (date, by)	_____
B13	Signature of the certifying professional, date	_____

Form 10-5 — As-built Certificate

Supports Clauses 10.9 and 10.3.5 of Chapter 10.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Lodged before the completion certificate. The Authority shall not issue the completion certificate until this form is accepted (Clause 10.9.4).

Table 10F.17 — Form 10-5, Section A: Project and survey

No.	Field	Entry	Clause
A1	Authority, file number; Stage 2 approval reference and date	_____	—
A2	Licensed surveyor: name, licence number, date of survey	_____	10.9.1(a)
A3	Vertical datum	_____	10.4.4(d)
A4	GIS data to Annex 10B, as built (file name)	_____	10.4.4(c)

Table 10F.18 — Form 10-5, Section B: Approved against as built (one block per facility)

Item	Approved	As built	Accepted (yes / no)	Clause
Storage volume at each design level, m³	_____	_____	_____	10.9.2(a)
Outlet dimensions (orifice, weir), mm	_____	_____	_____	10.9.2(b)
Outlet and outfall inverts, m	_____	_____	_____	10.9.2(b)
Spillway or overflow level, m	_____	_____	_____	4.9
Retention volume, m³	_____	_____	_____	4.4

Table 10F.19 — Form 10-5, Section C: Re-run and tests

No.	Field	Entry	Clause
C1	Compliance calculator re-run with as-built values: version, and Form 10-2 (Stage 4) attached	_____	10.9.1(b)
C2	Model re-run with as-built values (where a model was used): file name	_____	10.9.1(b)
C3	Every criterion of Chapters 4 and 5 met on re-run (yes / no; list any not met)	_____	10.9.2(c)
C4	Infiltration retention: measured emptying time, h (≤ 72 h)	_____	10.9.3
C5	Pumps: duty point achieved (flow at head)	_____	10.9.3
C6	Tide gates and non-return valves: shown to open and seal	_____	10.9.3
C7	Deviations, and how corrected or re-certified under Clause 10.3.5	_____	10.9.2

Table 10F.20 — Form 10-5, Section D: Attachments and certificate

No.	Field	Entry
D1	Completed hold-point records (Form 10-4)	_____
D2	Final O&M plan	_____
D3	Executed Maintenance Declaration (Form 10-6) or handover documents (Form 10-8)	_____

No.	Field	Entry
D4	I certify that the facilities listed were built as approved, except as stated at C7, and perform as designed. Certifying professional: name, registration number, signature, date	_____
D5	For the Authority: accepted / returned; officer, date	_____

Form 10-6 — Maintenance Declaration

Supports Clauses 10.10.1, 10.10.2, 10.10.4 and 10.13.1 of Chapter 10.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Model text for consideration by a competent authority. Not in force. Executed by the owner of every private stormwater facility before the completion certificate is issued, and registered so that it runs with the land.

> **Drafting note D10A.1.** The instrument under which this declaration is registered, and the Act that gives the Authority its right of entry and its power to carry out works in default, are to be confirmed by the competent authority. This form does not cite statute sections.

Table 10F.21 — Form 10-6, Section A: Parties and land

No.	Field	Entry
A1	Owner (the declarant): name and address; for a company or association, its registration number	_____
A2	Authority	_____
A3	Land: survey numbers, village, circle, district; extent	_____
A4	Approval reference (file number, Stage 2 approval date)	_____
A5	For multi-owner developments: the association or body that takes over after the developer (Clause 10.10.2)	_____

Table 10F.22 — Form 10-6, Section B: Schedule of facilities

Facility (FAC_ID)	Type	Location on the attached plan	Design volume (m³)	Outlet	O&M plan reference
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Model declaration. I/We, the owner named in Section A, declare and undertake, for myself/ourselves and for every successor in title to the land:

1. to operate, inspect and maintain each facility in Section B under the approved O&M plan, and to make the inspections of Clause 10.12 (Clause 10.10.1(b));
2. to give the Authority, its officers and its contractors a right of entry to inspect each facility and the access route shown on the plan, and to carry out works in default under Clause 10.15, with the cost recoverable from the owner (Clause 10.10.1(c));
3. not to remove, fill, cover, reduce or change the use of any facility, or obstruct its access route, without the Authority's written approval (Clauses 10.10.1(d), 10.13.5);
4. where Clause 10.10.3 applies, to lodge an Annual Maintenance Declaration and Inspection Report (Form 10-7) by 31 March each year;
5. for underground tanks, to follow the confined-space entry procedure stated here: _____ (Clause 4.15.6);
6. on sale or transfer of the land or any part of it, to disclose this declaration and the latest Form 10-7 to the purchaser, who takes on these obligations from the date of transfer (Clause 10.10.4); and
7. for a multi-owner development, that the developer remains responsible until the body named at A5 is legally constituted and has accepted this declaration in writing (Clause 10.10.2).

Table 10F.23 — Form 10-6, Section C: Execution and registration

Field	Entry
Owner: signature, name, date	_____
Witness 1: signature, name, address	_____
Witness 2: signature, name, address	_____
Acceptance by the association or body at A5 (when constituted): signature, date	_____
Registration: office, document number, date	_____
For the Authority: received and recorded in the facility register; officer, date	_____

Form 10-7 — Annual Maintenance Declaration and Inspection Report

Supports Clauses 10.10.3, 10.11.1(d) and 10.12 of Chapter 10.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Due by **31 March** each year from every owner of a facility in a Tier A area, and from every owner of a pumped facility, tide gate or regional facility anywhere (Clause 10.10.3). See Figure 10.3.

Table 10F.24 — Form 10-7, Section A: Owner and facilities

No.	Field	Entry
A1	Reporting year (1 April to 31 March)	_____
A2	Owner or association; Maintenance Declaration registration reference	_____
A3	Facilities covered (FAC_ID and type)	_____
A4	Any facility under Clause 10.6.1(c) or (d) (yes / no). If yes, Section E is required	_____

Table 10F.25 — Form 10-7, Section B: Inspections made during the year (Table 10.3)

Facility	Routine inspections (dates)	Pre-monsoon inspection (date)	After heavy-rainfall events (dates)	Monthly pump test runs (number)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Table 10F.26 — Form 10-7, Section C: Pre-monsoon checklist (one per facility)

No.	Item	Condition (OK / defect)	Defect and date corrected
C1	Inlets, pretreatment and silt traps clear	_____	_____
C2	Orifice, trash screen and outlet clear; orifice size unchanged	_____	_____
C3	Sediment below the trigger in the O&M plan	_____	_____
C4	Storage volume not reduced; no filling, covering or change of use	_____	_____
C5	Overflow and spillway route clear	_____	_____
C6	Retention drains within 72 h (observation well or surface)	_____	_____
C7	Pumps: full duty test; standby pump and standby power tested; fuel for 72 h on site	_____	_____
C8	Alarms and telemetry tested	_____	_____
C9	Flap or tide gates and non-return valves: operated and seal tested	_____	_____
C10	Safety: covers locked, fences, signs and depth markers in place	_____	_____
C11	Access routes clear and not used for parking	_____	_____

Table 10F.27 — Form 10-7, Section D: Declaration of the owner

Field	Entry
I/We declare that the pre-monsoon inspection of Clause 10.12 has been made, that the defects found have been corrected as listed in Section C, and that the facilities are maintained under the approved O&M plan. Owner: name, signature, date	_____

Table 10F.28 — Form 10-7, Section E: Empanelled professional (facilities under Clause 10.6.1(c) and (d))

Field	Entry
I have inspected the facilities listed and confirm Section C. Name, empanelment number, signature, date	_____

Table 10F.29 — Form 10-7, Section F: For the Authority

Field	Entry
Date received; on time (by 31 March) yes / no	_____
Entered in the facility register (Clause 10.17), date	_____
Follow-up action, if any (Clause 10.15)	_____

Form 10-8 — Asset Handover Certificate

Supports Clause 10.14 of Chapter 10.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Signed by the developer and the ULB when drains, open space facilities, regional facilities or other stormwater assets built by a developer are handed over.

Table 10F.30 — Form 10-8, Section A: Asset and parties

No.	Field	Entry
A1	Developer: name and address	_____
A2	ULB	_____
A3	Layout or project, approval reference	_____
A4	Assets handed over (FAC_ID, type, length or volume), with a plan	_____

Table 10F.31 — Form 10-8, Section B: Conditions of handover (Clause 10.14.1)

No.	Condition	Met (yes / no)	Reference or date
B1	As-built certificate (Form 10-5) accepted	_____	_____
B2	Facility cleaned; pipes and culverts inspected internally (CCTV or manual entry), record handed over	_____	_____
B3	Land, or an easement over it, transferred to the ULB	_____	_____
B4	O&M plan, drawings, GIS data (Annex 10B) and warranties handed over	_____	_____

Table 10F.32 — Form 10-8, Section C: Defects liability and register

No.	Field	Entry	Clause
C1	Defects liability period: from _____ to _____ (includes at least one full monsoon season, from 1 April to 31 October, after handover)	_____	10.14.2
C2	Developer responsible during the period for defects and routine maintenance	_____	10.14.2
C3	Security deposit held by the ULB, ₹, and release date	_____	10.14.2
C4	Entered in the ULB GIS drainage asset register and the facility register: date	_____	10.14.3

Table 10F.33 — Form 10-8, Section D: Signatures

Party	Name and designation	Signature	Date
Developer	_____	_____	_____
Certifying professional	_____	_____	_____
ULB	_____	_____	_____

ANNEXES TO CHAPTER 11

Basin and City Stormwater Master Plans

These annexes support Chapter 11. They give a terms of reference template for a Basin Stormwater Master Plan (BSMP), the layout of the basin list and boundary layer, the layout and method for depth–damage curves, the standard for publishing BSMP data and models, and the annual implementation report form. Annexes 11B and 11C need data that are not yet available; they say so and give the rule to use in the meantime. The template and the form are a model and a draft form for consideration by a competent authority, and are not in force.

Annex 11A — BSMP terms of reference template

Supports Clauses 11.1 to 11.12 of Chapter 11.

> *Model text for consideration by a competent authority. Not in force.* The Lead Authority adapts this template for each basin. Items in "[ ]" are for the Lead Authority to complete. Clause references are to this Manual, which the consultant shall follow in full.

11A.1 Background and purpose

1. The [Lead Authority] intends to prepare a Basin Stormwater Master Plan for the [name] basin under Chapter 11 of the Arunachal Pradesh Stormwater Design Manual.
2. The BSMP shall (Clause 11.1.2):
    - (a) map flood hazard for the basin under existing and future conditions;
    - (b) set the level of service for each part of the drainage system;
    - (c) identify, cost and rank the works, storage and land needed to reach that level of service;
    - (d) identify land to be reserved in the statutory land-use plan for regional storage, pond and tank restoration and major flow paths;
    - (e) set the basin inputs for site design: regional facilities, the fee-in-lieu unit rate, and any basin release rate stricter than Chapter 4; and
    - (f) recommend catchments for notification as flood-sensitive.
3. The BSMP may make the site criteria of Chapters 4 to 8 stricter for the basin. It shall not relax them, except through the regional detention and fee-in-lieu routes of Clauses 4.13 and 4.5.6 (Clause 11.1.3).

11A.2 Client, partners and study area

1. **Client:** [Lead Authority] (Clause 11.4.1).
2. **Partners:** WRD, wherever the basin includes a river, canal or tank under its control, and [other local bodies, the Itanagar Planning Authority or Urban Affairs, APSDMA] (Clause 11.4.1).
3. **Study area:** the whole of the [name] basin, draining to [outfall], as delineated under Clause 11.3, including the parts outside the client's limits (Clause 11.3.1). The provisional boundary is in [Annex 11B / attached map]. The consultant shall confirm it in Task 2.

4. **Links to other basins:** [for example the receiving river, stream, nallah, pond or reservoir corridor]. Diversions between basins by canal, drain or surplus course shall be mapped and represented in the model (Clause 11.3.2).

11A.3 Team

1. The study shall be led by an engineer empanelled as a Stormwater Design Professional with the basin modelling endorsement of Annex 10E (Clause 11.4.3).
2. The team shall include at least: [a hydrologist; a hydraulic modeller; a coastal or tidal specialist where the basin has a tidal outfall; a GIS and survey lead; a planner; a cost engineer; a community engagement lead]. The client sets the minimum qualifications and experience of each.

11A.4 Tasks

Task 1 — Inception. Review existing studies, data and projects in the basin. Prepare a data inventory against Table 11.1, a gap list, a survey plan, a consultation plan, and the work programme. Deliver the inception report.

Task 2 — Data and surveys. Assemble, survey where missing, and quality-check every item of Table 11.1 (Clause 11.5.1):

- (a) terrain: DEM from LiDAR or photogrammetry with vertical accuracy of 0.15 m RMSE or better in urban areas, tied to the Survey of India datum, with the accuracy test reported;
- (b) drain network: every public drain, culvert and outfall, with invert levels, sizes, condition and silt depth; private drains above 600 mm;
- (c) waterbodies: every tank, pond, pond and marsh under Chapter 7: FTL, MWL, bund level, stage–storage, sluices, surplus weirs, supply channels and encroachment, in the fields of Annex 7A;
- (d) rivers and canals: cross-sections at no more than 200 m spacing and at every structure;
- (e) outfalls, rivers, streams, nallahs, ponds and reservoirs: outfall invert levels, on a named datum, against a surveyed level of the receiving river at the outfall, with the CWC danger level and highest flood level for the Siang at Pasighat, the Noa-Dihing at Namsai and the Lohit at Tezu on CWC's datum once stated [TBC] and the Pasighat HFL marked as an outburst stage, surveyed flood marks for the Senki, the Pachin, the Dikrong and the Dibang, which have no CWC site in the towns, any local gauge kept as a separate series and any conflict between published values stated; for ungauged hill streams and nallahs, surveyed flood marks and the 1% AEP level with its sediment, debris and bulking; for outfalls on release reaches, the operator's levels, spillway and gate data and release records, and ponds at their surveyed spill levels; the glacial lakes, landslide dams, debris fans and landslide hazards above the basin; and flap gates, penstocks, debris racks, screens, silt traps, debris basins and any pumping stations on the outfalls, with their capacities and operating rules;
- (f) rainfall and water levels: all available records (IMD, including the network reported by the Meteorological Centre Itanagar, whose automatic weather stations and rain gauges were not listed in any source found [TBC], and the IMD stations at Pasighat (42220), Tezu (01203), Ziro (42312, printed "Zero") and Hayuliang (01212, rain records 1971–1985); the daily gauge of NERIST at Doimukh (1988–2012); the State ordinary gauges used in the CWC Flood Estimation Report for subzone 2(a), which are not named on the pages read [TBC]; the CWC sites on the Siang, the Noa-Dihing, the Lohit, the Subansiri and the Ranganadi; the rain and reservoir records of NEEPCO and NHPC at the Pare, Ranganadi, Kameng and Lower Subansiri projects [TBC]; and any gauges or sensors kept by the Itanagar Municipal Corporation, the Pasighat Municipal Council, the Smart City companies, WRD and the Arunachal Pradesh State Disaster Management Authority (APSDMA) [TBC]), including the September 2018 (the Modirijo and Donyi Polo floods in Itanagar–Naharlagun on or about 14 September, with 3 dead and at least 4 missing in early reports and up to 7 dead in later ones, a conflict, the Senki View culvert and the Press Colony bridge washed away, as reported, and no rainfall value found), 23 June 2024 (Itanagar and Naharlagun, with 66 houses inundated, as reported, and 40 mm between 10:30 and 12:30 "As per IMD", as quoted from the secretary of the State's disaster management authority, who said that IMD "confirmed there was no incident of cloudburst"), July 2024 (the reported Itanagar "cloudburst" of about 28 July, with NH-415 submerged and homes near Energy Park and Bank Tinali flooded, as reported, its date in conflict between dateline and publication and

kept apart from 23 June, and no rainfall value found), late May to 7 June 2025 (the statewide floods and landslides, with 12 dead by one count and 9 to 11 by others, a conflict, and a peak release of 1,310 m³/s from the Pare dam on 31 May, all as reported, with only press values of rain), 24 June 2025 or 2026 (the Poosa / NEEPCO colony flood at Yazali, dated 2026 by one report and 2025 by another, a conflict, with 73 mm in 24 hours, mostly in 3 hours, as reported) and the 2017 monsoon (the capital's floods that damaged the protection walls of nallahs and closed NH-415, recorded in the Master Plan of Itanagar Capital Region-2031, with no rainfall value found) events;

- (g) flood evidence: surveyed flood marks and mapped extents of past events, including public reports, photographs and residents' records;
- (h) land use: existing land use and imperviousness; future land use from the statutory master plan;
- (i) soils and groundwater: HSG map (Annex 3A or Clause 3.7.2), seasonal high groundwater, aquifer and recharge zones; and
- (j) sewer interaction: known cross-connections, dry-weather flow in drains, solid-waste hotspots.

Confirm the basin boundary and the inter-basin diversions (Clause 11.3.2). Deliver the data report and the data in the formats of Annex 11D.

Task 3 — Model build. Build a coupled 1D–2D hydraulic model of the minor system, the major (overland) system, rivers, canals and tanks, and the outfalls (Clause 11.7.1; Figure 11.2). Use the methods of Chapter 3 and the tidal and river boundaries of Chapter 5. Run the design storms of Chapter 2, including the 24-, 48- and 72-hour storms, for at least the 50%, 10%, 1% and 0.2% AEPs, with areal reduction under Clause 2.7.3 (Clause 11.7.2). Where the basin has tank cascades, run continuous simulation under Clause 3.13 with the full IMD gridded daily record where available, and at least 30 years, disaggregated by the temporal patterns of Annex 2D. The two-step approach of Clause 3.13.5 may be used: starting tank levels and antecedent conditions from the continuous run are passed to the design-storm runs (Clause 11.7.3).

Task 4 — Calibration and validation. Calibrate and validate the model under Clause 3.15, using at least two of the September 2018 (the Modirijo and Donyi Polo floods in Itanagar–Naharlagun on or about 14 September, with 3 dead and at least 4 missing in early reports and up to 7 dead in later ones, a conflict, the Senki View culvert and the Press Colony bridge washed away, as reported, and no rainfall value found), 23 June 2024 (Itanagar and Naharlagun, with 66 houses inundated, as reported, and 40 mm between 10:30 and 12:30 "As per IMD", as quoted from the secretary of the State's disaster management authority, who said that IMD "confirmed there was no incident of cloudburst"), July 2024 (the reported Itanagar "cloudburst" of about 28 July, with NH-415 submerged and homes near Energy Park and Bank Tinali flooded, as reported, its date in conflict between dateline and publication and kept apart from 23 June, and no rainfall value found), late May to 7 June 2025 (the statewide floods and landslides, with 12 dead by one count and 9 to 11 by others, a conflict, and a peak release of 1,310 m³/s from the Pare dam on 31 May, all as reported, with only press values of rain), 24 June 2025 or 2026 (the Poosa / NEEPCO colony flood at Yazali, dated 2026 by one report and 2025 by another, a conflict, with 73 mm in 24 hours, mostly in 3 hours, as reported) and the 2017 monsoon (the capital's floods that damaged the protection walls of nallahs and closed NH-415, recorded in the Master Plan of Itanagar Capital Region-2031, with no rainfall value found) events where data exist (Clause 11.7.5). Report the performance measures of Clause 3.15.4 and the reasonableness check of Clause 3.15.6.

Task 5 — Scenarios and hazard maps. Model the scenarios of Clause 11.7.4: (a) existing; (b) future, uncontrolled; (c) future, controlled; (d) future, with plan; and (e) climate, applied to (a) and (d). Produce flood hazard maps of extent, depth, velocity and hazard class (H1–H6, Chapter 6) for the 10%, 1% and 0.2% AEPs, existing and future-with-plan (Clause 11.8.4(a)).

Task 6 — Level-of-service assessment. Compare scenarios (a), (c) and (d) with the levels of service of Table 11.2 and any stricter levels the client adopts (Clause 11.6.1). Map every shortfall.

Task 7 — Options. Develop options in the order of Clause 11.8.1: protect and restore storage; regional retention and detention, sited by modelling; conveyance; outfall works; property-level protection; non-structural measures. Assess each option for the criteria of Clause 11.8.2: reduction in flood risk (buildings and people flooded, and expected annual damage using Annex 11C); capital and 30-year maintenance cost; land required; effect on the springs and streams that

supply the hill towns and villages, which in Papum Pare discharge 0.43–2 litres a second before the monsoon and of which "most of the springs become dry during dry season" (CGWB), and their recharge areas above the intakes, which this Manual keeps free of paving and of infiltrated road runoff, the stability of hill slopes on Siwalik shale, colluvium, slope debris and fill, where water put into the ground raises the pore pressure, recharge on the tested sandy terrace and valley-fill soils of the Naharlagun–Nirjuli–Doimukh valley and on the coarse bhabar fan heads, the only ground where it is allowed, and not within 30 m of a dug well or spring used for drinking water (Clause 4.11, recharge rule), although groundwater is not short (stage of extraction 0.39%, CGWB 2024, as summarised), the shallow water table of the valley floors and flood plains, and the quality of the groundwater, which carries iron (0.14–0.78 mg/L in the springs of Papum Pare, CGWB), and of the streams, nallahs, ponds and reservoirs that the runoff reaches; effect on downstream basins and the receiving river, stream, nallah, pond or reservoir; and who benefits.

Task 8 — Basin inputs for site design. Where scenario (c) does not meet the level of service, propose basin release rates (m³/s/ha) by AEP and sub-catchment (Clause 11.8.3). Recommend catchments for notification as flood-sensitive, with the evidence of Clause 4.5.4.1. Identify regional facility sites, with storage volumes, land needs and the sites they serve, and compute the fee-in-lieu unit rate, including land, construction and 10 years of maintenance (Clauses 4.13.3, 11.8.4(c), (d)).

Task 9 — Capital Improvement Programme. Rank the works by risk reduction per rupee, with cost, phasing and responsible agency (Clause 11.8.4(e)).

Task 10 — Maintenance and monitoring. Prepare the pre-monsoon maintenance programme: desilting, gate and pump testing, and tank operating rules (Clause 11.8.4(f); Chapters 7 and 10). Specify monitoring needs: new rain gauges, level sensors and flood-mark survey points (Clause 11.8.4(g); Clause 10.16.1).

Task 11 — Land-use integration. Prepare the material for the statutory land-use plan required by Clause 11.9.1: sites to be reserved; the 1% AEP hazard map with the Chapter 7 setbacks; land in hazard classes H5–H6 in the 1% AEP event; and open space locations that can form part of flow paths or regional storage.

Task 12 — Consultation. Publish the draft BSMP for public comment for at least 60 days, with public meetings in each affected local body (Clause 11.10.1). Keep a log of comments and responses.

Task 13 — Final BSMP and publication. Revise the BSMP after consultation. Prepare the package for approval by the State Stormwater Technical Committee, including the model for review (Clause 11.11.1). Publish the data, models, maps and CIP under Annex 11D (Clause 11.10.2).

11A.5 Deliverables

Table 11A.1 — Deliverables

No.	Deliverable	Task	Due (months from start)
D1	Inception report, data inventory and survey plan	1	[ ]
D2	Data report and data sets (Annex 11D)	2	[ ]
D3	Model build report and model files	3	[ ]
D4	Calibration and validation report	4	[ ]
D5	Scenario results, hazard maps and level-of-service assessment	5, 6	[ ]
D6	Options report, with basin inputs for site design	7, 8	[ ]
D7	Draft BSMP with draft CIP, for consultation	9–12	[ ]
D8	Final BSMP, consultation log, approval package and open-data release	13	[ ]

11A.6 Ownership and publication

All data, models, maps and reports produced under these terms are owned by the Lead Authority and shall be published under Annex 11D. The consultant shall not use any software licence, data licence or format that prevents publication, or that prevents a third party from re-running the model with the stated software version.

Annex 11B — Basin lists and boundaries for Tier A bodies

Supports Clauses 11.3 and 11.4 of Chapter 11.

To be prepared. This annex will contain the list of basins for every Tier A body, with a GIS layer of basin boundaries delineated under Clause 11.3.2. It needs the list of Tier A bodies (Annex 1A), a DEM of the accuracy of Clause 11.5.1, flown again over the valley floor of Naharlagun, Nirjuli and Doimukh, the fans of Pasighat, Tezu, Namsai and Roing, the release reaches and the slide-prone slopes after any large flood, landslide or outburst, the drain network of every drain-owning body (the Itanagar Municipal Corporation, the Pasighat Municipal Council and the other local bodies, the Department of Urban Affairs and the Smart City companies for the drains they have built and not handed over, PWD and PWD (Highways), and the communities for the drains on their land), a drain register giving every reach its owner, its land status (community, clan, individual, municipal or Government land), whether it carries sewage or septic overflow, and its outfall, the rivers and anti-erosion works of WRD, the reservoirs and release reaches with the levels, spillway, gates and release records of NEEPCO and NHPC on a stated datum, the CWC sites with their datum, the ponds with their spill levels, the springs and their recharge areas above the town intakes, the glacial lakes that NDMA lists, and the landslide, debris, flood and outburst hazards mapped by the State's disaster management authority and the District Disaster Management Authorities (other likely sources: Survey of India, CWC, CGWB, NIH, the master plan's maps and the Forest Department's wetland truthing). No basin map of any Arunachal Pradesh town was found. Until the annex is published, the basins of the capital (the Senki; the Pachin; the Dikrong with Papu Nallah; the NH-415 corridor; Modirijo and Donyi Polo), of Pasighat on the Siang, Tezu on the Lohit, Namsai and Miao on the Noa-Dihing, Roing on the Dibang, Yazali on the Ranganadi, and the glacial-lake and outburst reaches of Tawang and Dibang Valley, named in Clause 11.3.3, are at least those named there; other Tier A bodies define their basins in their first BSMP (Clause 11.3.3); on the hazard-first sites of Clause 2.3.6(i) the hazard screening of Clause 11.3.3 comes first; and the interim arrangements of Clause 11.12 apply in every basin without an approved BSMP.

Table 11B.1 — Basins named in Clause 11.3.3 (provisional)

Tier A body or area	Basin	Note from Chapter 11
Itanagar (Itanagar Municipal Corporation, with Urban Affairs and the Itanagar Planning Authority; communities for their land, if adopted)	Catchment of the Senki through Itanagar to the Pachin	Senki View culvert (2018) and the lift intake shown; reaches carrying sewage and reaches on community, clan or private land marked; surveyed flood marks and 1% AEP level with debris and bulking as boundary
Itanagar and Naharlagun (as above)	Catchment of the Pachin to the Dikrong near Nirjuli	Palaeochannels and swampy land mapped; Dikrong level at the confluence as boundary
Naharlagun, Nirjuli and Doimukh (as above)	Catchments draining to the Dikrong below the Pare dam, with Papu Nallah	Outfall-closed cases under the interim design tailwater (Clause 5.8.5(a)); river low and river high with the Pare release both modelled; flood marks of 1999–2025
NH-415, Itanagar to Naharlagun	Catchments crossing NH-415	Energy Park, Bank Tinali, Niti Vihar, Abo Tani Colony and earth-cutting sites mapped

Tier A body or area	Basin	Note from Chapter 11
Itanagar (as above)	Modirijo and Donyi Polo catchments	Press Colony bridge and the NH-415 dumping area mapped; hazard screening first
Pasighat (Pasighat Municipal Council, with Urban Affairs; Tier B, flood-sensitive)	Catchments draining to the Siang and its side channels	CWC danger level 153.96 m as design and HFL 157.54 m as check (Clause 5.8.5(c)); Yigong 2000 as the check event; erosion and fan channels mapped
Tezu	Catchments draining to the Lohit	CWC HFL 192.14 m as boundary until a danger level is given [TBC]
Namsai and Miao	Catchments draining to the Noa-Dihing	CWC levels at Namsai and Miao as boundaries
Roing	Catchments draining to the Dibang	No CWC site; 1% AEP model and surveyed flood marks as boundary
Yazali	Side streams on the Ranganadi reach at Yazali	Side streams as hill streams (Clause 5.8.5(b)); Ranganadi release as boundary (Clause 5.8.5(d)); hazard screening first
Tawang and Dibang Valley	Town catchments below NDMA's high-risk glacial lakes	Outburst screening first (Clause 2.3.6(i))
Other local bodies (Tier B)	To be defined in the first BSMP	Clause 11.3.3

Table 11B.2 — Attributes of the basin boundary layer (layout)

Field	Type	Content
BASIN_ID	Text	Basin identifier
NAME_EN, NAME_LOC	Text	Basin name in English and the local language
TIER_A	Text	Tier A body or bodies in the basin
OUTFALL	Text	Outfall to the sea, river or major waterbody (Clause 11.2)
AREA_KM2	Real	Basin area, km²
LEAD_AUTH	Text	Lead Authority (Clause 11.4.1)
PARTNERS	Text	Partners, including WRD where it applies
LINKS	Text	Diversions to and from other basins (Clause 11.3.2)
BSMP_STAT	Text	None / in preparation / draft published / approved
BSMP_DATE	Date	Date of approval of the current BSMP
REVIEW_DUE	Date	Date of the next review (Clause 11.11.2)

Annex 11C — Depth–damage curves for Arunachal Pradesh building types

Supports Clause 11.8.2 of Chapter 11.

To be prepared. This annex will contain depth–damage curves for the main building types of Arunachal Pradesh cities, for structure and contents, for use in computing expected annual damage under Clause 11.8.2. It needs a building-type classification and building stock data (Census housing tables, property-tax records, Lead Authority GIS), damage surveys and claims from the September 2018 (the Modirijo and Donyi Polo floods in Itanagar–Naharlagun on or about 14 September, with 3 dead and at least 4 missing in early reports and up to 7 dead in later ones, a conflict, the Senki View culvert and the Press Colony bridge washed away, as reported, and no rainfall value found), 23 June 2024 (Itanagar and Naharlagun, with 66 houses inundated, as reported, and 40 mm between 10:30 and 12:30 "As per IMD", as quoted from the secretary of the State's disaster management authority, who said that IMD "confirmed there was no incident of cloudburst"), July 2024 (the reported Itanagar "cloudburst" of about 28 July, with NH-415 submerged and homes near Energy Park and Bank Tinali flooded, as reported, its date in conflict between dateline and publication and kept apart from 23 June, and no rainfall value found), late May to 7 June 2025 (the statewide floods and landslides, with 12 dead by one count and 9 to 11 by others, a conflict, and a peak release of 1,310 m³/s from the Pare dam on 31 May, all as reported, with only press values of rain), 24 June 2025 or 2026 (the Poosa / NEEPCO colony flood at Yazali, dated 2026 by one report and 2025 by another, a conflict, with 73 mm in 24 hours, mostly in 3 hours, as reported) and the 2017 monsoon (the capital's floods that damaged the protection walls of nallahs and closed NH-415, recorded in the Master Plan of Itanagar Capital Region-2031, with no rainfall value found) floods (land revenue offices of the Deputy Commissioners and APSDMA damage assessments, insurers), and replacement costs (Public Works Department schedules of rates). Until it is published, each BSMP shall state the depth–damage relations it uses and their source, and shall report the reduction in buildings and people flooded for every option (Clause 11.8.2), which does not depend on the curves.

Table 11C.1 — Depth–damage curve (layout, one table per building type)

Depth of water above floor level (m)	0	0.25	0.5	1.0	1.5	2.0	3.0
Structure damage (% of replacement cost)	_____	_____	_____	_____	_____	_____	_____
Contents damage (% of contents value)	_____	_____	_____	_____	_____	_____	_____
Building type, source and year of costs	_____						

11C.1 Use in option assessment

Expected annual damage (EAD) is computed for each scenario from the damages at the modelled AEPs. With damages D_1, D_2, … at annual exceedance probabilities P_1 > P_2 > …, using at least the 50%, 10%, 1% and 0.2% AEP results of Clause 11.7.2:

> $EAD \approx \sum \tfrac{1}{2} \times (D_i + D_{(i+1)}) \times (P_i - P_{(i+1)})$

The reduction in EAD between scenario (c) and scenario (d), or between options, is the risk-reduction benefit used to rank works per rupee (Clause 11.8.4(e)). The BSMP shall state how damages beyond the 0.2% AEP and below the 50% AEP were treated.

Annex 11D — BSMP data and model publication standard

Supports Clauses 11.5.1 and 11.10 of Chapter 11, and Clause 10.17 of Chapter 10.

11D.1 What is published, and when

Table 11D.1 — Items to be published

Item	Format	At draft (Clause 11.10.1)	At approval (Clause 11.10.2)
BSMP report, with the level-of-service assessment and options	Searchable PDF	Yes	Yes, final
Flood hazard maps: extent, depth, velocity, hazard class, for each AEP and scenario of Clause 11.8.4(a)	GeoTIFF rasters; extents also as GeoPackage polygons	Yes	Yes
Capital Improvement Programme	CSV and PDF	Draft	Yes
Basin release rates, recommended flood-sensitive catchments, regional facility sites, fee-in-lieu unit rate	GeoPackage and CSV	Yes	Yes
Data of Table 11.1 (terrain, drains, waterbodies, cross-sections, river, nallah, pond and reservoir levels, outburst, slope and debris hazards and outfall structures, rainfall and levels, flood evidence, land use, soils and groundwater, sewer interaction)	GeoTIFF (terrain); GeoPackage (features); CSV (tables and time series)	Summary	Yes, except security-sensitive asset details
Model files: native, runnable, with all boundary-condition, rainfall and control files, the software name and version, and a run log	Native format, zipped	No	Yes
Calibration and validation report	Searchable PDF	Yes	Yes
Consultation log of comments and responses	PDF or CSV	—	Yes

11D.2 Formats and references

- (a) Raster data shall be GeoTIFF, preferably cloud-optimised, with the cell size stated. Vector data shall be GeoPackage. Tables and time series shall be CSV in UTF-8, with a header row and units in the column names.
- (b) Horizontal and vertical references shall be as in Annex 10B.1(b) and (c). The vertical datum and its relationship to the Chapter 5 river datums of the CWC sites on the Siang at Pasighat, the Noa-Dihing at Namsai and the Lohit at Tezu (levels as transcribed by SANDRP, on a datum not stated [TBC]), of any gauge or staff gauge on the Senki, the Pachin and the Dikrong in the capital and on the Dibang at Roing (none with a published datum was found [TBC]), of the reservoir and release levels of the Pare, Ranganadi, Kameng and Lower Subansiri projects (not found on a named datum [TBC]), and of the flood marks surveyed on ungauged streams, nallahs and ponds shall be stated in every data set that carries levels.
- (c) Times shall be in Indian Standard Time, written as ISO 8601 (yyyy-mm-ddThh:mm+05:30). Units shall be SI.
- (d) Hazard map files shall be named `<basin>_<scenario>_<AEP>_<variable>.tif`, where scenario is a to e of Clause 11.7.4, AEP is written as 50, 10, 1 or 0p2, and variable is depth, velocity, hazard or extent; for example `senki_d_1_depth.tif`.
- (e) Waterbody data shall use the fields of Annex 7A. Facility and outfall data shall use the fields of Annex 10B.

11D.3 Metadata

Every published data set shall carry: title; description; Lead Authority; source and method; date of capture; accuracy (for the DEM, the measured vertical RMSE); horizontal and vertical reference; scenario and AEP, where relevant; BSMP version; licence; and a contact.

11D.4 Withholding and personal data

- (a) Security-sensitive details of critical assets may be withheld, with the reason recorded and published (Clauses 10.17.3, 11.10.2). The flood hazard maps and the model shall still be published; only the sensitive attributes are removed.
- (b) Personal data shall not be published (Clause 10.17.3). Flood evidence collected from residents shall be published without names or contact details unless the person consents.

11D.5 Licence, viewer and versions

- (a) Published data and models shall be released under the Government Open Data Licence – India or an equivalent open licence (Clause 10.17.4).
- (b) The hazard maps, regional facility sites and CIP shall also be shown on a public map viewer (Clause 11.10.2).
- (c) Each approved BSMP shall carry a version number and date. Superseded versions shall stay available, marked as superseded, so that designs approved under them can be checked.
- (d) The published model package shall allow a third party with the stated software version to reproduce the published results. Designers may use its boundary conditions for site designs in the basin (Clause 11.10, Commentary).

Form 11-1 — Annual implementation report

Supports Clause 11.11.3 of Chapter 11, with Clauses 4.5.6.3 and 4.13.4 of Chapter 4.

Draft form — Arunachal Pradesh Stormwater Design Manual, Draft v1.0. Published by the Lead Authority for each basin with an approved BSMP before each monsoon season, by **31 March** (Clause 11.11.3).

Table 11F.1 — Form 11-1, Section A: Basin and plan

No.	Field	Entry
A1	Basin; Lead Authority; partners	_____
A2	BSMP version and date of approval	_____
A3	Reporting year (1 April to 31 March)	_____
A4	Date of publication (by 31 March) and web address	_____

Table 11F.2 — Form 11-1, Section B: CIP progress

CIP rank	Work	Agency	Cost in CIP (₹)	Spent this year (₹)	Spent to date (₹)	Status	Expected completion
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Table 11F.3 — Form 11-1, Section C: Fee-in-lieu ledger (Clauses 4.5.6.3(c) and 4.13.4)

Regional facility or tank	Volume credited to sites (m³)	Volume delivered (m³)	Fees received (₹)	Fees spent (₹)	Fees held, with year received
_____	_____	_____	_____	_____	_____
Basin total: volume owed and delivered	_____	_____	_____	_____	_____

Table 11F.4 — Form 11-1, Section D: Maintenance completed (Clause 11.8.4(f))

No.	Item	Planned	Done	Date completed
D1	Desilting of drains and canals (length, km; volume, m³)	_____	_____	_____
D2	Tank and pond desilting and restoration (tanks, number; storage restored, m³)	_____	_____	_____
D3	Gate tests (number of gates)	_____	_____	_____
D4	Pump station duty tests (number of stations)	_____	_____	_____
D5	Tank operating rules reviewed with the custodian (number)	_____	_____	_____
D6	Monitoring added: rain gauges, level sensors, flood-mark points (Clause 11.8.4(g))	_____	_____	_____

Table 11F.5 — Form 11-1, Section E: Flooding against the levels of service

Event (dates)	Rainfall compared with the design depths (Clause 10.16.2(a))	Level-of-service element (Table 11.2)	Location	Met (yes / no)	Event report reference (Clause 10.16.2)
_____	_____	_____	_____	_____	_____

Table 11F.6 — Form 11-1, Section F: Review triggers and sign-off

No.	Field	Entry
F1	Event exceeding the 1% AEP design depth in the basin this year (yes / no). If yes, review due within 2 years (Clause 11.11.2)	_____
F2	Statutory land-use plan revised this year (yes / no) (Clause 11.11.2)	_____
F3	Next 10-year review due (date)	_____
F4	Officer of the Lead Authority: name, designation, signature, date	_____