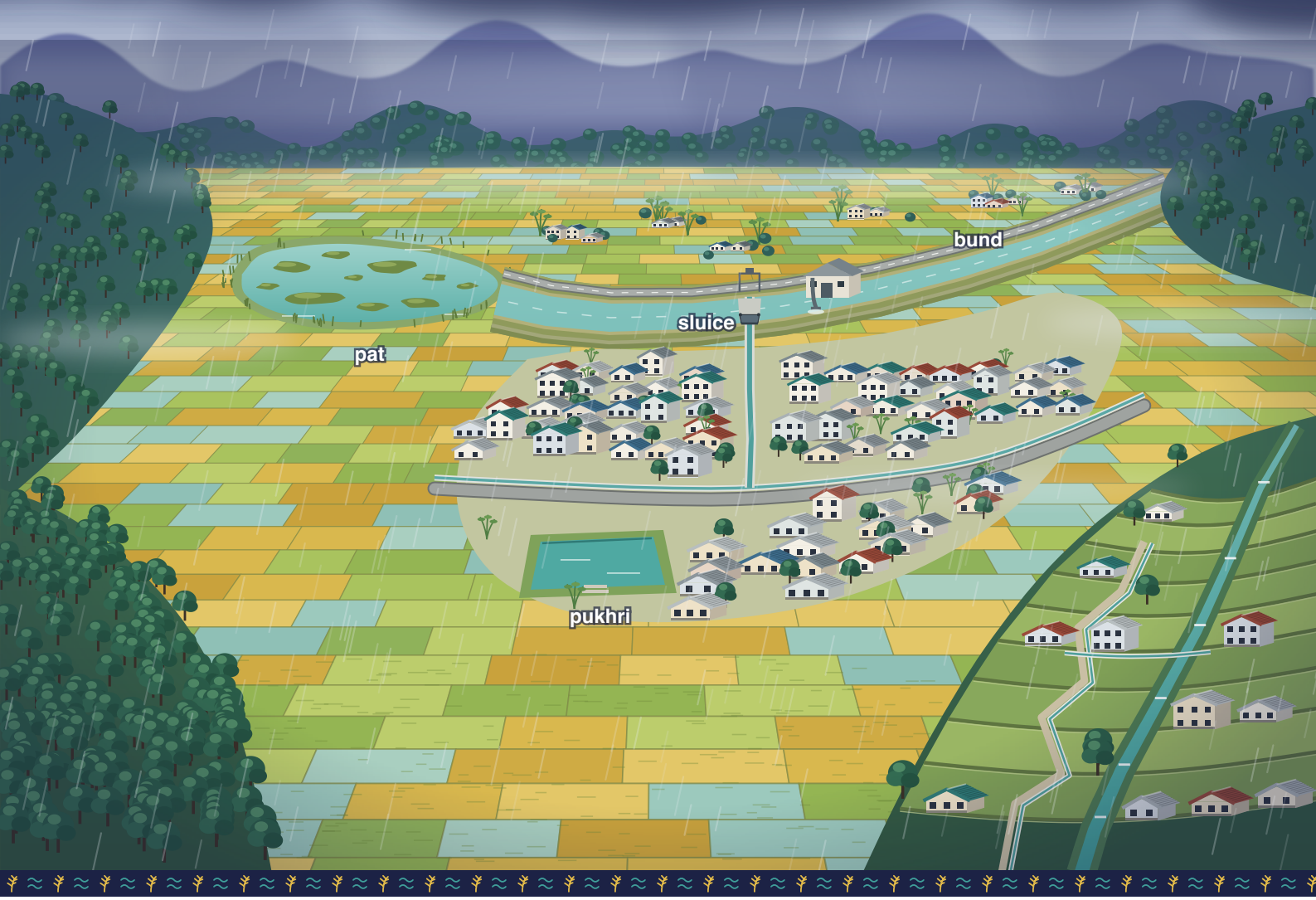
MANIPUR

Stormwater Design Manual

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



Preserve | Retain | Detain | Convey | Maintain

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Prepared by

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About this draft

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

Not adopted. This Manual has not been adopted, notified or endorsed by the Government of Manipur, 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 Municipal Administration, Housing and Urban Development Department (MAHUD), the Town Planning Department (TPD), the Planning and Development Authority, Manipur (PDA Manipur), the Imphal Municipal Corporation (IMC) or any Municipal Council or Nagar Panchayat, or Imphal Smart City Ltd. Nor has it been adopted, notified or endorsed by the Hill Areas Committee of the Legislative Assembly, by any Autonomous District Council or its administrator, by any Village Authority or other body of the hill areas, by any Local, District or State Level Committee under the Manipur Conservation of Paddy Land and Wetland Act, 2014, or by any Flood Zoning Authority under the Manipur Flood Plain Zoning Act, 1978. Where it names a body, such as the Water Resources Department (WRD), the Public Health Engineering Department (PHED), the Public Works Department (PWD), the Directorate of Environment and Climate Change (DoECC) or the Forest, Environment and Climate Change Department, the Manipur Pollution Control Board (MPCB), the Loktak Development Authority (LDA), the Manipur State Wetlands Authority (MSWA), the Manipur State Disaster Management Authority (MSDMA), the Relief and Disaster Management Department, the Revenue Department or a Deputy Commissioner, the High Court of Manipur, the National Green Tribunal (NGT) or the Supreme Court, or a body of the Union or another public 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 National Institute of Hydrology (NIH), NHPC, the Central Electricity Authority (CEA), the National Disaster Management Authority (NDMA) or the Ministry of Environment, Forest and Climate Change (MoEF&CC), or a research body, lender or consultant, such as the Manipur Science and Technology Council (MASTEC), the Asian Infrastructure Investment Bank (AIIB), the New Development Bank (NDB) or WAPCOS, 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 Model Manipur Unified Building Bye-Laws 2024 (the Unified Bye-Laws 2024) and the building bye-laws that each urban local body and PDA Manipur have brought into force on it; the Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026; the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification) and the master plans of the other towns; the Manipur Town and Country Planning Act, 1975 (the MTCP Act) and the Manipur Municipalities Act, 1994; the Manipur Loktak Lake (Protection) Act, 2006 (the Loktak Act); the Manipur Conservation of Paddy Land and Wetland Act, 2014 (the paddy-land Act); the Manipur Flood Plain Zoning Act, 1978; the Manipur (Hill Areas) District Councils Act, 1971 (the District Councils Act); orders of courts and tribunals; and approval conditions in force continue to apply.

Manipur and its hill areas. The State has two legal geographies, and this Manual reaches them differently. The hill areas are the areas specified in the First Schedule to the Manipur Legislative Assembly (Hill Areas Committee) Order, 1972, as the District Councils Act has defined them since its amendment of 2008; Article 371C of the Constitution provides for a Hill Areas Committee of the Legislative Assembly, of the members elected from the hill areas, as summarised in a secondary source. The Manipur Municipalities Act, 1994 "extends to the whole of the State of Manipur except the Hill Areas", as quoted in a secondary copy, the Act itself not having been read in full; the Unified Bye-Laws 2024 extend to the Master Plan areas, the notified planning areas and the areas of the urban local bodies; and the paddy-land Act, which extends to the areas under the Manipur Land Revenue and Land Reforms Act, 1960, does not reach the hill areas, as this Manual reads it. The MTCP Act and the Flood Plain Zoning Act, 1978 extend to the whole State. In the hill areas the District Councils have functions that touch drainage: section 29(1) of the District Councils Act lists, among others, "water supply and

sanitation schemes", "the construction, repair and maintenance of embankments", the conservation of soil, the allotment of land for "residential or other non-agricultural purposes", and "village planning or any other matter" that the Governor may entrust to a Council "in consultation with the Hill Areas Committee" (the item numbers were read from page images and are to be checked [TBC]). None of these is building control, and no building or drainage rule for the hill areas was found. Section 29(1A), inserted in 2006, would let a District Council "notify any part of the area of the Autonomous District as urban area for the purpose of formulation of development plan", but it comes into force on a date to be notified, and no such notification was found [TBC]. The Councils' terms expired on 30 November 2022, and since June 2025 the Deputy Commissioners of six hill districts have acted as their administrators, as reported; the number of Councils is given as six and as ten, and the sources conflict [TBC]. Village Authorities act under the Manipur Village Authorities in Hill Areas Act, 1956, which was not read [TBC]. In the hill areas, then, this Manual can reach the public works that the State's departments and agencies execute there (roads, bridges, culverts, drains, water supply, embankments and flood works, Clause 1.5.1(b)) and any body that adopts it; in future it could also reach a notified planning area under the master plans that TPD is preparing for the district headquarters "both valley and hills", where the Unified Bye-Laws 2024 would then extend. For a household or a village in the hill areas the Manual is guidance only. A District Council could take it up as a matter that the Governor entrusts to it under section 29, or through a development plan under section 29(1A) once that section is in force. In the valley, MAHUD could amend the Unified Bye-Laws 2024 under the same two sections under which it published them, and each urban local body and PDA Manipur could adopt the amendment in its own bye-laws; TPD and PDA Manipur could carry drainage reserves, pat buffers and flood areas into the master plans and the land-use check of building plans; WRD could set outfall, gate and pumping conditions at the river bunds and advise any Flood Zoning Authority; and LDA and the MSWA could apply it in the Loktak catchment and in notified wetlands. None has done so. Land in the valley is mostly patta land with revenue records; in the hill areas land is allotted under the District Councils Act and held under customary tenure, which was not researched for this Manual [TBC]. This Manual reserves drainage corridors and easements in a master plan or secures them by agreement; it does not assume that land can be taken.

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

- **Imphal (Tulihal) (A)** (index 42623, rainfall data 1953–2012) is IMD's station at Imphal airport, the only Manipur station in IMD's tables of extremes. This Manual writes "Tulihal" only in the station's name. MASTEC's annual-maximum series headed "Imphal" is the same gauge for most values, as this Manual reads it;
- the **Imphal river** (Imphal Turel) runs south through Imphal and the valley; the river at the **Ithai barrage** and below it, which leaves the State for Myanmar, is the **Manipur river**. The sources draw the change of name at different points: the Loktak Act names "the confluence of Manipur river and Khuga", and CPCB lists a stretch of the Manipur river from Thoubal to the Ithai bridge. **Ithai** is also spelt **Ethai**;
- the **Nambul** is the river that runs through Imphal; the **Nambol** is a different river, and a town, in Bishnupur district;
- the **Mapithel dam** is the dam of the Thoubal Multipurpose Project, and the press uses both names;
- **Chotebekra**, also spelt **Chotobekra**, is CWC's only site in the State, on the Barak near Jiribam; it is printed under Imphal East district in a transcription of CWC's tables and lies in Jiribam district today, as this Manual reads it;
- **Lamphelpat** is also spelt Lamphelphet; the **Shamushang nallah**, its outlet to the Nambul, is Samushang in the High Court's order and Samusang in CPCB's list; and the **Naga Nullah** is also the Naga Nallah;
- the **"Sugnu hump"** is MASTEC's name for the rock sill on the Manipur river below Ithai, where the bed rises from 756.7 m to 763.7 m in about 800 m. It controls the outlet of the whole valley, whatever the barrage gates do;
- the **Water Resources Department** (WRD) was formerly the Irrigation and Flood Control Department (IFCD), and older audits and reports use the old name;
- CWC's flood estimation reports place the whole State in **subzone 2(c), "Barak and others"**, whose rivers the subzone list of the report for subzone 2(b) gives as "Barak, Kalden and Manipur rivers"; "Kalden" is the Kaladan, as this Manual reads it. CWC never published a report for subzone 2(c). A strip in the north of

Senapati district may touch **subzone 2(b), South Brahmaputra**, on that report's plate, as this Manual reads it, with low confidence [TBC]. These subzones are not the three rainfall zones (MN-Z1 to MN-Z3) and five hydrologic sub-areas (MN-A, MN-A1, MN-B, MN-C and MN-C1) that this Manual sets in Annex 2A, nor Zones 1 and 2 of a waterbody setback in Chapter 7, nor a "flood zone" under the Flood Plain Zoning Act, 1978, nor the Core Zone and Buffer Zone of Loktak under the Loktak Act;

- the **Unified Bye-Laws 2024** are a *model*, and the bye-laws that grant a permit are those that each urban local body and PDA Manipur bring into force on it; the gazette spells the word **"Bye-Laws"**, and this Manual writes "bye-law 93" for a provision. **"MBBL 2016"**, in Chapters 1 and 10, is the national Model Building Bye-Laws of 2016, not the State's bye-laws;
- the **Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)** is the master plan of Greater Imphal; an "Imphal Master Plan 2043" is this plan, not a separate document. The **Risk Informed GIS Based Master Plans** for Imphal and for Moirang (RIMP) are separate plans, which were not read;
- **PDA Manipur** is the Planning and Development Authority constituted under section 13 of the MTCP Act, and this Manual uses no other short form for it; no separate Act constitutes it;
- WRD's river levels, which this Manual has only as the press printed them, are in metres, and no source read states their datum [TBC]: for example, the Imphal river at Minuthong has a warning level of 785.900 m, a flood level of 786.900 m and a highest flood level of 788.400 m. 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 Imphal is 5 June (1 June before IMD's normals of 2020) and its normal withdrawal 15 October, as quoted from IMD's release. The Manual's season begins on 1 April because Imphal's April and May storms are among its largest, and two of the recent damaging valley floods came before the onset (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 **Unified Bye-Laws 2024** are the Model Manipur Unified Building Bye-Laws, 2024, published by MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD-Part(1) of 4 December 2024 (Manipur Gazette Extraordinary No. 253 of 5 December 2024) under section 213 of the Manipur Municipalities Act, 1994 (Act 43 of 1994) and section 26(1) of the Manipur Town and Country Planning Act, 1975 (Manipur Act 11 of 1975), "for adoption by the Urban Local Bodies and Planning & Development Authority, Manipur". They "shall extend to the Master Plan areas or notified Planning areas and area under the jurisdiction of all the Urban Local Bodies of Manipur" (bye-law 1(2)). Their recitals record that the bye-laws of eight urban local bodies were "based on Model Building Bye-laws of 1998" and that 18 had none. The Kumbi, Moirang and Jiribam Municipal Councils' bye-laws of 2025 were finally notified on 16 January 2025, as listed on TPD's site; a "Building Bye-laws for ULBs of Manipur – Final Gazette Notification" of 15 December 2025 is listed there but was not read [TBC]; and IMC's Building Bye-Laws, 2025 are reported to have been notified on the same date. Before them IMC had the IMC Building Bye-laws, 2013, amended in 2019 and 2022, and a draft third amendment of 2024 was published for objections, to "come into force on such date as the State Government may … appoint"; its final status was not confirmed [TBC]. This Manual cites the Model's provision numbers; where the bye-laws that a local body has notified differ, the local body's text governs. Bye-law 92 of the Model, as printed, forbids construction "on land above 600 m from the mean sea level and with an average slope of 30 degrees", which would bar all of Greater Imphal; this Manual reads it with the draft IMC text of 2024, which forbids building and cutting on slopes above 30° and allows at most two floors or 7 m on slopes of 21–30°;
- **MAHUD** makes the bye-laws and the zoning bye-laws and notifies the master plans. **TPD**, a department under MAHUD set up in 1965-66, prepares the master plans, including GIS master plans for 14 district headquarters "both valley and hills" with a horizon of 2042, checks building plans for land-use compatibility on the Online Building Permission System (OBPS), and is the nodal department for AMRUT. **PDA Manipur** was constituted under section 13 of the MTCP Act, in 1975 or 1976, as reported differently [TBC]; on its constitution the State's khas land within a master plan area vests in it. The **Unified**

Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026 (MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD of 22 July 2026; Gazette Extraordinary No. 157 of 23 July 2026), made under section 91(1)(iv) read with section 24(e) of the MTCP Act, set the use zones of every Master Plan area, among them "Agriculture" and "Pond, Drain, Rivers and Canals";

- the **Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)** was notified by No. SCS-401/3/2021-MAHUD-MAHUD-Part(3) of 4 December 2024 and covers 151.38 km² of Imphal East and Imphal West. It has no section on storm-water drainage. The **Risk Informed GIS Based Master Plans** for Imphal and Moirang are listed as finally notified on 17 January 2025, while TPD's annual report for 2025-26 says that their draft report "has been submitted"; the two statements conflict, and the plans, with any flood-risk areas they map, were not read [TBC];
- **IMC** is the municipal corporation of Imphal under the Manipur Municipalities Act, 1994, with 27 wards; it became a corporation in 2014 or 2016, as reported differently [TBC]. The State has 27 urban local bodies in all. The Greater Imphal planning area is wider than IMC's area, and PWD (roadside drains), WRD (rivers, bunds, flood channels, Lamphelpat and its pumping), PHED (sewers), DoECC (the interception of the drains that fall into the Nambul) and LDA hold drains or channels in it;
- the **Loktak Act** (Manipur Act 3 of 2006, Gazette Extraordinary No. 13(E), as amended by Acts 5 of 2007 and 8 of 2019) applies to "the whole of 236.21 Sq. km" of the lake, but not to the Keibul Lamjao National Park (40 km²) or the Takmu Fishery Farm (5 km²). Its **Core Zone**, of 70.30 km², is "the No-Development Zone or Totally Protected Zone"; the rest of the lake is the **Buffer Zone**, in which section 19 bans, among other things, the "Discharge of untreated wastes and effluents from industries, cities or towns and other human settlements" and "Land reclamation, bunding or disturbing the natural course of drainages". LDA administers it, with the Forest and Environment Department as nodal department. The Act does not reach the land upstream of the lake. The lake's area is also given as 246.72 km² with its swamps (MASTEC) and as 250 km² (as reported), and the three figures differ in what they count. Loktak was designated a Ramsar site on 23 March 1990 and placed on the Montreux Record on 16 June 1993, as reported;
- the **Manipur Flood Plain Zoning Act, 1978** (Manipur Act 10 of 1978; Gazette Extraordinary No. 185 of 1 September 1978) provides for a Flood Zoning Authority, surveys of river plains, and zones delineated "with reference to relative risk". Only sections 1 to 7 were read, from the damaged text layer of a truncated copy [TBC]. No constitution of a Flood Zoning Authority and no zone notification was found, and the demarcation of flood zones in the State "is yet to be done", as reported in June 2026; this Manual treats no zone as notified;
- the **paddy-land Act** (Manipur Act 10 of 2014; Gazette Extraordinary No. 150 of 2 September 2014) allows paddy land and wetland to be converted only through the Local Level Monitoring Committees (led by the Sub-Divisional Officer), the District Level Committees and the State Level Committee, and counts "drainage channels, ponds, canals, bunds and ridges" as part of paddy land (section 2(c)). A Bill of 2026 to amend it, which would exempt land that conforms to a notified Master Plan, was introduced; its enactment was not confirmed, and this Manual does not cite it as law;
- the **MSWA** was set up on 31 January 2018. It has published draft notifications of three wetlands, Yaral Pat, Utra Pat and Waithou–Phumnom Pat; no final notification under Rule 4 of the Wetlands (Conservation and Management) Rules, 2017 was found;
- **WRD** holds the rivers, the river bunds and flood channels, Lamphelpat and the Shamushang pumping, and is named in this Manual as the State groundwater agency, although no State network of observation wells was found; the only network found is CGWB's, in its North Eastern Region. **PHED** builds and runs the Imphal sewerage project. **PWD** keeps the State's roads and their drains, including the 547 km of roads in Greater Imphal that the AIIB-assisted project is to rehabilitate. **DoECC**, under the Forest, Environment and Climate Change Department, runs the rejuvenation of the Nambul and acts as the secretariat of the MSWA. **MPCB** grants pollution consents;
- **MSDMA** is the State's disaster management authority; it was not researched for this Manual [TBC], and the flood situation reports quoted here are those of the **Relief and Disaster Management Department**, as reported. The District Disaster Management Authorities are written in full;

- the **High Court of Manipur** and the **NGT** have taken up the State's waters: the High Court's order of 16 June 2025 in PIL No. 8 of 2025 records WRD's inspection of the Lamphelpat works, and its special bench is reported to have barred development in or around Loktak without its leave (orders of 17 July 2019 and 25 February 2022, as reported; case number not found [TBC]); the State's reports in the NGT's case on solid waste and other environmental issues (OA 606 of 2018) record the sewage in Imphal's drains. This Manual cites court and tribunal orders with their status; and
- where a shared clause names a revenue subdivision, this Manual uses the **sub-division**. A district is headed by a **Deputy Commissioner** (DC). In the valley land records are kept under the Manipur Land Revenue and Land Reforms Act, 1960.

Where a shared clause calls for the local language on a sign, a form field or a basin name, this Manual writes "Manipuri". The Manipur Official Language Act, 1979 (Act 14 of 1979), as amended by the Manipur Official Language (Amendment) Act, 2021 (Act 7 of 2021; Gazette Extraordinary No. 427 of 10 March 2021), defines "Manipuri Language" as "Meeteilon written in Meetei Mayek", with "concurrent use of Bengali Script and Meetei Mayek … in addition to English language, for a period upto 10(ten) years from the date of commencement". **English is the language of this Manual.** So, as set by this Manual, **signs and flood-depth markers are in Manipuri, written in Meetei Mayek, and English; in the hill areas, in English and the language in local use of the village or town, with Manipuri where the Authority so directs.** The 1979 Act's provision on the hill areas was not read cleanly [TBC], and a sign must be readable by the people it warns. In Annex 7A the field WB_NAME_MNI holds a water body's name in Meetei Mayek; MNI is the code of this Manual for Manipuri, after its ISO 639 code, mni.

Some local words are used in the text, and are explained again where they first appear. This English edition writes them in Latin letters only; their Meetei Mayek forms are left to the Manipuri edition of this Manual.

- a **pukhri** (Manipuri: a pond; plural pukhris) is this Manual's word for a dug pond or a small body of standing water, such as the public ponds of the towns. Sharma's *Learners' Manipuri-English Dictionary* (2006, p. 117) gives "n. pond", with no other sense. Meeteilon marks the plural with suffixes, not with an ending of this kind, so the English plural "pukhris" is a convention of this Manual;
- a **pat** (Manipuri: a lake or wetland, as in Lamphelpat) is a natural lake, marsh or wetland of the valley, as in Lamphelpat, Utra Pat and Yaral Pat; the dictionary gives "n. lake" (p. 114), and CGWB notes "the places having the word PAT meaning lake". This Manual never calls a pat a pukhri, and calls engineered storage a **detention pond**, never a pukhri or a pat; Lamphelpat is a pat being developed as flood storage;
- a **turel** (also turen) is a river (p. 81), as in Imphal Turel, and a **khong** a stream (p. 54); the same word *khong* also means "a mine";
- a **khongban** (also khongbal) is "a ditch; a drainage" (p. 55). The word *nala* means both "a drain" and "a sewer" (p. 103), so this Manual writes "drain" and does not use *nala* alone;
- an **ithong** is a "floodgate; sluice gate" (p. 20), and a **pan** "a bund; embankment" (p. 111). The text keeps the English "sluice", "flap gate" and "bund"; and
- a **phumdi** is a floating mat of vegetation, organic debris and soil (p. 125, under *phum*), the "Phumdis" of the Loktak Act, which defines them as a "heterogeneous mixture of vegetation, organic debris and soil in floating condition". Phumdis can drift onto screens and outlets.

The pages given are those of the dictionary's online edition; only p. 117 was checked on the printed page, and the others are to be checked [TBC]. Words of the hill languages for streams, ponds and drains were not researched for this Manual [TBC].

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 Imphal Municipal Corporation. In other editions of this series and in some sources the same letters stand for other bodies; in this Manual IMC means only this one;
- DC is a Deputy Commissioner. The District Councils of the hill areas are written in full, and so is the Hill Areas Committee of the Legislative Assembly;

- "Unified Bye-Laws 2024" is the Model Manipur Unified Building Bye-Laws 2024, with the bye-laws that each local body has brought into force on it, and "MBBL 2016" the national Model Building Bye-Laws 2016. Neither is the building rule of any other State;
- HFL is the highest flood level recorded at a gauge, and WL and FL are the warning and flood levels that WRD sets at its river gauges. None is a design level. Bye-law 94 sets the plinth in "high Flood Risk Areas identified in the Master Plan of the towns" at "1m above the highest flood level of the surrounding areas"; no such level was found for any town, and in September 2025 the river stood above the printed HFL at Lilong and at Ithai, as reported. Chapters 5 and 7 say how this Manual finds a design level;
- FRL (full reservoir level) and MDDL (minimum draw-down level) are used for Loktak behind the Ithai barrage and for the reservoirs of the hills; for Loktak the sources give an FRL of 768.5 m and of 769.63 m, and an MDDL of 766.2 m and of 766.01 m, and the conflicts are stated where they matter; and
- I&D is the interception and diversion of drains to a treatment plant.

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

Manipur's towns flood, and fail, for three reasons. The Imphal valley showed the first on 28–31 May 2024, when the rains of Cyclone Remal breached the river bunds at 18 places and flooded Imphal from the Imphal river and the Nambul, as reported, and again from 30 May 2025, when the Nambul breached at four places and the Imphal river at Keirang, Khabam and Lairikyengbam Leikai, as reported; the hills show the second, because no CWC report covers any part of the State and no IDF relationship exists for any Manipur station, while 225 mm fell at Khoupum, in the western hills, in one night in July 2025, as reported; and Imphal shows the third every day, because its storm drains carry its sewage: the State told the NGT in December 2025 that the 72 drains that fall into the Nambul carry water with a biochemical oxygen demand (BOD) of 42.45–52.34 mg/L.

1. **A capital that drains into rivers and a lake higher than its drains, through bunds that fail.** "The town is below the high flood level of Imphal river and hence there are embankment roads on both sides of the river to protect the settlement from seasonal floods", the master plan for Greater Imphal records. The Imphal river's highest flood level at Minuthong, 788.400 m as the press printed WRD's figure, lies within a metre or two of the city's ground, at about 790 m, as this Manual reads the two. The valley is a closed basin with one outlet: the Imphal, the Nambul, the Iril, the Kongba, the Thoubal and the other valley rivers run to Loktak and the pats round it, and leave the valley only past the Ithai barrage and the rock sill below it, the "Sugnu hump". The rivers entering the valley carry a few hundred cumec each in flood, while the outlet at Ithai carries "of the order of 400 cumecs", and the "river down below the barrage does not have the capacity to cope up with such flow, as a result, water is piled up upstream", as MASTEC found. So the valley floods from its bunds and from drains that cannot discharge: in July and August 1989, after Imphal's record day of 158.6 mm on 30 July, the rivers breached in 40 places, and floods reached 361 localities, 7 lakh people and 97,500 ha of paddy; in August 2002 there were 59 breaches; and on 15 September 2025 the Imphal river at Lilong and the Manipur river at Ithai stood at 783.250 m and 770.05 m, above their printed highest flood levels of 782.850 m and 769.320 m, as reported. Counts of those affected by the floods of May 2024 differ, at 1,88,143 people and 24,265 houses (the Minister, 30 May) and 1,26,950 people, 255 localities and 16,364 houses (the Relief and Disaster Management Department, 31 May), as reported. "The failure of river dikes causes waterlogging in the low-lying areas for several weeks", the AIIB found, and the Lamphelpat area "remains waterlogged for many days every year", as the NDB's summary records. No operating rule, closing level or pump capacity for any sluice or pumping station on the valley's bunds was found.
2. **Rainfall that no CWC report covers: modest in the valley, heavy in the western hills.** The whole State is in CWC's subzone 2(c), for which no flood estimation report was ever published, so there is no CWC plate, ratio or synthetic unit hydrograph for any part of it. IMD's record at Imphal (Tulihal) is modest: 158.6 mm in 24 hours on 30 July 1989, in data from 1953 to 2012. MASTEC published Imphal's annual maximum daily falls for 1974 to 2000, and this Manual's own Gumbel fit of them gives about 157 mm in a day at 50 years; IMD's daily series for the station has not been fitted [TBC]. The reanalysis grids of NIH-DHAARA give Imphal a 50-year day of 231 mm, about 1.45 times the IMD record, and the western hills, which face the Barak, 306 mm at Noney, 431 mm at Tamenglong and 491 mm at Jiribam. IMD's national set of rainfall intensity curves (Das et al., 2022) has a panel for Imphal, but it repeats a curve printed for many other cities. No hourly maximum for any Manipur gauge was found, and the 225 mm of Khoupum came with no stated duration or gauge. The valley's floods are made by rain on the hills, which are 70% of its catchment, as MASTEC found, and WRD's rule of thumb, as reported, is that 135 mm in three days at Kangpokpi floods the valley.
3. **Storm drains that are the sewers.** The first phase of the Imphal sewerage project, commissioned in June 2020, covers 11 of IMC's 27 wards; the State told the NGT in July 2025 that "Sewage generation in urban areas is 70 MLD and existing treatment facilities are 44 MLD", that 8,600–8,700 households were connected out of 51,754 targeted, and that the treated effluent's "Final mode of disposal" is "Agriculture canals". The rest of Greater Imphal, and every other town, uses septic tanks and soak pits whose overflow, with all the sullage, goes to the open drains, as this Manual reads the State's reports. The State's answer is the "Interception & Diversion (I & D) of all drains (72 Nos.) falling into the Nambul River", reported as completed in December 2025, with a drain BOD of 42.45–52.34 mg/L and a chemical oxygen demand (COD) of 78.56–97.23 mg/L, against 3–6 mg/L of BOD at the

river stations: CPCB lists 18 polluted river stretches in Manipur, all in Priority V, among them the Nambul from Singda Dam to Bishnupur. The Naga Nullah, behind the main market, receives the market's solid waste, which "creates a stagnant pool all along the year", as the master plan records. In the hill areas "The existing reliance on septic tanks and twin soak pits … is appropriate", the State reported, and there is "minimal presence of underground drainage infrastructure".

Over all three lie four more. **Pats and paddy lost to building**: "there were nearly 500 lakes in Manipur Valley", MASTEC records, and the pats it names as degraded and disappearing include Lamphelpat, Porompat, Takyelpat, Sangaipat, Kharungpat and Ikop pat; "This valley was once full of swamps and marshy land represented by the places having the word PAT meaning lake", CGWB notes; and the master plan for Greater Imphal reduces its wetlands from 374.48 ha to 232.21 ha and its agricultural land from 5,616.53 ha to 2,604.70 ha by 2043, while its water bodies grow from 563.54 ha to 643.42 ha, and says that "new areas need to be unlocked as the paddy fields cannot be used for construction" under the paddy-land Act. **Hill slopes of shale that slide when cut**: the Disang shale "occupies almost 85 p.c. of the hilly region, have less infiltration and more run off", as MASTEC found; the landslide at Tupul, in Noney district, on 29 or 30 June 2022, at a construction site of the Jiribam–Imphal railway, killed 56, 58 or 61 people, as reported differently, and a published study attributes it to "poorly designed or implemented slope excavation coupled with heavy rainfall", as quoted in a summary of that study (Baruah et al., 2023); and the landslide at Joumol, in Chandel district, on 1 August 2015, killed 20 or 21 people, or 24 by ActionAid's count, as reported. **A clay valley floor that will not take water**: CGWB found "approximately 30 to 50 m of clayey formation" in Imphal West, with the water 2–5 m below the ground, and peaty organic soils round the lakes of Bishnupur. And **bye-laws with a river-buffer table and a plinth rule but no design storm**: bye-law 93 of the Unified Bye-Laws 2024 forbids new construction within a buffer of each named valley river, from 22.5 m to 62 m measured from mid-stream, and bye-law 94 sets the plinth 1 m above "the highest flood level of the surrounding areas" in the high flood risk areas of the master plans; bye-law 66 makes rainwater harvesting mandatory on plots of 100 m² and more; but no rule says what storm a drain or a store is designed for, what flood level a plinth is set above, or how fast a site may release its runoff.

Behind all of this lie Loktak, the pats and the pukhris, which set the level at the outfall and hold the water while the gates are shut. Loktak's statutory extent is 236.21 km², of which the Core Zone of 70.30 km² is closed to development; its level is held by the Ithai barrage, commissioned in 1983 by most accounts and in 1979 or 1986 by others, as reported, and the sources give its full level as 768.5 m (NHPC, as quoted) and as 769.63 m (as reported). Phumdis, the floating mats of the lake, can drift onto screens and outlets. The wetland atlas of the Space Applications Centre (2021) counts 132 wetlands larger than 2.25 ha in the State, and about 4,000 water bodies were listed after an order of the NGT, though their "Ground truthing, engineering surveys, and quality monitoring … are pending", as DoECC reported. Lamphelpat is being dredged over about 300 acres as flood storage, with "provision for pumping of flood water from the Lamphel pat water body to the Nambul River through Shamushang Nalla during high flood season", as WRD reported to the High Court; it is also proposed as a source of drinking water. About 90% of Imphal's drinking water comes from the Imphal, the Nambul and the Iril, as the master plan records, the same rivers that take its drains.

Design for Manipur therefore has to cover a wet season that begins with the storms of April and May, before the south-west monsoon reaches Imphal in about the first week of June, and that runs past its withdrawal in mid-October to storms such as that of 5 October 1980 at Imphal (119.4 mm) and the flood of October 1992; it is this Manual's monsoon season, 1 April to 31 October. Imphal's April and May records exceed 100 mm in a day, at 105.9 mm (16 April 2004) and 122.4 mm (27 May 1956), and the floods of 28–31 May 2024 and from 30 May 2025 struck before the onset. Large falls come outside the season too, as on 1 November 1991 (80.3 mm), 13 December 1966 (89.6 mm), 18 February 1993 (79.8 mm) and 24 March 1998 (72.9 mm) at Imphal, so design statistics use the annual maxima of every month. MASTEC gives Imphal a mean annual rainfall of 1,416.9 mm (1975–2000), and CGWB gives Imphal West 1,632.40 mm. There is no snow. Underground, every assessed unit of the State is safe, and the State draws 8.00% of its extractable groundwater (2024), as quoted; rainwater is worth storing for use, but on the clay of the valley floor it cannot be put into the ground.

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

- hold frequent rainfall on site, in tanks for use in the dry season, 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 river, pat, pukhri or Loktak is high, when the sluice in the river bund is shut and the town drains only by its pumps, when a dam upstream is releasing, or when a drain is choked with silt from the hills, phumdis or garbage.

The Manual also sets how public drains, roads and their drains, hill roads, streams, rivers and their bunds, sluices and pumped outfalls, pats and pukhris, and basin-wide master plans are designed, and how drains below the hills are protected against debris and silt, 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 Manipur's wet season of April to October, with its pre-monsoon storms; to a closed valley with one outlet past the Ithai barrage and the Sugnu hump, where the rivers run between bunds above the town and Loktak's level sets the tailwater of the south; to the Imphal, the Nambul, the Iril, the Kongba, the Thoubal and the other rivers of the valley, and to the release reach below the Mapithel dam; to the Barak and the Jiri at Jiribam; to the lacustrine clay and peat of the valley floor, the sand and gravel fans at the foot of the hills, the Disang shale of the hills and the sandstone cappings of the Barail ranges; to Loktak, the pats and the pukhris, and to the paddy land that stores the valley's floods; and to storm drains that carry sewage.

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.
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.** No CWC report covers any part of the State, so every design rainfall value in Manipur is set by this Manual, by sub-area. In the Imphal valley the design day comes from a table that this Manual fits to MASTEC's annual-maximum series at Imphal, 1974–2000, until IMD's daily series is obtained and fitted. In the northern, eastern and southern hills it is the higher of NIH-DHAARA's value for the site and the valley table: the one sub-area where NIH-DHAARA is a design value. In the western hills and on the Jiribam plain it is not less than 320 mm at 2% AEP and 351 mm at 1% AEP, the floors of the Barak-valley rule of the adjoining edition of this series, so that one storm reads alike on both sides of the State's border. Shorter durations use interim ratios for Manipur that are never lower than those of the CWC report for subzone 2(a), and, on the Jiribam plain, the ratios of the report for subzone 2(b), as on the Barak plain downstream. The design day is checked against the largest reliable days recorded within 25 km, but only within the same domain, so that a valley gauge never sets a hill depth or the reverse. NIH-DHAARA is reported beside the design value elsewhere, for comparison only, and IMD's Imphal panel is not used.
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 Unified Bye-Laws 2024, with the draft third amendment of IMC's bye-laws of 2024; the Unified Zoning/Use Regulation Bye-laws, 2026; the MTCP Act; the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification); the Loktak Act and its amendments; the Flood Plain Zoning Act, 1978; the paddy-land Act and the amending Bill of 2026; the District Councils Act and its amendments of 2006 and 2008; the Manipur Official Language Act, 1979 and its amendment of 2021; the Wetlands (Conservation and Management) Rules, 2017; the High Court's order in PIL No. 8 of 2025; and the State's reports to the NGT in OA 606 of 2018. This

Manual follows them or, where disclosed, makes them stricter. The bye-laws that the urban local bodies notified on 15 December 2025, the Risk Informed GIS Based Master Plans, sections 8 onward of the Flood Plain Zoning Act, the drainage sections of the Manipur Municipalities Act, 1994, the Manipur Village Authorities in Hill Areas Act, 1956, the State Action Plan on Climate Change and the CAG's report on flood control (Report No. 2 of 2017) were not read. Every rule cited must be checked against the current text.

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 Manipur 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 State Action Plan on Climate Change was not read, and the figures for a future increase in rainfall that officials have given in the press differ from one another, so this Manual uses none of them. A study of Manipur's rainfall from 1991 to 2024 (Singh, 2025) found "a statistically significant downward trend in Total Annual Rainfall", while the valley floods of 2015, 2024 and 2025 are among the largest recorded, as reported; no trend in extreme rainfall was found.
- **Design rainfall.** No national document gives design rainfall that a designer can apply directly to a given town. Each project chooses its own source. Manipur lies wholly in a CWC subzone for which no report was ever published; IMD's 2022 national set of rainfall intensity curves has a panel for Imphal, but it repeats a curve printed for many other cities; and the reanalysis grids of NIH-DHAARA give depths in the valley about 1.3 to 1.5 times what Imphal's own series supports.

Manipur has no drainage design standard of its own. Research for this Manual found no standard, IDF relationship or circular of MAHUD, TPD, PDA Manipur, IMC or any other urban local body, PWD, WRD or PHED that fixes a return period, a runoff coefficient or a design rainfall for town storm drains, and no IDF relationship with published constants for any station in the State; the Unified Bye-Laws 2024 defer to the National Building Code 2016 for services. The master plan for Greater Imphal has no section on storm-water drainage. The two live drainage projects state no design storm: the AIIB-assisted Manipur Urban Road, Drainage and Asset Management Improvement Project, which will build "547 km of both side stormwater covered drains" along the roads of Greater Imphal and records that "35% of the area" is "prone to floods", gives no return period, rainfall intensity or runoff coefficient in its project document of October 2024; and the NDB's summary of the Lamphelpat project of 2021, to "increase its water detention capacity, restore stormwater drainage system and channels / streams in the catchment area", gives none either. These are projects, not a State standard. This Manual is offered as a technical companion to the Unified Bye-Laws 2024 and the bye-laws of the local bodies, the zoning bye-laws and the master plans, the MTCP Act and the Municipalities Act, the Loktak Act, the paddy-

land Act and the Flood Plain Zoning Act, 1978: it supplies the design storm, detention, water-level, tailwater and buffer values that they leave open. It has not been adopted by MAHUD, TPD, PDA Manipur, IMC, WRD, any District Council or any other body. In particular:

- **The building rules require rainwater harvesting, but size nothing.** Bye-law 66 makes "storing of water runoff including rainwater in all existing and new buildings on plots of 100 square metre and above" mandatory, asks plans to show "the system of storm water drainage along with points of collection of rain water in surface reservoirs or in recharge wells", and sets soft cover of 15% of the plot where the covered area is 500 m² or more and 10% otherwise; bye-law 68 rebates 10% of the permission fee for recycling with rainwater harvesting; and bye-law 6(1)(D) asks multi-storeyed, lifeline and special buildings for a "Detailed drainage plan for both internal and external required to be constructed up to the available permanent/pucca drain of municipal/other authority". None gives a storage volume, a release rate or a design storm; the only mention of runoff is a green-building criterion to "Minimize storm water run-off from site by reducing hard paving on site";
- **The rules send grey water into clay.** Bye-law 67 connects the excess grey water of larger buildings "to the rain water recharge structures for ground water recharge". On the valley floor, with 30–50 m of clay and the water 2–5 m below the ground, such a structure is a soak pit in clay. This Manual states the conflict and asks for storage or a sewer connection in its place; it does not override the bye-law;
- **The river buffers are measured from mid-stream, and stop at the named rivers.** Bye-law 93 forbids new construction within a buffer of each named reach: 55 m, 60 m and 62 m on the Imphal river, 50 m on the Iril, 48 m on the Thoubal, 35 m on the Sekmai and the Kongba, 31 m on the Wangjing, 30 m on the Nambul within Greater Imphal and on the Arong, 25 m on the Nambol and 22.5–28 m on the Merakhong, measured from mid-stream, or, on most reaches, 6 m from the outer toe of the bund where that is further. A 30 m buffer on a reach 40 m wide leaves 10 m from the bank, as this Manual reads it. Activity in a "prohibited" or "restricted" area needs the permission of a Flood Zoning Authority that was not found to have been constituted. The table leaves out the pats, the pukhris, the hill streams and the city's channels, and no setback from a pat or a pukhri was found; only Loktak has statutory zones;
- **The floodplain law has no zones.** The Flood Plain Zoning Act, 1978 defines a "flood zone" by the flow of "the maximum probable" flood, as far as the damaged copy shows, without a return period, and no zone has been demarcated. An eviction order along the river channels of Imphal in April 2025 cited "Section 24" of the Act, as reported; that section was not read. Bye-law 94 sets the plinth 1 m above "the highest flood level of the surrounding areas" only in the "high Flood Risk Areas identified in the Master Plan of the towns", which are in the risk-informed master plans that were not read, so this Manual cannot say where it applies. This Manual offers a technical method for drawing a design flood line and corridors (Chapter 7) as an input to any future zoning; it does not replace any zone that is notified, a line that a master plan draws or a court orders, and where such a line binds and is wider, it governs;
- **The slope rules stop building, not water.** Bye-law 92 of the Model, as printed, would bar all of Greater Imphal, and the draft IMC text of 2024 that gives its intended rule, no building or cutting above 30° and at most two floors or 7 m on slopes of 21–30°, was published for objections and its final status was not confirmed. No rule restricts soak pits, recharge pits or infiltration trenches on slopes or on shale, and in the hill areas no building rule applies at all; and
- **No document sets the river or lake level for which an outfall is designed.** CWC has one site in the State, on the Barak at Chotebekra, whose highest flood level of 32.1 m (31 July 1989) was found only in a transcription. WRD's warning, flood and highest flood levels on the valley rivers were found only as the press printed them, on no stated datum, and two of them conflict between years; Loktak's full level is given as 768.5 m and as 769.63 m. No inventory of the sluices, flap gates and pumping stations on the valley's bunds, and no rule for operating them, was found. Highest flood levels are records, not design levels.

So each agency and each local body interprets the central manual its own way. IMC and the other urban local bodies, PDA Manipur and TPD, PWD and the national-highway agencies, WRD, PHED, DoECC, LDA, Imphal Smart City Ltd, their consultants and funding agencies fill the gaps differently. No notification assigns the Naga Nullah, the Waisel Maril or the Shamushang nallah to one owner. A drain in Imphal may be IMC's municipal drain for part of its length and a PWD

roadside drain for another, carry sewage that DoECC intercepts before the Nambul, pass through a gate in a WRD bund, and end in a pat being rebuilt as flood storage or in Loktak, under LDA. In the hill areas no building rule applies at all. 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 three rainfall zones and five hydrologic sub-areas, with a checked station analysis to govern where one exists; the valley table from Imphal's own series in the Imphal valley and on the Loktak margin; NIH-DHAARA, never below the valley table, in the northern, eastern and southern hills; the Barak-valley floors in the western hills and on the Jiribam plain, where subzone 2(c) has no report; 72-hour depths for the valley's multi-day floods; and a check of the design day against the largest reliable days recorded nearby that never crosses the valley rim or a ridge (Chapter 2);
- named return periods for every drainage element (Chapters 2 and 6);
- a required pre- versus post-development rule for private sites, with the rainwater stores of bye-law 66 sized and credited (Chapter 4);
- a required tailwater check for every outfall against a design river or lake level, which treats a gate shut against a high river as the normal monsoon case in the valley: the gate closed for the whole of the 72-hour design storm and for as long after it as the river stays above the sill, and for not less than 7 days on the valley's main rivers and on the Barak where no stage record has been analysed; an outfall on the Loktak margin below the design lake level treated as closed from 1 June to 30 September; the receiving pat or pukhri full to its outlet level at the start; and the stored water pumped down within 48 hours (Chapter 5);
- a design flood line, and corridors and setbacks along rivers, streams and the city's channels and around pats and pukhris, proposed by this Manual for use where nothing wider binds, with a corridor at least 15 m from the top of bank, or from the landward toe of the bund on a bunded reach, on every natural channel draining 8 ha or more, and the buffers of bye-law 93, the zones of the Loktak Act and any notified flood zone wherever those are wider; and the flood storage lost when paddy land or wetland is converted replaced in the same basin (Chapter 7);
- no deliberate infiltration on the clay, silt and peat of the valley floor, below the 1% AEP flood level, inside a bunded area that ponds when its outfalls close, at the margins of pats and pukhris, within the extent of the Loktak Act or where the water table rises within 2 m of the surface; none on slopes steeper than 10° or on Disang shale at any slope without a geotechnical certificate; recharge only on tested ground at the foot of the hills; roof runoff to storage for the dry season, as bye-law 66 already requires, with its overflow to lined drains; and the interception and screening of dry-weather flow before every outfall to a pat, Loktak or a polluted river stretch, where drains carry sewage (Chapter 8);
- debris racks, silt traps where hill streams reach the valley floor, allowances for sediment and blockage, screens against phumdis and garbage, and sluices, flap gates and pumps designed for the river's high stage (Chapters 6 and 9), with drains, inlets, screens, gates and pumps cleared, tested and certified ready by 31 March, before the April storms, cleared again by 15 May, before the late-May storms that flooded the valley in 2024 and 2025, and by 15 November after the season, and standby kept from 1 April to 31 October (Chapter 10); and
- basin-wide master plans, so that the agencies that share a basin, from the hills to the valley floor and Loktak, 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). An urban local body in its bye-laws, MAHUD in the Model, TPD and PDA Manipur in a master plan, or a District Council in a matter entrusted to it can still adopt a stricter standard (Chapter 1).

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); Model Manipur Unified Building Bye-Laws, 2024, MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD-Part(1) of 4 December 2024 (Manipur Gazette Extraordinary No. 253, 5 December 2024), bye-laws 1(2), 2(2), 6(1)(D), 16, 28, 66–68 and 92–94; Imphal Municipal Corporation Building Bye-Laws (3rd Amendment), 2024, draft text; Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026, MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD of 22 July 2026 (Gazette Extraordinary No. 157, 23 July 2026); Manipur Town and Country Planning Act, 1975 (Manipur Act 11 of 1975), ss. 1, 2, 13, 22 and 26; Revised GIS Based Master Plan for Greater Imphal

– 2043 (1st Modification), No. SCS-401/3/2021-MAHUD-MAHUD-Part(3) of 4 December 2024; Manipur Loktak Lake (Protection) Act, 2006 (Manipur Act 3 of 2006), ss. 1–4, 19, 20 and 35, as amended by Acts 5 of 2007 and 8 of 2019; Manipur Flood Plain Zoning Act, 1978 (Manipur Act 10 of 1978), ss. 1–7; Manipur Conservation of Paddy Land and Wetland Act, 2014 (Manipur Act 10 of 2014), ss. 2, 3, 4, 12 and 18, and Bill No. 6 of 2026; Manipur (Hill Areas) District Councils Act, 1971, ss. 29, 44A and 52, with the (Second Amendment) Act, 2006 (Manipur Act 10 of 2006) and the (Third Amendment) Act, 2008 (Manipur Act 7 of 2008); Manipur Official Language Act, 1979 (Act 14 of 1979) and the (Amendment) Act, 2021 (Act 7 of 2021); High Court of Manipur, PIL No. 8 of 2025, order of 16 June 2025, with WRD's inspection report; NGT, OA 606/2018, Government of Manipur, updated report (July 2025) and sixth six-monthly report (December 2025); CPCB, Polluted River Stretches for Restoration of Water Quality (2025); DoECC, Administrative Report 2025-26; Town Planning Department, Annual Administrative Report 2025-26; AIIB, Approval Project Document (October 2024) and Project Summary Information (29 November 2024), Manipur Urban Road, Drainage and Asset Management Improvement Project (P000723); NDB, Project Summary, Lamphelpat Waterbody Rejuvenation Project (2021); MASTEC, Flood Hazard Zonation in Manipur Valley, final report (data to 2001); CGWB, Ground Water Information Booklets, Imphal West and Bishnupur districts (2013); CWC, Flood Estimation Report for South Brahmaputra subzone 2(b) (Revised), No. SB-2(b)/R-4/44/99 (March 2000), Annexure 1.1, Table 4.1 and Plate 9, and Flood Estimation Report for North Brahmaputra subzone 2(a) (NB/18/1991); IMD, Extremes of Temperature and Rainfall for Indian Stations (up to 2012); Das et al. (2022), MAUSAM 73(4); NIH-DHAARA (queried 14 November 2026); H. Surmangol Sharma, Learners' Manipuri-English Dictionary (2006); M. Singh (2025), NEHU Journal; CWC levels as transcribed by SANDRP (2018); reports of the floods of 1989, 2002, 2015, 2024 and 2025, of the landslides at Joumol and Tupul, of the WRD river levels, of the District Councils, of the Flood Plain Zoning Act and of Loktak (press and secondary sources).

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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4	Site Runoff Control: Retention and Detention	Annexes 4
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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
AIIB	Asian Infrastructure Investment Bank
AMC	Antecedent moisture condition
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APD	Approval project document (AIIB)
APWA	American Public Works Association
ARF	Areal reduction factor
ASABE	American Society of Agricultural and Biological Engineers

Abbreviation	Meaning
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
CEA	Central Electricity Authority
CGP	Construction General Permit (US EPA)
CGWB	Central Ground Water Board
CIP	Capital Improvement Programme
CN	Curve number (SCS/NRCS method)
COD	Chemical oxygen demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSE	Centre for Science and Environment
CWC	Central Water Commission
DC	Deputy Commissioner
DEM	Digital elevation model
DoECC	Directorate of Environment and Climate Change, Manipur
DPR	Detailed project report
DSAL	Digital South Asia Library (the online edition of the Manipuri dictionary cited)
DST-NRDMS	Natural Resources Data Management System of the Department of Science and Technology
DWF	Dry-weather flow
EN	European Standard (Norme Européenne)
EPD	Environmental Protection Division (Georgia, United States)
ESC	Erosion and sediment control
EV1	Extreme value type I (Gumbel) distribution
FER	Flood Estimation Report (CWC)
FL / WL	Flood level / warning level (at WRD's river gauges)
FRL / MWL / MDDL	Full reservoir level / maximum water level / minimum draw-down level
FRP	Fibre-reinforced plastic
GIS	Geographic information system
GWRA	Ground water resource assessment (CGWB)

Abbreviation	Meaning
HAT / MHWS	Highest astronomical tide / mean high water springs (coastal terms; not applicable in Manipur)
HC	High Court of Manipur
HFL	High flood level (the highest level recorded at a gauge)
HGL	Hydraulic grade line
HSG	Hydrologic soil group
HY-8	FHWA's culvert hydraulic analysis program
I&D	Interception and diversion (of drains to a treatment plant)
IDF	Intensity–duration–frequency
IEE	Initial environmental examination
IFCD	Irrigation and Flood Control Department (the former name of WRD)
IIT	Indian Institute of Technology
IMC	Imphal Municipal Corporation
IMD	India Meteorological Department
IMDAA	Indian Monsoon Data Assimilation and Analysis (a regional reanalysis)
IRC	Indian Roads Congress
IS	Indian Standard (Bureau of Indian Standards)
ISO	International Organization for Standardization
IST	Indian Standard Time
JICA	Japan International Cooperation Agency
KC	Kansas City (Kansas City Metro APWA Section 5600)
LDA	Loktak Development Authority
LiDAR	Light detection and ranging (laser survey)
MAHUD	Municipal Administration, Housing and Urban Development Department, Manipur
MASTEC	Manipur Science and Technology Council
MBBL 2016	Model Building Bye-Laws 2016 (MoHUA; not the State's bye-laws)
MLD	Million litres a day
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MPCB	Manipur Pollution Control Board
MSDMA	Manipur State Disaster Management Authority
MSWA	Manipur State Wetlands Authority
MTCP Act	The Manipur Town and Country Planning Act, 1975
MW	Megawatt
NDB	New Development Bank

Abbreviation	Meaning
NDMA	National Disaster Management Authority
NGT	National Green Tribunal
NH	National Highway
NHPC	NHPC Ltd (operator of the Loktak hydroelectric project and the Ithai barrage)
NIH	National Institute of Hydrology, Roorkee
NIT	National Institute of Technology
NOC	No-objection certificate
NPDES	National Pollutant Discharge Elimination System (United States)
NRSC	National Remote Sensing Centre
NWIA	National Wetland Inventory and Assessment (ISRO)
OA	Original Application (NGT)
OBPS	Online Building Permission System
OCR	Optical character recognition (the text layer of a scanned document)
OGC	Open Geospatial Consortium
ORF	Observer Research Foundation
PDA Manipur	Planning and Development Authority, Manipur (section 13 of the MTCP Act)
PHED	Public Health Engineering Department
PIL	Public interest litigation
PSD	Permissible site discharge
PWD	Public Works Department, Manipur
RDSO	Research Designs and Standards Organisation (Railways)
RIMP	Risk Informed GIS Based Master Plan (for Imphal and for Moirang)
RMSE	Root-mean-square error
RRV	Required retention volume
RWH	Rainwater harvesting
SAC	Space Applications Centre, Indian Space Research Organisation
SANDRP	South Asia Network on Dams, Rivers and People
SH	State highway
SLA	Sea-level allowance (coastal term; not applicable in Manipur)
SRRG	Self-recording rain gauge
STP	Sewage treatment plant
SUH	Synthetic unit hydrograph (CWC)
TBC	To be confirmed: a fact or value not yet found in a source
TCPO	Town and Country Planning Organisation (MoHUA)

Abbreviation	Meaning
TPD	Town Planning Department, Manipur (under MAHUD)
TR-55	Technical Release 55 (USDA SCS/NRCS)
UH	Unit hydrograph
ULB	Urban local body (in Manipur, IMC, a Municipal Council or a Nagar Panchayat)
Unified Bye-Laws 2024	The Model Manipur Unified Building Bye-Laws 2024, with the bye-laws that each ULB and PDA Manipur bring into force on it
USACE	US Army Corps of Engineers
USD	United States dollar
UT	Union Territory
UTM	Universal Transverse Mercator
VR	Value rating (of a BMP treating the WQv)
WAPCOS	WAPCOS Ltd (the monitoring consultant for the Lamphelpat works)
WQv	Water quality volume
WRD	Water Resources Department, Manipur
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 Manipur. 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 in the Imphal valley come as spells of several days on the hills that feed its rivers (rain on 28 July–1 August 1989, when Imphal recorded its highest day, 158.6 mm on 30 July, and Kangpokpi 617.6 mm in the month; 175 mm in 72 hours at Kangpokpi on 30–31 May 2025, as reported) and fill the pats and Loktak while the bund gates are shut, and which in the western hills bring the State's heaviest falls (225 mm in one night at Khoupum on 15 July 2025, as reported), from the pre-monsoon storms of April and May to the October storms about the withdrawal of the south-west monsoon, as well as for short-duration intensities;
- (d) to design outfalls for the rivers of the Imphal valley, which in the monsoon stand above the towns behind their bunds ("The town is below the high flood level of Imphal river and hence there are embankment roads on both sides of the river", master plan for Greater Imphal), so that most valley outfalls pass through gates or flap gates that close, or are pumped, when the river is high: the Imphal river at Minuthong, whose highest flood level of 788.400 m lies within a metre or two of the city's ground (WRD level as reported), the Nambul, the Iril, the Kongba, the Thoubal and the other valley rivers; Loktak, held up by the Ithai barrage and the rock sill below it, the "Sugnu hump", whose level is the tailwater of the south of the valley; the pats that store a district's water while its outfall is shut, among them Lamphelpat with its pumped outlet to the Nambul; the Barak and the Jiri at Jiribam; the reaches below the Mapithel dam on the Thoubal and the dams on the Khuga and the Nambul, into which floods are released; and the hill streams, which rise within the hour, including the case where the outfall is closed;
- (e) to protect tanks (pukhris), 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 that each urban local body and the Planning and Development Authority, Manipur bring into force, by notification in the Manipur Gazette, on the model published by MAHUD under section 213 of the Manipur Municipalities Act, 1994 and section 26(1) of the Manipur Town and Country Planning Act, 1975 (the Model Manipur Unified Building Bye-Laws 2024), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

Commentary. Manipur's floods come from three sources, often together. The first is the river flood of the Imphal valley, a closed basin whose rivers run in bunds above the towns ("The town is below the high flood level of Imphal river and hence there are embankment roads on both sides of the river", master plan for Greater Imphal) and leave by one outlet, past the Ithai barrage and a rock sill, the "Sugnu hump", that "does not have the capacity to cope up with such flow, as a result, water is piled up upstream" (MASTEC). The valley floods when days of rain on the hills, about 70% of its catchment, fill the rivers, the bunds breach and the drains cannot discharge. MASTEC records the floods of June–July and October 1966, with breaches at 60 places; of late July and August 1989, after "continuous daily rainfall from 28th July to 1st August", when Imphal (Tulihal) recorded its highest day, 158.6 mm on 30 July, and the flood reached 361 localities through 40 breaches, affecting 7 lakh people, 97,500 ha of paddy and 49,069 houses; of October 1992; of September 1997; of September 1999; of September 2000, when the Iril carried 532.5 m³/s and the bunds breached at 30 places; and of August 2002, with 59 breaches, 10,000 houses and 20,000 ha affected (MASTEC). In late July and August 2015 about 5 lakh people were displaced by 3 August, by a State revenue estimate, and 60,000 ha were flooded, in what officials called a flood that "could be the worst flood in 200 years"; the Mapithel reservoir stood at 876 m on 1 August (all as reported). The monsoon of 2017 killed 22 people (as reported). On 28–31 May 2024, in the storm of Cyclone Remal, before the south-west monsoon's normal onset, the Imphal river at Minuthong rose above its highest flood level and the bunds breached at 18 places, 17 of which were sealed; the Minister gave 1,88,143 people and 24,265 houses affected on 30 May, while the Relief and Disaster Management Department's report of 31 May gave 1,26,950 people, 255 localities and 16,364 houses, and 3 to 5 deaths were reported (all as reported; conflict). From 30 May 2025, again before the onset, the Imphal river breached at Singjamei, Heingang, Bashikhong and New Checkon, and at Keirang, Khabam and Lairikyengbam Leikai, and the Nambul at four places, after Kangpokpi received 175 mm in 72 hours; 56,000 people and 10,477 houses were reported affected at an early stage, and 4 deaths, about 1.65 lakh people affected and more than 35,000 houses damaged by 24 June (official figures as reported). On 15 September 2025 the Imphal river at Lilong stood at 783.250 m and the Manipur river at Ithai at 770.05 m, both above their printed highest flood levels, the Iril breached at Kshetri Awang Leikai and one man was swept away (as reported). The tolls differ in what they count and by the date of the report, and the official final tolls of the Relief and Disaster Management Department or MSDMA were not obtained [TBC].

The second source is the town drain that cannot discharge or is blocked. Lamphelpat "remains waterlogged for many days every year" (NDB); the solid waste of the main market is "dumped in the Naga Nullah on the backside of the market, which creates a stagnant pool all along the year" (master plan for Greater Imphal), and its clogging flooded Nagaram, Laipham Khunou and Lairikyengbam Leikai in July 2024 (as reported); and when the river dikes fail, "waterlogging in the low-lying areas" lasts "for several weeks" (AIIB). The third, found in no plains State of the series, is landslides and debris on the Disang shale of the hills, which "occupies almost 85 p.c. of the hilly region" (MASTEC). On 1 August 2015, in the week of the valley flood, a landslide at Joumol in Chandel killed 20 or 21 people, or 24 by ActionAid's count (as reported; conflict). On 29 or 30 June 2022 a landslide at Tupul in Noney, at the site of the Jiribam–Imphal railway and a Territorial Army camp, killed 56 (reported on 20 July), 58 (29 soldiers and 29 civilians, with 3 missing) or 61 people (all as reported; the date and the toll conflict); NRSC's note of 5 July reported 42 dead and 20 missing at that date (as quoted). Noney district received 348.5 mm in June 2022, and May and June together 705.5 mm, "130% higher than the mean" of the previous decade (Baruah et al., 2023, as summarised). On 15 July 2025, 225 mm fell at Khoupum in Noney "on Tuesday night", the highest fall "ever in Manipur's recorded history" according to IMD Imphal officials, and the Khoupum valley was inundated (as reported; duration and gauge not stated).

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 largest drainage programme, 547 km of "both side stormwater covered drains" along the roads of Greater Imphal, states none (AIIB, Approval Project Document, 2024), and the master plan for Greater Imphal has no storm-water drainage section. The building bye-laws set a river buffer table, a plinth rule and rainwater harvesting, not runoff, and they do not reach the hill areas at all. Objectives (b) to (e) address the storage, outfall and building-level failures, which a drain-sizing manual alone cannot fix; the hill source is

answered by the siting, screening, infiltration and debris rules of Chapters 2, 4, 6 and 7, because no drain is sized to carry a slide, and the river source by the outfall-closed checks of Chapter 5 and the corridors and floor levels of Chapters 6 and 7.

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 Model Manipur Unified Building Bye-Laws 2024 mandate RWH only. Objective (a) is therefore the main new step this Manual takes.

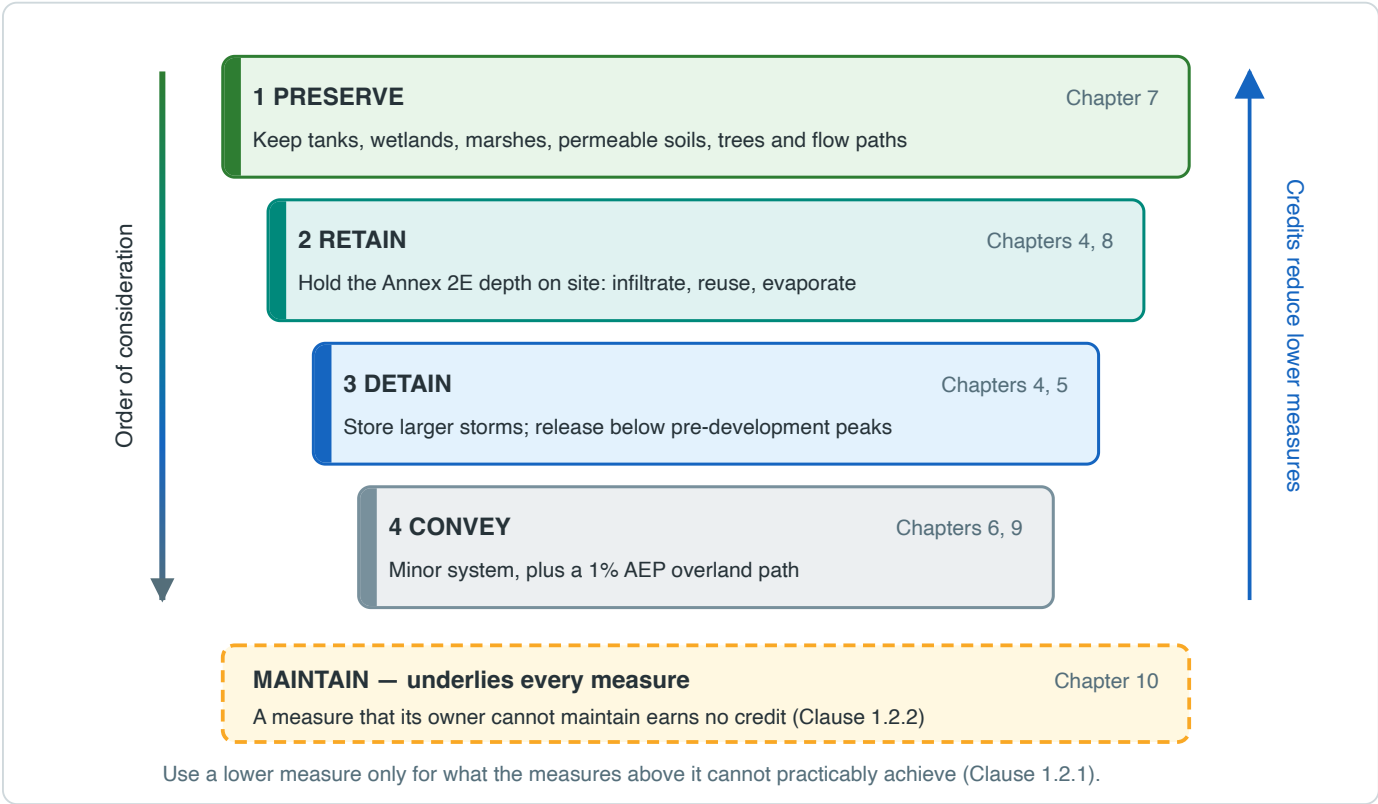
1.2 Stormwater management hierarchy

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.



Use a lower measure only for what the measures above it cannot practicably achieve (Clause 1.2.1).

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 Manipur, the top two layers have a particular meaning. Much of the valley's storage lies in its pats, the natural lakes and marshes of the valley floor; in Loktak, held up by the Ithai barrage; in its pukhris; and in its paddy land, which stands under water through the monsoon. MASTEC records that "there were nearly 500 lakes in Manipur Valley" and lists Lamphelpat, Porompat, Takyelpat, Sangaipat, Kharungpat and Ikop pat among the pats that are degraded or disappearing, and CGWB that the valley "was once full of swamps and marshy land represented by the places having the word PAT meaning lake" (MASTEC; CGWB, Imphal West, 2013). The notified master plan for Greater Imphal shrinks the planning area's wetlands from 374.48 ha to 232.21 ha and its agricultural land from 5,616.53 ha to 2,604.70 ha by 2043, while its water bodies grow from 563.54 ha to 643.42 ha (master plan for Greater Imphal). The law protects some of this. The Manipur Loktak Lake (Protection) Act, 2006 makes the lake's Core Zone of 70.30 km² a "No-Development Zone or Totally Protected Zone" and bans, in the Buffer Zone, the "Discharge of untreated wastes and effluents from industries, cities or towns" and "Land reclamation, bunding or disturbing the natural course of drainages" (ss.3, 19); the Manipur Conservation of Paddy Land and Wetland Act, 2014 forbids the conversion of paddy land and wetland, counting its "drainage channels, ponds, canals, bunds and ridges" as part of it, except through its committees (ss.2(c), 3); the Manipur State Wetlands Authority has published draft notifications of the Yaral, Utra and Waithou–Phumnom pats under the Wetlands Rules, 2017, none yet final; and the bye-laws set a buffer along the named rivers of the valley (bye-law 93 of the Model [TBC: confirm the number and text in the bye-laws the local body has notified]). No statute or bye-law sets a buffer round a pat or pukhri outside Loktak, and no flood zone has been notified under the Manipur Flood Plain Zoning Act, 1978. On the valley floor the second layer changes. Retention there is storage and reuse, not infiltration: the floor is "approximately 30 to 50 m of clayey formation", with water "2 to 5 m bgl" in most of Imphal West (CGWB, Imphal West, 2013), and peat with "high acidity" round the lakes (CGWB, Bishnupur, 2013), so a soak pit fills from below in the monsoon. This Manual therefore bars deliberate infiltration on the clay, silt and peat of the valley floor, below the 1% AEP flood level, behind a river bund and round a pat or pukhri (Clause 4.11, valley-floor rule); bars it in the hills on natural slopes of more than 10°, on the Disang shale at any slope, on colluvium, fill or slide debris and close upslope of a cut or retaining wall, unless a geotechnical certificate allows it (Clause 4.11, hill rule); and allows recharge only on the tested foothill fans at the edge of the valley, on Barail sandstone cappings of gentle slope and on tested sand lenses, because every groundwater assessment unit of the State is "Safe", with a stage of extraction of 8.00% (GWRA 2024, as quoted), and recharge is not a design objective there (Clause 4.11, recharge rule) (all set by this Manual). Rainwater harvesting is storage for the dry season: Imphal draws about 90% of its drinking water from the Imphal, Nambul and Iril rivers (master plan for Greater Imphal). Losing the pats and the paddy land cannot be offset by pipes, and in the hills drains that put water into a slope of shale 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 Manipur through:

- (a) an amendment to the Model Manipur Unified Building Bye-Laws 2024 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 Manipur the building rules are a model that each local body brings into force. The Model Manipur Unified Building Bye-Laws, 2024 were published by MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD-Part(1) of 4 December 2024 (Manipur Gazette Extraordinary No. 253 of 5 December 2024), under section 213 of the Manipur Municipalities Act, 1994 (Act 43 of 1994) and section 26(1) of the Manipur Town and Country Planning Act, 1975 (Manipur Act 11 of 1975), "for adoption by the Urban Local Bodies and Planning & Development Authority, Manipur", after a draft notice of 29 October 2024 (No. BBL-101/1/2024-MAHUD-MAHUD(Part-1)). The Model "shall extend to the Master Plan areas or notified Planning areas and area under the jurisdiction of all the Urban Local Bodies of Manipur" (bye-law 1(2)), and its "Act" is the Municipalities Act in the areas of urban local bodies and the 1975 Act "in respect of Master Plan areas but beyond the municipal limits" (2(2)). A permit, however, is given under the bye-laws that the urban local body or the Planning and Development Authority, Manipur (PDA Manipur) has brought into force on the Model. The TPD's site lists final gazettes of the building bye-laws of the Kumbi, Moirang and Jiribam Municipal Councils, 2025, of 16 January 2025, and a "Building Bye-laws for ULBs of Manipur – Final Gazette Notification" of 15 December 2025 (as listed; the second was not read for this Manual); Imphal Municipal Corporation Building Bye-Laws, 2025 are reported to have been notified on 15 December 2025 (as reported). Before the Model, Imphal had the IMC Building Bye-laws, 2013, amended in 2019 and 2022 (as listed); eight other local bodies had bye-laws "based on Model Building Bye-laws of 1998", and 18 had none (recitals of the Model). The IMC Building Bye-Laws (3rd Amendment), 2024 were published as a draft for objections, to "come into force on such date as the State Government may, by notification in the Official Gazette, appoint"; whether they were made final was not confirmed [TBC]. Provision numbers in this Manual are those of the Model: bye-laws 1(2), 2(2), 2(11), 6(1)(A), 6(1)(C)(j), 6(1)(D), 16, 28, 66, 67, 68 and 92–94 [TBC: confirm the number and text in the bye-laws the local body has notified]; where a local body's notified text differs, its text governs.
>
> The Model asks for a "Detailed drainage plan for both internal and external required to be constructed up to the available permanent/pucca drain of municipal/other authority" for multi-storeyed, lifeline and special buildings (6(1)(D)); forbids building "over any municipal drain" (16); sends rain-water pipes of at least 75 mm to a surface drain, "in no case" directly into a closed drain, and never into a soil pipe (28); makes rainwater harvesting mandatory on plots of 100 m² and more, with soft cover of 10% or 15% of the plot (66), grey-water recycling on the larger buildings (67) and a fee rebate (68); bars new construction within a buffer measured from mid-stream along named reaches of ten valley rivers, from 22.5 m to 62 m, "or 6 m from outer toe of bund, whichever is further from mid-stream" on most of them, subject to "the previous permission of the Flood Zoning Authority constituted under the Flood Plain Zoning Act, 1978" (93); and sets the plinth "above 1m above the highest flood level of the surrounding areas" in "high Flood Risk Areas identified in the Master Plan of the towns" (94). Its bye-law 92, as printed, reads "No construction shall be permitted on land above 600 m from the mean sea level and with an average slope of 30 degrees", which would bar all of Greater Imphal, which lies above 600 m (NEER reading); the IMC (3rd Amendment) draft of 2024 gives the intended rule, that "no construction will be permitted in the areas which have a slope of more than 30 degrees", that development is permitted "only upto two floors or 7m height in areas which have a slope of 21-30 degrees" (92.1) and that "no cutting of slopes will be permitted" above 30° (92.2), and this Manual reads bye-law 92 with that text. The Model sets no design storm, return period, release rate or detention volume. The Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026

(MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD of 22 July 2026; Gazette Extraordinary No. 157 of 23 July 2026), made under section 91(1)(iv) read with section 24(e) of the 1975 Act, add a use zone "Pond, Drain, Rivers and Canals" in every Master Plan area. The route of Clause 1.3.1(a) therefore runs through an amendment to the Model by MAHUD under the same two sections, and its adoption by each urban local body and PDA Manipur in their bye-laws: MAHUD could amend bye-laws 6(1)(D), 66 and 92–94 and the zoning bye-laws' "Pond, Drain, Rivers and Canals" zone and commend the amendment to the local bodies and PDA Manipur, which could adopt it in their bye-laws (Annex 1D).

That route reaches only the areas of the urban local bodies and the notified Master Plan and planning areas. **The hill areas** are a second legal geography. They are the areas in the First Schedule to the Manipur Legislative Assembly (Hill Areas Committee) Order, 1972, for which Article 371C provides a Hill Areas Committee of the Assembly (as summarised). The Manipur Municipalities Act, 1994 "extends to the whole of the State of Manipur except the Hill Areas" (as quoted), the Model reaches no hill area that is not a notified planning area, and the paddy-land Act stops at the hill boundary (NEER reading); the Manipur Town and Country Planning Act, 1975 and the Manipur Flood Plain Zoning Act, 1978 extend to the whole State. The Manipur (Hill Areas) District Councils Act, 1971, as amended, gives the District Councils functions that include "water supply and sanitation schemes", "the construction, repair and maintenance of embankments", soil conservation, the allotment of land for "residential or other non-agricultural purposes" and, by entrustment of the Governor "in consultation with the Hill Areas Committee", "village planning or any other matter" (s.29(1), the numbering of its items read from page images and to be verified [TBC]), but no building control. A section 29(1A), inserted in 2006, would let a Council "notify any part of the area of the Autonomous District as urban area for the purpose of formulation of development plan", on a date to be notified that was not found; this Manual does not treat it as in force. The Councils' terms expired on 30 November 2022, and the Governor appointed the Deputy Commissioners of six hill districts as their administrators in June 2025 (as reported); whether there are six Councils or ten after a reported amendment of 2022 is not settled [U]. **No building or drainage rule for the hill areas was found for this Manual.** In the hill areas the Manual can therefore reach the public works executed by the State's departments and agencies, among them roads, bridges, culverts, drains, water supply, embankments and flood works (Clause 1.5.1(b)); any body that adopts it; and, in future, the master plans that the TPD is preparing for the district headquarters "both valley and hills", with a horizon of 2042, under which the Model could extend to a notified planning area. A District Council could take the Manual up as a matter entrusted by the Governor under section 29, or through a development plan under section 29(1A) once that is in force. For a household or village in the hill areas the Manual is guidance only. This Manual is a draft: neither the Government, MAHUD, the TPD, PDA Manipur, IMC, any Municipal Council or Nagar Panchayat, the Hill Areas Committee, any District Council or its administrator, 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 an urban local body, that body (the Imphal Municipal Corporation (IMC), a Municipal Council or a Nagar Panchayat) for the building permit and for its own drains and works, under the building bye-laws it has brought into force on the Model Manipur Unified Building Bye-Laws, 2024 and under the Manipur Municipalities Act, 1994; in a Master Plan area or notified planning area outside municipal limits, the Planning and Development Authority, Manipur (PDA Manipur) under the Manipur Town and Country Planning Act, 1975 (bye-law 2(2) of the Model); the Town Planning Department (TPD) for the land-use check of a building plan against the master plan on the online building permission system (OBPS); the Water Resources Department (WRD) for any work on, through or within a river bund, flood channel, river or pumped outfall that it holds, as owner (no embankment statute of the State was found); the Flood Zoning Authority under the Manipur Flood Plain Zoning Act, 1978, where a flood zone has been notified (none has); the Loktak Development Authority (LDA) within the 236.21 km² of the Manipur Loktak Lake (Protection) Act, 2006 (prior permission under section 20); the Local, District and State Level Committees for the conversion of paddy land or wetland under the Manipur Conservation of Paddy Land and Wetland Act, 2014; the Manipur State Wetlands Authority (MSWA) for a wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (no notification is final); and, in the hill areas, the department that executes a public work (the Public Works Department (PWD), the Public Health Engineering Department (PHED), the WRD or another works agency) for that work and, for any other development, the District Council or its administrator, the Deputy Commissioner, only where the Governor has entrusted the matter to it under section 29 of the Manipur (Hill Areas) District Councils Act, 1971 or the Council has adopted this Manual (neither has been done), 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 Model Manipur Unified Building Bye-Laws 2024 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 Nambul through Greater Imphal, with the Naga Nullah and Waisel Maril channels and the 72 drains that fall into it; of the Imphal river through Imphal; of the Lamphelpat basin, with its pumped outlet through the Shamushang nallah to the Nambul; of the Kongba and Iril corridors of Imphal East; of Thoubal on the Thoubal river below the Mapithel dam; of the Loktak margin, Moirang, Ningthoukhong, Thanga, and Ithai–Sugnu–Wangoo with the Chakpi backwater; of Nambol and Bishnupur on the Nambol and Nambul rivers; of Kakching and Wangjing on the Sekmai and Wangjing rivers; of Jiribam on the Barak and the Jiri; and of the hill towns on landslide ground, Noney (Tupul), Tamenglong, Chandel and Kangpokpi, and any catchment the Authority notifies (Chapter 4; Annex 1B).
Waterbody	A river, stream, canal, tank (pukhri), lake, pond, marsh, supply channel or surplus course, whether perennial or seasonal (Chapter 7).

Term	Meaning in this Manual
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.
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 Model Manipur Unified Building Bye-Laws 2024 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 Manipur Gazette.
Competent authority for the area	The body that grants permission for the site, or consents to the work, under the instrument that applies there: in the area of an urban local body, that body (the Imphal Municipal Corporation (IMC), a Municipal Council or a Nagar Panchayat) for the building permit and for its own drains and works, under the building bye-laws it has brought into force on the Model Manipur Unified Building Bye-Laws, 2024 and under the Manipur Municipalities Act, 1994; in a Master Plan area or notified planning area outside municipal limits, the Planning and Development Authority, Manipur (PDA Manipur) under the Manipur Town and Country Planning Act, 1975 (bye-law 2(2) of the Model); the Town Planning Department (TPD) for the land-use check of a building plan against the master plan on the online building permission system (OBPS); the Water Resources Department (WRD) for any work on, through or within a river bund, flood channel, river or pumped outfall that it holds, as owner (no embankment statute of the State was found); the Flood Zoning Authority under the Manipur Flood Plain Zoning Act, 1978, where a flood zone has been notified (none has); the Loktak Development Authority (LDA) within the 236.21 km² of the Manipur Loktak Lake (Protection) Act, 2006 (prior permission under section 20); the Local, District and State Level Committees for the conversion of paddy land or wetland under the Manipur Conservation of Paddy Land and Wetland Act, 2014; the Manipur State Wetlands Authority (MSWA) for a wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (no notification is final); and, in the hill areas, the department that executes a public work (the Public Works Department (PWD), the Public Health Engineering Department (PHED), the WRD or another works agency) for that work and, for any other development, the District Council or its administrator, the Deputy Commissioner, only where the Governor has entrusted the matter to it under section 29 of the Manipur (Hill Areas) District Councils Act, 1971 or the Council has adopted this Manual (neither has been done). Where this Manual says "the Authority", the competent authority for the area is meant.
Model bye-laws; local body's bye-laws	The Model Manipur Unified Building Bye-Laws, 2024 (the Model), published by MAHUD "for adoption by the Urban Local Bodies and Planning & Development Authority, Manipur" (Notification No. BBL-101/1/2024-MAHUD-MAHUD-Part(1) of 4 December 2024), and the building bye-laws that an urban local body or PDA Manipur has brought into force on it by notification in the Manipur Gazette. A building permit is given under the local body's bye-laws. Provision numbers cited in this Manual are those of the Model; where the text a local body has notified differs, that text governs.
Master Plan area; planning area	An area for which a master plan has been notified under section 22 of the Manipur Town and Country Planning Act, 1975, or an area notified as a planning area; beyond municipal limits PDA Manipur, constituted under section 13 of that Act, is the Authority there (bye-law 2(2) of the Model). The Greater Imphal planning area of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification) covers 151.38 km², more than the area of IMC.

Term	Meaning in this Manual
Hill areas	The areas specified in the First Schedule to the Manipur Legislative Assembly (Hill Areas Committee) Order, 1972 (the definition substituted in the Manipur (Hill Areas) District Councils Act, 1971 in 2008), for which Article 371C of the Constitution provides a Hill Areas Committee of the Legislative Assembly (as summarised). The Manipur Municipalities Act, 1994 does not extend to them (as quoted), and the Model applies only in the areas of urban local bodies and in notified Master Plan or planning areas. The functions of the District Councils under section 29(1) of the 1971 Act include water supply and sanitation schemes, embankments, soil conservation and the allotment of land for residential or other non-agricultural purposes, but not building control. No building or drainage rule for the hill areas was found for this Manual. The Councils' terms expired in November 2022 and the Deputy Commissioners of six hill districts were appointed their administrators in June 2025 (as reported).
River bund; gated outfall	An embankment along a river or flood channel of the valley, built and held by the WRD, and an outfall that passes a town's drain through it by a gate, a flap gate or a pump. Most outfalls of the valley towns are of this kind, and they close when the river is high (Chapter 5).
Loktak; Core Zone; Buffer Zone	Loktak as defined by section 1(3) of the Manipur Loktak Lake (Protection) Act, 2006: 236.21 km² of open water and marshy land in the south of the valley up to the confluence of the Manipur river and the Khuga, excluding the Keibul Lamjao National Park (40 km²) and the Takmu Fishery Farm (5 km²). Its Core Zone of 70.30 km² is "the No-Development Zone or Totally Protected Zone" and the rest of the lake is the Buffer Zone (s.3).
Paddy land; wetland (2014 Act)	Land under paddy farming and "its allied constructions like drainage channels, ponds, canals, bunds and ridges", and wetland, as defined in section 2 of the Manipur Conservation of Paddy Land and Wetland Act, 2014, which may be converted only through the committees of that Act. The Act extends to the areas of the Manipur Land Revenue and Land Reforms Act, 1960, and so not to the hill areas (NEER reading).
Patta land	Land held privately and recorded in the revenue records of the valley under the Manipur Land Revenue and Land Reforms Act, 1960, by district, sub-division and revenue village. Where this Manual reserves a drainage corridor, an easement or a regional facility site on patta land, it is reserved in the master plan or secured by agreement, not taken (set by this Manual). In the hill areas land is allotted by the District Councils and held under customary tenure [TBC: not researched].

> **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 Model Manipur Unified Building Bye-Laws 2024;
- (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 Manipur, 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 bye-law 66 of the Model Manipur Unified Building Bye-Laws, 2024, as each urban local body and PDA Manipur bring it into force, to "all existing and new buildings on plots of 100 square metre and above", whose plans "shall indicate the system of storm water drainage along with points of

collection of rain water in surface reservoirs or in recharge wells" (66(a)), with soft cover of at least 15% of the plot where the covered area is 500 m² or more and 10% otherwise (66(b)), with grey-water recycling on the larger buildings, its excess "suitably connected to the rain water recharge structures for ground water recharge" (67), and with a rebate of 10% of the permission fee where both are provided (68), but with no storage volume or roof-area rate; no rainwater harvesting rule applies in the hill areas, 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.

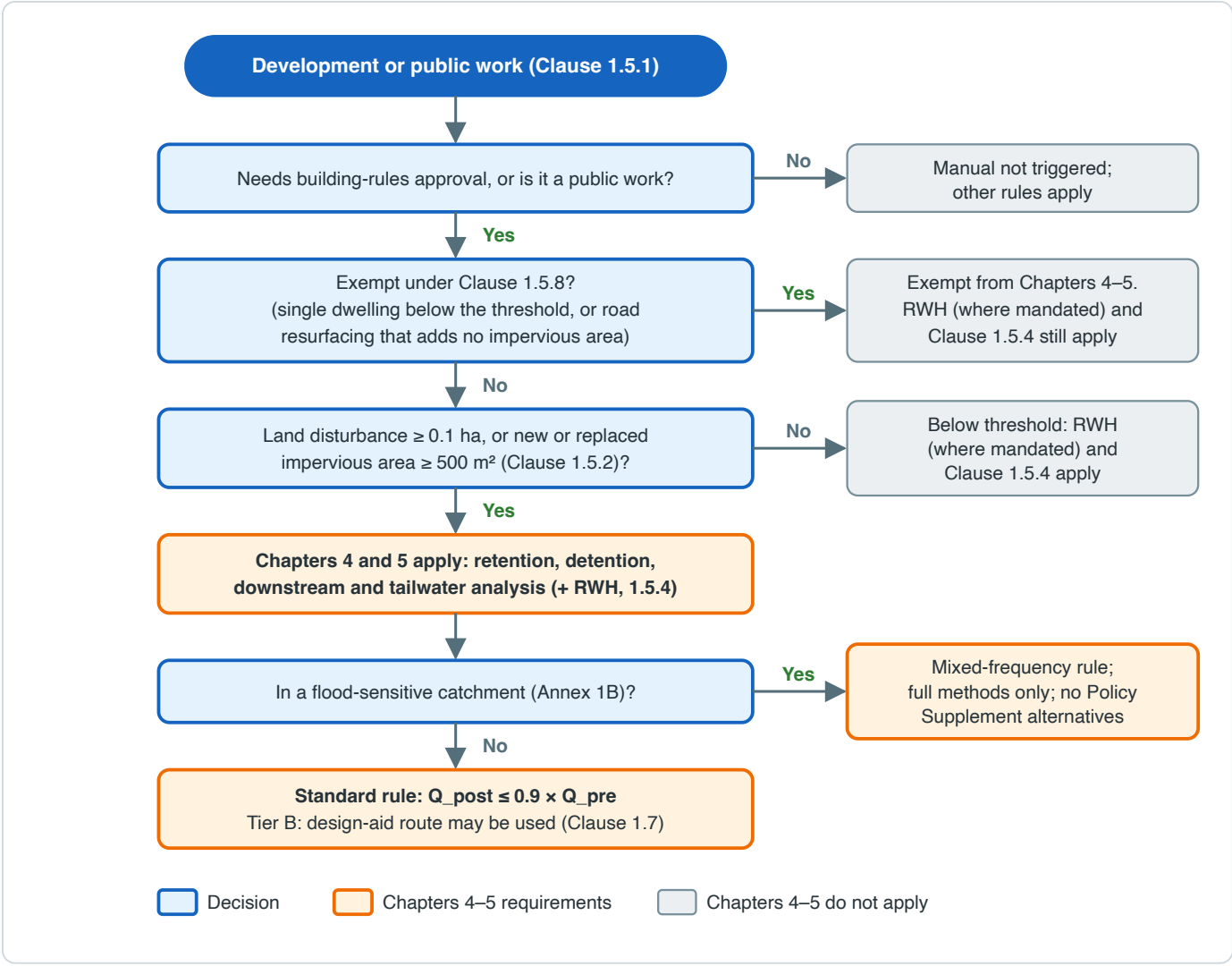


Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.

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 Manipur plots are small and the cumulative effect of many small plots is what fills Imphal's drains. For small buildings in Manipur, the bye-laws that the local bodies have brought into force on the Model reach every plot of 100 m² and more with rainwater harvesting, a plan showing "the system of storm water drainage along with points of collection of rain water in surface reservoirs or in recharge wells" and a soft cover of 10% of the plot or more (bye-law 66). None of it sets a volume, and on the valley floor the tank is full and the ground saturated when the season's storm arrives, so none of it limits what leaves the plot in a design storm. On the valley floor, too, a "recharge well" is a soak pit in clay below the water table; this Manual requires storage there instead (Clause 4.11, valley-floor rule), and where bye-law 67 sends the excess grey water of a larger building "to the rain water recharge structures for ground water

recharge", the two conflict: this Manual requires storage or a sewer connection in its place, the applicant seeks the local body's relaxation, and the Manual does not override the bye-law (Table 1.3). No rule asks a single building on the valley floor to set its floor above the water ponded behind a bund, except where bye-law 94 applies in a "high Flood Risk Area" of a master plan, which this Manual cannot locate until the risk-informed master plans are read [TBC]; Clause 1.5.4(b) applies to every building whatever its size for this reason. In the hill areas no building rule was found, and there is no permit to which a small building's drainage could be tied. There the small-site method of Chapter 4 and the hill rule of Clause 4.11, no soak pit on a slope of more than 10° or on the Disang shale, roof water to storage and its overflow to a lined drain, never down an unprotected slope, are offered to the household, the village and the agencies that build in the hills as guidance, not as a condition of any permit.

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 Imphal Municipal Corporation (IMC); and
- (b) PDA Manipur and every other approving authority within the Greater Imphal planning area (151.38 km², the area of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)), as that area is notified from time to time under the Manipur Town and Country Planning Act, 1975, whichever has jurisdiction over a site (which body issues building permission in the planning area outside IMC's limits is to be confirmed [TBC]).

1.6.2 **Tier B authorities.** All other Municipal Councils, Nagar Panchayats and planning authorities 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
Technical review	By the Authority	By the Authority, with TPD 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 Greater Imphal planning area of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification), 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.** Imphal Municipal Corporation, with 27 wards, no drain inventory or drainage design standard found for this Manual, and a drainage network that, across Greater Imphal, "is also not in good condition and is not properly connected to the primary drain", where "Drainage system links are missing … the drains are clogged" and "Imphal lacks decentralized stormwater management along streets" (AIIB, Approval Project Document, 2024), while the roadside drains, the river bunds, the city channels and the sewers within its limits are held by other bodies, and the Greater Imphal planning area extends beyond its limits, and a small Nagar Panchayat 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 Imphal.

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) ≤ 0.9 × 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 × 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
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
Model Manipur Unified Building Bye-Laws, 2024 (MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD-Part(1) of 4 December 2024; Manipur Gazette Extraordinary No. 253 of 5 December 2024), published under section 213 of the Manipur Municipalities Act, 1994 and section 26(1) of the Manipur Town and Country Planning Act, 1975 "for adoption by the Urban Local Bodies and Planning & Development Authority, Manipur" (read)	Continue, as each urban local body and PDA Manipur bring them into force. They extend to "the Master Plan areas or notified Planning areas and area under the jurisdiction of all the Urban Local Bodies of Manipur" (1(2)). They require a "Detailed drainage plan for both internal and external" drains "up to the available permanent/pucca drain" for multi-storeyed, lifeline and special buildings and an intermediate treatment chamber before any soak-pit outlet to a municipal drain (6(1)(A), (D)); forbid building over a municipal drain (16); send rain-water pipes to a surface drain, never directly into a closed drain or a soil pipe (28); allow no open drain "except for rain water" in a required open space; bar new construction in the buffers of bye-law 93 and set the plinth 1 m above the highest flood level in high flood risk areas of a master plan (94); define a basement (2(11)) without excluding it from low-lying or flood-prone land; and reference IS 14458 for retaining walls in hill areas. Bye-law 92, as printed, would bar all of Greater Imphal and is read with the IMC (3rd Amendment) 2024 draft text (Commentary to Clause 1.3). They set no design storm, return period, release rate or detention volume. The design criteria of Chapters 2–6, the valley-floor, hill and recharge rules of Clause 4.11 and the corridors of Chapter 7, whose Zone 1 is at least 15 m, are this Manual's proposals; they are not statutory values, and no authority has adopted them. Where the bye-laws, a master plan or a statute are stricter, they govern (Clause 1.3.3).
The building bye-laws brought into force on the Model: the Kumbi, Moirang and Jiribam Municipal Councils' building bye-laws, 2025 (final gazette of 16 January 2025, as listed on the TPD site); "Building Bye-laws for ULBs of Manipur – Final Gazette Notification" (15 December 2025, as listed; not read); the IMC Building Bye-Laws, 2025 (reported notified on 15 December 2025, as reported); the IMC Building Bye-laws, 2013, as amended in 2019 and 2022 (as listed), and the IMC Building Bye-Laws (3rd Amendment), 2024 (draft read)	Govern where in force. A building permit is given under them, not under the Model. Which text is in force in IMC and in each Municipal Council and Nagar Panchayat, and whether bye-laws 66 and 92–94 survive in it unchanged, are to be confirmed [TBC]; provision numbers in this Manual are the Model's. The IMC (3rd Amendment) 2024 draft inserts the slope classes of 92.1 and 92.2, repeats the river buffer table (93.1) and ties the plinth rule to "High Flood Risk Areas identified in the Risk-Informed GIS-Based Master Plan for Greater Imphal" (93.2); it was to come into force on a date to be appointed, and its final status was not confirmed [TBC].

Instrument	Relationship
Rainwater harvesting and grey water: bye-laws 66, 67, 68 and 6(1)(C)(j) of the Model; the green-building criteria annexed to it	Continue unchanged. Bye-law 66(a) makes "Water harvesting through storing of water runoff including rainwater in all existing and new buildings on plots of 100 square metre and above" mandatory, with "points of collection of rain water in surface reservoirs or in recharge wells" on the plans; 66(b) sets soft cover of at least 15% of the plot where the covered area is 500 m² or more, and 10% otherwise; 67 requires grey-water recycling for a covered area of 500 m² or more or 10,000 L/day, with the excess "suitably connected to the rain water recharge structures for ground water recharge"; 68 rebates 10% of the permission fee where both are provided; and the green-building criteria ask to "Minimize storm water run-off from site by reducing hard paving on site" and for "erosion and sedimentation control". None sets a storage volume or a roof-area rate. This Manual counts stored water against its retention requirement only as reuse (Clause 4.4.3), never as detention. Bye-law 66 is no conflict on the valley floor, because it allows surface reservoirs and the Manual chooses them; bye-law 67's routing to recharge structures is: on the valley floor such a structure is a soak pit in clay, so this Manual requires storage or a sewer connection in its place, the applicant seeks the local body's relaxation, and the Manual does not override the bye-law (Clause 4.11, valley-floor rule).
Manipur Town and Country Planning Act, 1975 (Manipur Act 11 of 1975; the (Fifth Amendment) Act, 2023 and (Sixth Amendment) Ordinance, 2026 listed, not read); the Planning and Development Authority, Manipur (PDA Manipur), constituted under its section 13; the Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026 (MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD of 22 July 2026; Gazette Extraordinary No. 157 of 23 July 2026); the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification) (No. SCS-401/3/2021-MAHUD-MAHUD-Part(3) of 4 December 2024); the Risk Informed GIS Based Master Plans for Imphal and Moirang (final notifications listed for 17 January 2025; not read)	Continue. The 1975 Act "extends to the whole of the State of Manipur" (s.1(2)), provides for master plans (s.22) and for Authorities with jurisdiction over notified areas (s.13), in which State khas land within the master-plan area vests; PDA Manipur's year of constitution is given as 1975 and as 1976 (as reported) [U]. The zoning bye-laws of 2026 classify uses in every Master Plan area, including the zones "Agriculture" and "Pond, Drain, Rivers and Canals", and list "Rain Water Harvesting System" as a use. The master plan for Greater Imphal covers 151.38 km² and has no storm-water drainage section: its "Physical Infrastructure" covers water supply, sewerage, electricity and solid waste. It records that "The town is below the high flood level of Imphal river", earmarks about 500 ha of wetland "for the construction of water bodies", and shrinks wetlands from 374.48 ha to 232.21 ha and agricultural land from 5,616.53 ha to 2,604.70 ha by 2043. The TPD reports the draft report of the risk-informed master plans for Imphal and Moirang as "submitted" while its site lists their final notifications, an inconsistency not resolved here [U]; their flood zones were not read and are not cited [TBC]. GIS master plans are being prepared for Thoubal, Kakching, Lilong (Thoubal), Mayang Imphal and Nambol and for 14 district headquarters "both valley and hills", with a horizon of 2042. Master plans would show the flood-sensitive catchments, drainage reserves and regional facility sites of this Manual (Chapter 11).
Manipur Municipalities Act, 1994 (Act 43 of 1994)	Continue. The Act "extends to the whole of the State of Manipur except the Hill Areas" (as quoted), and the bye-laws are made under its section 213. Its sections on the vesting of drains, consent to connect and nuisance were not read for this Manual [TBC]. The State has 27 urban local bodies, among them the Imphal Municipal Corporation with 27 wards; IMC's corporation status is dated 2014 by some sources and to the Manipur Municipalities (Tenth Amendment) Act, 2016 by another (as reported) [U].
Manipur Loktak Lake (Protection) Act, 2006 (Manipur Act 3 of 2006; No. 2/14/2006-Leg/L of 5 April 2006; Gazette Extraordinary No. 13(E)), as amended by Acts 5 of 2007 and 8 of 2019 (Act 1 of 2012 listed, not read)	Apply within the lake's 236.21 km² (s.1(3)), excluding the Keibul Lamjao National Park (40 km²) and the Takmu Fishery Farm (5 km²). The Core Zone of 70.30 km² is "the No-Development Zone or Totally Protected Zone" (s.3); in the Buffer Zone the Act bans, among other things, the "Discharge of untreated wastes and effluents from industries, cities or towns and other human settlements" and "Land reclamation, bunding or disturbing the natural course of drainages" (s.19(iv), (vi)); in the Core Zone no person shall "discharge or emit any sewage or domestic waste into the lake" without the Authority's prior permission (s.20). Its "Sewage effluent" includes "sludge from open drains" (s.2). The Loktak Development Authority administers it, with the Forest and Environment Department as nodal department (s.35(2)). The Act does not reach upstream of its 236.21 km², and this Manual does not claim that it does; the interception rules of Chapter 8 apply to outfalls in the lake's catchment.

Instrument	Relationship
Manipur Flood Plain Zoning Act, 1978 (Manipur Act 10 of 1978; assent 26 August 1978; Gazette Extraordinary No. 185 of 1 September 1978; read only in the OCR of a truncated copy, sections 1–7)	Apply in a flood zone once one is notified; none has been. The Act provides that flood plain zoning "shall be made" by notification, for surveys by the Deputy Commissioner "or such other authority" as the Flood Zoning Authority, and for zones delineated "with reference to relative risk", the flood zone being the area required to carry the flow of "the maximum probable" flood (OCR damaged); its provisions other than section 1 come into force on dates to be appointed. Demarcation of flood zones in the State "is yet to be done" (as reported, June 2026), and no constitution of a Flood Zoning Authority or zone notification was found; an eviction order of April 2025 along the channels of the Imphal river cited its "Section 24" (as reported; section 24 not read [TBC]). Bye-law 93 routes activity in "the prohibited area or restricted area" through that Authority. This Manual's 1% AEP map of Chapter 7 is offered as an input to any future zoning, not as a zone.
Manipur Conservation of Paddy Land and Wetland Act, 2014 (Manipur Act 10 of 2014; No. 2/38/2014-Leg/L of 2 September 2014; Gazette Extraordinary No. 150); the Manipur Conservation of Paddy Land and Wetland (Third Amendment) Bill, 2026 (Bill No. 6 of 2026, as introduced; not law)	Continue in the areas of the Manipur Land Revenue and Land Reforms Act, 1960, that is, not in the hill areas (NEER reading). Paddy land, with its "drainage channels, ponds, canals, bunds and ridges", and wetland may be converted only through the Local Level Monitoring Committees, led by Sub-Divisional Officers, and the District and State Level Committees (ss.2–4); "no local authority shall grant any licence or permit … for carrying out any activity or construction in a paddy land, converted or reclaimed in contravention" of the Act (s.12); and the penalty is imprisonment of three to five years and a fine of ₹50,000 to ₹2 lakh (s.18). The Bill of 2026 would exempt land in a notified Master Plan area used in "strict conformity" with the plan and allow "Deemed Conversion" on self-declaration; it is not cited as law. Where valley paddy land or wetland is converted and built on, this Manual requires the flood storage lost below the 1% AEP level to be replaced in the same basin (Chapter 7).
Manipur (Hill Areas) District Councils Act, 1971, as amended (continued under the Manipur (Adaptation of Laws) Order, 1972; amended in 2006, 2008, 2017 and 2018); Article 371C of the Constitution and the Manipur Legislative Assembly (Hill Areas Committee) Order, 1972; the Manipur Village Authorities in Hill Areas Act, 1956 (not read)	Continue in the hill areas. The District Councils' functions under section 29(1) include water supply and sanitation schemes, embankments, soil conservation and the allotment of land for non-agricultural purposes, and any matter the Governor entrusts "in consultation with the Hill Areas Committee"; they include no building control. Section 29(1A), inserted in 2006, would let a Council notify an urban area "for the purpose of formulation of development plan" from a date to be notified, which was not found; it is not treated as in force. Section 52(c) of the 1971 text provides for bye-laws on the pollution of waters "set apart for drinking or culinary purposes". The Deputy Commissioners of six hill districts have administered the Councils since June 2025 (as reported). No building or drainage rule of a District Council or Village Authority was found [TBC]. The Manual has no force in the hill areas except through public works and a body that adopts it (Commentary to Clause 1.3).
Wetlands (Conservation and Management) Rules, 2017; the Manipur State Wetlands Authority (set up on 31 January 2018)	Continue. The Authority has 22 members, with the Minister of Forest, Environment and Climate Change as Chairperson and the Director of the Directorate of Environment and Climate Change as Member Secretary; its seven priority wetlands are Jaimeng, Kachouphung (Achau Maki), Utra Pat, Yaral Pat, Waithou–Phumnom Pat, Pumlen–Khoidum Pat and Ikop–Kharung Pat; 71 wetlands have been delineated and 3 demarcated, and draft notifications of the Yaral, Utra and Waithou–Phumnom pats have been published (DoECC, 2025-26). Until a notification is final, no prohibition under rule 4 applies to them (NEER reading). Loktak is a Ramsar site (as reported). Pats and pukhris are governed by Chapter 7.
High Court of Manipur, PIL No. 8 of 2025, *Meeyam Amata Oina Punsinba Lup v. State of Manipur* (order of 16.06.2025); the special bench on Loktak (orders of 17.07.2019 and 25.02.2022, as reported; case number not found); the suo motu PIL on the Thoubal river (2019, as reported)	Apply where they bind; they are directions, not rules of this Manual. In PIL No. 8 of 2025 the Court recorded the WRD's inspection of Lamphelpat of 2 May 2025, found "no substance" in the petition and disposed of it; the petition recorded that "the entire rain water are required to be discharged through the water canal from Lamphelpat through Samushang and discharged to the Nambul River". The special bench is reported to have barred development or construction in or around Loktak "without the Court's leave" (as reported) [TBC]. The Thoubal river PIL is reported to bar quarrying, sand mining and pollution except under licence (as reported).

Instrument	Relationship
National Green Tribunal, OA 606/2018 (the State's reports of July 2025 and December 2025), OA 673/2018 (polluted river stretches; 13 rivers of the State named), OA 325/2015, OA 593/2017, OA 360/2018, OA 351/2019, OA 438/2018 and OA 392/2022, OA 462/2018, and M.A. 26/2019 (order of 22 May 2020) (as listed by DoECC)	Apply where they bind. The State reports the interception and diversion of all 72 drains that fall into the Nambul as completed, with their BOD at 42.45–52.34 mg/L and COD at 78.56–97.23 mg/L, sewage generation in urban areas of 70 MLD against 44 MLD of treatment, and treated effluent disposed to "Agriculture canals" (State reports in OA 606/2018); CPCB lists 18 polluted stretches in the State, all Priority V, among them the Nambul from the Singda dam to Bishnupur (CPCB, 2025); and some 4,000 water bodies have been inventoried under M.A. 26/2019, with "Ground truthing … pending" (DoECC). Sewage in storm drains is dealt with in Chapter 8 (Clause 8.9).
Comptroller and Auditor General of India, Report No. 2 of 2017 (Economic and Revenue Sectors, Government of Manipur), performance audit of flood control and flood forecasting to March 2016, and the audits of 2002 and 2008 of the Irrigation and Flood Control Department (as summarised; not read)	Inform this Manual. The 2017 audit found that "The overall flood fighting and control activities remained inadequate" (as quoted); the earlier audits cover the Loktak Lift Irrigation Project, whose canals failed "due to siltation of beds", and the Khoupum dam, the Sekmai and Imphal barrages and the Singda dam (as quoted). No audit of IMC's drainage, the Smart City works, AMRUT or the LDA was found.
Groundwater: no State groundwater Act; the Manipur Ground Water (Control & Regulation) Policy, 2023 (prepared, as listed by DoECC; text not read)	Continue. No State law regulating groundwater was found. Every assessment unit of the State is "Safe", with a stage of extraction of 8.00% (CGWB, GWRA 2024, as quoted), so recharge is not a design objective of this Manual (Clause 4.11, recharge rule). The WRD is named in this Manual for groundwater records; no State observation-well network was found, and CGWB's dug-well monitoring in Imphal West stopped "since 1991 due to disturbed law and order" (CGWB, Imphal West, 2013).
Environment (Protection) Act, 1986; Water (Prevention and Control of Pollution) Act, 1974; the Manipur Pollution Control Board (MPCB)	Continue. The MPCB gives consent to industry and categories of industry in the zoning bye-laws. Sewage in storm drains is dealt with in Chapter 8.
Disaster Management Act, 2005; MSDMA, the Relief and Disaster Management Department, the Revenue Department and the District Disaster Management Authorities	Continue. The Relief and Disaster Management Department issues the flood situation reports (as reported); no urban flood plan or standard operating procedure of MSDMA was read for this Manual [TBC], and no order of the State fixing a date for pre-monsoon desilting was found; the works calendar of Chapter 10 sets this Manual's dates, beginning with 31 March.
IRC:SP:42-2014, IRC:SP:48 (Hill Road Manual), IS 14458 ("Guidelines for retaining wall for hill area", referenced by the Model) and the practice of the Public Works Department and the national-highway agencies on road and hill-road drainage	Apply to the drainage of roads and 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].
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 Manipur 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, such as those of late July 1989 and late July 2015, 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.

Manipur is spending on its drains and channels, but without a design basis. The AIIB's Manipur Urban Road, Drainage and Asset Management Improvement Project (P000723) will rehabilitate 547 km of roads in Greater Imphal with "547 km of both side stormwater covered drains" that "channelize the storm water … to the out fall (river)", and states no return period, rainfall intensity or runoff coefficient (AIIB, Approval Project Document, October 2024); the Lamphelpat Waterbody Rejuvenation Project is to "increase its water detention capacity, restore stormwater drainage system" and set up a "real time flood management system with a command center", at a cost of USD 87.84 million, with no design storm in its published summary (NDB, 2021), while the WRD dredges about 300 acres of the pat with "provision for pumping of flood water from the Lamphel pat water body to the Nambul River through Shamushang Nalla during high flood season" (WRD site report in PIL No. 8 of 2025); and the State reports the "Interception & Diversion (I & D) of all drains (72 Nos.) falling into the Nambul River" as completed, with the drains' BOD at 42.45–52.34 mg/L (State report to the NGT in OA 606/2018, December 2025). None of these states a design storm, and 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 some of the tools. The bye-laws on the Model set a river buffer table and a flood plinth, require a drainage plan to "the available permanent/pucca drain" for larger buildings and rainwater harvesting on plots of 100 m² and more (bye-laws 6(1)(D), 66, 93, 94); the Unified Zoning Bye-laws, 2026 provide a use zone "Pond, Drain, Rivers and Canals"; the Loktak Act bans the discharge of untreated urban effluent and the disturbing of "the natural course of drainages" in the lake's Buffer Zone (s.19); the paddy-land Act bars any local authority from licensing construction on land converted in contravention of it (s.12); and the Manipur Flood Plain Zoning Act, 1978 provides for flood zones, none of which has been notified (zone demarcation "is yet to be done", as reported in June 2026). The courts and the tribunal have acted too: the High Court disposed of a PIL on Lamphelpat after the WRD's inspection (PIL No. 8 of 2025, order of 16.06.2025), its special bench is reported to have barred development in or around Loktak "without the Court's leave" (orders of 17.07.2019 and 25.02.2022, as reported), and the NGT's supervision of waste and polluted rivers (OA 606/2018; OA 673/2018) produced the Nambul interception works. 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 long a gated outfall stays shut while the river is high, how much storage a converted paddy field removes, or how much water a hill site may put into its slope; the bye-law buffers are measured from mid-stream, so that on a wide reach they leave little room beside the bank (NEER reading); and none applies in the hill areas. This Manual's checks are framed as part of the permission given by the competent authority for the area, under the bye-laws a local body has brought into force on the Model, not as a separate no-objection certificate. This Manual is offered as a technical companion to these instruments, to the orders of the courts and the tribunal and to the drainage and river works of the towns: it supplies the design storm, detention, outfall-closed, infiltration, hill-site drainage and corridor numbers they do not set, as a proposal for the Government, the local bodies and the other authorities to consider. Neither MAHUD, the TPD, PDA Manipur, IMC, any Municipal Council or Nagar Panchayat, the WRD, any District Council 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
Municipal Administration, Housing and Urban Development Department (MAHUD)	Publishes the Model bye-laws and the Unified Zoning Bye-laws and notifies the master plans. Would prepare the amendment of Clause 1.3.1(a) to the Model, under section 213 of the Manipur Municipalities Act, 1994 and section 26(1) of the Manipur Town and Country Planning Act, 1975, and commend it to the urban local bodies and PDA Manipur; could add the Manual's drainage reserves to the zoning bye-laws' "Pond, Drain, Rivers and Canals" zone.

Agency	Role under this Manual
Town Planning Department (TPD)	Prepares the master plans of Greater Imphal and the towns, and of 14 district headquarters "both valley and hills"; checks building plans for land-use compatibility with the master plan on OBPS (about 150 plans forwarded by IMC in 2025-26); is the nodal department for AMRUT and AMRUT 2.0, including 20 pond-rejuvenation projects. Would show flood-sensitive catchments, drainage reserves, pat buffers, the 1% AEP areas and regional facility sites in the master plans (Chapter 11), add the drainage report to the OBPS check, issue the model bye-law of Clause 1.3.1(b) and give regional support to Tier B authorities (Table 1.1).
Planning and Development Authority, Manipur (PDA Manipur)	The "Authority" under the Manipur Town and Country Planning Act, 1975 in the Master Plan and planning areas beyond municipal limits (bye-law 2(2) of the Model). Could adopt the amendment in its bye-laws; if it did, it would require the drainage report of Chapter 10 with each application, check floor levels and the hill rule at the plinth inspection, and record drainage reserves and easements in the permissions it grants.
State Stormwater Technical Committee (Clause 1.3.2)	Would adopt higher standards, issue Annexes, tables and the compliance calculator, concur with Tier A alternatives, decide variances referred to it and review the Manual (Clause 1.12).
Imphal Municipal Corporation (IMC) and the other urban local bodies (Municipal Councils and Nagar Panchayats; 27 in all)	Give building permits under the bye-laws they have brought into force on the Model and hold the municipal drains of their areas (bye-law 16). Could adopt the amendment in their bye-laws; would then apply this Manual to their own works, keep the drain register of Table 1.5, receive handed-over assets (Clause 10.14), and inspect and enforce (Clauses 10.12–10.15). IMC would also keep its drains free of the market waste that blocks the Naga Nullah.
Water Resources Department (WRD), formerly the Irrigation and Flood Control Department	Builds and holds the river bunds and flood channels of the valley, develops Lamphelpat as flood storage with its pumped outlet through the Shamushang nallah to the Nambul, provides machinery to clear the city channels, and keeps the river gauges whose levels the press prints. Would supply river levels, gauge zeros and flood marks for Chapter 5, set the conditions for any outfall, gate or pump through its bunds, approve the site study of Clause 2.3.6(b) for rural rivers, could advise any Flood Zoning Authority, and would apply this Manual to its own works.
Public Health Engineering Department (PHED)	Builds and runs the Imphal Sewerage Project (Phase I in 11 wards since June 2020; Phase II for the other 16 wards and 4 outgrowths) and the water supply. Would keep the sewer and storm networks separate in the Phase II wards and keep sewage overflows out of the storm drains it serves (Chapter 8).
Public Works Department (PWD) and the national-highway agencies	Build and maintain the roads, their side drains and culverts, among them the 547 km of roads and "both side stormwater covered drains" of the AIIB project in Greater Imphal, and NH-37 and NH-2. Would apply Chapter 6 and the hill-road rules to them and never discharge a road drain onto an unprotected slope; in the hill areas they are the main route by which this Manual reaches drainage.
Directorate of Environment and Climate Change (DoECC), under the Forest, Environment and Climate Change Department	Runs the Nambul rejuvenation, with the interception and diversion of 72 drains to a plant of 16–17 MLD, monitors the rivers, and is the secretariat of the Manipur State Wetlands Authority; its Department is the nodal department for the Loktak Act (s.35(2)). Would receive the records of sewage found in storm drains under Chapter 8 and could align wetland protection with the corridors of Chapter 7.
Loktak Development Authority (LDA)	Administers the Loktak Act within the lake's 236.21 km² and gives the prior permission of section 20; is reported to have led the cleaning of the Waisel Maril channel in Imphal (as reported). Could apply this Manual within the lake and its margin and would be the competent authority for the area there.
Manipur State Wetlands Authority (MSWA)	Identifies and notifies wetlands under the 2017 Rules; has published draft notifications of the Yaral, Utra and Waithou–Phumnom pats. Its consent would be needed before a notified wetland is used for storage or as an outfall (Chapter 7).
Manipur Pollution Control Board (MPCB)	Gives consent to industry. Would receive the records of sewage found in storm drains under Chapter 8.
Local, District and State Level Committees under the paddy-land Act	Decide the conversion of paddy land and wetland (the Local Level Monitoring Committees led by Sub-Divisional Officers). Could make the replacement of lost flood storage (Chapter 7) a condition of conversion.

Agency	Role under this Manual
Flood Zoning Authority (Manipur Flood Plain Zoning Act, 1978; not found constituted)	Once constituted, would survey rivers, notify flood zones and grant the permissions that bye-law 93 refers to; it could use the corridor maps of Chapter 7. Until then no flood zone exists.
Imphal Smart City Ltd	Carries out area-based development in Thangal, Paona Bazar, the DM College campus and Kangla, about 504 acres (as reported); its drainage role was not found [TBC]. Would design its drainage works to this Manual from the dates of Clause 1.11 and hand them over under Clause 10.14.
Hill Areas Committee, the District Councils (administered by the Deputy Commissioners since June 2025, as reported) and the Village Authorities	Govern the hill areas under Article 371C and the 1971 Act; the District Councils' functions include water supply and sanitation schemes, embankments and land allotment, but no building control, and no building or drainage rule of theirs was found [TBC]. The Manual has no force in the hill areas unless a body adopts it. A District Council could take it up as a matter entrusted by the Governor under section 29, or through a development plan under section 29(1A) once in force; none has. The Village Authorities hold or speak for much of the land on which hill drains and streams lie.
MSDMA, the Relief and Disaster Management Department, the Revenue Department, the Deputy Commissioners and the District Disaster Management Authorities	Prepare for and respond to floods and landslides, report their tolls and keep the land records of the valley. Would supply the flood, breach and landslide inventories used in the screening of Clause 2.3.6(i) and lead post-event reviews with the Authority (Clause 10.16). In the hill areas land is allotted by the District Councils and held under customary tenure [TBC].
NHPC (Loktak Hydroelectric Project and the Ithai barrage) and the operators of the Mapithel (Thoubal Multipurpose Project), Khuga and Singda dams [TBC]	Hold Loktak up at the Ithai barrage and the valley's reservoirs. Would supply lake and reservoir levels, release rules and release records in writing for Chapter 5 and the screening of Clause 2.3.6(i).
Central Water Commission (CWC), a body of the Union	Monitors the level of the Barak at Chotebekra, its one site in the State. Would supply its records for Chapter 5 and confirm whether a Flood Estimation Report for subzone 2(c) exists or is in preparation (Clause 2.3.6(b)).
Central Ground Water Board (CGWB), North Eastern Region, a body of the Union	Assesses the State's groundwater (every unit "Safe"; stage of extraction 8.00% in 2024, as quoted) and published the district booklets on which the valley-floor rule of Clause 4.11 rests. Would supply groundwater levels with the WRD.
IMD (Meteorological Centre Imphal), NRSC, MASTEC, and road and rail owners	IMD's station at Imphal (Tulihal) (42623) supplies the rainfall record of Chapter 2 and is the first data request of Clause 2.3.6(a); NRSC and MASTEC hold landslide and flood-hazard studies used in the screening of Clause 2.3.6(i). Road and rail owners would apply this Manual to road drainage (Chapter 6), culverts and linear works (Clause 1.5.7).

Commentary. Stormwater in Manipur is split, first, by the line between the valley and the hill areas. In the valley MAHUD makes the Model bye-laws, the zoning bye-laws and the master plans, the TPD prepares the plans and checks land use, the urban local bodies and PDA Manipur give permission under the bye-laws they have brought into force, and the land is mostly patta land with revenue records; in the hill areas no building or drainage rule was found, the District Councils hold land and village functions but no building control, and they have been run by Deputy Commissioners as administrators since June 2025 (as reported). The split is then repeated among the bodies that drain the valley: the urban local bodies for the municipal drains, the PWD for the roadside drains, among them the 547 km of the AIIB project, the WRD for the river bunds, the flood channels, Lamphelpat and the Shamushang pumping, PHED for the sewers, DoECC for the interception of the 72 drains that fall into the Nambul, the LDA for Loktak, NHPC for the Ithai barrage that holds the lake up, and the courts and the tribunal, which have acted on Lamphelpat, Loktak and the polluted rivers. Imphal shows why the split matters. The Nambul is at once the city's main urban river (AIIB), a trunk storm drain, the receiving water of drains whose BOD is 42–52 mg/L, a Priority V polluted stretch (CPCB, 2025) and the outfall of Lamphelpat's flood pumps; the Naga Nullah carries market waste into it; and the Imphal river, the Kongba and the Iril stand above the town behind their bunds. **No notification assigns the Naga Nullah, the Waisel Maril or the Shamushang nallah to one owner (NEER reading)**, and the drainage sections of the Manipur Municipalities Act, 1994 were not read [TBC]. Until the State issues 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, the river it reaches, the bund it crosses (with its gate or flap gate), whether it lies in a buffer of bye-law 93, its land status (patta or government land) 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 private land it is put into effect by reservation in the master plan or by agreement, not by acquisition.

Table 1.5 — Working assignment of drainage elements under this Manual

Element	Assigned to
Municipal drains within the limits of an urban local body	The urban local body (bye-law 16, "municipal drain"; the drainage sections of the Manipur Municipalities Act, 1994 not read [TBC]); in Imphal, IMC
Roadside drains of State roads, among them the 547 km of "both side stormwater covered drains" of the AIIB project in Greater Imphal	PWD
Drains of national highways	The national-highway agencies
River bunds, flood channels, Lamphelpat and the Shamushang pumping, and machinery for clearing the city channels	The WRD
The interception and diversion of the 72 drains that fall into the Nambul, and its plant of 16–17 MLD	DoECC
Sewers and sewage pumping stations	PHED
The cleaning of the Waisel Maril (as reported), and Loktak within its 236.21 km²	The LDA
Drains and channels of the hill areas	The department that executes the work (PWD, PHED or the WRD); other drains [TBC] (no District Council drainage rule was found)
Drains built by Imphal Smart City Ltd, until handed over in writing	Imphal Smart City Ltd [TBC], and the urban local body after handover

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. Manipur has no coast and no tidal reach, so no site in the State qualifies for this waiver. A site that drains to a valley river through a bund gate, a flap gate or a pumping station, to a pat or pukhri behind such an outfall, to Loktak, held up by the Ithai barrage, to the Barak or the Jiri at Jiribam, or to a reach below a dam, 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 hill stream or down a hill slope.

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 Manipur the notified master plan for Greater Imphal shrinks the planning area's wetlands from 374.48 ha to 232.21 ha and its agricultural land, which on the valley floor holds floodwater, from 5,616.53 ha to 2,604.70 ha by 2043 (Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)); a Bill of 2026, not known to have been enacted, would exempt land that conforms to a notified master plan from the paddy-land Act's bar on conversion and allow "Deemed Conversion" on self-declaration (Bill No. 6 of 2026); MASTEC records that "there were nearly 500 lakes in Manipur Valley" and names Lamphelpat, Porompat, Takyelpat, Sangaipat, Kharungpat and Ikop pat among the pats that are degraded or disappearing (MASTEC, *Flood Hazard Zonation in Manipur Valley*); and in April 2025 the authorities ordered the removal of encroachments along the Waisel Maril, the Naga Nallah and the eastern bank of the Nambul (as reported).

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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- Manipur Loktak Lake (Protection) Act, 2006 (Manipur Act 3 of 2006), with Amendment Acts 5 of 2007 and 8 of 2019. https://prsindia.org/files/bills_acts/acts_states/manipur/2006/Manipur%20Act%203%20of%202006.pdf
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Annexes and forms

Annex / Form	Content
1A	List of Tier A authorities, with the boundaries of the Imphal Municipal Corporation and of the Greater Imphal planning area of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)
1B	Maps of flood-sensitive catchments
1C	Policy Supplement: text of alternatives S-1 to S-5 and model council resolution
1D	Model Unified Bye-Laws 2024 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 Manipur. Where IMC, PDA Manipur, a Municipal Council, a Nagar Panchayat or a District Council has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

> **Commentary.** Most past drainage failures in Manipur trace to the rainfall input, not the hydraulics. Manipur shows how. No design storm was found for any town's drains in the State: the 547 km of "both side stormwater covered drains" of the AIIB project in Greater Imphal state no return period, rainfall intensity or runoff coefficient (AIIB, Approval Project Document, 2024), and the Lamphelpat project's summary states no design storm (NDB, 2021). The published sources that seem to fill the gap do not. The whole State lies in CWC subzone 2(c), for which CWC has published no Flood Estimation Report, so no CWC plate, ratio or unit hydrograph covers any part of it; the Imphal panel of IMD Das et al. (2022) is a generic curve, not station data, whose 24-hour end lies above every Imphal record at the long return periods; and NIH-DHAARA gives Imphal about 1.45 times its highest day and the western hills up to 2.2 times the State's largest reported fall (Clause 2.3.6). An Imphal IDF from 15-minute data of 1986–2009 is described in one uploaded document, but its author and values were not seen (as summarised). The rainfall figures that circulate conflict too: Imphal's wettest month, June 1966, is 605.0 mm in IMD's tables and 669.7 mm in MASTEC's report, and MASTEC's series prints 140 mm on 5 June 1984 where IMD's highest June day at the station is 106.6 mm (IMD, *Extremes*; MASTEC). 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.

Term	Meaning in this Manual
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 IMD's pre-monsoon months of April and May as well as the south-west monsoon; it is the Manual's season, not IMD's. IMD's south-west monsoon has its normal onset at Imphal on 5 June (previously 1 June) and its normal withdrawal on 15 October, in the normals in use since 1 June 2020 (as quoted from IMD's press release). The season begins on 1 April because the storms of April and May are among the valley's largest: Imphal's highest days are 105.9 mm in April (16 April 2004) and 122.4 mm in May (27 May 1956), and its wettest April and May months 459.6 mm (2004) and 464.3 mm (1956); every month from April to October has a highest day of more than 100 mm, and every month from February to December one of more than 70 mm (IMD, *Extremes*, Imphal (Tulihal), data 1953–2012; NEER reading of the table). Two of the recent damaging floods of the valley came before the onset, in the storm of Cyclone Remal on 28–31 May 2024 and on 30 May–2 June 2025 (as reported), and the flood of 1966 began in June (MASTEC). The AIIB finds "intense rains from March to October" (AIIB, 2024), CGWB that "Rainfall starts from the month of April end" (CGWB, Bishnupur, 2013) and MASTEC that the "Rainy season … starts from May and extent up to October" (MASTEC); those are their statements, not IMD's dates. No order of the State fixes a works date. A works deadline after the season began would leave the April and May storms uncovered, so the pre-monsoon deadline of 31 March is set before the season begins (Chapter 10); it covers the drains, inlets, gates, flap gates and pumps of the drainage system, while the WRD's works on the river bunds keep the WRD's own calendar. Because the Remal and 2025 floods struck on 28–31 May, the mid-season clearance of Chapter 10 is due by 15 May, before the late-May storms, not by the end of May. The wettest month on record at Imphal is June 1966, 605.0 mm in IMD's tables and 669.7 mm in MASTEC's report [U]; the mean annual rainfall at Imphal was 1,416.9 mm in 1975–2000 (MASTEC), and CGWB gives 1,632.40 mm for Imphal West (CGWB, Imphal West, 2013). 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 before and after the season, and the October storms that come about the time of the withdrawal fall inside it. In October Imphal recorded 119.4 mm on 5 October 1980, and a flood followed the heavy rain of 14–16 October 1992 (IMD, *Extremes*; MASTEC); outside the season it recorded 80.3 mm on 1 November 1991, 89.6 mm on 13 December 1966, 79.8 mm on 18 February 1993 and 72.9 mm on 24 March 1998 (IMD, *Extremes*). January's highest day is only 32.9 mm (IMD, *Extremes*), 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 standby to 31 October and a post-season clearance by 15 November for this reason.
Climate factor (CF)	Multiplier applied to present-day design depths to represent the design-life climate.
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 Manipur this clause is suspended until Annex 2A is published, except in sub-area MN-B, where Clause 2.3.6(c)(iii) uses NIH-DHAARA with a floor: Clause 2.3.6 sets the interim source.

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(c) (Barak and others), which this Manual takes to cover the whole of Manipur (Clause 2.3.6(b)) and for which CWC has published no Flood Estimation Report; the report for subzone 2(b) (South Brahmaputra) is used in its place only for its areal reduction curves and as a check on unit hydrographs, so that no CWC point rainfall exists for the cross-check of Clause 2.3.3(b), as applicable.

Where the design value is lower than the CWC subzone 2(b) (South Brahmaputra) plate (only at a site that a clean copy of the plate shows north of the 2(b)/2(c) line, which this Manual reads as touching at most the north of Senapati district [TBC]; the rest of the State lies in subzone 2(c), which no CWC plate covers, and there Clause 2.3.6 sets the floors 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.

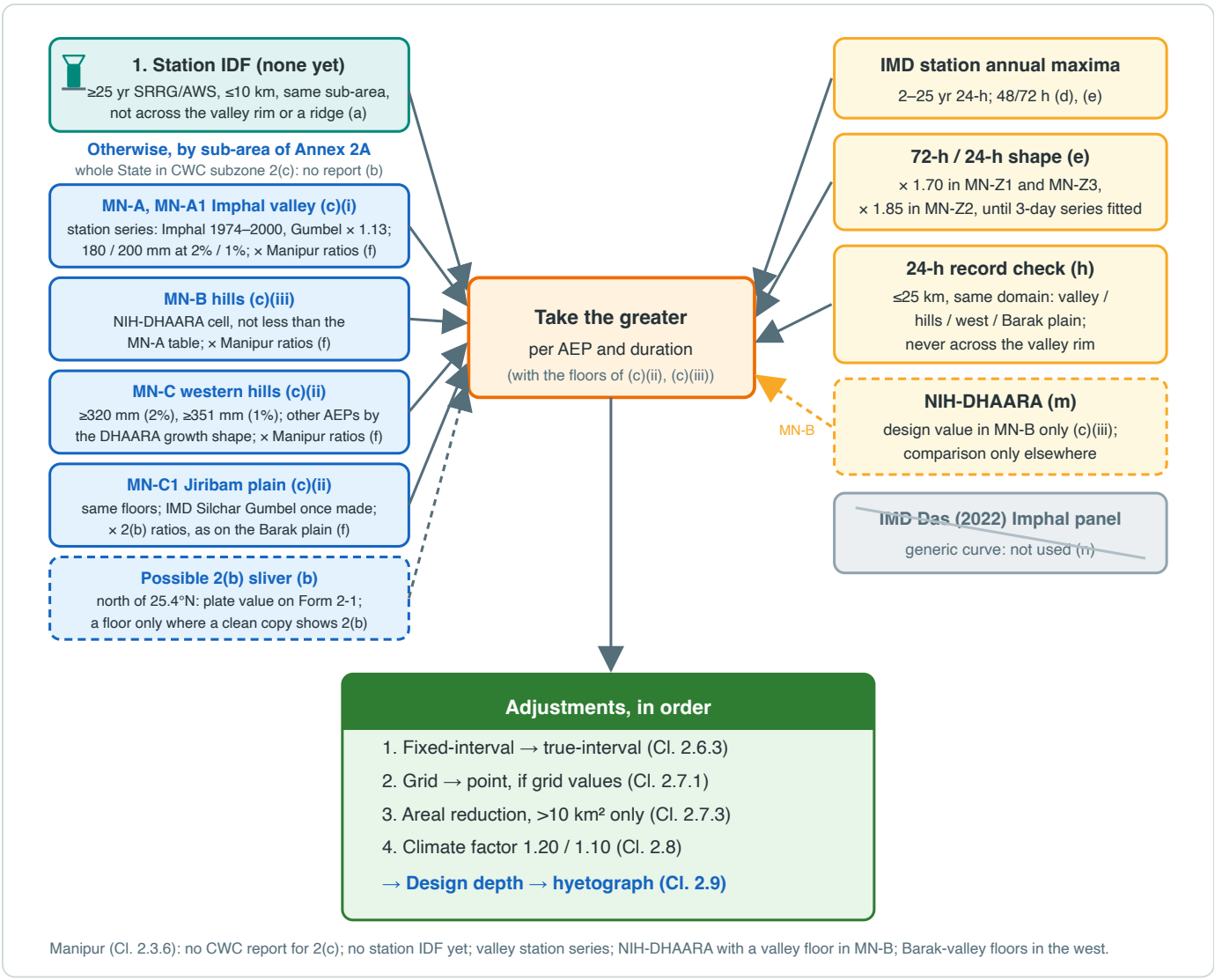

Figure 2.1 — Design rainfall source hierarchy and adjustment sequence. Original drawing for this Manual.

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 Manipur.** 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 Manipur, except in sub-area MN-B as (c)(iii) provides, 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, and never across the rim of the Imphal valley or a ridge, for the durations and AEPs it covers, in place of (f), and subject to the floors of (c)(ii) and (c)(iii); 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 Manipur Clause 2.3.2(a) is read with 25 years in place of 30, as in the other editions of this series that have no long recording-gauge fit (set by this Manual). No IDF has yet been published in Annex 2B, and no IDF with published constants was found for any station in the State: no paper from NIT Manipur, Manipur University or IIT Guwahati with constants for Imphal was found; a document uploaded to a file-sharing site under the title "Drainage Dimension" describes an Imphal IDF derived from 15-minute data of 1986–2009 with the IMD reduction formula and a Gumbel fit, but its author and values were not seen and it is not cited as a value (as summarised) [TBC]; and the Imphal panel of IMD Das et al. (2022) repeats a generic curve

(n). The first data requests of this Manual are, in order: (1) for **Imphal (Tulihal) (A) (42623)**, the IMD recording-gauge and automatic weather station annual maxima from 15 minutes to 72 hours, the 15-minute record of 1986–2009 that the document above implies, and the annual maximum daily series of 1953–2026, to replace the series of (c)(i); (2) the records of the Water Resources Department, IMD and agriculture gauges at **Kangpokpi, Tamenglong, Noney and Khoupum, Jiribam, Ukhrul, Churachandpur, Chandel and Moreh**, with the gauge and the duration of the 225 mm night at Khoupum (h) and the records of the gauges at Saikul and Litan used by MASTEC, whose owners and record lengths are not stated [TBC]; and (3) the IMD annual-maximum daily series of **Silchar (42619)** and **Silchar (Kumbhigram) (A) (42620)**, the stations of the adjoining Barak plain, for sub-area MN-C1 under (c)(ii) and (d).

- (b) **Reports, zones and sub-areas. The whole State lies in CWC subzone 2(c), "Barak and others", which Annexure 1.1 of the 2(b) report lists with the "Barak, Kalden and Manipur rivers" (CWC, 2(b), Annexure 1.1; "Kalden" is the Kaladan, NEER reading), and for which CWC has published no Flood Estimation Report**: the 2(b) report's list of the 21 reports published by 2000 holds none for 2(c), and CWC's archived page of regional reports lists none (CWC; Wayback Machine, 20 March 2024); written confirmation from CWC that none exists or is in preparation is still wanted [TBC]. The Imphal valley drains south through Loktak and the Manipur river, and so lies in 2(c), not outside every subzone. Plate 9 of the 2(b) report draws the 2(b)/2(c) line from about 25.2° N at 93° E to about 25.5° N at 94° E and then north along about 94.4° E (NEER reading of a page image, about ±0.1°), so that the line may touch the north of Senapati district near Mao (low confidence); the report's text names "the Manipur Hills" among the hills of its subzone (CWC, 2(b), p. 18), which this Manual reads as the northern ranges. A site north of 25.4° N records on Form 2-1 the Plate 9 value on the line, about 320 mm at 50 years (NEER reading), and the 2(b) plate governs there as a floor under Clause 2.3.3 only where a clean copy of the plate shows the site north of the line [TBC]; the rest of the State has no CWC plate. In place of the missing report this Manual uses (set by this Manual): for the areal reduction of Clause 2.7.3 on catchments of 25–5,000 km², the areal reduction curves of the 2(b) report, the nearest published CWC report; for rural rivers of 25–5,000 km², a site study calibrated to the discharges gauged by the Water Resources Department where they exist, among them 532.488 m³/s in the Iril at Moirang Kampu on 2 September 2000, 391.636 m³/s in the Thoubal on 30 August 1999, 202.006 m³/s in the Imphal river on 2 September 2000 and 68.495 m³/s in the Nambul on 2 July 2001 (MASTEC, from WRD records of 1999–2001), with the 2(b) unit hydrograph only as a check, because none of its 14 catchments drains Manipur (NEER reading) (Chapter 3); and no CWC value exists for the cross-check of Clause 2.3.3(b), which is recorded on Form 2-1 as not available. The rainfall zone and sub-area of the site are those of Annex 2A (set by this Manual): zone **MN-Z1 Imphal valley**, the valley floor of the Manipur river basin above the Sugnu hump, with sub-areas **MN-A Imphal valley floor (Imphal–Thoubal–Kakching–Bishnupur–Nambol–Mayang Imphal)** and **MN-A1 Loktak margin (Moirang–Ningthoukhong–Thanga–Ithai–Sugnu–Wangoo)**; zone **MN-Z2 Northern, eastern and southern hills**, with sub-area **MN-B Northern, eastern and southern hills (Senapati–Kangpokpi–Ukhrul–Kamjong–Chandel–Tengnoupal–Moreh–Churachandpur)**; and zone **MN-Z3 Western hills and the Jiribam plain**, facing the Barak, with sub-areas **MN-C Western hills (Tamenglong–Noney–Khoupum–Tupul–Tousem–Pherzawl)** and **MN-C1 Jiribam plain (Jiribam)**. They fix the source of (c), the ratios of (f), the domain 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 hillocks and foothill fans inside the valley belong to MN-A; a site on a slope above the valley floor, at the Imphal–Kangpokpi, Imphal–Ukhrul and Moirang–Churachandpur edges and on the hill fringes of the valley districts, is in MN-B. The town lists of Annex 2A are a guide; the boundaries follow the watersheds and district lines and are to be confirmed [TBC]. "Tulihal" is the name of the IMD station at Imphal airport.

- (c) **24-hour depths, interim, by sub-area.** No CWC plate covers the State, so the 24-hour depth at every AEP is set by sub-area as follows (all set by this Manual). Where the Gumbel estimate of (d) for the agreed station is higher for the same AEP, it governs; every depth is then checked under (h). The depths of (c)(i) and (c)(ii) are sliding (true-interval) 24-hour depths, and the fixed-interval factor of Clause 2.6.3 is not applied to them again.
    - (i) **Imphal valley (MN-A, MN-A1): the station series governs.** Until the IMD daily series of Imphal (Tulihal) is fitted under (d), the 24-hour depths are those of a Gumbel fit by the method of moments to the annual maximum 1-day rainfall at Imphal printed by MASTEC for 1974–2000 (27 values, mean 79.0 mm, standard

deviation 30.0 mm; MASTEC, *Flood Hazard Zonation in Manipur Valley*, Table 2), multiplied by 1.13 to convert the fixed day to a sliding 24 hours, and rounded up to 5 mm. The fit is NEER's, not MASTEC's:

AEP (return period)	50% (2-yr)	20% (5-yr)	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)
24-hour depth, MN-A and MN-A1	85 mm	115 mm	135 mm	160 mm	180 mm	200 mm

The series is the Tulihal gauge for most of its values: its falls of 158.6 mm (30 July 1989), 119.4 mm (5 October 1980), 80.3 mm (1 November 1991) and 79.8 mm (18 February 1993) are IMD's monthly records for that station (IMD, *Extremes*; NEER comparison). Its second value, **140 mm on 5 June 1984, conflicts with IMD's highest June day at Imphal (Tulihal), 106.6 mm on 2 June 1974** [U]; the fit keeps it, which raises the fit: with 106.6 mm in its place the 1-day values fall to 73 mm at 2 years, 114 mm at 10 years, 150 mm at 50 years and 165 mm at 100 years (NEER arithmetic). MASTEC's own reading of its plot is that "an intensity of 140 mm have the chance to occur every 14 year and 160 mm every 29 year" (MASTEC). The series ends in 2000; IMD's later days at the station, 106.3 mm (11 August 2002), 137.1 mm (26 September 2003) and 105.9 mm (16 April 2004), would not change it much (NEER reading). The CWC reports use 1.15 for the fixed-to-sliding factor (CWC, 2(b)); this Manual uses 1.13 for the station series. Once the IMD daily series of Imphal (Tulihal), with 30 or more years of record, is fitted under (d), that fit replaces the table at every AEP, and where it gives less than the table at any AEP, the difference and its reason are recorded on Form 2-1. NIH-DHAARA's valley cells give 181–231 mm at 50 years in 24 hours, 231 mm in the Imphal cell, about 1.3 times the table's 180 mm and about 1.45 times the IMD record of 158.6 mm (NIH-DHAARA, queried 14 Nov 2026; NEER comparison); they are reported beside the table for comparison only (m).

- (ii) **Western hills and Jiribam plain (MN-C, MN-C1): the Barak-valley values.** The 24-hour depth at 2% AEP (50-yr) is **not less than 320 mm** and at 1% AEP (100-yr) **not less than 351 mm**: the floors of the adjoining Barak-valley rule of this series, where 320 mm is the lowest value that Plate 9 of the 2(b) report prints on the 2(b)/2(c) line on the Barail ridge at Haflong (NEER reading of the plate) and 351 mm is the record of Silchar (Kumbhigram), 350.6 mm on 2 June 1974 (IMD, *Extremes*), rounded up. They are carried into Manipur because MN-C is the same Barail range and MN-C1 the same Barak plain, so that one storm reads alike on both sides of the State boundary. Until a station fit exists, the other AEPs are scaled from 320 mm by the **shape, not the values, of NIH-DHAARA's growth curve** in its Noney, Tamenglong and Jiribam cells, the 24-hour depth at each AEP divided by the 50-year depth: 0.396, 0.589, 0.718, 0.880, 1.000 and 1.122 at 2, 5, 10, 25, 50 and 100 years, the highest of the three cells, which agree within 0.012 (NIH-DHAARA, queried 14 Nov 2026; ratios NEER arithmetic), rounded up to 5 mm:

AEP (return period)	50% (2-yr)	20% (5-yr)	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)
24-hour depth, MN-C and MN-C1	130 mm	190 mm	230 mm	285 mm	320 mm	360 mm

In **MN-C1** the Gumbel estimate of (d) from the higher of the IMD annual-maximum daily series of **Silchar (42619, rainfall data 1901–2012)** and **Silchar (Kumbhigram) (A) (42620, rainfall data 1957–1990)**, the stations that the adjoining Barak-valley rule uses, with the fixed-interval factor of Clause 2.6.3, replaces the 2-, 5-, 10- and 25-year values once it is made, and never brings the 2% and 1% AEP depths below 320 mm and 351 mm; in **MN-C** a fit of a Tamenglong or Noney gauge under (d) does the same. This is an interim rule for hills and a plain that no CWC report covers, set by this Manual because no other source exists for them. It lies above every fall recorded in the zone: the State's largest reported day is **225 mm at Khoupum "on Tuesday night", 15 July 2025**, "the highest ever in Manipur's recorded history" according to IMD Imphal officials (as reported; its duration and gauge are not stated [U]), about the 10-year value of the table. NIH-DHAARA's cells give 306 mm at Noney, 431 mm at Tamenglong and 491 mm at Jiribam at 50 years, 1.4 to 2.2 times that record and more than Silchar's IMD records about 30 km away (NEER distance); they are reported for comparison only (m). The curves of IMD Das et al. (2022) are not used here (n).

    - (iii) **Northern, eastern and southern hills (MN-B): NIH-DHAARA with the valley floor.** The 24-hour depth at each AEP is **the higher of the NIH-DHAARA value for the site's cell and the MN-A value of (c)(i) for the same AEP**. Moreh's cell returned no data, and Moreh uses the Chandel cell (NIH-DHAARA, queried 14 Nov 2026). This is the one sub-area of the State in which NIH-DHAARA gives a design value, and a station fit under (a) or (d) replaces it there. No station, plate or study covers these hills, and NIH-DHAARA cannot be checked there, but it fails no check either: its MN-B cells give 220 mm at Kangpokpi, 203 mm at Senapati, 185 mm at Chandel, 183 mm at Churachandpur and 182 mm at Ukhrul at 50 years in 24 hours, 1.0 to 1.25 times the valley table, while MASTEC's monthly totals put the hills 1.3 to 1.5 times the valley (in July 1989, 617.6 mm at Kangpokpi and about 700 mm over the upper Sekmai and Chakpi catchment against 461.9 mm at Imphal; MASTEC; ratios NEER arithmetic). In the valley the platform errs high, so adopting it in the hills with the valley table as a floor errs safe (Commentary to Clause 2.3).

- (d) **Station fits for the 24-hour depth.** 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: Imphal (Tulihal) for MN-A and MN-A1, at every AEP, under (c)(i); the two Silchar stations for MN-C1, at 50% to 4% AEP, under (c)(ii); and a gauge at Tamenglong or Noney for MN-C, or a gauge agreed with the Authority for MN-B, once its record is confirmed [TBC]. No Gumbel fit to an IMD series of any station in the State was found for this Manual [TBC]; the fit of (c)(i) is NEER's, to MASTEC's series. A day of record excluded under (h) is left out of the series, and the fit with it is reported beside the fit without it on Form 2-1 (set by this Manual).

- (e) **48- and 72-hour depths.** The Gumbel estimate from the annual maximum 2-day and 3-day rainfall series of the station of (d), with the fixed-interval factors of Clause 2.6.3, and not less than the 24-hour depth for the same AEP, as checked under (h). Until those series are obtained, **the 72-hour depth is the 24-hour depth of (c) multiplied by 1.70 in zones MN-Z1 and MN-Z3 and by 1.85 in zone MN-Z2**, and the 48-hour depth is interpolated between the 24- and 72-hour depths on logarithmic axes (set by this Manual). The factors are the upper envelope, rounded up to 0.05, of the 72-hour to 24-hour ratios of NIH-DHAARA's cells in each zone, 1.57–1.67 in the valley, 1.64–1.82 in MN-B and 1.63–1.69 in the western hills and at Jiribam (NIH-DHAARA, queried 14 Nov 2026; ratios NEER arithmetic): the shape, not the values, of the platform. They are needed now because the valley's floods are multi-day volume events: rain from 28 July to 1 August 1989, from 22 to 28 September 1997, from 24 August to 3 September 1999 and from 26 August to 6 September 2000 lay behind the floods that MASTEC records (MASTEC); the Water Resources Department's flood cell is reported to hold that "135 mm in 3 days" at Kangpokpi brings floods to the valley, and Kangpokpi received 175 mm in 72 hours and 123 mm in 24 hours on 30–31 May 2025 (as reported); and the outfall-closed check of Clause 5.10 needs a 72-hour depth.

- (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-areas **MN-A** (Imphal valley floor), **MN-A1** (Loktak margin), **MN-B** (Northern, eastern and southern hills) and **MN-C** (Western hills), the **Manipur interim ratios: 0.33 at 1 hour, 0.51 at 2 hours, 0.59 at 3 hours, 0.74 at 6 hours, 0.81 at 9 hours, 0.85 at 12 hours, 0.89 at 15 hours and 0.94 at 18 hours**, which at each duration are the upper envelope, rounded up to 0.01, of the 50-year duration-to-24-hour ratios of the eleven NIH-DHAARA cells of the Manipur basin and the western hills (Imphal, Bishnupur, Moirang, Thoubal, Kangpokpi, Senapati, Ukhrul, Chandel, Churachandpur, Noney and Tamenglong; the 3-, 6- and 15-hour values interpolated on logarithmic axes between the platform's 2-, 4-, 8-, 12- and 18-hour durations) and of the ratios of the CWC report for subzone 2(a), North Brahmaputra, 0.260 at 1 hour, 0.370 at 2 hours, 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 (CWC, NB/18/1991, §3.1.2, p. 24, and Fig. 10, which gives the 2-hour value) (NIH-DHAARA, queried 14 Nov 2026; envelope NEER arithmetic); and
    - in sub-area **MN-C1** (Jiribam 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 ratios of the 10-year t-hour to the 10-year 24-hour rainfall from a partial-duration analysis of the hourly records of the report's six

recording gauges, recommended for every return period because "the average ratios beyond T=5 years were comparable in magnitude" (CWC, 2(b), §4.3.2 and Table 4.1, p. 20).

The envelope is set at 1 and 2 hours by the Thoubal cell, at 3 hours by the Chandel cell, at 6 to 15 hours by the Noney cell and at 18 hours by the Bishnupur cell, just above 2(a) (NEER arithmetic); NIH-DHAARA is used for the shape, not the values. The cells' own 1-hour ratios are 0.29–0.33 in the valley (Imphal 0.31), 0.20–0.22 in the northern and eastern hills, 0.28–0.29 at Churachandpur and Chandel, 0.27–0.31 in the western hills and 0.22 at Jiribam (NEER arithmetic). The 2(b) set is not used outside MN-C1, because the State does not lie in 2(b) and its 1-hour ratio of 0.48 is 1.45 times the highest Manipur cell; the editions of this series that met the same choice on a plateau rejected it there for the same reason. The 2(a) set is not used alone, because in the valley its 1-hour ratio of 0.26 is below every valley cell, and Imphal's pre-monsoon convective storms may push the true value higher; the envelope never falls below 2(a) at any duration. On the MN-A table the Manipur ratios give about 59 mm in 1 hour at 50 years, against 72 mm in NIH-DHAARA's Imphal cell, which is reported beside it; the Imphal 15-minute record is the first data request of (a). On the 320 mm floor of MN-C they give about 106 mm, within the 96–115 mm of the western-hill cells. In **MN-C1** the 2(b) set is the one that the adjoining Barak-valley rule uses on the same plain, so that a catchment that crosses the State boundary reads one rule: on the 320 mm floor it gives about 154 mm in 1 hour at 50 years, about 1.4 times NIH-DHAARA's 109 mm in the Jiribam cell, a margin accepted on the Barak plain downstream for having no data (NEER arithmetic). 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. The ratios apply to the 24-hour depth of (c) or (d) before the check of (h).

- (g) **Short storms.** No absolute floor in millimetres is set for any sub-area of the State (set by this Manual), because no recording-gauge maximum exists in the State to base one on, and the ratios of (f) are already the upper envelope of every cell and of the 2(a) set. The floors of the adjoining Barak-valley rule, 95 mm in 1 hour, 165 mm in 3 hours and 180 mm in 6 hours at 2% AEP, come from recording gauges of the Brahmaputra valley and would put the valley's 6-hour depth above Imphal's highest day of 158.6 mm, so they are not used in MN-A, MN-A1, MN-B or MN-C; in MN-C1 the 2(b) ratios on the 320 mm floor give about 154, 198 and 237 mm and exceed them anyway (NEER arithmetic). Where a station fit under (a) later replaces the ratios of (f), its 1-hour depth for every AEP shall be not less than 0.33 times its 24-hour depth for the same AEP in MN-A, MN-A1, MN-B and MN-C, and 0.48 times in MN-C1, until Annex 2B is published (set by this Manual). The depths of (f) are present-day, true-interval values: the fixed-interval factor of Clause 2.6.3 is not applied to the products of the tables of (c), which are already sliding, and the climate factor of Clause 2.8 is then applied.

- (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; the depths for the other AEPs are then raised in the proportion that the table of (c) for the sub-area gives them to its 1% AEP depth (all set by this Manual). The domains are four: the **valley floor** (MN-Z1), the **northern, eastern and southern hills** (MN-Z2), the **western hills** (MN-C) and the **Barak plain** (MN-C1 with the Barak plain downstream); a record never counts across the rim of the Imphal valley or a ridge, so that the valley gauge never sets a hill depth and no hill gauge sets a valley depth (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 of the State, 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, or IMD has confirmed that the gauge that made it stood where the present gauge stands and was read in the same way; 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). The outcomes at present are:
    - **Qualifies. Imphal (Tulihal) (A), 158.6 mm on 30 July 1989** (IMD, *Extremes*, rainfall data 1953–2012), below the MN-A depth of 200 mm at 1% AEP, raises nothing. In the Barak-plain domain, **Silchar (Kumbhigram) (A), 350.6 mm on 2 June 1974** (rainfall data 1957–1990), qualifies and is already the 1% AEP floor of (c)(ii);

whether its gauge lies within 25 km of a site in the Jiribam plain is to be confirmed from IMD's station coordinates [TBC], and the outcome is the same either way.
    - **Flags only (recorded on Form 2-1; they do not qualify). Khoupum, 225 mm on the night of 15 July 2025**, reported in the press as quoted from IMD Imphal officials, with its duration and gauge unknown [U], below the MN-C value of 230 mm at 10% AEP; **Kangpokpi, 123 mm in 24 hours and 175 mm in 72 hours on 30–31 May 2025** (as reported), below the MN-B values; and **MASTEC's 140 mm on 5 June 1984**, which conflicts with IMD's June record at the same station [U] and is kept in the fit of (c)(i) because keeping it is conservative.
    - **Excluded. Silchar, 290.3 mm on 30 May 1893**, made before 1901 and outside the station's printed data period (IMD, *Extremes*).

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

- (i) **Hazard-first sites.** Manipur has no snow-fed catchment. No design is complete without a screening, recorded in the drainage report, that identifies the hazards below and states whether the site lies on their path, from the landslide and flood records of MSDMA and NRSC [TBC], the hazard maps of the risk-informed master plans of Imphal and Moirang once they are read [TBC], and the Water Resources Department's records of its bunds and their breaches; where it does, the siting, setback and floor-level rules of Chapters 6 and 7 govern, because no drain is sized for them (set by this Manual). The hazards are: **landslide ground** on the Disang shale of the hills, cut slopes, colluvium and fill, such as Tupul in Noney, where the slide of 30 June 2022 at the site of the Jiribam–Imphal railway has been attributed to "poorly designed or implemented slope excavation coupled with heavy rainfall" (Baruah et al., 2023, as summarised), Joumol in Chandel, where a landslide struck on 1 August 2015 (as reported), and the cut slopes of NH-37 and NH-2; **river-bund breach paths** in the valley, among them the breaches of the Imphal river at Singjamei, Heingang, Bashikhong and New Checkon and at Keirang, Khabam and Lairikyengbam Leikai, of the Nambul at four places and of the Iril at Kshetri Awang Leikai in 2024 and 2025 (as reported); **dam-release reaches**, the Thoubal below the Mapithel dam, the Khuga below its dam [TBC] and the Nambul below the Singda dam [TBC], where the release-reach rule of Chapter 5 applies; **the Core Zone of Loktak and its phumdis**, where the 2006 Act allows no development; **peat and former pats** on the valley floor, where the ground settles and no data on settlement were found [TBC]; and **foothill fans**, where hill streams leave the hills and spread silt and gravel over the edge of the valley floor.

- (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 measured cloudburst rate was found for Manipur, and no hourly value for any gauge in the State: the night of 225 mm at Khoupum on 15 July 2025 is the only sub-daily value reported, and it has no duration (as reported). The 1-hour depth of (f) at 1% AEP reaches the threshold in MN-C1 (about 173 mm) and in MN-C (about 119 mm), but not in the valley (about 66 mm) (NEER arithmetic). What a burst does in a steep catchment of the hills that a design storm does not represent is to bring down shale, slope debris and garbage in its first minutes; in such catchments 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 Imphal 15-minute record of (a) is the first source to be analysed for it.

- (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 13 points in the State on 14 November 2026 (IMDAA dataset); 12 returned data and the Moreh cell returned an empty table. It is a **design value only in sub-area MN-B, under (c)(iii)**. In MN-A, MN-A1, MN-C and MN-C1 its present-day values at the site are reported on Form 2-1 beside the interim values, for comparison only; there they are never a design value, a floor or a check. In the valley its 50-year 24-hour depths, 181–231 mm, are about 1.3 times the station fit of (c)(i); in the western hills, 306–491 mm, they are 1.4 to 2.2 times the State's largest reported day (NIH-DHAARA, queried 14 Nov 2026; IMD; NEER comparison). Three of its shapes, not its values, are used: its duration ratios in (f), its growth curve in (c)(ii) and its 72-hour to 24-hour ratios in (e). Its projected depths are not used under Clause 2.8.4.

- (n) **IMD Das et al. (2022).** The paper's panel for Imphal (Fig. 4(x)) repeats the generic curve that it prints for several other cities, about 60, 73, 82, 93, 101 and 109 mm/h at 1 hour for 2 to 100 years, and its 24-hour end implies about 170–360 mm in a day, above every Imphal record at the long return periods (NEER reading). It is not station data and is not used as a value, a check or a floor anywhere, and the cross-check of Clause 2.3.3(a) is recorded on Form 2-1 as not available (IMD Das et al., 2022, p. 895).

- (o) **Earlier design values.** No design rainfall, return period or runoff coefficient was found for the drains of any town in the State. The Manipur Urban Road, Drainage and Asset Management Improvement Project of the AIIB (P000723), which provides "547 km of both side stormwater covered drains" along the roads of Greater Imphal, states no return period, rainfall intensity or runoff coefficient (AIIB, Approval Project Document, October 2024), and the summary of the Lamphelpat Waterbody Rejuvenation Project states no design storm (NDB, Project Summary, 2021). Road drainage follows IRC:SP:42-2014 and, in the hills, IRC:SP:48. A designer who uses any other value reports it on Form 2-1; the return periods 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 Manipur the platform has been shown to meet that purpose in part of the State only. It was queried at 13 points of the State for this Manual, and 12 returned data. In the valley it errs high: its 50-year 24-hour depths, 181–231 mm, are about 1.3 times the station fit of Clause 2.3.6(c)(i), and the 231 mm of the Imphal cell is about 1.45 times IMD's highest day at Imphal (Tulihal), 158.6 mm in a record of 1953–2012. In the western hills its cells, 306 mm at Noney, 431 mm at Tamenglong and 491 mm at Jiribam, are 1.4 to 2.2 times the State's largest reported day, 225 mm at Khoupum (as reported), and exceed Silchar's IMD records about 30 km from Jiribam. In the northern, eastern and southern hills it cannot be checked, because no station, plate or study covers them, but it fails no check either: its cells there lie at 1.0 to 1.25 times the valley table, below the 1.3 to 1.5 times by which MASTEC's monthly totals put the hills above the valley. Clause 2.3.6 therefore uses the valley's station series in MN-A and MN-A1, NIH-DHAARA with the valley table as a floor in MN-B, where adopting a source that errs high in the valley errs safe, and the floors of the adjoining Barak-valley rule in MN-C and MN-C1, and reports NIH-DHAARA beside the design values elsewhere, for comparison only; the shapes, not the values, of its duration ratios, its growth curve and its 72-hour to 24-hour ratios are used. The Imphal panel of IMD Das et al. (2022) is not used anywhere, because it repeats the generic curve that the paper prints for several of its cities, and its 24-hour end lies above every Imphal record at the long return periods. Manipur is the series' third North-East edition, and three things set its interim source apart. First, **no CWC report covers any part of the State**: the whole of it lies in subzone 2(c), "Barak and others", for which CWC has published no Flood Estimation Report, and at most a sliver of the north of Senapati district may touch the 2(b) plates. The earlier North-East editions met 2(c) only on part of their ground, one on an escarpment, where it used the one genuine IMD curve of Das et al. (2022) for an escarpment station, and one in the Barak valley, where it used two IMD stations with floors; here the gap is the whole State, and the method changes with the ground: a station series in the valley, NIH-DHAARA with a valley floor in the northern, eastern and southern hills, and the Barak-valley floors in the west. Every one of these methods is set by this Manual, and

every one states that CWC has published no report for 2(c). Second, **the capital lies in a closed, flat valley whose rainfall is modest and whose floods are not**: Imphal's highest day in sixty years of IMD record is 158.6 mm, yet the valley floods for weeks, because its rivers bring several days of rain from the hills, which make up about 70% of its catchment, into a basin whose one outlet, past the Ithai barrage and the Sugnu hump, carries about 400 m³/s (MASTEC). The 72-hour depths of Clause 2.3.6(e) and the outfall-closed checks of Chapter 5 matter more there than the peak hour. Third, **the rainfall rises steeply from the valley to the Barak-facing western hills**, where NIH-DHAARA gives two to two and a half times the valley's values and the State's largest reported fall came in one night at Khoupum; Clause 2.3.6(c)(ii) carries the floors of the adjoining Barak-valley rule across the State boundary, so that one storm on the Barail range and the Barak plain reads alike on both sides of it. The interim tables of the 24-hour depth, the 48- and 72-hour factors, the reading of the plate at the north of Senapati district, the sub-area of each town, the two sets of ratios, the absence of a millimetre floor, the domain-bounded record check, the hazard-first screening and durations below 1 hour are set by this Manual. Several points are unresolved. The fit of Clause 2.3.6(c)(i) is NEER's, to a series that ends in 2000 and keeps a June day of 140 mm in 1984 that IMD's June record at the same station does not confirm [U]. The 2(b)/2(c) line was read by eye from a page image, to about 0.1° [TBC]. The Imphal IDF from 15-minute data of 1986–2009 was seen only as a description, and its values are unknown [TBC]. The gauge and duration of the 225 mm night at Khoupum are not stated [U], and the distance of the Silchar (Kumbhigram) gauge from the Jiribam plain is to be confirmed from IMD's coordinates [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: Imphal, Thoubal, Kakching, Bishnupur and Churachandpur 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. Manipur's worst floods have come when days of rain on the hills fill the valley's rivers. MASTEC records "continuous daily rainfall from 28th July to 1st August" 1989 before the flood that reached 361 localities, with 617.6 mm at Kangpokpi and about 700 mm over the upper Sekmai and Chakpi catchment in that July, while Imphal recorded its highest day, 158.6 mm, on 30 July; and rain spells of 22–28 September 1997, 24 August–3 September 1999 and 26 August–6 September 2000 behind the floods of those years (MASTEC). In 2025 Kangpokpi received 175 mm in 72 hours and 123 mm in 24 hours on 30–31 May before the bunds breached in Imphal East (as reported). The rivers that enter the valley carry a few hundred cubic metres a second at flood, while the outlet at Ithai carries "of the order of 400 cumecs", so "water is piled up upstream" (MASTEC) and the low-lying areas stay waterlogged "for several weeks" (AIIB). A town drain on the valley floor fills within an hour of a burst, but its outfall is closed by the river for days, and the pats and paddy that store its water 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 Manipur recording gauges. They shall not be lower than the ratios that Clause 2.3.6 sets for the site's sub-area: the Manipur interim ratios of Clause 2.3.6(f), the upper envelope of the NIH-DHAARA duration ratios of the Manipur cells and of the ratios of the CWC Flood Estimation Report for subzone 2(a), in every sub-area except the Jiribam plain, and the ratios of the CWC report for subzone 2(b) in the Jiribam plain, as on the Barak plain downstream. The whole State lies in subzone 2(c), for which CWC has published no report. IMD Das et al. (2022) prints a panel for Imphal, but it repeats a generic curve and is not used.

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(c) (Barak and others), with the report for subzone 2(b) (South Brahmaputra) in place of the 2(c) report that CWC has not published: 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 of about 12 km over Imphal gives 231 mm for the 50-year 24-hour depth, against 180 mm from the station series of Clause 2.3.6(c)(i) and the 158.6 mm that the Imphal (Tulihal) gauge has recorded as its highest day in sixty years (NIH-DHAARA, queried 14 Nov 2026; IMD, *Extremes*). In the western hills the error runs the same way and further: the Jiribam cell gives 491 mm, more than Silchar's IMD records on the same plain, and the Tamenglong cell 431 mm, with no gauge to check it. Across the State the cells' 50-year values rise from 181 mm at Thoubal, in the valley, to 491 mm at Jiribam, a gradient whose direction MASTEC's gauges confirm but whose size no gauge does. 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 Manipur. The State Action Plan on Climate Change was not read for this Manual [TBC]; the figures for future rainfall that State officials have given in the press differ from one report to another, and none is cited here as a value. The observed record runs the other way in total: a study of 1991–2024 found "a statistically significant downward trend in Total Annual Rainfall" in the State, "primarily attributed to a substantial reduction in rainfall during the monsoon season" (Singh, 2025, *NEHU Journal*), and a study of extreme daily rainfall at Imphal for 1985–2003 reports trends only (*Indian Journal of Hill Farming* 32(1), seen as a summary). Yet the recent valley floods of 2015, 2024 and 2025 are among the largest recorded (as reported), and the monsoon of 2026 was reported the driest over the North East since 1901 (as reported). No trend statistic for extreme rainfall in the State was found. The case for an uplift rests on the size of recent floods, not on trend statistics. As in the other editions of this series, the factors of 1.20 for durations up to 6 hours and 1.10 for longer durations are applied after the record check of Clause 2.3.6(h). NIH-DHAARA's projected depths are not used (Clause 2.3.6(m)). The factors of Table 2.2 are therefore interim values, not Manipur estimates.

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.

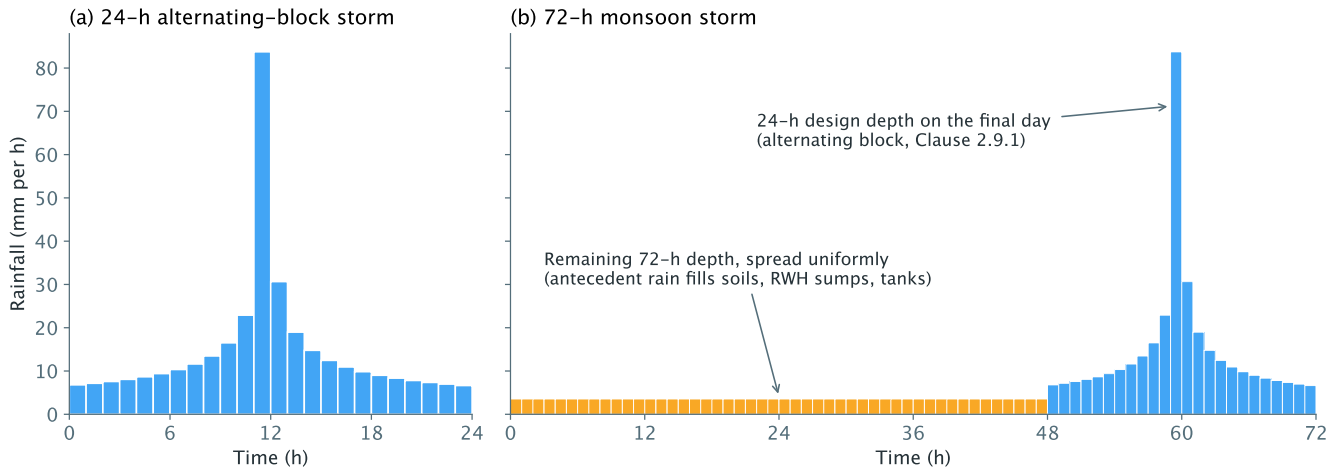

Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.

2.9.3 **Other temporal patterns.** Huff-type or mass-curve patterns derived from Manipur 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 Manipur: by the time the largest falls arrive, in a spell of several days in July to September, or in the pre-monsoon storms of late May that flooded the valley in 2024 and 2025, the clay of the valley floor is saturated, the pats and paddy are full, Loktak stands high behind the Ithai barrage, and the rivers are already near their flood levels behind the bunds. SCS distributions are excluded because they come from US convective and Gulf storm data and have no basis in Manipur 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 Nambul and the Imphal river through Greater Imphal, of the Lamphelpat basin, of the Kongba and the Iril, of Thoubal below the Mapithel dam, of the Loktak margin, of Nambol and Bishnupur, of Kakching and Wangjing, of Jiribam, and of the hill towns on landslide ground, 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 June to 15 October at a site in sub-area MN-A (Imphal valley floor) or MN-B (Northern, eastern and southern hills) of Annex 2A, and from 1 May to 31 October at a site in sub-area MN-C (Western hills) or MN-C1 (Jiribam plain). 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 a river, a stream or Loktak, on peat, on the margins of a pat or pukhri and on land behind a river bund. Use AMC III for every design storm at any time of year in sub-area MN-A1 (Loktak margin) and 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 Loktak, held up by the Ithai barrage, the Thoubal (Mapithel) and Khuga reservoirs and the reaches below their dams, and the Singda reservoir on the Nambul [TBC]. 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 Manipur the season, the ground and the receiving waters together decide how wet a catchment is. The valley floor is "approximately 30 to 50 m of clayey formation", with water "2 to 5 m bgl" in most of Imphal West (CGWB, Imphal West, 2013) and peaty soils round the lakes (CGWB, Bishnupur, 2013), and land behind the river bunds ponds "for several weeks" when the dikes fail (AIIB), so the valley floor is wet from the onset of the south-west monsoon until its withdrawal. The hills are mostly Disang shale, which has "less infiltration and more run off" (MASTEC). The western hills, facing the Barak, have the State's heaviest falls and the earliest wet season,

as on the Barak plain downstream. Loktak is held up all year by the Ithai barrage, and the Mapithel and Khuga reservoirs release water down the Thoubal and the Khuga, so a catchment that drains to one of them, or to a reach below a dam, is wet whenever it is high or spilling. This Manual therefore uses AMC III for every design storm from 1 June to 15 October in sub-areas MN-A and MN-B, the south-west monsoon from IMD's normal onset at Imphal to its withdrawal; from 1 May to 31 October in MN-C and MN-C1; from 1 April to 31 October on land below the 1% AEP flood level, on peat, round a pat or pukhri and behind a river bund; at any time of year in MN-A1 and where the outfall is Loktak, 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). 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 hill-fringe colony in Jiribam town draining to a stream of the Jiri 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.

Manipur has no coast, so no outfall in the State is tidal and cases (a) and (b) do not arise. The tailwater is the river behind a bund, Loktak held up by the Ithai barrage, the pat behind a gate or the hill stream into which a town drains. For an outfall under river or lake 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 levels are those of Clause 5.8.2; for an outfall that a bund gate or flap gate closes, as in Imphal and the valley towns, or that lies below the level of Loktak, the outfall-closed check of Clause 5.10 and the pumping rules of Clause 5.12 also apply, and generally govern (Clause 5.8.5). The levels of the valley rivers are known for this Manual only as the press prints the Water Resources Department's figures, with no datum stated (presumably metres above mean sea level [TBC]): on the Imphal river at **Minuthong**, in Imphal, warning, flood and highest flood levels of **785.900, 786.900 and 788.400 m**, the last exceeded on 29 May 2024; at **Lilong**, a warning level of 780.350 m, a flood level of 781.350 m (2025) or 781.250 m (2024) [U] and a highest flood level of 782.850 m (2024), **exceeded at 783.250 m on 15 September 2025**; on the Iril at Irilbung, 786.700 and 787.700 m, with a highest flood level printed as 782.200 m, below its flood level [U], and a reading of 788.850 m on 15 September 2025; on the Thoubal, 778.915 and 779.915 m (gauge not named); on the Nambul at Thong Nambonbi (Hump Bridge), a highest flood level of 783.695 m; on the Nambol at Nambol Thongkhong, 774.700 m

(2024) or 774.400 m (2025) [U]; and on the Manipur river at the **Ithai barrage, a highest flood level of 769.320 m, exceeded at 770.05 m on 15 September 2025** (all as reported; conflicts stated, not resolved). Loktak's full reservoir level is given as 768.5 m and its minimum drawdown level as 766.2 m by NHPC (as quoted), its minimum drawdown level as 766.01 m by CEA (as quoted), and its full reservoir level as 769.63 m in another account, which calls 768.50 m the "flood level" (as reported) [U]. CWC has one site in the State, a level-monitoring site on the Barak at Chotebekra, near Jiribam, with a highest level of 32.1 m on 31 July 1989 (CWC data as transcribed by SANDRP; a danger level of 26.2 m appears only in the press); the adjoining edition governs the Barak plain downstream. The full reservoir level of the Mapithel dam on the Thoubal is given as 880.7 m (WRD, September 2025, as reported), and the reservoir was reported at 876 m, "nearly 2 m above the spillways", on 1 August 2015 (as reported); the two do not reconcile [U]. The city's ground stands at about 790 m (AIIB), so that drains near the Imphal river discharge within a metre or two of its flood stage (NEER reading), and in the floods of 2024 and 2025 the rivers stood above their flood levels for days, so the outfalls of the valley towns are designed for gates closed for days, with the local storm falling before, during or after the river's peak (Chapter 5). 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 gauge and datum, as Chapter 5 requires.

> Commentary. Manipur has no coast, so no outfall is tidal and there is no storm surge; the coincident load is the level of the rivers behind their bunds, of Loktak behind the Ithai barrage and of the pats that receive the town drains. The coincidence is on record. On 29 May 2024, during the Remal storm, the Imphal river at Minuthong was reported above its highest flood level of 788.400 m, and the Nambul at Thong Nambonbi and the Nambol at Nambol Thongkhong above theirs (as reported); on 15 September 2025 the Imphal river at Lilong reached 783.250 m and the Manipur river at Ithai 770.05 m, both above their printed highest flood levels, while the Iril breached at Kshetri Awang Leikai (as reported). Behind the bunds the low-lying areas then stay waterlogged "for several weeks" (AIIB), because the valley's one outlet passes about 400 m³/s and "water is piled up upstream" (MASTEC). These levels give no warning of a local storm that falls while they are high. The levels quoted by different sources differ, and none states its datum: the WRD's levels are known only as the press prints them, Lilong's flood level is printed as 781.350 m in 2025 and 781.250 m in 2024, Irilbung's highest flood level is printed below its flood level, and Loktak's full level is given as 768.5 m by NHPC and 769.63 m in another account (as quoted or reported), which is why Chapter 5 requires every level to name its source and datum. Because rainfall and surge share a weather cause (in Manipur, which has no coast, the counterpart of surge is the stage of the valley rivers behind their bunds and of Loktak behind the Ithai barrage, raised by the same storms that fall on the towns: on 29 May 2024, in the Remal storm, the Imphal river at Minuthong and the Nambul at Thong Nambonbi were reported above their highest flood levels, and on 15 September 2025 the Imphal river at Lilong reached 783.250 m and the Manipur river at Ithai 770.05 m, both above their printed highest flood levels, all WRD levels as reported), 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.

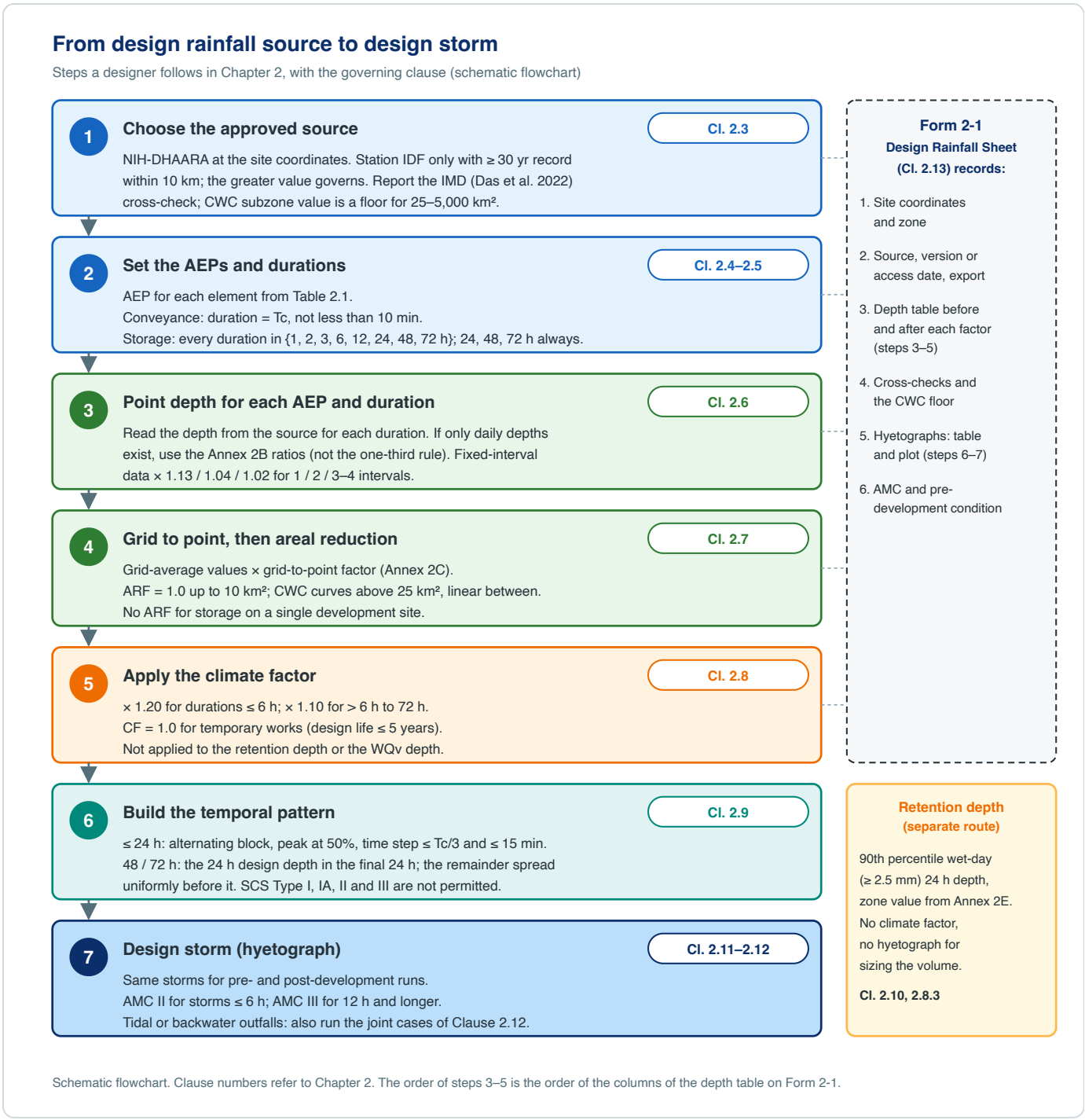

Figure 2.3 — From design rainfall source to design storm: the steps a designer follows (source, AEPs and durations, point depth, grid-to-point and areal reduction, climate factor, temporal pattern, design storm), the clause that governs each step, what Form 2-1 records, and the separate route for the 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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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	Manipur 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 (pukhri) 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 (pukhris) 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 lacustrine clays, silts and peat of the Imphal valley floor, the sands and gravels of the foothill fans at the valley edge, the thin soils over the Disang shale of the hills, the Barail sandstone cappings, and the Barak and Jiri alluvium of the Jiribam plain, 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).

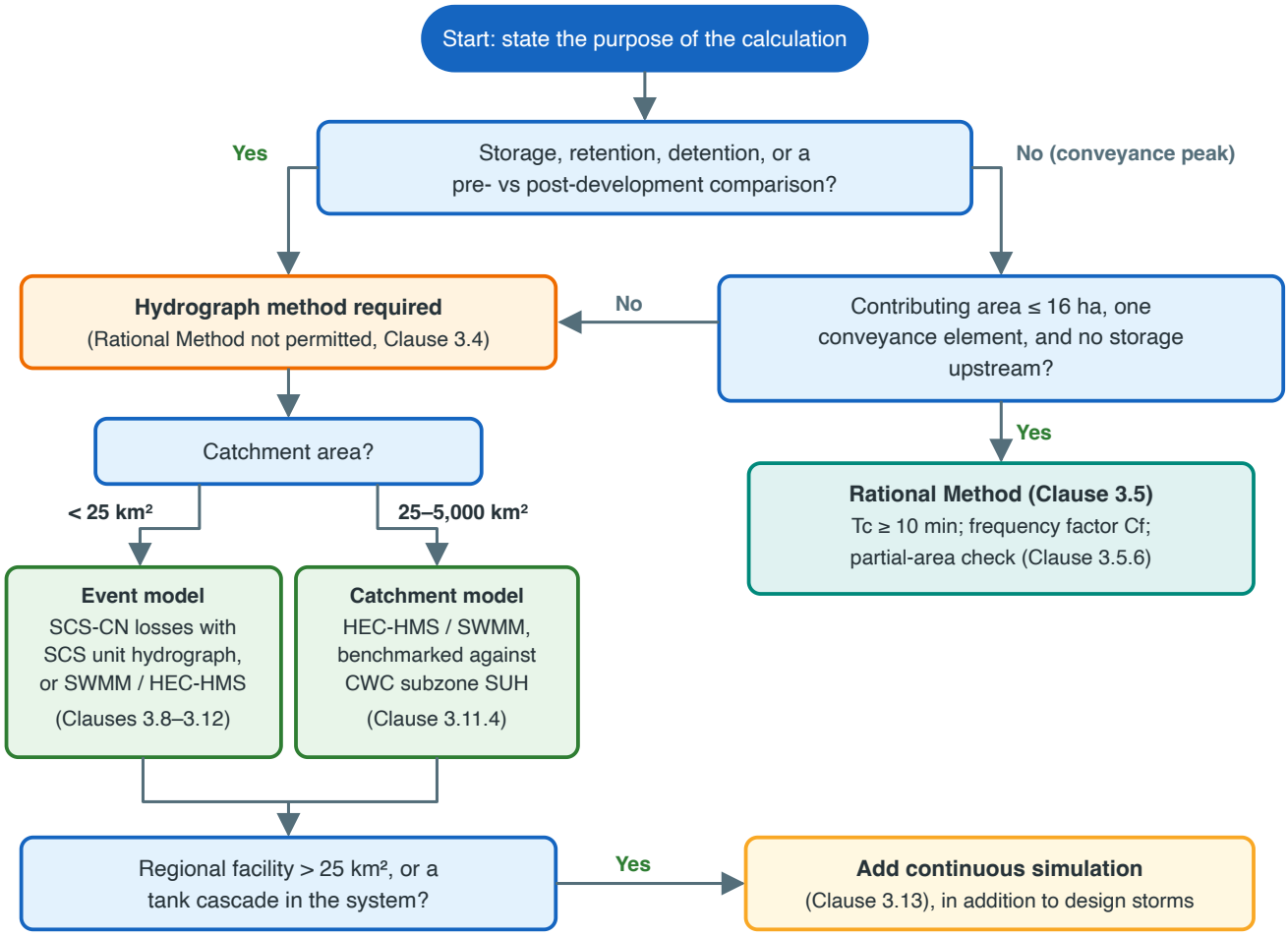
3.4 Selection of method

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(c) (Barak and others), with the report for subzone 2(b) (South Brahmaputra) in place of the 2(c) report that CWC has not published	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 (pukhri) 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 Manipur'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.

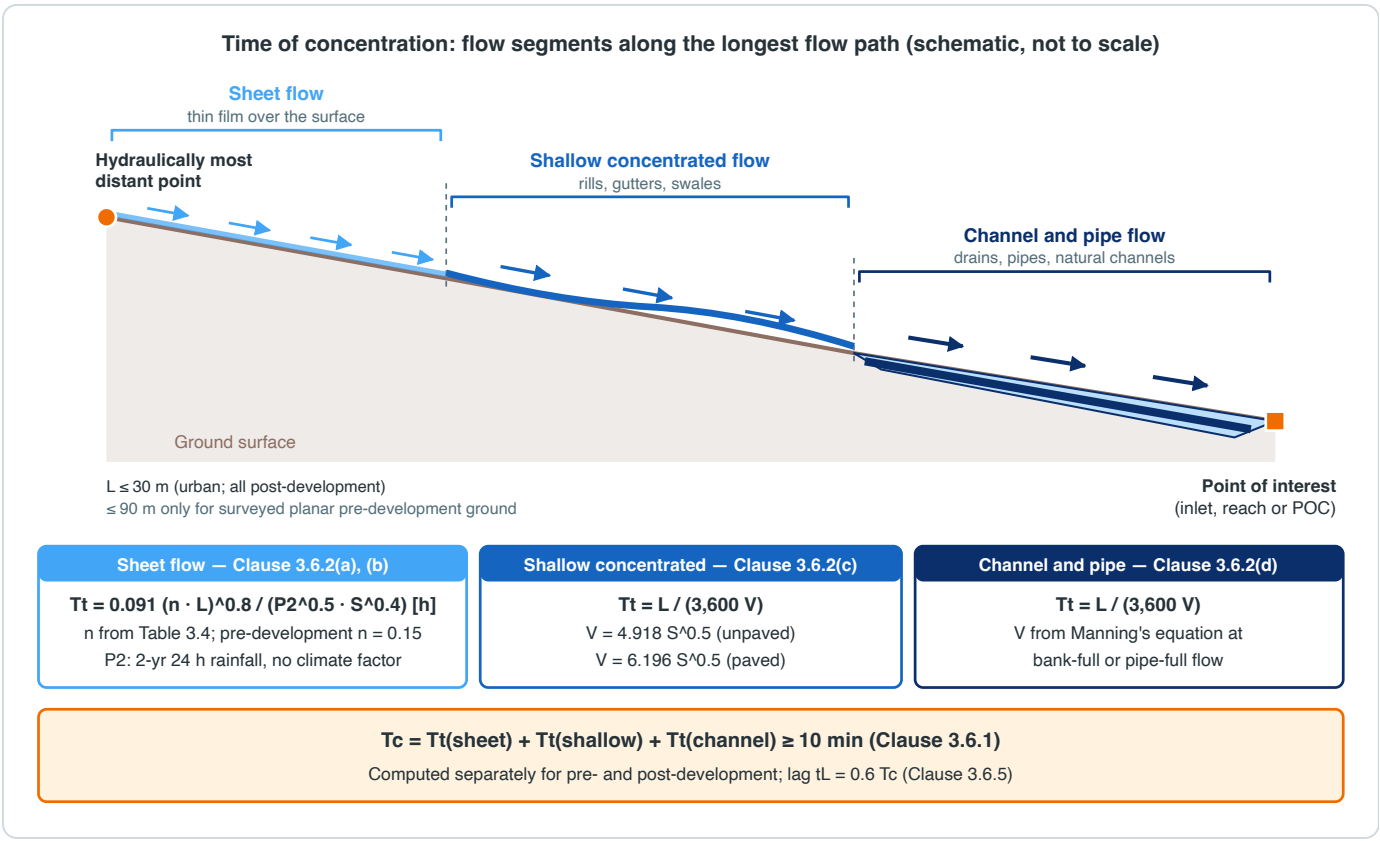


Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986),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

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 to be confirmed [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 Manipur: the lacustrine clay and silt of the Imphal valley floor in sub-areas MN-A and MN-A1, which include the paddy land and the former pats, HSG D for every design storm; the peat of the low land round Loktak and the other pats, and the phumdi margins, HSG D, taken as saturated, with no infiltration credit and with settlement to be checked (Clause 4.11, valley-floor rule); the sand, gravel and boulder fans of the foothills at the valley edge, HSG B or C by texture, on a site test; the Disang shale of the hills and of the hillocks inside the valley, with its thin soils, HSG D for runoff, whatever group the soil itself would take; the Barail sandstone cappings of the hills and hillocks, HSG C on a site test, away from scarps; the Barak and Jiri alluvium of the Jiribam plain in sub-area MN-C1, HSG C, and HSG D below the 1% AEP flood level for every design storm from 1 April to 31 October; colluvium and slide debris, HSG D for design, with no infiltration credit; and urban fill, HSG C, and HSG D where it is clayey or compacted. A field infiltration test is required on every site in a Tier A area and on every other 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 valley-floor rule, the hill 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 valley edge, where a foothill fan of sand and gravel passes into the lacustrine clay within a short distance and the water table rises towards the valley floor; on the hillocks inside the valley, where Disang shale carries a Barail sandstone capping; on the valley floor, where a sand lens in the clay can test well in March and stand in the water table in August; on the Jiribam plain, where the alluvium is dry above the Barak in the dry season and under it in flood; and on hill sites, where a high rate in a pit dug in colluvium or fill can be water entering a slope that cannot take it (Clause 4.11). No soil-series map of Manipur from NBSS&LUP, no HSG map or table, no SCS-CN calibration and no measured infiltration rate for any site in the State were obtained during research for this Manual [TBC]. The interim groups follow the soils and geology that the regional sources describe. "Manipur Valley is virtually a flat alluvium filled valley … nearly 780 m high above the mean sea level with a very low southerly gradient", "made up of alluvium of fluvio lacustrine origin", whose "principal constituents are clay, silt and sand whereas sand, gravel, pebbles and boulders are found in the foothill regions"; "The hillocks inside the valley are basically composed of Disang shales but some have sandstone capping … mainly Barails"; and the Disang, "which is predominantly shale, occupies almost 85 p.c. of the hilly region, have less infiltration and more run off" (MASTEC, *Flood Hazard Zonation in Manipur Valley*). Under the valley floor the clay is thick: in Imphal West "approximately 30 to 50 m of clayey formation, construction of shallow tube wells is problematic", with a "clayey deposit down to depth range of 30 to 65 m bgl" and "emanation of gas while constructing deep tube wells in some places" (CGWB, Imphal West district booklet, 2013). Round the lakes "The organic soils covered the low-lying areas surrounding the lakes. With dark grey colour and clayed loam texture, these peaty soils have high acidity, abundance of organic matter", and "lacustrine laminated sand and clay overlies the fresh Disang shale" (CGWB, Bishnupur district booklet, 2013). The valley was a lake country: "there were nearly 500 lakes in Manipur Valley", among them Lamphelpat, Porompat, Takyelpat, Sangaipat, Kharungpat and Ikop pat (MASTEC), and "This valley was once full of swamps and marshy land represented by the places having the word PAT meaning lake" (CGWB, Imphal West); a site on a former pat is valley floor whatever its present use. Water stands 2–5 m below ground over most of Imphal West, and 5–7 m near the hills (CGWB, Imphal West), so the valley floor is HSG D for every design storm on its clay alone, and wetter still in the monsoon season (Commentary to Clause 3.10). No primary source was read for the soils of the Jiribam plain or of the Barail sandstones [TBC]; the groups for them are set from the series' treatment of the Barak plain downstream and of sandstone hills, and are to be confirmed by tests. No subsidence or thickness record of the peat was found [TBC]. The only regional measure of losses is the design loss rate of the CWC subzone 2(b) report, 0.35 cm/h (3.5 mm/h), the modal value of 100 flood events on rural catchments gauged at bridges outside the State, none of which drains Manipur (Annex 3E). It shall be used only in a 2(b) SUH check run 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 design of the valley floor, the peat and the Disang shale as group D, the seasonal rule for the Jiribam plain and the rule for untested soil on small sites are set by this Manual pending a soil-series lookup for Manipur. The method rules matter as much as the soil, because the State's land is of two kinds that no CWC relationship describes: a flat lake basin whose rivers are bunded and whose outfalls close when the rivers are high, and hills of shale whose streams reach the valley floor within minutes. The valley's floods come from the hills: of the 6,332 km² that drain through the valley, the hills are 4,432 km² (70%) and the valley floor 1,900 km² (30%) (MASTEC; the master plan prints the basin area as 6,332 km²), and the valley floods follow rain spells of several days on the hill catchments, such as 28 July–1 August 1989, 22–28 September 1997, 24 August–3 September 1999 and 26 August–6 September 2000 (MASTEC). 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 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 slope or a paved hill road shall use the smooth-surface n of Table 3.4 and shall not exceed 30 m. (c) A catchment that runs from a hill flank onto the valley floor or a plain, such as the hill streams that "flow down with steep slope for a short distance before meeting the Loktak Lake" (MASTEC), the streams that leave the hills of Kangpokpi, Ukhrul and Churachandpur for the valley, or the streams of the western hills onto the Jiribam plain, shall be split at the break of slope and the hill sub-area modelled on its own, with the hill rainfall of Clause 2.3.6(c)(iii) or (c)(ii) on the hill part, so that a flatter lower reach does not average away the fast response of the hill. (d) On the valley floor (sub-areas MN-A and MN-A1), the Rational Method under Clause 3.4 sizes single conveyance elements on small, steeper sub-catchments only, such as the hillocks, the foothill fans and hill-fringe colonies; every other system, and every system that reaches a river, a pat or Loktak, is designed by SWMM or HEC-HMS with level-pool routing of the storage behind its outfall (the drains, sumps, pukhris, pats and paddy land upstream of the gate) together with the pump ratings and the gate rule (Clause 3.12.1), the river or lake level at the outfall as the tailwater (Chapter 5) and dynamic-wave routing where the outfall is submerged (Clause 3.12.4). (e) Two design cases are run for every such system: a short urban burst, of the durations of Clause 2.5.2 up to 6 hours, with the river at its WRD warning level and the gate open only while the river is below the gate sill; and a long storm, the 72-hour storm of Clause 2.3.6(e) over the whole catchment, hills included, with the river at its WRD flood level, checked at its highest flood level or the highest reading reported above it, and the outfall closed for the durations of Clause 5.8.5(a), or, on the Loktak margin, with the lake at the design level of Clause 5.8.5(c). (f) The rural rivers of 25–5,000 km², such as the Iril, the Thoubal, the Sekmai, the Khuga, the Chakpi, the Irang, the Makru and the Jiri, have no CWC unit hydrograph of their own: they are modelled by HEC-HMS or SWMM calibrated under Clause 3.15 to the WRD discharges, of which the largest printed are 532.488 m³/s on the Iril at Moirang Kampu (2 September 2000), 391.636 m³/s on the Thoubal at the Thoubal bridge (30 August 1999), 202.006 m³/s on the Imphal (2 September 2000) and 68.495 m³/s on the Nambul (2 July 2001) (MASTEC, from WRD data of 1999–2001), remembering that their stage–discharge curves are looped, so that one stage gives different flows on the rise and the fall; the CWC subzone 2(b) unit hydrograph, whose peak depends on area alone and none of whose catchments drains Manipur, is computed only as the check of Clause 3.11.4 (Annex 3E). In sub-areas MN-C and MN-C1 every cross-drainage structure and outfall of more than 1 km² needs a site-specific hydrology study with the design rainfall of Clause 2.3.6(c)(ii), the AMC of Clause 3.8.4 and the routing of the 72-hour storm, because volume governs there as well as the peak. (g) Catchments that drain to a reservoir or to a reach below a dam, such as the Thoubal below the Mapithel dam, the Khuga below its dam and the Nambul below the Singda dam [TBC], 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)). (h) No method of this chapter predicts debris flow; in the hill streams the design flow is bulked for sediment and debris, and silt traps at the break between hill and valley floor, inlets and culverts are designed for blockage under Chapters 6 and 9 (Clause 6.3.6).

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 June to 15 October at a site in sub-area MN-A (Imphal valley floor) or MN-B (Northern, eastern and southern hills) of Annex 2A, and from 1 May to 31 October at a site in sub-area MN-C (Western hills) or MN-C1 (Jiribam plain); 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 a river, a stream or Loktak, on peat, on the margins of a pat or pukhri and on land behind a river bund; AMC III for every design storm at any time of year in sub-area MN-A1 (Loktak margin) and 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 Loktak, held up by the Ithai barrage, the Thoubal (Mapithel) and Khuga reservoirs and the reaches below their dams, and the Singda reservoir on the Nambul [TBC]; 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.

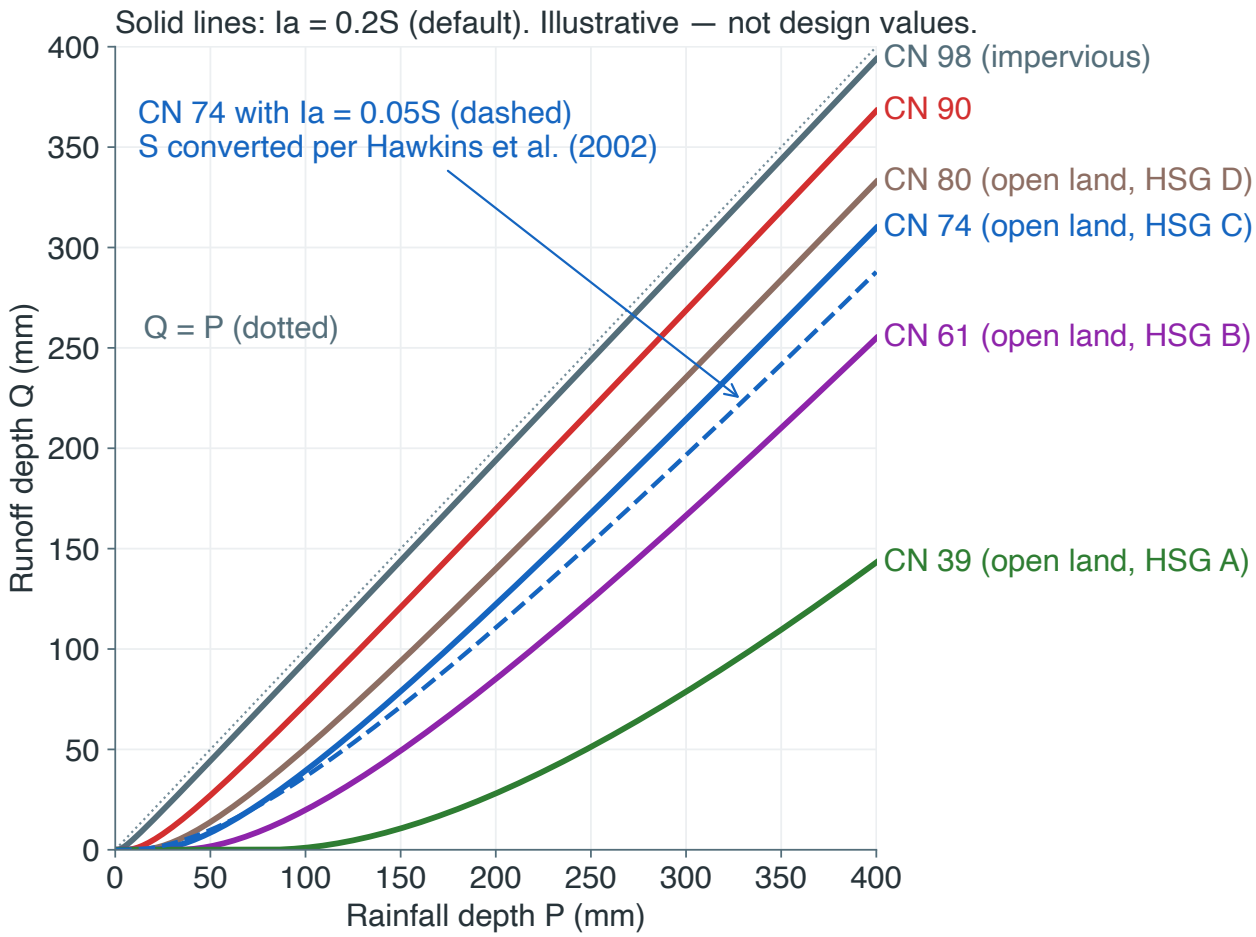


Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion 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 Manipur. 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: $CNc = CNp + (Pimp / 100)(98 - CNp)$;
- where total impervious area is below 30% and part of it is disconnected: $CNc = CNp + (Pimp / 100)(98 - CNp)(1 - 0.5\,R)$,

where CNp is the pervious CN, Pimp 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 (CNp 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, pukhri, 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 land on which most of the people of Manipur live, the floor of the Imphal valley, is wet for much of the year. In Imphal West "Depth to water level in major parts of the district varies from 2 to 5 m bgl", and 5 to 7 m "In the extreme southern and south-western parts close to hills"; the aquifers lie under "approximately 30 to 50 m of clayey formation", with a "clayey deposit down to depth range of 30 to 65 m bgl", and groundwater moves from south to north (CGWB, Imphal West district booklet, Technical Report Series D No. 28/2013-14, 2013). In Bishnupur the piezometric head stands 2.50–4.30 m below ground in a single aquifer within 44 m, with thin clay; the water level rises in April and May and "reaches its minimum during March-end" (CGWB, Bishnupur district booklet, 2013). The same booklet's summary table prints 2.73–16.02 m and 1.47–3.36 m below ground beside its pre- and post-monsoon rows, but the alignment of its columns in the copy read is uncertain, and these figures are not used [TBC]. Round the lakes the ground is peat, "peaty soils" with "high acidity" (CGWB, Bishnupur), and the floating mats of phumdi cover much of Loktak (as reported). The valley was once a country of lakes, "nearly 500 lakes in Manipur Valley" (MASTEC), and much of the paddy land and many of the town's localities stand on former pats. These depths are those of wells: the seasonal high at a site on the clay, beside a pat or behind a river bund is higher, and in a flood the ground is under water for "several weeks" (AIIB, *Approval Project Document*, 2024). On the valley floor the design groundwater level for flotation is ground level (Clause 4.12.1). No State observation-well network was found: the CGWB's dug-well monitoring in Imphal West stopped "since 1991 due to disturbed law and order" (CGWB, Imphal West), and no monsoon water-table depths for individual sites in Imphal, Thoubal, Kakching, Bishnupur, Moirang or Jiribam, and no map of the seasonal high water table, were obtained [TBC]; Annex 3A is to supply them. In the hills of Disang shale groundwater lies in fractures, weathered rock and debris and is perched in places; the soils are thin and the slopes shed water to the streams. Clause 3.10.4 reflects the State's receiving waters, which are bunded rivers that rise above the town, a lake held up by a barrage and a rock sill, pats and pukhris, and hill streams with no gauges. "The town is below the high flood level of Imphal river and hence there are embankment roads on both sides of the river to protect the settlement from seasonal floods"

(Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)). WRD publishes, through the press, a warning level, a flood level and a highest flood level for its valley gauges, with no datum stated (presumably metres above mean sea level [TBC]): the Imphal at Minuthong, in the city, 785.900 m, 786.900 m and 788.400 m, overflowing "above the highest flood level" on 29 May 2024; the Imphal at Lilong 780.350 m and 781.350 m (781.250 m in a 2024 report), with a highest level of 782.850 m that the river exceeded at 783.250 m on 15 September 2025; the Iril at Irilbung 786.700 m and 787.700 m, with a highest level printed at 782.200 m, below its flood level, an error in the figures [TBC]; the Thoubal 778.915 m and 779.915 m (gauge not named); the Nambul at Thong Nambonbi (Hump Bridge) a highest level of 783.695 m; the Nambol at Nambol Thongkhong 774.700 m or 774.400 m (the 2024 and 2025 reports differ); and the Manipur river at the Ithai barrage a highest level of 769.320 m, exceeded at 770.05 m on 15 September 2025 (Sangai Express, 30 May 2024 and 16 September 2025, printing WRD's figures; as reported). Imphal stands at about 790 m (AIIB), so the city's drains near the Imphal river discharge within a metre or two of its flood stage (NEER's reading). Loktak, the lake to which every valley river drains, is held by NHPC's Ithai barrage at a full reservoir level of 768.5 m, with a minimum drawdown level of 766.2 m (NHPC, as quoted; CEA gives 766.01 m, and an ORF article 769.63 m for the full level and 768.50 m as the "flood level", as reported: the figures conflict), and below the barrage the bed of the Manipur river rises "steeply upto 763.7 m" in about 800 m, a natural sill that limits the outflow whatever the gates do (MASTEC). Lamphelpat, in the city, "remains waterlogged for many days every year" (NDB, project summary) and is drained by pumping to the Nambul through the Shamushang nallah in high flood (WRD site report in HC PIL No. 8 of 2025). A site there drains to a water surface that the river, the barrage or the pumps hold, and Clause 3.10.4(b) applies to the land below the starting level of the receiving water set in the Commentary to Clause 3.12 and the tailwater of Clause 5.8.5. CWC has one site in the State, a level-monitoring site on the Barak at Chotebekra near Jiribam, with a highest flood level of 32.1 m on 31 July 1989 (CWC, as transcribed by SANDRP); none is on the Imphal, the Nambul, the Iril, the Thoubal or the Manipur river.

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(c) (Barak and others), which this Manual takes to cover the whole of Manipur (Clause 2.3.6(b)) and for which CWC has published no Flood Estimation Report; the report for subzone 2(b) (South Brahmaputra) is used in its place only for its areal reduction curves and as a check on unit hydrographs, so that no CWC point rainfall exists 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 2000; see Chapter 2). They were derived from natural, mostly rural catchments with data that predate the report of 2000 (its 14 gauged catchments are bridge sites outside Manipur, gauged at railway bridges from 1961 to 1983 and at national-highway bridges from 1981, and none drains Manipur; CWC has published no report for subzone 2(c), which covers the State), 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 pats, pukhris and Loktak at their outlet or design level in 3.12.5 because in the Imphal valley the heavy storm comes when the rivers are high, the outfalls through the bunds are shut and the water behind them is rising, not drawn down. The valley has one outlet: the rivers that enter it carry a few hundred cubic metres per second in flood, while "At Ithai, flow of the Manipur river during monsoon is of the order of 400 cumecs and river down below the barrage does not have the capacity to cope up with such flow, as a result, water is piled up upstream" (MASTEC). The water is stored in Loktak and the pats, so "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, *Approval Project Document*, 2024), and Lamphelpat "remains waterlogged for many days every year" (NDB, project summary). No pat or pukhri in the State was found to have a documented operating rule, a level record or a stage–storage relation [TBC]. The starting levels are therefore as follows (set by this Manual):
>
> - **A pat, pukhri or detention pond that drains through a gated, flap-gated or pumped outfall** shall be started full to the level of its outlet whenever the outfall is closed, and the outfall is taken as closed for the durations of Clause 5.8.5(a) (Clause 5.8.5(e)). In the valley this is the normal monsoon case: in May 2024 and again in September 2025 the Imphal, the Nambul and the Manipur river stood at or above their printed highest flood levels (WRD figures, as reported; Commentary to Clause 3.10).
> - **Lamphelpat**, a pat being developed as flood storage, about 300 acres being dredged under a work order of 9 November 2023, with "provision for pumping of flood water from the Lamphel pat water body to the Nambul River through Shamushang Nalla during high flood season" (WRD site report in HC PIL No. 8 of 2025), shall be started full to the level at which its pumps start, unless a notified operating rule commits it to be pumped down before the storm; its stage–storage relation and pump ratings are to be obtained from WRD [TBC].
> - **A pat or pukhri with a free outlet** is started at its surveyed outlet or spill level, and the small rain-fed pukhris of the towns and villages are started full throughout the monsoon season.
> - **Loktak.** The lake is held by NHPC's Ithai barrage, whose full reservoir level is 768.5 m and minimum drawdown level 766.2 m (NHPC, as quoted); CEA gives a minimum drawdown level of 766.01 m (as quoted), and an ORF article gives a full reservoir level of 769.63 m and calls 768.50 m the "flood level" (as

reported). The figures conflict, and this Manual does not resolve them. Loktak is started at the design lake level of Clause 5.8.5(c), the WRD highest flood level at the Ithai barrage of 769.320 m (as reported), checked at the 770.05 m reached on 15 September 2025, and never below the full reservoir level from June to September. CEA's daily reports of August 2026 show the lake at about 767.46–767.73 m (as quoted), its ordinary monsoon level, and Loktak reached 768.5 m in August 2002 (as reported). Below the barrage the Sugnu hump, where the bed rises from 756.7 m to 763.7 m in about 800 m (MASTEC), holds the outlet whatever the gates do, so the lake level is static tailwater for the event (Chapter 5).

- **Reservoirs.** The Thoubal (Mapithel) dam has a full reservoir level of 880.7 m (WRD, September 2025, as reported); it stood at 878.10 m in September 2025, and at 876 m on 1 August 2015, "nearly 2 m above the spillways" (as reported), figures that do not reconcile [TBC]. It is started at the maximum water level that its operator publishes in writing and, until then, at 880.7 m. No levels were found for the Khuga dam or the Singda dam on the Nambul [TBC]; they are started at their surveyed spillway crest until their operators publish a full or maximum level. The releases of all three are the tailwater of Clause 5.8.5(d), not storage for a town.
- **Paddy land.** The paddy land of the valley floor is ponded behind its bunds and ridges through the monsoon season and is modelled as full to the crest of its field bunds; its storage is the valley's, not a development's, and where it is filled it is replaced under Clause 7.6.4 (Chapter 7).

A gated pat, a reservoir or the lake 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 Imphal is 5 June (previously 1 June; IMD normals in use from 2020, as quoted in IMD's press release), because the storms of April and May are among the State's largest: Imphal's 24-hour records for April and May are 105.9 mm (16 April 2004) and 122.4 mm (27 May 1956), with months of 459.6 mm (April 2004) and 464.3 mm (May 1956) (IMD *Extremes*, Imphal (Tulihal)); two of the recent damaging valley floods, those of Cyclone Remal on 28–31 May 2024 and of 30 May–2 June 2025, came before the onset (as reported); and the sources describe "intense rains from March to October" (AIIB) and rainfall that "starts from the month of April end" (CGWB, Bishnupur). It ends on 31 October because the monsoon's normal withdrawal from Imphal is 15 October (as quoted) and October storms are a real threat, such as 119.4 mm on 5 October 1980 and the flood of October 1992 (IMD *Extremes*; MASTEC). Pumps, gates and 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.

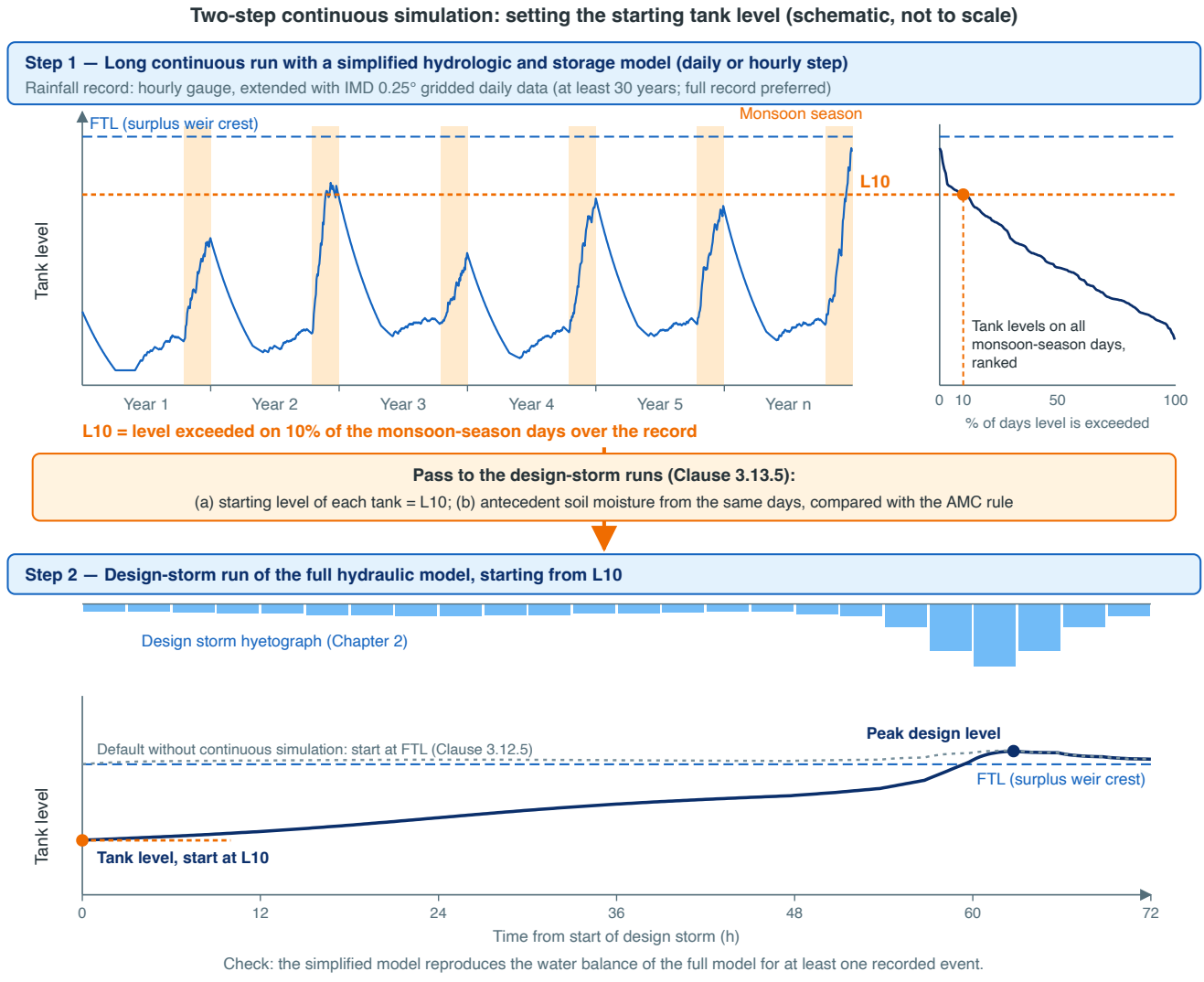


Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 April to 31 October (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in place 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 Manipur. 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 September 2025, when the Manipur river at the Ithai barrage stood at 770.05 m, above its printed highest flood level of 769.320 m, and the Imphal at Lilong at 783.250 m, above its printed 782.850 m (WRD figures, 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.

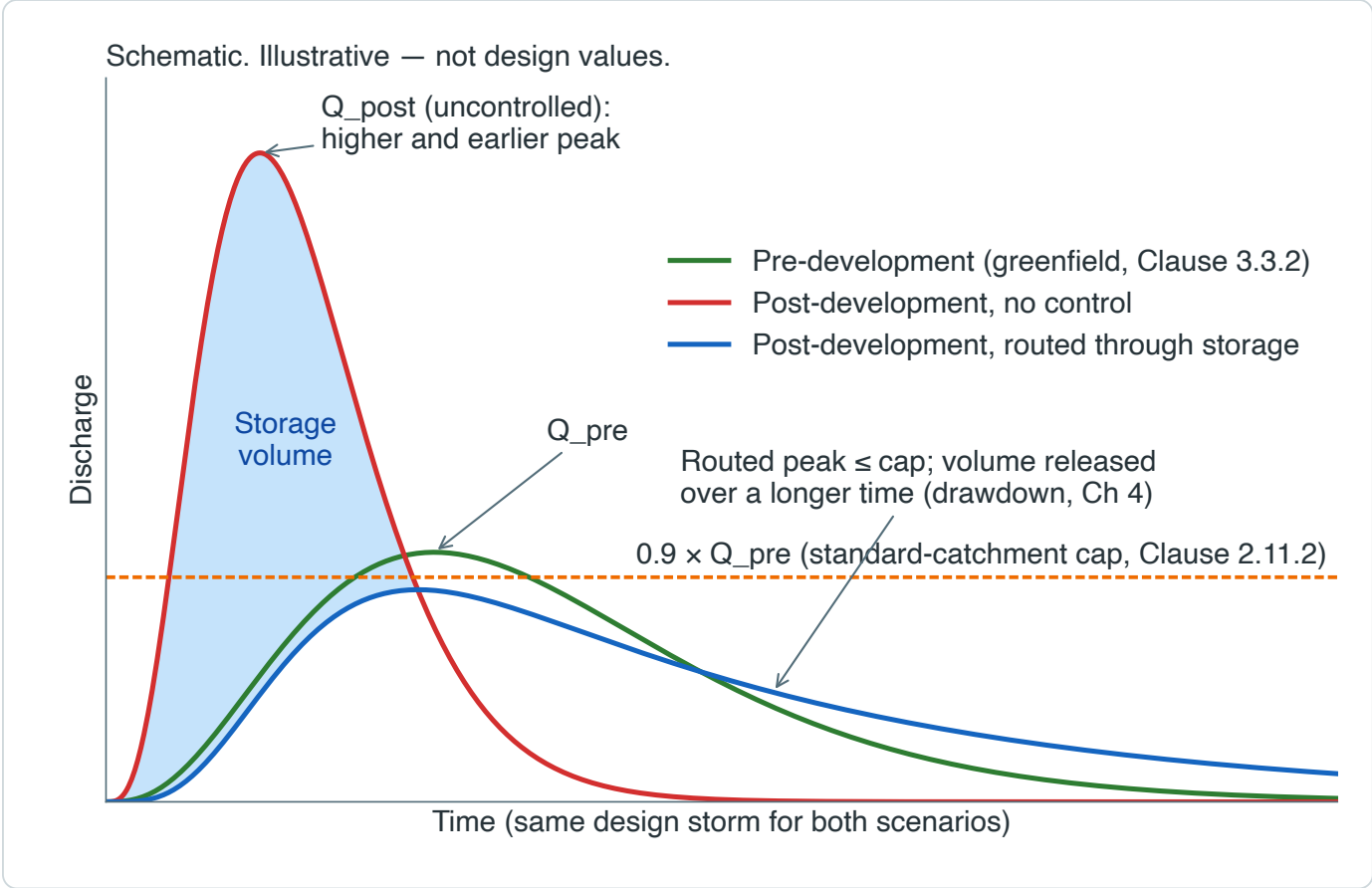


Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro 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) ≤ 0.9 × 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 Ia = 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 Manipur 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 MSDMA 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 the Imphal valley floods of 28–31 May 2024 (Cyclone Remal), 30 May–June 2025, September 2025, late July–August 2015 or July–August 1989, for which the only rainfall in the sources read for this Manual is Imphal's 158.6 mm of 30 July 1989 (IMD) and press values for 2025 [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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Annexes and forms

Annex / Form	Content
3A	Manipur soil series to HSG lookup; seasonal high water table map
3B	Manipur CN calibration and supplementary land covers (valley paddy land, pats and phumdi, hill forest and jhum land, landslide scars and hill-road and railway cuts, foothill fans, and the margins of Loktak and the reservoirs)
3C	Benchmark test problems for software acceptance
3D	Peak rate factor study for flat coastal land
3E	CWC SUH parameters for subzone 2(b), applied as a check in subzone 2(c), 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 (rainwater harvesting "through storing of water runoff including rainwater in all existing and new buildings on plots of 100 square metre and above", with the storm-water drainage and the points of collection of rain water "in surface reservoirs or in recharge wells" shown on the plans, under bye-law 66 of the Model as each local body has brought it into force, with its soft cover, the grey-water recycling of bye-law 67 and the fee rebate of bye-law 68; 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 Manipur rule found during research for this Manual limits the rate of discharge from a site, and none requires on-site detention or a storage volume sized to a storm. No Manipur document found sets a design storm, a return period, a runoff coefficient or a time of concentration for any town drain: the largest current drainage programme, the AIIB project for "547 km of both side stormwater covered drains" along the roads of Greater Imphal, states its purpose but no return period, rainfall intensity or runoff coefficient (AIIB, *Approval Project Document*, October 2024), the Lamphelpat project states no design storm (NDB, project summary), and the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification) has no storm-water drainage section, its chapter on physical infrastructure covering water supply, sewerage, electricity and solid waste only. The building rules are the Model Manipur Unified Building Bye-Laws, 2024, published by MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD-Part(1) of 4 December 2024 (Manipur Gazette Extraordinary No. 253 of 5 December 2024) under section 213 of the Manipur Municipalities Act, 1994 (Act 43 of 1994) and section 26(1) of the Manipur Town and Country Planning Act, 1975 (Manipur Act 11 of 1975), "for adoption by the Urban Local Bodies and Planning & Development Authority, Manipur". The Model "shall extend to the Master Plan areas or notified Planning areas and area under the jurisdiction of all the Urban Local Bodies of Manipur" (bye-law 1(2)), but a permit is given under the bye-laws that the urban local body or the

Planning and Development Authority, Manipur (PDA Manipur) has brought into force on it, such as the Kumbi, Moirang and Jiribam Municipal Councils' bye-laws of 2025 (final gazette 16 January 2025, as listed on the TPD site) and the "Building Bye-laws for ULBs of Manipur – Final Gazette Notification" of 15 December 2025 (as listed; not read); IMC's own Building Bye-Laws of 2025 are reported notified on the same date (as reported), and the older IMC Building Bye-laws of 2013, as amended in 2019 and 2022, are the Imphal lineage, with a third amendment published in draft in 2024. The provision numbers cited here are the Model's [TBC: confirm the number and text in the bye-laws the local body has notified]; where a local body's notified text differs, the local body's text governs. The bye-laws apply in the urban local bodies and the notified planning areas of the valley; the Manipur Municipalities Act, 1994 "extends to the whole of the State of Manipur except the Hill Areas" (as quoted). The bye-laws carry several drainage hooks, but every one of them protects the building, the plot or the watercourse; none sizes anything to a storm. For an outlet from a soak pit to a municipal drain "an intermediate treatment chamber should be installed" (bye-law 6(1)(A)); the plans show the "detail provisions made for conservation and harvesting of rain water" (6(1)(C)(j)) and, for multi-storeyed, lifeline and special buildings, a "Detailed drainage plan for both internal and external required to be constructed up to the available permanent/pucca drain of municipal/other authority" (6(1)(D)); no building or structure shall be built "over any municipal drain or land" (16); a rain-water pipe shall be "at least 75 mm" in diameter, shall discharge "into or over an inlet to a surface drain … but in no case shall it discharge directly into any closed drain", shall discharge into a gully "if a street drains within 30 m", and "shall not discharge into or connect with any soil pipe" (28); and "No open drain, except for rain water, shall be constructed in any open space required by these" bye-laws. Rainwater harvesting is required on plots of 100 m² and above (66), with grey-water recycling (67) and a fee rebate (68) (Commentary to Clause 4.11). Bye-law 92 reads, as printed, "No construction shall be permitted on land above 600 m from the mean sea level and with an average slope of 30 degrees", which would bar the whole of Greater Imphal, all of it above 600 m (NEER's reading); the IMC Building Bye-Laws (3rd Amendment), 2024 give the intended rule, "no construction will be permitted in the areas which have a slope of more than 30 degrees. Permission of development only upto two floors or 7m height in areas which have a slope of 21-30 degrees" (92.1) and "no cutting of slopes will be permitted in the areas which have a slope of more than 30 degrees" (92.2), but they were a draft published for objections, to "come into force on such date as the State Government may … appoint", and their final status was not confirmed [TBC]. Bye-law 93 prohibits "any new construction within the designated buffer zone to minimize human exposure to flood risk", with a table of buffers on the named rivers of the valley measured from mid-stream (Chapter 7), and routes any activity in a "prohibited area or restricted area" through "the previous permission of the Flood Zoning Authority constituted under the Flood Plain Zoning Act, 1978"; no Flood Zoning Authority has been found constituted and no zone notified under that Act, whose zones were reported in June 2026 to be "yet to be done" (as reported). Bye-law 94 sets the plinth "above 1m above the highest flood level of the surrounding areas" in "high Flood Risk Areas identified in the Master Plan of the towns", but the risk-informed master plans for Imphal and Moirang, where those areas would be shown, were not read [TBC], and no local authority's highest flood level was found for any town [TBC]: the WRD highest flood levels printed in the press were exceeded at Lilong and Ithai in September 2025 (as reported). This Manual supplies the method (gauge, model or surveyed flood marks, with the return period stated), and its 1% AEP level plus 0.5 m governs where it is higher (Chapters 5 and 7). The green-building criteria of the Model ask to "Minimize storm water run-off from site by reducing hard paving on site" and for "erosion and sedimentation control", and the bye-laws defer to the National Building Code 2016 for services. None of these sets a design storm, a release rate, a detention volume or an overflow path. Bye-law 6(1)(D) is the one hook for this chapter: its "Detailed drainage plan … up to the available permanent/pucca drain" needs a design storm, a release rate and a storage volume, which this chapter supplies. No duty to hold storm water on a plot, such as a dry sump, exists in the Manipur bye-laws; the only storage they name is the "surface reservoirs" of bye-law 66. The Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026 add a use zone for "Pond, Drain, Rivers and Canals" and list "Rain Water Harvesting System" as a use, but set no drainage rule. Three statutes protect the land that stores the valley's floods, and none sizes anything: the Manipur Conservation of Paddy Land and Wetland Act, 2014 forbids conversion of paddy land and wetland except through its Local, District and State Level Committees, counts "drainage channels, ponds, canals, bunds and ridges" as part of paddy land (s.2(c)), and bars any licence for construction on land converted in contravention of it (s.12); the Manipur Loktak Lake (Protection) Act, 2006 bans in the lake's Buffer Zone the "Discharge of untreated wastes and effluents from industries, cities or towns" and

"Land reclamation, bunding or disturbing the natural course of drainages" (s.19); and the Manipur Flood Plain Zoning Act, 1978 provides for zones that have never been notified. Where valley paddy land or wetland is converted and built on, the flood storage lost below the 1% AEP level is replaced in the same basin under Clause 7.6.4 (Chapter 7; set by this Manual). The drainage sections of the Manipur Municipalities Act, 1994 were not read [TBC]. In the hill areas no building or drainage rule was found: the Manipur (Hill Areas) District Councils Act, 1971 gives the District Councils functions that include "water supply and sanitation schemes", "the construction, repair and maintenance of embankments" and the allotment of land for "residential or other non-agricultural purposes" (s.29(1)), but no building control, and the Councils have been run by the Deputy Commissioners of six hill districts as administrators since June 2025 (as reported); there this chapter reaches public works and any body that adopts the Manual, and for a household it is guidance. Basements are not limited for flooding. The Model defines a basement as "the lower storey of a building which is minimum 2/3rd of the floor height below the finished ground level" (bye-law 2(11)) and allows basements within the setback lines for fire safety, but no rule found excludes them from low-lying or flood-prone land or sets a level for a basement ramp or opening. 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). On the Imphal valley floor, the Loktak margin and the Jiribam flood plain, where the design groundwater level is ground level (Clause 4.12.1), a basement is allowed only where it meets the rules of this chapter for flood-sensitive catchments, is watertight, and is checked for flotation with groundwater at ground level; on peat it also carries the geotechnical check of the Commentary to Clause 4.12; and in the flood-sensitive catchments of Clause 4.5.3.2 and any catchment notified under Clause 4.5.4 it recommends that no basement be permitted where the 1% AEP flood level stands above the surrounding ground. 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. For a sloping site, this chapter also supplies what the bye-laws leave open: runoff from the catchment above the site 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 or into fill. These are the Manual's proposals, not rules of the bye-laws. This chapter is written so that it can supply, as a technical companion to the bye-laws on the Model, the master plans and the Municipalities Act, the design storm, release rates and storage volumes that they leave open; a competent authority could adopt it for that purpose, but none has. In practice the storm drains of Imphal are its sewers: the first phase of the Imphal sewerage project, commissioned in June 2020, covers 11 of IMC's 27 wards (master plan); "Sewage generation in urban areas is 70 MLD and existing treatment facilities are 44 MLD", with 8,600–8,700 household connections of 51,754 targeted (State report in NGT OA 606/2018, July 2025); the 72 drains that fall into the Nambul carried a BOD of 42.45–52.34 mg/L before their interception and diversion (State report, December 2025), against 3–6 mg/L in the river; and the CPCB lists 18 polluted stretches in the State, all Priority V, among them the Nambul from the Singda dam to Bishnupur (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 and that, when the river is high, cannot empty at all. 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).

Term	Meaning in this Manual
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.
Authority	The approving authority under Chapter 1 (the urban local body, that is IMC, a Municipal Council or a Nagar Panchayat, for the building permit and its own drains, under the bye-laws it has brought into force on the Model and the Manipur Municipalities Act, 1994; PDA Manipur in a Master Plan or notified planning area outside municipal limits, under the Manipur Town and Country Planning Act, 1975; and, in the hill areas, where no building-control authority exists, the department that executes a public work, for that work, as applicable).
Tier A / Tier B	Adoption tiers defined in Chapter 1. Tier A: the Imphal Municipal Corporation (IMC), PDA Manipur and every other approving authority within the Greater Imphal planning area (151.38 km², the area of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)), whichever has jurisdiction over a site (which body issues building permission in the planning area outside IMC's limits is to be confirmed [TBC]). Tier B: Municipal Councils, Nagar Panchayats and planning authorities.

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, pukhris, 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

> $RRV\ (m^3) = 10 \times Q_R \times A$

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 $RRV = 10 \times P_R \times Rv \times A$, with $Rv = 0.05 + 0.009 \times I$ (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 Manipur, 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) ≤ 0.9 × 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 Nambul through Greater Imphal**: the catchment of the Nambul within the Greater Imphal planning area, with the Naga Nullah and Waisel Maril channels and the 72 drains that fall into the river, down to its outfall from the planning area;
- (b) **the Imphal river through Imphal**: the land of Imphal that drains to the Imphal river through its bunds, from Minuthong in the city downstream, including the localities at the points where the bunds breached in 2024 and 2025 (Clause 2.3.6(i));
- (c) **the Lamphelpat basin**: the land that drains to Lamphelpat and through its pumped outlet, the Shamushang nallah, to the Nambul;
- (d) **the Kongba and Iril corridors of Imphal East**: the land of Imphal East that drains to the Kongba and to the Iril, behind their bunds;
- (e) **Thoubal on the Thoubal river**: the land of Thoubal that drains to the Thoubal river, on the release reach below the Mapithel dam;
- (f) **the Loktak margin**: the land of Moirang, Ningthoukhong and Thanga, and of Ithai, Sugnu and Wangoo with the backwater of the Chakpi, that drains to Loktak, its fringing pats or the Manipur river between Ithai and Sugnu (sub-area MN-A1);
- (g) **Nambol and Bishnupur on the Nambol and Nambul rivers**: the land of the two towns that drains to the Nambol and the Nambul;
- (h) **Kakching and Wangjing on the Sekmai and Wangjing rivers**: the land of the two towns that drains to the Sekmai and the Wangjing;
- (i) **Jiribam on the Barak and the Jiri**: the land of Jiribam that drains to the Barak and the Jiri, on their flood plain (sub-area MN-C1);
- (j) **the hill towns on landslide ground**: the land of Noney, with Tupul, of Tamenglong, of Chandel and of Kangpokpi, with the landslide ground round them; and
- (k) 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 closed by a gate or flap gate in a river bund when the Imphal, the Nambul, the Iril, the Kongba, the Thoubal or another valley river stands at or above its WRD flood level, or that depends on pumping, such as the pumped outlet of Lamphelpat to the Nambul through the Shamushang nallah, or that discharges to Loktak or a pat held up above its invert by the Ithai barrage and the Sugnu hump, to the Barak or the Jiri at Jiribam in flood, or to a reach below the Mapithel or another dam that releases water, or that is blocked by phumdi, garbage or the debris of a hill stream, for part of the monsoon season (Chapter 5);
- (d) loss of more than a quarter of the mapped tank and pukhri 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 list follows the valley's rivers, its lake and its hill towns, because in Manipur flooding comes less from rain on a town than from rivers and a lake that stand higher than its drains. "The town is below the high flood level of Imphal river" (Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)); 35% of Imphal is "prone to floods", and "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, *Approval Project Document*, 2024). The Nambul entry follows "the main urban river" (AIIB): the State's reports to the NGT record the "Interception & Diversion (I & D) of all drains (72 Nos.) falling into the Nambul River", with a drain BOD of 42.45–52.34 mg/L (State report in NGT OA 606/2018, December 2025); the river breached its bunds at four places in 2025 (as reported); the clogged Naga Nullah flooded Nagaram, Laipham Khunou and Lairikyengbam Leikai in July 2024 (as reported); and the market waste "dumped in the Naga Nullah on the backside of the market … creates a stagnant pool all along the year" (master plan). At Thong Nambonbi (Hump Bridge) the Nambul has a highest flood level of 783.695 m, which it exceeded on 29 May 2024 (WRD figures, as reported). The Imphal river entry follows the river at Minuthong, whose flood level of 786.900 m and highest flood level of 788.400 m lie within a metre or two of the city's ground (about 790 m, AIIB; NEER's reading), and which overflowed "above the highest flood level" on 29 May 2024 (as reported); its bunds breached at Singjamei, Heingang, Bashikhong and New Checkon in 2025 and at Keirang, Khabam and Lairikyengbam Leikai in 2024–2025 (as reported). In Cyclone Remal, 28–31 May 2024, 18 embankments were reported breached and 17 sealed, with 1,88,143 people and 24,265 houses affected by the Minister's count of 30 May and 1,26,950 people, 255 localities and 16,364 houses by the Relief and Disaster Management Department's report of 31 May (as reported: the counts conflict). The Lamphelpat entry follows the pat being developed as flood storage, which "remains waterlogged for many days every year" because of "reduction in detention capacity" (NDB, project summary) and which is pumped to the Nambul through the Shamushang nallah in high flood (WRD site report in HC PIL No. 8 of 2025). The Kongba and Iril entry follows the bunded rivers of Imphal East, where the Iril breached at Kshetri Awang Leikai in September 2025, when it stood at 788.850 m at Irilbung, above its flood level of 787.700 m (as reported); Imphal East was the worst hit in 2025 (as reported). The Thoubal entry follows the release reach of the Mapithel dam: the Thoubal carried 391.636 m³/s at the Thoubal bridge on 30 August 1999 (MASTEC), the river has 14 vulnerable embankment points (MASTEC), and

the reservoir stood at 876 m, "nearly 2 m above the spillways", on 1 August 2015 (as reported). The Loktak margin entry follows the lake: the Ithai barrage holds Loktak at a full reservoir level of 768.5 m (NHPC, as quoted), the Manipur river at Ithai stood at 770.05 m on 15 September 2025, above its printed highest flood level of 769.320 m (as reported), and the Chakpi "meets the Manipur River at a reverse direction, thereby checking the current … making inundation of the surrounding area of Sugnu extending upto Wangoo" (MASTEC). The Nambol and Bishnupur entry follows the Nambol, which overtopped its highest flood level at Nambol Thongkhong (774.700 m or 774.400 m; the reports differ) on 29 May 2024 (as reported), and the Nambul below the city, on peat and clay with the piezometric head 2.50–4.30 m below ground (CGWB, Bishnupur). The Kakching and Wangjing entry follows the Sekmai and the Wangjing, both on the CPCB's list of polluted stretches (Priority V, CPCB, 2025) and both in the buffer table of bye-law 93; the Wangjing breached at two places in September 1997 (MASTEC). The Jiribam entry follows the Barak and the Jiri: the CWC site at Chotebekra recorded its highest level, 32.1 m, on 31 July 1989 (CWC, as transcribed by SANDRP), and on the Barak plain downstream, which the adjoining edition of this series governs, river-locked outfalls are treated as closed for at least 7 days. The hill-town entry follows the landslides: at Tupul, Noney, on 29 or 30 June 2022, a slope at the Jiribam–Imphal railway site failed after "poorly designed or implemented slope excavation coupled with heavy rainfall" (Baruah et al., 2023, via a search summary of the AGU Landslide Blog, as reported), killing 56, 58 or 61 people by different counts (as reported; NRSC reported 42 dead and 20 missing on 5 July); at Joumol, Chandel, on 1 August 2015, 20 or 21 died, or 24 by ActionAid's count (as reported); and the Khoupum valley was inundated after 225 mm fell at Khoupum in one night on 15 July 2025 (IMD Imphal officials, as reported; duration and gauge not stated). Kangpokpi is listed because its hills feed the valley's floods: WRD's rule of thumb, as reported, is that 135 mm in three days there floods the valley, and 175 mm fell in 72 hours on 30–31 May 2025 (as reported). Ukhrul, Senapati, Churachandpur and Moreh are candidates for notification under Clause 4.5.4. The official final tolls of the Relief and Disaster Management Department and MSDMA were not obtained [TBC]. 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 pukhri 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 Thangal and Paona Bazar in central Imphal (as reported), the localities that the clogged Naga Nullah flooded in July 2024, Nagaram, Laipham Khunou and Lairikyengbam Leikai (as reported), or the old centres of Thoubal and Kakching [TBC], 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 June to 15 October in sub-areas MN-A and MN-B, from 1 May to 31 October in MN-C and MN-C1, and from 1 April to 31 October on land below the 1% AEP level of a river, a stream or Loktak, on peat, on pat and pukhri margins and on land behind river bunds, at all times in sub-area MN-A1 and in catchments draining to a reservoir, its backwater or a release reach below a dam, 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 hill-fringe colony in Jiribam town draining to a stream of the Jiri. 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: $CN_{III} = 23 \cdot CN / (10 + 0.13 \cdot CN) = 84.3$ (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**
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.

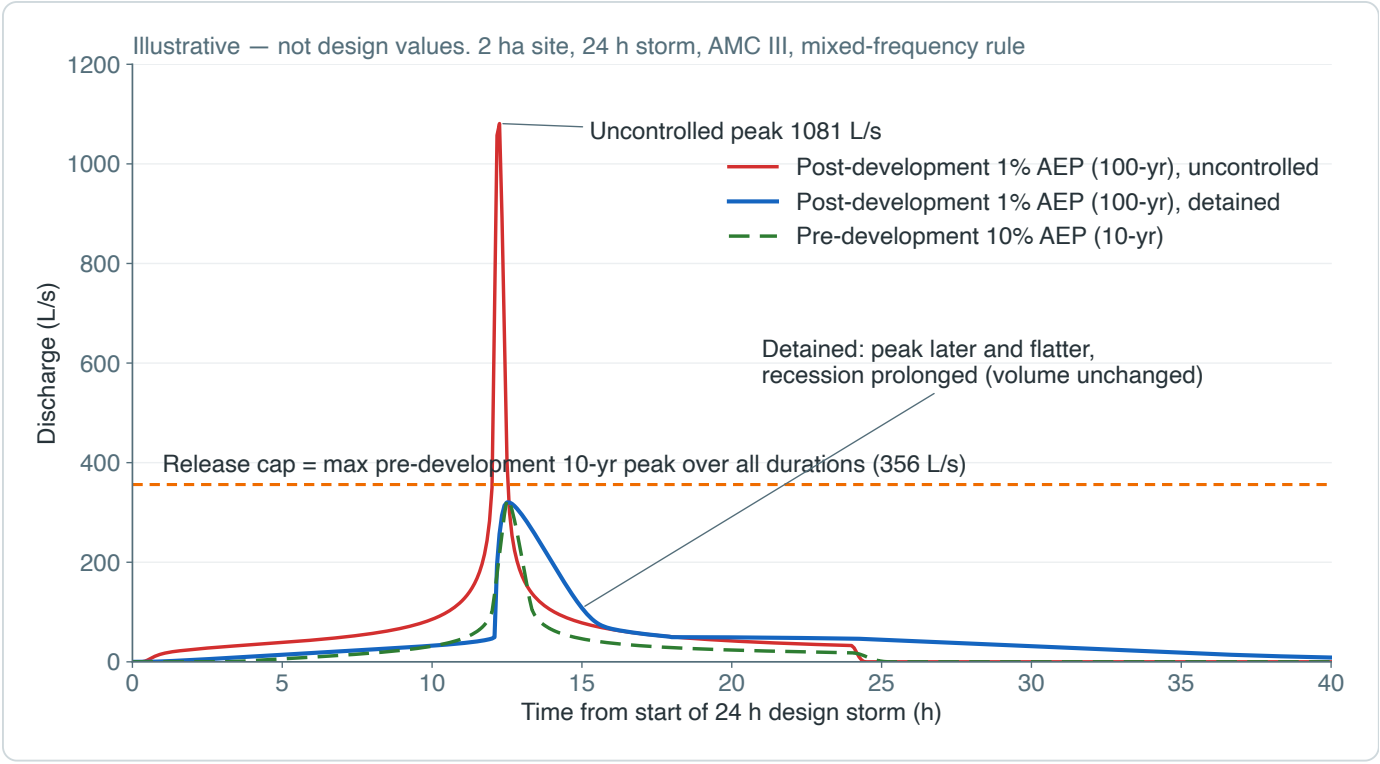


Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA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

late August and early September 1999, when the Thoubal peaked at 391.636 m³/s at the Thoubal bridge on 30 August and again at 330.906 m³/s on 2 September, within one spell of rain from 24 August to 3 September (MASTEC) 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).

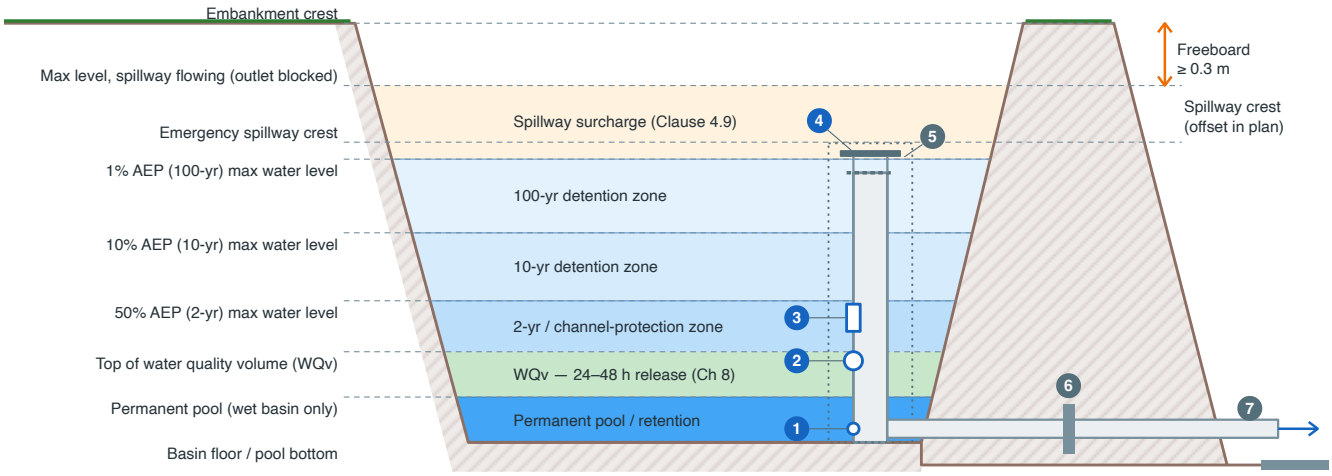
4.8.5 **Outlet barrels.** Outlet barrels through embankments shall:

- 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 the soft-cover rule of bye-law 66(b) of the Model, under which a building with a covered area of at least 500 m² keeps soft cover on at least 15% of the plot and any other building on at least 10%, and the green-building criterion that seeks to "Minimize storm water run-off from site by reducing hard paving on site"; the Model also allows no open drain, "except for rain water", in the open spaces it requires. Where the ground is outside the valley-floor and hill rules of Clause 4.11, a detention area graded into the soft cover below the level of the road keeps it pervious and usable, which is what 4.10.6 requires. On land to which the valley-floor rule applies, most of the Imphal valley floor, the same surface storage is the preferred form (Clause 4.12.4), but it earns no infiltration credit, its floor is set above the design groundwater level of Clause 4.12.1 or it is lined, and any permeable paving there is laid on a non-exfiltrating base with an underdrain. On hill-rule ground, slopes of more than 10°, Disang shale at any slope, colluvium, fill, slide debris and land within twice the height of a cut or wall downslope of it are not used for

ponding, and detention is provided in lined tanks, on rooftops and podiums under 4.10.3 and 4.10.4, or on a level open space only where the hill rule's geotechnical certificate covers it. Four kinds of land are not open space for this purpose. A pukhri or pat on the land is preserved under step 1 of Clause 4.3.1 and 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 pat and its margins are never turned into a detention pond, and engineered storage is called a detention pond, never a pukhri or a pat. The buffers of bye-law 93 of the Model on the named rivers and the Manual's corridor of Chapter 7 are flood land already: water reaches them first, so they are not counted as detention for the development beside them. The land within the 236.21 km² of the Loktak Lake (Protection) Act, 2006 is not graded or excavated for a development's detention, because the Act bans in its Buffer Zone "Land reclamation, bunding or disturbing the natural course of drainages" (s.19) and makes its Core Zone a "No-Development Zone" (s.3). And paddy land and wetland are the valley's flood storage already: they are not open space for a development's detention, and where they are converted and built on, the storage lost is replaced under Clause 7.6.4 (Chapter 7).
- Signs and depth markers under Clause 4.15.5, and the flood-warning signs of 4.10.5(b), are in Manipuri, written in Meetei Mayek, and English; in the hill areas they are in English and the language in local use of the village or town, with Manipuri where the Authority so directs (set by this Manual). The rule follows the Manipur Official Language (Amendment) Act, 2021 (Act 7 of 2021), which defines "Manipuri Language" as "Meeteilon written in Meetei Mayek" and allows the "concurrent use of Bengali Script and Meetei Mayek … in addition to English language, for a period upto 10(ten) years"; how section 7 of the Manipur Official Language Act, 1979 treats the hill areas was not read cleanly [TBC], and 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 bye-laws 6(1)(C)(j), 66 and 67 of the Model Manipur Unified Building Bye-Laws 2024 as each local body has brought them into force, the completion certificate that certifies the "water harvesting as well as waste water re-cycling systems", any condition of a building permission, the guidelines of the Central Ground Water Authority where they apply, the Manipur Ground Water (Control & Regulation) Policy, 2023 (as listed by DoECC; text not read [TBC]), or any rainwater harvesting rule or direction of an approving authority.

Commentary. Rainwater harvesting in Manipur is required by the bye-laws, which do not size it. Bye-law 66 of the Model Manipur Unified Building Bye-Laws, 2024 [TBC: confirm the number and text in the bye-laws the local body has notified] reads: "a) Water Harvesting: Water harvesting through storing of water runoff including rainwater in all existing and new buildings on plots of 100 square metre and above will be mandatory. The plans submitted shall indicate the system of storm water drainage along with points of collection of rain water in surface reservoirs or in recharge wells", and "b) Soft Cover: … For any building having a minimum covered area of 500 square metre, the applicant should provide soft cover of at least 15% of the plot area. … For any other building, having lesser covered area, the soft cover should be at least 10% of the plot area." Bye-law 67 requires grey-water recycling for a covered area of 500 m² or more or a flow of 10,000 L/day or more, and "The excess waste water not reused for toilet flushing shall be suitably connected to the rain water recharge structures for ground water recharge"; bye-law 68 gives a "rebate of 10 % on building permission fees" to owners "who undertake both recycling of waste water and rain water harvesting structures"; the plans show the "detail provisions made for conservation and harvesting of rain water" (6(1)(C)(j)); and the completion certificate certifies the "water harvesting as well as waste water re-cycling systems". None gives a storage volume, a release rate, a design storm, a drawdown or an infiltration test (NEER's reading). In the hill areas no rainwater harvesting rule was found. Groundwater is not short: every assessment unit is Safe, and the stage of groundwater extraction was 7.99% in GWRA 2023 and 8.00% in GWRA 2024 (CGWB, as quoted). Rainwater harvesting in Manipur is therefore storage and reuse for the dry season, when the towns draw on rivers that run low ("About 90% of the drinking water supply in Imphal is from the three major rivers namely Imphal River, Nambul River and Iril River", master plan), and, on the valley floor, storage in place of the ground. This Manual therefore sets three infiltration rules and one sizing rule for credit (all set by this Manual), and credits the bye-law structures as follows:

- An RWH tank or surface reservoir 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.
- **RWH credit rule.** Because bye-law 66 sets no volume, RWH storage shall hold at least 25 L per m² of roof area (about 25 mm of rain over the roof) to earn credit under this Manual. The value is the North-East value of this series; the 20 L per m² of the mountain editions is the precedent. It 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, and is then modelled under Clause 4.4.6 like any other retention practice; it is assumed full at the start of every monsoon design storm and never counted as detention. The rule makes the bye-law's requirement measurable; it does not replace it, and a larger tank is always allowed. On the valley floor and on hill-rule ground, 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.
- **Valley-floor 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 lacustrine clay, silt or peat of the Imphal valley floor (sub-areas MN-A and MN-A1), which includes paddy land and former pats; on land below the 1% AEP flood level of a river, a stream or Loktak; inside a river-bunded area that ponds when its outfalls close; on the margins of a pat or pukhri (its Zone 1 and Zone 2 under Chapter 7); within the 236.21 km² of the Loktak Lake (Protection) Act, 2006; on the Barak and Jiri flood plain of sub-area MN-C1 below its 1% AEP level; or wherever the seasonal high water table, the highest level from April to November, is less than 2.0 m below ground. Only on a foothill fan of sand and gravel at the valley edge, or on a sand lens shown by test pits, outside every one of these areas, may the recharge rule apply. On such land roof runoff goes to storage under the RWH credit rule above, detention is provided in lined, watertight storage (Clause 4.12.2), checked for flotation with the design groundwater level at ground level (Clause 4.12.1), and every sump or tank founded on peat carries a geotechnical check of bearing and settlement. The evidence is the clay itself: "approximately 30 to 50 m of clayey formation,

construction of shallow tube wells is problematic", a "clayey deposit down to depth range of 30 to 65 m bgl", and water "2 to 5 m bgl" in major parts of Imphal West (CGWB, Imphal West district booklet, 2013); "peaty soils have high acidity" round the lakes (CGWB, Bishnupur district booklet, 2013); and the valley is "made up of alluvium of fluvio lacustrine origin" of clay, silt and sand (MASTEC). No subsidence record of the peat was found, and the CGWB records "emanation of gas while constructing deep tube wells in some places" [TBC]. The rule is the series' valley-floor rule, with the floodplain conditions of the adjoining edition, and it reaches most of the valley's town land.

- **Bye-law 66: no conflict.** Bye-law 66 asks for the points of collection of rain water "in surface reservoirs or in recharge wells". On land under the valley-floor rule the Manual chooses surface reservoirs, which the bye-law allows, so the two agree.
- **Bye-law 67: a conflict, stated.** Bye-law 67 connects the excess grey water "to the rain water recharge structures for ground water recharge". On the valley floor that structure is a soak pit in clay or in saturated ground, which the valley-floor rule forbids, and the water it would take is waste water. This Manual does not override the bye-law. It states the conflict plainly: on such a site the Manual requires the excess grey water to go to storage for reuse or to a sewer connection in place of the recharge structure, and the applicant seeks the local body's relaxation of the recharge requirement, citing this rule. Until the local body relaxes it, the bye-law requirement stands, and a recharge structure that the bye-law forces on such a site earns no credit under this Manual.
- **Hill rule.** In sub-areas MN-B and MN-C, on the hill parts of sub-area MN-C1, on the valley-rim slopes and the hillocks of sub-area MN-A, and on any natural slope of more than 10° elsewhere, no deliberate infiltration practice shall be built or credited: on natural ground sloping more than 10°; on Disang shale, at any slope; on colluvium, fill or slide debris, whatever its slope; in a mapped landslide zone or landslide locality, among them Tupul in Noney district, Joumol in Chandel district and the cut slopes of NH-37 and NH-2; 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 that discharges through a silt trap and an energy dissipator to a stable natural channel, never onto an unprotected slope. The Disang shale "occupies almost 85 p.c. of the hilly region, have less infiltration and more run off" (MASTEC), and it fails when it is cut and wet: at Tupul on 29 or 30 June 2022 a slope at the Jiribam–Imphal railway site failed after "poorly designed or implemented slope excavation coupled with heavy rainfall" (Baruah et al., 2023, via a search summary of the AGU Landslide Blog, as reported), and at Joumol on 1 August 2015 a landslide killed 20 or 21 people, or 24 by another count (as reported). The hooks are the IMC Building Bye-Laws (3rd Amendment), 2024, whose bye-laws 92.1 and 92.2 permit no construction and no cutting on slopes of more than 30° and at most two floors or 7 m on slopes of 21–30° (a draft, final status not confirmed [TBC]), read with bye-law 92 of the Model as printed (Commentary to Clause 4.1); IS 14458, "Guidelines for retaining wall for hill area", which the Model references; and the green-building criterion of "erosion and sedimentation control". In the hill areas no bye-law applies, and the rule reaches public works and any body that adopts the Manual. 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.
- **Recharge rule.** Recharge is allowed only on tested ground outside the valley-floor and hill rules: the foothill fans of sand, gravel and boulders at the valley edge, HSG B or C by texture; the Barail sandstone cappings of the hills and hillocks, on slopes of 10° or less and away from scarps; and sand lenses on the valley floor shown by test pits, outside every area of the valley-floor rule. There it needs a silt trap, a filter and a first-flush diverter ahead of the structure, a field infiltration test, a seasonal high water table at least 2.0 m below ground, and the separation of Clauses 4.11.4 and 4.12. Recharge is not a design objective in Manipur, where the stage of extraction is 8.00% (GWRA 2024, as quoted); everywhere else rainwater harvesting is storage and reuse for the dry season, and on the valley floor storage for the storm.

- **Polluted runoff.** Runoff from fuel stations, workshops, industrial premises and the like, and from any drain that carries sewage, as most of the drains of Greater Imphal do (Commentary to Clause 4.1), 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 pit, bore or well (Chapter 8).

On the valley floor, water put into the ground has nowhere to go in the monsoon, and on the hills it goes into the slope. In the monsoon season an RWH tank is full after the first heavy rain, and on the clay a pit sits in or near the water table. 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 credit rule, the valley-floor rule, the hill rule, the recharge rule, the treatment of the bye-law 67 conflict, the check on peat and the polluted-runoff rule are set by this Manual. The 2.0 m water-table screen of the valley-floor rule is set by this Manual from the CGWB depths above, because where the water table rises above it a practice whose base must stand 1.0 m above the water (Clause 4.11.4) has less than a metre of depth to work in. No Manipur source sets a slope threshold for infiltration below the 21° of the IMC draft, which is a limit on building: the 10° limit and the Disang condition are 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, 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 Imphal valley floor, on its lacustrine clay, silt and peat, in and around Imphal, Thoubal, Kakching, Bishnupur, Nambol and Mayang Imphal, where water stands 2–5 m below ground over most of Imphal West and the piezometric head 2.50–4.30 m below ground in Bishnupur, the Loktak margin and the land within the 236.21 km² of the Loktak Act, the paddy land and former pats, the margins of Lamphelpat and the other pats and pukhris, the land behind the river bunds, the Barak and Jiri flood plain of the Jiribam plain, 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, pat, pukhri or Loktak, or of the water ponded behind any river bund that encloses the site.

For the flotation check of 4.12.3 at sites in the Imphal valley floor, with its lacustrine clays, peat and paddy land, the margins of Loktak and the other pats and pukhris, the land behind river bunds, and the Barak and Jiri flood plain of the Jiribam plain, 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. Manipur is landlocked, so the coastal provisions of this clause, the tidal water levels of 4.12.1 and 4.12.3 and the saline exposure of 4.12.5, do not apply in the State, and no saline groundwater was reported in the sources read for this Manual [TBC]. The peat round the lakes has "high acidity" (CGWB, Bishnupur district booklet, 2013), and gas emanates "while constructing deep tube wells in some places" in Imphal West (CGWB, Imphal West district booklet, 2013); on peat, and wherever a site test shows 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, and every sump, tank or chamber founded on peat carries a geotechnical check of its bearing and of settlement (set by this Manual; no subsidence or peat-thickness data were found [TBC]). The wet cases are most of the valley floor. Water stands 2–5 m below ground over most of Imphal West and 5–7 m near the hills, under 30–65 m of clay (CGWB, Imphal West), and the piezometric head 2.50–4.30 m below ground in Bishnupur, where the level rises in April and May and is lowest at the end of March (CGWB, Bishnupur). On the paddy land, the former pats, the margins of Loktak and the other pats and pukhris and the land behind the river bunds the ground is flooded or saturated when the rivers are high, for "several weeks" after a breach (AIIB). There an unlined tank fills with groundwater before the storm, and an empty lined tank can float, especially when a river in flood, a pat at its outlet level, Loktak at its design level or water ponded behind a bund 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, pat, pukhri or Loktak, or of the water ponded behind a river bund that encloses the site, where that is higher than the well record; and on the Imphal valley floor, the Loktak margin, the pat and pukhri margins, the land behind river bunds and the Barak and Jiri flood plain of the Jiribam plain it is taken as existing ground level for the flotation check unless piezometers show otherwise. Storage there is preferably above ground, on roofs, podiums and landscape (4.12.4), and storage below ground is lined, anchored and checked for flotation empty. 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 shall be lined and watertight, and its leakage and overflow taken to a lined drain (Clause 4.11, hill rule). 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 and the high water after the withdrawal in mid-October; because the water table in the valley is lowest at the end of March (CGWB, Bishnupur), a reading taken in March understates the design level. The State's observation wells are those of the CGWB, North Eastern Region: no State observation-well network was found, and the CGWB's dug-well monitoring in Imphal West stopped "since 1991 due to disturbed law and order" (CGWB, Imphal West), so the WRD record that 4.12.1(b) refers to does not yet exist [TBC]; no water-table depths for individual town sites were obtained [TBC]. The factor of 1.2, the 0.5 m allowance, the "ground level" default for the valley floor, the waterbody margins, the bunded land and the Jiribam flood plain, the exposure rule for acid groundwater and the check on peat have no direct precedent; this Manual sets them because no published site-scale seasonal groundwater depths for Manipur 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 pukhri 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.
>
> Manipur has no tank Act, and no pat or pukhri in its towns was found to be operated for flood control under a documented rule. The valley's regional storage is of five kinds: Loktak, held up by NHPC's Ithai barrage and protected over 236.21 km² by the Loktak Lake (Protection) Act, 2006, with its Core Zone of 70.30 km² a "No-Development Zone or Totally Protected Zone" (s.3); the other pats and marshes, "about 134 swampy and waterlogged marshy wetlands" in the master plan's count, of which the Manipur State Wetlands Authority has listed seven as Phase-1 priority wetlands and published draft notifications of three, Yaral Pat, Utra Pat and Waithou–Phumnom Pat, none yet final (DoECC, Administrative Report 2025-26); Lamphelpat, a pat being developed as flood storage with a pumped outlet (NDB; WRD site report in HC PIL No. 8 of 2025); the pukhris of the towns, the "public ponds" of the AMRUT 2.0 water-body projects, 20 approved and 19 in progress (TPD, Annual Administrative Report 2025-26); and the paddy land of the valley floor, which the Manipur Conservation of Paddy

Land and Wetland Act, 2014 protects from conversion and which the master plan shrinks from 5,616.53 ha of agricultural land in 2020 to 2,604.70 ha in 2043, with wetlands falling from 374.48 ha to 232.21 ha while water bodies grow from 563.54 ha to 643.42 ha (Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)). Four points follow:

- A pat on the record may not be a working pat, and a pat is not a detention pond. About 4,000 water bodies were inventoried after NGT M.A. 26/2019, but "Ground truthing, engineering surveys, and quality monitoring … are pending" (DoECC, 2025-26). A pat or pukhri is credited only after a survey shows its bed, rim and outlet, and only for the storage above its outlet level; a natural pat is never turned into a detention pond, and engineered storage is called a detention pond, never a pukhri or a pat.
- Lamphelpat is regional storage for the city, not spare capacity for a site. It is being dredged over about 300 acres to "increase its water detention capacity, restore stormwater drainage system and channels / streams in the catchment area", with a "real time flood management system with a command center" (NDB, project summary), but no stage–storage relation, design storm or pump rating was found [TBC], it is also proposed as a source of drinking water (NDB), and in high flood it can empty only by pumping to the Nambul. Its storage is credited to a development only under a Basin Stormwater Master Plan (Chapter 11), with WRD's written agreement and after the interception of dry-weather flow ahead of it (Clause 6.3.6(e); Chapter 8).
- Loktak is not spare capacity either. It is held for power by the Ithai barrage, its level is the tailwater of the Loktak margin (Clause 5.8.5(c)), its storage below the full reservoir level is not credited (Clause 4.13.2(c)), and the Loktak Act bans in its Buffer Zone the "Discharge of untreated wastes and effluents from industries, cities or towns" and "Land reclamation, bunding or disturbing the natural course of drainages" (s.19(iv) and (vi)); the High Court's special bench is reported to have barred development in or around Loktak "without the Court's leave" (orders of 17 July 2019 and 25 February 2022, as reported; case number not found [TBC]). Storm water spilled to Loktak can be relied on only with the written agreement of LDA and NHPC for a stated volume and level (set by this Manual).
- Paddy land and wetland are flood storage that is being lost. Where they are converted and built on, the storage lost below the 1% AEP level, or below the ponding level behind the bund in the outfall-closed case of Clause 5.8.5, is replaced under Clause 7.6.4 in the same sub-catchment (Chapter 7); the replacement does not legalise a conversion, which still needs the committees' approval under the 2014 Act, and s.12 of that Act bars any licence for construction on land converted in contravention of it. The Manipur Conservation of Paddy Land and Wetland (Third Amendment) Bill, 2026 would exempt land that conforms to a notified Master Plan and allow "Deemed Conversion" on self-declaration; it is a Bill, and its enactment was not confirmed [TBC].

No rule dividing natural streams and city channels from municipal drains was found: no notification assigns the Naga Nullah, the Waisel Maril or the Shamushang nallah to one owner (NEER's reading). Until one is made, this Manual follows the working assignment of Chapter 1: municipal drains as IMC's and the other urban local bodies' (bye-law 16 of the Model speaks of a "municipal drain"; the drainage sections of the Manipur Municipalities Act, 1994 were not read [TBC]); roadside drains as PWD's, including the "547 km of both side stormwater covered drains" of the AIIB project in Greater Imphal, and national-highway drains as the national-highway agencies'; river bunds, flood channels, Lamphelpat and the Shamushang pumping as WRD's; the interception and diversion of the 72 drains that fall into the Nambul, with its plant, as DoECC's; sewers as PHED's; and Loktak, with the cleaning of the Waisel Maril that it was reported to lead, as LDA's. Each town keeps a drain register giving every reach its owner, the river it reaches, the bund it crosses (gate or flap gate), whether it lies in a bye-law 93 buffer, its land status and its outfall. This is the Manual's working assignment, not a statutory one; where land is private patta land, a drainage corridor or easement is reserved in the master plan or secured by agreement, not taken, and in the hill areas the drains of public works are the executing department's.

The first point is the basis of condition 4.13.2(c) in Manipur. A pat or pukhri 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
MN-Z1 Imphal valley: MN-A Imphal valley floor (Imphal–Thoubal–Kakching–Bishnupur–Nambol–Mayang Imphal)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
MN-Z1 Imphal valley: MN-A1 Loktak margin (Moirang–Ningthoukhong–Thanga–Ithai–Sugnu–Wangoo)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
MN-Z2 Northern, eastern and southern hills: MN-B Northern, eastern and southern hills (Senapati–Kangpokpi–Ukhrul–Kamjong–Chandel–Tengnoupal–Moreh–Churachandpur)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(c)(iii))	—	—	—	—
MN-Z3 Western hills and the Jiribam plain: MN-C Western hills (Tamenglong–Noney–Khoupum–Tupul–Tousem–Pherzawl)	C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
MN-Z3 Western hills and the Jiribam plain: MN-C1 Jiribam plain (Jiribam)	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

Hydrologic soil group	C_10	C_2
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]

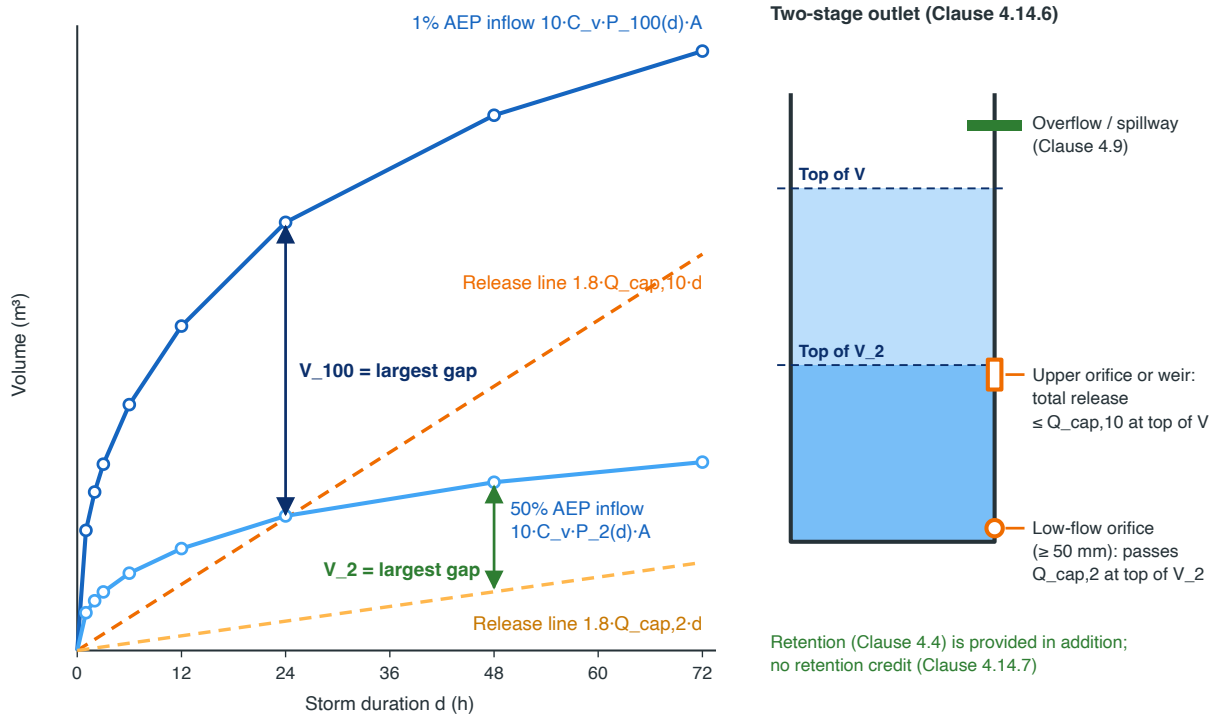
V_2 = max over d of [10 × C_v × P_2(d) × A − 1.8 × Q_cap,2 × d]

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 Imphal valley floor, 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 Manipuri 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 Manipur the closed outfall is not the exception but the normal monsoon case on the valley floor. "The town is below the high flood level of Imphal river and hence there are embankment roads on both sides of the river to protect the settlement from seasonal floods" (Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)); the Imphal at Minuthong has a highest flood level of 788.400 m, within a metre or two of the city's ground (AIIB; NEER's reading), and it overflowed above that level on 29 May 2024 (as reported). When the rivers are high their gated and flap-gated outfalls shut, and "During the rainy season, the rapid flows of water directed to the main urban river Nambul from its tributaries cannot be contained. As a result, the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, *Approval Project Document*, 2024). The valley as a whole has one outlet, the Manipur river past the Ithai barrage and the Sugnu hump, which carries "of the order of 400 cumecs" while "river down below the barrage does not have the capacity to cope up with such flow, as a result, water is piled up upstream" (MASTEC), so Loktak and the pats rise for weeks and the outfalls on the Loktak margin discharge to a lake that stands above them. Lamphelpat, in the city, drains only by pumping in high flood, through the Shamushang nallah to the Nambul (WRD site report in HC PIL No. 8 of 2025), and "Coping measures undertaken in the form of pumping … are not adequate and the area remains waterlogged for many days every year" (NDB, project summary). In the hills the outfall can be closed by debris and garbage, and in the reservoirs' release reaches by the release itself. What fills behind the closed gate is storm water mixed with sewage, because the drains carry it (Commentary to Clause 4.1). No inventory of the gates, flap gates and pumping stations through the bunds, no record of how long any of them stays shut and no operating rule were found [TBC]; Chapter 5 sets the river and lake levels and the closure to be assumed (Clause 5.8.5(a) to (c)). 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 pukhri 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 Manipur.** Manipur is landlocked: it has no coast, no tide and no Coastal Regulation Zone, and the monsoon reaches it as rainfall and as the floods of its valley rivers, of Loktak and of the Barak, which are dealt with in Chapter 2 and in Clause 5.8, 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 Manipur: 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 silt and attack by water that carries sewage), and Clause 5.13. They are kept so that the clause numbers of this Manual match its other State editions. In Manipur the receiving water is one of seven kinds: a valley river reached through a gate or flap gate (ithong, Manipuri: a sluice gate or floodgate) in a river bund (pan, Manipuri: a bund or embankment), or through a pumping station, which is normally closed in the monsoon because the river stands higher than the town behind it; the city rivers and channels of Imphal, among them the Nambul, the Naga Nullah and the Waisel Maril, and Lamphelpat with its pumped outlet through the Shamushang nallah; Loktak, held up by the Ithai barrage and by a rock sill below it, whose level is the tailwater for the south of the valley; a river below a dam, such as the Thoubal below the Mapithel dam; a pat (Manipuri: a lake or wetland, as in Lamphelpat) or a pukhri (Manipuri: a pond; plural pukhris) that stores the town's water while its outlet is closed; a khong (Manipuri: a stream) or other hill stream coming down from the hills, laden with silt and debris; or the Barak and the Jiri on the Jiribam plain; 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 behind a bund gate, a pumped outfall, Loktak, a release reach, a full pat or pukhri, a hill stream 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. Imphal drains into rivers and a lake that stand higher than its drains. "The town is below the high flood level of Imphal river and hence there are embankment roads on both sides of the river to protect the settlement from seasonal floods" (master plan); "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, 2024); and the valley has one outlet. Its rivers bring a few hundred cubic metres a second each in a flood (the largest discharges gauged in 1999–2001 were the Iril's 532.488 m³/s and the Thoubal's 391.636 m³/s), while at Ithai the Manipur river carries "of the order of 400 cumecs" and "river down below the barrage does not have the capacity to cope up with such flow, as a result, water is piled up upstream" (MASTEC). So the closed outfall is the design case, not the exception. The Imphal river at Minuthong has a highest flood level of 788.400 m (WRD, as reported) against city ground of about 790 m (AIIB, 2024), and in September 2025 the river at Lilong and the Manipur river at Ithai stood above their printed highest flood levels (as reported). The outfalls also belong to one body while the drains above them belong to others: the bunds and the pumping from Lamphelpat are WRD's, the municipal drains IMC's or another local body's, the road drains PWD's, the interception works on the Nambul DoECC's, the sewers PHED's, and Loktak is LDA's; no notification assigns the Naga Nullah, the Waisel Maril or the Shamushang nallah to one owner (Chapter 6, Clause 6.9). No document found during research sets a design level or a closure duration for any outfall in the State, and WRD's gate operating rules were not found [TBC]. A detention basin that meets every release rate in Chapter 4 still fails if the gate it drains to is shut for a week, if the pat below it is already full, if Loktak stands above its outlet all season, or if the hill stream it drains to has buried its outlet in silt. This chapter makes these failure modes part of the design. Manipur 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 Naga Nullah, the Waisel Maril and the Shamushang nallah in Imphal, every city channel and flood channel of WRD and every drain that discharges through a gate or flap gate in a river bund, any drain built or held by IMC, a Municipal Council, a Nagar Panchayat, PDA Manipur, PWD or a national-highway agency with an internal width of 1.0 m or more, and every khong or other natural channel that drains 8 ha or more, 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).
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.

Term	Meaning in this Manual
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, pukhri** 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 pukhri 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, MSDMA 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.

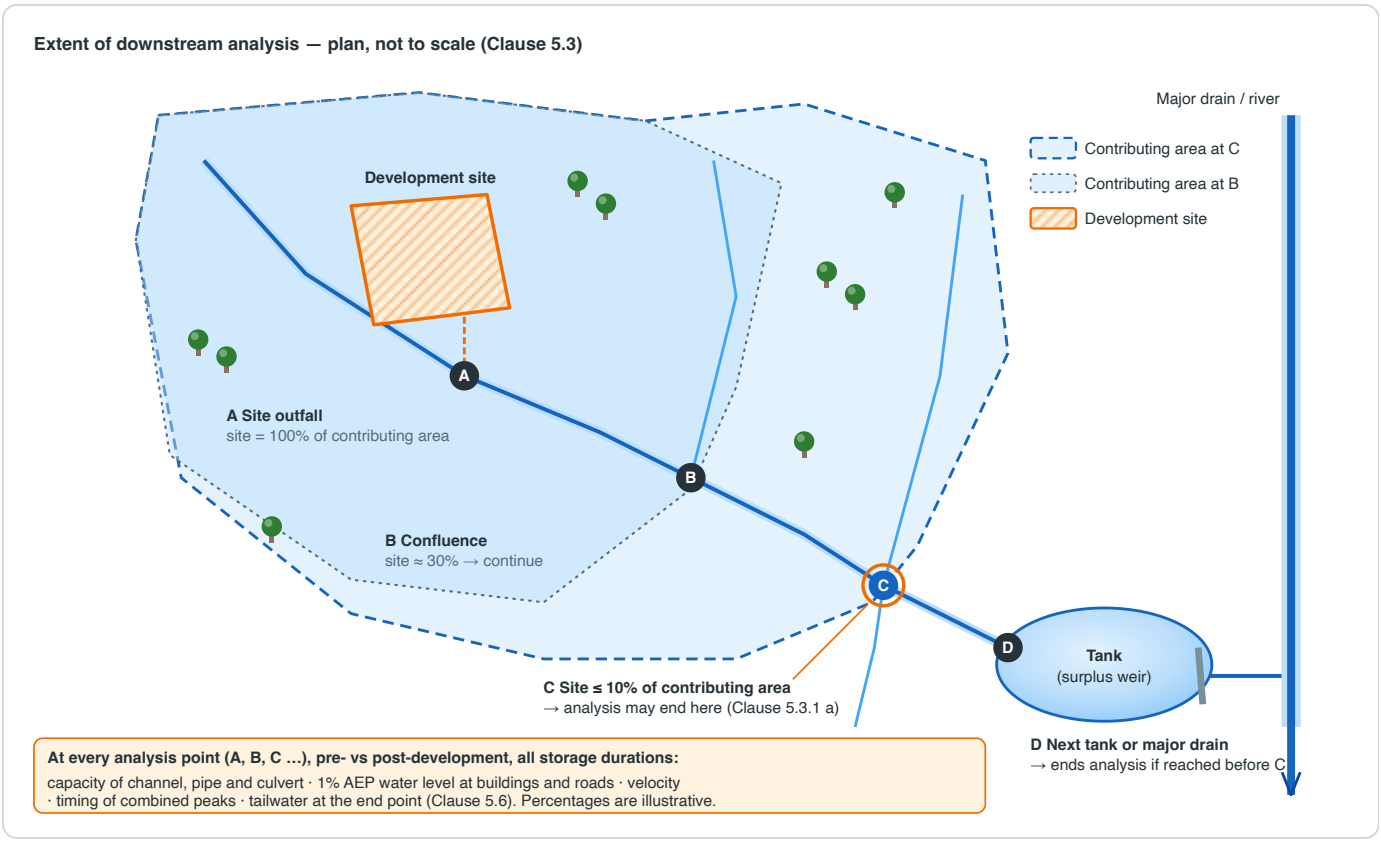

Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next pukhri or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia 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 Manipur. In the Imphal valley, where the drains of Greater Imphal run to the Nambul, the Imphal river, the Kongba and the Iril, and every valley river runs on across the valley floor and its pats to Loktak and to the valley's one outlet past the Ithai barrage, in a basin that the master plan gives as 6,332 km² (as printed), 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 Imphal valley, whose capital "is below the high flood level of Imphal river" and lives behind embankment roads on both banks (master plan), where "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, 2024), where Lamphelpat "remains waterlogged for many days every year" although it is pumped (NDB), and where the rivers bring a few hundred cubic metres a second each in a flood while the only outlet at Ithai carries "of the order of 400 cumecs", so that "water is piled up upstream" (MASTEC). 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 Manipur, 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, PDA Manipur 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.

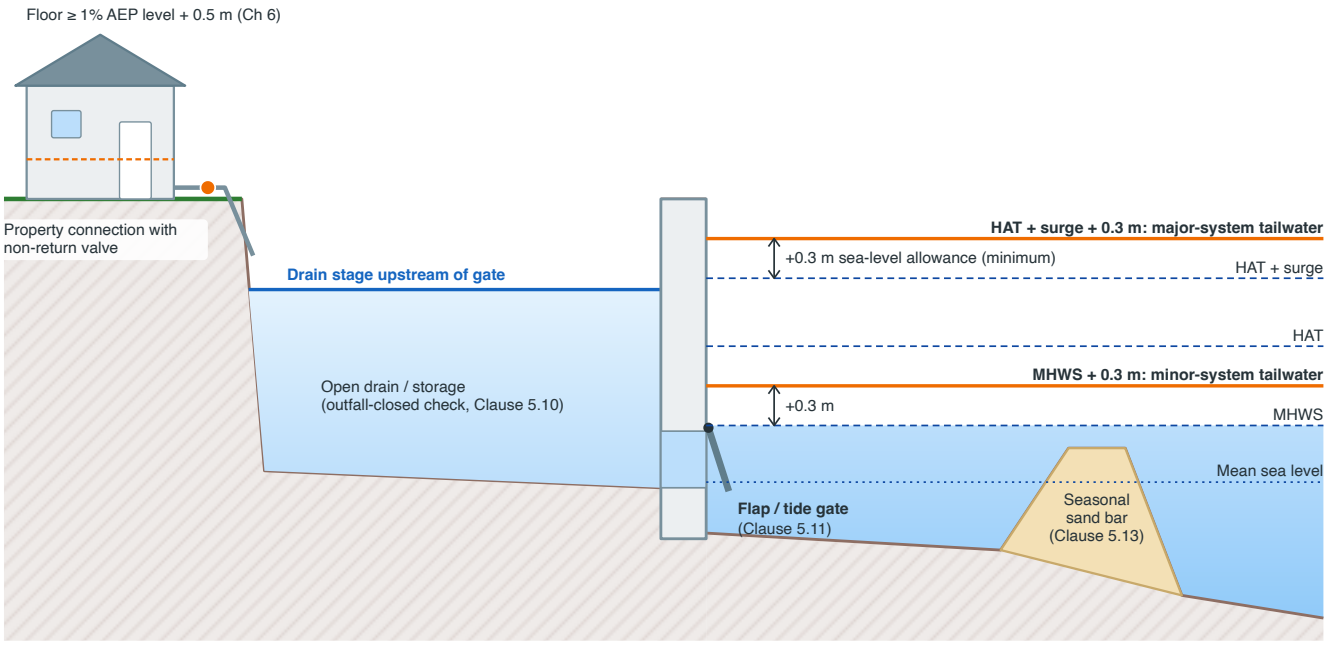

Figure 5.2 — Tidal outfall: flap gate, property non-return valve, and the design tailwater levels (MHWS + 0.3 m for the minor system; HAT + surge + 0.3 m for the major system), with a seasonal sand bar at the mouth. Schematic, not to scale. Original drawing for this Manual, adapted from the tidal tailwater 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; Manipur has no coast, and the surge term does not arise in the State, whose rivers are held high by their own floods behind the river bunds and by Loktak behind the Ithai barrage, not by the sea (Clause 5.8.5).

> 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 Manipur, 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 bunded rivers of the Imphal valley floor, the **Imphal river** (at Minuthong and Lilong), the **Nambul** (at Thong Nambonbi, Hump Bridge), the **Iril** (at Irilbung), the **Kongba**, the **Thoubal**, the **Sekmai**, the **Wangjing**, the **Nambol** (at Nambol Thongkhong), the **Khuga**, the **Merakhong** and the **Arong**, through the gates, flap gates and pumping stations in WRD's river bunds (Clause 5.8.5(a));
- in **Imphal**, the Imphal river through the city, the Nambul with the **Naga Nullah** and the **Waisel Maril**, **Lamphelpat** with its pumped outlet through the **Shamushang nallah** to the Nambul, and the Kongba and the Iril in Imphal East (Clause 5.8.5(b));
- **Loktak** and the pats that fringe it, the **Manipur river** from the **Ithai** barrage past the Sugnu hump to Sugnu, and the **Chakpi** at its confluence, for Moirang, Ningthoukhong, Thanga, Ithai, Sugnu and Wangoo (Clause 5.8.5(c));
- the release reaches of the **Thoubal** below the Mapithel dam, the **Khuga** below its dam and the **Nambul** below the Singda dam (Clauses 5.8.3 and 5.8.5(d));
- every pat, pukhri and detention pond that receives a town's drains, among them Lamphelpat, the pats of the State Wetlands Authority's priority list and the public pukhris of the towns (Clause 5.8.5(e));
- the khongs and hill streams of the hill towns and of the valley rim, where they come down to the valley floor and to Loktak, and the **Barak**, **Makru**, **Irang**, **Leimatak** and **Tuivai** catchments of the western hills (Clause 5.8.5(f));
- the **Barak** at **Chotebekra** and the **Jiri** on the Jiribam plain (Clause 5.8.5(g));
- any drain or channel of IMC, a Municipal Council, a Nagar Panchayat, PDA Manipur, PWD, a national-highway agency or DoECC, and any city channel or flood channel of WRD, 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 the Mapithel dam of the Thoubal Multipurpose Project on the Thoubal, the Khuga dam on the Khuga, the Singda dam on the Nambul, and the Ithai barrage of NHPC, which holds up Loktak), 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 **Bund-locked valley outfalls, Imphal, the Loktak margin and its outlet, dam-release reaches, pats and pukhris, hill streams, Jiribam and the Barak, and consents and lines.**

- (a) **Bund-locked valley outfalls.** For an outfall on the Imphal valley floor (sub-areas MN-A and MN-A1 of Annex 2A) to a river directly, through a gate, flap gate or culvert (ithong) in a river bund (pan), through a drainage pumping station, or into a drain, khong, pat or pukhri that itself discharges in one of those ways, the designer shall identify the body that operates each gate, flap gate and pumping station, and obtain from its written records the sill of each gate, the crest of the bund, the installed permanent capacity of each pumping station and its duty point, its sump levels, and the river level at which each gate is closed. Every level shall state its datum and its connection to a Survey of India benchmark, and shall name the WRD gauge with which it is compared. The river bunds, the flood channels and the pumping from Lamphelpat are WRD's. No Manipur statute on embankments was found during research (NEER reading), so WRD's consent is that of the owner of the bunds (item (h)); no list of the valley's gates, flap gates and pumping stations with these values, and no WRD rule for operating them, was found [TBC]. The bunds are long and weak in places: MASTEC counted 11 vulnerable points on the bunds of the Imphal river, 14 on the Thoubal and 5 on the Iril, and recorded breaches at 60 places in 1966, 40 in 1989 and 59 in 2002 (MASTEC).
    - **WRD levels.** The river levels of Clause 5.8.2(a) in the valley are the warning (WL), flood (FL) and highest flood levels (HFL) that WRD publishes through the press for its gauges. All are as reported, and none states its datum; they are taken as metres above mean sea level, to be confirmed for each gauge [TBC] (Table 5B.1): the Imphal river at **Minuthong** (Imphal city) WL 785.900 m, FL **786.900 m** and HFL **788.400 m**; the Imphal river at **Lilong** WL 780.350 m, FL **781.350 m** (2025 reports) or **781.250 m** (2024 reports) and HFL **782.850 m** (2024 report); the Iril at **Irilbung** WL 786.700 m and FL **787.700 m**, with an HFL printed as 782.200 m, below its own flood level, which is an error in the report or its source [U]; the Thoubal (gauge not named) WL 778.915 m and FL **779.915 m**; the Nambul at **Thong Nambonbi (Hump Bridge)** HFL **783.695 m**, with no flood level printed; the Nambol at **Nambol Thongkhong** HFL **774.700 m** (2024) or **774.400 m** (2025) [U]; and the Manipur river at the **Ithai barrage** HFL **769.320 m**. These levels have been passed. On 29 May 2024 the Imphal river at Minuthong ran above its HFL, and the Nambul and the Nambol above theirs; on 15 September 2025 the Imphal river stood at **783.250 m** at Lilong, above the printed HFL, the Iril at 788.850 m at Irilbung, "above FL, below HFL", and the Manipur river at **770.05 m** at Ithai, above its HFL (all as reported). WRD may have revised its HFLs since (NEER reading). The WRD gauge register, with the gauge zero, datum and levels of each gauge and every revision, is the first data request for every valley outfall [TBC].
    - **Design and check levels.** For an outfall to a gauged valley river, the **design case** for the major system and for storage (Clause 5.8.4(b) and Clause 5.10) is the river at its WRD **flood level** at the governing gauge, transferred to the outfall, with the gate closed. Where two flood levels are printed for one gauge, the higher applies (at Lilong, **781.350 m**); this Manual does not decide which of them is right. The **check case** is the river at the higher of its **HFL** and **the highest reading reported above it** (Minuthong 788.400 m; Lilong **783.250 m**; Ithai **770.05 m**), with the gate closed and the volume stored in the storm held behind it: in the check case no building floor or opening shall flood (Clause 6.11), and the pumps shall deliver against that level. Where only an HFL is printed, that HFL is the design level and the highest reading reported above it, or surveyed from flood marks at the gauge, is the check level: the Nambul at Hump Bridge, 783.695 m; the Nambol at Nambol Thongkhong, the higher printed value, 774.700 m; and the Manipur river at Ithai, 769.320 m and 770.05 m. At Irilbung the flood level of 787.700 m is the design level, and the highest reading reported, 788.850 m (15 September 2025), is the check level until WRD corrects the printed HFL [TBC]. For the cases with the river at its 10% AEP level (Clause 5.8.4(a)) and for the minor-system tailwater of Clause 5.1.4(b), the river stands at its WRD **warning level**, transferred (Minuthong 785.900 m; Lilong 780.350 m; Irilbung 786.700 m; the Thoubal 778.915 m), or, at a gauge with no warning level printed, at the design level of this item. All of these are set by this Manual. The recorded level of the nearest gauge upstream applies unchanged at the outfall, except that between two gauges on the same river with no tributary joining between them it may be interpolated linearly by river distance (set by this Manual). On an

ungauged river or stream, the level is the highest of the highest recorded level at the nearest WRD gauge on the same river, transferred; the flood marks of May 2024, May–June 2025 and September 2025, surveyed at the outfall with their source stated; and a hydraulic model under Clause 5.8.2(b); and no outfall shall be designed without the flood marks or the model (set by this Manual). The city's ground stands at about 790 m (AIIB, 2024), so on this Manual's reading drains near the Imphal river discharge within a metre or two of its highest flood level.

- **Gravity outfalls closed.** Every gravity outfall through a river bund, and every outfall to a drain, khong or pat that the river backs up, shall be taken as **closed from the time the river reaches the outfall invert or the level at which its gate is shut, and in no case later than the time the river reaches its WRD flood level** at the governing gauge, and shall stay closed for the whole of the river lock of this item. While the gates are shut, the area behind the bund drains only by storage and pumping (set by this Manual).
- **Tailwater.** The tailwater at the outfall shall be the higher of the river level beyond the gate or bund and the maximum level in the drain behind it, computed by routing the drain, with every pat, pukhri and low paddy field that it fills, as a closed storage for as long as the gates are shut, with the inflow of the whole catchment that drains to it, its storage as surveyed in its present condition, net of silt, solid waste, weed, phumdi and encroachment, 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 (set by this Manual). A pat or pukhri behind the gate starts the storm **full to its outlet level** (item (e)). Every pump, panel, generator and control shall remain operable with the river at the check level of this item and with the land behind the bund ponded (Clause 5.12.5).
- **River lock.** Portable dewatering pumps brought in for an event, and capacity that has been sanctioned or proposed but not commissioned, shall not be counted; they are a reserve for the failure of a station and for a breach. The outfall-closed check of Clause 5.10 applies with a single lock: the gate is closed for the **whole of the 72-hour storm** of Clause 5.10.2 and for as long after it as the river stays above the gate sill, or above the level at which the gate is shut if that is lower, taken from a river model or from WRD's stage record of the governing gauge in the floods of May 2024, May–June 2025 or September 2025 or in a comparable flood. Where no stage record has been analysed, the lock is **not less than 7 days (168 hours)** on the Imphal, Nambul, Iril, Kongba, Thoubal, Sekmai, Wangjing, Nambol, Khuga and Manipur rivers, and **not less than 72 hours** on a smaller stream (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 check level of this item, or where an analysis of a WRD stage record under Clause 5.10.6 shows it and the Authority approves it. Catchments behind a bund take the AMC that Chapter 3 sets for them.
- **Joint drain–pump–river analysis.** Every DPR for the drainage of a town on the valley floor, and every development whose outfall drains to a pumping station, shall route the drains, the storage behind the bund, the pumps and the river together, with the river hydrograph at the governing gauge as the downstream boundary, for two cases: a short storm on the town with the river at its warning level, and the 72-hour storm with the river at its flood level and the gates closed for the lock of this item, and shall report the check case. The installed and confirmed capacity of each pumping station, its sump levels and the level at which its gate is shut shall be entered on the drain register (Clause 6.9) [TBC: no station list was found].
- **Gate failure and breach.** A breach of a river bund is a residual risk, not a design case: no drain, pump or storage is sized for it. Floor levels behind a bund, the pumping stations and the emergency routes shall be checked, and the result reported on Form 5-1, for a gate that fails open and for a breach, with the land behind the bund filled to the river level beyond it. The valley's recent floods were breach floods: 18 embankment breaches in May 2024, 17 of them later sealed; breaches of the Imphal river at Singjamei, Heingang, Bashikhong and New Checkon and at Keirang, Khabam and Lairikyengbam Leikai, and of the Nambul at four places, in 2024 and 2025; and a breach of the Iril at Kshetri Awang Leikai in September 2025 (all as reported). Land on a breach path is a hazard-first site (Clause 2.3.6(i)).

- (b) **Imphal.** For an outfall in Greater Imphal (the 151.38 km² of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification), which is wider than IMC's area), where "the town is below the high flood level of Imphal river and hence there are embankment roads on both sides of the river to protect the settlement from seasonal floods" and where "Imphal river, Nambul river and Kongba river running in north-south direction have numerous tributaries through the town" (master plan):
    - **The Imphal river at Minuthong.** Every outfall to the Imphal river in the city is bund-locked under item (a), with Minuthong as the governing gauge (design 786.900 m; check 788.400 m, or a higher level surveyed from the flood marks of 29 May 2024, when the river ran above it), and downstream of the city with Lilong (design 781.350 m; check 783.250 m). Every outfall in the city whose invert is below 788.400 m is a bund-locked outfall.
    - **The Nambul at Hump Bridge.** The Nambul is "the main urban river", and "the rapid flows of water directed to the main urban river Nambul from its tributaries cannot be contained. As a result, the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, 2024). An outfall to the Nambul is bund-locked under item (a) at Thong Nambonbi (Hump Bridge): design 783.695 m, and check at the level surveyed from the flood marks of 29 May 2024, when the river ran above that HFL (as reported; the reading was not printed) [TBC]. The Nambul receives 72 drains that carry sewage, whose interception and diversion the State reports as completed (State report to the NGT in O.A. 606/2018, December 2025) (Clause 6.3.6(e); Clause 8.9).
    - **The Naga Nullah and the Waisel Maril.** These city channels drain to the Nambul and are owned by no single body (Chapter 6, Clause 6.9). Market waste is dumped in the Naga Nullah, "which creates a stagnant pool all along the year" (master plan); its clogging flooded Nagaram, Laipham Khunou and Lairikyengbam Leikai in July 2024; and in April 2025 encroachments along the Waisel Maril, the Naga Nullah and the eastern bank of the Nambul from Keishampat to Keishamthong and Elangbam Leikai were ordered removed, with WRD to provide machinery, while the cleaning of the Waisel Maril was led by LDA (all as reported). An outfall to either channel shall take as tailwater the higher of the channel's level, routed with its whole catchment and its section as surveyed, net of silt and waste, and the Nambul level of this item at the channel's outfall; a desilting or widening that has been proposed but not completed shall not be counted.
    - **Lamphelpat, the Shamushang nallah and the Nambul.** Lamphelpat is a pat being developed as regional flood storage with a pumped outlet. About 300 acres are being dredged under a work order of 9 November 2023 for two years, by a cutter-suction dredger, with WAPCOS as monitoring consultant, and with "provision for pumping of flood water from the Lamphel pat water body to the Nambul River through Shamushang Nalla during high flood season" (WRD site report, High Court PIL No. 8 of 2025). The NDB project is to "increase its water detention capacity, restore stormwater drainage system" and set up a "real time flood management system with a command center", at a cost of USD 87.84 million with a loan of USD 70.27 million (concept approval 17 November 2021); its summary records that "Coping measures undertaken in the form of pumping … are not adequate and the area remains waterlogged for many days every year" (NDB). A cost of about ₹650 crore and an area of 443 acres are also reported, and the funders are named differently in different reports (as reported). An outfall to Lamphelpat, or to a drain that ends in it, shall take as tailwater the pat's level under item (e), starting full to its outlet, with an outflow of no more than the Shamushang pumps that WRD confirms in writing are permanent and working, less the largest pump, and with gravity flow to the Nambul only while the Nambul at the Shamushang outfall stands below the pat. The storage made by the dredging, and the pumps and command centre of the project, are counted only once they are complete and WRD confirms the pat's stage–storage relation and the pumping capacity in writing; that storage belongs to the drainage system and is not credited to any one project. Lamphelpat is also a proposed source of drinking water, so no drain that carries sewage shall reach it without the interception of Clause 6.3.6(e).
    - **The Kongba and the Iril.** Outfalls in Imphal East to the Iril are bund-locked under item (a) at Irilbung (design 787.700 m; check 788.850 m). No WRD level was found for the Kongba [TBC], so its outfalls take the ungauged rule of item (a). The largest discharge that MASTEC records in the valley is the Iril's, 532.488 m³/s at Moirang Kampu on 2 September 2000 (MASTEC).

    - **Projects counted when built.** The AIIB project is to provide "547 km of both side stormwater covered drains" along the roads of Greater Imphal that "channelize the storm water … to the out fall (river)" (AIIB, 2024), and states no return period, intensity or outfall level. Each of its outfalls is a bund-locked outfall under item (a). No drainage master plan with a design level was found for Greater Imphal: the master plan has no storm-water drainage section.
- (c) **The Loktak margin and its outlet.** For an outfall in sub-area MN-A1 (Moirang, Ningthoukhong, Thanga, Ithai, Sugnu and Wangoo, and the land within the 236.21 km² of the Loktak Lake (Protection) Act, 2006) to Loktak, to a pat that fringes it, or to the Manipur river between Ithai and Sugnu, or to a drain that ends in one:
    - **The lake and its levels.** Loktak is held up by the Ithai barrage of NHPC's Loktak project (105 MW; commissioned in 1983 according to most sources, with 1979 and 1986 also printed), which "permanently raised the average water level of Loktak Lake by about a metre" (as reported). Its levels conflict, and this Manual states the conflict without resolving it: a full reservoir level (FRL) of **768.5 m** and a minimum drawdown level of **766.2 m** (NHPC, as quoted); a minimum drawdown level of **766.01 m** (CEA, as quoted); and an FRL of **769.63 m**, with 768.50 m called the "flood level" (ORF, as reported) [U]. CEA's daily reports of August 2026 show the lake at about 767.46–767.73 m (as quoted), its ordinary monsoon level; it reached 768.5 m in August 2002 (as reported). NHPC's and LDA's stage records and the barrage's operating rule were not obtained [TBC].
    - **Design lake level.** The tailwater is the lake level, static for the whole event: the **Ithai HFL of 769.320 m** (WRD, as reported) for design, **checked at 770.05 m**, the reading of 15 September 2025 (as reported), and in June to September never below the FRL (768.5 m, or a higher FRL that the operator confirms in writing) (set by this Manual). No fall of the lake during the storm shall be credited.
    - **Outfalls closed June to September.** An outfall whose invert lies below the design lake level is **closed from 1 June to 30 September**: the storm is stored and pumped, and no gravity discharge is credited. Outside that period the lock of item (a) applies, with the lake level of this item in place of the river level. The pump-down of item (a) applies (set by this Manual).
    - **The Sugnu hump.** The Manipur river's bed is 762.2 m at Ithai and falls below the barrage to a "deepest bed level of 756.7 m"; then "in a short stretch of about 800 metres, the bed level rises steeply upto 763.7 m and remains at the general elevation of 762.5 m … the outflow of the sediment is restricted" (MASTEC). At Ithai, "flow of the Manipur river during monsoon is of the order of 400 cumecs and river down below the barrage does not have the capacity to cope up with such flow, as a result, water is piled up upstream" (MASTEC). On this Manual's reading the rock sill controls the valley's only outlet whatever the barrage gates do, so no design shall assume that opening the barrage lowers Loktak or the river at an outfall during a storm unless NHPC's written records show it.
    - **The Chakpi backwater.** The Chakpi "meets the Manipur River at a reverse direction, thereby checking the current … making inundation of the surrounding area of Sugnu extending upto Wangoo" (MASTEC). An outfall at Sugnu or Wangoo, or to the Chakpi near its confluence, takes as tailwater the higher of the Manipur river level at Ithai of this item and the Chakpi level from a model or from surveyed flood marks; no Chakpi gauge was found [TBC].
    - **Phumdi at outlets.** Phumdi, which the Loktak Act defines as a "heterogeneous mixture of vegetation, organic debris and soil in floating condition" (s.2), drift and block outlets, gates and screens. Every outfall to Loktak or to a pat that carries phumdi shall have a screen or boom, designed under Chapter 9 (Clause 9.8), that keeps phumdi out of the gate, with machine access and a place to stack what it catches outside the lake; the flap gate shall be checked as held open by phumdi under item (a) (set by this Manual).
    - **The lake's law.** Within the lake's extent the consents of item (h) apply: no discharge into the Core Zone without LDA's prior permission (s.20), and none of the activities that s.19 bars in the Buffer Zone.
- (d) **Dam-release reaches.** For an outfall to the Thoubal below the Mapithel dam (the dam of the Thoubal Multipurpose Project), to the Khuga below its dam, or to the Nambul below the Singda dam, or to a drain that ends in one:
    - **Consent and levels of the operator.** Storm water shall not be discharged to a reservoir or its release reach without the written consent of its operator. The operator's levels shall be used as it gives them in writing; a level given in feet shall be converted at **1 ft = 0.3048 m** exactly, with the conversion and the datum stated on Form 5-1.

    - **The Mapithel dam.** WRD gave the dam's FRL as **880.7 m** in September 2025, when the reservoir stood at 878.10 m; on 1 August 2015 it was reported at 876 m, "nearly 2 m above the spillways"; its spillway design discharge is reported as **2,240 m³/s**, and the earth dam as 66 m high and 1,074 m long (all as reported). The 2015 report puts the spillway crest near 874 m, about 6.7 m below the FRL given in 2025 (NEER arithmetic), and the two reports do not reconcile [U]; the operator's levels in writing govern [TBC]. The Thoubal below the dam is also a bund-locked river under item (a) (design 779.915 m at the Thoubal gauge), and the higher tailwater of the two items governs.
    - **The Khuga and Singda dams.** No level, spillway capacity or release record was found for the Khuga dam or for the Singda dam, which the CPCB names as the head of the polluted stretch of the Nambul (CPCB, 2025) [TBC].
    - **Release reaches.** 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 dam, routed to the outfall, with the flow of the catchment below the dam as it occurred, and with the release placed before, during and after the site storm; until the operator states a larger recorded release and its duration, the release is the spillway design capacity (Mapithel, 2,240 m³/s, as reported; the Khuga and Singda dams, the operator's spillway capacity in writing [TBC]). The lock of item (a) applies for **not less than 72 hours** (set by this Manual). No attenuation by the storage of a reservoir shall be credited to the river below, and no dam gate shall be assumed to open earlier or wider than the operator's records show. Catchments that drain to a reservoir, its backwater or a release reach take the AMC that Chapter 3 sets for them.
    - **Warnings are not notices.** No design shall rely on a notice or a 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).
- (e) **Pats and pukhris as receiving storage.** For an outfall to a pat, a pukhri, a low paddy field that ponds or a detention pond, directly or through a drain that ends in it, among them Lamphelpat, Porompat, Takyelpat, Sangaipat, Kharungpat and Ikop pat, the pats of the State Wetlands Authority's priority list (Utra, Yaral, Waithou–Phumnom, Pumlen–Khoidum and Ikop–Kharung) and the public pukhris of the towns:
    - **Starting level.** The waterbody starts every design storm **full to its outlet level**: the crest of its outlet weir, the sill of its gate or the invert of the khong 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). This is the rule of the adjoining edition of this series for its floodplain lakes, which it took from a design that assumed the lake "is full and the drain is also flowing full" (as quoted there): a pat that has filled in the first storm of a spell is full for the next.
    - **Design level.** The tailwater for the major-system and storage cases is the level reached when the inflow of the waterbody's whole catchment is routed through its stage–storage relation from that starting level, with its outlet closed for as long as the river, lake or khong 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 Lamphelpat or any other pat or pukhri in the State, and the inventory of about 4,000 water bodies made after the NGT's order of 22 May 2020 records that "Ground truthing, engineering surveys, and quality monitoring … are pending" (DoECC, 2025-26) [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 waterbody itself drains through a bund-locked outlet or to Loktak, the lock of item (a) or the closure of item (c) applies to both.
    - **Storage is the system's.** The storage of a pat or pukhri is part of the drainage system: it shall not be credited to one project, and no project shall reduce it (Chapter 7). A pukhri with no outlet is a closed basin, and an outfall to it is closed for the whole storm. Low paddy land that ponds behind a gate is counted in the routing as it is when the design is made; storage lost when paddy land or wetland is filled is replaced under the compensatory storage rule of Chapter 7, not by an outfall. Engineered storage is a detention pond, never a pukhri or a pat; a pat developed as flood storage, such as Lamphelpat, remains a pat. No drain that carries sewage shall discharge to a pat or pukhri without the interception and screens of Clause 6.3.6(e) and Clause 8.9.

- (f) **Hill streams.** For an outfall to a khong or other hill stream in sub-areas MN-B and MN-C, in the hill parts of MN-C1 or on the hill fringes and hillocks of the valley, such as the streams of Tamenglong, Noney, Ukhrul, Senapati, Kangpokpi, Chandel and Churachandpur and the streams that come down to the valley floor and to Loktak, or to a drain that ends in one:
    - **Design level.** These streams have no gauge or published flood level [TBC]. 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 in Annex 2A, the bulking factor of Clause 6.3.6(g) on the peak flow and the crossings downstream blocked as Clause 6.3.6(h) requires, routed through a hydraulic model of the channel as surveyed, net of encroachment, silt, slide debris and solid waste; (ii) the level at the outfall of any flood study of the stream made by or for WRD, PWD or the local body [TBC]; and (iii) the highest flood level surveyed at the outfall from flood marks, such as those of the Khoupum valley flood of 15 July 2025 or of a later flood, and from the records of the local body, WRD or the Deputy Commissioner, with its source stated. No outfall to such a stream shall be designed without items (i) and (iii) (set by this Manual).
    - **Bed level and siting.** The designer shall survey the bed at the outfall and for at least 100 m upstream and downstream and state the range within which it has moved. 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 within 50 m downstream; the foundation shall be taken below the scour depth of Chapter 9 (Clause 9.6) for the 1% AEP flow with the bulking factor; and the outfall shall be built into the bank and not project into the active channel (set by this Manual). Where a hill stream drops its load on reaching the valley floor, the silt trap of Clause 6.3.6(m) shall be placed above the outfall: the hill streams "flow down with steep slope for a short distance before meeting the Loktak Lake … load carrying capacity is high which causes siltation of the lake" (MASTEC). A slide, a cut slope or fill on the Disang shale, and the path of a channel shift on a foothill fan, are hazard-first sites (Clause 2.3.6(i)), and no outfall structure shall be placed on them.
    - **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 no hydrograph of the stream has been computed, the lock lasts for the whole storm (set by this Manual). Where the hill stream itself ends at a bunded river on the valley floor, at Loktak or at the Barak, the lock of item (a), (c) or (g) governs. Where a stream leaves the State, for Nagaland, Mizoram or Myanmar, no lowering of its level downstream shall be assumed.
- (g) **Jiribam and the Barak.** For an outfall in sub-area MN-C1, the Jiribam plain, to the Barak or the Jiri, or to a drain or stream that ends in one:
    - **River levels.** CWC has one site in the State: the Barak at **Chotebekra**, printed under Imphal East and now in Jiribam district (NEER reading), a level-monitoring site with an HFL of **32.1 m** (31 July 1989) (SANDRP, 2018, as reported); a danger level of **26.2 m** is given only in the press (as reported). Neither states its datum [TBC]. The river level for the major-system and storage cases is the 1% AEP level at the outfall from a hydraulic model under Clause 5.8.2(b), and not less than 32.1 m, transferred; for the 10% AEP case it is not less than 26.2 m until CWC confirms the danger level [TBC] (set by this Manual). No gauge was found on the Jiri [TBC]: an outfall to it takes the ungauged rule of item (a), and near its confluence not less than the Barak level of this item.
    - **The Barak-valley lock.** The rule of the adjoining edition of this series for the Barak plain downstream applies in full: an outfall through a bund, gate or pumping station to the Barak, or to the Jiri where the Barak backs it up, is closed for the whole of the 72-hour storm and for as long after it as the river stays above the gate sill, **not less than 7 days (168 hours)** where no stage record has been analysed, and **not less than 72 hours** on a smaller stream that the Barak does not back up; receiving storage starts full to its outlet (item (e)); and the stored volume is pumped down within **48 hours** with the gate still closed (set by this Manual). The Barak at Chotebekra and at Lakhipur downstream set their highest levels on the same day, 31 July 1989 (as reported), so one flood reads alike on both sides of the border.
    - **Below Jiribam.** The Barak plain downstream, with its gauges at Lakhipur (HFL 26.96 m, 31 July 1989) and Fulertal (26.39 m, 21 July 2004) (as reported), is outside this Manual: the Assam edition governs those reaches.

- (h) **Consents and lines.**
  - **WRD and the bunds.** No outfall structure, gate, pumping station or drain shall cut, cross, alter or discharge through a river bund, a flood channel or a pumped outfall of WRD without WRD's written permission as the owner of the works; no Manipur statute on embankments, and no written procedure or form for this permission, was found during research [TBC]. Storm water shall not be discharged to a drain of another body without that body's written consent: a municipal drain of IMC or another urban local body, under its bye-laws on the Model and the Manipur Municipalities Act, 1994, whose drainage sections were not read [TBC]; a road drain or culvert of PWD or a national-highway agency; the interception works on the Nambul, of DoECC; and a city channel, flood channel or Lamphelpat, of WRD (Chapter 6, Clause 6.9) (set by this Manual). 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, encroachment, solid waste and weed, and a widening, resectioning 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.
  - **Loktak.** Within the 236.21 km² of the Loktak Lake (Protection) Act, 2006 (Keibul Lamjao National Park, 40 km², and the Takmu fishery farm, 5 km², are outside it), no one shall "discharge or emit any sewage or domestic waste into the lake" in the Core Zone of 70.30 km², a "No-Development Zone or Totally Protected Zone", "except with the prior permission of the authority" (ss.3 and 20); in the Buffer Zone the Act bars the "Discharge of untreated wastes and effluents from industries, cities or towns and other human settlements" and "Land reclamation, bunding or disturbing the natural course of drainages" (s.19(iv) and (vi)). An outfall, drain or bund within the lake's extent therefore needs LDA's prior permission, and the High Court's special bench orders of 17 July 2019 and 25 February 2022 against development in or around Loktak "without the Court's leave" (as reported; the case number was not found [TBC]) are to be checked for the site. The Act does not reach upstream of its 236.21 km².
  - **Flood zones.** Bye-law 93 of the Model [TBC: confirm the number and text in the bye-laws the local body has notified] requires "the previous permission of the Flood Zoning Authority constituted under the Flood Plain Zoning Act, 1978" for any activity in a prohibited or restricted area. No Flood Zoning Authority, and no prohibited or restricted area, was found constituted or notified (NEER reading), and the demarcation of flood zones "is yet to be done" (as reported, June 2026), so that permission is needed only where a zone has been notified, and none has. The 1% AEP levels of this clause are offered as an input to any future zoning, not as a zone.
  - **The lines that bind.** The designer shall check every outfall against the lines that bind at the time of design (Chapter 7): the buffers of the river table of bye-law 93, measured from mid-stream "or 6 m from outer toe of bund, whichever is further from mid-stream" on the bunded rivers, and from mid-stream only on the Merakhong, the Kongba and the Nambol; the corridor of Clause 7.4; and the plinth of bye-law 94 [TBC: confirm the number and text in the bye-laws the local body has notified], "above 1m above the highest flood level of the surrounding areas" in the "high Flood Risk Areas identified in the Master Plan of the towns". The risk-informed master plans that would show those areas were not read [TBC] and no local authority's highest flood level was found for any town [TBC], while the September 2025 readings passed the printed HFLs at Lilong and Ithai (as reported), so the 1% AEP level of this clause, not below the check level of item (a), and the floor levels of Clause 6.11 govern where they are higher.
  - **Paddy land and wetlands.** An outfall, drain or storage built on paddy land or a wetland in the valley converts it, and the Manipur Conservation of Paddy Land and Wetland Act, 2014 counts "drainage channels, ponds, canals, bunds and ridges" as part of paddy land (s.2(c)): the conversion needs the approval of the Local, District and State Level Committees, and "no local authority shall grant any licence or permit … for carrying out any activity or construction in a paddy land, converted or reclaimed in contravention" of the Act (s.12). The (Third Amendment) Bill, 2026 is a Bill, not law, and is not applied by this clause. Of the pats, the Yaral, Utra and Waithou–Phumnom pats have draft notifications under the

Wetlands (Conservation and Management) Rules, 2017 (DoECC, 2025-26); until they are final, no prohibition of those Rules applies to them (NEER reading), and the designer shall check their status with the Manipur State Wetlands Authority.

No pump, gate, barrage or dam operation that helps drainage, such as pumping a drain, pat or pukhri down before a storm, closing a gate late, opening a gate while the river is higher than the land behind it, or opening the Ithai barrage or 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 pat or the river (Clause 5.12.3). Pumping shall not be used to move water into a pat, a pukhri or another catchment without the consent of its custodian.

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. Manipur's rivers and towns break that assumption, because the same rain spell fills the rivers, the pats and Loktak and falls on the towns behind the bunds. The valley's floods follow spells of five to twelve days of rain on the hills, which are 70% of the catchment that drains through the valley: 28 July to 1 August 1989, when Imphal recorded 158.6 mm on 30 July; 22 to 28 September 1997; 24 August to 3 September 1999; and 26 August to 6 September 2000 (MASTEC; IMD *Extremes*). WRD's rule of thumb is that 135 mm in three days at Kangpokpi floods the valley (as reported). In 2024 and 2025 the rivers stood above their flood levels for days: the Imphal river and the Nambul were above danger from 28 May 2024 and above their highest flood levels on 29 May (as reported); in May and June 2025 the Imphal river breached at four places and the Iril was above danger on 1 June (as reported); and on 15 September 2025 the Imphal river at Lilong and the Manipur river at Ithai stood above their printed highest flood levels (as reported). Loktak, held up by the Ithai barrage, stays high for the whole season. Two of these floods, on 28–31 May 2024 and 30 May–2 June 2025, came before the south-west monsoon's normal onset at Imphal (as reported), so the coincident case is not confined to June–September. 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 on the rivers that feed the valley. The **Mapithel dam** of the Thoubal Multipurpose Project, an earth dam reported as 66 m high and 1,074 m long with a spillway design discharge of 2,240 m³/s (as reported), stands above Thoubal town. In the flood of late July and August 2015 its reservoir was reported at 876 m on 1 August, "nearly 2 m above the spillways", after rain in Imphal West 46% above normal on 23 to 27 July (as reported); in September 2025 WRD gave its FRL as 880.7 m with the reservoir at 878.10 m (as reported). The two reports put the spillway and the FRL more than 6 m apart and do not reconcile (NEER arithmetic) [U], and no operating rule or release record of the dam was obtained [TBC]. No level, spillway capacity or release record was found for the **Khuga** dam on the Khuga, which joins the Manipur river at the south of the valley, or for the **Singda** dam on the Nambul, above Greater Imphal [TBC]; the CPCB names the Singda dam as the head of the Nambul's polluted stretch (CPCB, 2025), and the CAG audited the Singda and Khoupum dams and the Sekmai and Imphal barrages in its audits of 2002 and 2008 (as listed). The **Ithai barrage** of NHPC holds up Loktak and so sets the level of the whole south of the valley (Clause 5.8.5(c)); it is a barrage, not a storage dam, and its gates do not lower the lake below the control of the rock sill downstream (MASTEC; NEER reading). Until the operators give their levels and releases in writing, Clause 5.8.5(d) uses the largest recorded release or the spillway design capacity, with the flow of the catchment below the dam as it occurred in the same event. The river levels used in this Manual are WRD's as printed in the press, and CWC's single Manipur level as transcribed by SANDRP; their datums and gauge zeros are to be confirmed with WRD and CWC [TBC].

Clause 5.8.5 is set by this Manual. In Manipur the tailwater at a town outfall is set not by the tide but by a river held above the town behind its bunds, by a lake held up by a barrage and a rock sill, by a pat that is already full, by the release of a dam, or by a hill stream in spate, and no document found during research gives a design level or a closure duration for any of them. No design standard for any town drain in the State was found either: the master

plan for Greater Imphal has no storm-water drainage section, and the AIIB road and drainage project and the NDB Lamphelpat project state no design storm (AIIB, 2024; NDB). The Flood Plain Zoning Act, 1978 has produced no notified zone, and no 1% AEP level has been published for any reach of any river in the State (Chapter 7).

The first case is the bund-locked outfall. Item (a) joins two forms that the series already uses: the river-locked form of the plains editions, which asks for the operator, the sills, crests, pumps and closing levels and ties every level to a gauge, and the valley-floor form of the mountain editions, which treats the gravity outfalls as closed from a declared river stage and asks for one analysis of the drains, the pumps and the river together. The levels come from WRD's gauges as the press prints them, without a datum, so each is "as reported". The design and check levels follow from what the records show. On this Manual's reading WRD's flood level is the stage at which its river is in flood, and the bunded city discharges within a metre or two of it, so the design case closes the gates at that level; where two flood levels are printed for one gauge the higher governs, because a tailwater set too low floods the town, while one set too high only costs storage. The highest flood levels are the check case, not the design case, because they are not stable: in September 2025 the river passed the printed highest levels at Lilong and at Ithai, and the printed level at Irilbung is below its own flood level. The warning level carries the 10% AEP case because no frequency analysis of any WRD gauge was found; it is the lowest stage that WRD reports for a river in flood (NEER reading). The lock is the heart of the clause. Where no stage record has been analysed, the minimum on the valley's main rivers is 7 days, because the valley's floods follow rain spells of five to twelve days (MASTEC), "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, 2024), and the only outlet carries about 400 m³/s while the rivers above it bring more (MASTEC); 7 days is also the lock that the adjoining Barak-valley edition and the valley-floor editions of this series set for their main rivers. On a smaller stream, which rises and falls faster, the minimum is 72 hours, the length of the longest design storm. The pump-down of 48 hours with the gate still shut is the drawdown time of Clause 4.7: storage that is still full when the next storm of the same high stage arrives fails in the event that matters more. Pumps are credited only as permanent, working and confirmed, less the largest unit, because the one pumped outfall described in the sources, at Lamphelpat, is recorded as "not adequate" (NDB). A breach is not a design case: no drain can be sized for a river entering the town, so item (a) asks for the check and the report, and leaves the defence to WRD's bunds and to the floor levels of Clause 6.11. A designer with an analysed WRD stage record can justify a different lock under Clause 5.10.6.

The second case is Imphal. Item (b) names the city's rivers and channels because the capital drains through them, because their bunds and pumps belong to WRD while the channels above them belong to no single body, and because the works that will change them, the AIIB drains and the NDB Lamphelpat project, were not complete when research was done; the clause counts them only once they are. Lamphelpat is the worked example of a pat used as flood storage with a pumped outlet, not a detention pond: it is a natural lake being dredged and pumped, its storage is the system's, and it is also to be a source of drinking water, so sewage is intercepted before it.

The third case is the Loktak margin. Item (c) takes the lake as a static tailwater for the event, because the lake changes over weeks and the storm over hours. The lake's levels conflict, and the Manual does not choose between NHPC's FRL of 768.5 m and the 769.63 m reported by ORF. It takes WRD's highest flood level at Ithai, 769.320 m, which lies between them, for design, and the September 2025 reading of 770.05 m for the check, so that the rule does not depend on which FRL is right. An outfall below that level is closed from June to September because Loktak stands high for the whole of the south-west monsoon, from its onset at Imphal on 5 June to the end of September, and because the outlet is held by the Sugnu hump: whatever the barrage gates do, the rock sill limits how fast the lake can fall, and the Chakpi, entering against the current, backs the water up to Sugnu and Wangoo (MASTEC). Phumdi are part of the lake and block its outlets, so the clause asks for screens.

The fourth case is the release reach. Item (d) applies the reservoir and release-reach rule of the hill editions of this series to the Mapithel dam on the Thoubal and to the Khuga and Singda dams: the largest recorded release, or the spillway capacity until the operator gives one, placed before, during and after the site storm, with no credit for warnings, drawdown or attenuation. The only levels found for the Mapithel dam are two press reports that do not reconcile, and none was found for the other two dams.

The fifth case is the pat and the pukhri. Item (e) treats them as storage that belongs to the drainage system and starts every storm full to its outlet, as the adjoining edition does for its floodplain lakes. The valley was once a field of pats: "there were nearly 500 lakes in Manipur Valley", and Lamphelpat, Porompat, Takyelpat, Sangaipat, Kharungpat and Ikop pat are among those degraded or disappearing (MASTEC). The master plan for Greater Imphal shrinks its wetlands from 374.48 ha to 232.21 ha and its agricultural land from 5,616.53 ha to 2,604.70 ha by 2043, while its water bodies grow from 563.54 ha to 643.42 ha (master plan). The storage lost with the paddy land is replaced under the compensatory storage rule of Chapter 7, not by the outfall. No stage–storage relation was found for any pat, so the clause asks for a survey rather than a figure.

The sixth, seventh and eighth cases are the hill streams, Jiribam and the consents. Item (f) follows the hill-stream rule of the hill and mountain editions of this series: a study with the bulking factor, surveyed flood marks, an invert at least 0.5 m above the highest bed level and a lock of at least 24 hours, because these streams fall within hours of the rain stopping, but carry the silt that fills Loktak (MASTEC). Item (g) carries the Barak-valley rule of the adjoining edition onto the Jiribam plain, because it is the same plain and the same river, and its single CWC gauge set its highest level in the same flood of July 1989 as the gauge downstream. Item (h) asks for WRD's permission and the owner's consent because a design that discharges through a bund or into another body's drain cannot be checked without them, and because no rule divides the drains of the State's towns (Chapter 6). The lines of item (h) decide where an outfall can be built, not its level: the bye-law 93 buffers, the Loktak Act's zones and the paddy-land Act bind where they apply, and the floor levels follow Clause 6.11 because no "highest flood level" of the kind that bye-law 94 refers to has been fixed for any town.

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 ≤ 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.

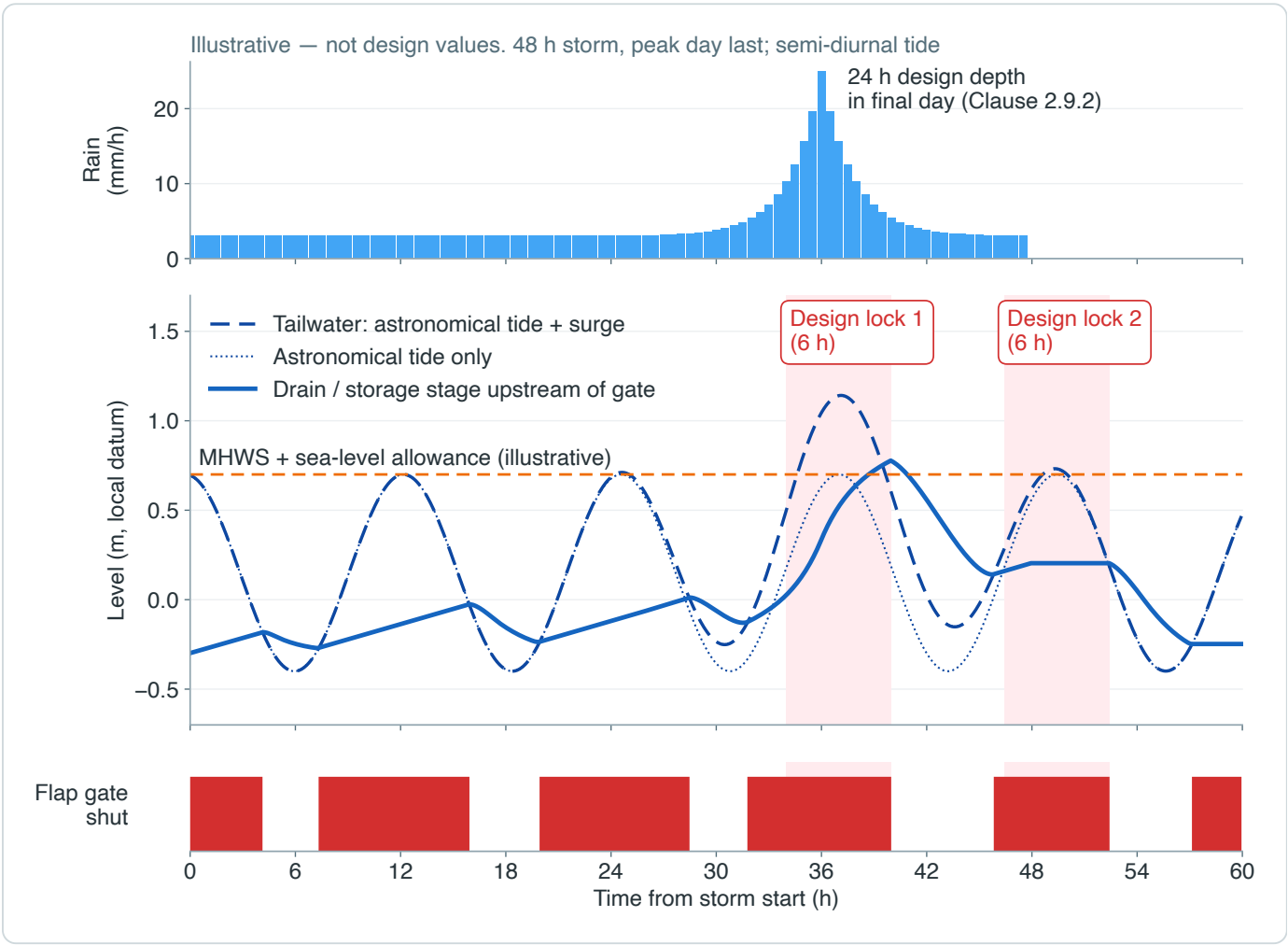

Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal 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 Manipur requirement in this Manual. In Manipur it applies where an outfall is shut not by the tide but by a river held above the town for days or weeks behind its bunds, by Loktak standing above the outfall for the whole season, by a pat that is already full, by the release of a dam upstream, or by a hill stream in spate. The Imphal river at Minuthong has a highest flood level of 788.400 m against city ground of about 790 m (WRD, as reported; AIIB, 2024), and it ran above that level on 29 May 2024 (as reported); "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, 2024); Lamphelpat "remains waterlogged for many days every year" although it is pumped (NDB); and the floods of the valley follow rain spells of five to twelve days: 28 July to 1 August 1989, 22 to 28 September 1997, 24 August to 3 September 1999 and 26 August to 6 September 2000 (MASTEC). That is why Clause 5.8.5 replaces the two 6-hour windows described below with a gate closed for the whole 72-hour storm and for as long as the river stays above the sill, not less than 7 days on the valley's main rivers and on the Barak and not less than 72 hours on a smaller stream or a release reach where no stage record has been analysed; an outfall below the design level of Loktak closed from 1 June to 30 September; a pat or pukhri full to its outlet at the start; a pump-down within 48 hours with the gate still shut; and a lock of at least 24 hours at a hill-stream outfall. 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 Manipur the outfalls do not cross a beach, but most outfalls on the Imphal valley floor pass through a gate, flap gate or culvert (ithong) in a WRD river bund (pan), and the gates and the pumps beside them are the towns' defence against the rivers. The valley's recent floods came through and over the bunds: 18 embankment breaches in May 2024; breaches of the Imphal river at Singjamei, Heingang, Bashikhong and New Checkon and of the Nambul at four places in 2025; and a breach of the Iril at Kshetri Awang Leikai in September 2025 (all as reported). The one pumped outfall described in the sources, from Lamphelpat to the Nambul through the Shamushang nallah, is recorded as not enough: "Coping measures undertaken in the form of pumping … are not adequate and the area remains waterlogged for many days every year" (NDB). The bunds and the pumping are WRD's, while the drains behind them are IMC's, another local body's, PWD's or DoECC's; no Manipur statute on embankments, no list of the valley's gates and pumping stations and no WRD rule for operating them was found during research [TBC], so a gate and the drains behind it can belong to different bodies and nobody may be bound to close it in time. 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 Manipur: 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. Manipur 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 that the hill streams bring down to the valley floor and to Loktak, the phumdi that drift onto outlets, and the rock sill below Ithai. The hill streams "flow down with steep slope for a short distance before meeting the Loktak Lake … load carrying capacity is high which causes siltation of the lake", and degraded land covers 1,545 km², 24% of the valley's catchment (MASTEC); below the Ithai barrage the bed of the Manipur river rises to 763.7 m in about 800 m, so that "the outflow of the sediment is restricted" (MASTEC); and phumdi, the floating mats that the Loktak Act names, cover much of the lake (as reported). A flap gate held open or shut by silt, phumdi or waste, an outlet buried by a rising bed, or a gate that cannot be moved turns a designed outfall into a dead end or a back-flow path. No WRD rule linking the operation of any gate to the levels of the drains behind it was found during research [TBC]. Clause 5.8.5 deals with this by setting hill-stream outfalls above the range of bed movement, screening outfalls to Loktak against phumdi, and giving no credit for a gate operation, a pump 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 hill-fringe colony in Jiribam town draining to a stream of the Jiri
Form 5-1	Downstream and Tailwater Report

Annex / Form	Content
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) Manipur 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.** Manipur'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 largest drainage programme in the State, the AIIB project's "547 km of both side stormwater covered drains" along the roads of Greater Imphal, states no return period, intensity or runoff coefficient (AIIB, 2024), and the master plan for Greater Imphal has no storm-water drainage section. The drains that exist work poorly: "The existing drainage in the Greater Imphal area is also not in good condition and is not properly connected to the primary drain. Drainage system links are missing … the drains are clogged … Imphal lacks decentralized stormwater management along streets" (AIIB, 2024). They also work in a setting that the plains editions of this Manual meet only in part. On the valley floor they end at gates (ithong, Manipuri: a sluice gate or floodgate) in the river bunds (pan, Manipuri: a bund or embankment), behind rivers that stand above the town for days, or in pats (Manipuri: lakes or wetlands, as in Lamphelpat) and pukhris (Manipuri: ponds) that are already full, and they carry sewage: 72 drains discharge to the Nambul with a BOD of 42.45 to 52.34 mg/L (State report to the NGT, December 2025). In the hills and on the valley rim they collect water from slopes of Disang shale that "have less infiltration and more run off" and slide when cut (MASTEC), and their khongs (Manipuri: streams) bring silt down to the valley floor and to Loktak. And they are divided among owners: IMC and the other urban local bodies, PWD, WRD, DoECC, PHED and LDA all build or hold drains, channels or receiving waters in Greater Imphal, and no notification assigns the Naga Nullah, the Waisel Maril or the Shamushang nallah to one of 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 drains.** Outside the sewered wards of Imphal, the public drain that receives storm water from a site or a public drainage project in Manipur normally also carries sewage and sullage, from septic tanks, soak pits and open connections (Clause 8.9); and in the hills and on the valley rim the drains also carry silt, gravel, slide debris and waste. 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 carries dry-weather flow of sewage or sullage, whatever its owner calls it:

- (a) **Separation on site.** Storm water and sewage 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 Model bye-laws already point this way, and are the hooks for this item: "For outlet from the soak-pit to municipal drain if provided, an intermediate treatment chamber should be installed" (bye-law 6(1)(A)); a latrine "shall be a connected latrine if a sewer is within 30 m … of the site" (bye-law 27); and a rain-water pipe "shall not discharge into or connect with any soil pipe" and "in no case shall it discharge directly into any closed drain" (bye-law 28(v) and (ii)) [TBC: confirm the numbers and text in the bye-laws the local body has notified]. In the wards of the Imphal sewerage project, the site's sewage goes to the sewer and its storm water to the storm drain, and the two shall not be joined. 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 ends at a bund-locked or pumped outfall, or at Loktak, the outfall-closed check of Clause 5.10 applies with the lock of Clause 5.8.5(a) or the closure of Clause 5.8.5(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 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 that carries sewage shall have dry-weather-flow interception and a screen before its outfall to a pat, a pukhri, Loktak or a river stretch on the CPCB list of polluted stretches (among them the Nambul from the Singda dam to Bishnupur), 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 pat without that treatment; Lamphelpat comes first, because it is both the city's flood storage and a proposed source of drinking water. Within the 236.21 km² of the Loktak Lake (Protection) Act, 2006 the "Discharge of untreated wastes and effluents from industries, cities or towns and other human settlements" is already barred in the Buffer Zone (s.19(iv)), and no sewage or domestic waste may be discharged into the Core Zone "except with the prior permission of the authority" (s.20(i)). Every such screen shall also hold back phumdi and the solid waste that the city's channels carry, with machine access and a place to stack what it catches away from the water. No drain that carries sewage shall be led into a paddy-field channel or an "agriculture canal" without treatment. The Authority shall identify in its master plan (Chapter 11) the areas where a separate public storm drain is feasible, among them the wards of the Imphal sewerage project as they are connected, and elsewhere the storage that will hold back the combined peak; in a hill town, every public drain below a settlement shall be taken as one that carries sewage until sewers exist; and 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 MN-B and MN-C of Annex 2A, the hill parts of MN-C1, the slopes of the valley rim and the hillocks inside the valley in MN-A, any catchment whose natural ground slopes more than 10% on average, and every khong or other stream that comes down from the hills, including those that reach the valley floor and Loktak:

- (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, jhum or other cultivated slope, bare slope, a quarry or a cut slope), or from a khong or other hill stream 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 khong, the margin of a pat or paddy land. 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–May storms, and after the season by 15 November (Chapter 10). 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, fan or channel-shift path, 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 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. 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, and where the 1% AEP flow cannot be kept within those limits, 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, among them NH-37 from Imphal to Jiribam and NH-2, 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, a national-highway agency, IMC or another urban local body, or the department that executes the road in the hill areas: (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 khong and stream, 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) and (h); (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, a national-highway agency 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 (vi) no spoil or excavated material from the construction, widening or maintenance of the road, or from hill cutting beside it, placed in or beside a khong or another line of natural drainage, or on a slope from which a storm can carry it into one. The same items apply to the drainage of a railway formation in a hill catchment.
- (l) **Sloping sites, hill cutting and retaining walls.** 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) and (h), 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 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. Every retaining wall that holds up a slope shall have weep pipes that discharge into a lined drain at its foot, not onto the slope below or into the backfill of a wall below: the typical drain sections of the AIIB project already show 50-mm PVC weep pipes every 5 m to "release pore water pressure" (AIIB IEE). Roof and paved-area runoff on such a site follows the hill rule of Clause 4.11. These items give a design standard to the slope rules that exist: the IMC (3rd Amendment) 2024 draft, under which "no construction will be permitted in the areas which have a slope of more than 30 degrees", development is allowed "only upto two floors or 7m height in areas which have a slope of 21-30 degrees" (92.1) and "no cutting of slopes will be permitted in the areas which have a slope of more than 30 degrees" (92.2), published for objections to "come into force on such date as the State Government may … appoint", whose final status was not confirmed [TBC]; bye-law 92 of the Model [TBC: confirm the number and text in the bye-laws the local body has notified], which as printed reads "No construction shall be permitted on land above 600 m from the mean sea level and with an average slope of 30 degrees" and would on that reading bar all of Greater Imphal, which lies above 600 m (NEER reading), so that it is read with the IMC text; IS 14458, the guidelines for retaining walls in hill areas that the Model refers to; and the green-building criterion of "erosion and sedimentation control". In the hill areas no building bye-law applies: this item reaches public works and any body that adopts this Manual.
- (m) **The hill–valley break, silt and waste.** Where a khong or hill stream, or a drain that receives one, reaches the valley floor or the flat land round Loktak, a silt trap designed under Chapter 9 (Clause 9.8) shall be provided above the point where the gradient falls, with machine access and a stockpile place that is not a khong, a pat margin, paddy land or a slope, sized for the sediment of item (i) and cleared on the dates of item (f) and after every heavy-rainfall day (Chapter 10). No spoil from hill cutting and no construction and demolition waste shall be placed where a storm can carry it into a drain, a khong, a pat or Loktak; within the extent of the Loktak Act, "Dumping of city or town waste for the purpose to land filling" and "Dressing or altering of hills, natural features

including landscape drainage" are already barred in the Buffer Zone (s.19(v) and (viii)). A trap or screen placed in a stream shall not raise its 1% AEP level at any outfall (Clause 5.8.5(f)) 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 Imphal 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 Manipur, 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. Imphal's sewerage Phase I, commissioned in June 2020, covers 11 of IMC's 27 wards (master plan); "Sewage generation in urban areas is 70 MLD and existing treatment facilities are 44 MLD", household connections stood at 8,600 to 8,700 of the 51,754 targeted, and the effluent's "Final mode of disposal" is "Agriculture canals" (State report to the NGT in O.A. 606/2018, July 2025); and the 72 drains that fall into the Nambul carry a BOD of 42.45 to 52.34 mg/L and a COD of 78.56 to 97.23 mg/L (State report to the NGT, December 2025), against a river whose own BOD the CPCB measured at 3.3 to 5.6 mg/L along its stretch from the Singda dam to Bishnupur (CPCB, 2025). The storm drains are the sewers, and the rivers dilute them. In the hills, "The existing reliance on septic tanks and twin soak pits in the hilly regions of Manipur is appropriate" and there is "minimal presence of underground drainage infrastructure" (State report, July 2025), so the drains below a hill settlement carry what the pits release. The Model bye-laws already reach towards separation without requiring it: an intermediate treatment chamber before a soak-pit outlet to a municipal drain (bye-law 6(1)(A)), a connected latrine where a sewer is within 30 m (bye-law 27), and no rain-water pipe to a soil pipe or a closed drain (bye-law 28). 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 the town can separate its system street by street as the sewerage wards are connected 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 a low-flow channel so that sewage solids do not settle in it between storms; and the outfall to a pat, Loktak or a polluted stretch is intercepted and screened, because the pats are the valley's storage, Lamphelpat is to be a source of drinking water, and the Loktak Act already bars untreated town effluent from the lake's Buffer Zone. Item (e) also keeps drain flow out of the paddy-field channels: the valley's paddy land is both its farmland and its flood storage, and the 2014 Act counts its "drainage channels, ponds, canals, bunds and ridges" as part of it. The screens deal with phumdi and with the waste that fills the city channels: market waste is dumped in the Naga Nullah, "which creates a stagnant pool all along the year" (master plan). Separation itself is for the Authority to plan, not for each site.

The second is the hills. Disang shale "occupies almost 85 p.c. of the hilly region, have less infiltration and more run off"; degraded land covers 1,545 km², 24% of the valley's catchment and 35% of its hills, and the high and moderate-to-high erosion classes cover 51% of the area studied (MASTEC). The slopes fail when they are cut and wet: the landslide at Tupul (Noney) on 30 June 2022 (29 June in some reports), at the Jiribam–Imphal railway site, killed 56, 58 or 61 people by different counts (as reported; NRSC's note of 5 July gave 42 dead and 20 missing, as quoted), and a study attributes it to "poorly designed or implemented slope excavation coupled with heavy rainfall" (Baruah et al., 2023, via a search summary of the AGU Landslide Blog); the landslide at Joumol (Chandel) on 1 August 2015 killed 20 or 21 people, or 24 by ActionAid's count (as reported). The hill streams drop their load where they reach the valley floor and Loktak, which is why item (m) puts a silt trap at the hill–valley break: they "flow down with steep slope for a short distance before meeting the Loktak Lake … load carrying capacity is high which causes siltation of the lake" (MASTEC). No Manipur 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 the interim value of the hill and mountain editions of this

series, with the same reasons. The 1 ha trigger for a debris rack reflects the few minutes' time of concentration on hill slopes. 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 behaves as a debris flow, which no drain can be sized for, so item (g) keeps buildings and outfalls out of its path. The 3.0 m limit in item (h) doubles the core's 1.5 m because stones, 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 mid-season clearance of item (f) is due by 15 May, not by 31 May as in the other North-East editions of this series, because the valley floods of 2024 and 2025 came at the end of May. IRC:SP:42-2014 (cl. 8.5.1) already treats hill roads differently, with lined side drains and culverts "at closer intervals compared to those in plain areas", and item (k) keeps road runoff off unprotected slopes because water discharged onto a slope raises its pore pressure (Clause 4.11); the weep pipes of item (l) do the same for the water behind a wall. The IMC 2024 draft's slope classes already set where building and cutting stop; items (l) and (m) give the drainage that goes with them a design standard of this Manual's own. The clause deals with sewage, silt and debris at the drain; it does not ask for the concrete channelisation of the khongs and city channels, whose capacity has been lost to encroachment, dumping and filling, 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: Imphal, Thoubal, Kakching, Bishnupur and Churachandpur 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 Greater Imphal, the localities that the sources name for flooding and waterlogging: Nagaram, Laipham Khunou and Lairikyengbam Leikai, flooded when the Naga Nullah clogged in July 2024, and the localities behind the bund breaches of 2024 and 2025 at Singjamei, Heingang, Bashikhong, New Checkon, Keirang, Khabam and Kshetri Awang Leikai (all as reported); the central area of Imphal of about 150 ha that TPD names as a local area plan site (TPD Annual Administrative Report 2025-26); and Thangal and Paona Bazar in the Smart City's area-based development area (as reported) [TBC]; with the boundary of each to be confirmed by IMC and PDA Manipur [TBC];
- (b) in every other urban local body and planning area, the area that the applicable master plan identifies as the core area, old town or central business district, and the main market of a town; 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.

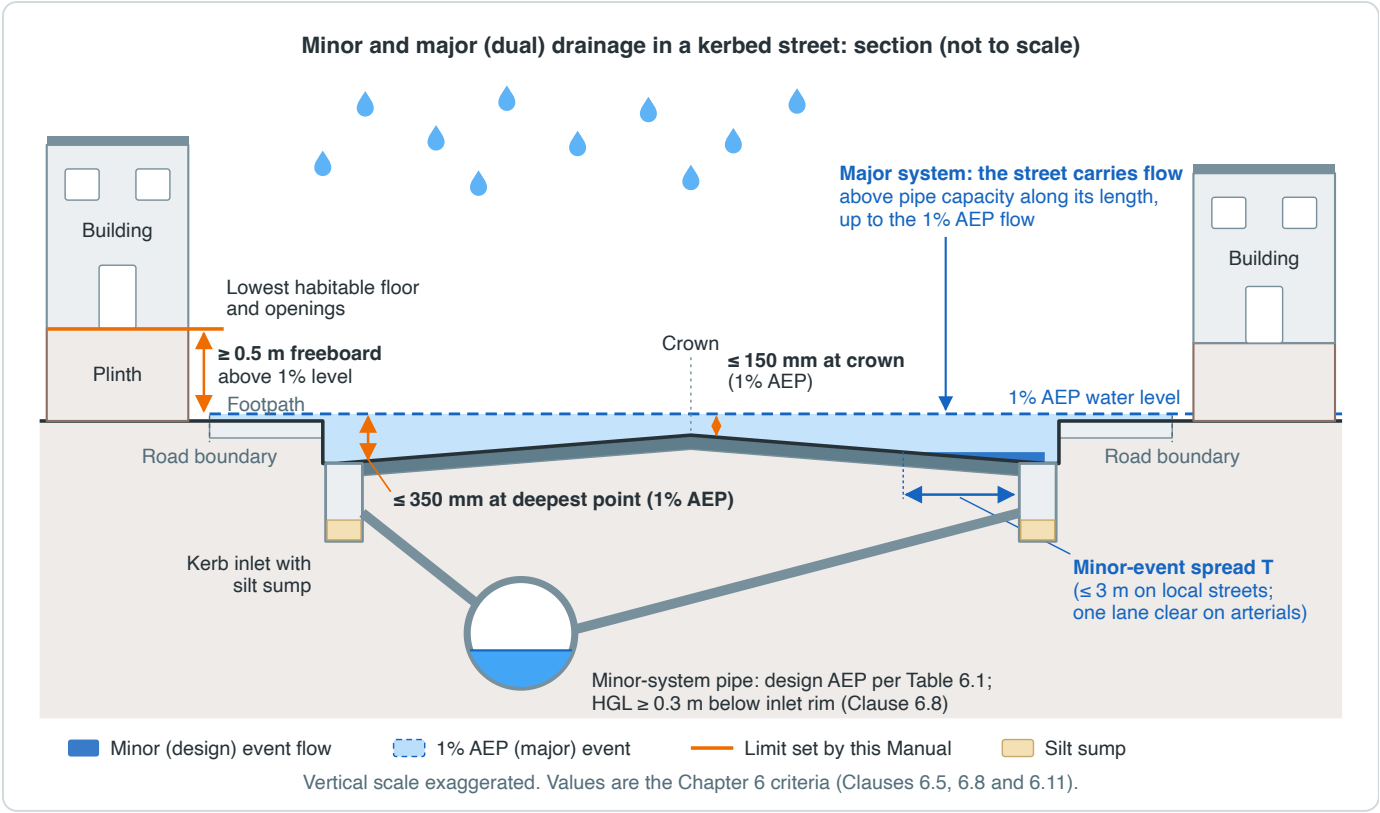


Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

> **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 Manipur 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:

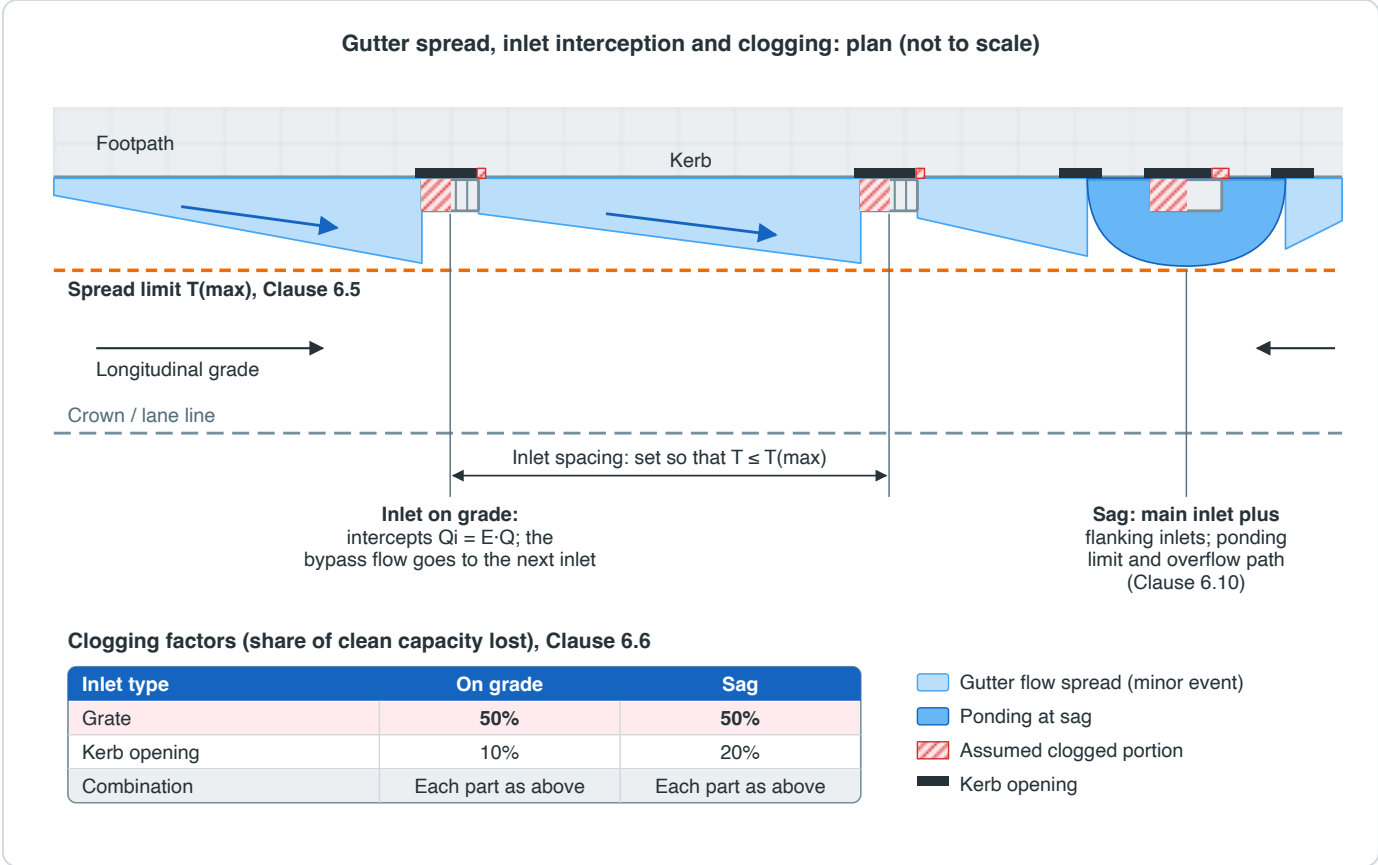
- (a) inlet spacing shall not exceed 30 m on kerbed roads, whatever the calculation gives;
- (b) inlets shall be provided at every sag, immediately upstream of pedestrian crossings and intersections, upstream of bridge decks and superelevation transitions, and at the end of every gutter run;
- (c) bypass 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.



Inlet type	On grade	Sag
Grate	**50%**	**50%**
Kerb opening	10%	20%
Combination	Each part as above	Each part as above

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 Manipur 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, of IMC or of any other local body in the State was found during research [TBC]. The typical sections of the AIIB project show PCC drains with gratings, outlets "@25 m interval" and 50-mm PVC weep pipes every 5 m to "release pore water pressure", with no hydraulic design (AIIB IEE); and the Model bye-laws ask only for a "Detailed drainage plan for both internal and external required to be constructed up to the available permanent/pucca drain of municipal/other authority" (bye-law 6(1)(D) [TBC: confirm the number and text in the bye-laws the local body has notified]). 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 Imphal valley floor, which has "a very low southerly gradient" (MASTEC), are very flat, which shortens the calculated spacing anyway; on the steep streets of the hill towns and of the valley rim 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 the hill fringes of the Imphal valley, Tamenglong, Noney, Ukhrul, Senapati, Kangpokpi, Chandel and Churachandpur 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.

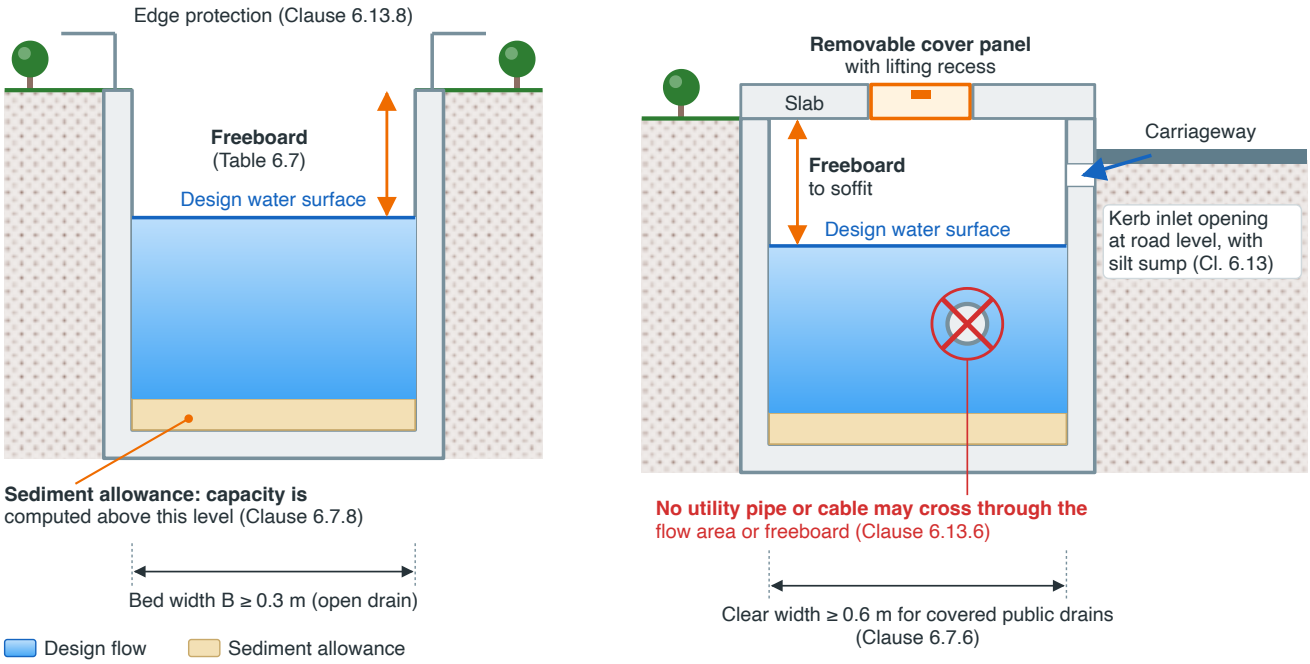


Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.

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 Manipur 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 Imphal floods of May 2024 and May–June 2025, in a city whose "existing drainage … is also not in good condition and is not properly connected to the primary drain. Drainage system links are missing … the drains are clogged" (AIIB, 2024), where market waste is dumped in the Naga Nullah, "which creates a stagnant pool all along the year" (master plan), and where the clogging of the Naga Nullah flooded Nagaram, Laipham Khunou and Lairikyengbam Leikai in July 2024 (as reported); the AIIB project is now to build "547 km of both side stormwater covered drains" along the roads of Greater Imphal (AIIB, 2024). 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. Imphal'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 Manipur most valley drains end at a gate in a river bund, behind which the river stands higher than the drain for days in the monsoon, or at Loktak, which stands high for the whole season, or in a pat that is already full (Clause 5.8.5). The Imphal river at Minuthong has a flood level of 786.900 m and a highest flood level of 788.400 m (WRD, as reported) against city ground of about 790 m (AIIB, 2024); "the town is below the high flood level of Imphal river" (master plan); and on 15 September 2025 the river at Lilong and the Manipur river at Ithai stood above their printed highest flood levels (as reported). No design level for any outfall in the State was found during research. A drain whose HGL is started from a free outfall, or computed one length at a time without the river, the closed gate, the lake or the full pat at its end, 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
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.

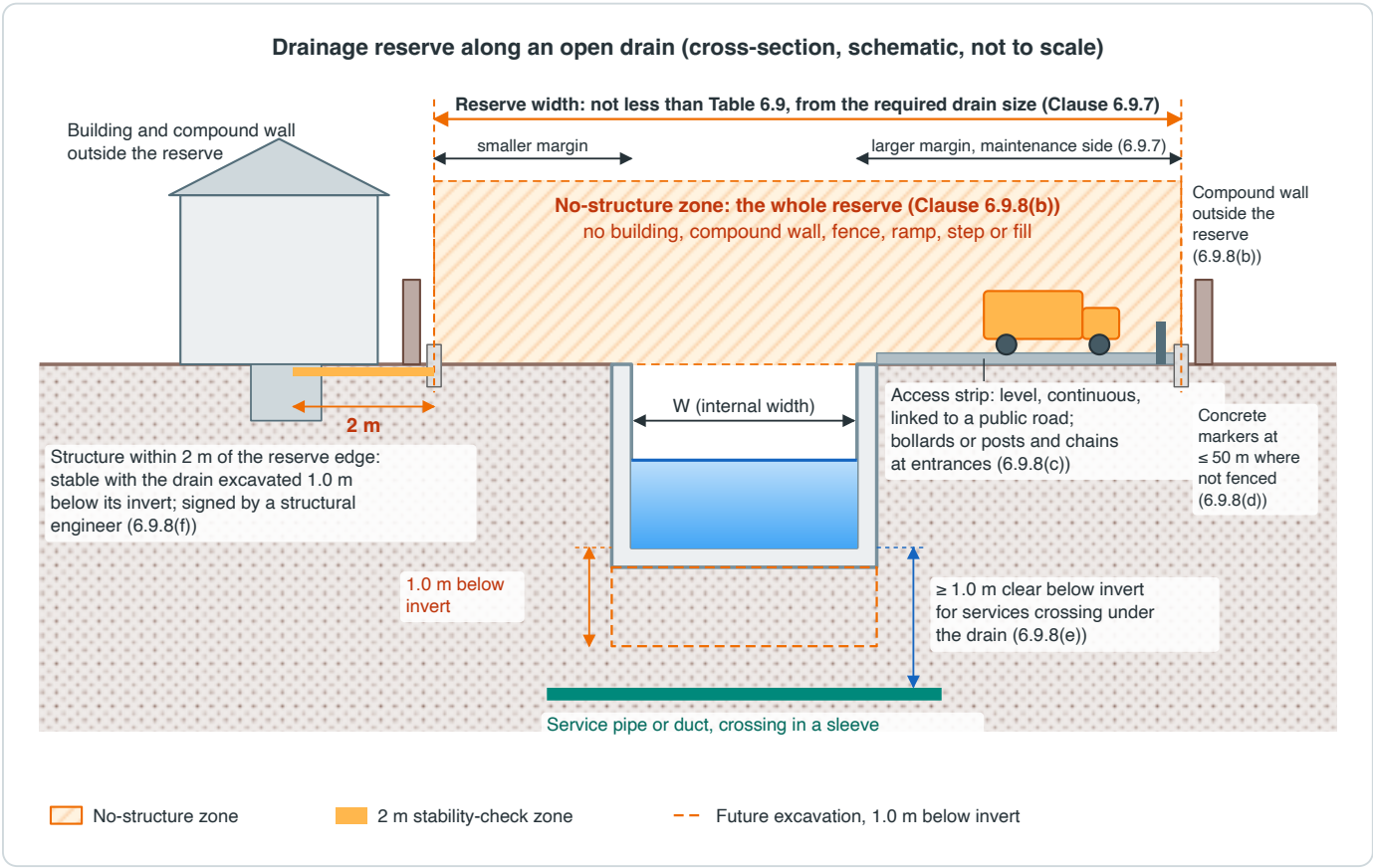


Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, 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 Manipur, 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. Manipur has a statutory building buffer along its named valley rivers, but no reserve width along a drain or a city channel, and no notified floodplain zone. The buffer is that of bye-law 93 of the Model [TBC: confirm the number and text in the bye-laws the local body has notified]: "Prohibit any new construction within the designated buffer zone to minimize human exposure to flood risk and preserve the natural integrity of natural ecosystems", with a table of rivers, the same for the left and right banks: the Imphal river 55 m from Koirengei to Lilong, 60 m from Lilong to Sekmaijin and 62 m from Sekmaijin to Ithai; the Wangjing 31 m from Heirok bridge to Kharungpat; the Nambul 30 m within the Greater Imphal area; the Iril 50 m from Sawombung to Lilong; the Thoubal 48 m from Yairipok to Irong Ichil; the Sekmai 35 m from Pallel bridge to its confluence with the Imphal river at Sekmaijin; and the Arong 30 m from Charangpat to Ikop pat, each "from mid-stream or 6 m from outer toe of bund, whichever is further from mid-stream"; and the Merakhong 22.5 m, 24.2 m and 28 m by reach, the Kongba 35 m and the Nambol 25 m, from mid-stream only. The IMC (3rd Amendment) 2024 draft repeats the table (93.1). The bye-law adds that "No person shall undertake any activity within the prohibited area or restricted area except with the previous permission of the Flood Zoning Authority constituted under the Flood Plain Zoning Act, 1978", but no Flood Zoning Authority and no prohibited or restricted area was found constituted or notified (NEER reading), and the demarcation of flood zones "is yet to be done" (as reported, June 2026). The buffers are measured from mid-stream, so that on a reach 40 m wide a 30 m buffer leaves 10 m from the bank (NEER reading). No building may be put "over any municipal drain or land" (bye-law 16). No buffer round a pat or pukhri exists in the bye-laws (NEER reading). Round Loktak, the Core Zone of 70.30 km² is a "No-Development Zone or Totally Protected Zone", the Buffer Zone bars "Land reclamation, bunding or disturbing the natural course of drainages" (Loktak Lake (Protection) Act, 2006, ss.3 and 19(vi)), and the High Court's special bench ordered on 17 July 2019 and again on 25 February 2022 that there be no development in or around Loktak "without the Court's leave" (as reported; the case number was not found [TBC]). The State Wetlands Authority has published draft notifications for the Yaral, Utra and Waithou–Phumnom pats (DoECC, 2025-26), and until they are final no prohibition of the Wetlands Rules, 2017 applies to them (NEER reading). The Unified Zoning Bye-laws, 2026 have a use zone "Pond, Drain, Rivers and Canals" in every master plan area, which is where a reserve can be shown. None of these gives a reserve width along a city channel or a town drain. For this Manual, as its own proposal and not as the meaning of the rules, the bank of a channel is its top of bank, and on a bunded reach the landward toe of the bund; the edge of a pat or pukhri is its boundary at its seasonal high level (Chapter 7); and every khong and other natural channel that drains 8 ha or more is a natural channel under Clause 7.4.1(b), 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) in the hills (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 and round every pat and pukhri that this Manual covers, the setbacks of Clause 7.4, with a Zone 1 of **not less than 15 m** from the top of bank, from the landward toe of the bund on a bunded reach, or from the boundary of a pat or pukhri, and a Zone 2 to the 1% AEP extent plus 10 m, the line that reaches furthest from the water governing; where the bye-law table, the master plan, the Loktak Act, a notified wetland or a court sets a wider line, that line applies for as long as it binds, and the widest governs (Clause 7.4.5). Four reference lines are compared (Chapter 7): mid-stream, with the distance of bye-law 93; the outer toe of the bund, with its 6 m; the top of bank, the landward toe of the bund on a bunded reach or the boundary of a pat or pukhri, with Zone 1; and the 1% AEP extent with the outfall closed, with 10 m. The comparison works both ways (NEER reading). On the bunded rivers of the table, the bye-law's distances of 30 m to 62 m from mid-stream, or its 6 m from the outer toe of the bund, usually give the wider line on wide reaches; the Manual's 15 m from the landward toe of the bund is stricter than the bye-law's 6 m wherever the bund stands well back from the stream; and on narrow reaches, and on every river, stream and pat that the table omits, among them the Khuga, the Chakpi, the hill streams, the Naga Nullah and the Waisel Maril, the pats and the pukhris, the Manual's 15 m governs. The corridor applies to new development and redevelopment approved under this Manual, not to existing buildings, and Clause 7.4.7 allows

no variance below it. Land on the valley floor is mostly private patta land, so Zone 1 land and reserve land that is private is **reserved in the master plan**, in the use zone "Pond, Drain, Rivers and Canals", **or secured by agreement with the owner**, recorded on the layout approval and in the land records, and 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; in the hill areas it is secured through the District Council's powers over the allotment of land, which were not researched for this purpose [TBC] (set by this Manual). The corridor should be shown in the master plan for Greater Imphal and in the master plans of the other towns as land kept free along drainage lines, and checked at TPD's land-use check on OBPS and at the building permit, where the plans already have to show a "Detailed drainage plan for both internal and external required to be constructed up to the available permanent/pucca drain of municipal/other authority" (bye-law 6(1)(D)), rather than made a new NOC.

The reserve matters because the drains of Manipur's towns are divided among owners, and no rule divides them. No notification assigns the Naga Nullah, the Waisel Maril or the Shamushang nallah to one owner (NEER reading), and the AIIB found that the drainage of Greater Imphal "is not properly connected to the primary drain. Drainage system links are missing" (AIIB, 2024). The Municipalities Act, 1994's sections on drains were not read for this Manual [TBC]; the bye-laws speak of the "municipal drain" (bye-law 16). In April 2025 encroachments along the Waisel Maril, the Naga Nullah and the Nambul were ordered removed with WRD to provide machinery, and the cleaning of the Waisel Maril was led by LDA (as reported). For the purposes of this Manual, and until the State issues such a rule [TBC], the drains are assigned as follows: the municipal drains to **IMC** and to the other urban local bodies in their areas; roadside drains to **PWD**, among them the AIIB project's "547 km of both side stormwater covered drains" in Greater Imphal (AIIB, 2024), and those of the national highways to the **national-highway agencies**; the river bunds, the flood channels and the city channels, Lamphelpat and the Shamushang pumping, and the machinery for clearing the city channels, to **WRD**; the interception and diversion of the 72 drains that fall into the Nambul, and its plant of 16 to 17 MLD, to **DoECC**; the sewers to **PHED** (Clause 8.9); the Waisel Maril cleaning, while LDA leads it (as reported), and Loktak and every drain and channel within the 236.21 km² of the Loktak Act, to **LDA**; and in the hill areas, the drains of a public work to the department that executes it, and other drains to the body that the District Council designates [TBC] (set by this Manual). Each town shall keep a **drain register** that gives every reach its owner under this assignment, the river it reaches, the bund it crosses and whether through a gate or a flap gate, whether it lies in a buffer of bye-law 93, its land status (patta or government land), and its outfall (set by this Manual). Under Clause 6.9.8(a), the reserve along a channel assigned to the Water Resources Department is transferred to, or secured for, the Water Resources Department. Where a channel's status is disputed, the corridor follows the channel and not its name: the city channels of Imphal are at once storm drains, carriers of sewage and channels that end at a WRD gate in a river bund. No approved drainage master plan with a design return period was found for any town in the State, and the master plan for Greater Imphal has no storm-water drainage section. 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 is a reserve that 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 Manipur 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 Manipur was found during research [TBC]. The roads already act as the major system: in July 2024 the clogged Naga Nullah flooded Nagaram, Laipham Khunou and Lairikyengbam Leikai in Imphal (as reported), and the AIIB road project measures its result by the "Number of days of road unavailability due to flooding" (AIIB, 2024). 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.

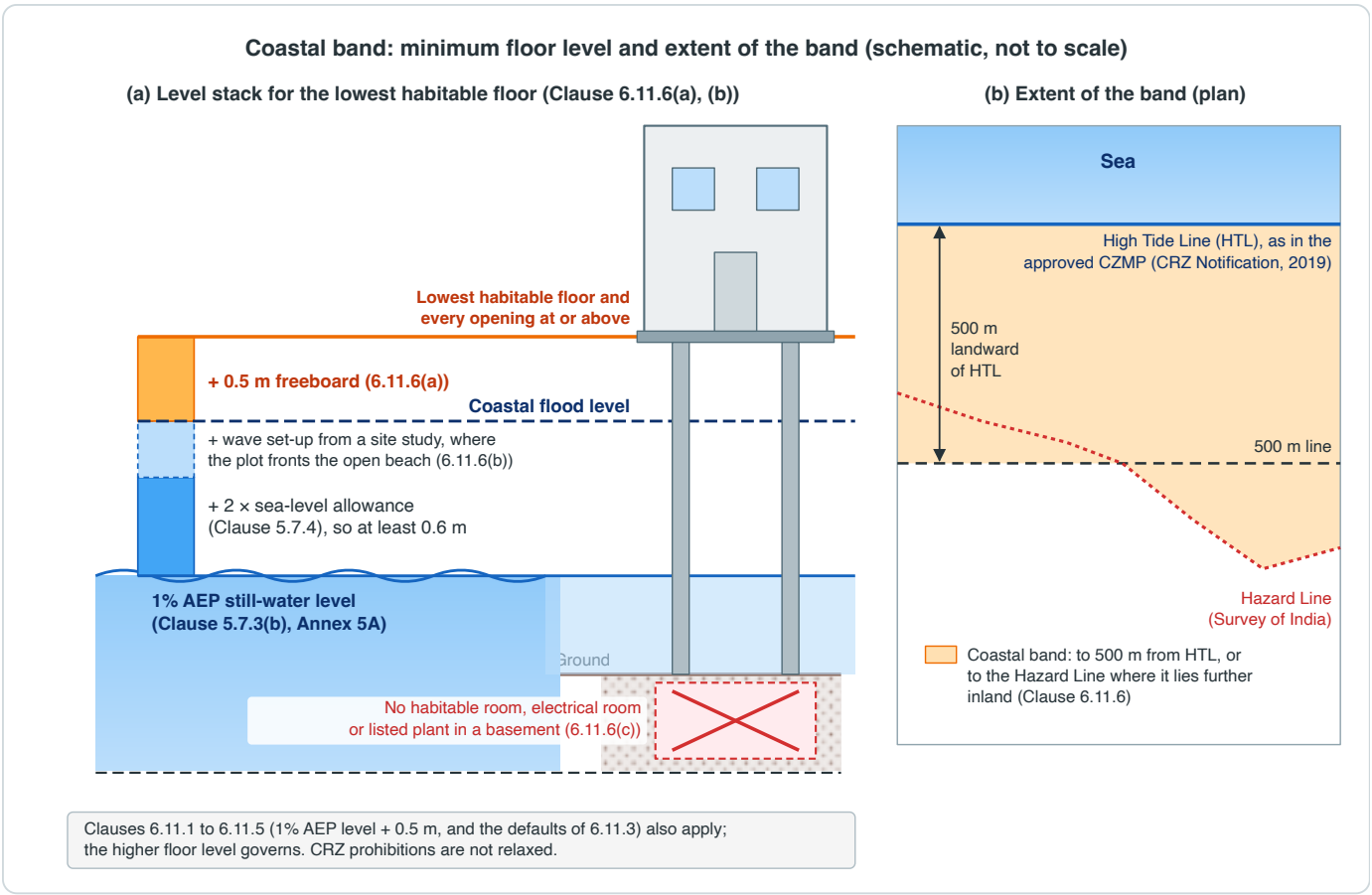


Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further 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. Manipur 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 Model bye-laws set a plinth for flood-prone land: "In high Flood Risk Areas identified in the Master Plan of the towns, the plinth level should be above 1m above the highest flood level of the surrounding areas" (bye-law 94 of the Model [TBC: confirm the number and text in the bye-laws the local body has notified]), and the IMC (3rd Amendment) 2024 draft ties the same rule to the "High Flood Risk Areas identified in the Risk-Informed GIS-Based Master Plan for Greater Imphal" (93.2; final status not confirmed [TBC]). The risk-informed master plans for Imphal and Moirang, where those areas would be shown, were not read [TBC], and no local authority's "highest flood level" was found for any town [TBC], so the bye-law gives no level to build to; and on 15 September 2025 the river at Lilong and the Manipur river at Ithai passed the highest flood levels printed for them (as reported). For this Manual, that level is taken as the 1% AEP flood level of Clause 6.11.2 at the site, computed with the bund-locked, lake and breach cases of Clause 5.8.5 and not below the check level of Clause 5.8.5(a) or (c), or, where none has been computed, the highest flood level surveyed from flood marks with its source stated; and the floor levels of Clause 6.11.1, 0.5 m above the 1% AEP level, govern where they are higher than the bye-law plinth (set by this Manual). Behind a river bund the level is that of the ponded area with its gates closed, and for a breach, the river level beyond the bund (Clause 5.8.5(a)). The Model defines a basement (bye-law 2(11)) and allows basements within the setback lines for fire safety, but no rule of the bye-laws excludes basements from low-lying or flood-prone land (NEER reading): on the Imphal valley floor a basement is allowed only where Clauses 6.11.3 and 6.11.4 are met and it passes the flotation check of Chapter 4 with the design groundwater level at ground level (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 bye-laws. On a hill site 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 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. Along the rivers and khongs and round the pats and pukhris, 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 m^3/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 Manipur 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 Manipur 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 Manipur that date is also the start of the wet season as this Manual defines it, 1 April to 31 October. The south-west monsoon's normal onset at Imphal is 5 June (previously 1 June) and its withdrawal 15 October (IMD normals in use from 1 June 2020, as quoted in IMD's press release), but the storms come earlier and later. Imphal's 24-hour records for April and May are 105.9 mm (16 April 2004) and 122.4 mm (27 May 1956), and every month from February to December has a 24-hour maximum of 80 to 160 mm (IMD *Extremes*, Imphal (Tulihal), 1953–2012); "intense rains from March to October" damage the city's roads (AIIB, 2024); and two of the recent damaging floods of the valley, those of Cyclone Remal on 28–31 May 2024 and of 30 May–2 June 2025, came before the monsoon's onset (as reported). After the season, Imphal has recorded 119.4 mm on 5 October 1980 and 80.3 mm on 1 November 1991 (IMD *Extremes*), and the valley flooded in October 1992 (MASTEC). No order with a completion date for desilting town drains was found during research [TBC]. So Clause 6.13.10 refers to the monsoon season as this Manual defines it, and Chapter 10 requires the desilting of drains and channels and the clearance of inlets, silt traps and screens to be complete by 31 March, with gates, flap gates, pumps and standby power certified ready on the same date (Clauses 5.11.5 and 5.12.9); a mid-season clearance of inlets, silt traps, screens and hill-stream traps by 15 May; standby from 1 April to 31 October; and a post-season clearance of silt and debris, with a survey of silt depths, by 15 November. The mid-season clearance is due by 15 May, not by 31 May as in the other North-East editions of this series, because the floods of 2024 and 2025 struck on 28–31 May, and a clearance due by 31 May would fall during them. WRD's own works on the river bunds keep WRD's calendar. These dates are set by this Manual. Manipur's towns have no snow regime.

Building over drains is already restrained by the bye-laws: "Any masonry building or structure shall not be constructed or extended, over any municipal drain or land" (bye-law 16 of the Model [TBC: confirm the number and text in the bye-laws the local body has notified]), and "No open drain, except for rain water, shall be constructed in any open space required by these" bye-laws. Yet the city's channels are encroached and used as dumps: market waste is dumped in the Naga Nullah, "which creates a stagnant pool all along the year" (master plan), and in April 2025 encroachments along the Waisel Maril, the Naga Nullah and the eastern bank of the Nambul were ordered removed (as reported). Natural khongs and city channels are open channels with a drainage reserve (Clause 6.9), and should not be covered, decked or built over. Where a drain is covered, as the AIIB project's roadside drains will be, Clause 6.13.2 applies to it in full; where it is open beside a footpath or a carriageway, Clause 6.13.8 applies.

Clause 6.13.7 is not yet the practice, and in Manipur it cannot be until sewers exist. Imphal's sewerage Phase I, commissioned in June 2020, covers 11 of IMC's 27 wards, and Phase II, for the other 16 wards and four outgrowths, is planned (master plan); household connections stood at 8,600 to 8,700 of the 51,754 targeted, and "Sewage generation in urban areas is 70 MLD and existing treatment facilities are 44 MLD" (State report to the NGT, July 2025). Elsewhere septic tanks and soak pits overflow to the drains, and "The existing reliance on septic tanks and twin soak pits in the hilly regions of Manipur is appropriate" (the same report). The 72 drains that fall into the Nambul carry a BOD of 42.45 to 52.34 mg/L, and their interception and diversion is reported as completed (State report to the NGT, December 2025). Clause 6.3.6(a) to (e) sets how a drain that carries sewage is designed meanwhile, and Clause 8.9 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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- *The Manipur Town and Country Planning Act, 1975* (Manipur Act 11 of 1975), ss.1(2), 2 and 13, https://prsindia.org/files/bills_acts/acts_states/manipur/1975/Act11of1975Manipur.pdf ; and *the Manipur Municipalities Act, 1994* (Act 43 of 1994) (extent; drainage sections not read).
- *The Manipur Flood Plain Zoning Act, 1978* (Manipur Act 10 of 1978), ss.1–7 (read from a truncated copy), https://www.indiacode.nic.in/bitstream/123456789/13383/1/the_manipur_flood_plain_zoning_act%2C_1978.pdf
- *The Manipur Loktak Lake (Protection) Act, 2006* (Manipur Act 3 of 2006), as amended, ss.3, 19 and 20, https://prsindia.org/files/bills_acts/acts_states/manipur/2006/Manipur%20Act%203%20of%202006.pdf
- *The Manipur Conservation of Paddy Land and Wetland Act, 2014* (Manipur Act 10 of 2014), ss.2, 12 and 18, https://faolex.fao.org/docs/pdf/ind194970.pdf
- *The Manipur (Hill Areas) District Councils Act, 1971*, as amended, s.29 (state compilation of subsequent amendments), https://manipur.gov.in/wp-content/uploads/2026/05/The-Manipur-Hill-Areas-District-Councils-Act-1971-subsequent-Amendments.pdf
- Government of India. *The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013*.

Annexes and forms

Annex / Form	Content
6A	Standard inlet types for Manipur 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, Pats and Pukhris (Lakes and Ponds) 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 (pukhri) 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 Manipur, a landlocked State, means Loktak, a Ramsar site (as reported), with its phumdi, within the 236.21 km² of the Manipur Loktak Lake (Protection) Act, 2006, the other pats of the valley, among them Lamphelpat, Utra Pat, Yaral Pat, Waithou–Phumnom Pat, Pumlen–Khoidum Pat and Ikop–Kharung Pat, and the wetland of Khonghampat, the marshes, swamps and waterlogged land of the valley floor, the wetlands of the Manipur Conservation of Paddy Land and Wetland Act, 2014, the land ponded behind river bunds when their sluices close, the hill wetlands among the Manipur State Wetlands Authority's priority wetlands, Jaimeng in Kangpokpi district and Kachouphung (Achau Maki) in Kamjong district, and any wetland notified under the 2017 Rules (the drafts published for the Yaral, Utra and Waithou–Phumnom pats are not final);
- (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 Manipur Municipalities Act, 1994 and the Manipur Town and Country Planning Act, 1975, the building bye-laws that each urban local body and PDA Manipur bring into force on the Model Manipur Unified Building Bye-Laws, 2024, the Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026 and the master plans, the Manipur Loktak Lake (Protection) Act, 2006, the Manipur Conservation of Paddy Land and Wetland Act, 2014, the Manipur Flood Plain Zoning Act, 1978, the Manipur (Hill Areas) District Councils Act, 1971, the Wetlands (Conservation and Management) Rules, 2017, or any other law, prohibits.

> **Commentary.** Manipur protects its waterbodies through its building bye-laws, a lake Act, a paddy-land and wetland Act, its master plans and the wetland rules, with the courts behind them; it has had a floodplain zoning Act since 1978, but no zone has been drawn under it. The **Model Manipur Unified Building Bye-Laws, 2024**,

published by MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD-Part(1) of 4 December 2024 (Manipur Gazette Extraordinary No. 253 of 5 December 2024) under section 213 of the Manipur Municipalities Act, 1994 (Act 43 of 1994) and section 26(1) of the Manipur Town and Country Planning Act, 1975 (Manipur Act 11 of 1975), "for adoption by the Urban Local Bodies and Planning & Development Authority, Manipur", extend to "the Master Plan areas or notified Planning areas and area under the jurisdiction of all the Urban Local Bodies of Manipur" (bye-law 1(2)); a permit is given under the bye-laws that the urban local body or PDA Manipur has brought into force on the Model, such as the Kumbi, Moirang and Jiribam Municipal Councils' bye-laws of 2025 (final gazette of 16 January 2025, as listed on the Town Planning Department's site) and the "Building Bye-laws for ULBs of Manipur – Final Gazette Notification" of 15 December 2025 (as listed; not read). The provision numbers in this chapter are the Model's [TBC: confirm the number and text in the bye-laws the local body has notified], and where a local body's notified text differs, its text governs. Bye-law 93 of the Model prohibits "any new construction within the designated buffer zone" along ten named rivers, measured from mid-stream, and routes any activity "within the prohibited area or restricted area" to "the previous permission of the Flood Zoning Authority constituted under the Flood Plain Zoning Act, 1978"; bye-law 94 sets the plinth "above 1m above the highest flood level of the surrounding areas" in "high Flood Risk Areas identified in the Master Plan of the towns"; and bye-law 16 bars building "over any municipal drain or land" (Clause 7.4, Disclosure). The draft IMC Building Bye-Laws (3rd Amendment), 2024 repeat the river table (93.1) and tie the plinth rule to the Risk-Informed GIS-Based Master Plan for Greater Imphal (93.2); the draft was published for objections, and its final status was not confirmed [TBC]. The **Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026** (MAHUD, 22 July 2026; Gazette Extraordinary No. 157 of 23 July 2026) have a use zone "Pond, Drain, Rivers and Canals" in every master-plan area. The **Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)** (No. SCS-401/3/2021-MAHUD-MAHUD-Part(3) of 4 December 2024; 151.38 km²) has no storm-water drainage section, records that "The town is below the high flood level of Imphal river and hence there are embankment roads on both sides of the river", and plans for wetlands to shrink from 374.48 ha to 232.21 ha and agricultural land from 5,616.53 ha to 2,604.70 ha by 2043, while water bodies grow from 563.54 ha to 643.42 ha, because the wetlands "are now earmarked by the government for the construction of water bodies for an area of approximately 500 hectares". The **Manipur Loktak Lake (Protection) Act, 2006** (Manipur Act 3 of 2006, as amended by Acts 5 of 2007 and 8 of 2019) applies to "the whole of 236.21 Sq. km" of the lake, except the Keibul Lamjao National Park (40 km²) and the Takmu Fishery Farm (5 km²) (s.1(3)), makes its Core Zone of 70.30 km² "the No-Development Zone or Totally Protected Zone" (s.3), forbids any part of the lake to be sold, leased, transferred "or converted in any form whatsoever" (s.4), and gives the Loktak Development Authority the duty "to administer the affairs of the Loktak Lake and to protect and improve the natural environment of lake" (s.17). The **Manipur Conservation of Paddy Land and Wetland Act, 2014** (Manipur Act 10 of 2014) allows paddy land, with "its allied constructions like drainage channels, ponds, canals, bunds and ridges" (s.2(c)), and wetland to be converted only through its Local, District and State Level Committees, and bars any licence "for carrying out any activity or construction in a paddy land, converted or reclaimed in contravention" of it (s.12); it extends to the areas of the Manipur Land Revenue and Land Reforms Act, 1960, and so not to the hill areas (NEER reading); a (Third Amendment) Bill, 2026 that would exempt land conforming to a master plan was introduced, and is not law [TBC: enactment not confirmed]. The **Manipur Flood Plain Zoning Act, 1978** (Manipur Act 10 of 1978) provides for flood zones by "relative risk", but no zone has been demarcated ("yet to be done", as reported in June 2026) and no Flood Zoning Authority was found constituted (Clause 7.3, Commentary). Wetlands are the concern of the **Manipur State Wetlands Authority** (Clause 7.12, Commentary). In the hill areas none of the building bye-laws, the Municipalities Act or the paddy-land Act applies, and the Manipur (Hill Areas) District Councils Act, 1971 gives the District Councils water supply and sanitation schemes, embankments and land allotment but no building control (s.29(1)); who is the competent authority for the area there is set out in Chapter 1. In this chapter **WRD** means the Water Resources Department, formerly the Irrigation and Flood Control Department, which holds the river bunds, flood channels and sluices of the valley, is developing Lamphelpat as flood storage with the Shamushang pumping to the Nambul, and publishes the levels of the valley's river gauges. A pat or pukhri has no gate of its own unless it drains through WRD's works, so WRD is the custodian this chapter names where a clause speaks of levels, a datum, freeboard or an operating rule; the level of Loktak is held by NHPC's Ithai barrage and the lake is the Loktak Development Authority's, and these and the other custodians are recorded one by one in the inventory (Annex 7A).

This Manual treats every recorded waterbody as drainage infrastructure. Six features set Manipur apart. The first is the **closed valley with one outlet**: every river of the Imphal valley, the Imphal, the Iril, the Thoubal, the Nambul, the Kongba, the Sekmai, the Khuga and the rest, runs to Loktak and leaves the valley as the Manipur river past the Ithai barrage and a rock sill below it, the "Sugnu hump", where the bed rises from 756.7 m to 763.7 m in about 800 m (MASTEC). The rivers are held in by river bunds (pan, the Manipuri word for a bund or embankment), and Imphal drains through sluices (ithong, a sluice gate or floodgate) that close when the river is high, so the outfall is normally shut in the monsoon (Chapter 5). The second is **Loktak**, 236.21 km² under its Act, with its Core Zone and Buffer Zone and its **phumdi**, the floating mats that the Act defines as a "heterogeneous mixture of vegetation, organic debris and soil in floating condition"; it is a Ramsar site, designated on 23 March 1990 and placed on the Montreux Record on 16 June 1993 (both as reported). The third is the **pats** (pat, the Manipuri word for a lake or wetland, as in Lamphelpat), the valley's natural storage: "there were nearly 500 lakes in Manipur Valley", among them Lamphelpat, Porompat, Takyelpat, Sangaipat, Kharungpat and Ikop pat, many degraded or gone (MASTEC), and the valley "was once full of swamps and marshy land represented by the places having the word PAT meaning lake" (CGWB, 2013); Lamphelpat is now a pat being developed as flood storage, with a pumped outlet to the Nambul. The fourth is the **pukhris** (pukhri, the Manipuri word for a pond; plural pukhris), the ponds of the towns and villages, among them the public ponds of the 20 water-body rejuvenation projects of AMRUT 2.0 (TPD, 2025-26), which this Manual keeps apart from the pats. The fifth is **paddy land**, which on the valley floor is flood storage: the flood of 1989 lay on 97,500 ha of paddy (MASTEC), and the land behind the bunds stores the town's runoff while the sluices are shut. The sixth is the **hill streams** (khong, a stream), which leave the hills that make up 70% of the valley's catchment (MASTEC) and "flow down with steep slope for a short distance before meeting the Loktak Lake … load carrying capacity is high which causes siltation of the lake" (MASTEC). Manipur has no irrigation tank cascades; the tank clauses of this chapter apply to pukhris, to pats that drain through a channel or a sluice, to the reservoirs, and to Loktak as held by the barrage, and storage built under this Manual is a "detention pond", never a pukhri or a pat. Because the storm drains are also the sewers (Clause 8.9, Commentary), most pats and pukhris in the towns receive sewage. This chapter gives the design rules that protect the storage and conveyance of these waterbodies. It does not replace the bye-laws, the Loktak Act, the paddy-land and wetland Act, the master plans and the wetland procedures that record and protect them, or the directions of the High Court of Manipur, the National Green Tribunal and the Supreme Court.

7.2 Definitions

Term	Meaning in this Manual
Waterbody	A river (turel, a river), such as the Imphal, the Iril, the Thoubal, the Nambul, the Kongba, the Sekmai, the Wangjing, the Nambol, the Khuga and the Chakpi, which run to Loktak or to the Manipur river, by which the valley drains past the Ithai barrage, and, in the west, the Barak, the Jiri, the Makru, the Irang, the Leimatak and the Tuivai; hill stream (khong, a stream), which brings water, silt and debris from the hills that ring the valley; city channel, such as the Naga Nullah, the Waisel Maril and the Shamushang nallah in Imphal; pat (a natural lake or wetland), such as Loktak, Lamphelpat, Utra Pat, Yaral Pat, Waithou–Phumnom Pat, Pumlen–Khoidum Pat and Ikop–Kharung Pat, and the wetland of Khonghampat; pukhri (a pond), dug or small standing water, such as the public ponds of the towns; the floating mats of vegetation (phumdi) of Loktak and the pats; paddy land, with its drainage channels, ponds, bunds and ridges; the land ponded behind a river bund (pan) when its sluice (ithong) is closed; reservoir, such as the Thoubal (Mapithel) and Khuga reservoirs, with its drawdown zone; spring; retention pond or basin built for flood storage; supply channel or surplus course, perennial or seasonal (as in Chapter 1).
Tank (pukhri)	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 (overflow, outlet or spillway, or the control at the head of the channel or sluice (ithong) by which a pat drains) of a tank, or the permanent crest of its regulating structure. The tank holds water up to FTL without spilling.

Term	Meaning in this Manual
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 (feeder stream (khong), channel or drain)	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 (ithong), regulator or flap gate, including a sluice through a river bund (pan))	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.
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).

Manipur terms. The following terms are used in this chapter in addition to those above (see also Annex 7E). Manipuri terms are given in Latin transliteration; their forms in Meetei Mayek belong to the Manipuri edition of this Manual.

Term	Meaning in this Manual
Pat	A natural lake or wetland: *pāt*, "n. lake" (Sharma, *Learners' Manipuri-English Dictionary*, 2006, p. 114), the word in the names of Lamphelpat, Utra Pat, Yaral Pat and the other pats of the valley. First used in this Manual as "pat (Manipuri: a lake or wetland, as in Lamphelpat)". A pat that drains through a channel, a sluice or a pumped outlet is a tank under Clause 7.2: its FTL is the crest or sill of that outlet, found by survey, and its MWL is set under Clause 7.2 with the outfall closed where Clause 5.8.5 so requires. A pat with no outlet is a wetland under Clause 7.12. Lamphelpat is a pat being developed as flood storage, not a detention pond. A natural lake or wetland is never called a pukhri, and storage built under this Manual is never called a pat.

Term	Meaning in this Manual
Pukhri	A pond: *pukhri*, "n. pond" (Sharma, 2006, p. 117, checked on the printed page), with no other sense; it names dug or small standing water. First used in this Manual as "pukhri (Manipuri: a pond; plural pukhris)". Meeteilon marks the plural with suffixes, so the English plural "pukhris" is a convention of this Manual. A pukhri with an outlet pipe, sluice or overflow is a tank under Clause 7.2, and its FTL is the crest of that outlet or overflow, found by survey; a pukhri with no outlet has its FTL at the level at which it would spill to the ground around it, found by survey. Engineered storage built under this Manual is a "detention pond", never a pukhri.
Turel; khong; city channel	A turel is a river (*turen*, "n. a river … Variant: turel", Sharma, 2006, p. 81), as in "Imphal Turel"; a khong is a stream (Sharma, 2006, p. 54, where the same word also means "mine"), and in this Manual always a hill stream or a natural stream of the valley; a city channel is a natural or former stream of a town, lined, narrowed or built along, such as the Naga Nullah, the Waisel Maril and the Shamushang nallah in Imphal. Every river, khong or city channel that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whatever its name and whether it is lined, piped or covered. A hill stream carries silt and debris in flood: its inlets and culverts take the racks, bulking and blockage of Clause 6.3.6(f) to (h), and where it reaches the valley floor it passes a silt trap (Clause 6.3.6(m)). These readings are set by this Manual.
River bund (pan); sluice (ithong)	A river bund is a flood embankment along a river, *pan*, "a bund; embankment" (Sharma, 2006, p. 111), such as the bunds that hold the Imphal, the Nambul and the Iril through Imphal and carry its embankment roads. A sluice is a gated outlet through a bund, *ithong*, "floodgate; sluice gate" (Sharma, 2006, p. 20), with or without a flap gate. No Manipur statute on embankments was found (NEER reading): WRD holds the bunds and sluices as owner, and no one other than WRD, or a body acting under its written consent, opens, shuts or alters a sluice or cuts a bund under this Manual.
Phumdi; athaphum	Phumdi are the floating mats of Loktak and the pats: "'Phumdis' means heterogeneous mixture of vegetation, organic debris and soil in floating condition", and "'Athaphum' mean long strip of Phumdis in circular shape in floating condition, planted or cultured artificially for catching fish" (Manipur Loktak Lake (Protection) Act, 2006, s.2). Phumdi block outlets, screens and channels (Chapter 9); no outfall, screen or channel is designed on the assumption that they are absent, and no phumdi or athaphum is removed, planted or moved under this Manual within the lake except as the Act and the Loktak Development Authority allow.
Ponded area behind a river bund	The land inside a river-bunded area that is flooded when its sluices are closed, up to the level reached in the outfall-closed case of Clause 5.8.5(a) for the 1% AEP storm. It is recorded in the inventory (Annex 7A), and that level is part of the 1% AEP flood extent of Clause 7.3.4; Zone 1 applies to the pats, pukhris and channels within it, not to the ponded area as a whole. This definition is set by this Manual.
Valley paddy land and wetland as flood storage	On the Imphal valley floor (sub-areas MN-A and MN-A1 of Annex 2A), paddy land and wetland as section 2 of the Manipur Conservation of Paddy Land and Wetland Act, 2014 defines them, with their "drainage channels, ponds, canals, bunds and ridges" (s.2(c)), and every former pat, are flood storage for this Manual. Where such land is filled or built on, the storage lost below the 1% AEP flood level, or below the level of the ponded area behind a river bund in the outfall-closed case of Clause 5.8.5(a) where that is higher, is replaced as **compensatory storage** under Clause 7.6.4: volume for volume in each band of not more than 0.3 m, in the same sub-catchment and draining to the same river, pat or pumped outfall, built before or with the fill, and secured by covenant. Where the land drains to a pumped outfall, the replacement drains by gravity to the ponded area that the pumps serve, and the "no pumping" of Clause 7.6.4(d) applies between the replacement and that area. The replacement is not counted as detention (Clause 7.6.5), and it does not make a conversion lawful: the approval of the committees under the 2014 Act is still needed, and no local authority may licence construction on land converted in contravention of it (s.12). This rule is set by this Manual.
Loktak zones	The Core Zone, of 70.30 km², is "the No-Development Zone or Totally Protected Zone", and the Buffer Zone is "the remaining area of the lake excluding Core Zone area" (Manipur Loktak Lake (Protection) Act, 2006, s.3), within the 236.21 km² of section 1(3). Their boundaries are recorded in the inventory (Annex 7A) as the Act and its Rules draw them (the Rules were not read [TBC]); the Act does not reach the rivers and land upstream of that area (NEER reading).
Recorded waterbody	A pat, pukhri, river, khong, city channel, marsh, reservoir or ponded area shown in any source of Clause 7.3.3(a): a land record, the inventory of about 4,000 water bodies made after the National Green Tribunal's order in M.A. 26/2019, the Wetland Atlas (2021), a delineation or draft notification of the Manipur State Wetlands Authority, a master-plan map, the Loktak Act, WRD'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.
Boundary of a pat or pukhri	For this Manual, the boundary of a pat or pukhri under Clauses 7.3.3 and 7.13.1 is the largest of its boundary in the land records, inventory or notification, 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. For Loktak it is the larger of the 236.21 km² of the Act and that edge. This reading is set by this Manual.

Term	Meaning in this Manual
Reference lines for setbacks	Four lines are used, and the setback that reaches furthest from the water governs: (a) the mid-stream line of a river in the table of bye-law 93 of the Model, with that bye-law's distance; (b) the outer (landward) toe of the bund on such a river, with the bye-law's 6 m, where the table applies it; (c) the top of bank of a channel or the boundary of a pat or pukhri, with Zone 1 of Clause 7.4.3, except that **on a bunded reach Zone 1 is measured from the landward toe of the bund**; and (d) the 1% AEP flood extent of Clause 7.3.4, found with the outfall closed where Clause 5.8.5 so requires, with the 10 m of Clause 7.4.4. The landward toe is used on a bunded reach because there the bund, not the natural bank, is the edge of the flood channel, with the river standing against it at flood level; because bye-law 93 already measures from the outer toe of the bund, so that both lines start from one surveyed line; because the strip at the landward toe is where seepage, piping and breaches show and are repaired, as the breaches of 2024 and 2025 were (as reported); and because many bunds carry the embankment roads, on which a line from the river-side bank would fall. This rule is set by this Manual.
Patta land and landholding	On the valley floor most land is patta land, held under the land records of the Revenue Department; some is government land, and State khas land in a master-plan area vests in PDA Manipur. Zone 1 land that is private patta land is reserved in the master plan, for which the use zone "Pond, Drain, Rivers and Canals" of the Unified Zoning/Use Regulation Bye-laws, 2026 is the hook, or secured by a written agreement with the owner, and is not taken. In the hill areas, where land is allotted under section 29 of the Manipur (Hill Areas) District Councils Act, 1971 and held under customary tenure, it is secured through the District Council's land allotment powers (not researched [TBC]). 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 Revenue Department, 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 (IMC or another urban local body (for the municipal drains within its limits, and for the public ponds of the AMRUT 2.0 water-body rejuvenation projects, which the municipal councils carry out), PDA Manipur (for State khas land, which vests in it within a master-plan area under the Manipur Town and Country Planning Act, 1975), WRD (for the river bunds, flood channels and sluices it holds, for Lamphelpat, which it is developing as flood storage, and for the Shamushang pumping to the Nambul), the Loktak Development Authority (for Loktak within the 236.21 km² of the Manipur Loktak Lake (Protection) Act, 2006), NHPC (for the Ithai barrage, which holds the lake's level; the Act does not apply to the Power Department acting under its agreements with NHPC, s.36), PWD and the national-highway agencies (for the drains and culverts of their roads), PHED (for sewers and water-supply intakes), the Directorate of Environment and Climate Change (for the interception and diversion works of the Nambul), the Forest, Environment and Climate Change Department (for forest land), the Revenue Department and the Deputy Commissioner (for government land recorded as water), the Gram Panchayat, a private owner (for a pukhri or pat on patta land), the District Council or a Village Authority in the hill areas (not researched [TBC]), the Manipur State Wetlands Authority (for a notified wetland; none is final), 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) land records of the Revenue Department under the Manipur Land Revenue and Land Reforms Act, 1960 in the valley, kept by district, sub-division, revenue village and patta, including government land recorded as water; in the hill areas, where land is allotted under section 29 of the Manipur (Hill Areas) District Councils Act, 1971 and held under customary tenure, the records of the District Councils and Village Authorities (not researched [TBC]); the inventory of about 4,000 water bodies prepared after the National Green Tribunal's order of 22 May 2020 in M.A. 26/2019, for which "Ground truthing, engineering surveys, and quality monitoring … are pending" (DoECC, 2025-26); the Space Applications Centre's Wetland Atlas (2021), with 132 wetlands larger than 2.25 ha; the 71 wetlands delineated and 3 demarcated by the Manipur State Wetlands Authority in 2025-26, and its draft notifications of the Yaral, Utra and Waithou–Phumnom pats; the land-use maps of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification), with its water bodies and ponds (about 502.95 ha), river bed (about 76.85 ha) and wetlands, and of the GIS master plans of the other towns; the 236.21 km² of Loktak and its Core Zone of 70.30 km² under the Manipur Loktak Lake (Protection) Act, 2006; WRD's records of its river bunds, sluices and pumping stations, and its river gauges; and each town's drain register (Chapter 6);
- (b) WRD and Gram Panchayat or, in the hill areas, 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 WRD records use a local or older datum, the conversion to the project datum shall be surveyed and stated.

> Commentary. Manipur has a floodplain law but no flood line. The **Manipur Flood Plain Zoning Act, 1978** (Manipur Act 10 of 1978; assent 26 August 1978; Manipur Gazette Extraordinary No. 185 of 1 September 1978; read from the OCR of a truncated copy, sections 1 to 7 only) lets the State declare that flood plain zoning "shall be made", direct a survey of a river by the Deputy Commissioner "or such other authority", and have the Flood Zoning Authority "delineate the areas which are subject to [flooding] … with reference to relative risk"; it defines a flood zone as "the area which is required to carry the [flow] of the maximum probable [flood]" (OCR damaged), and its provisions other than section 1 come into force on dates to be appointed. No Flood Zoning Authority was found constituted and no zone notified: demarcation "is yet to be done" (as reported, June 2026), although an eviction order along the channels of the Imphal river in April 2025 cited "Section 24" of the Act (as reported; section 24 was not read [TBC]). Bye-law 94 of the Model ties the plinth to "high Flood Risk Areas identified in the Master Plan of the towns"; the Risk Informed GIS Based Master Plans for Imphal and Moirang, where those areas would be shown, are listed as finally notified on 17 January 2025, while the Town Planning Department's report for 2025-26

says their draft report "has been submitted" (the two conflict), and neither plan was read [TBC], so this Manual cannot say where bye-law 94 applies. The AIIB found 35% of Imphal "prone to floods" (APD, 2024), but no flood map was found. The levels that exist are WRD's river gauges, as printed in the press (datum not stated [TBC]): at Minuthong on the Imphal river a highest flood level of 788.400 m, exceeded on 29 May 2024; at Lilong 782.850 m, exceeded at 783.250 m on 15 September 2025; at the Ithai barrage 769.320 m, exceeded at 770.05 m on the same day; and at Thong Nambonbi (Hump Bridge) on the Nambul 783.695 m (all as reported; Chapter 5). CWC has one site in the State, on the Barak at Chotebekra, with a highest flood level of 32.1 m on 31 July 1989 (as reported). No "highest flood level" fixed by a local authority was found for any town [TBC], and the readings of September 2025 rose above two of the printed ones. Clause 7.3.4 lets the Authority adopt 1% AEP maps; a map prepared under this Manual is offered as an input to any future zoning under the 1978 Act and to the risk-informed master plans, not as a zone or a notification under either. Until maps are adopted, the Applicant produces the 1% AEP extent for larger and flood-sensitive sites with the outfall closed as Clause 5.8.5 requires, because behind a river bund the flood extent is set by the ponding behind a shut sluice, and by the paths of bund breaches, as often as by the river; and a highest flood level stated in a permission is a minimum that the 1% AEP extent of this Manual, with the climate factor, may exceed but never reduce. Levels shall be stated to one datum (Clause 7.3.5) and tied to the WRD or CWC gauge. 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 and round every pat and pukhri, measured on a bunded reach from the landward toe of the bund (definitions after Clause 7.2) (wider lines govern under Clause 7.4.5 where they bind: bye-law 93 of the Model Manipur Unified Building Bye-Laws, 2024, where a local body has brought it into force, bars new construction within 55 to 62 m of mid-stream on the Imphal river, 50 m on the Iril, 48 m on the Thoubal, 35 m on the Sekmai and the Kongba, 31 m on the Wangjing, 30 m on the Nambul within Greater Imphal and on the Arong, 25 m on the Nambol and 22.5 to 28 m on the Merakhong, on most of these rivers "or 6 m from outer toe of bund, whichever is further from mid-stream"; it sets no line for any other river or stream, for any pat or pukhri, or in the hill areas; the Core Zone of Loktak is a no-development zone under the Manipur Loktak Lake (Protection) Act, 2006; and no flood zone has been notified under the Manipur Flood Plain Zoning Act, 1978; 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 the prior permission of the Loktak Development Authority within the 236.21 km² of the Manipur Loktak Lake (Protection) Act, 2006, whose Core Zone is a "No-Development Zone or Totally Protected Zone" (s.3) and in whose Buffer Zone "Land reclamation, bunding or disturbing the natural course of drainages" is barred (s.19(vi)); the leave of the High Court of Manipur for development in or around Loktak under its special bench orders of 17 July 2019 and 25 February 2022 (as reported; the case number was not found [TBC]); a condition of WRD for a work on, through or next to a river bund, flood channel, sluice or pumped outfall that it holds (as owner; no Manipur embankment statute was found); the permission of a Flood Zoning Authority under the Manipur Flood Plain Zoning Act, 1978 in a prohibited or restricted area (bye-law 93 of the Model; no Authority has been constituted and no area notified); a decision of the Local, District or State Level Committee under the Manipur Conservation of Paddy Land and Wetland Act, 2014; the views or permission of the Manipur State Wetlands Authority for a wetland notified under the 2017 Rules (none is final); a line of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification) or another master plan, such as land in the use zone "Pond, Drain, Rivers and Canals" of the Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026; or a direction of the High Court of Manipur, the National Green Tribunal or the Supreme Court 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 where no wider line binds. Manipur's distances from water are in its building rules: bye-law 93 of the Model Manipur Unified Building Bye-Laws, 2024 (MAHUD Notification No. BBL-101/1/2024-MAHUD-MAHUD-Part(1) of 4 December 2024; Manipur Gazette Extraordinary No. 253 of 5 December 2024), which binds only where an urban local body or PDA Manipur has brought it into force in its own bye-laws, prohibits "any new construction within the designated buffer zone" along ten named rivers, reach by reach, measured from mid-stream: 55, 60 and 62 m on three reaches of the Imphal river, 50 m on the Iril, 48 m on the Thoubal, 35 m on the Sekmai, 31 m on the Wangjing, and 30 m on the Nambul within Greater Imphal and on the Arong, each "or 6 m from outer toe of bund, whichever is further from mid-stream", and, from mid-stream only, 35 m on the Kongba, 25 m on the Nambol and 22.5, 24.2 and 28 m on three reaches of the Merakhong. It names no other river or stream and no pat or pukhri, and because it is measured from mid-stream, a 30 m buffer on a reach 40 m wide leaves 10 m beyond the bank (NEER reading). The 15 m floor is measured from the top of bank, or on a bunded reach from the landward toe of the bund, so it is stricter than the bye-law's 6 m wherever the bund stands well back from the river and on narrow reaches, and it reaches every channel, pat and pukhri that the table omits; on the wide bunded reaches the bye-law's distances

usually reach further and govern (NEER reading). It applies to new development and redevelopment approved under this Manual, not to existing buildings; and where Zone 1 land is private patta land, it is reserved in the master plan or secured by agreement with the owner, not taken (in the hill areas, through the District Council's land allotment powers [TBC]). It is this Manual's proposal, not a statutory width, and it never reduces a wider line (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 Manipur flood maps are mostly coarser than US maps, the Imphal valley is "virtually a flat alluvium filled valley … with a very low southerly gradient" (MASTEC), and Imphal's ground, at about 790 m (AIIB, 2024), lies within a metre or two of the high flood level of the Imphal river at Minuthong, 788.400 m (WRD, as reported; NEER reading) (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).

Manipur's setbacks from water are in its building bye-laws and its lake Act. Bye-law 93 of the Model Manipur Unified Building Bye-Laws, 2024, "Flood risk prone areas", reads: "Prohibit any new construction within the designated buffer zone to minimize human exposure to flood risk and preserve the natural integrity of natural ecosystems", and gives a table, the same for the left and right banks: the Imphal river from Koirengei to Lilong, 55 m; from Lilong to Sekmaijin, 60 m; from Sekmaijin to Ithai, 62 m; the Wangjing from the Heirok bridge to Kharungpat, 31 m; the Nambul within Greater Imphal, 30 m; the Iril from Sawombung to Lilong, 50 m; the Thoubal from Yairipok to Irong Ichil, 48 m; the Sekmai from the Pallel bridge to its confluence with the Imphal river at Sekmaijin, 35 m; and the Arong from Charangpat to Ikop pat, 30 m, each "from mid-stream or 6 m from outer toe of bund, whichever is further from mid-stream"; and, from mid-stream only, the Merakhong 22.5 m (Yurembam to the Tiddim Road crossing), 24.2 m (to Langpok) and 28 m (Langpok to Chingphu), the Kongba 35 m (Chairenthong to Kiyamgei) and the Nambol 25 m (Maklang to Heikrujam and Heikrujam to Yangoi). It ends: "No person shall undertake any activity within the prohibited area or restricted area except with the previous permission of the Flood Zoning Authority constituted under the Flood Plain Zoning Act, 1978". The draft IMC Building Bye-Laws (3rd Amendment), 2024 repeat the table as bye-law 93.1 (draft; final status not confirmed [TBC]). The Model binds only where an urban local body or PDA Manipur has brought it into force in its own bye-laws (Chapter 1), and its numbering may differ there [TBC per body]. Bye-law 16 adds that a masonry building "shall not be constructed or extended, over any municipal drain or land", and bye-law 94 sets the plinth "above 1m above the highest flood level of the surrounding areas" in "high Flood Risk Areas identified in the Master Plan of the towns" (Clause 7.3, Commentary). Round Loktak the Manipur Loktak Lake (Protection) Act, 2006 makes the Core Zone of 70.30 km² "the No-Development Zone or Totally Protected Zone" (s.3), bars in the Buffer Zone, among eight items, "Land reclamation, bunding or disturbing the natural course of drainages" and "Construction activities in ecologically sensitive areas as specified in the notification" (s.19(vi) and (vii)), and, in the Core Zone, bars anyone from building "any hut or house on phumdis inside the lake" without the Authority's prior permission

(s.20(iv)); the High Court of Manipur's special bench ordered on 17 July 2019, and reaffirmed on 25 February 2022, that no development or construction take place in or around Loktak "without the Court's leave" (as reported; the case number was not found [TBC]). The rules leave gaps for drainage: bye-law 93 measures from mid-stream, so that a 30 m buffer on a reach 40 m wide leaves 10 m beyond the bank (NEER reading); its 6 m from the outer toe of the bund is narrow for a bund that must be patrolled and repaired; it names ten rivers and none of their tributaries, hill streams, city channels such as the Naga Nullah and the Waisel Maril, the Khuga or the Chakpi; **no setback from any pat or pukhri** was found in the bye-laws (NEER reading), and none from a wetland outside Loktak, because no wetland has yet been notified under the 2017 Rules; no Flood Zoning Authority has been constituted and no "prohibited area or restricted area" notified, so the bye-law's last sentence has nothing yet to work on (NEER reading); and in the hill areas no building rule applies at all. Clause 7.4.7 makes 15 m the floor of Zone 1 everywhere the Manual applies.

Disclosure. Manipur **has a named-river buffer in its building bye-laws, but it is measured from mid-stream, it names ten rivers and none of the pats, pukhris, hill streams or city channels, and it binds only where a local body has adopted the Model**: bye-law 93 of the Model Manipur Unified Building Bye-Laws, 2024 bars new construction within **55 to 62 m of mid-stream on the Imphal river, 50 m on the Iril, 48 m on the Thoubal, 35 m on the Sekmai, 31 m on the Wangjing and 30 m on the Nambul within Greater Imphal and on the Arong, "or 6 m from outer toe of bund, whichever is further from mid-stream"**, and **35 m on the Kongba, 25 m on the Nambol and 22.5 to 28 m on the Merakhong from mid-stream only**; it is in force only where an urban local body or PDA Manipur has brought the Model into force in its bye-laws [TBC per body]; **no Flood Zoning Authority has been constituted and no flood zone or "prohibited" or "restricted" area notified** under the Manipur Flood Plain Zoning Act, 1978 (none found); **no pat or pukhri buffer** exists in the bye-laws; and the three wetlands that the Manipur State Wetlands Authority has published in draft, the Yaral, Utra and Waithou–Phumnom pats, are **not yet notified**, so no prohibition under rule 4 of the Wetlands (Conservation and Management) Rules, 2017 applies to them (NEER reading). 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 where nothing wider binds: along every natural channel draining 8 ha or more, river, khong or city channel, whether or not the bye-law names it, round every pat and pukhri, and, **on a bunded reach, measured from the landward toe of the bund**. So are the setback zones of Clause 7.4, the 1% AEP extent that governs Zone 2, this Manual's four reference lines, its reading of the boundary of a pat or pukhri, of the ponded area behind a river bund and of valley paddy land as flood storage, and its compensatory storage for converted paddy land and wetland (definitions after Clause 7.2). They are **this Manual's proposal, not a statutory width or rule**, and no government body, Authority, committee, District Council or Village Authority has adopted or endorsed them. **The comparison runs both ways.** On the wide bunded reaches of the rivers in the table, the bye-law's 30 to 62 m from mid-stream, or its 6 m from the outer toe of the bund, usually reach further than Zone 1 and govern (NEER reading); the Manual's 15 m from the landward toe of the bund is **stricter than the bye-law's 6 m** wherever the bund stands well back from the river, and on narrow reaches, where the mid-stream distance falls on the bund or inside it; and on every river, stream, channel, pat and pukhri that the table omits, among them the Khuga, the Chakpi, the hill streams, the Naga Nullah and the Waisel Maril, the pats and the pukhris, the Manual's 15 m governs alone. It applies to **new development and redevelopment approved under this Manual, not to existing buildings**; Clause 7.4.7 allows no variance below it; and where Zone 1 land is private patta land, it is **reserved in the master plan or secured by agreement with the owner, not taken** (in the hill areas, through the District Council's land allotment powers [TBC]). The setback is applied as **whichever of the four reference lines and its setback reaches furthest** (definitions after Clause 7.2), so the Manual is stricter than statute along the pats, pukhris, hill streams and city channels and at bunds that stand back from the river, and no less strict anywhere. What exists, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **The building bye-laws on the Model.** The distances of bye-law 93 above, which the Applicant states on Form 7-1, measured from mid-stream; bye-law 16, no building over a municipal drain; and bye-law 94, the plinth more than 1 m above "the highest flood level of the surrounding areas" in the "high Flood Risk Areas identified in the Master Plan of the towns", which were not read [TBC]; this Manual's floor of the 1% AEP level plus 0.5 m (Clause 7.6.6(b); Chapter 6) governs where it is higher. The Model defines a basement (bye-

law 2(11)) but **no rule keeps basements off low-lying or flood-prone land** (NEER reading); on the valley floor this Manual allows a basement only under its flood-sensitive rules and with a flotation check at ground level (Chapter 4).

- **Loktak.** The Core Zone of 70.30 km², a "No-Development Zone or Totally Protected Zone" (s.3), and the bans of the Buffer Zone, among them "Land reclamation, bunding or disturbing the natural course of drainages" (s.19(vi)), under the Manipur Loktak Lake (Protection) Act, 2006, with the prior permission of the Loktak Development Authority (s.20); and the High Court's special bench orders of 17 July 2019 and 25 February 2022 against development in or around Loktak "without the Court's leave" (as reported; case number not found [TBC]).
- **Paddy land and wetland.** Conversion only through the Local, District and State Level Committees under the Manipur Conservation of Paddy Land and Wetland Act, 2014, with no licence for construction on land converted in contravention (s.12) and imprisonment of three to five years and a fine of ₹50,000 to ₹2 lakh (s.18); the (Third Amendment) Bill, 2026 is a Bill, not law [TBC].
- **Master plans and zoning.** The use zone "Pond, Drain, Rivers and Canals" of the Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026, and the lines of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification) and the other GIS master plans; the risk-informed master plans for Imphal and Moirang were not read [TBC].
- **Wetlands, courts and custodians.** Any wetland notified under the 2017 Rules (none is final); the orders of the High Court of Manipur, the National Green Tribunal and the Supreme Court as they stand; and WRD's lines at its bunds and sluices.

This Manual sets 15 m as the floor because the bye-law's line, measured from mid-stream, can leave only a few metres beyond the bank or the bund; because the pats, pukhris, hill streams and city channels, which carry and store most of the towns' water, have no line at all; because a bund needs a strip at its landward toe for patrol, seepage control and breach repair, which the breaches of the Imphal, Nambul and Iril bunds in 2024 and 2025 needed (as reported); and because 15 m is above the smallest APWA default stream buffer (12 m) from which Table 7.1 is scaled. The reasons for the corridor are the record: "The town is below the high flood level of Imphal river" (master plan); "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, APD, 2024); 18 embankment breaches were reported in the Remal floods of 28 to 31 May 2024, 17 of them sealed (as reported); the market waste dumped in the Naga Nullah "creates a stagnant pool all along the year" (master plan); and the clogging of the Naga Nullah flooded Nagaram, Laipham Khunou and Lairikyengbam Leikai in July 2024 (as reported). Until a bye-law amendment, a master plan, a notification under the 1978 Act or the Wetlands Rules, or a court adopts it, the 15 m minimum is this Manual's recommended standard, and the bye-laws, the Loktak Act, the paddy-land Act, the master plans and the orders above remain the only legal minimum. Approving authorities should state in each approval which was applied.

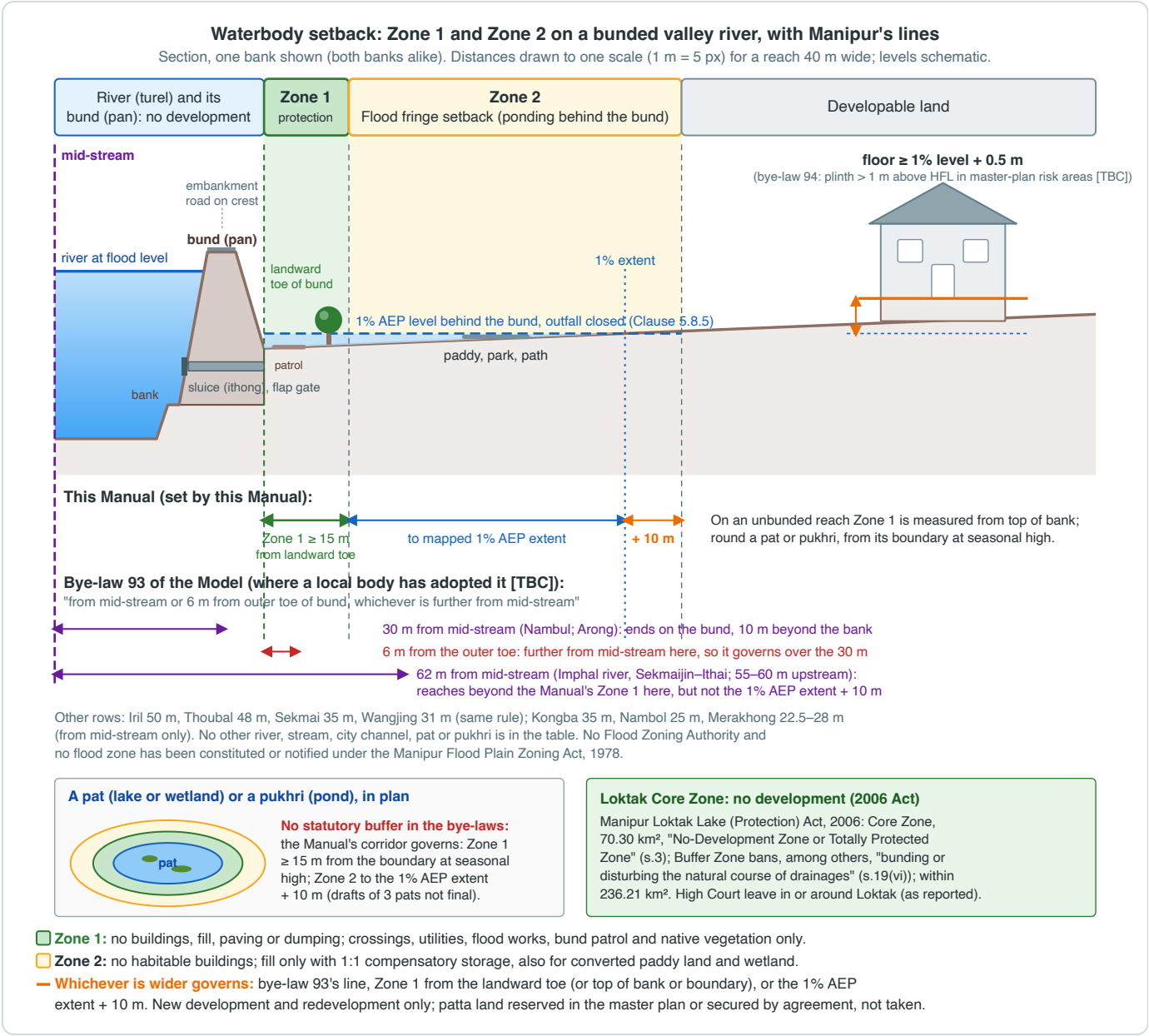

Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).

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 Model Manipur Unified Building Bye-Laws 2024, 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 Imphal valley 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 Imphal valley floor is flat, its towns lie at or below the high flood level of the rivers behind their bunds, and the Loktak margin is held at the lake's level by the Ithai barrage and the rock sill below it, so a small rise in level spreads flooding over a wide area, and many small encroachments along the same channel add up.
>
> In Manipur the land records fix a pat or pukhri by its recorded plot, and the Loktak Act fixes the lake by its area of 236.21 km², but nothing gives a line for the edge of a pat whose water spreads and shrinks through the year, or for the paddy land round it that floods with it. The difference matters because the valley's storage is being lost. "There were nearly 500 lakes in Manipur Valley", and Lamphelpat, Porompat, Takyelpat, Sangaipat, Kharungpat and Ikop pat are among those MASTEC lists as degraded or disappearing; Loktak, with its swamps 246.72 km² in MASTEC's figure against the Act's 236.21 km² (and "250 km²" in other sources, as reported; the figures conflict), is "becoming shallower" and its "water holding capacity" is "reducing" (MASTEC). The master plan for Greater Imphal plans for wetlands to fall from 374.48 ha to 232.21 ha and agricultural land from 5,616.53 ha to 2,604.70 ha between 2020 and 2043, and notes that "new areas need to be unlocked as the paddy fields cannot be used for construction" under the 2014 Act; a (Third Amendment) Bill, 2026 would exempt land that conforms to a master plan and allow "Deemed Conversion" on self-declaration (as introduced; not law [TBC]). Paddy land is flood storage in this valley: the flood of July and August 1989 lay on 97,500 ha of paddy, and that of August 2002 on 20,000 ha (MASTEC). A line drawn from the edge of the water in the dry months would leave a pat's own flood storage open to building, one drawn from today's edge would give up its lost area for good, and a conversion of paddy land approved without replacing its storage moves the flood onto the next field or street. This Manual therefore gives every pat and pukhri a boundary measured from a high level, not from the water's edge on the day of survey (definitions after Clause 7.2), treats the foreshore up to MWL as its flood storage, and requires the

storage of valley paddy land and wetland that is filled or built on to be replaced under Clause 7.6.4 (definitions after Clause 7.2). 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 Imphal, which "is below the high flood level of Imphal river" behind embankment roads on both banks (Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)) and of which 35% is "prone to floods" (AIIB, 2024) — Singjamei, Heingang, Bashikhong, New Checkon, Keirang, Khabam and Lairikyengbam Leikai, on the breach paths of the Imphal river in 2024 and 2025, and Nagaram and Laipham Khunou, flooded when the Naga Nullah clogged in July 2024 (all 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.

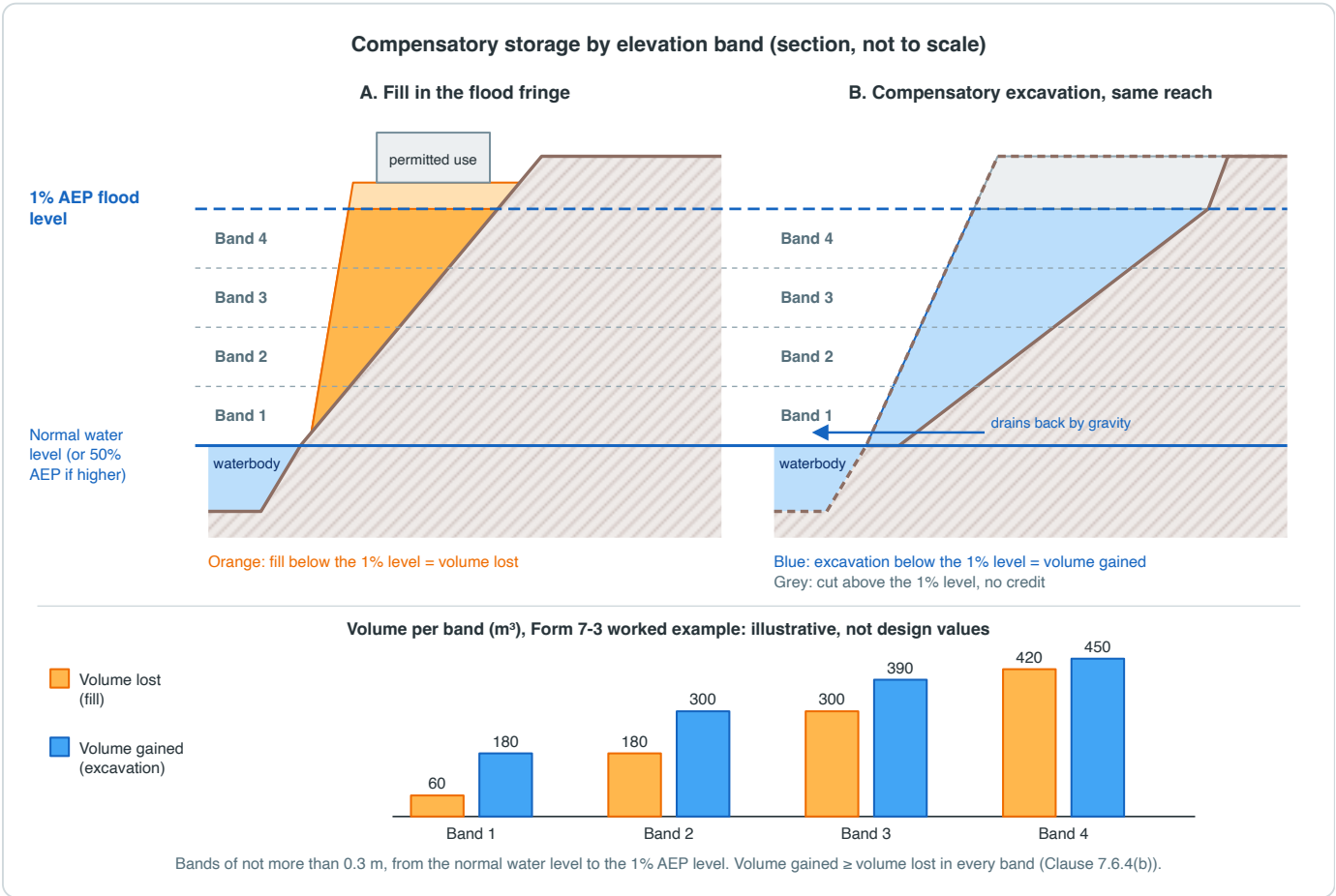

Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation 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

Manipur has no tank Act and no irrigation tank cascades; its valley pats lie in a chain that drains to Loktak, and the outlet of the whole valley is the Manipur river at the Ithai barrage. The storages that matter for urban drainage are of six kinds. The first is **Loktak**, the valley's terminal storage, held up by NHPC's Ithai barrage (Loktak hydroelectric project,

105 MW; commissioned in 1983 by most accounts, with 1979 and 1986 also printed, as reported; the dates conflict) at a full reservoir level of 768.5 m and a minimum drawdown level of 766.2 m (NHPC, as quoted; the CEA gives 766.01 m, and an ORF article gives 769.63 m and calls 768.50 m the "flood level", as reported; the figures conflict), and by the rock sill of the "Sugnu hump" below it (MASTEC); "At Ithai, flow of the Manipur river during monsoon is of the order of 400 cumecs and river down below the barrage does not have the capacity to cope up with such flow, as a result, water is piled up upstream" (MASTEC). The second is **Lamphelpat**, a pat being developed as flood storage with a pumped outlet: WRD is dredging a waterbody of "around 300 acres" under a work order of 9 November 2023, with "provision for pumping of flood water from the Lamphel pat water body to the Nambul River through Shamushang Nalla during high flood season" (WRD's site report in High Court PIL No. 8 of 2025), and the NDB's summary describes a project to "increase its water detention capacity, restore stormwater drainage system" with a "real time flood management system with a command center" (USD 87.84 million, loan USD 70.27 million; concept approval 17 November 2021); its cost, area and funders in the press conflict (as reported); no stage–storage relation or design storm was found [TBC]. The third is the **other pats** of the valley, among them the Manipur State Wetlands Authority's priority wetlands, Utra Pat, Yaral Pat, Waithou–Phumnom Pat, Pumlen–Khoidum Pat and Ikop–Kharung Pat, and the wetland of Khonghampat; no levels, areas or outlet records were found for any of them [TBC]. The fourth is the **reservoirs** of the hills that feed the valley, the Thoubal (Mapithel) reservoir, with a full reservoir level of 880.7 m (WRD, September 2025, as reported) and a spillway designed for 2,240 cumec (as reported), and the Khuga reservoir, for which no levels were found [TBC]. The fifth is the **pukhris**, the ponds of the towns and villages, among them the public ponds of the 20 water-body rejuvenation projects of AMRUT 2.0 (₹4.11 crore; work in progress at 19, TPD, 2025-26); no levels or outlet records were found for them [TBC], so their storage is modelled as an existing feature and not counted unless Clause 7.7.1 is met. The sixth is the **ponded area behind a river bund** and the **paddy land** round the pats, which store the town's runoff while the sluices are shut (definitions after Clause 7.2); they are modelled as existing features where they intercept runoff but never counted as design storage, because they are not surveyed, have no controlled outlet and are full by the time of the peak storm. The inventory of about 4,000 water bodies made after the National Green Tribunal's order in M.A. 26/2019 still awaits "Ground truthing, engineering surveys, and quality monitoring" (DoECC, 2025-26). These are the waterbodies for which Figure 7.3 and Clause 7.8 matter: on the valley floor every drain ends in a channel, a pat or a river, every river behind a bund in a sluice that the river closes, and the whole valley in Loktak. Any pat, pukhri or reservoir whose storage is to be counted is subject to Clause 7.7.1 in full, with WRD where the outlet is its sluice or pump, with NHPC and the Loktak Development Authority for Loktak, and with the other custodian where it is neither, and the custodian of each 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.** WRD, 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 valley-floor town behind river bunds (pan), every pat and pukhri that stores its runoff, the paddy land that floods behind the bunds, the channels that join them, the outfall sluice (ithong), flap gate and pumps through the bund, and the river stage that closes the sluice, and, on the Loktak margin, the lake level held up by the Ithai barrage and the rock sill below it (Clause 5.8.5), 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 WRD'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. In Manipur the starting level of a pat is its outlet level because the outlet is shut when the river is high, and the starting level of Loktak is the lake's level as the barrage and the sill hold it. Lamphelpat "remains waterlogged for many days every year" despite pumping (NDB), and the rivers stand above their outfalls for days: the Imphal river at Minuthong rose above its printed highest flood level of 788.400 m on 29 May 2024, and on 15 September 2025 the Imphal river at Lilong stood at 783.250 m and the Manipur river at the Ithai barrage at 770.05 m, above the printed highest flood levels of 782.850 m and 769.320 m (WRD, as reported); "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, APD, 2024). Loktak reached 768.5 m in August 2002 (as reported), and the CEA's readings of August 2026, about 767.46 to 767.73 m (as quoted), show its ordinary monsoon level. This Manual therefore takes the case that the adjoining edition of this series takes from a design report for its floodplain lakes behind sluices, in which the lake is full and the drain is also flowing full, as the rule for every pat or pond that drains through a sluice or a gated pumped outfall: it starts full to its outlet level (Clause 5.8.5(a) and (e)), and on the Loktak margin the lake starts at the design lake level of Clause 5.8.5(c), never below its full reservoir level from June to September. The Manual's season begins on 1 April because large falls come before the south-west monsoon as well as during it (Imphal (Tulihal) 105.9 mm on 16 April 2004 and 122.4 mm on 27 May 1956, IMD), and the floods of 28 to 31 May 2024 and 30 May to June 2025 came before its normal onset on 5 June (as reported), so a pat or pukhri may be full at any time from April to October. No record of how long any pat stays at or above its outlet level in a wet spell, or of how long any sluice stays closed, was found [TBC]. While a pat is full and its sluice shut, it stores nothing more below FTL, and the drains and channels that flow into it discharge against its level. 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.

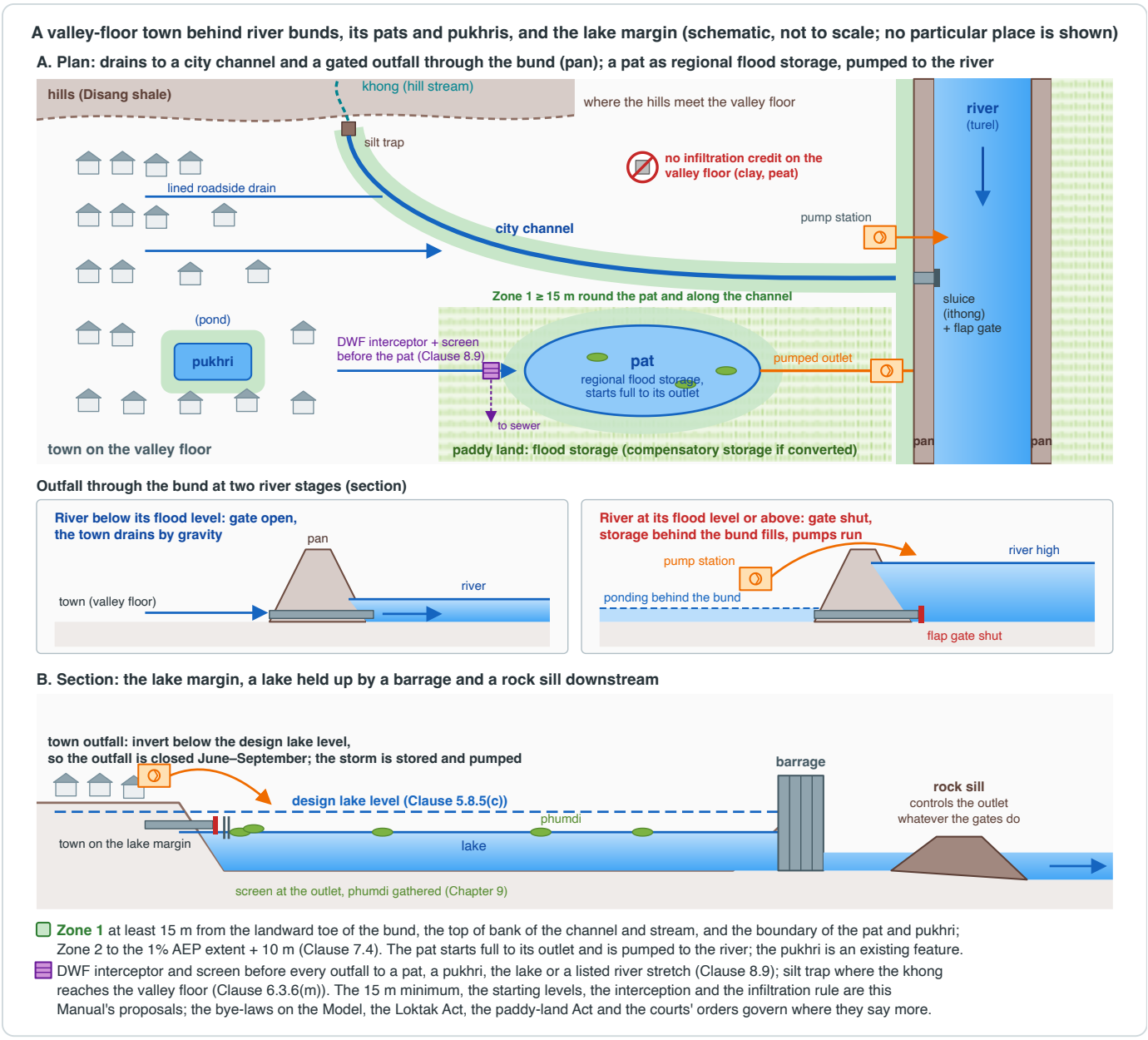

Figure 7.3 — A valley-floor town behind river bunds, its pats and pukhris, and the lake margin (schematic, not to scale; no particular town, pat, lake, barrage or landmark is shown). A: in plan, a town stands on the valley floor behind river bunds (pan). Its roadside drains fall to a city channel, which runs to a gated outfall through the bund, a sluice (ithong) with a flap gate on the river side and a pump station beside it (Clause 5.8.5(a); Chapter 9). When the river is below its flood level the gate is open and the town drains by gravity; when the river is at its flood level or above, the gate is shut, the storage behind the bund fills and the pumps run, and the outfall is designed for the river stage and the outfall-closed duration of Clause 5.8.5, not for the storm alone. Part of the town drains to a pat, the natural lake or wetland that serves as regional flood storage, through a dry-weather-flow interceptor and a screen, because the drains carry sewage (Clause 8.9); the pat starts full to its outlet level and is pumped to the river over the bund (Clauses 5.8.5(e) and 7.7.3). A pukhri, a pond, stands in the town; it is modelled as an existing feature and counted as storage only under Clause 7.7.1. The paddy land round the pat floods when the sluices are shut and is flood storage: if it is converted and built on, its storage is replaced under Clause 7.6.4 (definitions after Clause 7.2). No infiltration is credited on the clay and peat of the valley floor (Clause 4.11, valley-floor rule). A hill stream (khong) from the hills passes a silt trap where it reaches the valley floor (Clauses 6.3.6(m) and 8.12). Zone 1 is at least 15 m from the landward toe of the bund, from the top of bank of the channel and stream, and from the boundary of the pat and the pukhri, and Zone 2 runs to the 1% AEP extent plus 10 m (Clause 7.4). B: in section through the lake margin, the lake is held up by a barrage downstream and by a rock sill below it; floating vegetation (phumdi) gathers at the screen of a town outlet (Chapter 9); and the design lake level of Clause 5.8.5(c) is marked on a town outfall, which is treated as closed from June to September where its invert lies below that

level, so that the town's storm is stored and pumped. The 15 m minimum, the landward-toe line, the interception rule, the starting levels, the compensatory storage for paddy land and the infiltration rule are this Manual's proposals; the building bye-laws on the Model, the Manipur Loktak Lake (Protection) Act, 2006, the Manipur Conservation of Paddy Land and Wetland Act, 2014 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, MSDMA 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 WRD control, the operating rule shall be WRD's rule. This Manual does not authorise any other body to operate a WRD tank.

> **Commentary.** No pat or pukhri in Manipur was found with a written operating rule, and most have no gates to operate. Where a pat drains through a river bund, its only controllable outlet is a sluice that WRD holds, and WRD's sluice operating rules and closure periods were not found [TBC]; the sluices close because the river rises, not because a forecast is issued. Pumps are the only means of drawing a pat down while the river is high, and the one pumped pat on the record, Lamphelpat, with "provision for pumping of flood water … to the Nambul River through Shamushang Nalla during high flood season" (WRD), still "remains waterlogged for many days every year" because the pumping is "not adequate" (NDB); its pump capacity was not found [TBC]. Loktak's level is set by NHPC's operation of the Ithai barrage for the Loktak hydroelectric project, to which the Loktak Act does not apply (s.36), and the barrage's operating rule was not found [TBC]; the barrage "permanently raised the average water level of Loktak Lake by about a metre" (as reported), and below it the rock sill of the "Sugnu hump" restricts the outflow whatever the gates do (MASTEC). The reservoirs of the hills release into the valley's rivers: the Mapithel reservoir on the Thoubal stood at 876 m on 1 August 2015, "nearly 2 m above the spillways" (as reported), against a full reservoir level of 880.7 m given by WRD in September 2025 (as reported; the two do not reconcile). Without an agreed rule with dates, levels, pumping rates and a named operator, storage in a pat or a reservoir cannot be

relied on, and a release made without warning to the land 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, such as those of late July 1989 and late July 2015, 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 pat or pukhri with no controllable outlet, Clause 7.8.3 is the governing condition: no cushion is assumed, a design that relies on it routes the storm through it from its outlet level, and the outflow is limited by the channel below it and, at the bund, by the sluice and the river stage. A cushion made by pumping is counted only where the pumps, their standby power and their operator are in the rule and were certified ready by 31 March (Chapter 10). Many pats are fisheries, and many pukhris belong to private owners, which is why Clause 7.8.2(d) requires the custodian to accept any drawdown and any loss to the fishery, and why no detention pond built under this Manual is called a pukhri or a pat. No drawdown of Loktak, and no work on the barrage or its gates, is proposed under this Manual.

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 Manipur Pollution Control Board (MPCB) 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, channels or pats was found. The cleaning that is done is large and reactive: a meeting in April 2025 ordered the removal of encroachments along the Waisel Maril, the Naga Nallah and the eastern bank of the Nambul, with WRD to provide machinery, the Loktak Development Authority was named to lead the cleaning of the Waisel Maril, and dredged spoil was piled on Dingku Road (all as reported); the market waste dumped in the Naga Nullah "creates a stagnant pool all along the year" (master plan); and at Lamphelpat a cutter-suction dredger is at work under a work order of 9 November 2023 for two years, with its spoil taken to dykes on institutional campuses (WRD's site report in High Court PIL No. 8 of 2025, which the Court disposed of on 16 June 2025, finding "no substance" in the petition against the dumping of spoil). Silt comes from the hills: the hill streams' "load carrying capacity is high which causes siltation of the lake", and degraded land covers 1,545 km², 24% of the catchment and 35% of the hills (MASTEC); earlier audits found the "failure of canals … due to siltation of beds" in the Loktak lift irrigation project (CAG audits of 2002 and 2008, as cited). The date of 31 March in this Manual is set by this Manual, before its season begins on 1 April, because Imphal's April and May storms come before the south-west monsoon (105.9 mm on 16 April 2004 and 122.4 mm on 27 May 1956, IMD); because the floods of 28 to 31 May 2024 and from 30 May 2025 struck in the last days of May (as reported), the inlets, screens and silt traps are cleared again by **15 May**, not by 31 May as in the other North-East editions, and after the season by 15 November (Chapter 10). WRD's works on the river bunds keep WRD's own calendar. Excavation to "increase capacity" is governed by Clause 7.9.3. The bed of a pat is clay and peat, and the silt of a town pat is laden with sewage: every desilting of a pat or pukhri that receives town drains tests the silt under Clause 7.9.1(c) and disposes of it as the MPCB directs, and no desilting, dredging or deposit of spoil within the 236.21 km² of Loktak is begun without the prior permission of the Loktak Development Authority and the leave of the High Court where its orders require it (Clause 7.12). 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 Manipur 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 Manipur no notification assigns the Naga Nullah, the Waisel Maril or the Shamushang nallah to one owner (NEER reading). The municipal drains are the urban local bodies' (bye-law 16 of the Model speaks of a "municipal drain"; the drainage sections of the Manipur Municipalities Act, 1994 were not read [TBC]); the roadside drains of Greater Imphal are PWD's, which is to build "547 km of both side stormwater covered drains" under the AIIB-financed road project; the river bunds, flood channels, Lamphelpat and the Shamushang pumping are WRD's; the interception and diversion of the 72 drains that fall into the Nambul, with its 16 or 17 MLD plant, is the Directorate of Environment and Climate Change's; the sewers are PHED's; and the Loktak Development Authority was named to lead the cleaning of the Waisel Maril (as reported); Chapter 6 gives this Manual's working split and each town's drain register. The record shows a network that is partial, disconnected and built over: "The existing drainage in the Greater Imphal area is also not in good condition and is not properly connected to the primary drain. Drainage system links are missing … the drains are clogged … Imphal lacks decentralized stormwater management along streets" (AIIB, APD, 2024); the market waste of Imphal is "dumped in the Naga Nullah on the backside of the market, which creates a stagnant pool all along the year" (master plan); the clogging of the Naga Nullah flooded Nagaram, Laipham Khunou and Lairikyengbam Leikai in July 2024 (as reported); and an eviction drive along the channels of the Imphal river, the Waisel Maril, the Naga Nallah and the eastern bank of the Nambul was ordered in April 2025 (as reported). The law reaches some of these channels: the paddy-land Act counts the "drainage channels", meaning "the inlets or outlets for the flow of water to or from a paddy land", as part of paddy land (s.2(c) and (h) of the 2014 Act); the Loktak Act bars "disturbing the natural course of drainages" in the lake's Buffer Zone (s.19(vi)); and the petition in High Court PIL No. 8 of 2025 recorded that "the entire rain water are required to be discharged through the water canal from Lamphelpat through Samushang and discharged to the Nambul River". None of these keeps a city channel, a hill stream or the outlet channel of a pat at its recorded width once it has been lined, covered, built over or narrowed by a culvert, 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 pukhri 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 Manipur no shared form of storage is required by the building rules: bye-law 66 of the Model asks for rainwater harvesting with "points of collection of rain water in surface reservoirs or in recharge wells", and bye-law 6(1)(D) for a "Detailed drainage plan for both internal and external required to be constructed up to the available permanent/pucca drain of municipal/other authority" for multi-storeyed, lifeline and special buildings, but the Model has no detention, release-rate or design-storm rule (Chapter 4). The first public storage being built for flood control is Lamphelpat, a pat being developed as flood storage, whose project is to "increase its water detention capacity" (NDB), and the master plan for Greater Imphal earmarks about 500 ha of its wetlands "for the construction of water bodies". The 20 pond projects of AMRUT 2.0 rejuvenate public ponds but are not counted as flood storage (TPD, 2025-26). The GIS master plans that the Town Planning Department is preparing for the towns and for 14 district headquarters "both valley and hills" (horizon 2042), and the Lamphelpat project, are the natural home for basin storage targets (Chapter 11). 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 Manipur State Wetlands Authority;
- (b) Loktak, within the 236.21 km² of the Manipur Loktak Lake (Protection) Act, 2006, with its Core Zone and Buffer Zone, its phumdi and athaphum, and its Ramsar boundary (designated 23 March 1990, as reported; the boundary was not obtained [TBC]), and the Keibul Lamjao National Park and the Takmu Fishery Farm, which the Act excludes;
- (c) every pat of the valley, among them Lamphelpat, Utra Pat, Yaral Pat, Waithou–Phumnom Pat, Pumlen–Khoidum Pat and Ikop–Kharung Pat, the wetland of Khonghampat, the hill wetlands of Jaimeng and Kachouphung (Achau Maki), and every marsh, swamp and waterlogged area of the valley floor within the 1% AEP extent of Clause 7.3.4, including the wetlands of section 2(t) of the Manipur Conservation of Paddy Land and Wetland Act, 2014, "land lying between terrestrial and aquatic system where the water table is usually at or near the surface or which is covered by shallow water"; paddy land is flood storage under the definitions after Clause 7.2, not a wetland under this Clause; and
- (d) any other pat, marsh or wetland that the Authority notifies, that the Manipur State Wetlands Authority lists, delineates or notifies (its drafts for the Yaral, Utra and Waithou–Phumnom pats are not final), or that the High Court of Manipur, 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. Manipur's wetlands are the concern of the **Manipur State Wetlands Authority**, "set up on 31st January 2018, along with its Technical and Grievance committees", with 22 members, the Minister for Forest, Environment and Climate Change as Chairperson, the Chief Secretary as Vice-Chairperson and the Director of Environment and Climate Change as Member Secretary (DoECC, 2025-26). Its Phase-1 priority wetlands are Jaimeng (Kangpokpi), Kachouphung or Achau Maki (Kamjong), Utra Pat (Bishnupur), Yaral Pat (Imphal East), Waithou–Phumnom Pat (Imphal East and Thoubal), Pumlen–Khoidum Pat (Kakching) and Ikop–Kharung Pat (Thoubal and Kakching); in 2025-26 it delineated 71 wetlands, demarcated 3, and "Published the draft notification" of the Yaral, Utra and Waithou–Phumnom pats in the e-Gazette (DoECC, 2025-26). No wetland notified under rule 4 of the 2017 Rules was found, so until the drafts are final their prohibitions do not apply (NEER reading). The Space Applications Centre's Wetland Atlas (2021) counts 132 wetlands larger than 2.25 ha, about 3% of the State, and the master plan for Greater Imphal counts "about 134 swampy and waterlogged marshy wetlands" and 69 waterlogged areas in the Imphal valley, 40 in Thoubal and 21 in Bishnupur district. **Loktak** is a Ramsar site, designated on 23 March 1990, and was placed on the Montreux Record on 16 June 1993 (both as reported); its Ramsar area was not confirmed [TBC], and its statutory extent is 236.21 km² (Clause 7.1, Commentary). The Act gives the lake to the Loktak Development Authority, with the Forest and Environment Department as nodal department (s.35(2)), and the High Court's special bench has barred development in or around the lake without its leave and directed that the missing "Brief Document" of its Integrated Management Plan be fixed under the Wetlands Rules (order of 25 February 2022, as reported). The Keibul Lamjao National Park, about 40 km² and outside the Act, is mostly phumdi (as reported). Lamphelpat, where WRD is dredging and building flood storage, is not among the priority wetlands, and the dumping of its dredged spoil was the subject of PIL No. 8 of 2025, which the High Court disposed of. A drain outfall, desilting, diversion or gate operation in or next to Loktak therefore needs the prior permission of the Loktak Development Authority and, where its orders reach, the leave of the High Court; one in or next to a notified wetland needs the views or permission of the Manipur State Wetlands Authority; and for the pats and marshes they do not reach, this chapter, the paddy-land and wetland Act and the bye-laws where they apply 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 Manipur's pats, rivers and Loktak through the drains (Clause 8.9, Commentary). The 72 drains that fall into the Nambul had a BOD of 42.45 to 52.34 mg/L (State report of December 2025 to the National Green Tribunal), the CPCB lists the Nambul from the Singda Dam to Bishnupur among the State's 18 polluted stretches (2025), and the Loktak Act counts "sludge from open drains" as sewage effluent (s.2) and bars "Discharge of untreated wastes and effluents from industries, cities or towns and other human settlements" in the lake's Buffer Zone (s.19(iv)). Clauses 7.10.6(d) and 7.12.3 therefore cannot yet be met by most existing outfalls in Greater Imphal. In Manipur they apply in full to every new outfall, and every existing outfall to a pat, a pukhri, Loktak or a listed river stretch 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 hill stream that enters a pat or Loktak from the hills also passes a silt trap where it reaches the valley floor (Figure 7.3; Clause 6.3.6(m)), because the hill streams' "load carrying capacity is high which causes siltation of the lake" (MASTEC), and the pat or the lake is the end of the slope's drainage and loses its storage to that silt.

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. Manipur's controls on building and filling in its waterbodies have come from its statutes and, round Loktak, from the courts. The Loktak Act forbids any part of the lake to be sold, leased, transferred "or converted in any form whatsoever" (s.4); its core-zone rule has been used to clear floating huts (phumshangs) from the lake, and critics say that fishers were treated as encroachers (as reported). The High Court's special bench ordered on 17 July 2019, and reaffirmed on 25 February 2022, that no development or construction take place in or around Loktak "without the Court's leave" (as reported; case number not found [TBC]); a suo motu public interest litigation of 2019 on the Thoubal river barred stone quarrying, sand mining and pollution of the river except under licence or lease (as reported). In the valley the paddy-land and wetland Act punishes conversion in contravention of it with imprisonment of three to five years and a fine of ₹50,000 to ₹2 lakh (s.18), and bars any licence for construction

on land so converted (s.12). Along the city channels, a meeting in April 2025 ordered the removal of encroachments along the Waisel Maril, the Naga Nallah and the eastern bank of the Nambul from Keishampat to Keishamthong and Elangbam Leikai, and an eviction order along the channels of the Imphal river cited "Section 24" of the Manipur Flood Plain Zoning Act, 1978 (both as reported; section 24 was not read [TBC]). At Lamphelpat the High Court found "no substance" in a petition against the dumping of dredged spoil and disposed of it (PIL No. 8 of 2025, order of 16 June 2025). The National Green Tribunal's order of 22 May 2020 in M.A. 26/2019 led to the inventory of about 4,000 water bodies, whose ground truthing is pending (DoECC, 2025-26), and the State reports to the Tribunal in O.A. 606/2018 and O.A. 673/2018 on its polluted rivers. The CAG found that "The overall flood fighting and control activities remained inadequate" (Report No. 2 of 2017, as cited); no audit of drainage in Imphal, of the Smart City or of the Loktak Development Authority was found. The master plan's own figures show the storage being given up: wetlands from 374.48 ha to 232.21 ha by 2043 (Clause 7.6, Commentary). 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. Manipur's river bunds along the Imphal, the Nambul, the Iril, the Thoubal and the other valley rivers are flood embankments, which the Act excludes; their lengths and heights were not found [TBC], and MASTEC counted 11 vulnerable points on the Imphal river, 14 on the Thoubal and 5 on the Iril. The Thoubal (Mapithel) dam, an earth dam reported as 66 m high and 1,074 m long, is a dam across a river under the Act, and so, on the Act's definition, is the Ithai barrage (NEER reading; its height was not obtained [TBC]); the Khuga and Singda dams were named in the sources without their dimensions [TBC]. No pat or pukhri in Manipur was found to be held by a bund high enough to be a specified dam, though no bund or outlet was surveyed for this Manual [TBC]; each shall be screened under Clause 7.14.1. Where the storage of a pat or pukhri is counted under Clause 7.7, the bund that holds it, with its sluice, 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 Manipur the bund hazard is the breach. In the Remal floods of 28 to 31 May 2024 there were 18 embankment breaches, 17 of them sealed (as reported); in the floods of 2024 and of 30 May to June 2025 the Imphal river breached at Singjamei, Heingang, Bashikhong and New Checkon and at Keirang, Khabam and Lairikyengbam Leikai, and the Nambul at four places; and in September 2025 the Iril breached at Kshetri Awang Leikai (all as reported). The record is old: the flood of 1966 breached the bunds at 60 places, that of 1989 at 40 and that of 2002 at 59 (MASTEC). A failed bund floods the land behind it, and a breach closes no sluice: "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, APD, 2024). Releases from the dams upstream are the other hazard: the Mapithel reservoir stood at 876 m on 1 August 2015, "nearly 2 m above the spillways" (as reported), and its spillway is designed for 2,240 cumec (as reported). No breach map or emergency action plan for any bund, dam, pat or pukhri was read for this Manual. That is why Clause 7.14.3 asks for breach mapping and an emergency action plan for high-hazard embankments counted under this Manual, why Clause 2.3.6(i) treats the breach paths of the river bunds as hazard-first sites, and why Chapter 5 treats bund-locked towns and release reaches as flood-sensitive outfalls. 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.

References (chapter)

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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 Manipuri 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 Manipur 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 Manipur 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 Manipur, 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 m^3;
- A = the contributing area, m^2;
- $Rv = 0.05 + 0.009 \cdot I$; 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 (m^3) = 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 Manipur 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 Manipur, 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.

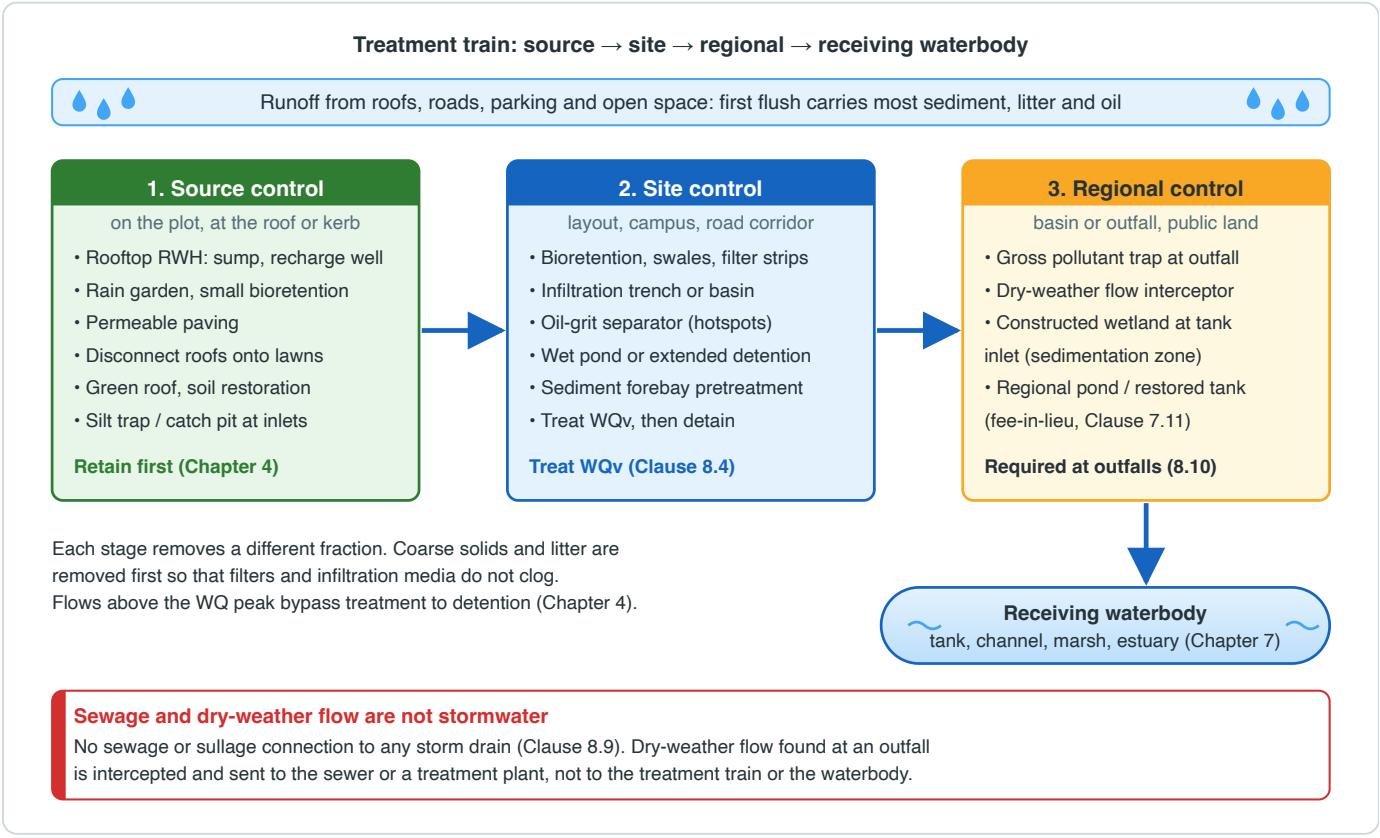


Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater 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 Manipur

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Foothill fans and tested sand lenses (recharge rule)	Laterite / hard rock	Valley-floor clay and peat, pat and pukhri margins / high water table	Manipur 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	Foothill fans and tested sand lenses (recharge rule)	Laterite / hard rock	Valley-floor clay and peat, pat and pukhri margins / high water table	Manipur 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 Manipur 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. Manipur 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.**

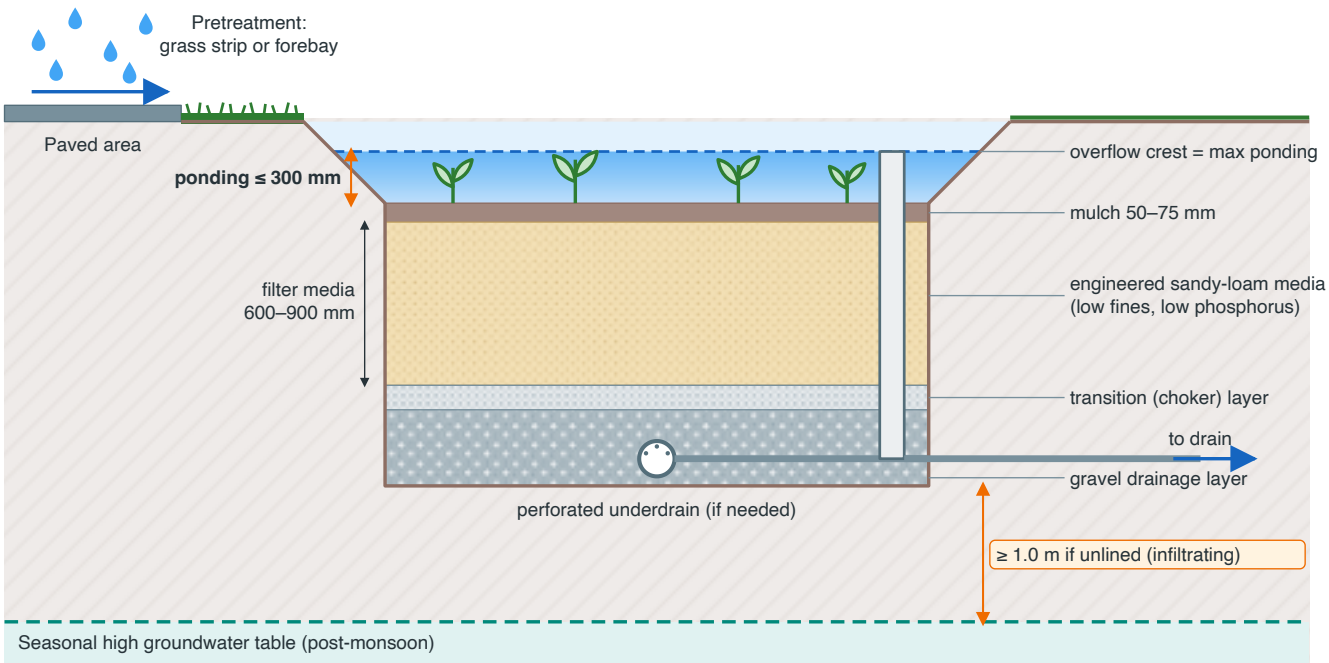
- (a) At every inlet that receives runoff from unpaved ground, and at the inlet of every drain discharging to a BMP or waterbody.
- (b) A sump at least 300 mm below the outlet invert.
- (c) Silt traps are pretreatment only and earn no VR.

> **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 Manipur. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in Manipur. 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 Manipur's rain falls in the monsoon season of 1 April to 31 October: at Imphal the "Rainy season … starts from May and extent up to October", July (241.28 mm) and June (236.06 mm) are the wettest months, and the mean annual fall was 1,416.9 mm in 1975–2000 (MASTEC); in Bishnupur

"Rainfall starts from the month of April end" and "About 80% rainfall is from South West monsoon" (CGWB, 2013); and IMD's highest January month at Imphal is 49.3 mm and highest December month 94.0 mm, against 459.6 mm in April and 605.0 mm in June (IMD, data 1953–2012). From December to February the pats shrink and pukhris fall, though on the valley floor the water table stays a few metres below the ground (Clause 8.8.1), and in the towns the dry-weather feed of a drain, channel or pat is sewage, because the drains carry it (Clause 8.9, Commentary). A wet pond or constructed wetland whose water balance (Clause 8.7.8) cannot keep its permanent pool from December to March on its own catchment's runoff is not to be used, and none is kept full with dry-weather flow; on the valley floor, where Clause 4.11 bars infiltration, the practical forms are lined bioretention with an underdrain, swales, storage for use and lined extended dry detention. Clause 8.7.8 applies to BMPs, which shall not be topped up with sewage; pats, pukhris, Loktak and other 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 Manipur 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.



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 Manipur, 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). Manipur needs the three rules of Clause 4.11 here, and Clause 8.8.1 applies with the following. **(i) No infiltration on the valley floor (Clause 4.11, valley-floor 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 lacustrine clay, silt or peat of the Imphal valley floor (sub-areas MN-A and MN-A1 of Annex 2A), which includes paddy land and former pats; on land below the 1% AEP flood level of a river, a stream or Loktak; inside a river-bunded area that ponds when its outfalls close; on the margins of a pat or pukhri (its Zone 1 and Zone 2 under Chapter 7); within the 236.21 km² of the Manipur Loktak Lake (Protection) Act, 2006; on the Barak and Jiri flood plain of sub-area MN-C1 below its 1% AEP level; or wherever the seasonal high water table is less than 2.0 m below ground. On such land the exception for roof water in Clause 8.11.3(c) does not apply; roof water goes to storage for use, retention is met by storage for use and by surface measures that do not infiltrate below ground, and detention under Chapter 4 is in lined, watertight storage checked for flotation with the groundwater at ground level. The valley floor has "approximately 30 to 50 m of clayey formation, construction of shallow tube wells is problematic", with "clayey deposit down to depth range of 30 to 65 m bgl" and water "2 to 5 m bgl" in major parts of Imphal West (CGWB, 2013); round the lakes of Bishnupur "peaty soils have high acidity" (CGWB, 2013); and the valley's soils are of "fluvio lacustrine origin", of clay, silt and sand (MASTEC). Bye-law 66 of the Model Manipur Unified Building Bye-Laws, 2024 [TBC: confirm the number and text in the bye-laws the local body has notified] offers "surface reservoirs or recharge wells", and this Manual chooses surface reservoirs, which is no conflict; bye-law 67 sends the excess grey water "to the rain water recharge structures for ground water recharge", which on the valley floor is a soak pit in clay: this Manual states the conflict, requires storage or a sewer connection in its place, and leaves the Applicant to seek the local body's relaxation of the bye-law, which this Manual does not override. Gas has been met "while constructing deep tube wells in some places" (CGWB, 2013), and no subsidence record for the peat was found [TBC]: a sump, tank or detention structure on peat has a geotechnical check (set by this Manual). **(ii) No infiltration on hill slopes (Clause 4.11, hill rule).** In sub-areas MN-B and MN-C, on the hill parts of MN-C1, on the valley-rim slopes and hillocks of MN-A, and on any natural slope steeper than 10° elsewhere, no deliberate infiltration practice shall be built or credited on natural ground sloping more than 10°; on Disang shale at any slope; on colluvium, fill or slide debris; in a mapped landslide zone or landslide locality, such as Tupul in Noney district and Joumol in Chandel district, and the cut slopes of NH-37 and NH-2; or upslope of a cut slope or retaining wall within twice its height — unless a geotechnical certificate shows that the added water will not destabilise the slope. Roof runoff goes to storage of at least 25 L per m² of roof (Clause 4.11), with its overflow, and all other runoff, by a lined drain through a silt trap and an energy dissipator to a stable channel, never onto an unprotected slope. The Disang shale "occupies almost 85 p.c. of the hilly region, have less infiltration and more run off" (MASTEC), and it failed when cut and saturated at Tupul, where a landslide at the Jiribam–Imphal railway site on 29 or 30 June 2022 was attributed to "poorly designed or implemented slope excavation coupled with heavy rainfall" (as reported). The draft IMC Building Bye-Laws (3rd Amendment), 2024 would bar construction on slopes of more than 30° and cutting of them, and allow at most two floors or 7 m on slopes of 21 to 30° (92.1 and 92.2; a draft published for objections, final status not confirmed [TBC]), in place of bye-law 92 of the Model, which as printed bars construction "on land above 600 m from the mean sea level and with an average slope of 30 degrees"; the 10° threshold and the Disang condition are set by this Manual, because no Manipur numeric threshold exists below 21°. In the hill areas no building bye-law applies, and this rule reaches public works and any body that adopts this Manual. **(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 foothill fans of sand, gravel and boulders at the valley edge, where "sand, gravel, pebbles and boulders are found in the foothill regions" (MASTEC), on Barail sandstone cappings on slopes of 10° or less away from scarps, and on sand lenses in the valley floor that test pits show, outside the areas of item (i). Recharge is a choice, not a duty: every assessment unit is Safe, and the stage of groundwater extraction was 8.00% in the assessment of 2024 and 7.99% in 2023 (CGWB, as quoted); Imphal draws about 90% of its drinking water from the Imphal, Nambul and Iril rivers (master plan). **(iv) Quality.** 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 foothill fan, a sandstone capping or a sand lens takes only roof water or runoff that has passed a filtering BMP. The 2.0 m limit, the April–November record, the 10° threshold and these conditions are set by this Manual; no Manipur rule on infiltration near the water table or on slopes below 21° 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. Manipur has none, so the Clause has no effect in the State; it is kept only so that the clause numbers stay unchanged. The sands and gravels of the foothill fans at the edge of the Imphal valley, the sand lenses in its clays and the Barak and Jiri alluvium of the Jiribam plain are not coastal sand areas: Clause 8.8.1 applies there in full, with the valley-floor 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 Barail sandstone cappings of the hills and of some hillocks in the valley, the only rock on which this Manual allows recharge, after testing, on slopes of 10° or less away from scarps (Clause 4.11, recharge rule), and the Disang shale, which "occupies almost 85 p.c. of the hilly region, have less infiltration and more run off" (MASTEC) and on which no infiltration is allowed at any slope without a geotechnical certificate (Clause 4.11, hill rule); no laterite was described in the sources read for this Manual; on any slope in these areas the hill rule of Clause 4.11 applies first under Clause 8.8.1):

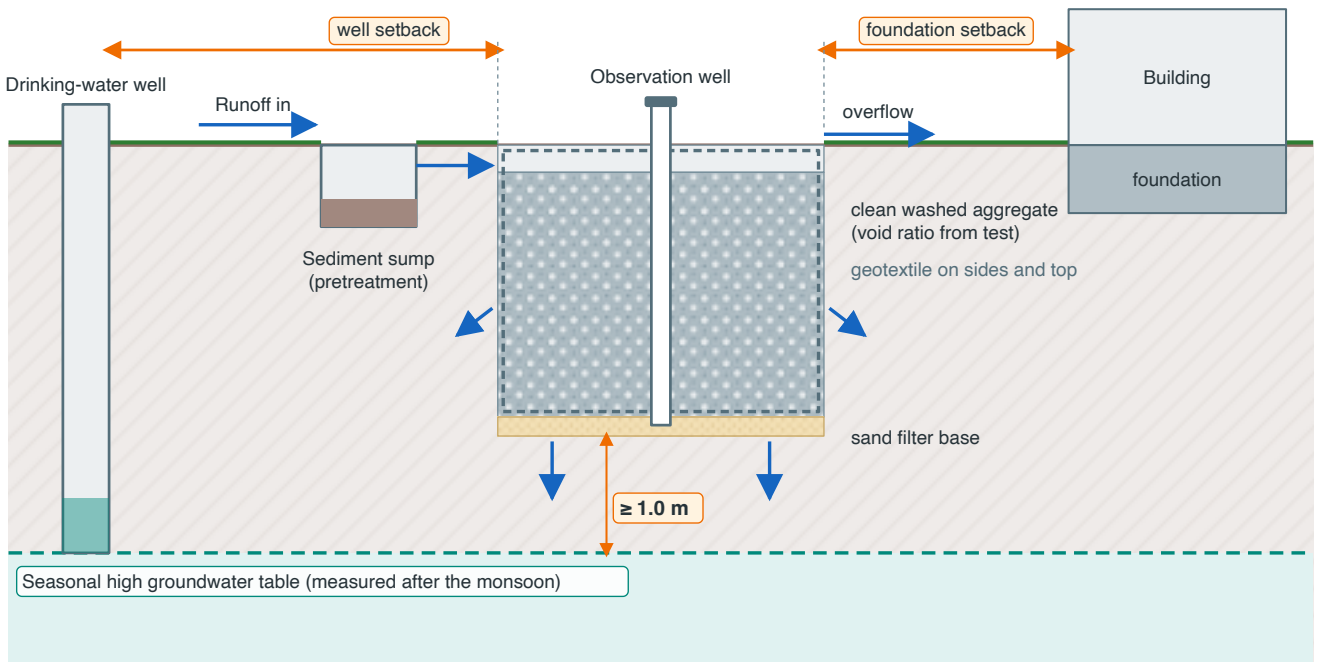
- (a) tests shall be made at the facility base, below any surface crust or hardpan;
- (b) recharge into weathered or fractured rock is permitted only for roof runoff, or for runoff that has passed through a filtering BMP, because fractures give little treatment; and
- (c) infiltration on or above slopes shall be checked for slope stability.

8.8.11 **Delta clays and black cotton soils.** In the lacustrine clays, silts and peat of the Imphal valley floor, with its paddy land and former pats, the clay beds of the pats and pukhris, the margins of Loktak, and the Barak and Jiri alluvium of the Jiribam plain below its 1% AEP level, 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 Manipur precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. Manipur 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 Manipur, no soil series and no measured infiltration rate anywhere in the State was found [TBC]; every infiltration design needs the tests of Clause 8.8.3. "Manipur Valley is virtually a flat alluvium filled valley … Basically Manipur Valley is made up of alluvium of fluvio lacustrine origin. They are usually dark grey to black in colour. The principal constituents are clay, silt and sand whereas sand, gravel, pebbles and boulders are found in the foothill regions" (MASTEC). Under Imphal West there are "approximately 30 to 50 m of clayey formation, construction of shallow tube wells is problematic", with "clayey deposit down to depth range of

30 to 65 m bgl"; the "Depth to water level in major parts of the district varies from 2 to 5 m bgl", and 5 to 7 m close to the hills; and "emanation of gas while constructing deep tube wells in some places" has been met (CGWB, Imphal West, 2013). Round the lakes of Bishnupur "peaty soils have high acidity", "lacustrine laminated sand and clay overlies the fresh Disang shale", and the water stands 2.50 to 4.30 m below ground, rising in April and May (CGWB, Bishnupur, 2013; a summary table there prints other ranges whose columns could not be aligned [TBC]). In the hills the Disang shale "occupies almost 85 p.c. of the hilly region, have less infiltration and more run off", with Barail sandstone cappings on some hills and hillocks (MASTEC). Groundwater is not short: every assessment unit is Safe, and the stage of extraction was 8.00% in the assessment of 2024 and 7.99% in 2023 (CGWB, as quoted); no State network of observation wells was found, and the CGWB's dug-well monitoring in Imphal West stopped "since 1991 due to disturbed law and order" (CGWB, 2013). A Manipur Ground Water (Control & Regulation) Policy, 2023 was prepared (as listed by DoECC; text not read [TBC]). This Manual's interim soil groups follow from these (Chapter 3): the valley's lacustrine clay and silt D; peat and the margins of phumdi D, saturated and settling; the foothill fans B to C, by test; the Disang shale hills D for runoff; the Barail sandstone cappings C, by test and away from scarps; the Barak and Jiri alluvium of the Jiribam plain C to D, and D below its 1% AEP level in the season; and urban fill C (D if clayey or compacted). **The State therefore needs three rules, not one** (Clause 4.11). On the valley floor, which holds most of the towns, no water is put into the ground on purpose, under the valley-floor rule, because it would go into clay, peat or saturated ground. On hill slopes, on Disang shale, on colluvium and fill and in landslide zones, no water is put into the ground on purpose, under the hill rule. On the foothill fans, the Barail sandstone cappings and tested sand lenses, recharge is allowed after testing, under the recharge rule, as a choice rather than a duty. 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 Manipur, 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 Manipur Pollution Control Board (MPCB) 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 Manipur. 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 Greater Imphal the storm drains carry sewage, and this Clause is the normal case, not the exception. Sewers are partial. The Imphal Sewerage Project Phase I of PHED, "commissioned in June 2020", covers 11 municipal wards with "one STP of 27 MLD, 5 nos. of Pumping station and 69.44 km of sewer network" for a population of 2.59 lakh by 2031; Phase II is to serve the remaining 16 wards and 4 outgrowths, 3.84 lakh people by 2054, with plants of 6 MLD at Lamphelpat, 27 MLD at Langthabal Kunja and 16 MLD at Uchekon Loukol, 21 pumping stations

and 277 km of sewers, at ₹1,200 crore "for construction with a total capacity of 49 MLD"; and the treatment needed by 2043, 104 MLD, exceeds the 76 MLD the two phases would give (Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)). The State reported to the National Green Tribunal that "Sewage generation in urban areas is 70 MLD and existing treatment facilities are 44 MLD (27 MLD for Imphal Phase I and II and 17 MLD under Nambul rejuvenation)", that the 27 MLD and 16 MLD plants treated 21.59 MLD and 11.50 MLD, that their "Final mode of disposal" is "Agriculture canals", and that 8,600 to 8,700 households were connected out of 51,754 targeted by 2027 (report of July 2025 in O.A. 606/2018). Everywhere else the septic tanks and soak pits of the town overflow, with all the sullage, to the open drains. The drains reach the rivers: the "Interception & Diversion (I & D) of all drains (72 Nos.) falling into the Nambul River" to a plant of 16 or 17 MLD is reported completed, and the drains' BOD was 42.45 to 52.34 mg/L and their COD 78.56 to 97.23 mg/L (State report of December 2025 in O.A. 606/2018), while the CPCB's list of 2025 places 18 stretches of 18 rivers in the State in Priority V, among them the Nambul from the Singda Dam to Bishnupur, with a maximum BOD of 3.3 mg/L at Singda, 4.8 at Samusang, 4.7 at Naoremthong, 5.6 at the Hump Bridge and at Heirangoithong and 3.4 at Bishnupur (CPCB, *Polluted River Stretches for Restoration of Water Quality*, 2025): the drains carry sewage and the rivers dilute it (NEER reading). The market waste of Imphal is "dumped in the Naga Nullah on the backside of the market, which creates a stagnant pool all along the year" (master plan). In the hill towns, "The existing reliance on septic tanks and twin soak pits in the hilly regions of Manipur is appropriate" and "There is minimal presence of underground drainage infrastructure in these areas" (State report of July 2025), so their drains, too, receive what the pits and tanks release. The law already points the same way. The Model Manipur Unified Building Bye-Laws, 2024 [TBC: confirm the number and text in the bye-laws the local body has notified] require that "For outlet from the soak-pit to municipal drain if provided, an intermediate treatment chamber should be installed" (bye-law 6(1)(A)), make a latrine "a connected latrine if a sewer is within 30 m" of the site (bye-law 27), and forbid a rain-water pipe to "discharge into or connect with any soil pipe" (bye-law 28(v)); the Manipur Loktak Lake (Protection) Act, 2006 counts "sludge from open drains" as sewage effluent (s.2), bars in the lake's Buffer Zone the "Discharge of untreated wastes and effluents from industries, cities or towns and other human settlements" (s.19(iv)), and bars anyone from discharging or emitting "any sewage or domestic waste into the lake" in the Core Zone "except with the prior permission of the authority" (s.20(i)); the Act reaches only the lake's 236.21 km², not the rivers and drains upstream (NEER reading). Lamphelpat, a pat being developed as flood storage for the drains and channels of its catchment, is also to supply drinking water from its stored water (NDB). In Manipur, therefore: **(i)** every storm-drain outfall to a pat, a pukhri, Loktak, a river stretch on the CPCB's list, or a paddy-field or agriculture canal 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 water, and before any detention or retention pond; the outfalls to Lamphelpat come first, because it is both flood storage and a proposed source of drinking water; **(ii)** within the 236.21 km² of the Loktak Act, no outfall carrying untreated sewage is designed or approved, sections 19(iv) and 20(i) of the Act are the hooks, and the prior permission of the Loktak Development Authority is obtained for every outfall; and on the rivers and drains that reach the Loktak margin from upstream, where the Act does not reach, this Manual applies the same interception at the outfalls; **(iii)** no septic tank or soak-pit overflow and no sullage pipe is connected to a storm drain on any site approved under this Manual (Clauses 8.9.1 and 8.9.2): within 30 m of a sewer the site connects to it (bye-law 27); in the wards of Phase I and Phase II the site's sewage and storm water are kept in separate systems, each with its own last inspection chamber at the boundary, so that it connects to the sewer and to a storm drain without rework (Clause 6.3.6(a)); and where no sewer exists, the intermediate treatment chamber of bye-law 6(1)(A) is the least that is provided, and its outlet reaches a municipal drain only with the written consent of the MPCB and the drain owner under Clause 8.9.3; **(iv)** until sewers connect, a drain that receives sewage 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, and with covers or screens where it passes homes; in the hill towns a drain below a settlement is treated as such a channel until sewers exist; **(v)** no storm drain, and no interceptor, discharges to a paddy-field or agriculture canal without treatment, and where no sewer or treatment plant exists to receive the intercepted flow, the interceptor delivers it to an interim treatment unit that the MPCB approves, never to a pat, pukhri, canal or pond; and **(vi)** a pat, pond or basin that stores storm water mixed with sewage, as any pat does that receives the drains of a town, has the dry-weather flow of its inflows intercepted ahead of it; keeps no permanent pool fed by dry-weather flow; is pumped or drained down to its normal level as soon as the river stage allows and within the pumping period of Clause

5.8.5; has its inlets screened against garbage and phumdi and set so that they do not stand exposed as the level falls; is cleared of sludge in the post-season clearance by 15 November, with the sludge tested under Clause 7.9.1(c) and disposed of as the MPCB directs; and leaves no isolated pool standing more than 72 hours after drawdown, because of mosquitoes. Every interceptor is sized from the measured dry-weather flow of its drain and does not reduce the drain's capacity for the minor and major events (Clause 8.9.5(b)); at an outfall that a sluice closes when the river is high, it and its chamber are placed above the 1% AEP level or made watertight, and work with the gate shut. 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 Manipur 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 Model Manipur Unified Building Bye-Laws 2024 (bye-law 66(a) of the Model: "Water harvesting through storing of water runoff including rainwater in all existing and new buildings on plots of 100 square metre and above will be mandatory. The plans submitted shall indicate the system of storm water drainage along with points of collection of rain water in surface reservoirs or in recharge wells"; bye-law 66(b), soft cover of at least 15% of the plot for a building with a covered area of 500 m² or more and 10% for

any other; bye-law 67, grey-water recycling, with the excess "suitably connected to the rain water recharge structures for ground water recharge"; bye-law 68, a rebate of 10% on the building permission fee where both recycling and rainwater harvesting are provided; and bye-law 6(1)(C)(j), the details of rainwater harvesting on the plans [TBC: confirm the number and text in the bye-laws the local body has notified]) continues to apply, where the local body has brought it into force, subject to the limits of Clause 8.8.1: this Manual chooses the bye-law's "surface reservoirs", which is no conflict; where bye-law 67 sends grey water to a recharge structure on a site where Clause 4.11 bars infiltration, this Manual states the conflict, requires storage or a sewer connection in its place, and leaves the Applicant to seek the local body'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. Manipur's building bye-laws make rainwater harvesting compulsory on plots of 100 m² and above, but they set no storm, no volume for use and no detention rule. Bye-law 66(a) of the Model reads: "Water harvesting through storing of water runoff including rainwater in all existing and new buildings on plots of 100 square metre and above will be mandatory. The plans submitted shall indicate the system of storm water drainage along with points of collection of rain water in surface reservoirs or in recharge wells"; bye-law 66(b) asks for soft cover of at least 15% of the plot for a building with a covered area of 500 m² or more and 10% for any other; bye-law 67 asks for grey-water recycling for a covered area of 500 m² or more or a use of 10,000 L a day, and sends "The excess waste water not reused for toilet flushing" to "the rain water recharge structures for ground water recharge"; bye-law 68 gives "rebate of 10 %

on building permission fees" to owners "who undertake both recycling of waste water and rain water harvesting structures"; bye-law 6(1)(C)(j) asks the plans for the "detail provisions made for conservation and harvesting of rain water"; the completion certificate certifies "water harvesting as well as waste water re-cycling systems"; and the green-building criteria include "Water recycle, reuse and rainwater harvesting" (Criterion 9). None of these gives a storage volume, a release rate or a design storm (NEER reading). The Unified Zoning/Use Regulation Bye-laws, 2026 list "Rain Water Harvesting System" as a use, and AMRUT 2.0 funds an "Oxygen Park & Rain Water Harvesting Park" (TPD, 2025-26). On the valley floor a recharge well or pit stands in "approximately 30 to 50 m of clayey formation" with the water 2 to 5 m below ground (CGWB, 2013): it is a soakaway in clay, not recharge, and a pit that receives grey water there is a soak pit. In the hills, on Disang shale, it adds water to a slope that slides when wet. Groundwater is not short (stage of extraction 8.00% in 2024, CGWB, as quoted), and Imphal draws about 90% of its drinking water from the Imphal, Nambul and Iril rivers (master plan), so what harvesting can do in Manipur is hold water for the dry months. This Manual therefore treats rainwater harvesting as **storage for use** for the months from December to March, and as storage on valley-floor and hill sites: where the valley-floor or hill rule of Clause 4.11 bars infiltration, the bye-law's "surface reservoirs" are provided, of at least 25 L per m² of roof (about 25 mm over the roof; Clause 4.11), credited as retention only through reuse, emptied within 72 hours by a continuous non-potable use (Clauses 4.4.3 and 8.11.4), assumed full at the start of every storm (Clause 4.11.2), and never counted as detention (Clause 8.11.5). On the foothill fans, the Barail sandstone cappings and tested sand lenses, recharge may be one function of harvesting where Clause 8.8.1 allows it (Clause 8.11.2(b)); where bye-law 67 sends grey water to a recharge structure on a site where Clause 4.11 bars infiltration, this Manual states the conflict and requires storage or a sewer connection in its place (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, such as those of late July 1989 and late July 2015, 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 Manipur'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 Manipur it fills the pats and Loktak as well: the hill streams "flow down with steep slope for a short distance before meeting the Loktak Lake … load carrying capacity is high which causes siltation of the lake", degraded land covers 1,545 km², 24% of the valley's catchment and 35% of its hills, and the high and moderate-to-high erosion classes cover 51% of the area studied (MASTEC); Loktak is "becoming shallower" (MASTEC); and the cut slopes of the hill roads and the railway fail when wet, as at Tupul in 2022, where the landslide was attributed to "poorly designed or implemented slope excavation coupled with heavy rainfall" (as reported). The Model Manipur Unified Building Bye-Laws, 2024 [TBC: confirm the number and text in the bye-laws the local body has notified] name "erosion and sedimentation control" among the criteria of their green-building certification (Criterion 1) and ask, in Criterion 2, to "Minimize storm water run-off from site by reducing hard paving on site", and the draft IMC Building Bye-Laws (3rd Amendment), 2024 would bar cutting of slopes of more than 30° (92.2; draft, final status not confirmed [TBC]); they give no size, area, date or inspection, which Clause 8.12 supplies, and in the hill areas no bye-law applies. The stabilisation date of 31 March is set by this Manual, before its season begins on 1 April, because Imphal's April and May storms come before the south-west monsoon (Chapter 2). The reason given above for the larger basin volume, that the 2-year 24-hour depths are high, holds: this Manual's interim 2-year 24-hour depth is 85 mm on the valley floor and 130 mm in the western hills and the Jiribam plain (Clause 2.3.6(c)), on ground of soil group D with AMC III through much of the season (Chapter 3), so the 2-year runoff, not 250 m³/ha, will usually govern (NEER reading); the rule of Clause 8.12.3(c) is kept unchanged everywhere. In Manipur 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 the whole valley floor and every slope steeper than 10°; no spoil, silt or debris from a site is placed in a pat, pukhri, river, khong or city channel, within its Zone 1, on a river bund, or within the 236.21 km² of Loktak; and a site on the hill fringe of the valley keeps its sediment behind a silt trap where its drains or streams reach the valley floor (Clause 6.3.6(m)) before any drain reaches a pat, a river or Loktak.

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 Manipur 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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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	Manipur 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, a khong, a pat, a pukhri, Loktak or a 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 flood released from any dam upstream, such as the Thoubal (Mapithel) dam on the Thoubal, the Khuga dam on the Khuga and the Singda dam on the Nambul; the outfall-closed check of Clause 5.10 wherever the receiving water can rise above the outfall

invert, which in the monsoon is the normal case, not the exception, for the drains of the Imphal valley floor that reach the Imphal, the Nambul, the Iril, the Kongba, the Thoubal and the other valley rivers through gates in their bunds or by pumping (Clause 5.8.5(a) and (b)), for Lamphelpat, whose flood water is pumped through the Shamushang channel to the Nambul, and for the drains of the Loktak margin, whose tailwater is the lake held up by the Ithai barrage and the rock sill below it (Clause 5.8.5(c)); for an outfall to a gauged valley river, the river at its WRD flood level, with the gate closed, as the design case, and its high flood level, or the highest reading reported above it, as the check case (Clause 5.8.5(a)); for an outfall on the Loktak margin, the high flood level at the Ithai barrage, 769.320 m, checked at the 770.05 m reached on 15 September 2025, and never below the lake's full reservoir level from June to September, with an outfall whose invert lies below the design lake level treated as closed from 1 June to 30 September (Clause 5.8.5(c)); for an outfall below the Thoubal (Mapithel), Khuga or Singda dam, the largest recorded release or, until the operator gives one, the spillway capacity (Clause 5.8.5(d)); for an outfall to a pat or pukhri, its level full to its outlet at the start of the storm when its own outfall is closed (Clause 5.8.5(e)); for an outfall to a hill stream that has no gauge, the level of the 1% AEP flood in the reach, computed with the sediment, debris and garbage allowances of Chapter 6 (Clause 6.3.6) and checked against surveyed flood marks (Clause 5.8.5(f)); for an outfall at Jiribam, the level of the Barak or the Jiri, with the high flood level of 32.1 m at the CWC site at Chotebekra (31 July 1989, as reported; datum not stated) (Clause 5.8.5(g)); the level held in a drain by any gate, flap gate or pumping station downstream of the outfall, taken as a fixed control at its gate-closing level, its sill or the start level of its pumps; and the joint case of Clause 2.12. WRD publishes its valley gauges through the press with warning, flood and high flood levels, and two of the printed high flood levels have been exceeded: the Imphal at Minuthong, 785.900, 786.900 and 788.400 m; at Lilong, 780.350 m, 781.350 m (2025) or 781.250 m (2024) and 782.850 m, exceeded at 783.250 m on 15 September 2025; the Iril at Irilbung, 786.700 and 787.700 m, with a printed high flood level of 782.200 m that lies below its flood level and must be an error; the Thoubal, 778.915 and 779.915 m (gauge not named); the Nambul at Thong Nambonbi (Hump Bridge), high flood level 783.695 m; the Nambol at Nambol Thongkhong, 774.700 or 774.400 m; and the Manipur river at the Ithai barrage, 769.320 m, exceeded at 770.05 m on 15 September 2025 (WRD levels as reported; the datum, presumed metres above mean sea level, is not stated [TBC]). Loktak's full reservoir level is 768.5 m and its minimum drawdown level 766.2 m (NHPC, as quoted), with 766.01 m from CEA and a full level of 769.63 m in another account (as reported); these conflicts are stated, not resolved. Readings published in the press are never mixed with WRD's register once it is obtained. No document found sets a design river or lake level at any outfall in Manipur, and no flood zone has been notified under the Manipur Flood Plain Zoning Act, 1978; until one is, 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 = ho + H − L·S

> H = [1 + ke + (19.63 n² L) / R^1.33] · V² / 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.

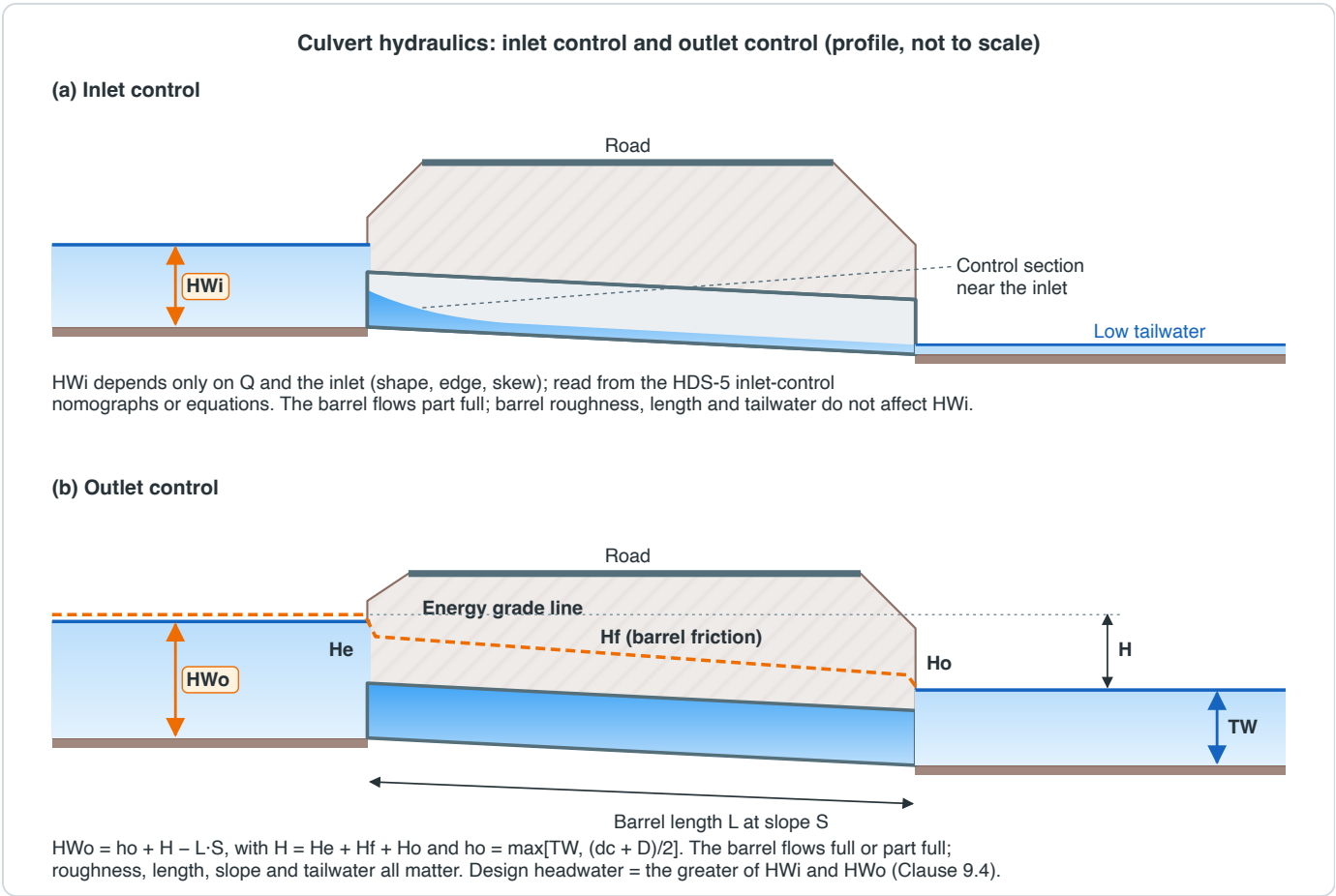

Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

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 Manipur 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 drains of the Imphal valley floor that reach the Imphal, the Nambul, the Iril, the Kongba, the Thoubal and the other valley rivers through gates in their bunds or by pumping, on the drains to Lamphelpat and the other pats that a closed outfall holds full, on the drains of the Loktak margin, whose receiving level the lake sets, and on the nearly level channels of the valley floor and of the Jiribam plain under the backwater of the Barak is the normal case, as it is on the steep drains, khongs and streets of the hill towns, Tamenglong, Noney, Ukhrul, Senapati, Kangpokpi, Chandel and Churachandpur among them, stepped by drop structures and chutes and passing through critical depth at every step.

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 Manipur (the lacustrine clays, silts and peat of the Imphal valley floor, the sands, gravels and boulders of the foothill fans at the valley edge, the thin soils over the Disang shale of the hills, which "have less infiltration and more run off" (MASTEC), the Barail sandstone cappings, and the Barak and Jiri alluvium of the Jiribam plain, on which the gravel, boulders, garbage and phumdi a flow carries, rather than the soil itself, decide what a channel bed or a screen 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 Manipur 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:

> $$D_{50} = 0.2 \cdot D \cdot \left[Q / \left(g^{0.5} \cdot D^{2.5} \right) \right]^{(4/3)} \cdot (D / TW)$$

where D_{50} 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.

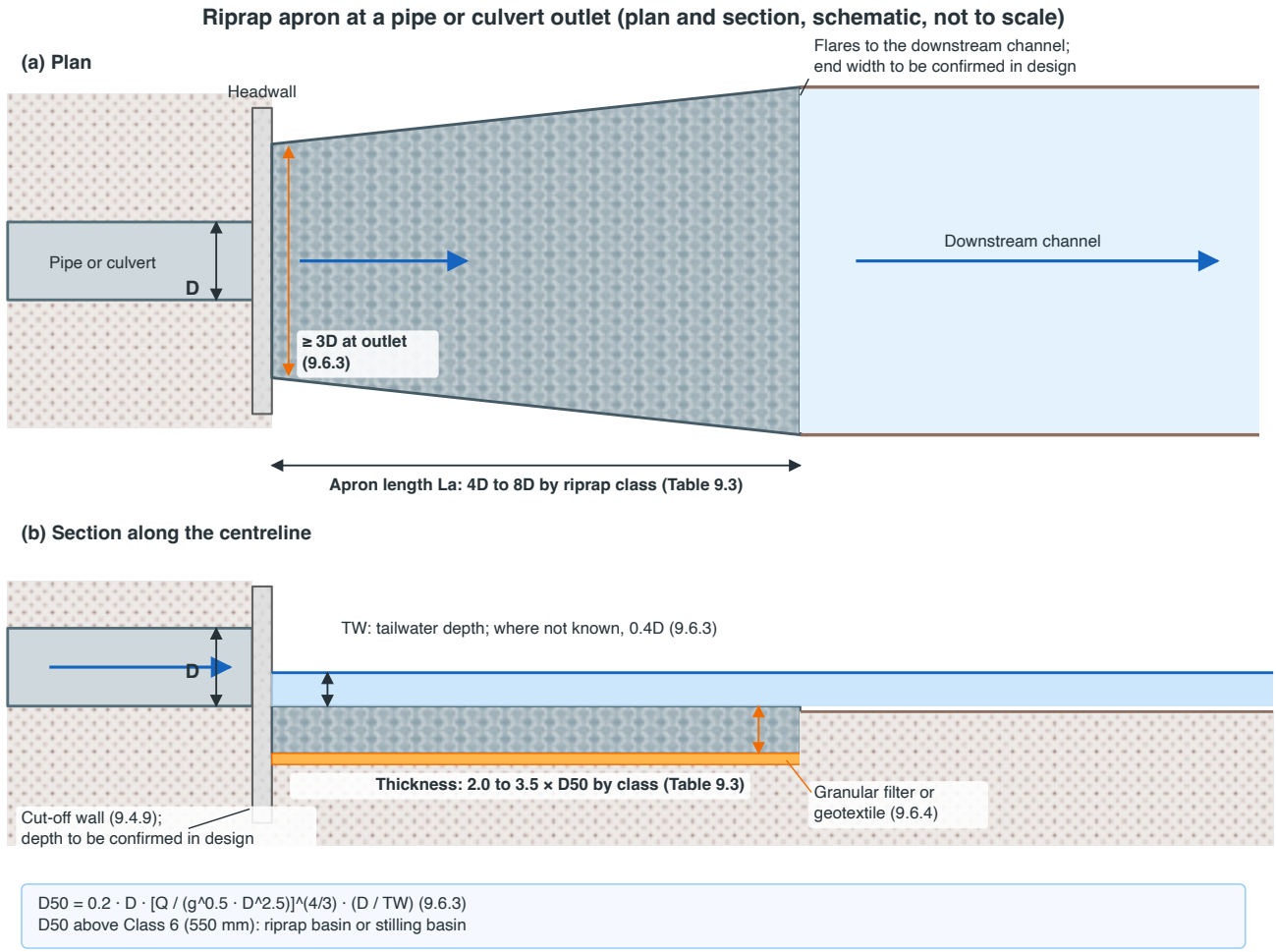

Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design 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:

> $Q = C_d \cdot A \cdot (2\,g\,h)^{0.5}$

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 $Q = C_w \cdot L \cdot H^{1.5}$, 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: $Q = 1.38 \cdot \tan(\theta/2) \cdot H^{2.5}$ (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 m^3/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 m^3/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.

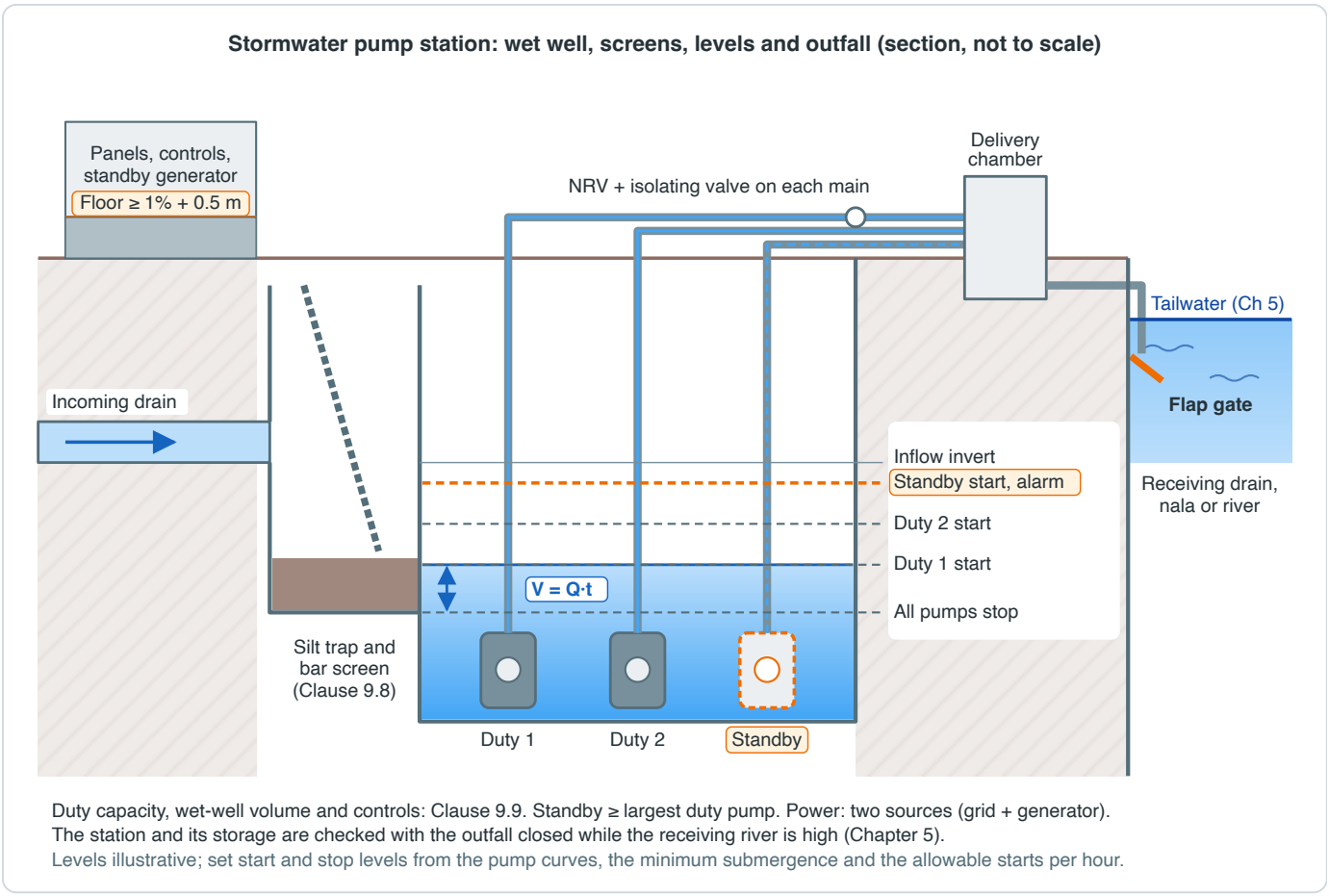

Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).

> **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". Manipur 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, lake, pat or ponded level of Chapter 5. The rivers and the lake close the outfalls instead. The Imphal valley is a closed basin with one outlet: every valley river runs to Loktak and leaves past the Ithai barrage and a rock sill below it, the "Sugnu hump", where the bed of the Manipur river rises from 756.7 m to 763.7 m in about 800 m (MASTEC). Imphal "is below the high flood level of Imphal river and hence there are embankment roads on both sides of the river to protect the settlement from seasonal floods" (Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)); the Imphal at Minuthong, in the city, has a high flood level of 788.400 m (WRD, as reported), within a metre or two of a city that stands at about 790 m (AIIB, 2024; comparison made for this Manual); and "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, 2024). The valley's rivers bring a few hundred cubic metres a second each in flood (the Iril 532.488 m³/s on 2 September 2000, the Thoubal 391.636 m³/s on 30 August 1999), while at Ithai "flow of the Manipur river during monsoon is of the order of 400 cumecs and river down below the barrage does not have the capacity to cope up with such flow, as a result, water is piled up upstream" (MASTEC), so the valley stores its floods for days and weeks (this Manual's reading). Pumps, sumps and gates under Clauses 9.9 and 9.10 are therefore the normal monsoon case on the valley floor, and the outfall-closed check of Chapter 5 sizes them. **Lamphelpat.** The one storm pumping arrangement found in the public record is at Lamphelpat, a pat being developed as flood storage: WRD's site report to the High Court records the dredging of a waterbody of "around 300 acres" and a "provision for pumping of flood water from the Lamphel pat water body to the Nambul River through Shamushang Nalla during high flood season" at the Shamushang station (PIL No. 8 of 2025, order of 16 June 2025), and NDB found that the "Coping measures undertaken in the form of pumping … are not adequate and the area remains waterlogged for many days every year" (proposed project summary, 2021); the capacity of the Shamushang pumps and the rule for running them were not found [TBC]. No inventory of storm-water pumping stations, gates or flap gates on the drains of any Manipur town was found [TBC]; the five pumping stations of the Imphal Sewerage Project Phase I and the 21 planned for Phase II (Revised GIS Based Master Plan for Greater Imphal – 2043) lift sewage, not storm water, and are not counted here. **The Loktak margin.** On the drains of Moirang, Ningthoukhong, Thanga, Ithai, Sugnu and Wangoo the tailwater is the lake, held up by the Ithai barrage of NHPC's Loktak project and by the sill: the design level is the high flood level at the Ithai barrage, 769.320 m, checked at the 770.05 m reached on 15 September 2025 (WRD levels as reported), and never below the lake's full reservoir level in June to September (768.5 m, NHPC, or 769.63 m in another account, as quoted; a conflict this Manual does not resolve); an outfall whose invert lies below the design lake level is treated as closed from 1 June to 30 September, so the storm is

stored and pumped (Clause 5.8.5(c)). The Chakpi "meets the Manipur River at a reverse direction … making inundation of the surrounding area of Sugnu extending upto Wangoo" (MASTEC), and phumdi drifts against outlets and screens. The bunds themselves are the weak point: MASTEC counts 11 vulnerable points on the Imphal river, 14 on the Thoubal and 5 on the Iril, and the floods of May 2024 and May–June 2025 came through breaches of the Imphal at Singjamei, Heingang, Bashikhong, New Checkon, Keirang, Khabam and Lairikyengbam Leikai and of the Nambul at four places (as reported).

In Manipur the following are set by this Manual for every outfall that passes through a river bund (pan), every gated or pumped outfall and every outfall on the Loktak margin: (a) the outfall shall have a flap gate and, behind it, a penstock or stop-log slot (Clause 9.10.3) whatever its size, because the river closes the outfall for the whole of a flood and the flap gate is the only closure the town controls; (b) the sill, the gate-closing level and the bund crest at the outfall shall be surveyed on a named datum and tied to the governing WRD gauge (Clause 10.4.4(d)); (c) the storage and pumping behind the gate shall meet the outfall-closed check of Chapter 5 for the durations that Clause 5.8.5 sets, which on the Imphal, the Nambul, the Iril, the Kongba, the Thoubal, the Sekmai, the Wangjing, the Nambol, the Khuga and the Manipur rivers, where no stage record has been analysed, are the whole of the 72-hour design storm and not less than 7 days, with any receiving pat full to its outlet at the start of the storm and the stored volume pumped down within 48 hours of the end of the storm with the gate still closed (Clause 5.8.5(a) and (e)), and the pumps shall be selected for the full range of static head up to the check level of Clause 5.8.5(a), the high flood level or the highest reading reported above it; (d) each pumping station shall be designed for stated duty points, the discharge of every pump at the lowest static head and at the highest, and its pump curves, sump levels and the river stage at which its gate shuts shall be entered on the drain register (Clause 10.17); mobile pumps are counted only as backup, never as duty or standby capacity under Clause 9.9.4 or as pumped capacity in the outfall-closed check, which credits the permanent pumps less the largest, and every station shall have the emergency connection of Clause 9.9.12; (e) the 72 hours of fuel of Clause 9.9.9(b) are a minimum, and a station whose outfall can stay closed for longer shall store fuel, or have a written arrangement with its owner for resupply by road when the land around it floods, for the whole closure, not less than 7 days on the rivers named in (c); the 1% AEP level of Clause 9.9.10 at a station behind a bund shall be taken as the higher of the local 1% AEP ponding level and the level reached behind the bund in a recorded breach, such as the flood marks of 2024 and 2025, because the stations must keep running when the land around them floods; (f) on the clay and peat of the valley floor and the Loktak margin a wet well, sump or storage tank shall be checked for flotation with the groundwater at ground level, and on peat it needs a geotechnical check of settlement, because the water stands 2 to 5 m below ground over 30 to 65 m of clay (CGWB, 2013) and no subsidence data exist [TBC]; and (g) the work needs the consent of WRD as owner of the bund, since no Manipur embankment statute was found, and within the 236.21 km² of the Manipur Loktak Lake (Protection) Act, 2006 the prior permission of LDA where the Act requires it (s.20); a gate in a bund is operated only by the body that runs it, and WRD's own works on the bunds keep WRD's calendar. Gates are also required where an outfall reaches a river reach below a dam: the Thoubal (Mapithel) dam has a full reservoir level of 880.7 m and a spillway design discharge of 2,240 m³/s, and its reservoir stood at 876 m on 1 August 2015, "nearly 2 m above the spillways" (all as reported; the two accounts do not reconcile), and the levels and release rules of the Khuga dam and of the Singda dam on the Nambul were not found [TBC]; an outfall to such a 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 (Clause 5.8.5(d)). These dams and the Ithai barrage are designed to dam-safety standards, not to this chapter, but their levels and releases are this chapter's boundary conditions. At Jiribam the drains reach the Barak and the Jiri, whose high flood level at the CWC site at Chotebekra is 32.1 m (31 July 1989, as reported; datum not stated), and an outfall there is locked for not less than 7 days where no stage record has been analysed, as on the Barak plain downstream (Clause 5.8.5(g)).

The hills set the other half of this chapter. Disang shale "occupies almost 85 p.c. of the hilly region, have less infiltration and more run off", degraded land covers 1,545 km², 24% of the valley's catchment, and the hill streams "flow down with steep slope for a short distance before meeting the Loktak Lake … load carrying capacity is high which causes siltation of the lake" (MASTEC). The landslide at Tupul, in Noney, on 29 or 30 June 2022 (the date and the toll, 56, 58 or 61 dead, differ between accounts) struck the Jiribam–Imphal railway works and has been attributed to "poorly designed or implemented slope excavation coupled with heavy rainfall" (Baruah and others, 2023, as reported); the Joumol landslide in Chandel on 1 August 2015 killed 20 or 21 people, or 24 in another

count (as reported). The IMC Building Bye-Laws (3rd Amendment), 2024, published as a draft whose final status was not confirmed [TBC], forbid construction and the cutting of slopes above 30° and limit building to two floors or 7 m at 21–30° (bye-laws 92.1 and 92.2), in place of bye-law 92 of the Model as printed, which would bar all land above 600 m with "an average slope of 30 degrees" [TBC: confirm the number and text in the bye-laws the local body has notified]; the Model refers to IS 14458, "Guidelines for retaining wall for hill area", and the drains of the AIIB project carry 50-mm weep pipes every 5 m "to release pore water pressure" (initial environmental examination, 2024); none sets a design for a structure. In Manipur the following are therefore also 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 or a khong, in sub-areas MN-B and MN-C, on the hill parts of MN-C1 and on the valley-rim slopes and hillocks of MN-A: (h) 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); (i) where such a drain enters a pipe, covered drain or culvert, with the sediment bulking and blockage factors that Chapter 6 sets (Clause 6.3.6(g) and (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 silt trap or debris basin upstream of the rack, and where a hill stream reaches the valley floor a silt trap shall stand at the break of slope (Clause 6.3.6(m)), because the silt it drops otherwise ends in the drains, the pats and Loktak; the basin volume shall be estimated from the silt and debris deposited at the site in past floods and a stated sediment-yield method, counting every road cut, slide scar, quarry and building site in the catchment as a source, because no Indian or Manipur guidance on sizing debris basins and no Manipur debris or bulking allowance was found [TBC]; its spillway shall pass the 1% AEP inflow with the basin full, as for Clause 9.7.6, and it shall have a ramp for the machines that empty it; (j) a culvert on a khong shall have a single barrel where possible (Clause 9.4.8(a)), an armoured headwall and apron at the inlet, an invert that follows the bed (Clause 9.4.8(c)), and an outlet protected under Clause 9.6 and led to a stable channel, never onto an unprotected slope, as Clause 6.3.6(k) requires of the hill roads, the NH-37 and NH-2 corridors among them, and as IRC:SP:42-2014 and IRC:SP:48 ask of road drainage; (k) every lined drain that receives runoff from cut slopes, hill roads, quarries or building sites shall have a silt trap before it joins a public drain, a khong, a pat or a reservoir; and (l) a lining in a steep drain, and a drain at the toe of a cut or retaining wall, shall be designed for the abrasion of the gravel and boulders it carries as well as for the velocity of Table 9.2, shall not leak into the slope, and shall relieve the water behind the wall through weep holes to the drain. No structure of this chapter is designed to pass a debris flow or a landslide, or to hold back a river at a breach: on Disang shale cut slopes, colluvium and fill, on any drain below a mapped landslide zone, in the breach path behind a river bund, on peat and former pats, on a foothill fan where a hill stream leaves the hills and in a dam-release reach, the screening of Clause 2.3.6(i) comes first, and a structure is sited out of the hazard.

No structure of this chapter is built to exfiltrate on the clay, silt and peat of the Imphal valley floor, on the Loktak margin, behind a river bund that ponds when its outfalls close, on the margins of a pat or pukhri, on the Barak and Jiri flood plain below its 1% AEP level or where the seasonal high water table is less than 2.0 m below ground (Clause 4.11, valley-floor rule), or on natural slopes over 10°, on Disang shale, colluvium or fill without a geotechnical certificate (Clause 4.11, hill rule): no soakaway, exfiltrating chamber, perforated pipe or open-jointed drain. Screens matter as much as gates, because the drains also carry sewage, garbage and phumdi: the Imphal Sewerage Project serves 11 of IMC's 27 wards in its first phase, with 8,600–8,700 of 51,754 targeted household connections made (State report to the National Green Tribunal in O.A. No. 606 of 2018, July 2025), the 72 drains that fall into the Nambul carried a BOD of 42.45–52.34 mg/L, and their interception and diversion is reported as completed (the same Tribunal case, December 2025), CPCB lists 18 polluted river stretches in the State, all in Priority V, among them the Nambul from the Singda dam to Bishnupur (2025), and the Naga Nullah behind the main market is "a stagnant pool all along the year" of dumped waste (Revised GIS Based Master Plan for Greater Imphal – 2043), so a screen on a pump sump or a gate in Manipur is checked in the blocked case of Clause 9.8.4, cleaned mechanically where the sump serves more than one drain, and placed with the interception of dry-weather flow before every outfall to a pat, Loktak or a river stretch on CPCB's list (Chapter 6, Clause 6.3.6(e); Chapter 8, Clause 8.9.5). No inventory of the gates, flap gates, screens and pumping stations on the drains of any Manipur town, with their sills, capacities and operating rules, no rule of WRD linking the closing of a gate to a river stage or stating how long its gates stay closed, no operating rule for the Ithai barrage or the dams linked to the towns below them, and no design river or lake 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 gate that fails, or is jammed open by silt, garbage, debris or phumdi (the floating mats of "vegetation, organic debris and soil" that the Manipur Loktak Lake (Protection) Act, 2006 defines as "Phumdis"), lets the Imphal, the Nambul, another valley river or Loktak in flood back into the drain network, and one jammed shut blocks it. The drains of Greater Imphal carry garbage and sewage to their outfalls: the 72 drains that fall into the Nambul carried a BOD of 42.45–52.34 mg/L (State report to the National Green Tribunal in O.A. No. 606 of 2018, December 2025), against 3–6 mg/L in the rivers (CPCB, 2025); the solid waste of the main market is "dumped in the Naga Nullah on the backside of the market, which creates a stagnant pool all along the year" (Revised GIS Based Master Plan for Greater Imphal – 2043), and the clogging of the Naga Nullah flooded Nagaram, Laipham Khunou and Lairikyengbam Leikai in July 2024 (as reported), so a gate, its screen and the pump sump behind it are exposed to the same load and must be kept clear together; and because the valley rivers stay high for days in a large flood (the Imphal at Lilong reached 783.250 m on 15 September 2025, above its printed high flood level of 782.850 m, WRD levels as reported) and "the failure of river dikes causes waterlogging in the low-lying areas for several weeks" (AIIB, 2024), a gate that leaks or jams can be exposed for days or weeks; no Manipur embankment statute was found, so WRD consents to a gate in its bund as owner, and only the body that runs a gate operates it (set by this Manual).

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 Manipur 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 Manipur 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 Manipur 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 Manipur 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 Manipur the failure is one of missing criteria, of a building rule that takes effect only through each local body, and of hill areas that no building rule reaches. No document of MAHUD, TPD, the Planning and Development Authority, Manipur (PDA Manipur), IMC or another urban local body, PWD or WRD stating a design return period, intensity or runoff coefficient for the storm drains of any town was found, and the AIIB found that "The existing drainage in the Greater Imphal area is also not in good condition and is not properly connected to the primary drain. Drainage system links are missing … the drains are clogged" (project document, 2024). The approval route shapes this chapter. The Model Manipur Unified Building Bye-Laws, 2024 were published by MAHUD (Notification No. BBL-101/1/2024-MAHUD-MAHUD-Part(1) of 4 December 2024, Manipur Gazette Extraordinary No. 253 of 5 December 2024) under section 213 of the Manipur Municipalities Act, 1994 and section 26(1) of the Manipur Town and Country Planning Act, 1975 "for adoption by the Urban Local Bodies and Planning & Development Authority, Manipur"; they "extend to the Master Plan areas or notified Planning areas and area under the jurisdiction of all the Urban Local Bodies of Manipur" (bye-law 1(2)), but a permit is given under the bye-laws that the local body or PDA Manipur has brought into force on the Model, among them the bye-laws of the Kumbi, Moirang and Jiribam Municipal Councils (final gazette of 16 January 2025, as listed by TPD) and those notified for the urban local bodies on 15 December 2025 (as listed; not read [TBC]); before the Model, eight towns had bye-laws "based on Model Building Bye-laws of 1998" and 18 urban local bodies had none (the Model's recitals). Provision numbers below are the Model's [TBC: confirm the number and text in the bye-laws the local body has notified]. Plans are submitted through the Online Building Permission System, in use since a circular of 17 October 2022 (as listed by TPD), on which TPD checks each plan for land-use compatibility with the master plan; it examined "about 150 building plans forwarded by Imphal Municipal Corporation" in 2025-26 (TPD administrative report). The Model already asks for much of what a drainage submittal needs: a "terrace plan indicating the drainage and the slope of the roof"; "detail provisions made for conservation and harvesting of rain water" (bye-

law 6(1)(C)(j)); for multi-storeyed, lifeline and special buildings a "Detailed drainage plan for both internal and external required to be constructed up to the available permanent/pucca drain of municipal/other authority" (6(1)(D)) and "an intermediate treatment chamber" before any soak-pit outlet to a municipal drain (6(1)(A)); rain-water pipes of at least 75 mm that never discharge "directly into any closed drain" or into a soil pipe (28); on plots of 100 m² and above, plans that "indicate the system of storm water drainage along with points of collection of rain water in surface reservoirs or in recharge wells" (66(a)); no building over a municipal drain (16); and a completion certificate in which the professional certifies "that water harvesting as well as waste water re-cycling systems has been provided as per the sanctioned building plan". Other approvals stand beside the permit: the previous permission of the Flood Zoning Authority under the Manipur Flood Plain Zoning Act, 1978 for activity in a prohibited or restricted area (bye-law 93), though no Authority has been found constituted and no zone notified; the prior permission of the Loktak Development Authority (LDA) within the lake's 236.21 km² (Manipur Loktak Lake (Protection) Act, 2006, s.20); and the approval of the Local, District and State Level Committees for converting paddy land or wetland, without which "no local authority shall grant any licence or permit" for construction on it (Manipur Conservation of Paddy Land and Wetland Act, 2014, s.12). The hill areas lie outside all of these: the Manipur Municipalities Act, 1994 "extends to the whole of the State of Manipur except the Hill Areas" (as quoted), the Model reaches only urban local bodies and notified planning areas, and the District Councils' functions under s.29 of the Manipur (Hill Areas) District Councils Act, 1971 include "water supply and sanitation schemes" and land allotment but no building control; no building or drainage rule for the hill areas was found. No rule asks for a drainage report, limits peak runoff, requires on-site detention or sets a design storm. Every stormwater item in this chapter is therefore written so that the architect or engineer on record can certify it on Forms 1-1, 2-1, 10-2 and 10-3, and the Authority can check it with the drawings that the Model already requires through the Online Building Permission System, beside the detailed drainage plan of bye-law 6(1)(D), which the submittals of this chapter extend to every site that Chapter 1 covers and give the design storm it lacks, and at completion; in the hill areas, the department that executes a public work, PWD, PHED, WRD or another works agency, applies it to that work, and a District Council or its administrator could take it up only if the Governor entrusts the matter or the Council adopts the Manual (neither has been done). 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 Model Manipur Unified Building Bye-Laws 2024 (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.

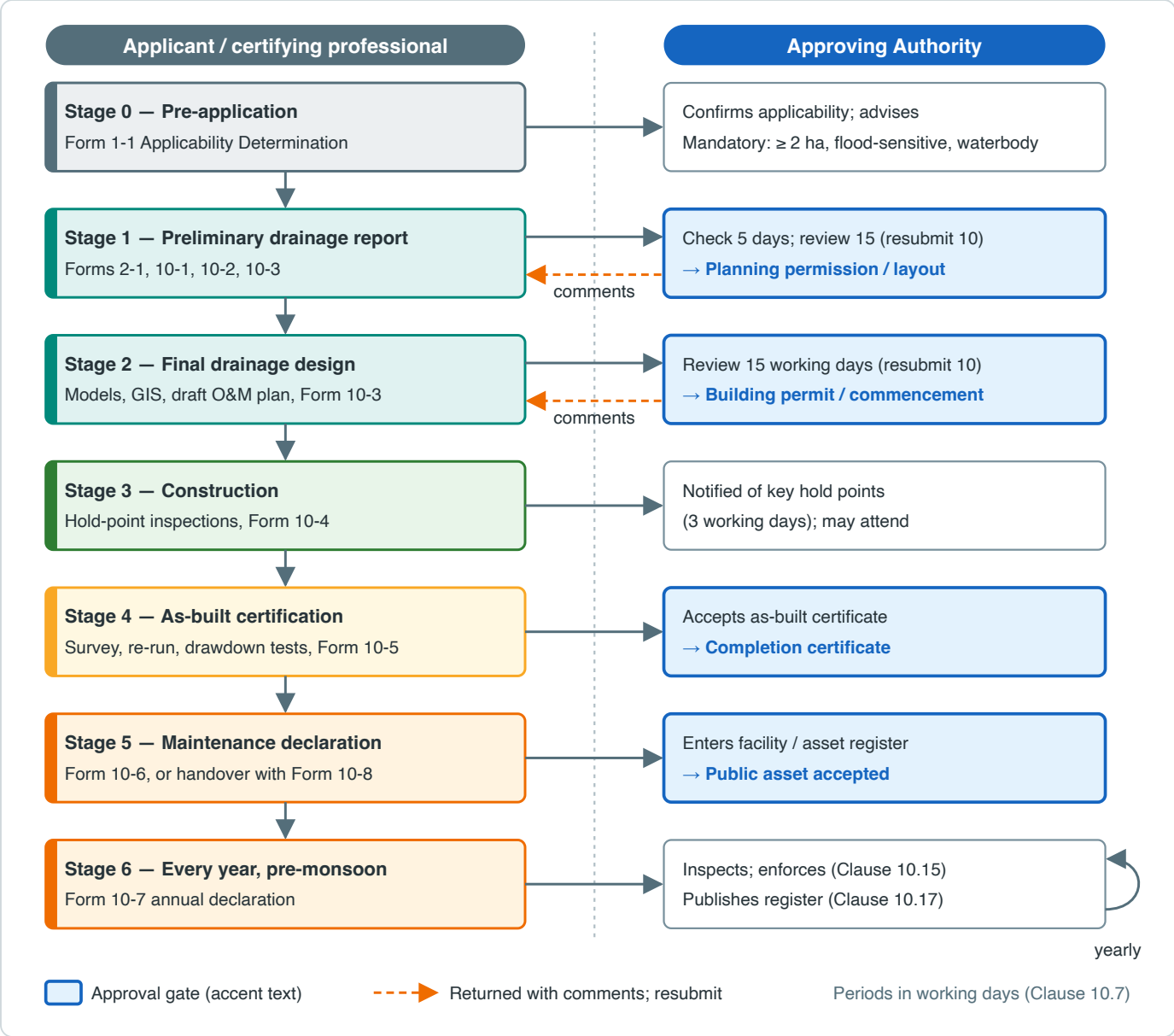

Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.

> **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 Unified Bye-Laws 2024 steps a Manipur 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 the whole State, which lies between about 92°58' E (the State portal) or 93.03° E (knowindia) and about 94.78° E (both as quoted), inside zone 46N (90°–96° E), so that no project needs another zone (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 WRD gauges on the valley rivers and at the Ithai barrage (levels published in the press in metres, presumed above mean sea level, the datum not stated [TBC]), of the CWC level-monitoring site on the Barak at Chotebekra, of the Loktak levels of NHPC and CEA, of the reservoir levels of the Thoubal (Mapithel) dam, of WRD's bund crests, gate sills and gate-closing levels, and of the flood marks surveyed on ungauged rivers, khongs, pats and pukhris 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

Form	Title	Stage
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. Manipur has no notified design return period or design storm for its urban drains, and no document of MAHUD, TPD, PDA Manipur, IMC or another urban local body, PWD, WRD or Imphal Smart City Ltd stating a return period, a runoff coefficient or a drain standard was found; the Model Manipur Unified Building Bye-Laws, 2024 refer the services of a building to the National Building Code 2016. The two largest drainage works under way state none either: the AIIB's Manipur Urban Road, Drainage and Asset Management Improvement Project (P000723) will build "547 km of both side stormwater covered drains" along the roads of Greater Imphal, but its project document gives no return period, rainfall intensity or runoff coefficient (2024), and the NDB summary of the Lamphelpat project, which will "increase its water detention capacity, restore stormwater drainage system" (2021), states no design storm. The general 5-year return period of the CPHEEO manual for urban drains is cited in a JICA report (as reported) and is not a Manipur value. The rainfall studies do not supply one either. No intensity–duration–frequency relation with constants was found for any Manipur station; an Imphal relation built from 15-minute data of 1986–2009 is described in an online upload whose author and values could not be seen (as reported), and is not cited as a value; IMD's national study (Das et al., 2022) has an Imphal panel that repeats the generic curve of most other cities and implies 24-hour depths above every Imphal record at the long return periods, so it is not used; NIH-DHAARA gives a 50-year 24-hour depth at Imphal of 231 mm, about 1.45 times the station's record of 158.6 mm (tool output; ratio computed for this Manual); and MASTEC's annual-maximum series for Imphal, 1974–2000, is the only station series in print (MASTEC, Table 2). The whole State lies in CWC subzone 2(c), "Barak, Kalden and Manipur rivers", for which CWC has published no Flood Estimation Report. The State's design values are therefore those of Chapter 2: the station series of Clause 2.3.6(c)(i) on the Imphal valley floor and the Loktak margin, the Barak-valley floors of Clause 2.3.6(c)(ii) in the western hills and on the Jiribam plain, and NIH-DHAARA with the valley table as a floor in the northern, eastern and southern hills (Clause 2.3.6(c)(iii)), 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). A Manipur 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 TPD:

- (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 TPD 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 Unified Bye-Laws 2024 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 TPD 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 consent of WRD for any work on, through or within a river bund, flood channel, river or pumped outfall in its charge, which it gives as owner because no Manipur embankment statute was found, among them the bunds of the Imphal, the Nambul, the Iril, the Kongba and the Thoubal and the pumping of Lamphelpat through the Shamushang channel, the previous permission of the Flood Zoning Authority under bye-law 93 of the Model and the Manipur Flood Plain Zoning Act, 1978 for any activity in a prohibited or restricted area, once an Authority is constituted and an area notified (neither has been found), the prior permission of LDA for an act that the Manipur Loktak Lake (Protection) Act, 2006 forbids without it in the lake's 236.21 km² (s.20), and the leave of the High Court for development in or around Loktak while its orders of 17 July 2019 and 25 February 2022 stand (as reported), the approval of the Local, District or State Level Committee under the Manipur Conservation of Paddy Land and Wetland Act, 2014 for the conversion of paddy land or wetland, the views of the Manipur State Wetlands Authority for a work in or next to a wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (the notifications of the Yaral, Utra and Waithou–Phumnom pats are still drafts), the consent of PWD or the national-highway agency for a discharge to a side drain or culvert of one of their roads, the consent of the Manipur Pollution Control Board 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 (in Greater Imphal, IMC, PWD, WRD, DoECC for the drains intercepted under the Nambul project, or PHED for a sewer), 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.

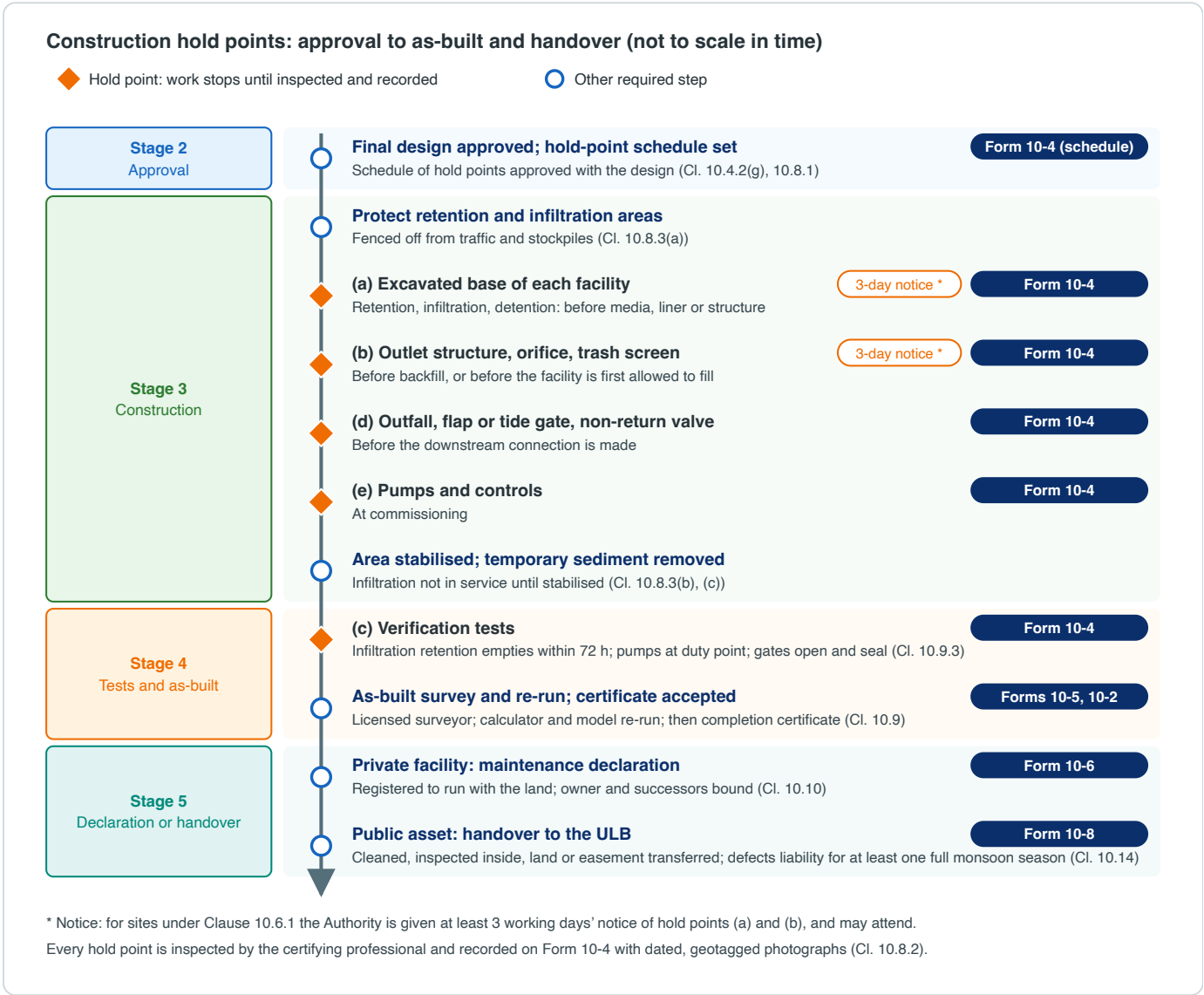

Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement 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 Manipur 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 Manipur 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. Manipur has no dated State or municipal order fixing pre-monsoon desilting or the readiness of gates and pumps. The drains are run by several hands, and no rule divides them: no notification assigns the Naga Nullah, the Waisel Maril or the Shamushang channel to one owner (this Manual's reading of the record). IMC and the other urban local bodies keep the municipal drains, which the Model names in its bar on building "over any municipal drain" (bye-law 16), though the drainage sections of the Manipur Municipalities Act, 1994 were not read [TBC]; PWD keeps the roadside drains, among them the 547 km of covered drains of the AIIB project in Greater Imphal, and the national-highway agencies those of the national highways; WRD keeps the river bunds and flood

channels, Lamphelpat and the pumping of its flood water through the Shamushang channel to the Nambul, and was to provide the machinery for clearing encroachments from the Waisel Maril and the Naga Nallah in April 2025 (as reported); DoECC runs the interception and diversion of the 72 drains that fall into the Nambul and its treatment plant of 16 or 17 MLD, as the reports differ (State reports to the National Green Tribunal in O.A. No. 606 of 2018, 2025); PHED runs the sewers and the five sewage pumping stations of the Imphal Sewerage Project Phase I; LDA governs Loktak under the Manipur Loktak Lake (Protection) Act, 2006 and was named to lead the cleaning of the Waisel Maril (as reported); and the role of Imphal Smart City Ltd in the drains of its area was not found [TBC]. The gates that matter most are run for other purposes: the Ithai barrage holds Loktak for NHPC's Loktak hydroelectric project, and the Loktak Act does not apply to the Power Department acting under its agreements with NHPC (s.36); the release rules of the Thoubal (Mapithel), Khuga and Singda dams were not found [TBC]. No operating rule for any gate, flap gate or pumping station in a Manipur town, linking it to a river level, a dam release or a rainfall warning, was found in the public domain, and the CAG found in its audit of flood control to March 2016 that "The overall flood fighting and control activities remained inadequate" (Report No. 2 of 2017, as summarised). 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 Manipur, the pre-monsoon inspection of gates, flap gates, non-return valves, screens, silt traps, debris racks and pumped facilities, including the gates and pumps on outfalls through the river bunds of the valley, on the Lamphelpat outfall to the Nambul and on outfalls to Loktak and the other pats, with the desilting of every drain, khongban and city channel, the clearance of inlets, silt traps, screens and hill-stream traps, and the pump duty and gate seal tests, shall be completed by **31 March**; gates, flap gates and pumped facilities, with their standby power and fuel, shall be certified ready on the same date, with every gate on an outfall to a river, a pat or Loktak operated through its full travel, by or with WRD where the gate is in its charge, because the season of this Manual begins on 1 April and the storms of April and May are among the State's largest.

Pumps, their standby power, gates and screens shall then be kept on standby, with the monthly test run, from **1 April to 31 October**, and at an outfall to a river or to Loktak until the river at the governing WRD gauge has fallen below its flood level, or the lake below the outfall invert, and the gates have been reopened, if that is later. Inlets, silt traps, screens and hill-stream traps shall be cleared again by **15 May**, of the silt, debris, garbage and phumdi of the April and early-May storms, before the late-May storms that flooded the valley in 2024 and 2025, and every public drain, khongban and city channel, inlet, trap and screen in every town shall be cleared of the silt and debris of the season, and its silt depths surveyed, by **15 November**. WRD's own works on the river bunds 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).

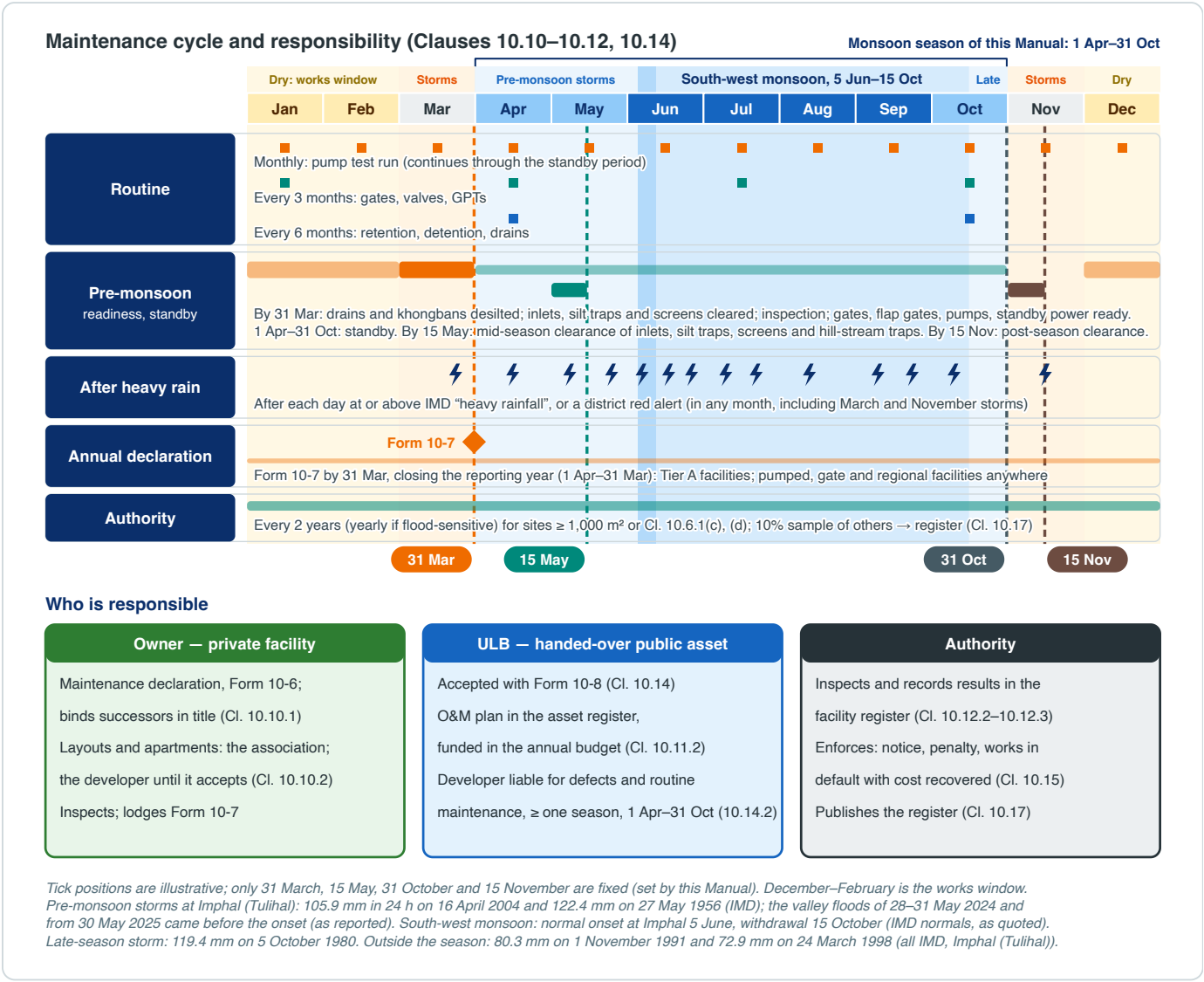

Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 31 March) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the monsoon season (April–October); 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, and its first two months bring storms as large as the monsoon's: Imphal (Tulihal) recorded 105.9 mm in 24 hours on 16 April 2004 and 122.4 mm on 27 May 1956, and its wettest April and May months are 459.6 mm (2004) and 464.3 mm (1956), against a 24-hour record for the station of 158.6 mm (IMD, *Extremes*, data 1953–2012); every month from February to December has a 24-hour maximum of 80–160 mm (this Manual's reading of the same table). Two of the recent damaging valley floods came before the monsoon's onset, with Cyclone Remal on 28–31 May 2024 and the rain of 30 May to early June 2025 (as reported), and the flood of June 1966 also began early (MASTEC). The AIIB found "intense rains from March to October" in Greater Imphal (project document, 2024); CGWB found that in Bishnupur "Rainfall starts from the month of April end" (2013); and MASTEC that the "Rainy season … starts from May and extent up to October". NDMA (2010) sets 31 March for pre-monsoon desilting nationally, and this Manual keeps that date, as the other North-East editions of this series do. December to February is the works window. No Manipur order fixing a date for desilting drains or readying gates and pumps was found. This Manual's 31 March covers the drains, inlets, gates, flap gates and pumps of the drainage system; WRD's own works on the river bunds keep WRD's calendar. This Manual therefore takes 31 March for desilting, the clearance of inlets, silt traps and screens, the pre-monsoon inspection, the annual declaration and the readiness of gates, flap gates, pumps and standby power, with no later readiness date; the research's suggestion of 30 April for the gates in the bunds is not used, because the April storms would find them unready. The south-west monsoon's normal onset at Imphal is 5 June (previously 1 June), and its withdrawal 15 October (IMD's normals in use from 2020, as quoted in IMD's press release). Here Manipur's own record moves one date: the other North-East editions of this series clear inlets and traps a second time by 31 May, before the onset, but in Manipur the floods of 2024 and 2025 struck in the last days of May, so a clearance due by 31 May would fall during them. Inlets, silt traps, screens and hill-stream traps are therefore cleared again by 15 May, after the April and early-May storms and before the late-May storms. Storms continue after the withdrawal: Imphal recorded 119.4 mm on 5 October 1980 and the valley flooded in October 1992 (IMD; MASTEC), so pumps, gates and screens are kept on standby to 31 October (Figure 10.3). Large falls also come outside the season, 80.3 mm on 1 November 1991, 89.6 mm on 13 December 1966, 79.8 mm on 18 February 1993 and 72.9 mm on 24 March 1998 at Imphal (IMD), and the drains fill with silt and garbage during the season, so every town clears its drains a second time, and surveys their silt depths, by 15 November. The post-event inspections of Table 10.3 cover storms at any time of year. 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 Manipur 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 Manipur 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 Model Manipur Unified Building Bye-Laws 2024 are made and from the municipal Acts. The graduated steps are set by this Manual. In Manipur the courts and the National Green Tribunal have become working regulators of the lake, the rivers and their pollution. The High Court's special bench barred development or construction in or around Loktak "without the Court's leave" by orders of 17 July 2019 and 25 February 2022 (as reported; case number not found [TBC]), and in a suo motu PIL on the Thoubal river in 2019 forbade quarrying, sand mining and pollution except under licence (as reported); in PIL No. 8 of 2025 it took WRD's inspection report on the dredging of Lamphelpat on record and disposed of the petition, finding "no substance" (order of 16 June 2025). The Tribunal supervises the State's sewage and solid waste in O.A. No. 606 of 2018, under which the interception of the 72 drains that fall into the Nambul is reported as completed (State report, December 2025), and its polluted rivers in O.A. No. 673 of 2018, which names 13 rivers of the State, the Imphal, the Iril, the Nambul and the Manipur among them; its order of 22 May 2020 in M.A. No. 26 of 2019 led to an inventory of about 4,000 water bodies whose "Ground truthing … are pending" (DoECC, 2025-26). The statutes differ in force. The Manipur Conservation of Paddy Land and Wetland Act, 2014 carries a real penalty, imprisonment of not less than three years and up to five, and a fine of ₹50,000 to ₹2 lakh (s.18), and bars any licence or permit for construction on paddy land converted in contravention of it (s.12); a Bill of 2026 would exempt land that conforms to a notified master plan and allow "Deemed Conversion" on self-declaration, but it is a Bill, not law. The Manipur Loktak Lake (Protection) Act, 2006 makes the Core Zone of 70.30 km² a "No-Development Zone or Totally Protected Zone" (s.3), bans in the Buffer Zone the "Discharge of untreated wastes and effluents from industries, cities or towns" and "Land reclamation, bunding or disturbing the natural course of drainages" (s.19), and in the lake forbids discharging sewage or domestic waste except with LDA's prior permission (s.20); its penalties were not read [TBC], and it was used to clear huts from the phumdis (as reported). The Manipur Flood Plain Zoning Act, 1978 is nominal in practice: no Flood Zoning Authority has been found constituted and no zone notified, and demarcation "is yet to be done" (as reported, June 2026), although an eviction order of April 2025 along the channels of the Imphal river cited its "Section 24" (as reported; s.24 not read [TBC]); the permission of the Flood Zoning Authority that bye-law 93 of the Model requires is nominal for the same reason. The penalties of the Manipur Municipalities Act, 1994 and of the Manipur Town and Country Planning Act, 1975 were not read, so whether they are nominal is not known [TBC]. The Model is enforced through the permit and the completion certificate, and its fee rebate of 10% for rainwater harvesting with waste-water recycling (bye-law 68) is its one incentive found. The CAG found that "The overall flood fighting and control activities remained inadequate" (Report No. 2 of 2017, audit of flood control and flood forecasting to March 2016,

as summarised; the chapter was not read [TBC]), and earlier audits found the "failure of canals … due to siltation of beds" of the Loktak Lift Irrigation Project (2002 and 2008, as summarised); no audit of the drains of IMC, of Imphal Smart City Ltd, of AMRUT or of LDA was found. This shows that a rule without routine enforcement does little, and that where the State has not drawn a line on the ground the courts have. 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 stage of the receiving river at the nearest WRD gauge (the Imphal at Minuthong or Lilong, the Iril at Irilbung, the Nambul at Thong Nambonbi (Hump Bridge), the Nambol at Nambol Thongkhong, the Thoubal, or the Manipur river at the Ithai barrage), against its warning, flood and high flood levels, or the level of Loktak, or, at Jiribam, of the Barak at the CWC site at Chotebekra, and, where it is gauged, at the outfall and inside the bund, each on a named datum, with any reading published in the press kept apart from WRD's register; the times at which each gate and flap gate on the outfall and on the drain upstream of it closed and reopened, the level in the receiving pat or pukhri, the hours each pump ran, any loss of power, the fuel used and the phumdi, garbage and debris removed from each screen; any breach of a river bund, with its time and the level the water reached behind it; and the releases of any dam that set the receiving level, such as the Thoubal (Mapithel), Khuga or Singda dam, with the times of the warnings given;
- (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), MSDMA, 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. Manipur's floods have been counted more often than they have been reviewed, and the counts conflict. MASTEC's report records the valley floods to 2002: in July–August 1989, after Imphal (Tulihal) recorded 158.6 mm on 30 July, the station's 24-hour record (IMD), and rain fell daily from 28 July to 1 August, 361 localities were flooded, the bunds breached in 40 places, about 7 lakh people and 49,069 houses were affected and 97,500 ha of paddy damaged; and in August 2002 the bunds breached in 59 places. In late July and August 2015 about 5 lakh people were displaced by 3 August, by a State revenue estimate, and officials called it a flood that "could be the worst flood in 200 years", while the Joumol landslide in Chandel on 1 August killed 20 or 21 people, or 24 in another count (as reported). The Tupul landslide in Noney on 29 or 30 June 2022 killed 56, 58 or 61 people by different counts, and NRSC reported 42 dead and 20 missing on 5 July (as reported). For the floods of Cyclone Remal on 28–31 May 2024 the Minister gave 1,88,143 people and 24,265 houses affected on 30 May, and the Relief and Disaster Management Department's report of 31 May gave 1,26,950 people, 255 localities and 16,364 houses, with 3 to 5

deaths reported; for the floods of 30 May–June 2025, more than 56,000 people and 10,477 houses were affected at an early count and about 1.65 lakh people and more than 35,000 houses by the official figures of 24 June, with 4 deaths; and on 15 September 2025 the Imphal at Lilong and the Manipur river at Ithai stood above their printed high flood levels and the Iril breached at Kshetri Awang Leikai (all as reported). The tolls differ in what they count, and the final tolls of the Relief and Disaster Management Department or MSDMA were not obtained [TBC]. No IMD rainfall for the floods of 2024 and 2025 was found, only press values such as 123 mm in 24 hours and 175 mm in 72 hours at Kangpokpi on 30–31 May 2025 (as reported); no review of any flood in a Manipur town, and no record of flood extents, depths or durations kept by IMC, another urban local body, WRD or MSDMA, 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. Much of Manipur's drainage record is public: the Model Manipur Unified Building Bye-Laws, 2024, the draft IMC Building Bye-Laws (3rd Amendment), 2024, the Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026 and the report of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification) on the Town Planning Department's website; the Manipur Town and Country Planning Act, 1975, the Manipur Loktak Lake (Protection) Act, 2006, the Manipur Conservation of Paddy Land and Wetland Act, 2014 and its amending Bill of 2026, and the Manipur Official Language Act, 1979 as amended in 2021, in PRS's collection; the amendments to the Manipur (Hill Areas) District Councils Act, 1971 on the State portal; the High Court's order in PIL No. 8 of 2025 with WRD's site report on Lamphelpat; the State's reports to the National Green Tribunal in O.A. No. 606 of 2018; CPCB's list of polluted river stretches (2025); the administrative reports of DoECC and TPD for 2025-26; NDB's summary of the Lamphelpat project and the AIIB's documents for its road and drainage project; MASTEC's report on flood hazard zonation in the valley; CGWB's booklets for Imphal West and Bishnupur; and IMD's station extremes for Imphal (Tulihal). Much else could not be found or read: the building bye-laws for the urban local bodies notified on 15 December 2025, posted only as a folder of files, and the final text and commencement of the IMC (3rd Amendment); the risk-informed master plans for Imphal and Moirang, listed as notified in January 2025 but reported elsewhere as a draft report submitted, and with them the "High Flood Risk Areas" on which bye-law 94 of the Model depends; the Manipur Flood Plain Zoning Act, 1978 beyond its section 7, any constitution of a Flood Zoning Authority and any

zone; the drainage sections and penalties of the Manipur Municipalities Act, 1994; WRD's gauge register, with the zero, datum and any revision of each level, and any rule for its gates; NHPC's operating rule for the Ithai barrage and a record of the lake's levels; the release rules of the Thoubal (Mapithel), Khuga and Singda dams; the design basis of any storm drain, including the AIIB project's drainage design, the Lamphelpat project report and the works of Imphal Smart City Ltd; the High Court's case number for its Loktak orders; the chapter of the CAG's Report No. 2 of 2017 on flood control; MSDMA's procedures for urban floods and its final tolls; the State Action Plan on Climate Change; and an inventory of the gates, flap gates, screens and pumping stations 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

Annex / Form	Content
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
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, pukhri 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. Manipur's capital has a master plan, a river project and a road-drainage programme, but no published storm-drainage master plan with a design storm. The Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification), notified by MAHUD (No. SCS-401/3/2021-MAHUD-MAHUD-Part(3) of 4 December 2024), covers a planning area of 151.38 km² in Imphal East and Imphal West, wider than IMC's limits; it finds that "The town is below the high flood level of Imphal river and hence there are embankment roads on both sides of the river", records that wetlands in the planning area are "earmarked by the government for the construction of water bodies for an area of approximately 500 hectares", and plans the land use of 2043, but its chapter on physical infrastructure covers water supply, sewerage, electricity and solid waste and has no section on storm-water drainage. The Risk Informed GIS Based Master Plans for Imphal and Moirang are listed as finally notified on 17 January 2025, while TPD's report for 2025-26 says their draft report "has been submitted", an inconsistency; they were not read, so the flood-risk areas they may map are not known [TBC]. TPD is preparing GIS master plans for Thoubal, Kakching, Lilong (Thoubal), Mayang Imphal and Nambol and for 14 district headquarters "both valley and hills", with a horizon of 2042 (TPD administrative report, 2025-26). Drainage capacity is being built by project, not by plan. The AIIB's Manipur Urban Road, Drainage and Asset Management Improvement Project (P000723) will rehabilitate 547 km of roads in Greater Imphal with "547 km of both side stormwater covered drains" that "channelize the storm water … to the out fall (river)", without a stated return period, intensity or runoff coefficient (project document, 2024). The Lamphelpat Waterbody Rejuvenation Project of the Water Resources Department (WRD), with a loan from NDB (total cost USD 87.84 million, loan USD 70.27 million, concept approval 17 November 2021), is to "increase its water detention capacity, restore stormwater drainage system and channels / streams in the catchment area" and set up a "real time flood management

system with a command center" (NDB summary); dredging of about 300 acres began under a work order of 9 November 2023, with WAPCOS as monitoring consultant (WRD's site report in PIL No. 8 of 2025), and press accounts of its cost, area and funders differ (as reported). DoECC's interception of the 72 drains that fall into the Nambul is a pollution work, not a capacity work. No published document sets a design return period for the storm-drain network of any Manipur 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 MAHUD, TPD, the Planning and Development Authority, Manipur (PDA Manipur), IMC or any other urban local body, WRD, LDA, MSDMA, any District Council or its administrator, or any other body. A site-level manual cannot fix basin-level problems: lost tank storage, pats and paddy land that once held the valley's floods being filled and built on, river bunds that breach and drains that cannot discharge while the rivers stand above their flood levels, city channels such as the Naga Nullah and the Waisel Maril clogged with garbage, drains that carry the sewage of most of Greater Imphal to the Nambul, Lamphelpat and Loktak, hill slopes of Disang shale that slide when cut and wet, and single channels split between IMC, PWD, WRD, DoECC and LDA with no notification assigning them to one owner, 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 Manipur, the series' third North-East edition and its first closed lake basin inside a hill State: to a capital on a flat valley floor at about 780–790 m whose rivers stand in flood above its drains, behind bunds that breach, and whose only outlet runs through Loktak, the Ithai barrage and a rock sill below it; to a lake margin where the lake level is the tailwater for the season; to pats and paddy land that once stored the valley's floods and are being filled; to hill towns on Disang shale that slides when cut and wet, as at Tupul in 2022, and to the western hills and the Jiribam plain, which face the Barak and receive far more rain than the valley; to a State that lies wholly in a CWC subzone for which no Flood Estimation Report has been published; to drains that carry the sewage of most of Greater Imphal to the Nambul, Lamphelpat and Loktak; to a building rule that is a model each local body brings into force, with a river-buffer table and a flood-plinth rule but no design storm, a Flood Plain Zoning Act of 1978 with no zone, and hill areas that no building rule reaches; and to a wet season that begins with the storms of April and May, so that on the valley floor a BSMP begins with the river and the lake, and in the hills with the hazard (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.

Term	Meaning in this Manual
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 Manipur 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:

- **Greater Imphal, the Nambul:** the catchment of the **Nambul** through Greater Imphal, with the **Naga Nullah** and the **Waisel Maril** and the 72 drains that fall into it in the 1D network, the breaches of its bunds at four places in 2025 and the flooding of Nagaram, Laipham Khunou and Lairikyengbam Leikai by the clogged Naga Nullah in July 2024 (as reported) as calibration evidence, and the river at Thong Nambonbi (Hump Bridge), with its high flood level of 783.695 m (WRD, as reported), as the boundary, the gates closed (Clause 5.8.5(a) and (b));
- **Greater Imphal, the Imphal river:** the catchments that drain to the **Imphal** through the city, with the river at Minuthong (flood level 786.900 m, high flood level 788.400 m) and Lilong (781.350 m or 781.250 m; 782.850 m, exceeded at 783.250 m in September 2025) (WRD, as reported) as the boundary, and the breach paths of 2024 and 2025 at Singjamei, Heingang, Bashikhong, New Checkon, Keirang, Khabam and Lairikyengbam Leikai mapped;
- **Lamphelpat:** the basin of **Lamphelpat**, a pat being developed as flood storage, with its pumped outlet through the **Shamushang** channel to the Nambul, the pat full to its outlet at the start of the storm and the pumps' capacity, once WRD states it [TBC], as the outfall (Clause 5.8.5(e));
- **Imphal East, the Kongba and the Iril:** the corridors of the **Kongba** and the **Iril**, with the Iril at Irilbung (flood level 787.700 m; a printed high flood level below it; 788.850 m reached on 15 September 2025, as reported) and its breach at Kshetri Awang Leikai in September 2025 as evidence;
- **Thoubal:** the catchments of Thoubal town on the **Thoubal** below the **Thoubal (Mapithel) dam**, with the river's WRD levels and the dam's largest recorded release, or its spillway capacity until WRD gives one, as boundary conditions (Clause 5.8.5(d));
- **The Loktak margin:** the catchments of **Moirang**, **Ningthoukhong**, **Thanga** and **Ithai–Sugnu–Wangoo** that drain to **Loktak**, its fringing pats or the Manipur river between Ithai and Sugnu, with the high flood level at the Ithai barrage, 769.320 m, checked at 770.05 m, as the boundary, the backwater of the **Chakpi** at Sugnu, and the outfalls below the design lake level closed from 1 June to 30 September (Clause 5.8.5(c));
- **Nambol and Bishnupur:** the catchments that drain to the **Nambol** and the lower **Nambul**, with the Nambol at Nambol Thongkhong (774.700 or 774.400 m, as reported) as the boundary;
- **Kakching and Wangjing:** the catchments that drain to the **Sekmai** and the **Wangjing**, with surveyed flood marks as the boundary until a WRD level is obtained;
- **Jiribam:** the catchments of Jiribam town that drain to the **Barak** and the **Jiri**, with the high flood level at the CWC site at Chotebekra (32.1 m, 31 July 1989, as reported) as the boundary for at least the 7-day lock of Clause 5.8.5(g), the reaches below governed by the adjoining edition of this series; and
- **Hill towns on landslide ground:** the catchments of **Noney**, with Tupul and the Khoupum valley, **Tamenglong**, **Chandel** and **Kangpokpi**, under the hazard-first rule below.

Hazard first in the hills and at the breaches (set by this Manual). In sub-areas MN-B (Northern, eastern and southern hills) and MN-C (Western hills) of Annex 2A, on the hill parts of MN-C1 and the valley-rim slopes and hillocks of MN-A, and in any basin below a mapped landslide zone, in the breach path behind a river bund, in a dam-release reach, in the Loktak core zone or on its phumdi, on peat and former pats, or on a foothill fan where a hill stream leaves the hills, the BSMP begins with a hazard screening for landslides, debris, bund breaches, dam releases and settlement, made with the inventories of MSDMA and NRSC where they exist [TBC], the hazard maps of the risk-informed master plans once read [TBC] and WRD's records of its bunds and breaches, and uses site-specific hydrology in place of a CWC report, which subzone 2(c) does not have (Clause 2.3.6(c) and (i)). The hills' failures are of another order than the drains': the Tupul landslide of 29 or 30 June 2022, with 56, 58 or 61 dead by different counts, followed 348.5 mm of rain in June in Noney district and has been attributed to "poorly designed or implemented slope excavation coupled with heavy rainfall" (Baruah and others, 2023, as reported), and the reported record for the State, 225 mm in one night at Khoupum on 15 July 2025, inundated the Khoupum valley (as reported; duration and gauge not stated). 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 a breach. Other Tier A bodies and the other urban local bodies define their basins in the first BSMP that covers them. Where WRD, CWC, NHPC, a master plan, the Flood Zoning Authority or a court has a high flood level, a lake level, a flood line or an operating rule for a dam, barrage, gate or pumping station, the BSMP shall take its boundary conditions from it and show those levels against its own 1% AEP map.

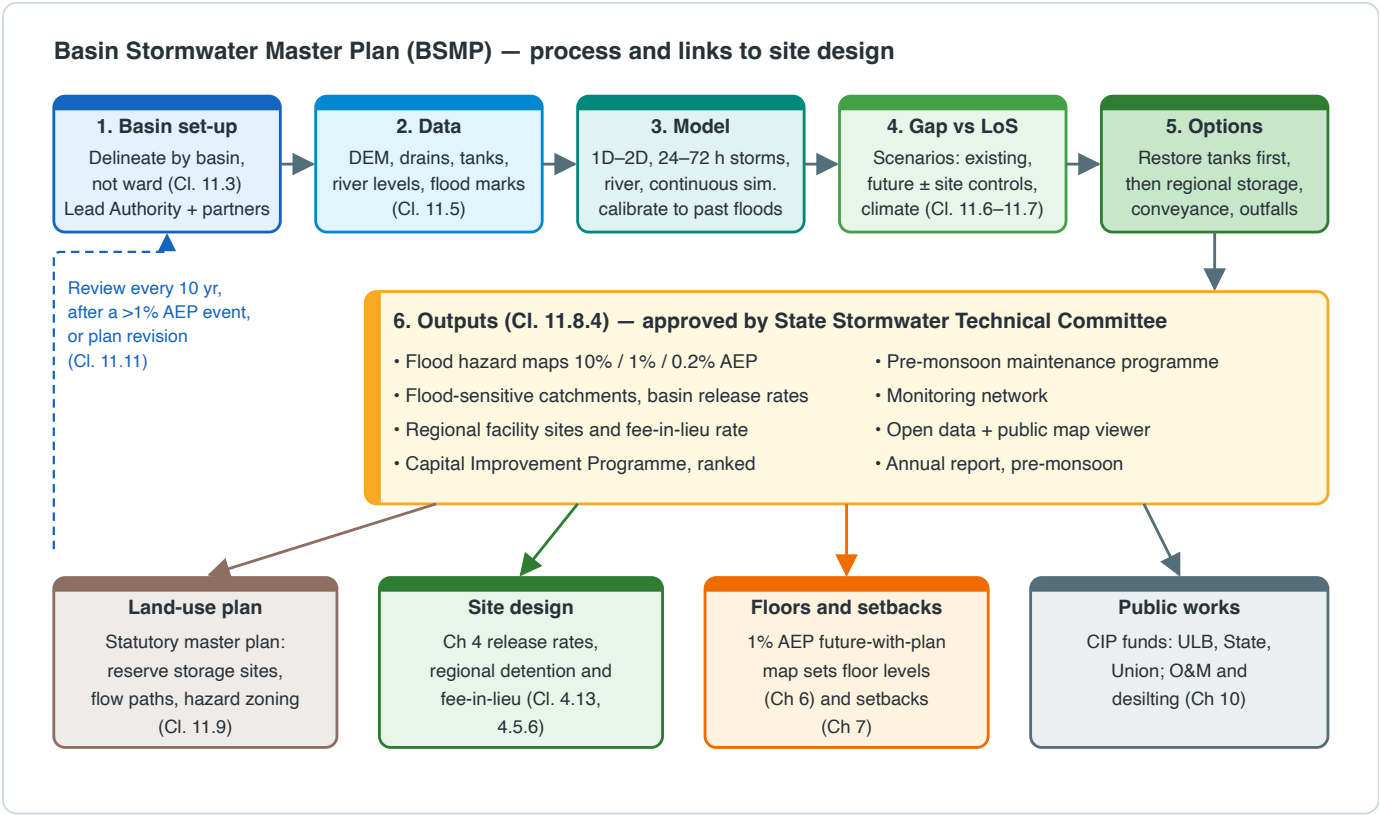

Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.

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 Manipur a single channel passes through many hands on its way to a river, and every valley river ends in the same lake. The Imphal, the Nambul and the Kongba run north to south through Greater Imphal and "have numerous tributaries through the town" (Revised GIS Based Master Plan for Greater Imphal – 2043), and the Manipur river basin above the valley's outlet drains 6,332 km² "flowing north to south" (the same plan, as printed), of which the hills are 4,432 km², 70%, and the valley 1,900 km² (MASTEC); the floods of the valley floor come from rain on those hills, as WRD's rule of thumb, as reported, that 135 mm in three

days at Kangpokpi floods the valley shows. The city's channels are at once storm drains, sewers and the feeders of a lake: the 72 drains that fall into the Nambul carried a BOD of 42.45–52.34 mg/L (State report to the National Green Tribunal, December 2025), and the Nambul flows on past Bishnupur towards Loktak. No notification assigns the Naga Nullah, the Waisel Maril or the Shamushang channel to one owner (this Manual's reading of the record): IMC and the other urban local bodies keep the municipal drains, PWD the roadside drains, WRD the river bunds, flood channels and the pumping of Lamphelpat to the Nambul, DoECC the interception of the Nambul drains, PHED the sewers, and LDA the lake and, as reported, the cleaning of the Waisel Maril. Beyond the valley the hill streams of the north and east feed the valley rivers through the Thoubal (Mapithel) and Khuga reservoirs, the western hills and Jiribam drain to the Barak, and the east of Ukhrul and Kamjong and the country round Moreh drain towards the Chindwin system in Myanmar (this Manual's reading, to be confirmed [TBC]). This clause makes the basin the planning unit, so that one model carries each channel from the hill stream to the river, the pat or Loktak whoever owns each reach, and the drain register of this Manual gives every reach an owner, the river it reaches, the bund it crosses, with its gate or flap gate, whether it lies in a buffer of bye-law 93 of the Model [TBC: confirm the number and text in the bye-laws the local body has notified], and its outfall, and so that the sewage it carries is separated before it reaches a pat, the lake or a river (Chapter 8, Clause 8.9.5).

11.4 Who prepares, and when

11.4.1 **Lead Authority.**

- For the basins of the Greater Imphal planning area (151.38 km²): the **Imphal Municipal Corporation (IMC)**, which grants building permits and keeps the municipal drains within its limits, jointly with **PDA Manipur**, the planning authority under the Manipur Town and Country Planning Act, 1975 for the parts of the planning area beyond municipal limits, and the **Town Planning Department (TPD)**, which prepares the master plan and checks building plans for land use, with **MAHUD**, which notifies the master plan into which the BSMP is taken (Clause 11.9). Each role is the one the body would have if the Manual were adopted. Which body issues building permission in the planning area outside IMC's limits is to be confirmed [TBC]. Where a basin extends beyond the planning area, the other urban local bodies in the basin are partners, and one BSMP covers the whole basin (Clause 11.3.1).
- No notification dividing the city channels from the municipal drains, or the drains of the local bodies from the rivers, bunds and the lake, 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: **WRD** for the rivers, their bunds, gates and flood channels, Lamphelpat and the pumping of its flood water through the Shamushang channel to the Nambul, and the machinery for clearing the city channels (as reported); **IMC** and the other **urban local bodies** for the municipal drains within their limits; **PWD** for the roadside drains, among them the 547 km of the AIIB project in Greater Imphal, and the **national-highway agencies** for the drains and culverts of the national highways; **DoECC** for the interception and diversion of the drains that fall into the Nambul and its treatment plant; **PHED** for the sewers and their pumping stations; **LDA** for Loktak within the 236.21 km² of the Manipur Loktak Lake (Protection) Act, 2006, and for the cleaning of the Waisel Maril that it was named to lead (as reported); **Imphal Smart City Ltd** for the drains of its works, until handed over in writing [TBC]; and **MSDMA**, with the Relief and Disaster Management Department and the Deputy Commissioners, for the mapping of the flood, breach and landslide hazards that a BSMP must show.
- In the other urban local bodies (Thoubal, Kakching, Bishnupur, Nambol, Moirang, Jiribam and the rest) and in Tier B bodies: the Lead Authority is the urban local body, with PDA Manipur or TPD where a master plan or planning area covers the town, as MAHUD would name them. In the hill areas, where no building rule applies, the department that executes a public work, PWD, PHED, WRD or another works agency, prepares the drainage of that work to this chapter, and a District Council, or its administrator, could act as Lead Authority for a hill town only if the Governor entrusts the matter to it or it adopts the Manual (neither has been done). Basins draining to a common river reach, to Loktak or to the Barak may be grouped into one district-level plan.

MSDMA and the Deputy Commissioner shall be consulted on every BSMP; WRD on every BSMP whose basin drains to a river, a bund or a pumped outfall; LDA on every BSMP whose basin drains to Loktak; NHPC on every BSMP whose levels the Ithai barrage sets; the Revenue Department and the Local, District and State Level Committees under the Manipur Conservation of Paddy Land and Wetland Act, 2014 on every BSMP that proposes storage, a corridor or development on paddy land or wetland; the Manipur Pollution Control Board on every BSMP that proposes works on a drain or river that carries sewage, among them the Nambul and the Naga Nullah; the Manipur State Wetlands Authority on every BSMP whose basin includes a wetland it has notified or proposed; and, for a basin whose outfall lies on the Barak below Jiribam, the water resources department of the adjoining State, through WRD.

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, pukhri, 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

Data	Minimum requirement
Outfalls, rivers, khongs, pats, pukhris, Loktak and reservoirs	The datum of every level named; outfall invert levels against the warning, flood and high flood levels of the receiving river at the nearest WRD gauge (the Imphal at Minuthong, 785.900, 786.900 and 788.400 m, and at Lilong, 780.350 m, 781.350 or 781.250 m and 782.850 m, exceeded at 783.250 m on 15 September 2025; the Iril at Irilbung, 786.700 and 787.700 m, with a printed high flood level below its flood level; the Thoubal, 778.915 and 779.915 m; the Nambul at Thong Nambonbi (Hump Bridge), high flood level 783.695 m; the Nambol at Nambol Thongkhong, 774.700 or 774.400 m; the Manipur river at the Ithai barrage, 769.320 m, exceeded at 770.05 m on 15 September 2025; WRD levels as reported, the datum not stated [TBC]), with every conflict stated and WRD's gauge register obtained [TBC]; Loktak's full reservoir level (768.5 m, NHPC, or 769.63 m in another account) and minimum drawdown level (766.2 m, NHPC, or 766.01 m, CEA), as quoted, naming which is used; the Barak at the CWC site at Chotebekra (high flood level 32.1 m, 31 July 1989, as reported); the full reservoir level (880.7 m, as reported) and spillway design discharge (2,240 m³/s, as reported) of the Thoubal (Mapithel) dam, and the levels of the Khuga and Singda dams from WRD [TBC]; the sill, gate-closing level and bund crest at every gate in a bund, the capacity and operating rule of every pumping station, among them the pumping of Lamphelpat to the Nambul through the Shamushang channel, and the breach paths of the bunds; pats and pukhris at their surveyed outlet levels; for ungauged khongs and hill streams, surveyed flood marks and the 1% AEP level with its sediment, debris and garbage; and the landslide hazards of the Disang shale slopes and the foothill fans above the basin
Rainfall and levels	All available rain gauges (IMD, including Imphal (Tulihal) (A), 42623, the only Manipur station in IMD's *Extremes* (rainfall data 1953–2012), and the gauges behind the district warnings of the Meteorological Centre Imphal (list not read [TBC]); the river gauges of WRD and the rain gauge at Kangpokpi that its flood rule uses (as reported); the gauges at Kangpokpi, Saikul and Litan used by MASTEC (owners and record lengths [TBC]); the CWC level-monitoring site on the Barak at Chotebekra; the Loktak levels of NHPC and CEA; the IMD stations on the Barak plain downstream that Clause 2.3.6(c)(ii) uses for the Jiribam plain; and any gauges or sensors kept by IMC, Imphal Smart City Ltd, LDA, MSDMA or the flood management system proposed for Lamphelpat [TBC]) and water-level records, including those for the 28–31 May 2024 (Cyclone Remal: the Imphal at Minuthong above its high flood level of 788.400 m and at Lilong at 782.250 m, and the Manipur river at Ithai at 768.640 m, on 29 May; 18 embankment breaches; 1,88,143 people and 24,265 houses affected by the Minister's count of 30 May, or 1,26,950 people, 255 localities and 16,364 houses by the Relief and Disaster Management Department's report of 31 May, all as reported; no IMD rainfall for the event was found), 30 May–June 2025 (breaches of the Imphal at Singjamei, Heingang, Bashikhong and New Checkon and of the Nambul at four places after 123 mm in 24 hours and 175 mm in 72 hours at Kangpokpi on 30–31 May, as reported; no IMD rainfall for Imphal was found), September 2025 (the Imphal at Lilong at 783.250 m and the Manipur river at Ithai at 770.05 m on 15 September, both above their printed high flood levels, and a breach of the Iril at Kshetri Awang Leikai, as reported; no rainfall value was found), late July–August 2015 (rain 46% above normal in Imphal West on 23–27 July, the Mapithel reservoir at 876 m on 1 August and about 5 lakh people displaced by 3 August by a State revenue estimate, as reported; no gauge value was found) and July–August 1989 (158.6 mm at Imphal (Tulihal) on 30 July, the station's 24-hour record, after daily rain from 28 July to 1 August, with 461.9 mm at Imphal and 617.6 mm at Kangpokpi in the month, 40 breaches and 361 localities flooded, IMD and MASTEC) 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 Imphal valley floor, "virtually a flat alluvium filled valley … with a very low southerly gradient" (MASTEC), where the rivers in flood stand within a metre or two of the city's ground behind their bunds, on the paddy land and pat margins round Lamphelpat and the other pats, on the Loktak margin, where the lake level sets the water's edge, and on the Jiribam plain under the backwater of the Barak, where slopes are gentle, a closed gate ponds the land behind it, and a raised road, a bund or a dumped fill can turn an overflow from one part of a town to another, 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 28–31 May 2024 (Cyclone Remal: the Imphal at Minuthong above its high flood level of 788.400 m and at Lilong at 782.250 m, and the Manipur river at Ithai at 768.640 m, on 29 May; 18 embankment breaches; 1,88,143 people and 24,265 houses affected by the

Minister's count of 30 May, or 1,26,950 people, 255 localities and 16,364 houses by the Relief and Disaster Management Department's report of 31 May, all as reported; no IMD rainfall for the event was found), 30 May–June 2025 (breaches of the Imphal at Singjamei, Heingang, Bashikhong and New Checkon and of the Nambul at four places after 123 mm in 24 hours and 175 mm in 72 hours at Kangpokpi on 30–31 May, as reported; no IMD rainfall for Imphal was found), September 2025 (the Imphal at Lilong at 783.250 m and the Manipur river at Ithai at 770.05 m on 15 September, both above their printed high flood levels, and a breach of the Iril at Kshetri Awang Leikai, as reported; no rainfall value was found), late July–August 2015 (rain 46% above normal in Imphal West on 23–27 July, the Mapithel reservoir at 876 m on 1 August and about 5 lakh people displaced by 3 August by a State revenue estimate, as reported; no gauge value was found) and July–August 1989 (158.6 mm at Imphal (Tulihal) on 30 July, the station's 24-hour record, after daily rain from 28 July to 1 August, with 461.9 mm at Imphal and 617.6 mm at Kangpokpi in the month, 40 breaches and 361 localities flooded, IMD and MASTEC) events are the best calibration data Manipur 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 pukhri 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 rarely measured. Manipur's storage is in Loktak, its pats, its pukhris and its paddy land more than in tanks; it has no irrigation tank cascades. Loktak covers 236.21 km² under the Manipur Loktak Lake (Protection) Act, 2006, with a Core Zone of 70.30 km² that is a "No-Development Zone or Totally Protected Zone" (s.3); MASTEC gives 246.72 km² with its swamps and other sources "250 km²" (as reported), and the Ithai barrage, commissioned in 1983 by most accounts (1979 and 1986 are also printed, as reported), is reported to have raised its average level by about a metre. Loktak was designated a Ramsar site on 23 March 1990 and placed on the Montreux Record on 16 June 1993 (as reported). The Manipur State Wetlands Authority, set up on 31 January 2018, has named seven priority wetlands, Jaimeng, Kachouphung (Achau Maki), Utra Pat, Yaral Pat, Waithou–Phumnom Pat, Pumlen–Khoidum Pat and Ikop–Kharung Pat, delineated 71 wetlands and published draft notifications for Yaral, Utra and Waithou–Phumnom pats, none yet final (DoECC, 2025-26). The SAC Wetland Atlas of 2021 counts 132 wetlands larger than

> 2.25 ha in the State, and after the Tribunal's order of 22 May 2020 about 4,000 water bodies were inventoried, with "Ground truthing, engineering surveys, and quality monitoring … pending" (DoECC); twenty pond projects under AMRUT 2.0, worth ₹4.11 crore, are carried out by the municipal councils (TPD, 2025-26). Paddy land and wetland are protected from conversion by the Manipur Conservation of Paddy Land and Wetland Act, 2014, whose "conversion" includes the land's "drainage channels, ponds, canals, bunds and ridges" (s.2(c)), and the master plan for Greater Imphal says that "the paddy fields cannot be used for construction" because of it, yet plans the fall in wetland and agricultural land given above. No survey of the stage–storage of any pat or pukhri, or of the flood storage of the valley's paddy land, was found [TBC].

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 Manipur has been adopted with a design factor, the State Action Plan on Climate Change was not read [TBC], and the figures for future rainfall that officials have given in the press differ from one another and are not used; annual rainfall in Manipur shows "a statistically significant downward trend" over 1991–2024 (Singh, 2025), yet the valley floods of 2015, 2024 and 2025 are among the largest on record (as reported), which is a reason to keep the factors, not to reduce them; and in sub-areas MN-B, MN-C and MN-C1 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 28–31 May 2024 (Cyclone Remal: the Imphal at Minuthong above its high flood level of 788.400 m and at Lilong at 782.250 m, and the Manipur river at Ithai at 768.640 m, on 29 May; 18 embankment breaches; 1,88,143 people and 24,265 houses affected by the Minister's count of 30 May, or 1,26,950 people, 255 localities and 16,364 houses by the Relief and Disaster Management Department's report of 31 May, all as reported; no IMD rainfall for the event was found), 30 May–June 2025 (breaches of the Imphal at Singjamei, Heingang, Bashikhong and New Checkon and of the Nambul at four places after 123 mm in 24 hours and 175 mm in 72 hours at Kangpokpi on 30–31 May, as reported; no IMD rainfall for Imphal was found), September 2025 (the Imphal at Lilong at 783.250 m and the Manipur river at Ithai at 770.05 m on 15

September, both above their printed high flood levels, and a breach of the Iril at Kshetri Awang Leikai, as reported; no rainfall value was found), late July–August 2015 (rain 46% above normal in Imphal West on 23–27 July, the Mapithel reservoir at 876 m on 1 August and about 5 lakh people displaced by 3 August by a State revenue estimate, as reported; no gauge value was found) and July–August 1989 (158.6 mm at Imphal (Tulihal) on 30 July, the station's 24-hour record, after daily rain from 28 July to 1 August, with 461.9 mm at Imphal and 617.6 mm at Kangpokpi in the month, 40 breaches and 361 localities flooded, IMD and MASTEC) events where data exist.

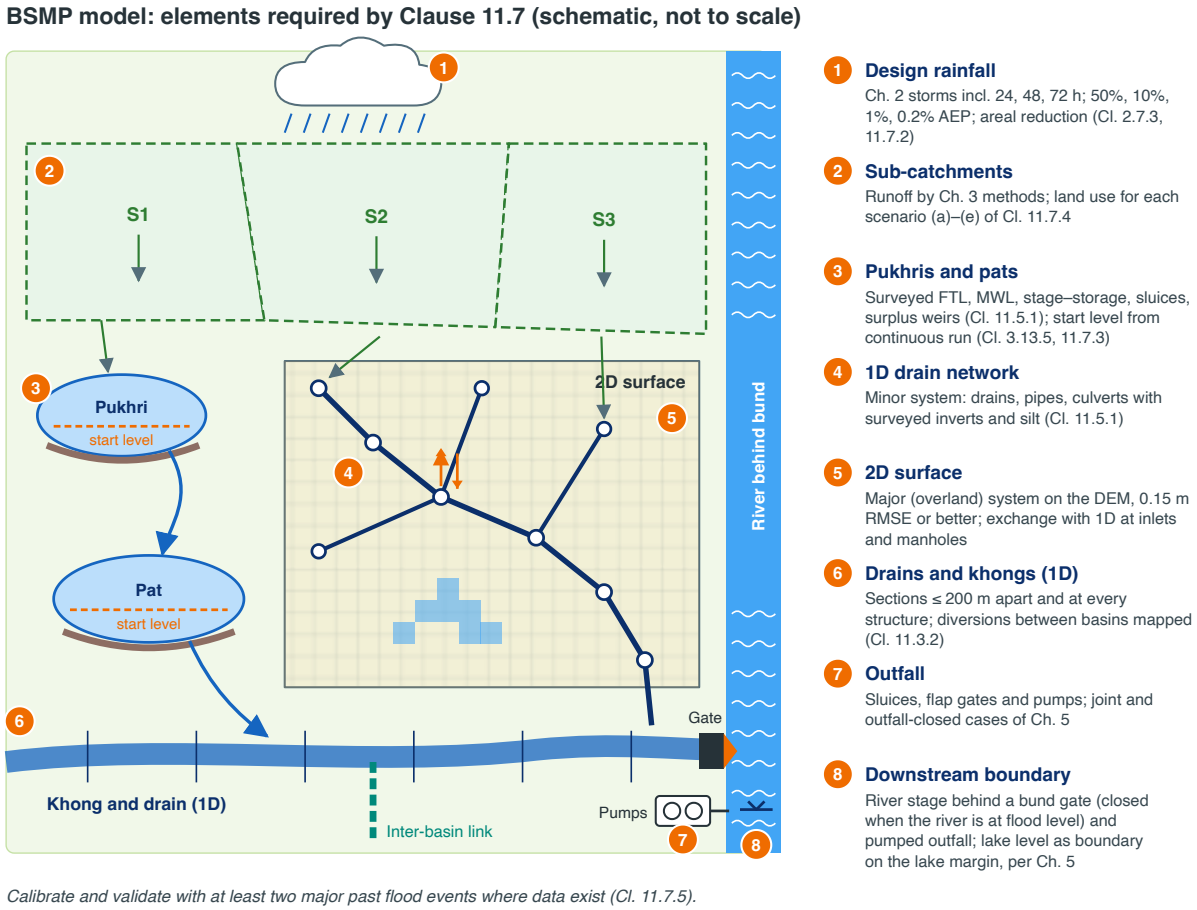

Figure 11.2 — Elements of the BSMP model required by Clause 11.7: sub-catchments, the 1D drain and channel network, the 2D surface, tanks and pukhris with starting levels from continuous simulation, and the tidal or river boundary at the outfall (schematic, not to scale). Original drawing for this Manual, 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:** pukhris, 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:** gates and flap gates on the outfalls through the bunds of the Imphal, the Nambul, the Iril, the Kongba, the Thoubal and the other valley rivers, with the storage and pumping behind them sized for the outfall-closed durations of Chapter 5 (Clause 5.8.5), among them the pumping of Lamphelpat to the Nambul through the Shamushang channel and the outfalls of the city channels, the Naga Nullah and the Waisel Maril; standby power and fuel for the whole closure; on the Loktak margin, pumped outfalls for the drains whose inverts lie below the design lake level; screens against phumdi and garbage where drains enter a pump sump, a gate, a pat or Loktak; silt traps and debris racks where hill streams reach the valley floor; drop structures, chutes and energy dissipators where the drains of the hill towns reach a stream, never an unprotected slope; the interception and screening of dry-weather flow before every outfall to a pat, Loktak or a river stretch on CPCB's list (Chapter 8, Clause 8.9); and the operating rules of WRD's gates and pumps and of the releases of the Thoubal (Mapithel) dam, agreed with WRD;
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 from the Meteorological Centre Imphal, the river levels that WRD publishes for its gauges at Minuthong, Lilong, Irilbung, Thong Nambonbi, Nambol Thongkhong, Thoubal and Ithai against their warning, flood and high flood levels, WRD's rule of thumb that 135 mm in three days at Kangpokpi floods the valley (as reported), level gauges with alarms at the gates and pumping stations of the city channels and of the Lamphelpat outfall, the "real time flood management system with a command center" proposed for the Lamphelpat project (NDB), warnings before releases from the Thoubal (Mapithel) dam, whose release rules were not found [TBC], and the levels of the Barak at the CWC site at Chotebekra for Jiribam), 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 clay and peat of the valley floor, on which no infiltration is allowed (Clause 4.11, valley-floor rule), and the water table 2 to 5 m below ground in most of Imphal West (CGWB, 2013), which makes buoyancy and inflow a hazard to sumps, tanks and basements, the Disang shale of the hills, which has "less infiltration and more run off" (MASTEC) and slides when cut and wet, as at Tupul in 2022, recharge on the tested foothill fans, Barail sandstone cappings and sand lenses, the only ground where it is allowed (Clause 4.11, recharge rule), although every assessment unit in the State is safe (stage of extraction 8.00%, GWRA 2024, as quoted from CGWB), and the quality of the rivers, pats and Loktak that the runoff reaches, the Imphal, the Nambul and the Iril among them, from which Imphal draws about 90% of its drinking water (Chapter 8);
- effect on downstream basins and the receiving river, khong or pat; 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** ($m^3/s/ha$) 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 valley's outfalls are closed in the wettest weeks and its storage is being built on. The rivers that enter the valley carry a few hundred cubic metres a second each in flood while the only outlet, at Ithai, carries "of the order of 400 cumecs" and the river below the barrage "does not have the capacity to cope up with such flow, as a result, water is piled up upstream" (MASTEC), so the valley holds its floods in Loktak, the pats and the paddy until the outlet can pass them, and drains that cannot discharge behind their bunds leave "waterlogging in the low-lying areas for several weeks" (AIIB, 2024). That storage is shrinking: "there were nearly 500 lakes in Manipur Valley", and Lamphelpat, Porompat, Takyelpat, Sangaipat, Kharungpat and Ikop pat are among those degraded or disappearing (MASTEC); Loktak is "becoming shallower" (the same report); and the master plan for Greater Imphal plans a fall in wetlands from 374.48 ha to 232.21 ha and in agricultural land from 5,616.53 ha to 2,604.70 ha between 2020 and 2043, while water bodies grow from 563.54 ha to 643.42 ha (Revised GIS Based Master Plan for Greater Imphal – 2043). Lamphelpat is being dredged back into flood storage with a pumped outlet to the Nambul because pumping alone was "not adequate and the area remains waterlogged for many days every year" (NDB). Wider drains on their own would only bring the water sooner to a closed gate, and on the clay and peat of the valley floor storage means lined or surface storage, never a pond that soaks into the ground (Clause 4.11, valley-floor rule); the rainwater storage of at least 25 litres per m² of roof that Clause 4.11 sets, where bye-law 66(a) of the Model requires rainwater harvesting without a volume, is the first of it, and it also serves the dry months, when the city draws about 90% of its drinking water from its three rivers (the master plan). The storms are modest at Imphal, 158.6 mm in 24 hours on 30 July 1989 the station's record (IMD), but the floods they bring last for days because the outfalls do. Conveyance upgrades on their own move water faster to an outfall that the Imphal, the Nambul, the Iril or another valley river in flood closes at its gate for days or weeks, to Loktak, held up by the Ithai barrage and the rock sill below it, to a pat that a closed outfall holds full, or to an outfall limited by the capacity of its gate or pumping station, as at Lamphelpat, where pumping is "not adequate and the area remains waterlogged for many days every year" (NDB). Groundwater in Manipur calls for storage, not recharge. Every assessment unit in the State is safe, with a stage of extraction of 8.00% in the assessment of 2024 and 7.99% in 2023 (CGWB, as quoted), and Imphal draws about 90% of its drinking water from the Imphal, the Nambul and the Iril (Revised GIS Based Master Plan for Greater Imphal – 2043), so the groundwater is not short. The ground of the valley floor will not take water: Imphal West has "approximately 30 to 50 m of clayey formation" in which "construction of shallow tube wells is problematic", with clay "down to depth range of 30 to 65 m bgl", water 2 to 5 m below ground in most of the district and "emanation of gas while constructing deep tube wells in some places" (CGWB, 2013), and round the lakes of Bishnupur "peaty soils have high acidity" (CGWB, 2013); so the water table is a hazard to the buoyancy of sumps, tanks and basements more than a resource to recharge. Water put into the hills can do harm: Disang shale, most of the hills, has "less infiltration and more run off" (MASTEC), and the slide at Tupul in 2022 has been attributed to slope excavation coupled with heavy rainfall (as reported). No State observation-well network was found: CGWB's dug-well monitoring in Imphal West stopped "since 1991 due to disturbed law and order" (CGWB, 2013), and a Manipur Ground Water (Control & Regulation) Policy, 2023 was prepared, as listed by DoECC, but its text was not read [TBC]. This is why storage and reuse, buoyancy, slope stability, recharge only on the tested foothill fans, sandstone cappings and sand lenses, and the quality of the rivers that supply the city are all assessment criteria. 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 plans notified under the Manipur Town and Country Planning Act, 1975, among them the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification) and the risk-informed master plans for Imphal and Moirang, once their status and contents are confirmed [TBC], and the GIS master plans that TPD is preparing for the other towns and the district headquarters, with the Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026 and the building bye-laws that each urban local body and PDA Manipur have brought into force on the Model; the flood zones notified under the Manipur Flood Plain Zoning Act, 1978, once any are; in the hill areas outside any notified planning area, a development plan under s.29(1A) of the Manipur (Hill Areas) District Councils Act, 1971, once that provision is in force and if the District Council adopts the Manual; and the layouts and buildings permitted under them. 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. Manipur already draws some of its water lines by bye-law and by statute, and has a floodplain Act with no zone. Bye-law 93 of the Model prohibits "any new construction within the designated buffer zone" along named reaches of ten rivers, both banks alike, measured from mid-stream: 55 m to 62 m on the Imphal, 50 m on the Iril, 48 m on the Thoubal, 35 m on the Sekmai, 31 m on the Wangjing, 30 m on the Nambul within Greater Imphal and on the Arong, each "from mid-stream or 6 m from outer toe of bund, whichever is further from mid-stream", and 22.5–28 m on the Merakhong, 35 m on the Kongba and 25 m on the Nambol from mid-stream only; activity in a "prohibited area or restricted area" then needs "the previous permission of the Flood Zoning Authority constituted under the Flood Plain Zoning Act, 1978" [TBC: confirm the number and text in the bye-laws the local body has notified]. Because the distances run from mid-stream, a 30 m buffer on a reach 40 m wide leaves 10 m from the bank (this Manual's reading). Bye-law 94 sets the plinth "above 1m above the highest flood level of the surrounding areas" in "high Flood Risk Areas identified in the Master Plan of the towns", but the risk-informed master plans that would show those areas were not read [TBC], so where it applies is not known, and no local authority's highest flood level was found for any town. The Manipur Flood Plain Zoning Act, 1978 defines a flood zone as the area required to carry "the maximum probable" flood and provides for zones by "relative risk", but no Flood Zoning Authority has been found constituted and demarcation "is yet to be done" (as reported, June 2026); no pat or pukhri has a setback in the bye-laws. Loktak's Core Zone of 70.30 km² is a "No-Development Zone or Totally Protected Zone", and its Buffer Zone bars "Land reclamation, bunding or disturbing the natural course of drainages" (Manipur Loktak Lake (Protection) Act, 2006, ss.3 and 19), and the High Court has barred development in or around the lake "without the Court's leave" (orders of 2019 and 2022, as reported). The Manipur Conservation of Paddy Land and Wetland Act, 2014 forbids the conversion of paddy land and wetland without the committees' approval and bars a licence for construction on land converted in contravention (s.12); a Bill of 2026 would exempt land that conforms to a notified master plan, but it is not law. The Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026 have a use zone "Pond, Drain, Rivers and Canals", the hook for reserving a corridor in the master plan. Where a notified flood zone, a statutory line or a master-plan line governs, it applies; elsewhere, and where it is narrower, the hydraulic corridor and setback zones of Chapter 7 apply, with a Zone 1 of at least 15 m on every channel draining 8 ha or more and round every pat and pukhri, measured on a bunded reach from the landward toe of the bund, and a Zone 2 to the 1% AEP extent plus 10 m, whichever is wider, as this Manual's proposal, with the 1% AEP map offered as an input to any future zoning under the 1978 Act, not as a zone, and Zone 1 land that is private patta land reserved in the master plan or secured by agreement, not taken. A BSMP gives the master plans, TPD and any future Flood Zoning Authority the 1% AEP drainage-flood map, with the outfalls closed, 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 Model already makes rainwater harvesting mandatory on plots of 100 m² and above, with the storm-water drainage and the points of collection of rain water "in surface reservoirs or in recharge wells" shown on the plans (bye-law 66(a)), requires soft cover of at least 15% of the plot for buildings with a covered area of 500 m² or more and 10% for others (66(b)), allows no open drain "except for rain water" in the open spaces it requires, and counts among its green-building criteria to "Minimize storm water run-off from site by reducing hard paving on site", and the Unified Zoning/Use Regulation Bye-laws for the Master Plan Areas of Manipur, 2026 list a "Rain Water Harvesting System" as a use and a use zone "Pond, Drain, Rivers and Canals", but no rule sets a detention or peak-runoff limit; storage placed in a layout's open space builds on these duties, and because that land still serves as open space, the storage must stay usable as one, and on the valley floor, where the water table lies 2 to 5 m below ground over 30 to 65 m of clay (CGWB, 2013), it is a shallow lined storage that drains to the outfall, never an infiltration basin (Clause 4.11, valley-floor 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.

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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 Manipur 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 Imphal Municipal Corporation and of the Greater Imphal planning area of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)

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 Imphal Municipal Corporation (IMC)	1.6.1(a)
(b)	PDA Manipur and every other approving authority within the Greater Imphal planning area (151.38 km², the area of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification)), whichever has jurisdiction over a site (which body issues building permission in the planning area outside IMC's limits is to be confirmed [TBC])	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 Greater Imphal planning area, with the date from which each is Tier A, and the boundaries of that area and of the Imphal Municipal Corporation as a map and as a GIS layer. It needs the notified boundary of the planning area of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification) and its zones (MAHUD, the TPD); the limits of IMC's 27 wards and of the other urban local bodies whose areas fall in the planning area, among them those in the draft boundary notifications of 23 urban local bodies of November 2025 (the TPD, the urban local bodies); the area in which PDA Manipur is the Authority beyond municipal limits, and the body that issues building permission in the planning area outside IMC's limits, which was not confirmed for this Manual [TBC] (PDA Manipur, MAHUD); and the district and sub-division boundaries (Revenue Department, 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 / Nagar Panchayat / PDA Manipur / District Council / 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 IMC and Greater Imphal planning area 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 Nambul through Greater Imphal	The catchment of the Nambul through Greater Imphal, with the Naga Nullah and Waisel Maril channels and the 72 drains that fall into it, down to Bishnupur. The Nambul is "the main urban river" of the city (AIIB); the State reports the interception and diversion of all 72 drains as completed, with their BOD at 42.45–52.34 mg/L (State report to the NGT, December 2025), and CPCB lists the river from the Singda dam to Bishnupur as a polluted stretch (CPCB, 2025). It breached at four places in 2025, and the clogging of the Naga Nullah flooded Nagaram, Laipham Khunou and Lairikyengbam Leikai in July 2024 (as reported). Its bye-law 93 buffer is 30 m from mid-stream within Greater Imphal [TBC: confirm the number and text in the bye-laws the local body has notified]
(b)	The Imphal river through Imphal	The land of Imphal that drains to the Imphal river between its bunds, from Koirengei to Lilong, including the breach paths of 2024 and 2025 at Singjamei, Heingang, Bashikhong, New Checkon, Keirang, Khabam and Lairikyengbam Leikai (as reported). The WRD gauge at Minuthong has a highest flood level of 788.400 m, exceeded on 29 May 2024, within a metre or two of the city's ground (WRD levels as reported; AIIB)
(c)	The Lamphelpat basin	The land that drains to Lamphelpat, a pat being developed as flood storage on about 300 acres, with its pumped outlet through the Shamushang nallah to the Nambul (WRD site report in PIL No. 8 of 2025); the area "remains waterlogged for many days every year" (NDB). Lamphelpat is also proposed as a source of drinking water (NDB)
(d)	The Kongba and the Iril in Imphal East	The land of Imphal East that drains to the Kongba and to the Iril between their bunds, the Iril gauged at Irilbung (flood level 787.700 m; 788.850 m on 15 September 2025, as reported); the Iril breached at Kshetri Awang Leikai in September 2025 (as reported), and its gauged flood of 2 September 2000 carried 532.488 m³/s at Moirang Kampu (MASTEC)
(e)	Thoubal below the Mapithel dam	The land of Thoubal that drains to the Thoubal river below the Mapithel dam (Thoubal Multipurpose Project), a release reach, whose reservoir has a full reservoir level of 880.7 m (WRD, September 2025, as reported) and stood at 876 m, "nearly 2 m above the spillways", on 1 August 2015 (as reported; the two do not reconcile [U]); the Thoubal carried 391.636 m³/s on 30 August 1999 (MASTEC)
(f)	The Loktak margin	The land of Moirang, Ningthoukhong and Thanga, and of Ithai, Sugnu and Wangoo with the Chakpi backwater, that drains to Loktak, its fringing pats or the Manipur river between Ithai and Sugnu, and the land within the 236.21 km² of the Loktak Act. The lake level is the tailwater: the WRD gauge at the Ithai barrage has a highest flood level of 769.320 m, exceeded at 770.05 m on 15 September 2025 (as reported), and the Chakpi "meets the Manipur River at a reverse direction … making inundation of the surrounding area of Sugnu extending upto Wangoo" (MASTEC)

Item	Catchment	Extent as described in Chapter 4
(g)	Nambol and Bishnupur	The land of Nambol and Bishnupur that drains to the Nambol and the Nambul, the Nambol gauged at Nambol Thongkhong (highest flood level 774.700 m or 774.400 m, as reported [U]), with the peat round the lakes of Bishnupur district (CGWB)
(h)	Kakching and Wangjing	The land of Kakching and Wangjing that drains to the Sekmai and the Wangjing, whose bye-law 93 buffers are 35 m and 31 m from mid-stream on their named reaches; the Wangjing breached in September 1997 (MASTEC)
(i)	Jiribam on the Barak and the Jiri	The land of Jiribam that drains to the Barak and the Jiri, on the Barak plain, where CWC's site at Chotebekra has a highest level of 32.1 m (31 July 1989; CWC data as transcribed by SANDRP); the rainfall of Clause 2.3.6(c)(ii) and the outfall rule of the Barak plain apply
(j)	The hill towns on landslide ground	The land of Noney, including Tupul, where the landslide of 29 or 30 June 2022 killed 56 to 61 people (as reported; conflict), and of Tamenglong, Chandel and Kangpokpi, on the Disang shale; the Khoupum valley was inundated after 225 mm fell in one night on 15 July 2025 (as reported)
(k)	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 network (IMC and the other urban local bodies, PDA Manipur, the TPD, the PWD for the roadside drains of the AIIB project, the District Councils for the hill towns, Survey of India); the drain register of Table 1.5, with the bund each drain crosses, its gate or flap gate and its outfall, and the 72 drains intercepted on the Nambul (DoECC); the levels of the WRD gauges at Minuthong, Lilong, Irilbung, Thong Nambonbi, Nambol Thongkhong, Thoubal and Ithai with their gauge zeros and datums, the bund breach points and flood marks of 2024 and 2025, and the stage–storage of Lamphelpat (the WRD); the lake levels of Loktak and the operating rule of the Ithai barrage (NHPC, the LDA); the levels and release records of the Mapithel, Khuga and Singda dams [TBC]; the flood-hazard maps of the risk-informed master plans of Imphal and Moirang, which were not read [TBC] (the TPD); the landslide inventories of MSDMA and NRSC [TBC]; and the CWC levels at Chotebekra (CWC). Thoubal town on the Imphal and Thoubal rivers below their confluence, Mayang Imphal, Lilong and Yairipok, and the hill towns of Ukhrul, Senapati and Churachandpur are candidates for notification under Clause 4.5.4 once their catchment boundaries and flood record are documented [TBC]. The buffers of bye-law 93 and the corridors of Chapter 7 are governed by Chapter 7 and by the instruments that bind there 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 (j), 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 Manipur 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, MSDMA, the Relief and Disaster Management Department or the Water Resources Department (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 pukhri 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 / Nagar Panchayat), dated _____

Subject: Adoption of alternatives under the Policy Supplement to the Manipur Stormwater Design Manual.

The Council, having considered the report of the Commissioner / Executive Officer dated _____, and noting that:

- (i) the Manipur 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 Unified Bye-Laws 2024 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 Model Manipur Unified Building Bye-Laws 2024 at which the new rule and the conditions would be inserted, and the enabling sections of the Manipur Town and Country Planning Act, 1975 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 Model Manipur Unified Building Bye-Laws 2024

A.1 **Short title and commencement.**

- (1) These rules may be called the Model Manipur Unified Building (Stormwater Management) (Amendment) Bye-Laws, _____.
- (2) They shall come into force on the date six months after their publication in the Manipur Gazette (Clause 1.11.1).

A.2 **Insertion of a new rule.** After rule [_____] of the building bye-laws that each urban local body and the Planning and Development Authority, Manipur bring into force, by notification in the Manipur Gazette, on the model published by MAHUD under section 213 of the Manipur Municipalities Act, 1994 and section 26(1) of the Manipur Town and Country Planning Act, 1975, the following rule shall be inserted:

Rule [_____]. Stormwater management.

(1) *Definitions.* In this rule, "the Manual" means the Manipur 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 Manipur 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 — Manipur 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 Model Manipur Unified Building Bye-Laws 2024 — 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 (Model bye-law 66(a) [TBC: confirm the number and text in the bye-laws the local body has notified]: every existing and new building on a plot of 100 m² or more, where the local body or PDA Manipur has brought the bye-laws into force; hill areas: no rule found) — 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 — Manipur 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 rain gauges of the Water Resources Department, among them the Kangpokpi gauge whose rainfall it cites for its valley-flood watch (as reported), the gauges at Kangpokpi, Saikul and Litan used in MASTEC's isohyetal analysis of the valley floods, and any gauges of the State's agriculture department, whose owners, logging intervals, archives and record lengths are to be confirmed [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
MN-Z1 Imphal valley	The valley floor of the Manipur river basin above the Sugnu hump, the closed, flat valley at about 780–790 m that drains south through Loktak and past the Ithai barrage; in CWC subzone 2(c), for which no report exists (Clause 2.3.6(b)); catchments that cross a zone line take the higher zone value	Imphal (Tulihal) (A) (42623, IMD, rainfall data 1953–2012); the gauges of the MASTEC study [TBC]	Interim 24-h depths from the NEER Gumbel fit of MASTEC's Imphal series (1974–2000) × 1.13: 85 / 115 / 135 / 160 / 180 / 200 mm at 50% / 20% / 10% / 4% / 2% / 1% AEP (Clause 2.3.6(c)(i)); Manipur interim ratios, 1-h ratio 0.33 (Clause 2.3.6(f)); 72-h depth = 24-h × 1.70 (Clause 2.3.6(e)). NIH-DHAARA 50-yr 24-h 181–231 mm, comparison only. Fluvio-lacustrine clay, silt and peat, "approximately 30 to 50 m of clayey formation", water 2–5 m below ground in most of Imphal West (CGWB): valley-floor rule of Clause 4.11. Rivers in bunds above the towns; outfalls gated, flap-gated or pumped (Chapter 5)
MN-Z1 Imphal valley: MN-A Imphal valley floor (Imphal–Thoubal–Kakching–Bishnupur–Nambol–Mayang Imphal)	Also Lamphel, Porompat, Singjamei, Wangjing, Yairipok, Lilong and the valley floor of Imphal East and Imphal West; the hillocks and foothill fans inside the valley; outfalls to the Imphal, Nambul, Iril, Kongba, Thoubal, Sekmai, Wangjing, Nambol and Khuga rivers and to the pats; boundaries [TBC]	Imphal (Tulihal) (A) (42623)	Station series of Clause 2.3.6(c)(i); record check against Imphal (Tulihal)'s 158.6 mm (30 July 1989), which raises nothing (Clause 2.3.6(h)). NIH-DHAARA 50-yr 24-h 231 mm and 1-h 72 mm at Imphal, 224 mm at Bishnupur, 181 mm at Thoubal (comparison only). WRD gauges (as reported): Imphal river at Minuthong (highest flood level 788.400 m) and Lilong, the Iril at Irilbung, the Thoubal, the Nambul at Thong Nambonbi, the Nambol at Nambol Thongkhong. Lamphelpat, a pat being developed as flood storage with a pumped outlet to the Nambul. Peat round the lakes of Bishnupur district (CGWB); gas emanation in some deep tube wells (CGWB)
MN-Z1 Imphal valley: MN-A1 Loktak margin (Moirang–Ningthoukhong–Thanga–Ithai–Sugnu–Wangoo)	Land whose drains outfall to Loktak, its fringing pats or the Manipur river between Ithai and Sugnu, and the land within the 236.21 km² of the Loktak Act (Core Zone 70.30 km²); the Chakpi backwater to Wangoo; boundaries [TBC]	Imphal (Tulihal) (A) (42623); no gauge on the lake margin found [TBC]	Station series of Clause 2.3.6(c)(i), as MN-A. NIH-DHAARA 50-yr 24-h 204 mm at Moirang (comparison only). The lake level governs the tailwater: WRD's highest flood level at the Ithai barrage 769.320 m, exceeded at 770.05 m on 15 September 2025 (as reported); Loktak's full reservoir level 768.5 m (NHPC, as quoted) or 769.63 m (as reported) [U]. The Sugnu hump, where the bed of the Manipur river rises from 756.7 m to 763.7 m in about 800 m (MASTEC), controls the outlet whatever the barrage gates do. Phumdi at outlets and screens. AMC III at all times (Clause 2.11.4)
MN-Z2 Northern, eastern and southern hills	The hills that feed the valley rivers, in Senapati, Kangpokpi, Ukhrul, Kamjong, Chandel, Tengnoupal and Churachandpur districts, and the hill fringes of the valley districts; north Senapati drains to the Barak headwaters and the east of Ukhrul, Kamjong and Moreh towards the Chindwin (NEER reading, to be confirmed); in subzone 2(c), with a possible sliver of 2(b) north of 25.4° N near Mao (Clause 2.3.6(b))	No IMD station; the rain gauge at Kangpokpi whose rainfall the WRD watches (as reported), and MASTEC's gauges at Kangpokpi, Saikul and Litan [TBC]	24-h depth at each AEP the higher of the NIH-DHAARA cell value and the MN-A value (Clause 2.3.6(c)(iii)); Manipur interim ratios; 72-h depth = 24-h × 1.85 (Clause 2.3.6(e)). Disang shale, about 85% of the hills, with "less infiltration and more run off" (MASTEC): hill rule of Clause 4.11. The hills are about 70% of the valley's catchment, and their rain floods the valley: the WRD's rule of thumb, as reported, is that 135 mm in 3 days at Kangpokpi brings floods to the valley

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
MN-Z2 Northern, eastern and southern hills: MN-B Northern, eastern and southern hills (Senapati–Kangpokpi–Ukhrul–Kamjong–Chandel–Tengnoupal–Moreh–Churachandpur)	The whole of zone MN-Z2, with the Thoubal (Mapithel) and Khuga reservoirs and the hill fringes of the valley districts; a site on a slope above the valley floor at the Imphal–Kangpokpi, Imphal–Ukhrul and Moirang–Churachandpur edges is in MN-B; boundaries [TBC]	As for the zone; gauges at Ukhrul, Churachandpur, Chandel and Moreh are first data requests (Clause 2.3.6(a))	NIH-DHAARA 50-yr 24-h 220 mm at Kangpokpi, 203 mm at Senapati, 185 mm at Chandel, 183 mm at Churachandpur and 182 mm at Ukhrul, 1-h 40–55 mm; Moreh's cell empty, Chandel's used (design values with the MN-A floor, Clause 2.3.6(c)(iii)). Kangpokpi 123 mm in 24 hours and 175 mm in 72 hours on 30–31 May 2025 (as reported; a flag under Clause 2.3.6(h)). Joumol (Chandel) landslide of 1 August 2015 (as reported). Release reaches below the Mapithel dam (full reservoir level 880.7 m, as reported) and the Khuga dam [TBC]
MN-Z3 Western hills and the Jiribam plain	The Barak-facing west of the State: the Barail ridge country of Tamenglong, Noney and western Churachandpur and Pherzawl, and the Barak and Jiri flood plain round Jiribam; in subzone 2(c), for which no report exists (Clause 2.3.6(b))	No IMD station in the State; Silchar (42619) and Silchar (Kumbhigram) (A) (42620) on the Barak plain downstream; gauges at Tamenglong, Noney, Khoupum and Jiribam are first data requests [TBC]	Interim 24-h depths 130 / 190 / 230 / 285 / 320 / 360 mm at 50% / 20% / 10% / 4% / 2% / 1% AEP, not less than 320 mm at 2% and 351 mm at 1% AEP, the floors of the adjoining Barak-valley rule (Clause 2.3.6(c)(ii)); 72-h depth = 24-h × 1.70 (Clause 2.3.6(e)). The State's largest reported fall, 225 mm in one night at Khoupum (15 July 2025, as reported). NIH-DHAARA 50-yr 24-h 306–491 mm, comparison only
MN-Z3 Western hills and the Jiribam plain: MN-C Western hills (Tamenglong–Noney–Khoupum–Tupul–Tousem–Pherzawl)	Also western Churachandpur; the NH-37 and railway cut slopes; the Barak, Makru, Irang, Leimatak and Tuivai catchments; boundaries [TBC]	No station found; Tamenglong and Noney gauges [TBC]	Table of Clause 2.3.6(c)(ii); Manipur interim ratios, about 106 mm in 1 hour at 50 years on the 320 mm floor (Clause 2.3.6(f)). NIH-DHAARA 50-yr 24-h 306 mm at Noney and 431 mm at Tamenglong, 1-h 96–115 mm (comparison only). Disang shale and Barail sandstone, steep slopes and cut-slope failures: the Tupul landslide of 29 or 30 June 2022 at the railway site (as reported). Hill rule of Clause 4.11; hazard-first screening of Clause 2.3.6(i). AMC III from 1 May to 31 October
MN-Z3 Western hills and the Jiribam plain: MN-C1 Jiribam plain (Jiribam)	The Barak and Jiri flood plain round Jiribam, with CWC's site at Chotebekra; continuous with the Barak plain downstream, which the adjoining edition governs; boundaries [TBC]	Silchar (42619, rainfall data 1901–2012) and Silchar (Kumbhigram) (A) (42620, 1957–1990), whose fit replaces the 2–25-yr values once made (Clause 2.3.6(c)(ii), (d))	Table of Clause 2.3.6(c)(ii); 2(b) ratios, 1-h ratio 0.48, about 154 mm in 1 hour at 50 years (Clause 2.3.6(f)). Record check: Silchar (Kumbhigram) 350.6 mm (2 June 1974) qualifies and is already the 1% AEP floor; distance to the site [TBC]. NIH-DHAARA 50-yr 24-h 491 mm and 1-h 109 mm at Jiribam (comparison only). The Barak at Chotebekra: highest level 32.1 m (31 July 1989; CWC data as transcribed by SANDRP). Valley-floor rule of Clause 4.11 on the flood plain below its 1% AEP level

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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 Manipur are those of Clause 2.3.6(f) for the site's sub-area in Table 2B.1 (the Manipur interim ratios in MN-A, MN-A1, MN-B and MN-C, and the ratios of the 2(b) report in MN-C1), applied to the 24-hour depth of Clause 2.3.6(c) or (d) before the record check of Clause 2.3.6(h); no absolute short-storm floor applies (Clause 2.3.6(g)) (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
MN-Z1 (MN-A Imphal valley floor; MN-A1 Loktak margin), MN-Z2 (MN-B Northern, eastern and southern hills) and MN-Z3 (MN-C Western hills)	Manipur interim ratios (interim design ratios, Clause 2.3.6(f), set by this Manual): at each duration the upper envelope, rounded up to 0.01, of the 50-yr ratios of eleven NIH-DHAARA cells (IMDAA, queried 14 Nov 2026; 3-, 6- and 15-h values interpolated on logarithmic axes) and of the CWC FER 2(a) ratios; also 0.81 at 9 h, 0.89 at 15 h and 0.94 at 18 h	0.33	0.51	0.59	0.74	0.85	1.00
MN-Z3 (MN-C1 Jiribam plain)	CWC FER 2(b), Table 4.1, p. 20, 10-yr basis, six recording gauges (interim design ratios, Clause 2.3.6(f), as on the Barak plain downstream; 2-h value interpolated on logarithmic axes); also 0.81 at 9 h, 0.91 at 15 h and 0.95 at 18 h	0.48		0.62	0.74	0.87	1.00
All sub-areas, every AEP	24-hour depths to which the ratios apply, set by this Manual (Clause 2.3.6(c)), in mm at 50% / 20% / 10% / 4% / 2% / 1% AEP: MN-A and MN-A1 85 / 115 / 135 / 160 / 180 / 200 (NEER Gumbel fit of MASTEC's Imphal series, 1974–2000, × 1.13); MN-C and MN-C1 130 / 190 / 230 / 285 / 320 / 360 (Barak-valley floors of 320 and 351 mm at 2% and 1%, other AEPs by the shape of NIH-DHAARA's western-hill growth curve); MN-B the higher of the NIH-DHAARA cell value and the MN-A row; no absolute short-storm floor (Clause 2.3.6(g))						
MN-Z1 and MN-Z2, MN-C (reference)	CWC FER 2(a), NB/18/1991, §3.1.2, p. 24 and Fig. 10, 50-yr basis, 12 IMD recording gauges (lower bound of the Manipur ratios; not used alone)	0.260	0.370	0.457	0.615	0.805	1.000
MN-Z1 (MN-A, MN-A1): Imphal, Bishnupur, Moirang and Thoubal cells	NIH-DHAARA, IMDAA, 50-yr (queried 14 Nov 2026; comparison only)	0.31 / 0.29 / 0.29 / 0.33					1.00

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
MN-Z2 (MN-B): Kangpokpi, Senapati, Ukhrul, Chandel and Churachandpur cells	NIH-DHAARA, IMDAA, 50-yr (the cell values are design values in MN-B under Clause 2.3.6(c)(iii); the ratios shown for comparison)	0.20 / 0.21 / 0.22 / 0.29 / 0.28					1.00
MN-Z3 (MN-C, MN-C1): Noney, Tamenglong and Jiribam cells	NIH-DHAARA, IMDAA, 50-yr (comparison only)	0.31 / 0.27 / 0.22					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 rain gauges of the Water Resources Department, among them the Kangpokpi gauge whose rainfall it watches for valley floods, and the gauges at Kangpokpi, Saikul and Litan used in MASTEC's study of the valley floods, whose owners and record lengths are to be confirmed [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 Manipur NIH-DHAARA was queried at 13 points for this Manual, and 12 returned data; its reanalysis cells, of about 12 km, run high against the State's only long gauge: the Imphal cell gives 231 mm at 50 years in 24 hours, against 180 mm from the station series of Clause 2.3.6(c)(i) and the 158.6 mm that Imphal (Tulihal) has recorded as its highest day (NIH-DHAARA, queried 14 Nov 2026; IMD, *Extremes*). In the western hills the Jiribam cell gives 491 mm and the Tamenglong cell 431 mm, 1.9 to 2.2 times the State's largest reported fall, 225 mm in one night at Khoupum (as reported), with no gauge to support them. 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 they are not used as design depths in Manipur until this annex and Annex 2A are published, except in sub-area MN-B, where the cell value is used with the valley table as a floor (Clause 2.3.6(c)(iii)), and NIH-DHAARA is reported elsewhere 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 — Manipur 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 Manipur 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, the automatic weather stations and automatic rain gauges of the Meteorological Centre Imphal in the State, whose list was not read for this Manual, the recording gauge at Imphal (Tulihal) behind the 15-minute record of 1986–2009 that one unseen document describes, the six recording gauges of the CWC 2(b) report used for the ratios of sub-area MN-C1, and any recording gauges of the Water Resources Department [TBC]), separated into independent storms by a stated rule, and the storm of 28 July–1 August 1989, in which Imphal (Tulihal) recorded its highest day, 158.6 mm on 30 July, the storms of 22–28 September 1997, 24 August–3 September 1999 and 26 August–6 September 2000 behind the valley floods that MASTEC records, the storms of 28–31 May 2024 (Cyclone Remal) and of 30 May–2 June 2025, the Khoupum storm of 15 July 2025 and the storm of mid-September 2025, for none of which a recording-gauge hyetograph was found for this Manual [TBC] 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 rain gauges of the Water Resources Department, among them the Kangpokpi gauge whose rainfall it watches for valley floods, and the gauges at Kangpokpi, Saikul and Litan used in MASTEC's study of the valley floods, whose owners and record lengths are to be confirmed [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
MN-Z1 Imphal valley					
MN-Z2 Northern, eastern and southern hills					
MN-Z3 Western hills and the Jiribam plain					

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 — Manipur 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(c) (no report; enter "none") or 2(b) 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 June–15 October in sub-areas MN-A and MN-B and of 1 May–31 October in MN-C and MN-C1, whatever its duration; III for every design storm of 1 April–31 October on land below the 1% AEP level of a river, a stream or Loktak, on peat, on pat and pukhri margins and on land behind river bunds; III at any time in MN-A1 and in catchments draining to a reservoir, its backwater or a release reach; 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	
	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 — Manipur 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 Manipur 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 to be confirmed [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 Imphal valley floor in and around Imphal, Thoubal, Kakching, Bishnupur, Nambol and Mayang Imphal, where water stands 2–5 m below ground over most of Imphal West and the piezometric head 2.50–4.30 m below ground in Bishnupur, the Loktak margin and the land within the 236.21 km² of the Loktak Act, the paddy land and former pats, the margins of Lamphelpat and the other pats and pukhris, the land behind the river bunds, the foothill fans at the valley edge, where water stands 5–7 m below ground near the hills, the Barak and Jiri flood plain at Jiribam, and hill towns with perched water or springs on Disang shale. 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 — Manipur CN calibration and supplementary land covers (valley paddy land, pats and phumdi, hill forest and jhum land, landslide scars and hill-road and railway cuts, foothill fans, and the margins of Loktak and the reservoirs)

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 Manipur 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 paddy land of the Imphal valley floor, ponded through the monsoon season behind its bunds and ridges, which the Manipur Conservation of Paddy Land and Wetland Act, 2014 counts, with its drainage channels and ponds, as part of the paddy land (s.2(c)); the pats and marshes of the valley, with their mats of phumdi (floating biomass of vegetation, organic debris and soil, the "Phumdis" of the Loktak Lake (Protection) Act, 2006), wet at the start of every storm; the forest, scrub and degraded land of the hills, of which MASTEC classes 1,545 km² as degraded, 24% of the valley's catchment and 35% of its hills, with the jhum (shifting cultivation) land that the Manipur (Hill Areas) District Councils Act, 1971 lists for regulation; the fresh scars, slide debris and fills of landslides and of hill-road and railway cuts on the Disang shale, such as those of Tupul in June 2022; the sand, gravel and boulder fans where hill streams leave the hills for the valley floor; and the margins of Loktak and of the Thoubal (Mapithel) and Khuga reservoirs, exposed or drawn down 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)
Paddy land of the valley floor, ponded behind its bunds and ridges, with the bunds and drainage channels recorded						
Pat or marsh, with the phumdi (floating biomass) cover recorded; wet at the start of the storm						
Hill forest or scrub on Disang shale, with the depth of soil recorded; jhum (shifting cultivation) land, with the year of clearing recorded						
Fresh landslide scar or slide debris; hill-road or railway cut slope or fill						

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Foothill fan of sand, gravel and boulders where a hill stream reaches the valley floor						
Margin of Loktak or of a reservoir (Thoubal (Mapithel), Khuga) exposed or drawn down 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 Manipur.** Manipur is landlocked, 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 Imphal valley floor, the Loktak margin and the Jiribam plain are flat and slow to drain, but they are not coastal plain; their slow response is represented by storage, pumping and backwater (Clauses 3.10.4, 3.12.1 and 3.12.4) and by the outfall-closed check of Chapter 5, not by a lower peak rate factor, while the hills of Disang shale 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 subzone 2(b), applied as a check in subzone 2(c), with worked example

Supports Clauses 3.4.3 and 3.11.4 of Chapter 3.

To be prepared. This annex will tabulate, for CWC subzone 2(b) (South Brahmaputra), whose report this Manual applies in place of the unpublished report for subzone 2(c) (Barak and others), 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 a CWC Flood Estimation Report for subzone 2(c) (Barak and others), which covers the whole of Manipur, the Imphal valley and the northern, eastern and southern hills through the Manipur river and the western hills and the Jiribam plain through the Barak, and which CWC has never published, with written confirmation from CWC that none exists or is in preparation [TBC]; until then, from the South Brahmaputra subzone 2(b) report (Revised; Design Office Report No. SB-2(b)/R-4/44/99, March 2000), in which no part of Manipur is known to lie except, at most, a sliver of northern Senapati district near Mao that a clean copy of its Plate 9 is still to confirm [TBC], the areal reduction curves of its Figs 12(a) and 12(b), whose values were not read on the copy used [TBC], and its unit-hydrograph relationships, which this Manual uses only as a check (see the References of Chapter 3); and the stage–discharge records and flood hydrographs of the WRD gauging sites on the Iril, the Thoubal, the Imphal and the Nambul, of which only the peaks of 1999–2001 printed by MASTEC were read [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(b) (South Brahmaputra) relationship, applied in Manipur as a check only
Peak discharge of the 1-hour unit hydrograph	Qp	m³/s	Qp = 0.905 A^0.758 (Eq. 3.4.3.2); the peak depends on the catchment area alone
Peak discharge per unit area	qp	m³/s per km²	qp = Qp / A
Time from centre of unit rainfall to peak	tp	h	tp = 2.87 qp^−0.839
Width of UH at 50% of peak	W50	h	W50 = 2.304 qp^−1.035
Width of UH at 75% of peak	W75	h	W75 = 1.339 qp^−0.978
Width of rising limb at 50% of peak	WR50	h	WR50 = 0.814 qp^−1.018
Width of rising limb at 75% of peak	WR75	h	WR75 = 0.494 qp^−0.966
Base width of UH	TB	h	TB = 2.447 tp^1.157

Parameter	Symbol	Unit	Subzone 2(b) (South Brahmaputra) relationship, applied in Manipur as a check only
Time to peak from start of rise	Tm	h	Tm = tp + tr/2
Unit duration	tr	h	1
Design storm duration	TD	h	TD = 1.1 tp
Design loss rate	—	mm/h	3.5 (printed "0.35 cm/hr", the modal value of 100 flood events, as in the report of 1984); for the 2(b) SUH check run only, never to assign an HSG or in an urban model (Clause 3.7)
Design base flow	—	m³/s per km²	0.05 (68 of 100 events in the range 0.01–0.09)
Ratio of t-hour to 24-hour rainfall	—	—	10-yr, partial duration, mean of the six self-recording gauges of the report: 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 MN-C1, the Jiribam plain (Clause 2.3.6(f))
Time distribution of rainfall	—	cumulative fraction by hour	Fig. 11 and Annex 4.4 not read [TBC]
Conversion of 1-day to 24-hour rainfall	—	factor	1.15 (§4.3.1); the interim table for sub-areas MN-A and MN-A1 uses 1.13 (Clause 2.3.6(c)(i))
Areal reduction factor	ARF	% of point rainfall	Figs 12(a) (1, 3 and 6 h) and 12(b) (12 and 24 h); curve values not read [TBC]. Used in Manipur for catchments of 25–5,000 km² in place of the unpublished 2(c) report (Clause 2.7.3)
50-yr 24-hour point rainfall at Manipur towns	—	mm	None: the plates of the report stop at its southern boundary, which runs from about 25.2°N at 93°E to about 25.5°N at 94°E and then north along about 94.4°E (NEER's reading of Plate 9, within about 0.1°). No Manipur town is on the plates; only the north of Senapati district near Mao may lie north of the line, where the 320-mm contour runs along it [TBC]
Gauged catchments that drain Manipur	—	—	None of the 14 used
Catchment area for which the relationships apply	A	km²	more than 50 to 1,500; up to 5,000 "judiciously"
Report reference	—	—	Annexure 1.1, §§3.4–3.7, Table 3.3, Table 4.1, §4.3, worked example, Plate 9

Note: relationships as printed in the CWC subzone 2(b) report (References of Chapter 3), read from a scanned copy and with Table 3.3 checked against its page images for the earlier North-East editions of this series. A is the catchment area in km². **Coverage.** The report's subzone list gives subzone 2(c), "Barak and others", as covering the "Barak, Kalden and Manipur rivers" (Annexure 1.1; "Kalden" is the Kaladan, NEER's reading). Both of Manipur's river systems are therefore in subzone 2(c): the Imphal valley and the northern, eastern and southern hills drain through the Manipur river, past Ithai and Sugnu, towards Myanmar, and the western hills and the Jiribam plain drain to the Barak. CWC has published no report for subzone 2(c): the 2(b) report's list of the 21 reports published by 2000 has none, and neither has CWC's download page of 2024. The earlier North-East editions of this series met subzone 2(c) only in part of their land; **in Manipur it covers the whole State**. **Basis.** The unit hydrograph rests on 14 catchments gauged at railway and national-highway bridges outside Manipur, 100 bridge-years of record in all; none drains Manipur, and none is urban, embanked, pumped or a closed lake basin. The 50-yr peaks the report reproduces err by "+ 40.72% − 57.84%", and "very small catchments have larger variation". **Area only.** The 2(b) peak depends on A alone: slope enters nowhere, so the SUH gives the same unit hydrograph to a steep catchment of Disang shale in the western hills and to a flat catchment of the same area on the plains of subzone 2(b), and it knows nothing of the bunds, the pats or the lake that govern the valley. **Worked example.** The report's example is railway bridge 160, outside Manipur (470 km², L 56.35 km, Lc 31.40 km, S 2.02 m/km): Qp = 96.00 m³/s, qp = 0.20 m³/s per km², tp = 11.07 h, adjusted to 11.50 h, W50 = 12.19 h, W75 = 6.46 h,

WR50 = 4.19 h, WR75 = 2.34 h and TB = 41.00 h, with a loss of 0.35 cm/h and a base flow of 0.05 × 470 = 23.50 m³/s. **Use in the State.** The 2(b) SUH is used in Manipur only as the check of Clause 3.11.4, for the rural rivers of more than 50 km² that enter the valley or the towns, such as the Iril, the Thoubal, the Sekmai, the Khuga and the Chakpi, and the Irang, the Makru and the Jiri of the western hills; the design model is HEC-HMS or SWMM, calibrated under Clause 3.15 to the WRD discharges where they exist (Commentary to Clause 3.7). The largest discharges printed for the valley rivers are 532.488 m³/s on the Iril at Moirang Kampu (stage 11.04 m above the gauge datum, 2 September 2000), 391.636 m³/s on the Thoubal at the Thoubal bridge (9.49 m, 30 August 1999), 202.006 m³/s on the Imphal (7.3 m, 2 September 2000) and 68.495 m³/s on the Nambul (4.7 m, 2 July 2001), and their stage–discharge curves are looped (MASTEC, from WRD data of 1999–2001); no longer record, no catchment area at the gauges and no unit hydrograph derived from them were found [TBC]. Where a calibrated model gives a lower 1% AEP peak than the 2(b) SUH, Clause 3.11.4(d) applies as written. Below the Mapithel, Khuga and Singda dams the flood is set by releases (Clause 5.8.5(d)), and on the valley floor by the bunds, the pumps and the lake (Clause 5.8.5(a) to (c)), not by any unit hydrograph. The urban catchments of Imphal, Thoubal, Kakching, Bishnupur, Churachandpur, Ukhrul, Tamenglong and Jiribam are far smaller than 50 km² and are designed by the Rational Method or SWMM under Clause 3.4. In sub-areas MN-C and MN-C1 every cross-drainage structure and outfall of more than 1 km² needs a site-specific hydrology study with the design rainfall of Clause 2.3.6(c)(ii). The design loss rate of 3.5 mm/h is a φ-index fitted to the floods of rural catchments on the plains and foothills of subzone 2(b); it 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).

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 — Manipur 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 Manipur 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 — Manipur Stormwater Design Manual, Draft v1.0. One form for each point of comparison (POC). Flows in m^3/s, volumes in m^3.

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 — Manipur 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 Imphal valley floor, on its lacustrine clay, silt and peat, in and around Imphal, Thoubal, Kakching, Bishnupur, Nambol and Mayang Imphal, where water stands 2–5 m below ground over most of Imphal West and the piezometric head 2.50–4.30 m below ground in Bishnupur, the Loktak margin and the land within the 236.21 km² of the Loktak Act, the paddy land and former pats, the margins of Lamphelpat and the other pats and pukhris, the land behind the river bunds, the Barak and Jiri flood plain of the Jiribam plain, 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 bunds, flood channels, gated and flap-gated outfalls, pumping stations and gauges of WRD, with their warning, flood and highest flood levels and their datum [TBC], the buffer table of bye-law 93 of the Model, the High Flood Risk Areas of the risk-informed master plans for Imphal and Moirang on which bye-law 94 relies (not read [TBC]), any flood zone notified under the Manipur Flood Plain Zoning Act, 1978 (none notified), the Core and Buffer Zones of the Loktak Lake (Protection) Act, 2006, with the levels of Loktak and the Ithai barrage from NHPC and LDA, the wetlands delineated and notified by the Manipur State Wetlands Authority and the inventory of about 4,000 water bodies made after NGT M.A. 26/2019, the paddy land and wetland of the Manipur Conservation of Paddy Land and Wetland Act, 2014 from the revenue records, the levels and release records of the Thoubal (Mapithel), Khuga and Singda dams [TBC], and the CWC level-monitoring site on the Barak at Chotebekra, town boundaries (MAHUD and TPD for the master-plan and notified planning areas, PDA Manipur, IMC and the 26 other urban local bodies (draft boundary notifications for 23 of them were posted on 3 November 2025, as listed), and, in the hill areas, the Deputy Commissioners and the District Councils [TBC]), flood maps held by MSDMA, observation-well records of the CGWB and the WRD, and the extent of the lacustrine clay, silt and peat of the Imphal valley floor, the paddy land and former pats, the foothill fans of sand and gravel at the valley edge, the Disang shale of the hills and of the hillocks inside the valley, the Barail sandstone cappings, the Barak and Jiri alluvium of the Jiribam plain and urban fill, with the land to which the valley-floor rule of Clause 4.11 applies and the slopes of more than 10°, and the Disang shale at any slope, to which its hill rule applies from soil survey maps (NBSS&LUP, the State soil survey (agency to be confirmed [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, pat, pukhri or Loktak, or of the water ponded behind any river bund that encloses the site (Clause 4.12.1(b)). For the flotation check in the Imphal valley floor, with its lacustrine clays, peat and paddy land, the margins of Loktak and the other pats and pukhris, the land behind river bunds, and the Barak and Jiri flood plain of the Jiribam plain 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	Imphal valley floor (Imphal, Thoubal, Kakching, Bishnupur–Nambol, Mayang Imphal or other); Loktak margin (Moirang, Ningthoukhong, Thanga, Ithai–Sugnu–Wangoo or other); paddy land or former pat; pat or pukhri margin (Lamphelpat, Utra Pat, Yaral Pat, Waithou–Phumnom Pat, Pumlen–Khoidum Pat, Ikop–Kharung Pat or other); land behind a river bund (Imphal, Nambul, Iril, Kongba, Thoubal, Sekmai or other); Barak or Jiri flood plain at Jiribam; 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
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 (m^3/ha), standard	SSR (m^3/ha), flood-sensitive
MN-Z1 Imphal valley: MN-A Imphal valley floor (Imphal–Thoubal–Kakching–Bishnupur–Nambol–Mayang Imphal)	B / C / D	50% / 70% / 90%	—	—	—	—	—
MN-Z1 Imphal valley: MN-A1 Loktak margin (Moirang–Ningthoukhong–Thanga–Ithai–Sugnu–Wangoo)	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
MN-Z2 Northern, eastern and southern hills: MN-B Northern, eastern and southern hills (Senapati–Kangpokpi–Ukhrul–Kamjong–Chandel–Tengnoupal–Moreh–Churachandpur)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(c)(iii))	—	—	—	—
MN-Z3 Western hills and the Jiribam plain: MN-C Western hills (Tamenglong–Noney–Khoupum–Tupul–Tousem–Pherzawl)	C / D	50% / 70% / 90%	—	—	—	—	—
MN-Z3 Western hills and the Jiribam plain: MN-C1 Jiribam plain (Jiribam)	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 hill-fringe colony in Jiribam town draining to a stream of the Jiri; 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 a stream of the Jiri at Jiribam, on the Barak and Jiri flood plain of the Jiribam plain 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 a stream of the Jiri at Jiribam, on the Barak and Jiri flood plain of the Jiribam plain (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 — Manipur 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 Manipur 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 — Manipur 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 — Manipur 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 — Manipur 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 — Manipur 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 — Manipur 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 Manipur. Manipur has no coast, so no outfall in the State has a tidal tailwater, and this annex has no Manipur 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 a bund-locked outfall, row F10 records the gate, the WRD gauge and its datum, the design and check levels, the lock and the pump-down of Clause 5.8.5(a); for an outfall on the Loktak margin, the design lake level and the closure of Clause 5.8.5(c); and for an outfall to a pat, pukhri or pond, its starting level and surveyed stage–storage relation under Clause 5.8.5(e).

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
Imphal river at Minuthong and Lilong	Imphal valley floor (Greater Imphal and below)	Riverine outfall reach through WRD bund gates; WRD levels as reported, datum [TBC]: Minuthong WL 785.900, FL 786.900, HFL 788.400 m (above HFL on 29 May 2024); Lilong WL 780.350, FL 781.350 m (2025) or 781.250 m (2024), the higher applies, HFL 782.850 m, exceeded at 783.250 m on 15 September 2025; design at FL, check at the HFL or the highest reading above it; lock the 72-hour storm and while the river stays above the sill, not less than 7 days without a stage record; bye-law 93 buffer of the Model [TBC: confirm the number and text in the bye-laws the local body has notified] 55, 60 and 62 m by reach	5.8.1, 5.8.5
Nambul at Thong Nambonbi (Hump Bridge), with the Naga Nullah and the Waisel Maril	Greater Imphal	Riverine outfall reach and major drains; HFL 783.695 m (WRD, as reported; no FL printed), above it on 29 May 2024; breached at four places in 2025 (as reported); 72 drains that carry sewage, intercepted and diverted (State report, December 2025); city channels with no single owner; bye-law 93 buffer 30 m within Greater Imphal	5.2, 5.8.1, 5.8.5
Lamphelpat and the Shamushang nallah	Greater Imphal (Lamphel)	Receiving storage: a pat being developed as flood storage, about 300 acres dredged from November 2023, pumped to the Nambul through the Shamushang nallah in high floods (WRD site report, 2025); starts full; stage–storage and pump capacity [TBC]; counted when complete and confirmed by WRD; proposed drinking-water source, interception before it	5.8.5
Iril at Irilbung, and the Kongba	Imphal East	Riverine outfall reaches; Irilbung WL 786.700, FL 787.700 m, printed HFL 782.200 m (an error, not used), 788.850 m on 15 September 2025 (as reported); breach at Kshetri Awang Leikai (September 2025, as reported); Kongba level [TBC]; bye-law 93 buffers 50 m (Iril) and 35 m (Kongba, from mid-stream)	5.8.1, 5.8.5
Thoubal, Sekmai, Wangjing, Nambol, Khuga, Merakhong and Arong	Imphal valley floor	Riverine outfall reaches; Thoubal WL 778.915, FL 779.915 m (gauge not named); Nambol at Nambol Thongkhong HFL 774.700 m (2024) or 774.400 m (2025), the higher applies; others [TBC]; ungauged rule of Clause 5.8.5(a); lock not less than 7 days without a stage record	5.8.1, 5.8.5

Water body	Region	Listed as	Clause
Loktak and the Manipur river at the Ithai barrage, with the Sugnu hump and the Chakpi	Loktak margin (MN-A1)	Lake tailwater; Ithai HFL 769.320 m, 770.05 m on 15 September 2025 (WRD, as reported); FRL 768.5 m and MDDL 766.2 m (NHPC, as quoted), MDDL 766.01 m (CEA, as quoted), FRL 769.63 m (ORF, as reported) — conflict; design 769.320 m, check 770.05 m, not below the FRL in June–September; outfalls below the design level closed 1 June–30 September; rock sill at 763.7 m below the barrage; Chakpi backwater to Sugnu and Wangoo; phumdi screens; Loktak Act zones (Core 70.30 km², 236.21 km² in all)	5.8.1, 5.8.5
Thoubal below the Mapithel dam; Khuga below its dam; Nambul below the Singda dam	Imphal valley	Release reaches; Mapithel FRL 880.7 m (WRD, 2025, as reported), 876 m "nearly 2 m above the spillways" on 1 August 2015 (as reported) — conflict; spillway 2,240 m³/s (as reported); Khuga and Singda levels and releases [TBC]; release before, during and after the storm; lock not less than 72 hours	5.8.3, 5.8.5
Mapithel (Thoubal Multipurpose Project), Khuga and Singda dams; the Ithai barrage (NHPC)	Upstream of the valley's reaches; outlet of Loktak	Releases and gate operation to be included in river levels (operating rules and release records [TBC]); no credit for warnings, drawdown, attenuation or early barrage opening	5.8.3, 5.8.5
Pats and pukhris that receive town drains, among them Porompat, Takyelpat, Sangaipat, Kharungpat, Ikop pat, Utra, Yaral, Waithou–Phumnom, Pumlen–Khoidum and Ikop–Kharung pats, and the public pukhris of the towns	Imphal valley	Receiving storage; full to the outlet at the start; surveyed stage–storage [TBC]; storage belongs to the system; interception and screens before any outfall that carries sewage; Yaral, Utra and Waithou–Phumnom pats in draft notification under the Wetlands Rules, 2017	5.8.5
Khongs and hill streams of Tamenglong, Noney, Ukhrul, Senapati, Kangpokpi, Chandel and Churachandpur, of the valley rim, and of the Makru, Irang, Leimatak and Tuivai catchments	Hill sub-areas MN-B and MN-C	Hill streams; ungauged; 1% AEP study with bulking and blockage and surveyed flood marks; invert at least 0.5 m above the highest surveyed bed; silt trap where they reach the valley floor; lock not less than 24 hours	5.2, 5.8.1, 5.8.5
Barak at Chotebekra, and the Jiri	Jiribam plain (MN-C1)	Riverine outfall reaches; Chotebekra HFL 32.1 m (31 July 1989; SANDRP, as reported), danger level 26.2 m (press only, as reported), datum [TBC]; the Barak-valley lock, not less than 7 days without a stage record; the Assam edition governs the reaches downstream	5.8.1, 5.8.5
Drains of IMC, the Municipal Councils and Nagar Panchayats, PDA Manipur, PWD and the national-highway agencies 1.0 m wide or more; WRD's city and flood channels; DoECC's interception works on the Nambul	Manipur	Major drains; WRD permission through a bund; owner's consent, design water level and flap gate	5.2, 5.8.5
River mouths subject to sand-bar closure	None in Manipur	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 Naga Nullah, the Waisel Maril and the Shamushang nallah in Imphal, every city channel and flood channel of WRD and every drain that discharges through a gate or flap gate in a river bund, any drain built or held by IMC, a Municipal Council, a Nagar Panchayat, PDA Manipur, PWD or a national-highway agency with an internal width of 1.0 m or more, and every khong or other natural channel that drains 8 ha or more 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 Manipur) 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
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 hill-fringe colony in Jiribam town draining to a stream of the Jiri

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, on the hill fringe of Jiribam town. It discharges through its own outlet chamber and a flap gate to a public storm drain that joins a stream of the Jiri, whose level rises when the stream comes down from the hills in spate and stays up while the Jiri and the Barak below it are in flood, 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 Manipur an outfall to a hill stream whose invert is below its design level is closed for the storm and the stream's recession, and for not less than 24 hours; where the Barak backs the stream up, as it can on the Jiribam plain, the outfall is closed for the whole 72-hour storm and for as long as the river stays above the sill, not less than 7 days where no stage record has been analysed, and its stored volume is pumped down within 48 hours with the gate still shut; a bund-locked outfall on the Imphal valley floor is closed in the same way, and an outfall below the design level of Loktak is closed from 1 June to 30 September; an outfall to a release reach is closed for not less than 72 hours; and an outfall below the design level of a full pat, pukhri or pond is closed for the whole storm, under Clause 5.8.5. In each of those cases 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 stream would also need the debris rack, the bulking factor and the silt trap of Clause 6.3.6 and an invert above the range of bed movement of Clause 5.8.5(f); and on a natural slope of more than 10°, or on Disang shale at any slope, 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

Time (h)	Inflow (L/s)	Outlet	Outflow (L/s)	Stage (m)	Storage (m³)
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 Imphal valley floor, with its lacustrine clays, peat and paddy land, the margins of Loktak and the other pats and pukhris, the land behind river bunds, and the Barak and Jiri flood plain of the Jiribam plain 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 — Manipur 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 pukhri, or major drain or the sea (Clause 5.3.1 (a) to (c))	
B2. Where the end point is a tank or pukhri: change in maximum water level (m) and in surplus-weir discharge (m³/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. Bund-locked valley outfalls, Imphal, the Loktak margin, release reaches, pats and pukhris, hill streams, Jiribam and the Barak, and drains of other bodies: for a bund-locked outfall, the operator of each gate, flap gate and pumping station identified (WRD or the local body), gate sills, bund crest, installed permanent capacity, duty point, sump levels and gate-closing level obtained, with every level tied to a Survey of India benchmark and to the WRD gauge named; the WRD levels used (WL, FL, HFL and the highest reading above the HFL) with their source and the datum confirmed or flagged; the design level (the WRD flood level, the higher printed value where two are printed, e.g. Lilong 781.350 m; the HFL where no flood level is printed, e.g. Hump Bridge 783.695 m, Nambol Thongkhong 774.700 m), the check level (the HFL or the highest reading above it, e.g. Minuthong 788.400 m, Lilong 783.250 m, Irilbung 788.850 m), and the 10% AEP case at the warning level, each transferred to the outfall with the method stated; for an ungauged river or stream, the flood marks of 2024 and 2025 surveyed, or a model; the drain behind the gate routed with its whole catchment, the pats, pukhris and paddy land it fills and its present storage, starting full to its outlet, pumping confirmed available (permanent pumps only, not more than installed capacity less the largest pump), pumps operable at the check level; the lock (the whole 72-hour storm and while the river stays above the sill, from the WRD stage record used, or not less than 7 days on the Imphal, Nambul, Iril, Kongba, Thoubal, Sekmai, Wangjing, Nambol, Khuga and Manipur rivers and 72 hours on a smaller stream) and the pump-down to the starting level within 48 hours with the gate shut; the joint drain–pump–river analysis for the two valley cases; the gate-failure and breach checks reported; for Imphal, the governing gauge (Minuthong, Lilong, Hump Bridge or Irilbung), the channel (the Naga Nullah, the Waisel Maril or another) and its present section, and for Lamphelpat the pat level starting full, the Shamushang pumps confirmed by WRD and the Nambul level at the Shamushang outfall, with the NDB works counted only once complete and confirmed; for the Loktak margin, the design lake level (Ithai HFL 769.320 m, checked at 770.05 m, not below the FRL in June–September) with the FRL conflict recorded, the closure from 1 June to 30 September of an outfall below it, the Chakpi level at Sugnu and Wangoo, the phumdi screen, and LDA's prior permission; for a release reach, the operator's consent, levels in writing (feet converted at 1 ft = 0.3048 m, datum stated), the largest recorded release or the spillway capacity (Mapithel 2,240 m³/s, as reported), placed before, during and after the storm, and a lock of not less than 72 hours, with no warning, drawdown or attenuation credited; for a pat, pukhri or pond, its outlet level, surveyed monsoon water line, surveyed stage–storage relation, starting level and design level, and the interception and screens before it; for a hill stream, the 1% AEP study with the rainfall of its sub-area, the bulking and blockage of Clause 6.3.6, the surveyed flood marks and their sources, 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 silt trap where the stream reaches the valley floor, and a lock of not less than 24 hours; for Jiribam, the Barak level (not below Chotebekra's 32.1 m, transferred; 10% AEP case not below 26.2 m) with its datum flagged, the Jiri level, and the Barak-valley lock; WRD's written permission for any work through a bund; owner's consent (IMC or the local body, PWD, a national-highway agency, DoECC or WRD), permitted rate, design water level or computed channel level, and flap gate; and the bye-law 93 buffers, the corridor of Clause 7.4, the bye-law 94 plinth, the Loktak Act zones, the paddy-land conversion approval and the status of any wetland notification checked (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				
J3				

Case	Rainfall	Tailwater used (m, project datum)	Applies?	Governing result (storage, level, pipe size or pump capacity)
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 (m³/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 Manipur 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 — Manipur Stormwater Design Manual, Draft v1.0.

Form 5-2 — Simplified Downstream Statement (small sites)

Supports Clause 5.3.4 of Chapter 5.

Draft form — Manipur 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, MSDMA, 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 — Manipur 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 Manipur 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 Manipur 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), the national-highway agencies and Imphal Municipal Corporation standard details, NIT Manipur and Manipur University, whose hydraulic testing capability was not confirmed 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
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)

Item	Requirement	Clause
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 Manipur, 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 Imphal Municipal Corporation and other urban local bodies, WRD records for channels, land cover from NRSC, soils from the Manipur 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.

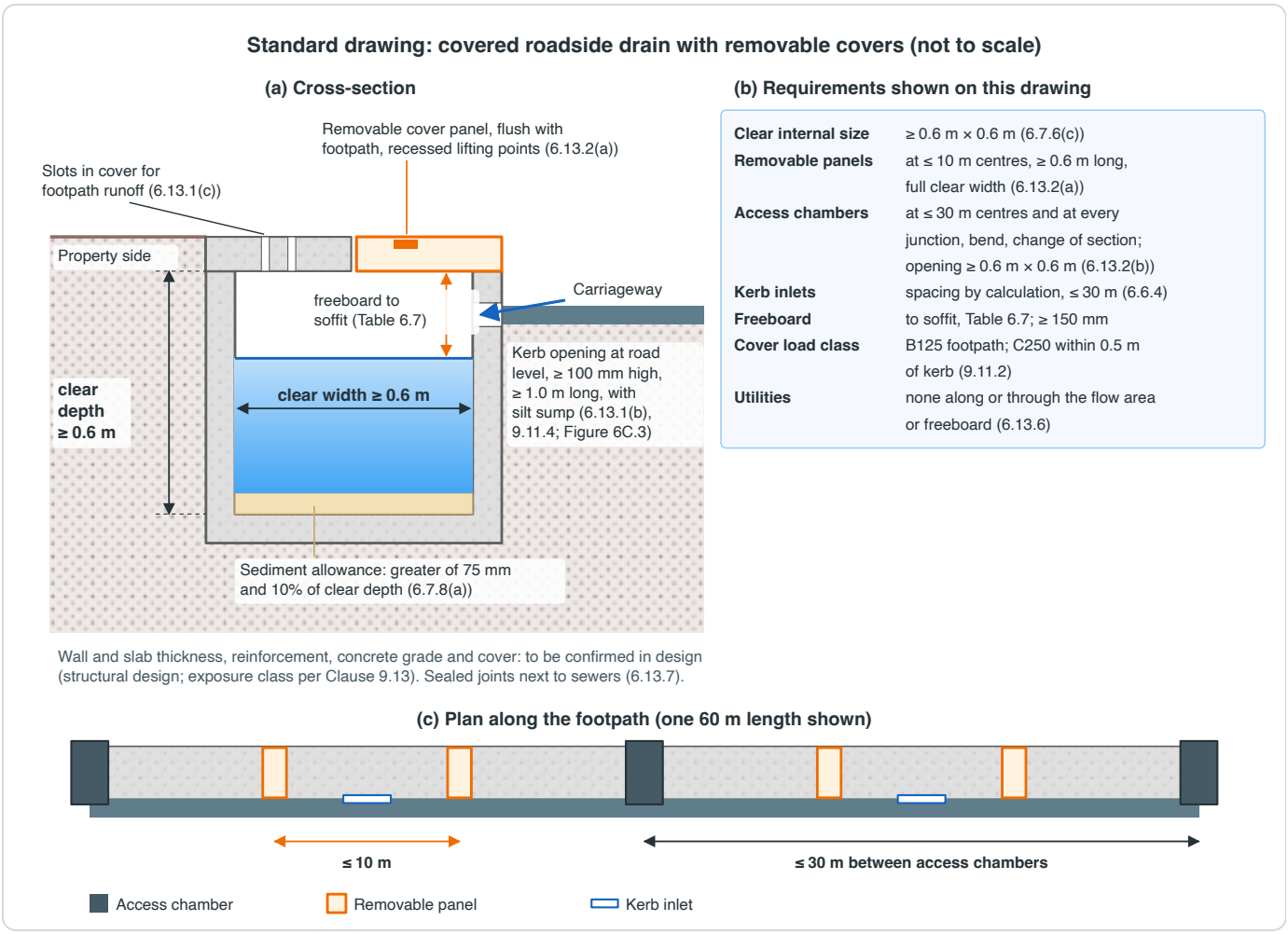


Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 5, and IRC:SP:50-2013.

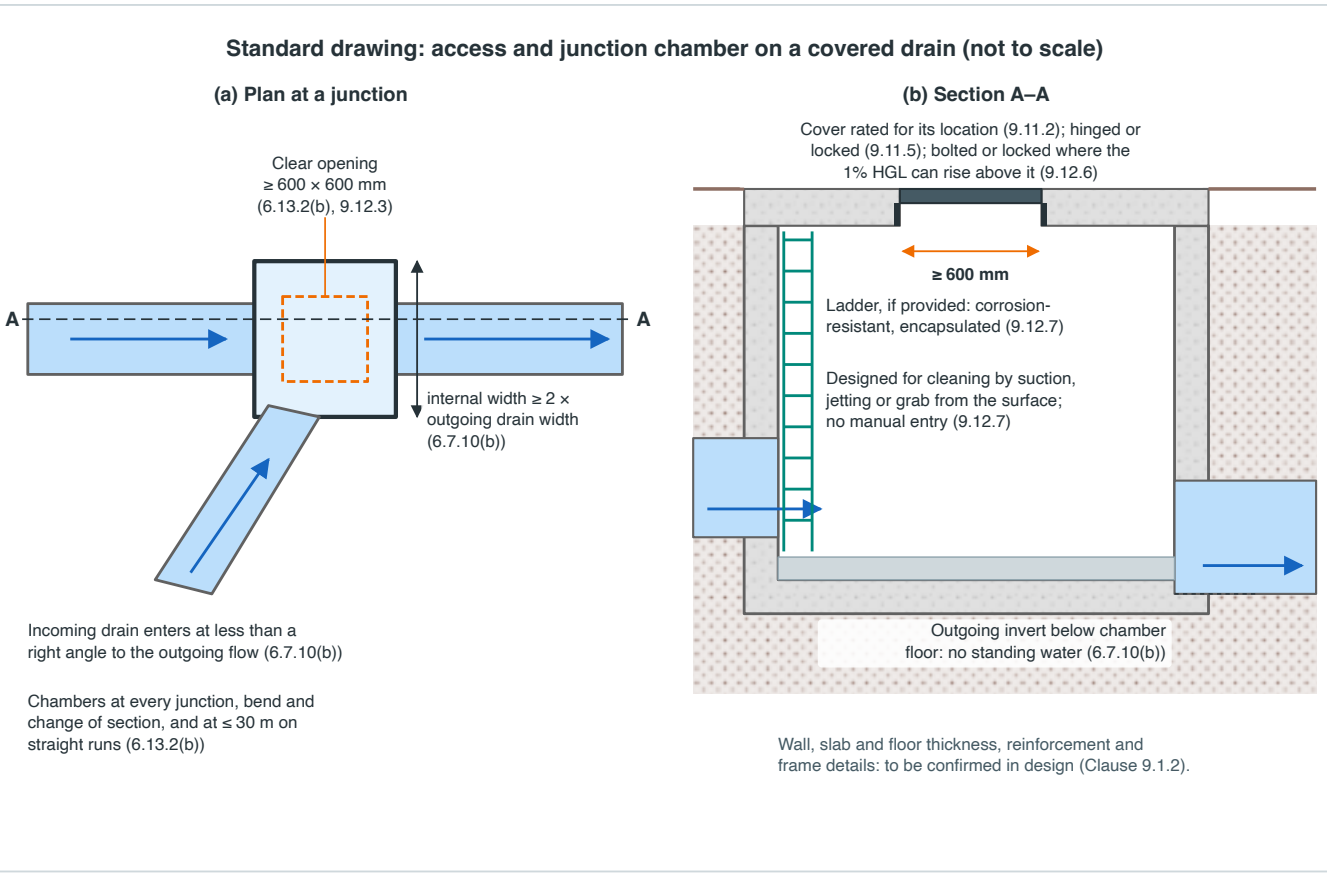


Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), §5.3.4 and Chapter 11.

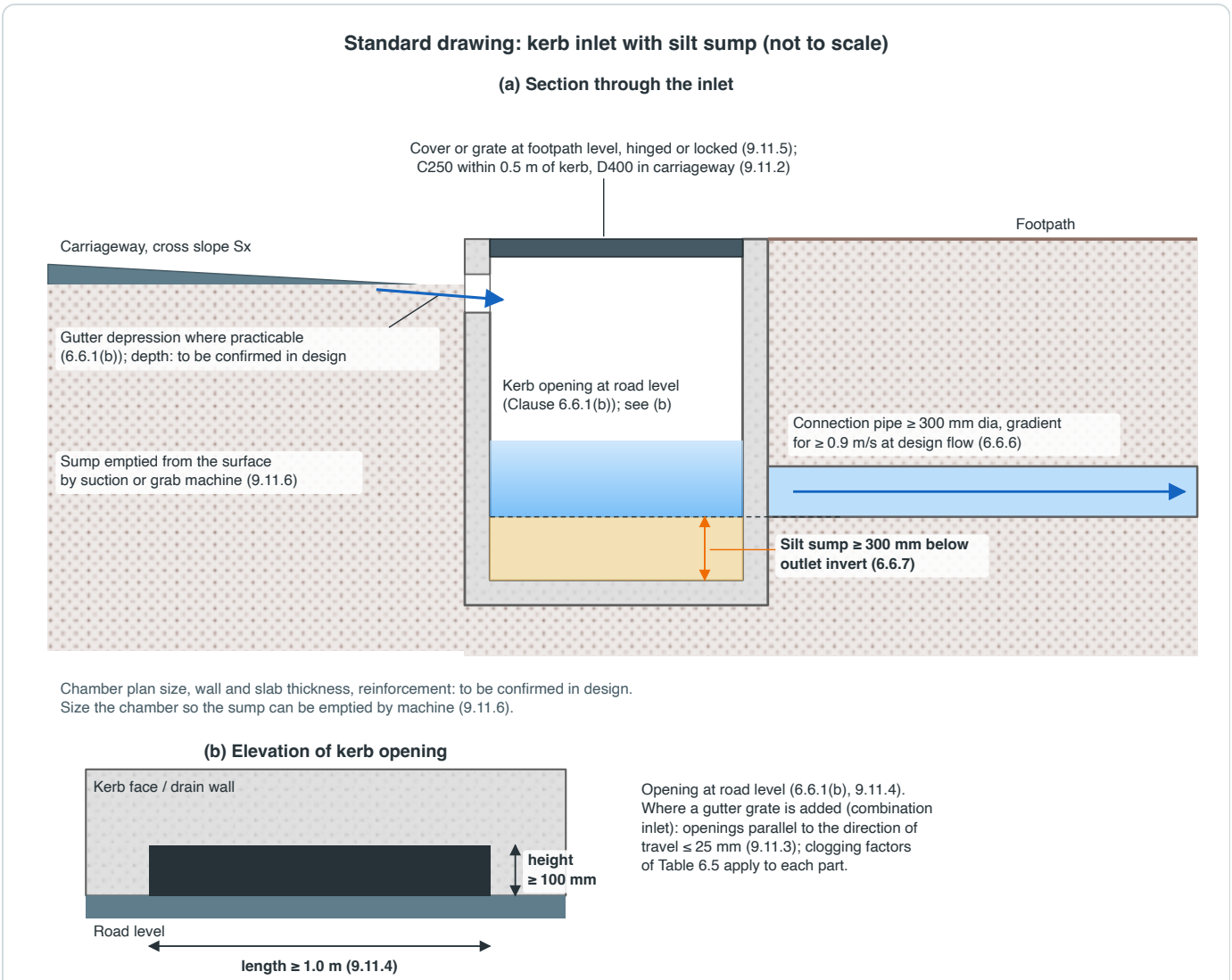


Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th 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 — Manipur 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 — Manipur Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 7

Waterbodies, Pats and Pukhris (Lakes and Ponds) 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 Manipuri 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 Revenue Department. It needs the land records of the Revenue Department under the Manipur Land Revenue and Land Reforms Act, 1960 in the valley, kept by district, sub-division, revenue village and patta, including government land recorded as water; in the hill areas, where land is allotted under section 29 of the Manipur (Hill Areas) District Councils Act, 1971 and held under customary tenure, the records of the District Councils and Village Authorities (not researched [TBC]); the inventory of about 4,000 water bodies prepared after the National Green Tribunal's order of 22 May 2020 in M.A. 26/2019, for which "Ground truthing, engineering surveys, and quality monitoring … are pending" (DoECC, 2025-26); the Space Applications Centre's Wetland Atlas (2021), with 132 wetlands larger than 2.25 ha; the 71 wetlands delineated and 3 demarcated by the Manipur State Wetlands Authority in 2025-26, and its draft notifications of the Yaral, Utra and Waithou–Phumnom pats; the land-use maps of the Revised GIS Based Master Plan for Greater Imphal – 2043 (1st Modification), with its water bodies and ponds (about 502.95 ha), river bed (about 76.85 ha) and wetlands, and of the GIS master plans of the other towns; the 236.21 km² of Loktak and its Core Zone of 70.30 km² under the Manipur Loktak Lake (Protection) Act, 2006; WRD's records of its river bunds, sluices and pumping stations, and its river gauges; and each town's drain register (Chapter 6); the WRD and Gram Panchayat or, in the hill areas, 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 WRD records, with local name	7.3.1(a)
WB_NAME_MNI	Text	Manipuri script	Yes	Name in Manipuri	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, sub-division 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	WRD 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 WRD 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 (turel); hill stream (khong); city channel or drain; pat (natural lake or wetland; Loktak Core Zone, Loktak Buffer Zone, other pat; notified, draft or not notified); pukhri (pond); phumdi or athaphum area; paddy land and its channels (2014 Act); ponded area behind a river bund (with its sluice); reservoir (with its drawdown zone); spring; retention pond or basin; supply channel; surplus course	7.2
CUSTODIAN	IMC or other ULB (municipal drain; AMRUT pond); PDA Manipur (khas land in a master-plan area); WRD (river bund, flood channel, sluice, pump; Lamphelpat); LDA (Loktak, 2006 Act); NHPC (Ithai barrage); PWD or national-highway agency (road drains and culverts); PHED (sewer, intake); DoECC (Nambul interception works); Forest, Environment and Climate Change Department (forest land); Revenue Department or Deputy Commissioner (government land); Gram Panchayat; private owner (patta land); District Council or Village Authority (hill areas) [TBC]; Manipur State Wetlands Authority (notified wetland); 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 WRD control, the operating rule is WRD'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, sub-division, district].
2. Custodian: [WRD division / ULB / Gram Panchayat or, in the hill areas, 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 MSDMA red alert	IMD, MSDMA	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 Manipur Pollution Control Board (MPCB) 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 Manipur Pollution Control Board (MPCB) 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 Manipuri waterbody terms and regional variants

Supports Clause 7.2 and Clause 7.3 of Chapter 7.

The terms below are Manipuri (Meeteilon) words for waterbodies, channels, bunds and gates. Many of them appear in the names of pats, rivers and places (Lamphelpat, Utra Pat, Yaral Pat; Imphal Turel), and the name used in the land records, the inventory of water bodies, WRD's records or a municipal record for each waterbody should be recorded in the inventory (Annex 7A) alongside the Manual's term. A meaning is given below only where it was found in H. Surmangol Sharma, *Learners' Manipuri-English Dictionary* (Imphal: Sangam Book Store, 2006), as served by the Digital South Asia Library (page numbers as DSAL gives them; p. 117, *pukhri*, was checked against the printed page), or in the Manipur Loktak Lake (Protection) Act, 2006. **Three cautions apply.** The dictionary's headwords are in Meetei Mayek with a romanisation; this English edition gives the romanisation only, and the Meetei Mayek forms, which the field WB_NAME_MNI of Annex 7A holds for each waterbody's name, belong to the Manipuri edition. No Bengali-script dictionary was read, so no Bengali-script form is given, although the Manipur Official Language (Amendment) Act, 2021 allows the concurrent use of Bengali script and Meetei Mayek for up to ten years. And modern usage may be narrower or wider than the dictionary's English glosses. Terms whose meaning or use was not confirmed, and terms this Manual avoids, are in Table 7E.4. The list is to be extended by the State Stormwater Technical Committee, with modern land-record, WRD and municipal usage and the terms of the other languages of the State.

The Manual's term for a pond is **pukhri**, written on first use as "**pukhri (Manipuri: a pond; plural pukhris)**", and its term for a natural lake or wetland is **pat**, written on first use as "**pat (Manipuri: a lake or wetland, as in Lamphelpat)**". *Pukhri* is glossed "n. pond" with no other sense (p. 117): it names dug or small standing water, which matches the "tank" of this chapter and the public ponds of the AMRUT 2.0 projects, and leaves *pat*, the State's own word in Lamphelpat, Utra Pat and Yaral Pat and in the Manipur State Wetlands Authority's lists, for the natural lakes and wetlands. Meeteilon marks the plural with suffixes, not with an ending of this kind, so the English plural **pukhris** is a convention of this Manual; "pats" is used in the same way. Engineered storage built under this Manual is a **detention pond**, never a pukhri or a pat; a natural lake or wetland is never called a pukhri; and Lamphelpat is "a pat being developed as flood storage". In running text this Manual uses the plain forms pukhri, pat, turel, khong, khongban, ithong, pan and phumdi; the dictionary's romanisation, with its marks, is given once below.

Table 7E.1 — Waterbodies

Manipuri term (romanised)	Meaning (source)	Manual term (Clause 7.2)
pukhri	"n. pond" (Sharma, p. 117, checked on the printed page)	Pukhri (pond), see the definitions after Clause 7.2
pāt (pat)	"n. lake"; *pātpān* "lakeside"; *pātyā* "an area of land adjoining a lake" (Sharma, p. 114)	Pat (natural lake or wetland), see the definitions after Clause 7.2; in names, as Lamphelpat
pātthabi	"a swamp; slough" (Sharma, p. 114)	A marsh under Clause 7.12; optional
pātthi komthi	"a marsh; swamp" (Sharma, p. 114)	A marsh under Clause 7.12; optional
phum; phumdi	"floating thick biomass of weeds, etc. … Variant: phumdi"; *phumthi* "a mat of floating biomass" (Sharma, p. 125); "'Phumdis' means heterogeneous mixture of vegetation, organic debris and soil in floating condition" (Loktak Act, s.2)	Phumdi, as the Loktak Act defines it
athaphum	"long strip of Phumdis in circular shape in floating condition, planted or cultured artificially for catching fish" (Loktak Act, s.2(a))	Athaphum, as the Act defines it
iphut	"fountain: a natural spring of water" (Sharma, p. 22)	Spring
ikā; icāo	"n. flood" (Sharma, pp. 17 and 18); *ising icāo* "flood" (p. 25)	Flood; not a defined term

Table 7E.2 — Rivers, streams, channels and drains

Manipuri term (romanised)	Meaning (source)	Manual term (Clause 7.2)
turen; turel	"n. a river … Variant: turel" (Sharma, p. 81)	Turel (river), as in "Imphal Turel"
khong	"1) a stream. 2) mine"; *khongjāo* "a large canal or stream"; *khonglam* "a canal" (Sharma, p. 54)	Khong (stream; in this Manual a hill stream or natural stream); the second sense, "mine", is never meant
khongbān; khongbāl (khongban)	"a ditch; a drainage" (Sharma, p. 55)	Khongban (ditch, drainage): a drain or ditch, always glossed; the Manual's term is "drain"
tu	"a stream, ditch, canal, etc."; *tu-khong* "stream and the like" (Sharma, p. 80)	Optional
iram	"n. drainage. Morph: i-ram [water-path]" (Sharma, p. 23)	Drainage (the system); optional
ising khong	"a small canal or channel" (under *ising*, Sharma, p. 25)	Optional
loukhong	"irrigation canal" (Sharma, p. 182)	Paddy-field channel; a "drainage channel" of the paddy-land Act where it drains paddy land
nālā (nala)	"n. a drain; sewer" (Sharma, p. 103)	Not used alone (Table 7E.4); "nallah" and "nullah" are kept only in names, as the Naga Nullah and the Shamushang nallah

Table 7E.3 — Bunds, gates, banks and land

Manipuri term (romanised)	Meaning (source)	Use in this Manual
pan; pal	"1) a bund; embankment" (Sharma, p. 111)	Pan: a river bund (definitions after Clause 7.2)
ithong	"floodgate; sluice gate" (Sharma, p. 20)	Ithong: a sluice or floodgate, written with the English word

Manipuri term (romanised)	Meaning (source)	Use in this Manual
leirāi	"bank of a pond, lake, river" (Sharma, p. 179)	Bank; optional
torbān	"riverbank" (Sharma, p. 84)	Optional
irong	"the place where a river or stream branches off" (Sharma, p. 24)	Optional
cing (ching); cingkhong	"hill; mountain"; *cingkhong* "the foot of a mountain or hill" (Sharma, p. 67)	Hill; the foot of a hill, where a hill stream reaches the valley floor

Table 7E.4 — Terms avoided or not yet verified

These terms or senses are in use or have been proposed but were not confirmed in the dictionary during research for this Manual, or are avoided because they mislead. They shall not be used in a record or a drawing as defined terms.

Term	Reported meaning or use	Status
"lok"	Suggested as a word for a stream	**Not checked; not used**
pātcāba (patchaba)	"a lessee of fishery" (Sharma, p. 114)	**Not a waterbody; not used**
nālā (nala) alone	"a drain; sewer" (Sharma, p. 103)	**Avoided** as a defined term, because it also means a sewer; "drain" is used
loktāk	A headword (Sharma, p. 180); its definition was not captured	Used only as the name Loktak
Bengali-script forms of these terms	NEER transliterations, not taken from a dictionary	**Not printed** until checked against a Bengali-script Manipuri dictionary [TBC]
Terms in Tangkhul, Thadou-Kuki, Mao, Rongmei, Paite and the other languages of the hill areas	—	Not researched for this Manual [TBC]

The Manual uses the terms in the last column of Tables 7E.1 to 7E.3 and the Manipur terms defined after Clause 7.2.

Form 7-1 — Waterbody Sheet

Supports Clauses 7.3.2, 7.4 and 7.15(1) of Chapter 7.

Draft form — Manipur 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 Manipuri) 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): Revenue land records (district, sub-division, revenue village, patta), District Council and Village Authority records (hill areas) [TBC], inventory of about 4,000 water bodies (NGT M.A. 26/2019), SAC Wetland Atlas 2021, MSWA delineations and draft notifications, master-plan maps, Loktak Act area and zones, WRD bund, sluice and gauge records, drain register □; WRD / Gram Panchayat or, in the hill areas, 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 WRD 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 (WRD 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

No.	Field	Entry	Clause
C4	Zone 1 width, m (greatest of 15 m, floodway edge, MWL contour)	_____	7.4.3
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 statutory, plan or approval line: the buffer of bye-law 93 of the Model, where the local body has brought it into force [TBC: confirm the number and text in the bye-laws the local body has notified], measured from mid-stream or 6 m from the outer toe of the bund, whichever is further from mid-stream (on the rivers and reaches of its table only); the Core Zone or Buffer Zone of Loktak under the Manipur Loktak Lake (Protection) Act, 2006, or the High Court's bar on development in or around Loktak without its leave (as reported); a prohibited or restricted area under the Manipur Flood Plain Zoning Act, 1978 (none notified); a decision under the Manipur Conservation of Paddy Land and Wetland Act, 2014; a line or use zone ("Pond, Drain, Rivers and Canals") of a master plan; the boundary of a notified wetland (none is final); a WRD condition at a river bund; 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 — Manipur 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; WRD 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 — Manipur 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 Manipur 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 Manipur 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 — Manipur 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 Manipur, 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 Manipur 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. The Model Manipur Unified Building Bye-Laws, 2024 ask for soft cover of 10% or 15% of the plot (bye-law 66(b)) without naming any species for drainage. This annex therefore lists **no species** for Manipur, and gives no Manipuri plant names, 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 Forest, Environment and Climate Change Department for the site's sub-area of Annex 2A, its soil and its water table, under the following rules (set by this Manual):

- (a) **Native or long naturalised species only**, as the Forest, Environment and Climate Change Department 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.** On the valley floor, species that stand saturated ground and ponding through the season of 1 April to 31 October, when the water table is near the surface, and that survive the dry months of December to February without irrigation once established.
- (c) **Slopes.** In the hills and on the hill fringes and hillocks of the valley, species chosen first to bind soil on banks, cut slopes and the margins of hill streams; bioretention on a slope is lined (Clause 8.8.1).
- (d) **Not in the waterway or on the bund.** No planting in the bed or on the banks of a river, khong or city channel, or on a river bund, without the consent of its custodian (WRD, the urban local body or another body), and none that would obstruct the flow of a channel or the outlet of a pat or pukhri.
- (e) **Not in the pats or Loktak.** No planting under this annex in a pat, a pukhri, a notified or draft-notified wetland, or within the 236.21 km² of the Manipur Loktak Lake (Protection) Act, 2006, whose vegetation and phumdi are managed by their custodians 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 Manipur 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 Manipur 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 Forest, Environment and Climate Change Department lists as invasive in Manipur	—	No list of invasive species for Manipur 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

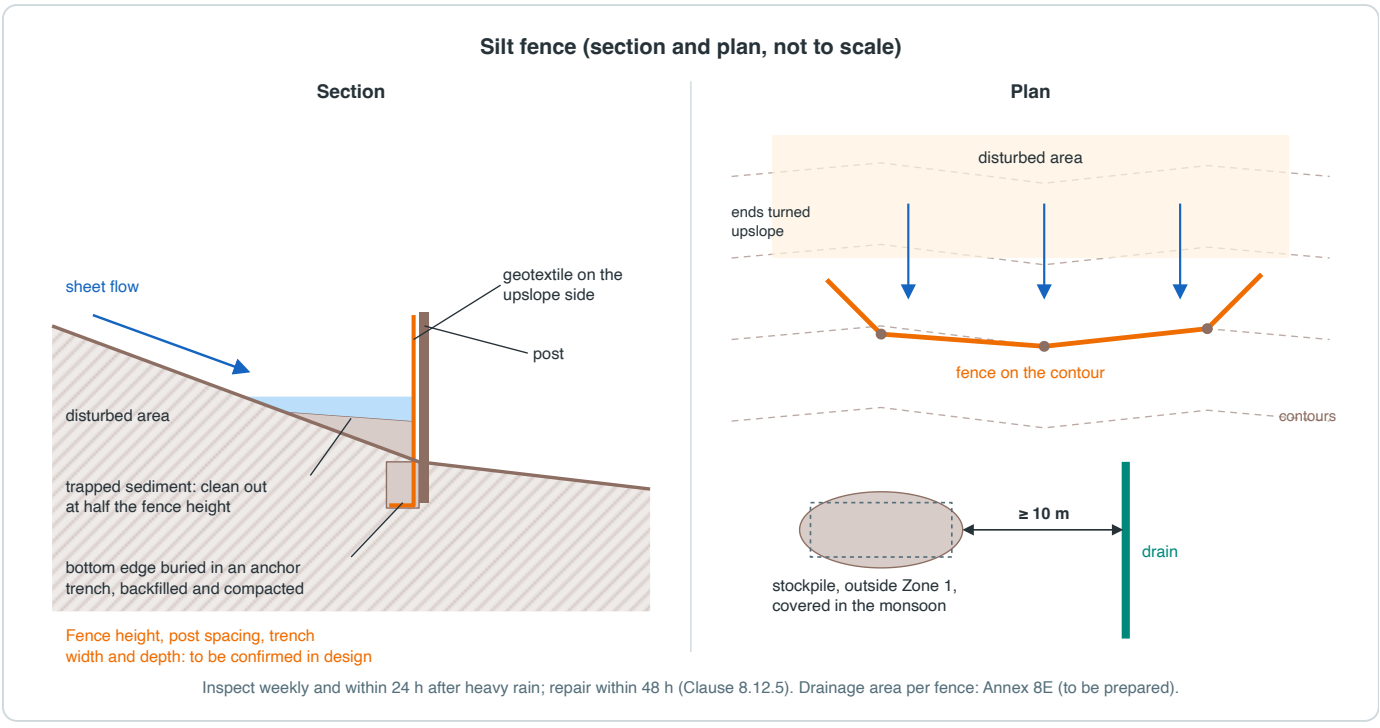


Figure 8E.1 — Silt fence: section showing geotextile on posts with the bottom edge buried in an anchor trench on the upslope side, and plan showing the fence on the contour with returns at the ends. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted 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 Manipur 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):

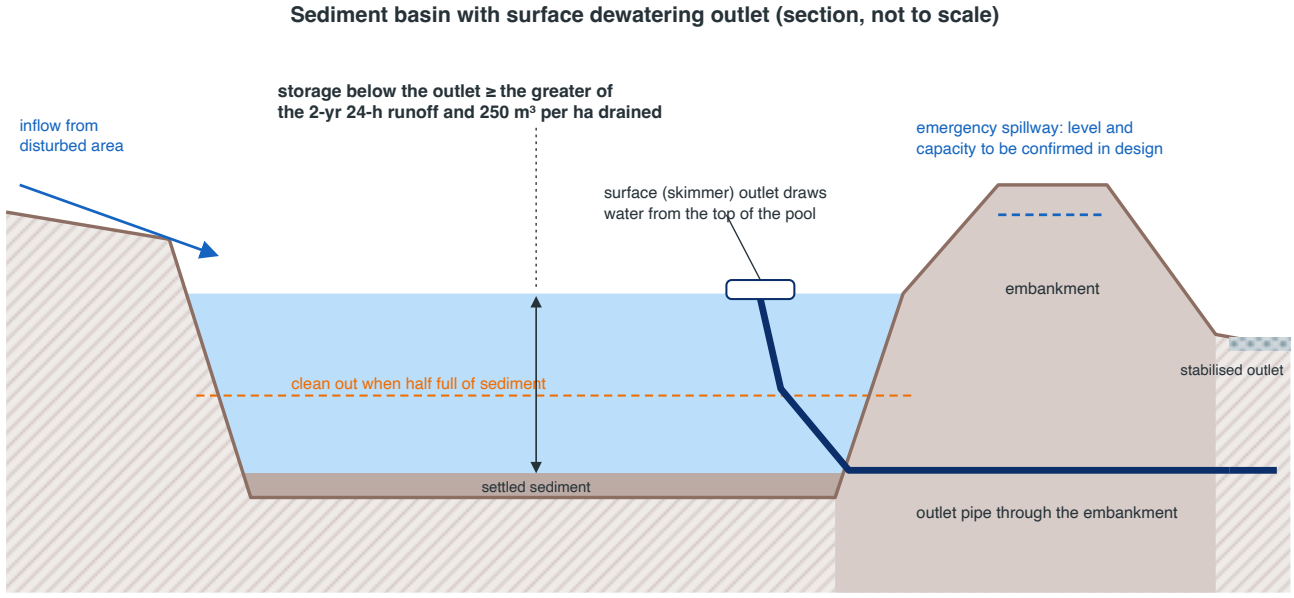
- drainage area: not more than **0.1 ha per 30 m** of fence;
- slope length above the fence: not more than 30 m on slopes under 2%, 23 m at 2–5%, 15 m at 5–10%, 8 m at 10–20% and 5 m steeper than 20%;
- wherever flow arrives concentrated, or a limit cannot be met, a sediment trap (Figure 8E.2) is used 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

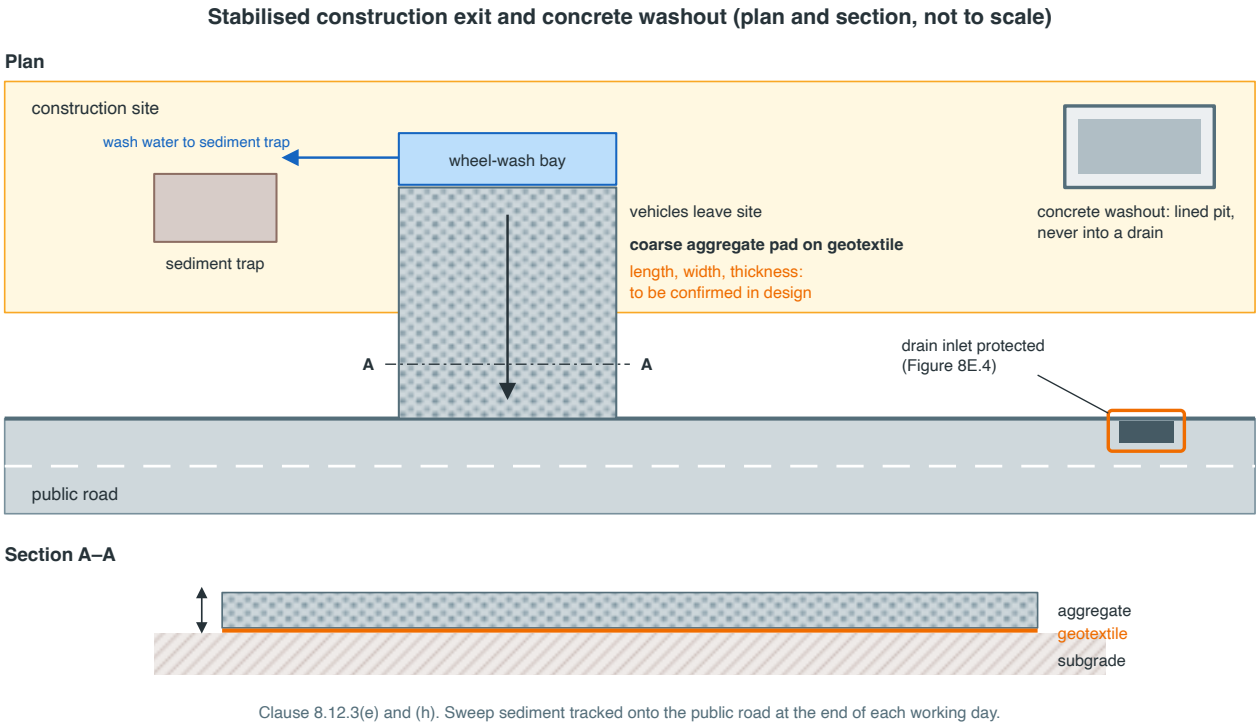


Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing 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

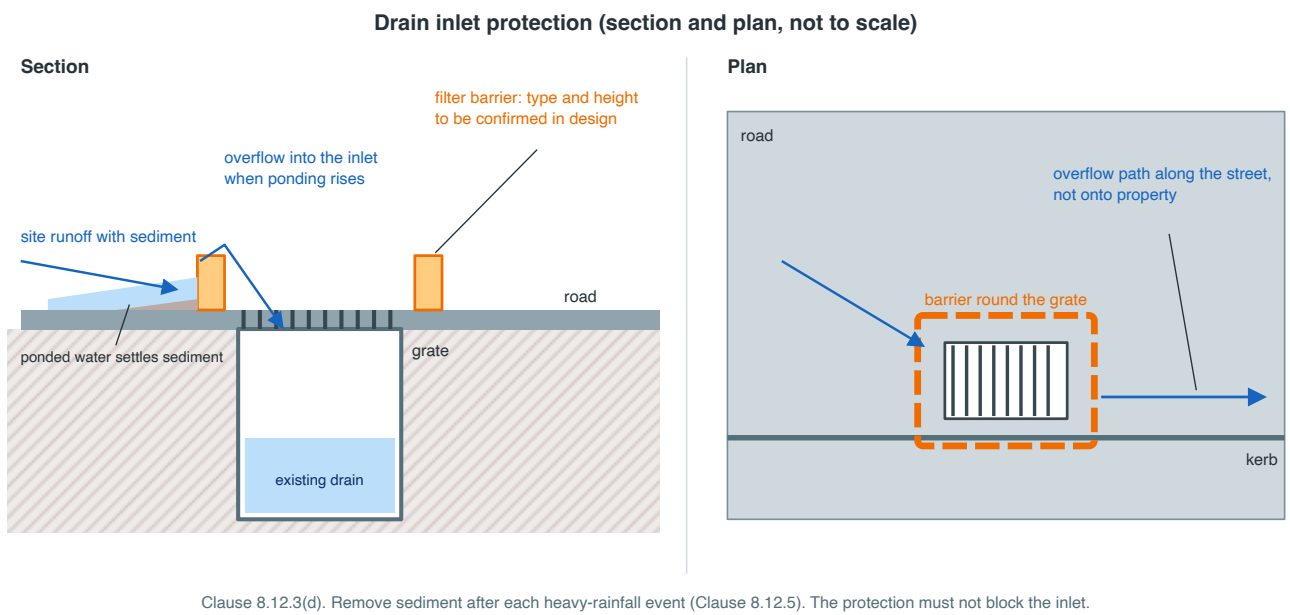


Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (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 — Manipur 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 — Manipur 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. $A = \pi \cdot 1.2^2 / 4 = 1.131$ 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. $X = 1.811 \cdot Q / (1.131 \times 1.095) = 1.462 \cdot Q$.

Table 9A.4 — Inlet-control headwater

Q (m³/s)	X	Equation	HWi/D	HWi (m)
1.80	2.631	Unsubmerged, Form 1: $0.873 + 0.0098 \times 2.631^2 - 0.5 \times 0.005 = 0.873 + 0.068 - 0.003$	0.939	1.127
2.20	3.216	Unsubmerged, Form 1: $0.987 + 0.0098 \times 3.216^2 - 0.003 = 0.987 + 0.101 - 0.003$	1.085	1.302
3.00	4.385	Submerged: $0.0398 \times 4.385^2 + 0.67 - 0.003 = 0.765 + 0.67 - 0.003$	1.433	1.719

Step 4 — Headwater under outlet control (Clause 9.4.3). The friction term is $19.63 \cdot n^2 \cdot L / R^{1.33} = 19.63 \times 0.015^2 \times 20.0 / 0.300^{1.33} = 0.0883 / 0.2016 = 0.438$, so $H = (1 + 0.5 + 0.438) \cdot V^2/2g = 1.938 \cdot V^2/2g$. $L \cdot S = 20.0 \times 0.005 = 0.100$ 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.

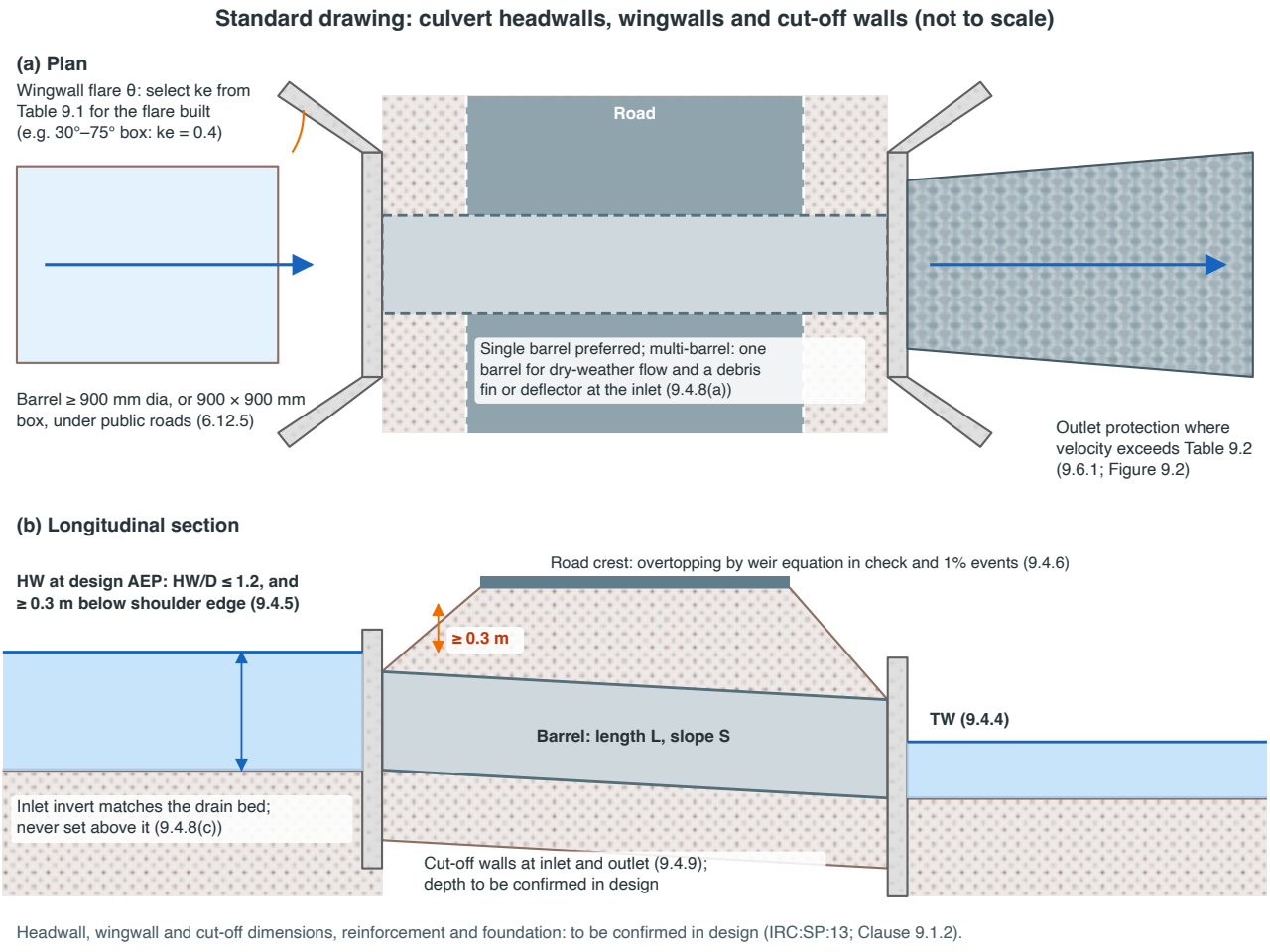


Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

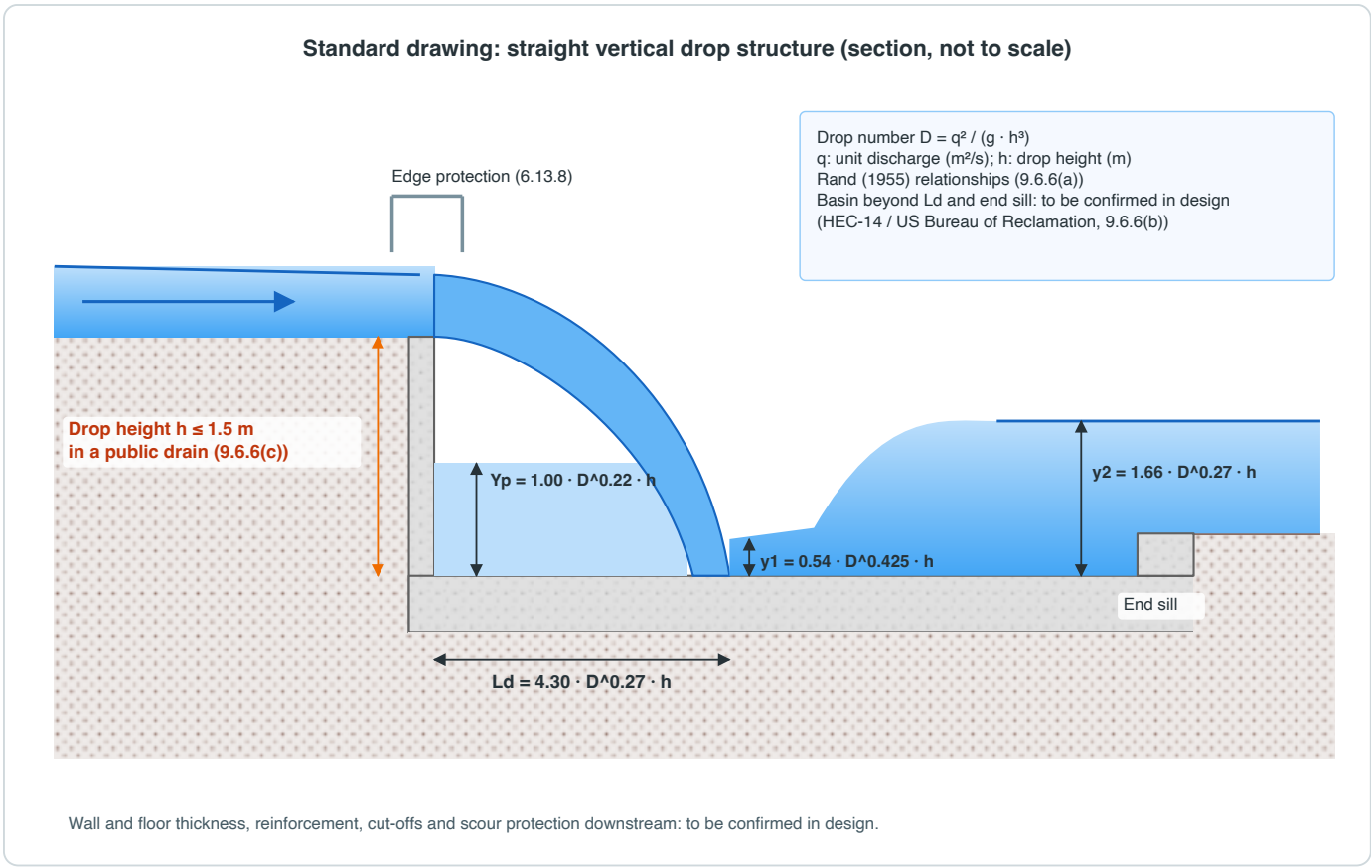


Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).

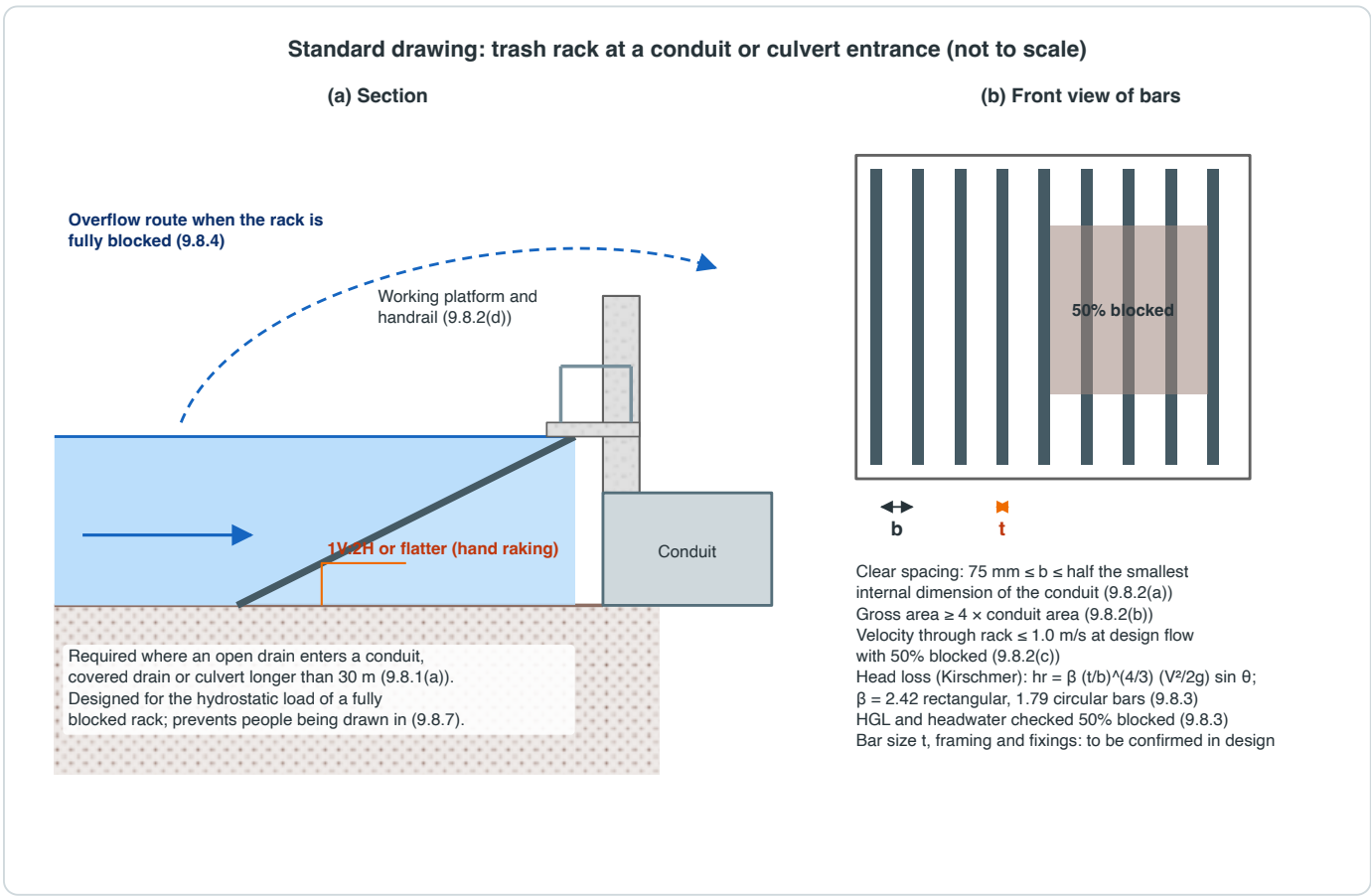


Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm Water Drainage Systems (2019), §8.3.1.3.

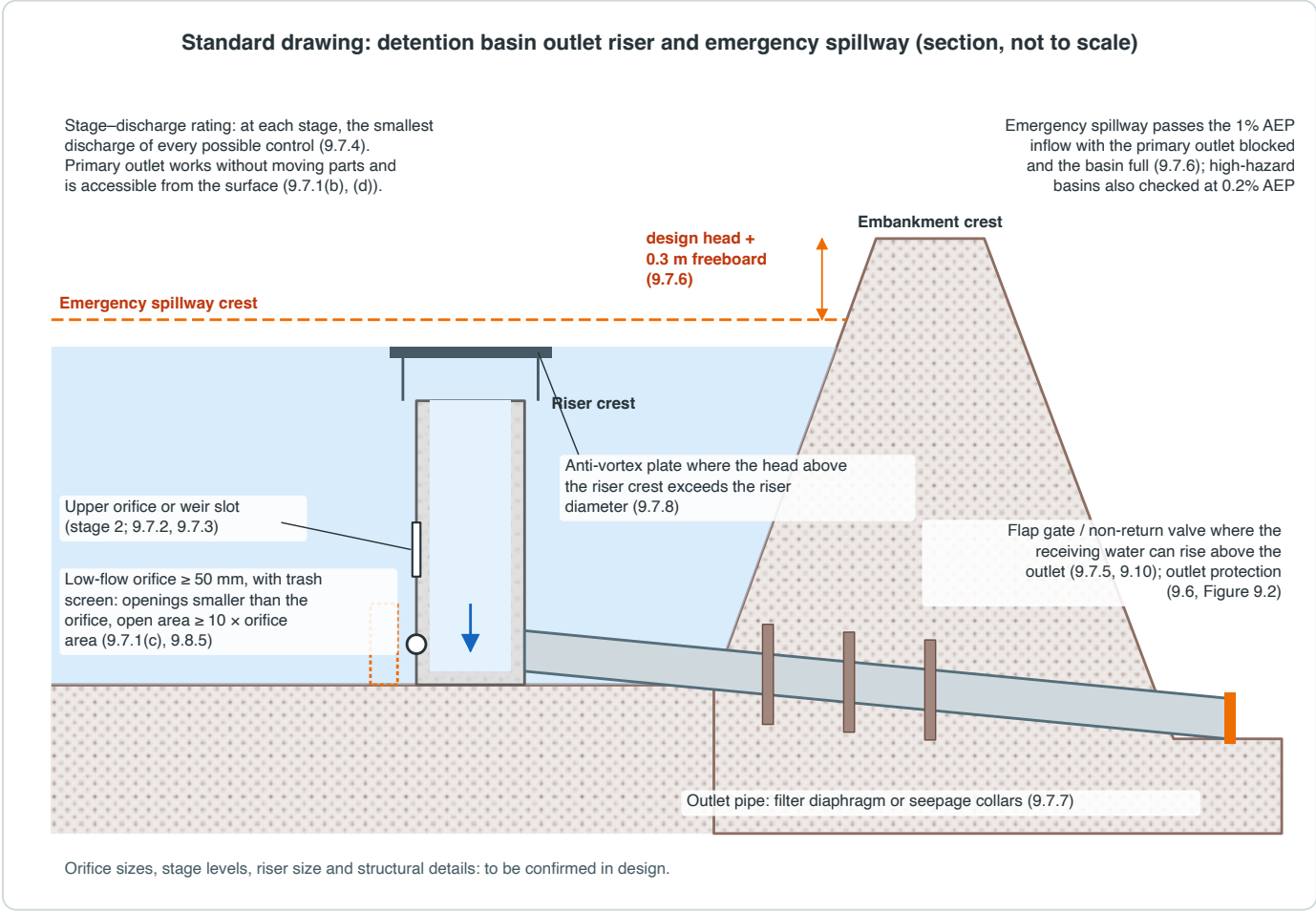


Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).

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 — Manipur 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 — Manipur 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 bye-law 66(a) of the Model [TBC: confirm the number and text in the bye-laws the local body has notified] to all existing and new buildings on plots of 100 m² and above, whose plans show the storm-water drainage and the points of collection of rain water, as storage of at least 25 litres per m² of roof (Clause 4.11, set by this Manual, since the Model sets no volume), credited as retention only through reuse; on the Imphal valley floor, the Loktak margin, land behind a river bund and the Jiribam flood plain the storage is a "surface reservoir" of bye-law 66(a), never a recharge well, and the excess grey water that bye-law 67 sends to recharge structures goes to storage or a sewer instead, with the local body's relaxation (Clause 4.11, valley-floor rule); on natural ground sloping more than 10°, on Disang shale at any slope, on colluvium, fill or slide debris, or within twice the height of a cut slope or retaining wall upslope of it, nothing is infiltrated without a geotechnical certificate (Clause 4.11, hill rule); recharge is credited only on tested ground under Clause 4.11 (recharge rule), which is on the foothill fans, the Barail sandstone cappings on slopes of 10° or less, and tested sand lenses on the valley floor.	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
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

Step	Calculation	Clause
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), which covers the whole State, 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 WRD gauges on the valley rivers and at the Ithai barrage (levels published in the press in metres, presumed above mean sea level, the datum not stated [TBC]), of the CWC level-monitoring site on the Barak at Chotebekra, of the Loktak levels of NHPC and CEA, of the reservoir levels of the Thoubal (Mapithel) dam, of WRD's bund crests, gate sills and gate-closing levels, and of the flood marks surveyed on ungauged rivers, khongs, pats and pukhris 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 `IMC-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	—
OWNER_TYP	T	—	Yes	PRIVATE / ASSOC / DEVELOPER / ULB / DEPT	Clauses 10.10, 10.14

Field	Type	Unit	Req.	Content	Source
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
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

Field	Type	Unit	Req.	Content	Source
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 WRD gauges on the valley rivers and at the Ithai barrage (levels published in the press in metres, presumed above mean sea level, the datum not stated [TBC]), of the CWC level-monitoring site on the Barak at Chotebekra, of the Loktak levels of NHPC and CEA, of the reservoir levels of the Thoubal (Mapithel) dam, of WRD's bund crests, gate sills and gate-closing levels, and of the flood marks surveyed on ungauged rivers, khongs, pats and pukhris (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
APPROVED	Stage 2 approved; not yet built

Code	Meaning
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 Manipur 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 Manipuri 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 TPD. 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 Model Manipur Unified Building Bye-Laws 2024 (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 — Manipur 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 WRD gauges on the valley rivers and at the Ithai barrage (levels published in the press in metres, presumed above mean sea level, the datum not stated [TBC]), of the CWC level-monitoring site on the Barak at Chotebekra, of the Loktak levels of NHPC and CEA, of the reservoir levels of the Thoubal (Mapithel) dam, of WRD's bund crests, gate sills and gate-closing levels, and of the flood marks surveyed on ungauged rivers, khongs, pats and pukhris	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 — Manipur 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 — Manipur 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, Unified Bye-Laws 2024 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 Manipur 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 — Manipur 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 — Manipur 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 — Manipur 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, sub-division, 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 — Manipur 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 — Manipur 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 Manipur 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, pukhri 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, PDA Manipur or TPD, MSDMA] (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, khong or pat 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, pukhri, 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, khongs, pats, pukhris, Loktak and reservoirs: outfall invert levels, on a named datum, against the warning, flood and high flood levels of the receiving river at the nearest WRD gauge, with every conflict between published values stated and WRD's gauge register obtained; Loktak's full reservoir and minimum drawdown levels, naming which value is used; the Barak at the CWC site at Chotebekra; the levels, spillways and release records of the Thoubal (Mapithel), Khuga and Singda dams; the sills, gate-closing levels and bund crests of the gates in the river bunds and the capacities and operating rules of the pumping stations; pats and pukhris at their surveyed outlet levels; for ungauged khongs and hill streams, surveyed flood marks and the 1% AEP level with its sediment, debris and garbage; the breach paths of the bunds; and the landslide and debris hazards above the basin;
- (f) rainfall and water levels: all available records (IMD, including Imphal (Tulihal) (A), 42623, the only Manipur station in IMD's *Extremes* (rainfall data 1953–2012), and the gauges behind the district warnings of the Meteorological Centre Imphal (list not read [TBC]); the river gauges of WRD and the rain gauge at Kangpokpi that its flood rule uses (as reported); the gauges at Kangpokpi, Saikul and Litan used by MASTEC (owners and record lengths [TBC]); the CWC level-monitoring site on the Barak at Chotebekra; the Loktak levels of NHPC and CEA; the IMD stations on the Barak plain downstream that Clause 2.3.6(c)(ii) uses for the Jiribam plain; and any gauges or sensors kept by IMC, Imphal Smart City Ltd, LDA, MSDMA or the flood management system proposed for Lamphelpat [TBC]), including the 28–31 May 2024 (Cyclone Remal: the Imphal at Minuthong above its high flood level of 788.400 m and at Lilong at 782.250 m, and the Manipur river at Ithai at 768.640 m, on 29 May; 18 embankment breaches; 1,88,143 people and 24,265 houses affected by the Minister's count of 30 May, or 1,26,950 people, 255 localities and 16,364 houses by the Relief and Disaster Management Department's report of 31 May, all as reported; no IMD rainfall for the event was found), 30 May–June 2025 (breaches of the Imphal at Singjamei, Heingang, Bashikhong and New Checkon and of the Nambul at four places after 123 mm in 24 hours and 175 mm in 72 hours at Kangpokpi on 30–31 May, as reported; no IMD rainfall for Imphal was found), September 2025 (the Imphal at Lilong at 783.250 m and the Manipur river at Ithai at 770.05 m on 15 September, both above their printed high flood levels, and a breach of the Iril at Kshetri Awang Leikai, as reported; no rainfall value was found), late July–August 2015 (rain 46% above normal in Imphal West on 23–27 July, the Mapithel

reservoir at 876 m on 1 August and about 5 lakh people displaced by 3 August by a State revenue estimate, as reported; no gauge value was found) and July–August 1989 (158.6 mm at Imphal (Tulihal) on 30 July, the station's 24-hour record, after daily rain from 28 July to 1 August, with 461.9 mm at Imphal and 617.6 mm at Kangpokpi in the month, 40 breaches and 361 localities flooded, IMD and MASTEC) 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 28–31 May 2024 (Cyclone Remal: the Imphal at Minuthong above its high flood level of 788.400 m and at Lilong at 782.250 m, and the Manipur river at Ithai at 768.640 m, on 29 May; 18 embankment breaches; 1,88,143 people and 24,265 houses affected by the Minister's count of 30 May, or 1,26,950 people, 255 localities and 16,364 houses by the Relief and Disaster Management Department's report of 31 May, all as reported; no IMD rainfall for the event was found), 30 May–June 2025 (breaches of the Imphal at Singjamei, Heingang, Bashikhong and New Checkon and of the Nambul at four places after 123 mm in 24 hours and 175 mm in 72 hours at Kangpokpi on 30–31 May, as reported; no IMD rainfall for Imphal was found), September 2025 (the Imphal at Lilong at 783.250 m and the Manipur river at Ithai at 770.05 m on 15 September, both above their printed high flood levels, and a breach of the Iril at Kshetri Awang Leikai, as reported; no rainfall value was found), late July–August 2015 (rain 46% above normal in Imphal West on 23–27 July, the Mapithel reservoir at 876 m on 1 August and about 5 lakh people displaced by 3 August by a State revenue estimate, as reported; no gauge value was found) and July–August 1989 (158.6 mm at Imphal (Tulihal) on 30 July, the station's 24-hour record, after daily rain from 28 July to 1 August, with 461.9 mm at Imphal and 617.6 mm at Kangpokpi in the month, 40 breaches and 361 localities flooded, IMD and MASTEC) 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 clay and peat of the valley floor, on which no infiltration is allowed (Clause 4.11, valley-floor rule), and the water table 2 to 5 m below ground in most of Imphal West (CGWB, 2013), which makes buoyancy and inflow a hazard to sumps, tanks and basements, the Disang shale of the hills, which has "less infiltration and more run off" (MASTEC) and slides when cut and wet, as at

Tupul in 2022, recharge on the tested foothill fans, Barail sandstone cappings and sand lenses, the only ground where it is allowed (Clause 4.11, recharge rule), although every assessment unit in the State is safe (stage of extraction 8.00%, GWRA 2024, as quoted from CGWB), and the quality of the rivers, pats and Loktak that the runoff reaches, the Imphal, the Nambul and the Iril among them, from which Imphal draws about 90% of its drinking water; effect on downstream basins and the receiving river, khong or pat; 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, the Loktak margin and the slide-prone slopes after any large flood or landslide, the drain network of every drain-owning body (IMC and the other urban local bodies, PWD and the national-highway agencies, WRD, DoECC, PHED, LDA and Imphal Smart City Ltd), a drain register giving every reach its owner, the river it reaches, the bund it crosses with its gate or flap gate, whether it lies in a river buffer of the bye-laws, its land status (patta or government land) and its outfall, the river bunds of WRD with their crests, gates, sills and breach records, the gauge register of WRD with the datum of every level, the pumping stations with their capacities and operating rules, among them the Lamphelpat pumps on the Shamushang channel, the levels of Loktak and the operating rule of the Ithai barrage from NHPC, the levels, spillways and release rules of the Thoubal (Mapithel), Khuga and Singda dams, the pats and pukhris with their outlet levels and stage–storage, the paddy land and wetland of the valley floor, and the landslide hazards of the Disang shale slopes mapped by MSDMA and NRSC (other likely sources: Survey of India, CWC, CGWB, MASTEC, TPD's GIS master-plan maps and the Revenue Department's land records). No basin map of any Manipur town was found. The NAME_MNI field of Table 11B.2 holds each basin's name in Manipuri, written in Meetei Mayek; while the concurrent use of the Bengali script allowed by the Manipur Official Language (Amendment) Act, 2021 continues, a Bengali-script form may be added in a note. Until the annex is published, the basins of the Nambul, the Imphal river through the city, Lamphelpat, the Kongba and the Iril, Thoubal below the Mapithel dam, the Loktak margin, Nambol and Bishnupur, Kakching and Wangjing, Jiribam and the hill towns on landslide ground 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); in the hills, at the breach paths of the bunds and in the dam-release reaches 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
Greater Imphal planning area (IMC, PDA Manipur, TPD)	Catchment of the Nambul through Greater Imphal, with the Naga Nullah, the Waisel Maril and the 72 drains that fall into it	Gates closed; Thong Nambonbi (Hump Bridge) high flood level 783.695 m (WRD, as reported) as boundary; breaches of 2025 and Naga Nullah flooding of 2024 as evidence
Greater Imphal planning area (as above)	Catchments draining to the Imphal river through the city	Minuthong and Lilong WRD levels as boundary, with the conflicts stated; breach paths of 2024 and 2025 mapped
Greater Imphal planning area (as above; WRD)	Lamphelpat basin, with its pumped outlet through the Shamushang channel to the Nambul	Pat full to its outlet at the start of the storm; pump capacity from WRD [TBC]
Greater Imphal planning area (as above)	Corridors of the Kongba and the Iril in Imphal East	Irilbung WRD levels as boundary; 2025 breach as evidence
Thoubal (urban local body)	Catchments of Thoubal on the Thoubal below the Mapithel dam	WRD levels and the dam's largest recorded release or spillway capacity as boundary
Moirang, Ningthoukhong, Thanga, Ithai–Sugnu–Wangoo	Catchments draining to Loktak, its pats and the Manipur river between Ithai and Sugnu	Ithai high flood level 769.320 m, checked at 770.05 m; outfalls below the design lake level closed 1 June–30 September; Chakpi backwater
Nambol and Bishnupur	Catchments draining to the Nambol and the lower Nambul	Nambol Thongkhong WRD level as boundary, with the conflict stated

Tier A body or area	Basin	Note from Chapter 11
Kakching and Wangjing	Catchments draining to the Sekmai and the Wangjing	Surveyed flood marks as boundary until a WRD level is obtained
Jiribam (Municipal Council)	Catchments draining to the Barak and the Jiri	Chotebekra high flood level 32.1 m (CWC, as reported); lock not less than 7 days
Noney, Tamenglong, Chandel and Kangpokpi	Catchments of the hill towns on landslide ground	Hazard screening first; site-specific hydrology
Other Tier A bodies and urban local bodies	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_MNI	Text	Basin name in English and Manipuri
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 Manipur 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 Manipur 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 28–31 May 2024 (Cyclone Remal: the Imphal at Minuthong above its high flood level of 788.400 m and at Lilong at 782.250 m, and the Manipur river at Ithai at 768.640 m, on 29 May; 18 embankment breaches; 1,88,143 people and 24,265 houses affected by the Minister's count of 30 May, or 1,26,950 people, 255 localities and 16,364 houses by the Relief and Disaster Management Department's report of 31 May, all as reported; no IMD rainfall for the event was found), 30 May–June 2025 (breaches of the Imphal at Singjamei, Heingang, Bashikhong and New Checkon and of the Nambul at four places after 123 mm in 24 hours and 175 mm in 72 hours at Kangpokpi on 30–31 May, as reported; no IMD rainfall for Imphal was found), September 2025 (the Imphal at Lilong at 783.250 m and the Manipur river at Ithai at 770.05 m on 15 September, both above their printed high flood levels, and a breach of the Iril at Kshetri Awang Leikai, as reported; no rainfall value was found), late July–August 2015 (rain 46% above normal in Imphal West on 23–27 July, the Mapithel reservoir at 876 m on 1 August and about 5 lakh people displaced by 3 August by a State revenue estimate, as reported; no gauge value was found) and July–August 1989 (158.6 mm at Imphal (Tulihal) on 30 July, the station's 24-hour record, after daily rain from 28 July to 1 August, with 461.9 mm at Imphal and 617.6 mm at Kangpokpi in the month, 40 breaches and 361 localities flooded, IMD and MASTEC) floods (Revenue Department and MSDMA 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 ≈ Σ ½ × (D_i + D_(i+1)) × (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, lake, pat, pukhri and reservoir levels, bund gates and pumping stations, 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 WRD gauges on the valley rivers and at the Ithai barrage (levels published in the press in metres, presumed above mean sea level, the datum not stated [TBC]), of the CWC level-monitoring site on the Barak at Chotebekra, of the Loktak levels of NHPC and CEA, of the reservoir levels of the Thoubal (Mapithel) dam, of WRD's bund crests, gate sills and gate-closing levels, and of the flood marks surveyed on ungauged rivers, khongs, pats and pukhris 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 `nambul_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 — Manipur 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 pukhri 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	_____