HIMACHAL PRADESH

Stormwater Design Manual

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

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Prepared by

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About this draft

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

Not adopted. This Manual has not been adopted, notified or endorsed by the Government of Himachal Pradesh or by any of its departments, local bodies or agencies. In particular, it has not been adopted, notified or endorsed by the Town and Country Planning Department (TCP), the Urban Development Department (UDD), Jal Shakti Vibhag, the Shimla Municipal Corporation (SMC) or any other Municipal Corporation, Nagar Parishad, Nagar Panchayat or other local body, any Special Area Development Authority (SADA), the Baddi Barotiwala Nalagarh Development Authority (BBNDA), the Himachal Pradesh Housing and Urban Development Authority (HIMUDA), or any other agency. Where it names a body, such as the Revenue Department, the Public Works Department (PWD), Shimla Jal Prabandhan Nigam Limited (SJPNL), the Himachal Pradesh State Industrial Development Corporation (HPSIDC), the Himachal Pradesh State Pollution Control Board (HPSPCB), the Himachal Pradesh Council for Science, Technology and Environment (HIMCOSTE), the Himachal Pradesh State Wetlands Authority (HPSWA), the State Centre on Climate Change, the Himachal Pradesh Ground Water Authority, the Himachal Pradesh State Disaster Management Authority (HPSDMA), a Deputy Commissioner or a district administration, a dam operator such as the Bhakra Beas Management Board (BBMB), NTPC, SJVN, NHPC or the Himachal Pradesh State Electricity Board Limited (HPSEBL), a Smart City company, or a body of the Union, such as the Central Water Commission (CWC), the Central Ground Water Board (CGWB), the India Meteorological Department (IMD), the National Highways Authority of India (NHAI) or the Central Pollution Control Board (CPCB), it describes the role that body would have if the Manual were adopted. It does not say the body has agreed to that role.

No legal force. Until a competent authority adopts it, with or without changes, this Manual has no legal force. The Himachal Pradesh Town and Country Planning Act, 1977 and the Himachal Pradesh Town and Country Planning Rules, 2014 as amended, the Interim Development Plans and Development Plans and their regulations, including the Shimla Development Plan, the Himachal Pradesh Ground Water Act, 2005, the Himachal Pradesh Minor Canals Act, 1976, the Municipal Acts, drainage schemes, orders of courts and tribunals and approval conditions in force continue to apply.

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

- Himachal Pradesh reached its present extent in 1966, when Kangra, Kullu, Lahaul and Spiti, the Shimla hill areas and the areas of Una and Nalagarh were transferred to it from Punjab, and became a State in 1971. Older records of those areas may be filed under **Punjab**. The district map has also changed: Kangra district included today's Hamirpur and Una until 1972, and the CWC flood estimation report for zone 7 (1994) still lists a district of **Mahasu**, whose area is now in Shimla and Kinnaur districts. IMD and CWC sources, and the rainfall data in this Manual, use the districts of their time, and a clause that names a district must be checked against the current list;
- **Shimla** is Simla in older sources; **Dharamshala** is written **Dharmsala**, Dharmshala or Dharamsala on IMD's stations and in many sources, and IMD's airport station near it, at Gaggal, is **Kangra Aero**; **Keylong** is also written **Kyelang**; **Kullu** is Kulu, **Lahaul** Lahul, **Sirmaur** Sirmur or Sirmour, **Nalagarh** Nallagarh, **Indora** Indaura and **Renuka** Renukaji, and the CWC report prints Renuka's gauge as Rainka. The **Sutlej** is also the Satluj; the **Swan** of Una is also the Soan; the **Ashwani Khad** of Shimla is also the Ashwini Khad; the reservoir of the Bhakra dam on the Sutlej is **Gobind Sagar**, written Govind Sagar in the High Court's orders; and the reservoir of the Pong dam on the Beas is **Pong Dam Lake**, its name as a Ramsar site, also called **Maharana Pratap Sagar** and the Pong reservoir;

- **Rampur** in this Manual is Rampur Bushahr, the town on the Sutlej in Shimla district, with a CWC gauge; **Una Rampur** is the IMD automatic weather station at Rampur in Una district, which recorded 228.5 mm on 9 July 2023, and is a different place. **Dharampur** is the self-recording raingauge in Solan district on the road below Kasauli, which recorded 100 mm in one hour on 9 August 1985; it is not the town of that name in Mandi district. **Barauli** is a raingauge of Shimla district, not of the town; and **Samej**, where a flash flood came down the Samej Khad on 31 July 2024, lies near Rampur. This Manual names the station each figure comes from;
- CWC's **zone 7** ("Western Himalayas", report No. WH/22/1994) is the hydrometeorological region of the CWC flood estimation reports that covers the whole State. Its boundary with **subzone 1(e)** ("Upper Indo-Ganga Plains", 1984) runs along the Siwalik front just outside the State: Una, Nalagarh, Baddi, Parwanoo, Nahan and Paonta Sahib all lie on the zone 7 side, about 5–15 km inside it, and no town of the State is in 1(e). Three of the six gauged catchments on which the zone 7 report rests drain the State: the Neogal Khad and the Banu Khad in Kangra, and the Chakki Khad, which drains the Kangra and Chamba hills and is gauged at Pathankot in Punjab; the Sewa catchment, another of the six, is in Jammu & Kashmir. Zone 7 is not one of the three rainfall zones (HP-Z1 to HP-Z3) and five hydrologic sub-areas (HP-A, HP-B, HP-B1, HP-B2 and HP-C) that this Manual sets in Annex 2A, nor Zones 1 and 2 of a waterbody setback in Chapter 7, nor the sinking and sliding zones of the development plans;
- where a shared clause names the State's main city or its municipal corporation, this Manual names **Shimla**, the State capital, and the **Shimla Municipal Corporation (SMC)**, written MC Shimla in many sources. The State has no metropolitan development authority: the Shimla Planning Area, and every other planning area, is planned by **TCP**. **SADAs** are Special Area Development Authorities under the Town and Country Planning Act; **BBNDA** is the Baddi Barotiwala Nalagarh Development Authority for the industrial belt of Solan district; and **HIMUDA** builds and approves housing colonies;
- the State has five belts, broadly from south-west to north-east. The **Siwalik foothills and outer valleys**, low hills of sandstone, shale and conglomerate, with the valleys of Una (the Swan), Nalagarh (the Sirsa) and Paonta–Kala Amb, whose deep fills of boulder, gravel and sand are the State's main aquifers and recharge zones; the **mid-hills** of the Lesser Himalaya, of schist, phyllite and slate under a thick debris cover, on which Shimla, Solan, Mandi and Chamba are built, with the **Balh valley** near Mandi, a flat valley of alluvium where the water table lies within 0.3–7 m of the ground; the **Dhauladhar front** above Dharamshala, Kangra and Palampur, the wettest part of the State, where the monsoon meets the first high range; the **Kullu–Manali inner valley** of the Beas; and the **high and trans-Himalaya** of Kinnaur, Lahaul and Spiti, of crystalline rock, moraine and alpine soils, fed by snow and glaciers. The names describe regions, not administrative units, except where a district bears the same name;
- the hills have their own names for water, from the Pahari dialects and Hindi. A **tal** (ताल) is a pond, lake or tank, and this Manual uses it as its general term for lakes and ponds; the word also means rhythm. A **khad** (खड्ड) is a seasonal hill torrent or ravine stream, written **khud** in the TCP Rules; in Hindi dictionaries the word means a pit or hollow, and the stream sense is recorded only in the Pahari dictionary, so this Manual always glosses it. A **nallah** (नाला; also *nala*, written **nullah** in the TCP Rules) is a natural drainage channel or a large storm drain, and a **nali** (नाली) a small street drain; in the Pahari dictionary *nala* can also mean a spring or a waterfall. A **kuhl** (कूहल; also *kuhal*) is a gravity irrigation channel led along the contour from a khad, especially in Kangra, and kuhls are "canals" under the Minor Canals Act. A **baoli** (बावड़ी; also *bauri*, *bawdi* and *bawri*, as in Shiv Bawri at Shimla) is in the hills a small stone-built tank fed by a spring, not the stepwell of the plains; a **naun** (नौण) is a spring-fed stone tank or water source; and a **panihar** (पनिहार) is the water place of a village, though in Hindi the word means a water carrier. A **dhar** (धार) is a ridge or crest, though Hindi readers take it as a stream; a **chashma** (चश्मा) is a spring; a **choe** is a seasonal torrent of the Siwalik, as the streams south of Pong are locally called; and a **gharat** (घराट) is a water mill on a khad. The TCP Rules' forms ask a site plan to show "Existing water bodies like Bauri, Well, Nallah, khud"; and
- many levels and flows in the sources are not in metric or not on a stated datum. BBMB publishes the levels of its reservoirs in **feet** (1 ft = 0.3048 m): the full reservoir level of Pong is 1,390 ft (about 423.67 m), and its maximum level is given as 1,400 ft, 1,410 ft and 1,421 ft in different sources; that of Bhakra is 1,680 ft (about 512.06 m). Flows at dams are given in **cusecs** (cubic feet a second; 1 cusec = 0.0283 m³/s), often in **lakh** (100,000): the inflow to Pong on 14 August 2023 was reported as 7.3 lakh cusecs

(about 20,670 m³/s) and as 5.13 lakh cusecs. CWC's levels for its sites in the State were read only in transcriptions by SANDRP, which give two highest flood levels for the Sutlej at Pandoa, 740.6 m (2005) and 689.6 m (2022), and say the first is incorrect. No source read states the datum of these levels, and they are quoted as reported [TBC].

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 **Himachal Pradesh Town and Country Planning Act, 1977** is the State's planning law, and the **Himachal Pradesh Town and Country Planning Rules, 2014** (the **TCP Rules 2014**), made under it, are its building rules. The Rules were read in TCP's consolidation to 2022, which includes the amendments of 2016 to 2022, and in the live text of Appendix-1 as it stood in June 2025; the later amendments, including a Twelfth Amendment (2024) and a draft Sixteenth Amendment (2025) published for objections, are known only from the press and were not read [TBC]. **Appendix-1** of the Rules is the general regulation only for areas where land use is frozen and no Interim Development Plan or Development Plan has been prepared; in a planning area with such a plan, the plan's own regulations govern. Shimla was planned for 44 years under an **Interim Development Plan** of 1979; its **Development Plan** was published on 20 June 2023, the date the Supreme Court gives, and reported as notified on 23 June 2023, and its text was read only as the Supreme Court quotes it [TBC]. The Act operates in the 54 urban local bodies and about 102 other notified areas, covering 21.70% of the State's people but less than 10% of its area, as the post-disaster needs assessment of 2023 records; outside them, building in villages was to follow model bye-laws for rural construction that the Cabinet approved in September 2025, as reported, whose text was not found;
- a **Municipal Corporation** is constituted under the Himachal Pradesh Municipal Corporation Act, 1994, and a **Nagar Parishad** (Municipal Council) or **Nagar Panchayat** under the Himachal Pradesh Municipal Act, 1994. Their chapters on drains were not read for this Manual [TBC]. All three are urban local bodies (ULBs) under **UDD**. The CAG counted 54 ULBs in March 2020; the Municipal Corporations are taken to include Shimla, Dharamshala, Mandi, Solan and Palampur, and the current list was not confirmed [TBC]. In the sources "MC" stands for a Municipal Corporation (MC Shimla) and also for a Municipal Council (MC Parwanoo); this Manual writes the names in full;
- **Jal Shakti Vibhag**, formerly the Irrigation and Public Health (IPH) Department, renamed in the Ground Water Act by an amendment of 2022, supplies water, runs the sewers and treatment plants of the towns other than Shimla and Solan, builds flood protection and the channelisation of rivers, such as that of the Swan in Una, and is named in this Manual as the State groundwater agency, under the Ground Water Act, 2005. **SJPNL** supplies water to Shimla and runs its sewers; the CAG found in 2022 that SMC has "limited control" over it. The **PWD** keeps the State's roads and their roadside and hill-road drains and culverts, and **NHAI** the national highways, whose four-laning has dumped muck into khads, as the High Court has recorded. **HPSIDC** plans the State's industrial areas;
- **HPSDMA** is the State's disaster management authority, and published the reports of the technical committees on the events of 2023. **HIMCOSTE** coordinated the State technical committee on the landslides of Shimla in 2023, and is the secretariat of **HPSWA**, the State Wetlands Authority, constituted by notification of 7 November 2017; the State Centre on Climate Change keeps the inventories of glacial lakes and landslides. No wetland notified under Rule 4 of the Wetlands (Conservation and Management) Rules, 2017 was found;
- **BBMB** operates the Bhakra dam on the Sutlej, the Pong dam on the Beas and the Pandoh dam, which diverts the Beas to the Sutlej. Other dams are operated by NTPC (Kol, on the Sutlej), SJVN (Nathpa Jhakri), NHPC (Chamera on the Ravi; Parbati), HPSEBL (Larji, on the Beas) and private companies (Karcham Wangtoo); the needs assessment of 2023 counts 135 dams in the State;
- the **Himachal Pradesh Minor Canals Act, 1976** makes the kuhls of the Government and the larger private kuhls statutory canals, and lets the Government regulate the flow in any "line of natural drainage" and remove obstructions; it is the only law of the State found that names lines of natural drainage;
- the **National Green Tribunal** (NGT) gave 29 directions for Shimla on 16 November 2017, including a slope limit and a direction that runoff from concretised areas be kept from the overburden and the slopes; the **Supreme Court** set all of them aside on 11 January 2024. This Manual cites them, and the findings of the

NGT's Expert Committee, as expert guidance only, never as binding; and
- a **tehsil** is the revenue subdivision of a district, under a Tahsildar. A district is headed by a **Deputy Commissioner** (DC), who is also the Collector.

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;
- SMC is the Shimla Municipal Corporation. DC is the Deputy Commissioner; DP is a Development Plan and IDP an Interim Development Plan under the Town and Country Planning Act; disaster management is written in full;
- TCP is the Town and Country Planning Department; its Act and Rules are written "the Town and Country Planning Act" and "the TCP Rules 2014";
- HFL is the highest flood level recorded at a gauge, as CWC uses it. It is not a design level, and sources sometimes give different values for the same gauge. The TCP Rules use the same words for the line from which a development plan measures distances along rivers, khads and nallahs. WL and DL are CWC's warning and danger levels, which only one site in the State, the Yamuna at Paonta, has;
- FRL (full reservoir level) and MWL (maximum water level) are used for reservoirs, and BBMB gives them in feet; and
- SWD is a storm water drain.

The sense is clear from the context. Hindi and Pahari terms used in the text, such as *tal*, *khad*, *nallah*, *nali*, *kuhl*, *baoli*, *naun*, *panihar*, *dhar*, *chashma*, *choe* and *gharat*, are explained where they first appear.

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

Himachal Pradesh's towns flood, and fail, for three reasons. The monsoon of 2023 showed the first, when more than 500 people died, over 5,400 landslides were recorded and the State's recovery needs were put at about ₹9,043 crore; Shimla showed the second on 14 August 2023, when a slope of saturated debris slid about 230 m from Summer Hill onto the Shiv Bawri temple, and the State's technical committee named open drainage among its causes; and the khads of Shimla showed the third in January 2016, when sewage reached the Ashwani Khad, from which the town drew water, and an outbreak of hepatitis E followed.

1. **Monsoon bursts and western disturbances on steep, debris-covered slopes, where drains fail by debris and blockage before they fail by capacity.** The monsoon reaches the State after crossing the plains, and where its currents meet a western disturbance over the first ranges the rain is among the heaviest in north India. From 7 to 11 July 2023 such a meeting brought the State 223 mm in four days, 436% above normal, as reported; Una's automatic weather station recorded 228.5 mm on 9 July, Pachhad 220.3 mm on 10 July and Nahan 250.0 mm on 11 July; and on 14 August Kangra Aero recorded 273.4 mm and Dharmsala 250.2 mm. The post-disaster needs assessment (PDNA) of 2023 counts more than 500 deaths, over 5,400 landslides, 45 cloudbursts and 83 flash floods (HPSDMA's count, through IMD, is 52 cloudbursts), damage and losses of ₹8,304.21 crore and recovery needs of ₹8,667.66 crore, with ₹375 crore more for disaster risk reduction; over 8,040 km of road, 21% of the State's road length, were damaged, and the State's recovery plan rebuilds box culverts only after a "Drainage Analysis". The records exceed the national maps: Dharamshala recorded 600 mm in a day on 18 July 1967, where the CWC map for zone 7 gives a 50-year day of about 320–400 mm; and short bursts are severe: Dharampur in Solan district recorded 100 mm in one hour on 9 August 1985. On slopes of 45–60° a street drain fills in minutes, and it fills with stones, gravel, felled wood and road spoil as well as water: in 2023 the streams at Thunag were choked with wood and road debris, and the Malana II reservoir was "filled with debris and silts causing its overspill", as reported. The worst floods of recent years were not measured at all: no raingauge recorded the storms that sent flash floods down the Samej Khad on 31 July 2024, killing 56 people, as reported, or through Seraj and Thunag in Mandi district on 30 June and 1 July 2025, and the State's counts of cloudbursts are counts of damage, not of rain. Like the Parechu lake burst that raised the Sutlej by 12–15 m on 26 June 2005, such events set where towns may build, not how their drains are sized.
2. **Towns on slopes where water put into the ground moves the ground.** About 90% of Shimla is built on slopes of 45–60°, on schist, phyllite and slate under a debris cover up to 10–12 m thick, as the NGT's Expert Committee found in 2017; the development plans name sinking and sliding zones, and that committee named two in Shimla, around Lakkar Bazar and down to Dhobighat, and around Ladakhi Mohalla and Krishna Nagar. After a wet spell from April to August 2023 the slopes failed: the State technical committee led by HIMCOSTE found that the Summer Hill slide followed "the weak plane of the depression which seems to be old buried channel of a dry stream", and named among seven causes "Deposition of thick debris cover on the fragile slopes", "Open Drainage systems leading to poor disposal of surface water" and structural depressions that act as "conduits for the infiltration of subsurface water"; at Navbahar Chowk, it found, "Input of rainwater from the road also accelerated the process". The TCP Rules require a geologist's report before building in a sinking or sliding zone, and their rainwater rule asks for storage, not recharge; the draft Ground Water Rules of 2006 exempt the sinking zones from rainwater harvesting directions where the structures "would be detrimental to the safety of the building structures". But no rule restricts soak pits or recharge on slopes: the site plan must show a soak pit, and a new sub-division must keep 5% of its area for soak pits. The plains habit of recharging everywhere must therefore be reversed on the slopes. It holds in the Siwalik valleys, whose fills transmit 150–2,600 m² a day at Una and 211–3,336 m² a day at Paonta–Kala Amb and whose water tables lie as deep as 43.20 m: these are the State's recharge zones, and the State's most used aquifers, Una at 63.72% of its extractable groundwater and Solan (Nalagarh) at 57.89% in 2024, though all ten assessed valley units are safe. It does not hold in the Balh valley, where the water table is within 0.3–7 m of the ground. The hills' springs, about 500 of them inventoried in a standard format, feed many of their water supplies; Palampur pays a forest committee to protect the recharge area of the Bohal spring that supplies the town.

3. **Khads and rivers narrowed by building, muck and channelisation, laden with sewage, without a floodplain law, a gauge or a design storm.** The PDNA found that "most of the destruction that occurred along the Beas river in Kullu district was mainly due to overflow of the water along the palaeo channels following the old river course along which the developmental activities have taken place", and that "The lack of well-defined river boundaries in floodplains is a prominent issue in Himachal Pradesh"; it warned that channelisation by concrete "is not advisable in Himalayan Ecology", and the State told the NGT in 2024 that it had recommended dropping the channelisation of river stretches. The muck of the Kiratpur–Nerchowk four-lane highway was dumped into Gobind Sagar and the khads that feed it, and the High Court ordered penal action and clearance on 31 May 2024. In Shimla the khads are storm drains, sewers and water sources at once: the hepatitis E outbreak that began in January 2016 was traced to the Ashwani Khad, whose water was "contaminated with sewage effluent from Malyana and Dhalli STP", and the intake was shut; case counts differ between the medical study and the press. In 2022 CPCB put four stretches of the State in Priority I of its list of polluted river stretches: the Ashwani Khad, the Bald along Baddi, the Sirsa along Nalagarh and the Sukhna along Parwanoo. In August 2025 Shimla's three treatment plants used 18.1 MLD of their installed 35.88 MLD, and 50.8 km of its sewers were still to be connected, by 2039. The State has no floodplain zoning law; only one CWC site in the State, the Yamuna at Paonta, has a warning and danger level, and the Beas at Manali, Kullu, Mandi and Pandoh, the Sutlej at Bilaspur and the Ravi at Chamba have no CWC site at all. Of the drains themselves, no State or municipal standard states a design storm, and the NGT's Expert Committee found in 2017 that Shimla's drains covered 30% of the city and were "not able to carry the peak flow".

Behind all three lie the State's reservoirs, lakes, springs and kuhls, which set the level at the outfall. Gobind Sagar, behind the Bhakra dam (full reservoir level 1,680 ft, about 512.06 m), reaches Bilaspur, and Pong Dam Lake (1,390 ft, about 423.67 m) the towns of Dehra and Indora; in 2023 Pong rose to 1,399.65 ft by 15 August and in 2025 to 1,394.71 ft, as reported, and the Pandoh and Larji dams govern the Beas below Kullu, where 14 students died during a release from Larji in 2014. The reservoirs fill with sediment: the storage of Bhakra fell from 9,868 to 7,769 million m³ between 1958 and 2012, as reported, and the Nathpa Jhakri plant stops when the Sutlej carries too much silt. Above them, the State Centre on Climate Change counted 562 glacial lakes in the Sutlej basin, 242 in the Chenab, 93 in the Beas and 37 or 38 in the Ravi in 2019. Pong Dam Lake (15,662 ha), Chandertal (49 ha) and Renuka (20 ha) are Ramsar sites, and Rewalsar, where leaking sewage drains around the lake cause eutrophication, and Khajjiar are wetlands of national importance, but no wetland in the State has been notified under the Wetlands Rules, and no statute protects a baoli, a naun or a spring. The kuhls of Kangra and the other valleys carry runoff as well as irrigation water, and the Minor Canals Act makes it an offence to obstruct or foul them.

Design for Himachal Pradesh therefore has to cover a monsoon that reaches the State about 25 June and withdraws about 25 September under IMD's new normals, but whose withdrawal came later than normal in eight of the nine years from 2018 to 2026, as late as 11 October in 2019; western disturbances that bring storms after it has gone, such as those of 4 October 1955 (285 mm at Batheri), 10–12 October 1956 (268 mm at Nichar and 246 mm at Renuka) and 5–7 October 2025; and winter snow above about 1,500 m. The State's normal rainfall for June to September is 734.4 mm, but the gauges range from an annual normal of 3,099 mm at Dharamshala, on the Dhauladhar front, to 984 mm at Kullu and 622 mm at Keylong in the rain shadow. Underground, the State draws about a third of its extractable groundwater (35.48% in 2024), and all its ten assessed valley units are safe, but seven of its twelve districts, Kullu, Shimla, Bilaspur, Hamirpur, Chamba, Kinnaur and Lahaul and Spiti, have no assessed unit at all.

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 the ground where the ground can take it and in tanks where a slope cannot;
- 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 nallah, khad, river, tal or reservoir is high, when a dam upstream is releasing, or when a drain is choked with debris.

The Manual also sets how public drains, hill roads and their drains, nallahs, khads, rivers, tals, reservoirs, springs and kuhls, outfalls and basin-wide master plans are designed, and how drains in steep catchments are protected against debris and sediment, 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 Himachal Pradesh's south-west monsoon from late June to late September, with its storms against the Dhauladhar and the outer ranges, its western disturbances and its storms in October; to the Sutlej under the Karcham Wangtoo, Nathpa Jhakri, Kol and Bhakra dams; to the Beas under the Larji, Pandoh and Pong dams; to the Ravi under the Chamera dams; to the Chandra and the Bhaga in Lahaul; to the Yamuna at Paonta with the Giri, the Pabbar and the Bata; to the Swan, the Sirsa and the Markanda of the Siwalik valleys; to the khads and nallahs of the hill towns; to the boulder fills of the Siwalik valleys, the alluvium of the Balh valley, the schist, phyllite and slate with their debris cover in the mid-hills, and the moraine and alpine soils of the high valleys; to the tals, Ramsar sites, baolis, nauns and kuhls; and to towns whose roads and stepped houses lie across the natural lines of drainage on the slopes.

1. **National base.** The CPHEEO *Manual on Storm Water Drainage Systems* (2019). This Manual builds on it and sets higher standards where it allows a State to do so. IRC road-drainage codes, including IRC:SP:42-2014 on hill roads, and the NDMA urban flood guidelines are also used. The drainage chapter of the IRC's hill road manual, IRC:SP:48, was not read for this Manual.
2. **Overall structure.** Kansas City Metro APWA Section 5600 (Version 2025.01), the most recent comprehensive regional standard. It supplies the preserve, retain, detain, convey and maintain sequence and the required retention volume.
3. **Design rainfall.** The CWC *Flood Estimation Report* for zone 7, Western Himalayas (1994), as the interim source for the whole State. It rests on only six gauged catchments, of which three drain the State and its worked example is the Banu Khad in Kangra; it warns against using its relations without checking them, and does not apply them to snow-fed catchments, which this Manual leaves to site-specific study with a screening for glacial lake outbursts, landslide lakes and debris flows. Its ratio of the 1-hour to the 24-hour rain, 0.425, fits the bursts recorded at Dharampur and Nahan and is used in the Siwalik foothills, the mid-hills and the Kullu–Manali valley; but on the Dhauladhar front it gives about twice the largest hour recorded at Dharamshala, 73 mm, so there this Manual sets a lower ratio, not below 0.34; and at Shimla, which lies in a relative low on the maps, it keeps the map's day but sets the hour no lower than Shimla's own recorded hour of 50 mm, scaled to the design frequency. It checks the design day against the largest reliable days recorded nearby once their gauges' records are confirmed (Dharamshala's 600 mm of 1967 is the first to confirm), and does not rely on the falls of 610 mm at Kilba and 559 mm at Sangla in December 1958, which are doubtful. IMD's national set of rainfall intensity curves (Das et al., 2022) has no panel for any station in the State; an equation for the northern region gives a 50-year day of about 129 mm, less than half Dharamshala's recorded 270 mm, and is not used; and the gridded rainfall of NIH-DHAARA was not consulted for the State.
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 Himachal Pradesh Town and Country Planning Act, 1977 and the TCP Rules 2014 as amended, with the regulations of the Interim Development Plans and Development Plans, including the Shimla Development Plan published on 20 June 2023 and the Chopal Planning Area Development Plan 2041; the Himachal Pradesh Ground Water (Regulation and Control of Development and Management) Act, 2005 as amended in 2022 and 2023; the Himachal Pradesh Minor Canals Act, 1976; the Himachal Pradesh Municipal Corporation Act, 1994 and the Himachal Pradesh Municipal Act, 1994; the Wetlands (Conservation and Management) Rules, 2017 and the State's notification of 7 November 2017 constituting HPSWA; the State's stone crusher policy of 29 June 2021; and the orders of the High Court of Himachal Pradesh and the NGT on muck dumping, polluted river stretches and the disasters of 2023, and the judgment of the Supreme Court of 11 January 2024. This Manual follows them or, where disclosed, makes them stricter. The TCP Rules were read in their consolidation to 2022 and the live text of Appendix-1 of June 2025, not in the amendments of 2024 and 2025; the setbacks reported in the press in 2025, 5 m from drains and 7 m from rivers and ravines, no government building within 150 m of rivers, nullahs and other water bodies, and no building on the banks of rivers and streams under the rural bye-laws, were not found in any gazetted text and are not applied as rules. The Shimla Development Plan was read only as the Supreme Court quotes it, the Municipal Acts were not read, the final Ground Water Rules were not seen, and the

orders in the Supreme Court's own case on the State's ecology (WP(C) No. 758 of 2025) and the first report of its Central Empowered Committee (October 2026) were read only as reported. 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 Himachal Pradesh can cite 1, 2, 5, 10 or 25 years, depending on the code chosen.
- **Detention.** CPHEEO describes limiting peak outflow to pre-development rates as general practice. It uses no "shall" and names no storm frequencies.
- **Climate.** The NDMA Urban Flooding Guidelines (2010) call for detention and retention facilities and for rainfall curves adjusted for climate change, but give no sizing rule or return period. The State's Action Plan on Climate Change (version 2, 2021–2030) expects heavy rainfall and floods to increase, but finds the observed trend of the heaviest day falling, with low confidence, and gives no factor for design.
- **Design rainfall.** No national document gives design rainfall that a designer can apply directly to a given town. Each project chooses its own source. IMD's 2022 national set of rainfall intensity curves has no panel for any station in the State, and its nearest panels, Jammu, Amritsar and Dehradun, repeat the curve printed for many other cities. The one CWC report that covers the State dates from 1994 (zone 7); it takes the 1-hour rain as 0.425 of the 24-hour rain, which gives a 50-year hour of about 68–85 mm at Shimla, where the largest hour on the self-recording gauge was 50 mm, and more than 136 mm at Dharamshala, where it was 73 mm, while at Dharampur the gauge recorded 100 mm. At the other end its maps are exceeded at gauges: Dharamshala recorded 600 mm in a day where the map gives a 50-year day of about 320–400 mm. At Kullu the map gives a 50-year day of about 280–320 mm, above the 236 mm of 1888, the largest day recorded there, while Kullu district reported 26 cloudbursts in July 2023, counted from their damage, not from any gauge. An equation for the northern region by Ram Babu and others gives a 50-year day of about 129 mm, below the map at Shimla and less than half the 270 mm recorded in 24 hours at Dharamshala.

Himachal Pradesh has no drainage design standard of its own. Research for this Manual found no standard, IDF relationship or circular of TCP, UDD, Jal Shakti Vibhag, SJPNL, the PWD, SMC or any other Municipal Corporation that fixes a return period, a runoff coefficient or a design rainfall for town storm drains. The NGT's Expert Committee found in 2017 that storm drainage covered 30% of Shimla, that the "Carrying capacity of these drains is not sufficient", that their "Catchments" were "improperly selected" and that drains were "constructed for longer distances with much lesser gradients than actually required", so that they were "not able to carry the peak flow". The sources do not agree on what Shimla has: 13 major nallahs and about 67 storm drains with a network of about 42.33 km in a plan of SMC with the United Nations Development Programme (2015), against 191 drains and nallahs, 55.43 km, built under AMRUT. After the slides of 2023 SMC asked SJPNL for a study and a detailed project report on the town's drains, as reported, which was not found; Jal Shakti Vibhag has proposed storm water drainage for Una town at ₹19.66 crore; and Dharamshala's drainage is reported inadequate despite the spending of its Smart City company. These are projects, not a State standard. This Manual is offered as a technical companion to the Town and Country Planning Act and the TCP Rules

2014, the development plans, the Ground Water Act, the Minor Canals Act and the Municipal Acts: it supplies the design storm, detention, slope, water-level and buffer values that they leave open. It has not been adopted by TCP, UDD or any other body. In particular:

- **The TCP Rules require rainwater storage, but not detention.** Appendix 6 makes the collection of rain from roofs compulsory for all buildings, existing and new, where the Town and Country Planning Act operates, with storage of at least 20 litres per m² of roof, about 20 mm of rain on the roof; no water connection is given until it is installed, and existing buildings were to comply within eighteen months. It is a storage rule, not an infiltration rule. The Ground Water Act, 2005 adds a power, which the Authority "may" use, to direct rainwater harvesting on premises with a plinth of 100 m² or more. No rule requires on-site detention, limits peak runoff, sets "zero runoff" or deals with permeable paving; the NGT's direction of 2017 that "All the storm water available as surface run off in all the concretised areas like roads, lanes, platforms and market places should be diverted in such a manner to ensure that such run off does not go in to over burden or flow along hills and depressions" was set aside with the rest of its judgment in 2024;
- **The slope rules stop building, not infiltration.** Appendix-1 of the TCP Rules sets 45° as the maximum slope for development (30° for IT parks), allows a hill cut of at most 3.50 m, and Rule 21(1) requires a geologist's soil investigation report before building in a sinking or sliding zone; the NGT's Expert Committee would have kept building off slopes of more than 35° where soil covers the rock, but its direction was set aside. No rule restricts soak pits, recharge pits or infiltration trenches on slopes, on debris cover or above a cut or retaining wall: the site plan must show a soak pit, and a new sub-division must keep 5% of its area for soak pits;
- **The setbacks are small, and their reference line is not defined.** Appendix-1 allows building 3.00 m from a nullah and 5.00 m from a khad, but only in areas without a development plan, and does not say whether the distance is measured from the bank, the centre line or a flood level; in planning areas the distance from the highest flood level along rivers, khads and nallahs "shall be as delineated in the Interim Development Plans / Development Plans", and elsewhere "no construction shall be allowed in parcel of land prone to floods". In 2025 the press reported setbacks of 5 m from drains and 7 m from rivers and ravines, no government building within 150 m of rivers, nullahs and other water bodies, and no building on the banks of rivers and streams under model bye-laws for villages; no gazetted text of any of them was found. No rule sizes a buffer along a khad or a nallah by the flood it carries;
- **The State has no floodplain law.** The PDNA of 2023 found that "It becomes challenging to establish setback distances and zoning regulations that account for floodplains" and that "there is a pressing need for comprehensive river boundary mapping and the establishment of floodplain management guidelines", and costed them at ₹10 crore; no flood line has been notified on any river. This Manual offers a technical method for drawing a design flood line and corridors (Chapter 7); it does not replace any line that the State notifies, a development plan draws or a court orders, and where such a line binds and is wider, it governs; and
- **No document sets the river, khad or reservoir level for which an outfall is designed.** CWC's warning level (383.5 m), danger level (384.5 m) and highest flood level (384.6 m, 5 September 1995) for the Yamuna at Paonta were found only in transcriptions, and its 29 other sites in the State record only a highest flood level, such as 933 m for the Sutlej at Rampur in the Parechu flood of 2005 and 367 m for the Swan at Ghaluwal; the khads and nallahs of the towns are ungauged; and BBMB gives its reservoir levels in feet, with three values for the maximum level of Pong. Danger levels and highest flood levels are flood-warning levels and records, not design levels.

So each agency and each local body interprets the central manual its own way. SMC and the other Municipal Corporations, the Nagar Parishads and Nagar Panchayats, TCP and the SADAs, BBNDA, HIMUDA, HPSIDC, Jal Shakti Vibhag, SJPNL, the PWD, NHAI, the Smart City companies, the dam operators, their consultants and funding agencies fill the gaps differently. The CAG found in 2022 that HIMUDA approves colony plans without the ULBs, that HPSIDC plans the industrial areas, and that Jal Shakti Vibhag runs the sewers of every town but Shimla and Solan. No rule divides the khads and nallahs from municipal drains: in Shimla a nallah may be SMC's storm drain, carry sewage that SJPNL is to intercept, drain a road of the PWD or NHAI, and run on Revenue or Forest land; and in most of the State, outside the areas of the Town and Country Planning Act, no building rule applies at all, as the PDNA noted among the causes of the disaster of 2023. 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 zone 7 ratios where the records support them and a lower ratio on the Dhauladhar front, a check of the design day against the largest reliable days recorded nearby, once their gauges' records are confirmed; and, in the snow-fed catchments of the high and trans-Himalaya, site-specific hydrology with a screening for glacial lake outbursts, landslide lakes and debris flows (Chapter 2);
- named return periods for every drainage element (Chapters 2 and 6);
- a required pre- versus post-development rule for private sites (Chapter 4);
- a required tailwater check for outfalls to nallahs, khads, rivers, tals and reservoirs, against a design river or lake level: CWC's levels where they exist, the reservoir levels of BBMB and the other operators, converted from feet, the releases of the dams upstream, and, on the ungauged khads and nallahs, surveyed flood marks and a 1% AEP study that allows for debris (Chapter 5);
- a design flood line, and corridors and setbacks along khads, nallahs and rivers and around tals, baolis, nauns and springs, proposed by this Manual for use where nothing wider binds, with the TCP Rules' 3 m and 5 m lines and the development plans' flood lines wherever those are wider, and old river courses kept free of building (Chapter 7);
- recharge first on the fills of the Siwalik valleys, none in the Balh valley where the water table rises within 1 m of the ground, and no deliberate infiltration on slopes steeper than 10°, in sinking or sliding zones, on debris cover, colluvium or moraine, or above a cut slope or retaining wall, unless a geotechnical certificate allows it; roof runoff to the storage tanks the TCP Rules already require, with their overflow to lined drains; protection of the recharge areas of springs and of the kuhls; and treatment where drains carry sewage (Chapter 8);
- debris racks and traps, allowances for sediment and blockage, energy dissipation in steep drains, and hill-road drainage that never discharges onto an unprotected slope (Chapters 6 and 9), with debris cleared before the monsoon and again by 31 October in the hill towns, standby kept to 31 October for the late storms, and inlets kept clear of snow and ice in winter (Chapter 10); and
- basin-wide master plans, so that the agencies that share a basin 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). A Municipal Corporation, TCP in a development plan, or UDD 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); Himachal Pradesh Town and Country Planning Rules, 2014, consolidated to 2022 (TCP Department), Rule 21(1), Appendix-1 cl. 3, 8, 11, 16 and 20, Appendix-3 cl. 15, Appendix-6 and Appendix-7, and the live Appendix-1 page (June 2025); Chopal Planning Area Development Plan 2041; Himachal Pradesh Ground Water (Regulation and Control of Development and Management) Act, 2005 (Act 31 of 2005, as amended by Acts 14 of 2022 and 9 of 2023) and draft Rules, 2006, r.28–29; Himachal Pradesh Minor Canals Act, 1976 (Act No. 42 of 1976), s.2, 3, 43–48 and 65; Department of Environment, Science and Technology notification No. STE-E(3)-10/2017-Pt-I of 7 November 2017 (HPSWA) and No. STE-F(2)-10/2009 of 15 June 2017; HPSWA, Major Wetlands of Himachal Pradesh; MoEFCC, list of Ramsar sites of India (31 January 2024); NGT, Yogindra Mohan Sengupta v. Union of India, O.A. 121/2014, judgment of 16 November 2017, and the report of its Expert Committee (May 2017); Supreme Court, State of Himachal Pradesh v. Yogendera Mohan Sengupta, 2024 INSC 30 (11 January 2024); High Court of Himachal Pradesh, CWP 5243/2022 (26 June 2023) and CWPIL 31/2023 (31 May 2024); NGT O.A. 726/2023 (HPSPCB reply of 20 February 2024), O.A. 673/2018 and O.A. 735/2023 (affidavits of the Chief Secretary of 2024 and 1 February 2026; CPCB interim report of 6 May 2024); CAG Report No. 1 of 2022 (74th Constitutional Amendment Act, Himachal Pradesh); Government of Himachal Pradesh, Post Disaster Needs Assessment, Monsoon 2023, and Monsoon 2023 Recovery and Reconstruction Plan; HIMCOSTE-led technical committee, preliminary report on the landslides and land subsidence in and around Shimla, July–August 2023 (HPSDMA); SMC and GoI–UNDP, Action Plan for Mainstreaming DRR and CCA (2015); SMC, AMRUT status (2022); NITI Aayog DMEO, Swan River best-practice note (2020); Bhagra et al. (2017), Int J Community Med Public Health 4(6); CWC, Flood Estimation Report for Western Himalayas – Zone 7 (WH/22/1994), Annexes 3.1, 4.3 and 4.4 and Plates 8–10,

read by eye, and Flood Estimation Report for Upper Indo-Ganga Plains subzone 1(e) (1984), plates; CWC levels as transcribed by SANDRP (2022 and 2023); IMD Meteorological Centre Shimla, Monsoon Reports 2023–2026; IMD press releases of 10 July and 7 August 2023 and Disastrous Weather Events report (July 2024); Das et al. (2022), MAUSAM 73(4); Ram Babu et al., ISCO-14; Government of Himachal Pradesh, State Action Plan on Climate Change, version 2 (2021–2030); CGWB, Dynamic Ground Water Resources of Himachal Pradesh 2022 and 2024, and NAQUIM reports for Una, Nalagarh, Paonta–Kala Amb and Balh; NITI Aayog, IWMI and SDC, Resource Book on Springshed Management in the Indian Himalayan Region (2021); IHA case study of Nathpa Jhakri; reports of the floods of 2005, 2023, 2024 and 2025, of BBMB's reservoir levels and of the setbacks and rural bye-laws announced in 2025 (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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Abbreviations

Abbreviation	Meaning
AEP	Annual exceedance probability
AMC	Antecedent moisture condition
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APWA	American Public Works Association
ARF	Areal reduction factor
AWS	Automatic weather station
BBMB	Bhakra Beas Management Board (operator of the Bhakra, Pong and Pandoh dams)
BBN	Baddi–Barotiwala–Nalagarh
BBNDA	Baddi Barotiwala Nalagarh Development Authority
BSMP	Basin Stormwater Master Plan
CAG	Comptroller and Auditor General of India
CEC	Central Empowered Committee (of the Supreme Court)
CGWA	Central Ground Water Authority
CGWB	Central Ground Water Board
CN	Curve number (SCS/NRCS method)
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 (the Collector)
DL / WL	Danger level / warning level (CWC)

Abbreviation	Meaning
DP / IDP	Development Plan / Interim Development Plan (under the Town and Country Planning Act, 1977)
DPR	Detailed project report
DWF	Dry-weather flow
EIA	Environmental impact assessment
ESC	Erosion and sediment control
FAR	Floor area ratio
FER	Flood Estimation Report (CWC)
FRL / MWL	Full reservoir level / maximum water level
GLOF	Glacial lake outburst flood
GWRA	Ground water resource assessment (CGWB)
HAT / MHWS	Highest astronomical tide / mean high water springs (coastal terms; not applicable in Himachal Pradesh)
HFL	High flood level (the highest level recorded at a gauge)
HGL	Hydraulic grade line
HIMCOSTE	Himachal Pradesh Council for Science, Technology and Environment
HIMUDA	Himachal Pradesh Housing and Urban Development Authority
HPSDMA	Himachal Pradesh State Disaster Management Authority
HPSEBL	Himachal Pradesh State Electricity Board Limited
HPSIDC	Himachal Pradesh State Industrial Development Corporation
HPSPCB	Himachal Pradesh State Pollution Control Board
HPSWA	Himachal Pradesh State Wetlands Authority
HSG	Hydrologic soil group
IDF	Intensity–duration–frequency
IMD	India Meteorological Department
IPH	Irrigation and Public Health Department (now Jal Shakti Vibhag)
IRC	Indian Roads Congress
MLD	Million litres a day
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
NDMA	National Disaster Management Authority
NGT	National Green Tribunal
NHAI	National Highways Authority of India
NIH	National Institute of Hydrology, Roorkee
NOC	No-objection certificate
PDNA	Post-disaster needs assessment (Himachal Pradesh, monsoon 2023)

Abbreviation	Meaning
PSD	Permissible site discharge
PWD	Public Works Department, Himachal Pradesh
RRV	Required retention volume
RWH	Rainwater harvesting
SADA	Special Area Development Authority (under the Town and Country Planning Act, 1977)
SANDRP	South Asia Network on Dams, Rivers and People
SAPCC	State Action Plan on Climate Change
SJPNL	Shimla Jal Prabandhan Nigam Limited
SLA	Sea-level allowance (coastal term; not applicable in Himachal Pradesh)
SMC	Shimla Municipal Corporation
SoI	Survey of India
SRRG	Self-recording rain gauge
STP	Sewage treatment plant
SUH	Synthetic unit hydrograph (CWC)
SW monsoon / JJAS	South-west monsoon, June–September
SWD	Storm water drain
TCP	Town and Country Planning Department, Himachal Pradesh
TCP Rules 2014	The Himachal Pradesh Town and Country Planning Rules, 2014, as amended
UDD	Urban Development Department, Himachal Pradesh
ULB	Urban local body (a Municipal Corporation, Nagar Parishad or Nagar Panchayat)
UTM	Universal Transverse Mercator
WQv	Water quality volume
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 Himachal Pradesh. It applies to private development and to public works, as set out in Clause 1.5.

1.1.2 The Manual has the following objectives:

- (a) to make stormwater management a **condition of development approval**, so that new development and redevelopment do not increase flood peaks or runoff volumes downstream;
- (b) to retain frequent rainfall on site, so that groundwater recharge is sustained and pollutant loads are reduced;
- (c) to size storage for the long-duration south-west monsoon storms of July–September, forced up against the Dhauladhar and the outer ranges and often joined by a western disturbance, as in July and August 2023, and the western-disturbance storms that follow the withdrawal, as in October 1955 and 1956, which fall on debris-covered slopes, springs and valley water tables already raised by weeks of rain, on reservoirs at their full levels and on rivers and khads already in flood, as well as for short-duration intensities;
- (d) to design outfalls for the stage of the rivers, khads and nallahs into which the towns drain, the Beas at Manali, Kullu and Mandi, the Sutlej at Rampur, the Ravi at Chamba, the Yamuna at Paonta Sahib, the Swan at Una, the Sirsa and the Balad at Baddi–Nalagarh and the Giri and the Ashwani Khad below Shimla, which rise within hours and carry boulders and debris; the levels of the reservoirs of Bhakra (Gobind Sagar), Pong, Pandoh, Kol and Chamera, held and released by their operators; and the levels of tals such as Rewalsar and Renuka at their outlets, including the case where the outfall is closed;
- (e) to protect tanks (tals), 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 rules made by the Government under the Himachal Pradesh Town and Country Planning Act, 1977 (the Himachal Pradesh Town and Country Planning Rules 2014), or the statutes on waterbodies. It adds runoff control requirements to them (Clause 1.8).

> **Commentary.** Himachal Pradesh's floods come from four sources, often together. The first is the heavy storm of the monsoon, or of a western disturbance meeting it, forced up against the Dhauladhar and the outer ranges. Dharamshala recorded 600 mm in a day on 18 July 1967, the State's highest day in the CWC zone-7 report (CWC). On 7–11 July 2023, when an active monsoon met a western disturbance, the State received 223 mm in four days, more than five times the normal, the Una Rampur automatic weather station recorded 228.5 mm, Nahan 250.0 mm and Pachhad 220.3 mm in a day, and Manali, Rohru and Keylong set new highest days; on 14 August 2023 Kangra Aero recorded 273.4 mm (IMD). The post-disaster needs assessment of the monsoon of 2023 counted more than 500 deaths and more than 5,400 landslides and put the recovery needs at ₹8,667.66 crore, with ₹375 crore more for disaster risk reduction (PDNA, 2023); the monsoon of 2025 was the wettest in 29 years, 39% above normal, with the losses reported as more than ₹4,881 crore (IMD; as reported). The second is the rivers and the

khads. In July 2023 the Beas submerged the Panchvaktra temple at Mandi, and in Kullu "most of the destruction … along the Beas river … was mainly due to overflow of the water along the palaeo channels following the old river course along which the developmental activities have taken place" (PDNA, 2023); the Sutlej rose by a reported 12–15 m on 26 June 2005, when the Parechu lake in Tibet burst, and set its highest level at Rampur (as reported); a flash flood of the Sutlej in Kinnaur and Rampur on 1 August 2000 was reported to have carried away more than 100 people and 25 bridges; and the Yamuna at Paonta Sahib reached 384.6 m, its highest level, on 5 September 1995 (CWC data as transcribed by SANDRP). The third, found in no plains State of the series, is debris, outbursts and unstable ground. On 14 August 2023 a slide about 230 m long ran from Summer Hill to the Shiv Bawri temple in Shimla along "the weak plane of the depression which seems to be old buried channel of a dry stream", killing about 20 people, and buildings collapsed at Krishna Nagar the next day; the technical committee on the slides named "Open Drainage systems leading to poor disposal of surface water" among their causes (HIMCOSTE-led committee, 2023). In Kinnaur, rockfall and slides struck travellers at Batseri on 25 July 2021 and at Nigulsari on 11 August 2021 (as reported); on 31 July 2024 a debris flow down the Samej khad killed 56 people, and floods struck Bagipul and Rajban, where there was no rain gauge (as reported; IMD); on 30 June–1 July 2025 floods and debris flows struck Seraj and Thunag in Mandi district, which recorded 140.7 mm in 24 hours against a normal of 6.9 mm (as reported); and in August 2025 pilgrims on the Manimahesh route in Chamba were stranded by floods and slides, and deaths were reported (as reported). The fourth is the town drainage that fails in a fall that is not extreme: a flash flood swept through Bhagsunag above Dharamshala on 12 July 2021 (as reported); Dharamshala's drainage is reported inadequate despite more than ₹500 crore of Smart City spending (as reported); and in Shimla the nallahs that carry storm water also carried sewage to the Ashwani Khad intake, where it caused the outbreak of hepatitis E that began in January 2016 (Bhagra et al., 2017).

Missing design makes all four worse. No design storm, return period or drain standard was found for the drains of any town in the State: the NGT's expert committee found in 2017 that Shimla's drains were "not able to carry the peak flow" and covered about 30% of the city (NGT, OA 121/2014, as quoted; the judgment was later set aside by the Supreme Court). The TCP Rules 2014 control rainwater storage, slopes and the siting of buildings, not runoff, and they have no rule against soak pits on unstable slopes, although the committee on the Shimla slides of 2023 found that water entering the debris cover through depressions helped them fail. Objectives (b) to (e) address the storage, outfall and building-level failures, which a drain-sizing manual alone cannot fix; the third source is answered by the siting, screening and debris rules of Chapters 2, 6 and 7, because no drain is sized to carry a debris flow.

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 Himachal Pradesh Town and Country Planning Rules 2014 mandate RWH only. Objective (a) is therefore the main new step this Manual takes.

1.2 Stormwater management hierarchy

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

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

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

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

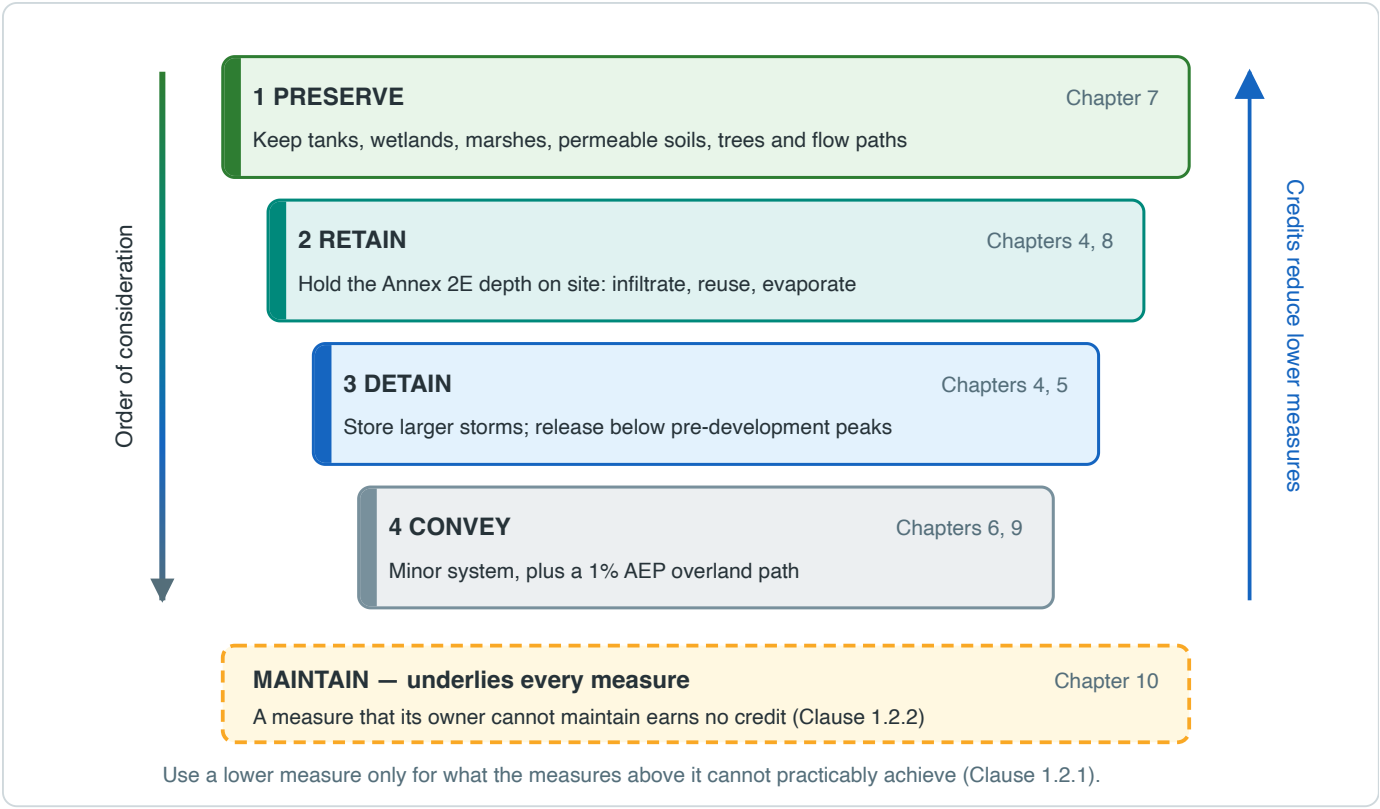

Figure 1.1 — Stormwater management hierarchy: preserve, retain, detain, convey, with maintenance underlying each measure. Original drawing for this Manual, adapted from Mid-America Regional Council / Kansas City Metro Chapter APWA, "Layers of Stormwater Management", APWA 5600 Manual Factsheet, 2025 (concept).

Commentary. The order follows the "layers" of Kansas City Metro APWA Section 5600, Version 2025.01: preserve or restore, retain, detain, convey, maintain (MARC factsheet, 2025). The same logic is behind Georgia's runoff-reduction standard and CSE's "attenuate and infiltrate first" principle (CSE, 2023). For Himachal Pradesh, the top two layers have a particular meaning. Much of the State's natural storage and recharge lies in its tals (Rewalsar, Renuka and Khajjiar), in its reservoirs, in its springs (naun, a spring-fed stepped tank, and baoli, a small spring-fed pool or tank), in its kuhls (gravity irrigation channels), in the beds and floodplains of its rivers and khads, and in the coarse valley fills of the Siwalik foothills, at Una, Nalagarh and Paonta–Kala Amb, where the water table may lie more than 40 m down and transmissivity reaches thousands of m² per day (CGWB). About 500 springs have been inventoried in the State in a standard format (NITI Aayog, 2021); Palampur pays to protect the recharge area of the Bohal spring that supplies the town; and the State has three Ramsar sites, Pong Dam Lake (15,662 ha, designated on 19 August 2002), Chandertal (49 ha) and Renuka (20 ha), both designated on 8 November 2005 (MoEFCC, list of Ramsar sites). The law protects some of this. The TCP Rules 2014 keep construction 3 m from a nullah and 5 m from a khud where no plan has been prepared (Appendix-1, cl. 16) and leave the distance from the highest flood level to the development plans; the Minor Canals Act of 1976 protects scheduled kuhls and lets the Government regulate any "line of natural drainage" and order obstructions removed (s.43); the Wetlands Rules 2017 apply to notified wetlands through the State Wetlands Authority; and the High Court has barred the dumping of muck into Gobind Sagar and its feeding khads (2023–24). The State has no floodplain zoning law. In the hills the second layer changes. Retention on a slope is storage and reuse, not infiltration: water put into debris cover, colluvium or moraine raises the pressure in the slope, as the technical committee on the Shimla slides of 2023 found, so this Manual bars deliberate infiltration on natural slopes of more than 10°, in the sinking and sliding

zones of the development plans, including Shimla's two zones, on debris cover, colluvium or moraine and close upslope of a cut or retaining wall, unless a geotechnical certificate allows it (Clause 4.11, hill infiltration rule, set by this Manual). Infiltration remains a choice on the coarse Siwalik valley fills, which are the State's main recharge zones, and is not credited in the Balh valley, where the seasonal water table is within about 1 m. Losing that storage and those springs cannot be offset by pipes, and in the hills drains that put water into a slope can make it fail.

1.3 Legal basis and status

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

- (a) an amendment to the Himachal Pradesh Town and Country Planning Rules 2014 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 Himachal Pradesh the building rules are the Himachal Pradesh Town and Country Planning Rules 2014, made under the Himachal Pradesh Town and Country Planning Act, 1977 and amended many times since; this Manual read the text consolidated by the TCP Department to the Eighth Amendment of 2022 and the live page of Appendix-1 as it stood in June 2025, but not the Twelfth to Fifteenth Amendments of 2024–25 or the draft Sixteenth Amendment published for objections in 2025 [TBC]. Within a planning area that has an Interim Development Plan or a Development Plan, the plan's regulations govern; Appendix-1 is the general regulation for areas where land use is frozen and no plan has been prepared. Appendix-1 allows development on slopes of up to 45° (cl. 3), a hill cut of up to 3.50 m with at least 1.00 m between the building and the toe wall (cl. 11), and construction at 3.00 m from a nullah and 5.00 m from a khud (cl. 16), without saying from which line the distance is measured; it asks that new sub-divisions be laid out for the "natural flow of surface drainage" with "un-obstructed rain water discharge" and at grades of at least 1 in 15, and sets aside 5% of the scheme area for soak pits (cl. 20). The appendices for IT parks and real estate leave the distance from the highest flood level along rivers, khuds and nullahs to the development plans and allow "no construction … in parcel of land prone to floods" elsewhere. Appendix 6 makes rooftop rainwater storage of at least 20 litres per m² of roof compulsory for every building, existing or new, where the Act operates, with no water connection until it is in place, and Rule 21(1) requires a geologist's soil investigation report before building in the sliding and sinking zones of a plan. The rules set no design storm, return period, release rate or detention volume, no "zero runoff" rule and no rule on infiltration on slopes; site plans show the "septic tank, soak pit, rain water harvesting tank" without any bar on soak pits on a slope. Setbacks of 5 m from drains and 7 m from rivers and ravines, said in the press in July 2025 to replace the 3 m and 5 m of cl. 16, were not found in a gazetted text and are not applied by this Manual (as reported). The route

of Clause 1.3.1(a) therefore runs through an amendment of the TCP Rules 2014 under the 1977 Act, and through the regulations of each development plan. This Manual is a draft; neither the Government nor any 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 Director of Town and Country Planning (TCP), or an officer to whom the Director's powers are delegated, in a planning area or special area under the Himachal Pradesh Town and Country Planning Act, 1977; a Special Area Development Authority (SADA), or the Baddi Barotiwala Nalagarh Development Authority (BBNDA), in its area; the Himachal Pradesh Housing and Urban Development Authority (HIMUDA) for the colonies it plans; or, where it grants building permission, the Municipal Corporation, Nagar Parishad or Nagar Panchayat concerned (the division of these powers, and the bodies that grant permission outside planning areas, are to be confirmed [TBC]), 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 Himachal Pradesh Town and Country Planning Rules 2014 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).

Term	Meaning in this Manual
Flood-sensitive catchment	The catchments of the nallahs of the Shimla Planning Area that drain north to the Sutlej and south to the Ashwani Khad and the Giri, with Shimla's two sinking and sliding zones; the land of Mandi that drains to the Beas and the Suketi, and the Balh valley round Sundernagar and Ner Chowk; the land of Kullu, Bhuntar and Manali on the valley floor, low terraces and old channels of the Beas and on the fans of its side streams; the land of the Baddi–Barotiwala–Nalagarh area that drains to the Sirsa and the Balad; the land of Una and the Una valley that drains to the Swan; the land of Paonta Sahib that drains to the Yamuna and the Bata; the land of Dharamshala, McLeodganj and Kangra that drains to the khads of the Dhauladhar front; the land of Rampur Bushahr on the Sutlej; the land of Bilaspur that drains to Gobind Sagar, and of Dehra and the other towns on the Pong reservoir; and the land of Chamba on the Ravi, and any catchment the Authority notifies (Chapter 4; Annex 1B).
Waterbody	A river, stream, canal, tank (tal), lake, pond, marsh, supply channel or surplus course, whether perennial or seasonal (Chapter 7).
Regional facility	A detention, retention or tank storage facility serving more than one development, built or restored under a basin plan (Chapter 4).
Tier A / Tier B authority	An Approving Authority classed under Clause 1.6.
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 Himachal Pradesh Town and Country Planning Rules 2014 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 Rajpatra, Himachal Pradesh.

> **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 Himachal Pradesh Town and Country Planning Rules 2014;
- (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 Himachal Pradesh, to the extent that the Authority's approval or no-objection is required.

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

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

1.5.3 **RWH.** The existing RWH mandate continues to apply under Appendix 6 of the Himachal Pradesh Town and Country Planning Rules 2014 to every building, existing or proposed, wherever the Himachal Pradesh Town and Country Planning Act, 1977 is in operation, as rooftop storage of at least **20 litres per m² of roof area** (about 20 mm of rain over the roof), with no water supply connection until it is in place and existing buildings to comply within eighteen months; and the Himachal Pradesh Ground Water (Regulation and Control of Development and Management) Act, 2005 (Act 31 of 2005) empowers the Ground Water Authority to direct rainwater harvesting structures on urban premises with a plinth area of 100 m² or more (section 15), a power from which the draft rules of 2006 exempt the sinking zones, 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.

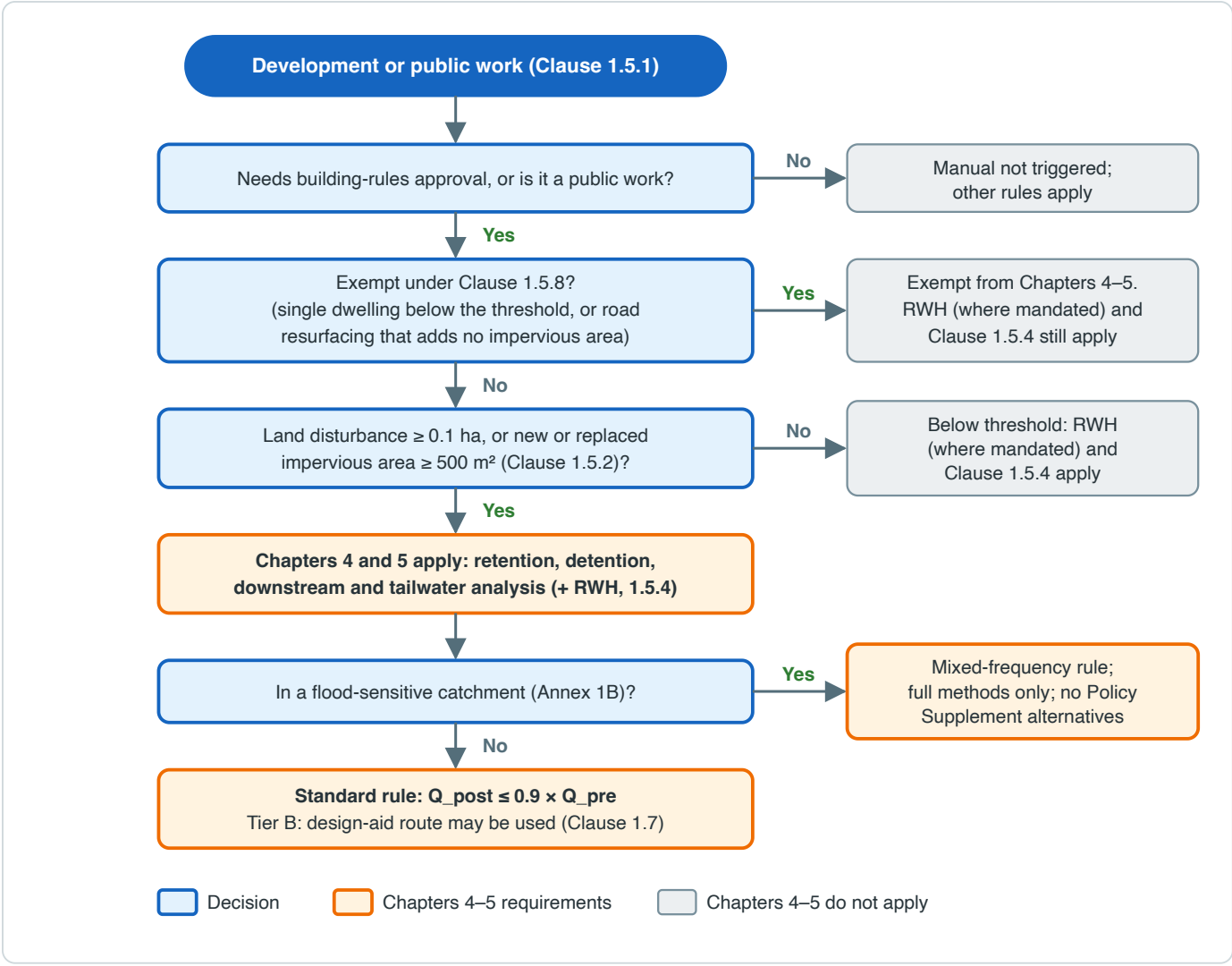

Figure 1.2 — Applicability decision flowchart for Clause 1.5. Original drawing for this Manual.

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 Himachal Pradesh plots are small and the cumulative effect of many small plots is what fills Shimla's drains. For small buildings in Himachal Pradesh, Appendix 6 of the TCP Rules 2014 already reaches every building, whatever its size, where the 1977 Act operates: it requires rooftop storage of at least 20 litres per m² of roof, about 20 mm of rain over the roof, before the building may have a water connection. That is a supply measure, and the tank is full when the monsoon storm arrives, so none of it limits what leaves the plot in a design storm. Outside the areas where the Act operates, which the post-disaster needs assessment of 2023 puts at more than 90% of the State, small buildings follow the rural model bye-laws approved in 2025 (as reported), whose drainage provisions were not read for this Manual [TBC]. Appendix-1 asks that sub-division layouts allow the "natural flow of surface drainage", but no rule asks a

single building to carry the water from uphill around its foundations or to discharge its roof water to a stable channel rather than down the slope. Clause 1.5.4(b) applies to every building whatever its size for this reason. A small building on a hill slope is also where a soak pit can do most harm; the TCP Rules 2014 show soak pits on the site plan without forbidding them on a slope, and an Authority may make the hill infiltration rule of Clause 4.11 a condition of every building permit in its hill area, whatever the size of the site (a recommendation of this Manual, not a requirement of Clause 1.5.4).

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) Shimla Municipal Corporation (SMC);
- (b) every Approving Authority within the Shimla Planning Area, notified under the Himachal Pradesh Town and Country Planning Act, 1977, as that area is notified from time to time, including the TCP Department and SMC and the other local bodies and special area authorities in that area; and
- (c) every other Municipal Corporation constituted under the Himachal Pradesh Municipal Corporation Act, 1994, as constituted from time to time, among them Dharamshala, Mandi, Solan and Palampur, and the TCP Department, a SADA or HIMUDA where it grants permission within the area of a Municipal Corporation; and the Baddi Barotiwala Nalagarh Development Authority in its area.

1.6.2 **Tier B authorities.** All other Nagar Parishads and Nagar Panchayats 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 TCP 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 Shimla Planning Area or another planning area or special area under the Himachal Pradesh Town and Country Planning Act, 1977, 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.** Shimla Municipal Corporation, with its engineering wing and a city of 13 major nallahs on slopes of 45° to 60°, with about 67 drains and 42.33 km of storm drains counted in 2015 and 55.43 km built under AMRUT (Shimla Municipal Corporation, 2015 and 2022), and a small hill 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 Shimla.

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
Himachal Pradesh Town and Country Planning Rules, 2014, made under the Himachal Pradesh Town and Country Planning Act, 1977, as consolidated by the TCP Department to the Eighth Amendment of 2022 (read), with the live page of Appendix-1 as of June 2025 (read); the Twelfth to Fifteenth Amendments of 2024–25 and the draft Sixteenth Amendment of 2025 (not read [TBC])	Continue. In areas where no Interim Development Plan or Development Plan has been prepared, Appendix-1 allows development on slopes of up to 45° (cl. 3), a hill cut of up to 3.50 m with at least 1.00 m from the toe wall (cl. 11) and construction at 3.00 m from a nullah and 5.00 m from a khud (cl. 16), with no reference line stated, and asks that sub-divisions be laid out for the "natural flow of surface drainage" at grades of at least 1 in 15, with 5% of the scheme area for soak pits (cl. 20); the appendices for IT parks and real estate leave the distance from the highest flood level along rivers, khuds and nullahs to the development plans and allow no construction on land prone to floods elsewhere; Rule 21(1) requires a geologist's soil investigation report before building in the sliding and sinking zones of a plan; and site plans show the waterbodies ("Bauri, Well, Nallah, khud"), contours and soak pits. The rules set no design storm, release rate, detention volume or "zero runoff" rule, and no rule on infiltration on slopes. The design criteria of Chapters 2–6, the hill rules of Chapters 4, 6 and 8 and the hydraulic corridor and setbacks 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 rules, a development plan or a statute are stricter, they govern (Clause 1.3.3).
Rainwater harvesting: TCP Rules 2014, Appendix 6; Himachal Pradesh Ground Water (Regulation and Control of Development and Management) Act, 2005 (Act 31 of 2005), as amended in 2022 and 2023, section 15, and its draft Rules of 2006	Continue unchanged. Appendix 6 makes rooftop rainwater storage compulsory for every building, existing or proposed, where the 1977 Act operates, at a minimum of 20 litres per m² of roof (cl. (vi)), about 20 mm of rain over the roof, with no water supply connection until it is in place, disconnection for violators and eighteen months for existing buildings to comply; colonies and IT parks provide it underground in parks and open spaces. Section 15 of the Ground Water Act is enabling: the Ground Water Authority "may" issue guidelines and direct rainwater harvesting structures on urban premises with a plinth area of 100 m² or more; the draft Rules of 2006 exempt from such directions premises under 100 m² and "the sinking zones, where construction of rain water harvesting structures would be detrimental to the safety of the building structures" (r.29; final rules not read [TBC]). This Manual counts the Appendix 6 storage against its retention requirement only as reuse (Clause 4.4.3), never as detention, and in the hills only as storage, under the hill infiltration rule of Clause 4.11.

Instrument	Relationship
Himachal Pradesh Town and Country Planning Act, 1977; the Interim Development Plans and Development Plans of the planning areas, among them the Shimla Development Plan 2041 (published on 20 June 2023 according to the Supreme Court, notified on 23 June 2023 according to the press; its text not read [TBC]) and the Chopal Development Plan 2041; special areas and SADAs	Continue. Development plans are subordinate legislation under the Act and must address water and drainage (Supreme Court, 2024 INSC 30). The Shimla plan requires a geologist's soil investigation report in its sinking and sliding zones and allows construction there only as the geologist's report permits (§17.2.2.9, as recorded by the Supreme Court); the Chopal plan treats slopes of more than 45°, flood plains and "areas adjacent to major drainage lines" as non-developable. The storm-water chapter of the Shimla plan's draft of 2022 was not read [TBC]. Development plans would show the flood-sensitive catchments, drainage reserves and regional facility sites of this Manual (Chapter 11).
NGT, *Yogindra Mohan Sengupta v. Union of India*, OA 121/2014 with OA 505(THC)/2015, judgment of 16 November 2017; Supreme Court, *State of Himachal Pradesh v. Yogendera Mohan Sengupta*, CA 5348-5349/2019, 2024 INSC 30, judgment of 11 January 2024	Not binding; cited as expert guidance only. The NGT's directions for Shimla included slope limits of 35° on soil-covered and 45° on rocky slopes (XIII), compulsory rainwater harvesting (XIV) and the diversion of runoff from concretised areas "in such a manner to ensure that such run off does not go in to over burden or flow along hills and depressions" (XV), on the findings of an expert committee that the city's drains could not carry the peak flow. The Supreme Court set aside all the NGT's orders, holding that the Tribunal had "transgressed its limitations" by directing how subordinate legislation should be made, let the State implement the development plan of 20 June 2023 subject to its observations, and said that it gave the plan no "imprimatur". This Manual uses the expert committee's findings and direction XV as technical evidence for its hill rules, not as orders.
Supreme Court, *In Re: Issues Relating to Ecology and Environmental Conditions Prevailing in the State of Himachal Pradesh*, WP(C) No. 758 of 2025 (suo motu), and the reports of the Central Empowered Committee (first report reported in October 2026)	Apply any direction when issued. The case was registered in July 2025, and in July 2026 the Court reportedly referred Shimla's green belts, tree felling and construction to the Central Empowered Committee, whose first report is reported to cover hydropower projects, roads and tourism construction (as reported; orders and reports not read [TBC]).
Setback changes of 2025 (as reported): 5 m from drains and 7 m from rivers and ravines for buildings, in place of the 3 m and 5 m of Appendix-1 (July 2025); no government building within 150 m of rivers, nullahs and other waterbodies (announcement, July 2025); model building bye-laws for rural areas banning building on the banks of rivers and streams (cabinet, September 2025)	Not applied as rules. No gazetted text of any of these was found for this Manual [TBC]; they are reported in the press only, and the press reports differ on the distances. Where one is notified, it governs as a statutory setback under Clause 7.4.5 for the uses it restricts. Until then the setbacks of Appendix-1 and of the development plans bind, and the hydraulic corridor of Chapter 7 applies where nothing wider binds.
Himachal Pradesh Municipal Corporation Act, 1994 and Himachal Pradesh Municipal Act, 1994	Continue. The Municipal Corporations run on the first and the Nagar Parishads and Nagar Panchayats on the second; their drainage sections were not read for this Manual [TBC]. The local bodies run few of the functions that bear on drainage alone: sewerage is run by the Jal Shakti Vibhag except in Shimla (SJPNL) and Solan, HIMUDA approves colony plans without them and HPSIDC plans the industrial areas (CAG, Report No. 1 of 2022).
Himachal Pradesh Minor Canals Act, 1976 (Act No. 42 of 1976)	Continue, and apply where a kuhl or line of natural drainage is concerned. The Act brings the kuhls of the Government and listed private kuhls under its Schedules, lets the Government "regulate the flow of water in any river, creek, natural channel or line of natural drainage" and prohibit or remove obstructions to it (s.43), requires works where a kuhl crosses a road or drain (s.46) and makes obstructing or fouling a canal an offence (s.65). It is the only statute of the State found that names a "line of natural drainage". A drain that crosses or discharges to a scheduled kuhl needs the consent of the body that manages it (Chapters 5 and 7).

Instrument	Relationship
Floodplains: no floodplain zoning law	No law of the State zones floodplains or notifies flood lines. The post-disaster needs assessment of 2023 asks for "comprehensive river boundary mapping and the establishment of floodplain management guidelines" and found the damage in Kullu concentrated along the Beas's old channels (PDNA, 2023). Until a law or guideline is made, the hydraulic corridor of Chapter 7, with a Zone 1 of at least 15 m, and the setbacks of Appendix-1 and the development plans apply, whichever is wider, as this Manual's proposal, and old river courses are kept free under Chapter 7.
Ground Water Act, 2005, section 5A (2022), and the statewide notification under section 5 (reported from 19 November 2019 [TBC])	Continue. Section 5A bars any person from releasing "any effluent that contaminates the groundwater"; this Manual applies it to infiltration practices, which shall not receive polluted runoff (Chapter 8). All ten valley units assessed by CGWB were "Safe" in 2024, with Una (63.72%) and Solan (57.89%) the most used.
Wetlands (Conservation and Management) Rules, 2017; Himachal Pradesh State Wetlands Authority (notification No. STE-E(3)-10/2017-Pt-I of 7 November 2017); Ramsar sites: Pong Dam Lake (15,662 ha, 19 August 2002), Chandertal (49 ha) and Renuka (20 ha) (8 November 2005)	Continue. The Rules' restrictions apply to wetlands once notified; no wetland of the State was found notified under rule 4. The Ramsar sites and the wetlands of national importance, Rewalsar and Khajjiar, are governed by Chapter 7.
High Court of Himachal Pradesh, *Fourlane Visthapit and Prabhavit Samiti v. State*, CWP 5243/2022 (order of 26 June 2023) and *Madan Lal v. State*, CWPIL 31/2023 (order of 31 May 2024); NGT, OA 726/2023 (the monsoon disaster of 2023), OA 673/2018 (polluted river stretches) and OA 735/2023 (Ashwani Khad)	Apply where they bind. The High Court barred the dumping of muck into Gobind Sagar and "its feeding khuds/nallahas", and ordered penal action against those who dumped it and the clearance of the muck from the shores, tributaries and public land; HPSPCB has levied environmental compensation for illegal dumping; the NGT oversees the cleaning of the four stretches that CPCB placed in Priority I in 2022, the Ashwani Khad, the Bald along Baddi, the Sirsa along Nalagarh and the Sukhna along Parwanoo. Sewage in storm drains is dealt with in Chapter 8, and muck and debris in Chapters 6 and 9.
Disaster Management Act, 2005; HPSDMA and the District Disaster Management Authorities	Continue. No urban flood plan or standard operating procedure of HPSDMA was read for this Manual [TBC]; directions to clean drains "before the onset of monsoon" were found only in press reports, with no fixed date, and the works calendar of Chapter 10 sets this Manual's dates.
IRC:SP:48, Hill Road Manual, and the practice of the Public Works Department on hill-road drainage	Apply to the drainage of hill roads, cross-referenced from Chapter 6, where they do not conflict with it; the drainage clauses of IRC:SP:48 were not read for this Manual [TBC].
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 Himachal Pradesh is framed as a water supply and recharge measure. It works well for that purpose. It cannot, however, be relied on for flood control in the SW monsoon, because RWH sumps are usually full or the ground saturated by the time a July or August monsoon burst or cloudburst, often with a western disturbance, as in July and August 2023 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.

Himachal Pradesh is spending on its town drains, but without a design basis. Shimla built 191 drains and nallahs, 55.43 km, under AMRUT (Shimla Municipal Corporation, 2022), its draft City Development Plan 2041 lists ₹25.47 crore for new drains and ₹179 crore for the rejuvenation of its major nallahs (Shimla Municipal Corporation, 2015), and after the slides of 2023 the Corporation asked SJPNL for a geological, remote-sensing and drone study of its drains and a DPR (as reported); the plan for recovery from the monsoon of 2023 lists proposals for storm-water drainage of Una town (₹19.66 crore) and for flood protection on the Beas at Manali and Bhuntar (Government of Himachal Pradesh, Recovery and Reconstruction Plan); and the Swan river flood management project, covering the main river from Daulatpur to the Gagret bridge and its tributaries, is reported complete (NITI Aayog, 2020; as reported). None of the documents found states a design storm. 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. It keeps development off slopes of more than 45°, keeps buildings 3 m from nullahs and 5 m from khads where no plan has been made, asks for a geologist's report in sinking and sliding zones and requires rooftop storage of 20 litres per m² of roof on every building (TCP Rules 2014); it lets the Government protect any line of natural drainage (Minor Canals Act 1976, s.43) and bars effluent that contaminates groundwater (Ground Water Act 2005, s.5A); and the High Court has acted against the dumping of muck in Gobind Sagar and its khads. The NGT's directions of 2017 for Shimla, among them that runoff from concretised areas be diverted so that it "does not go in to over burden or flow along hills and depressions", were set aside by the Supreme Court in 2024 and are cited in this Manual as expert guidance only. What the law lacks is a design standard and a floodplain law. None of these instruments says how large a drain must be, which storm it must carry, how much water a hill site may put into its slope, how a khad's flood level is to be fixed, or how much storage a paved plot removes; the setbacks of 2025 reported in the press have not been found in a gazetted text, and the post-disaster needs assessment of 2023 asks for the mapping of river boundaries and for floodplain guidelines that do not yet exist. This Manual's checks are framed as part of the planning and building permission of the TCP Department and the local bodies, 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 to the drainage works of the towns: it supplies the design storm, detention, hill-site drainage, infiltration and buffer numbers they do not set, as a proposal for the Government and the authorities to consider. Neither the TCP Department, the Urban Development Department, the Jal Shakti Vibhag 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
Town and Country Planning Department (TCP)	Administers the Himachal Pradesh Town and Country Planning Act, 1977 and the TCP Rules 2014, prepares the Interim Development Plans and Development Plans of the planning areas, among them the Shimla Development Plan, and grants planning permission in the planning and special areas where no other body does. Would prepare the amendment of Clause 1.3.1(a), show flood-sensitive catchments, drainage reserves and regional facility sites in the development plans (Chapter 11), and, with the Urban Development Department, give regional support to Tier B authorities (Table 1.1).
Urban Development Department	Administers the Municipal Corporations, Nagar Parishads and Nagar Panchayats, 54 local bodies in March 2020 (CAG, 2022), and the AMRUT and Smart Cities programmes. Would issue the model ULB bye-law of Clause 1.3.1(b), apply this Manual to the drainage works it funds, and maintain the empanelled reviewer list (Clause 10.7).

Agency	Role under this Manual
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).
Shimla Municipal Corporation (SMC) and the other Municipal Corporations (Dharamshala, Mandi, Solan and Palampur, as reported [TBC]); Nagar Parishads and Nagar Panchayats	Hold, clean and maintain the public drains and nallahs of their areas under the Himachal Pradesh Municipal Corporation Act, 1994 and the Himachal Pradesh Municipal Act, 1994 (drainage sections not read [TBC]), and grant building permission where the law gives them that power [TBC]; SMC's engineering wing built the AMRUT drains of Shimla. Would apply this Manual to their works, receive handed-over assets (Clause 10.14), and inspect and enforce (Clauses 10.12–10.15).
Special Area Development Authorities (SADAs), the Baddi Barotiwala Nalagarh Development Authority (BBNDA), HIMUDA and HPSIDC	Plan and grant permission in their special areas (SADAs, BBNDA), plan and approve colonies (HIMUDA, without the local bodies, CAG, 2022) and plan industrial areas (HPSIDC). Would require the drainage report of Chapter 10 with each application or scheme, check the hill rules at the plinth inspection, and hand over drains and storage to the local body under Clause 10.14.
Smart City companies of Shimla and Dharamshala	Build drains under the Smart Cities Mission and hand them to the Municipal Corporation. Would design them to this Manual from the dates of Clause 1.11.
Jal Shakti Vibhag (formerly the Irrigation and Public Health Department)	Builds and maintains flood-protection and channelisation works on the rivers and khads, among them the Swan; runs the water supply of the State and its sewerage outside Shimla; manages the kuhls of the Government under the Minor Canals Act, 1976; and is the State's groundwater agency. Would supply river levels and flood marks for Chapter 5, approve the site-specific hydrology of Clause 2.3.6(i), apply this Manual to its drainage and flood works, and design its sewers and treatment plants so that sewage stays out of the storm drains (Chapter 8).
Shimla Jal Prabandhan Nigam Ltd (SJPNL)	Runs the water supply and sewerage of Shimla, including the treatment plants at Lalpani, Malyana and Dhalli (35.88 MLD installed, 18.1 MLD used; Chief Secretary, affidavit before the NGT in OA 735/2023), and was asked by SMC to study the city's drains after the slides of 2023 (as reported). Would keep sewage out of the nallahs that feed the Ashwani Khad and apply Chapter 8 to its works.
Public Works Department (PWD)	Builds and maintains State roads and hill roads with their side drains, catch-water drains, scuppers and culverts, which in the hill towns are much of the minor drainage system. Would apply Chapter 6 and the hill-road rules to them; national highways are for NHAI or MoRTH, including the disposal of muck from road works, which the High Court has supervised, and border roads are for BRO.
Himachal Pradesh State Disaster Management Authority (HPSDMA) and the District Disaster Management Authorities	Prepare for and respond to floods, cloudbursts and landslides; HPSDMA published the reports of the technical committees on the events of 2023. Would supply the hazard and landslide maps used in the screening of Clause 2.3.6(i) and the hill rules, and lead post-event reviews with the Authority (Clause 10.16).
HIMCOSTE, the State Centre on Climate Change and the Himachal Pradesh State Wetlands Authority	HIMCOSTE coordinated the technical committee on the Shimla slides of 2023 and is the secretariat of the State Wetlands Authority (constituted on 7 November 2017); the State Centre on Climate Change inventories glacial lakes and landslides. Would supply those inventories for Clause 2.3.6(i), and the Wetlands Authority's consent is needed before a wetland or Ramsar site is used for storage or an outfall (Chapter 7).
Himachal Pradesh State Pollution Control Board (HPSPCB)	Monitors rivers and drains, levies environmental compensation for the illegal dumping of muck and reports to the NGT. Would receive the records of sewage found in storm drains under Chapter 8.
Ground Water Authority, under the Ground Water Act, 2005	May issue guidelines and directions for rainwater harvesting and recharge (s.15) and enforces the bar on effluent that contaminates groundwater (s.5A). Would be consulted where recharge is proposed under Chapters 4 and 8.
Revenue Department, the Deputy Commissioners and the Forest Department	The revenue records show the rivers, khads, nallahs and kuhls; the Collector may remove obstructions to scheduled kuhls and lines of natural drainage under the Minor Canals Act, 1976; much land along the khads is forest land. Would record drainage reserves in the land records.
Panchayati Raj Department and the gram panchayats	Apply the model building bye-laws for rural areas approved by the cabinet in September 2025 (as reported; text not read [TBC]). Would apply the hill rules of this Manual to rural building where the bye-laws allow.

Agency	Role under this Manual
BBMB, NTPC, SJVN, NHPC, HPSEBL, HPPCL and the other dam operators	Operate Bhakra (Gobind Sagar), Pong and Pandoh (BBMB), Kol (NTPC), Nathpa Jhakri (SJVN), Chamera and Parbati (NHPC), Larji and the other dams of the State. Would supply reservoir levels, release rules and release records for Chapter 5.
Central Water Commission (CWC), a body of the Union	Publishes the Flood Estimation Report for zone 7 used in Chapters 2 and 3, the river levels at its sites and its monitoring of glacial lakes. Would supply river stage records and forecasts for Chapter 5.
Central Ground Water Board (CGWB), a body of the Union	Assesses the groundwater of the State (stage of extraction 35.48% in 2024, all ten assessed valley units "Safe", seven districts unassessed). Would supply groundwater levels and quality with the Jal Shakti Vibhag.
IMD (Meteorological Centre Shimla), and road and rail owners (PWD, NHAI, BRO, Indian Railways)	IMD's stations supply the rainfall records of Chapter 2. Road and rail owners would apply this Manual to road drainage (Chapter 6), culverts and linear works (Clause 1.5.7).

Commentary. Stormwater in Himachal Pradesh is split between the TCP Department, through the TCP Rules 2014, the development plans and planning permission; the Urban Development Department and the local bodies, through the drains vested in them; the special area authorities, BBNDA, HIMUDA and HPSIDC, through their schemes; the Jal Shakti Vibhag, through the rivers, khads, kuhls and flood works, and through sewerage outside Shimla; SJPNL, through the sewers of Shimla; the PWD and NHAI, through the drains of the roads, which in the hills are the minor drainage system; the dam operators, through the reservoirs that hold the outfalls up; and the courts, which have acted on muck in the khads and on Shimla's planning. Shimla shows why the split matters. Its 13 major nallahs are at once trunk storm drains, carriers of sewage from households without a sewer connection, more than half of them in 2017 (NGT expert committee, as quoted), and the catchments of drinking-water sources: in 2016 effluent from the Malyana and Dhalli treatment plants reached the Ashwani Khad intake and caused an outbreak of hepatitis E (Bhagra et al., 2017). The nallahs are SMC's, the sewers and the treatment plants are SJPNL's, the road drains that feed them are the PWD's, the slopes they cross are governed by the development plan, and the land beside many of them is forest; the Comptroller and Auditor General found that SMC has "limited control" over SJPNL (CAG, 2022). The Municipal Acts of 1994 are understood to vest public drains in the local bodies (drainage sections not read [TBC]), and the Minor Canals Act of 1976 lets the Government regulate any line of natural drainage, but no rule or order found divides the khads and nallahs from the municipal drains, or the road drains of the hill towns from the town drains, between the bodies concerned [TBC]. Until such a rule is made, 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 register of its drains and nallahs with an owner for each reach. The assignment is this Manual's working split for applying its clauses; it does not change any agency's powers.

Table 1.5 — Working assignment of drainage elements under this Manual

Element	Assigned to
Rivers, khads and nallahs outside the limits of a local body, with their beds, banks and floodplains, and the flood-protection and channelisation works on any river or khad, such as those of the Swan, the Sirsa and the Beas	The Jal Shakti Vibhag; the land remains with its recorded owner (Revenue or Forest), and within the limits of a local body the local body keeps the bed free of encroachment
Natural nallahs and khads and public drains within the limits of a local body, other than the works assigned to the Jal Shakti Vibhag	The Municipal Corporation, Nagar Parishad or Nagar Panchayat (in Shimla, SMC)
Drains built under AMRUT or by the Smart City companies of Shimla and Dharamshala, until handed over in writing	The body that built them, and the local body after handover
Drains and storage within a scheme of a SADA, BBNDA, HIMUDA, HPSIDC or a colony developer, until handed over in writing	The body that built the scheme

Element	Assigned to
Road drains, catch-water drains above cuts, scuppers and cross-drainage of State roads and hill roads	The PWD; on national highways, NHAI or MoRTH, which also answer for the muck of their works; on border roads, BRO
Sewers, the interception of sewage from nallahs, and sewage treatment plants	SJPNL in Shimla; the Jal Shakti Vibhag elsewhere, or the local body where it runs the sewerage, as at Solan
Kuhls (gravity irrigation channels) listed in the Schedules of the Minor Canals Act, 1976	The Jal Shakti Vibhag or the local authority for the kuhls they manage (Schedule I), and the beneficiaries under the Collector for listed private kuhls (Schedule II)
Reservoirs and their gates and releases	BBMB (Bhakra, Pong, Pandoh); NTPC (Kol); SJVN (Nathpa Jhakri); NHPC (Chamera, Parbati); HPSEBL and the other operators of the State's dams
Springs (naun, baoli) used for supply	The Jal Shakti Vibhag, SJPNL, the local body or the panchayat that uses them
Wetlands and Ramsar sites (Pong Dam Lake, Chandertal, Renuka) and the wetlands of national importance (Rewalsar, Khajjiar)	The Himachal Pradesh State Wetlands Authority, with the Forest Department

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. Himachal Pradesh has no coast and no tidal reach, so no site in the State qualifies for this waiver. A site that drains to a river or khad in flood, to a reservoir such as Gobind Sagar, Pong or Pandoh, or to a tal held by its outlet, 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 nallah 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 Himachal Pradesh the NGT's expert committee found in 2017 that the debris of Shimla's slopes was "dumped in the valley or near water channels, obstructing the natural drainage", the High Court has had to bar the dumping of muck into Gobind Sagar and its feeding khads and order penal action against those who dumped it (*Madan Lal*, CWPIL 31/2023, 2024), and the post-disaster needs assessment of 2023 found that the water channels that should act as natural outlets "are often encroached upon".

1.11 Transition provisions

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

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

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

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

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

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

1.12 Review and amendment

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

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

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

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Annexes and forms

Annex / Form	Content
1A	List of Tier A authorities, with the boundaries of the Municipal Corporations and of the planning areas and special areas notified under the Himachal Pradesh Town and Country Planning Act, 1977
1B	Maps of flood-sensitive catchments
1C	Policy Supplement: text of alternatives S-1 to S-5 and model council resolution
1D	Model TCP Rules 2014 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 Himachal Pradesh. Where a Municipal Corporation, Nagar Parishad, Nagar Panchayat, TCP, a SADA or BBNDA has adopted a stricter rainfall standard under Chapter 1, the stricter standard governs.

> **Commentary.** Most past drainage failures in Himachal Pradesh trace to the rainfall input, not the hydraulics. Himachal Pradesh shows how. No design storm was found for any town's drains in the State: the NGT's expert committee found in 2017 that Shimla's drains were "not able to carry the peak flow", with catchments "improperly selected" and gradients "much lesser … than actually required" (NGT, OA 121/2014, as quoted; the judgment was set aside in 2024), and neither the 55 km of drains built in Shimla under AMRUT nor any later scheme states the storm it was built for. The published sources that seem to fill the gap do not. IMD Das et al. (2022) has no station in the State; the northern-zone equation of Ram Babu et al. (2006) gives about 129 mm in 24 hours at 50 years, below the Shimla plate value and about half the 270 mm recorded in 24 hours at Dharamshala; and NIH-DHAARA has not been checked in the State (Clause 2.3.6). The rainfall figures that circulate after a flood are often conflicting: Shimla's fall of 14 August 2023 is reported as 108.5 mm at its automatic weather station and as 126 mm and 135 mm in the press, the number of cloudbursts of 2023 as 27, 45 and 52, and Una's highest day as 228.5 mm in 2023 by IMD and 276 mm in 1947 by the CWC zone-7 report (IMD; CWC; as reported). The CWC zone-7 report is the only regional sub-daily source, and its 1-hour ratio of 0.425 would give the Dhauladhar front more than twice the largest hour its recording gauge has measured. Fixing one transparent source and method for the whole state is the main purpose of this chapter.

2.2 Definitions

Term	Meaning in this Manual
Annual exceedance probability (AEP)	Probability that a given rainfall depth is equalled or exceeded in any one year. A 1% AEP storm is the "100-year" storm. Both forms are used here: T-year = 1/AEP.
IDF / DDF	Intensity–duration–frequency and depth–duration–frequency relationships for a location.
Point rainfall	Rainfall at a single location, as measured by a rain gauge.
Design storm	A hyetograph (rainfall depth versus time) of stated AEP, duration and temporal pattern.
Critical duration	The storm duration that produces the largest peak flow, water level or storage requirement for the element being designed.
Areal reduction factor (ARF)	Ratio of catchment-average rainfall to point rainfall for the same AEP and duration.
SW monsoon season (JJAS)	June–September. The State's normal for the season is 734.4 mm, with 255.9 mm in July and 256.8 mm in August, against 240.7 mm in March–May and 82.9 mm in October–December (IMD, Meteorological Centre Shimla). Gauge normals run from 309.9 cm a year at Dharamshala on the Dhauladhar front, through 140.4 cm at Solan and 123.7 cm at Barauli in Shimla district, to 98.4 cm at Kullu and 62.2 cm at Keylong in the snow-fed north (CWC, zone 7, Annex 4.3). The monsoon reaches the State against the outer ranges, and western disturbances often join it, as in each of the four spells of July 2023 (IMD). IMD's normal date of onset over the State is 25 June and of withdrawal 25 September (new normals from 2024; 24 June and 24 September before). The earliest onset of 1997–2026 was 9 June 2000 and the latest withdrawal 11 October 2019, and withdrawal was later than normal in every year from 2018 to 2026, by a single day in 2025, and in October in seven of those nine years (IMD). The antecedent moisture rule of Clause 2.11.4 refers to this season; the pre-monsoon deadline of 31 May is set ahead of the earliest onset (Chapter 10). Directions to clean drains "before the onset of monsoon" were found only in press reports, with no fixed date.
Storms outside the season	Large falls come before, after and outside the monsoon, and **October is the main late-season threat**. Seven of the fourteen heaviest daily falls printed for the State's gauges in the CWC zone-7 report fell in September–December, among them Batheri 285 mm (4 October 1955), Nichar 268 mm (10 October 1956) and Rainka 246 mm (12 October 1956) (CWC, zone 7, Annex 4.3), and the post-monsoon season of 1955 brought 429.4 mm to the State (IMD). In 2025 a western disturbance brought heavy rain and snow on 5–7 October, after the monsoon had withdrawn on 26 September (IMD; as reported). In June, before the monsoon is established, the Dalhousie recording gauge measured 182 mm in 24 hours on 9–10 June 1971 (CWC), and pre-monsoon storms caused floods in Mandi district in June 2023 (as reported); the wettest May on record brought 214.2 mm (1987) (IMD). In winter, western disturbances bring rain and snow, December has brought up to 176 mm to the State (1929), and the doubtful falls of 610 mm and 559 mm at Kilba and Sangla in December 1958 are printed in the zone-7 report (Clause 2.3.6(h)); above about 1,500 m snow and ice block inlets (Chapter 10), and rain on snow adds to the runoff. Design statistics use annual maxima from all months, and no works deadline or operating rule shall assume that heavy rain is confined to June–September; the works calendar of Chapter 10 keeps standby to 31 October 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 Himachal Pradesh this clause is suspended until Annex 2A is published: 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 zone 7 (Western Himalayas), which covers the whole State, other than its snow-fed catchments, as applicable.

Where the design value is lower than the CWC zone 7 (Western Himalayas) 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.

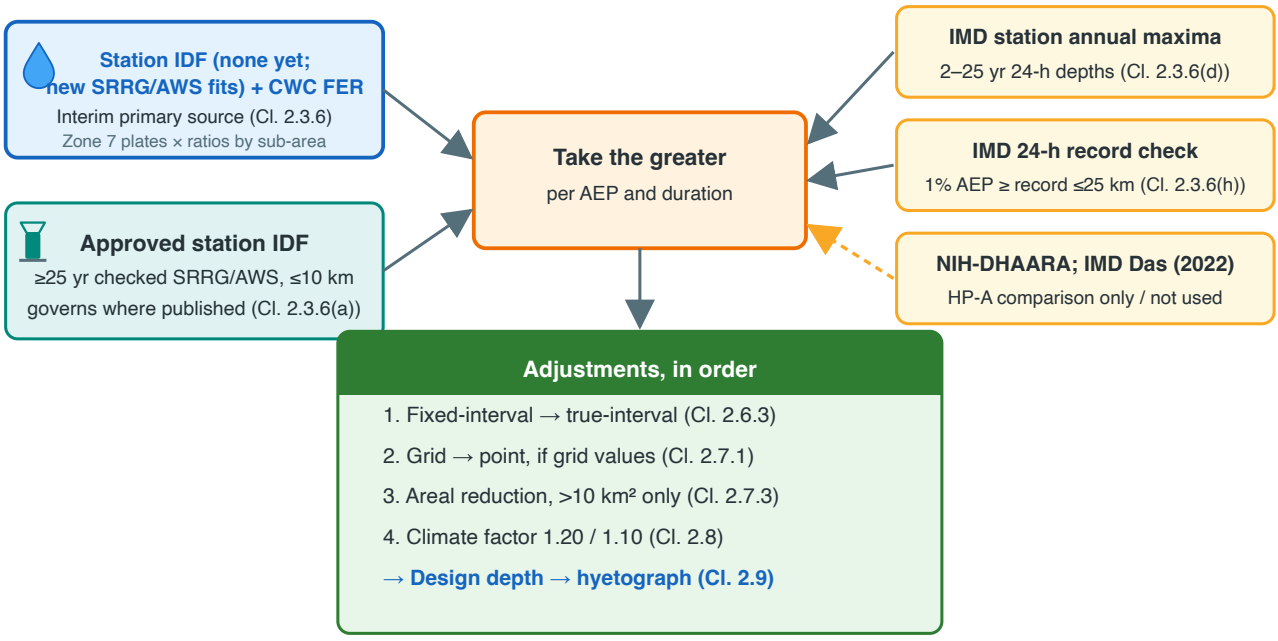

Figure 2.1 — Design rainfall source hierarchy and adjustment sequence. Original drawing for this Manual.

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

- (a) **Station IDF.** Where a station IDF fitted to a checked IMD recording-gauge (SRRG) or automatic weather station record of at least 25 years has been published in Annex 2B, it governs, within 10 km of the station and in the same sub-area of Annex 2A, for the durations and AEPs it covers, in place of (f), and subject to the 1-hour floors of (g); the comparison of Clause 2.3.2 is then made with the 24-hour and longer depths of (c) to (e) and (h), and the CWC floor of Clause 2.3.3 still applies. 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 Himachal Pradesh Clause 2.3.2(a) is read with 25 years in place of 30 (set by this Manual, so that the recording gauges and automatic weather stations of the main towns can qualify once analysed), and the gauge shall not be separated from the site by a ridge (set by this Manual, because the Dhauladhar front, the mid-hills and the inner valleys receive very different rain over short distances: the annual normal is 309.9 cm at Dharamshala and 98.4 cm at Kullu (CWC, zone 7, Annex 4.3)). No IDF has yet been published in Annex 2B, and no station IDF with constants was found for any town in the State: IMD Das et al. (2022) has no station in the State (n), the northern-zone equation of Ram Babu et al. (2006) is a generalised formula that does not fit the State (o), the station table of Ram Babu et al. (1979) was not obtained [TBC], and no IDF study of IIT Mandi, NIT Hamirpur or the State's universities with published constants was found [TBC]. The first data request of this Manual is for the recording-gauge and automatic weather station records of the IMD stations of the main towns, to be fitted under this paragraph: Shimla (the observatory, the recording gauge used by the CWC zone-7 report and the automatic weather station), for the Shimla Planning Area; Dharamshala (the observatory, the recording gauge and the automatic weather station) and Kangra Aero (Gaggal), for Dharamshala, McLeodganj and Kangra; Mandi (42078) and the recording gauge at Sundernagar, for Mandi and the Balh valley; Una and the Una Rampur automatic weather station, for Una; Solan (42106) and the recording gauge at Dharampur, for Solan, Dharampur, Kasauli, Parwanoo and Baddi; Bhuntar and Manali, for Kullu–Manali; Kalpa and Keylong, for the towns of sub-area HP-C; and the automatic weather stations and automatic rain gauges of the Meteorological Centre Shimla elsewhere. The years of recording-gauge and automatic weather station data held at each are to be confirmed [TBC].

- (b) **Report, zone and sub-area.** One CWC report covers the whole State: the report for zone 7, Western Himalayas (WH/22/1994), which names Himachal Pradesh among the States of the zone and draws on 13 of its districts. No part of the State lies in subzone 1(e), Upper Indo-Ganga Plains: on the plates of the 1(e) report the boundary between the two reports runs along the Siwalik front just outside the State, so that Una, Nalagarh, Baddi, Parwanoo, Nahan and Paonta Sahib lie about 5–15 km inside zone 7 (distances read by eye on the plates, about ±5 km); whether the Indora–Damtal area at the exit of the Beas near Pathankot lies in 1(e) has not been resolved [TBC]. The 1(e) plates may be read at the southern edge of the State for comparison, and are recorded on Form 2-1, but they are not design values (set by this Manual). The rainfall zone and sub-area of the site are those of Annex 2A: zone **HP-Z1 Siwalik foothills**, with sub-area **HP-A Siwalik foothills and outer valleys (Una–Baddi–Nahan–Paonta–Bilaspur–Hamirpur)**; zone **HP-Z2 Mid-hills**, with sub-areas **HP-B Mid-hills (Shimla–Solan–Mandi–Chamba–Rampur)**, **HP-B1 Dhauladhar front (Dharamshala–Kangra–Palampur–Jogindernagar)** and **HP-B2 Kullu–Manali inner valley**; and zone **HP-Z3 High and trans-Himalaya**, with sub-area **HP-C High and trans-Himalaya (Kinnaur–Lahaul–Spiti; snow-fed)**. They fix the ratios of (f), the floors of (g) and the rule of (i). A catchment that crosses the line between two zones or two sub-areas of Annex 2A takes, at every duration, the higher value of the two (set by this Manual). The town lists of Annex 2A are a guide, and their boundaries are to be confirmed [TBC].

- (c) **24-hour depth, 2% and 1% AEP (50- and 100-yr).** The 24-hour point value at the site read from the 50- and 100-year isopluvial plates of the zone-7 report (Plates 9 and 10), whatever the catchment area. Where the site lies between two contours, the higher contour value is used; where it lies inside a closed contour with no higher contour within it, the value is that contour plus one contour interval (40 mm); and where the plate cannot be read at the site, the highest contour legible within 25 km of the site is used until the plate has been read for it [TBC] (all set by this Manual). Plates are read by the coordinates of the site, not by the town labels; the plates are drawn on

a skewed projection, the scan available is poor, and on the copy used for this Manual the town positions on Plate 10 are misregistered by about 0.3°, so each reading is recorded on Form 2-1 with the contours on either side. For orientation only, read by eye to about one contour on scans re-rendered for this Manual, the 50-year plate gives **about 160–200 mm at Shimla**, which lies in a relative low, with a closed contour of less than 180 mm just north-east of the town; about 240–280 mm at Solan, Dharampur, Kasauli, Nahan and Paonta Sahib; about 280 mm at Una, Bilaspur and Nalagarh–Baddi–Parwanoo, with a spot of more than 280 mm near Nalagarh; about 320 mm at Hamirpur; 320–360 mm at Kangra, Palampur and Sundernagar; 320–400 mm at Jogindernagar; **a closed 400 mm cell over Mandi**, which the rule above takes as 440 mm; **a closed cell at Dharamshala** inside the 320 mm line, whose inner label, about 400 mm, is not legible [TBC], so that the rule above gives 440 mm if the inner contour is confirmed as 400 mm; a closed cell over Dalhousie and Chamba whose labels are uncertain [TBC]; about 280–320 mm at Kullu and Bhuntar, more than any day recorded at Kullu (commentary); about 200–240 mm at Manali and Rohru and about 200 mm at Rampur Bushahr; about 280 mm at Reckong Peo and Sangla, on the ring of a closed cell over the Baspa valley; and about 120–160 mm at Keylong and 120 mm at Kaza, in the snow-fed north. The 100-year values are about one contour (40 mm) higher: about 200–240 mm at Shimla, 280 mm at Solan, 320 mm at Una and Nahan and 240–280 mm at Rampur, with closed cells near Pong and near Sundernagar labelled, probably, 440 mm [TBC]. The worked example of the zone-7 report, the Banu Khad in Kangra, reads 32.0 cm at 50 years, consistent with the reading at Kangra and Palampur. Where the Gumbel estimate of (d) for the station of the site is higher for the same AEP, it governs; the 24-hour depth is then checked under (h).

- (d) **24-hour depth, 50%, 20%, 10% and 4% AEP (2-, 5-, 10- and 25-yr).** The depth is the Gumbel (EV1) estimate from the annual maximum daily rainfall series, of all months, of the IMD station agreed with the Authority, with 30 or more years of daily record, checked as in (a), multiplied by the fixed-interval factor of Clause 2.6.3; the 4% AEP depth is not less than the 25-year plate value (Plate 8) read as in (c) (set by this Manual). The station is, for example, Shimla for the Shimla Planning Area; Dharamshala for Dharamshala, McLeodganj and Kangra; Mandi (42078) for Mandi and the Balh valley, with Sundernagar as a check; Solan (42106) for Solan and Dharampur; Una for Una; Nahan for Nahan and Paonta Sahib; Bilaspur for Bilaspur; Kullu or Bhuntar, and Manali, for the Kullu valley; and Kalpa and Keylong for the towns of HP-C. No Gumbel fit to the annual maxima of any station in the State was found for this Manual, and the years of daily record held at each station are to be confirmed [TBC]; IMD's monsoon reports of the Meteorological Centre Shimla show records of more than 20 years at Una, Manali, Rohru, Pachhad and Keylong, whose previous highest days they date to 1927, 1971, 1966, 1973 and 1951. The annual normal of Solan is printed as 140.4 cm in the zone-7 report and as 737.8 mm in a study of its record of 1988–2019 (Das & Ganguli, 2022, preprint); the record is to be checked as in (a) before it is fitted [TBC]. 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 same station, 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).

- (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 **HP-A** (Siwalik foothills and outer valleys), **HP-B** (Mid-hills) and **HP-B2** (Kullu–Manali inner valley), and in the local catchments of HP-C that (i) allows, the ratios of zone 7: 0.425 at 1 hour, 0.600 at 3 hours, 0.725 at 6 hours, 0.790 at 9 hours, 0.845 at 12 hours, 0.895 at 15 hours and 0.935 at 18 hours, derived from the 10-year depths of the nine recording gauges of the zone with eight years or more of data (CWC, zone 7); and
    - in sub-area **HP-B1** (Dhauladhar front), the 50-year ratios of the CWC report for subzone 1(e), applied to the 24-hour depth of the zone-7 plates: 0.34 at 1 hour, 0.475 at 2 hours, 0.56 at 3 hours, 0.607 at 4 hours, 0.647 at 5 hours, 0.68 at 6 hours, 0.77 at 9 hours, 0.84 at 12 hours, 0.89 at 15 hours and 0.93 at 18 hours.

  The zone-7 ratios are the highest of any report in the series; the report found them comparable at return periods beyond 5 years, and they are applied at every AEP. In HP-A and HP-B they give about 102–119 mm in 1 hour at 50 years at Solan and Dharampur and at Nahan, against the 100 mm recorded by the Dharampur recording gauge on

9 August 1985 and the 84 mm recorded at Nahan on 1 August 1980, from a record of less than five years (CWC, zone 7, Annex 4.4); they are consistent with the hours of record at the Siwalik front. At Shimla they give about 68–85 mm, against 50 mm, the largest hour of its recording gauge (12 July 1979), and the floor of (g) is added because Shimla's plate value is low. On the Dhauladhar front the 24-hour depths are orographic: the front catches long monsoon rain whose daily totals are very large, while its hours are not larger in proportion. There the zone-7 ratio would give about 170–187 mm in 1 hour on a plate value of 400–440 mm, against the 73 mm recorded by the Dharamshala recording gauge on 4 August 1975, the largest hour of a record whose 24-hour maximum is 270 mm (1-hour ratio 0.27), and the 59 mm recorded at Dalhousie on 9 June 1971 (ratio 0.32, from a record of less than five years) (CWC, zone 7, Annex 4.4). The 1(e) ratio gives about 136–150 mm, still about twice the recorded hour, and is used as a conservative interim value; it is the ratio that the Uttarakhand edition of this Manual uses for the same reason on its outer ridge, and it sits above every 1-hour ratio recorded on the front. Between the tabulated durations the ratio is interpolated on logarithmic axes; the 2-hour ratio of zone 7, which the report does not give, is interpolated in the same way. The 24-hour depth itself is that of (c) or (d) as checked under (h).

- (g) **Short storms.** No absolute floor in millimetres is set for any sub-area of the State, because the State has no plain and the ratios of (f), applied to the plate depths, already give 1-hour depths at or above the hours of record. Two floors guard against lower values where a station analysis governs (all set by this Manual):
    - (i) **Dhauladhar front.** In sub-area HP-B1 the 1-hour depth for every AEP shall be not less than 0.34 times the 24-hour depth of (c) or (d) for the same AEP, before the check of (h), including where a station IDF governs under (a). A station fit at Dharamshala, whose recording gauge gives a single-event ratio of 0.27, may otherwise fall below the ratio of (f); the floor keeps the 1(e) ratio as the lower bound until Annex 2B publishes frequency analyses of the front's recording gauges.
    - (ii) **Shimla.** In the Shimla Planning Area the plate's relative low is kept, but the 1-hour depth for every AEP shall be not less than 50 mm multiplied by the ratio of the 24-hour depth of (c) or (d) for that AEP to the 24-hour depth for the 10% AEP (10-yr), before the check of (h); that is, the largest hour of Shimla's recording gauge, 50 mm on 12 July 1979, is treated as the 10-year 1-hour depth and scaled to the other AEPs by the growth of the 24-hour depths. The gauge's record, of the 1970s and 1980s, is of the order of ten years (its length is not printed in the zone-7 report [TBC]), which is why its largest hour is treated as a 10-year depth. With the zone-7 ratio the floor binds only where the 10-year 24-hour depth used is below about 118 mm; it guards against a light station fit, not against the plate.

  Where a floor of this paragraph governs the 1-hour depth, the 2-hour depth shall be not less than the value interpolated on logarithmic axes between the 1-hour and 3-hour depths for the same AEP. The floors are present-day, true-interval values: the fixed-interval factor of Clause 2.6.3 is not applied to them, and the climate factor of Clause 2.8 is. They are interim, to be revisited when Annex 2B publishes frequency analyses of the recording-gauge and automatic weather station records of the stations of (a), beginning with Shimla, Dharamshala, Mandi and Dharampur: if any shows 1- or 3-hour depths above those of (f) and (g) for a sub-area, a floor shall be set or raised for it; if together they show depths well below them, a reduction may be proposed to the State Stormwater Technical Committee. The depths of (f) and (g) are present-day, true-interval values once the fixed-interval factor has been applied to the 24-hour depth; the climate factor of Clause 2.8 is then applied.

- (h) **24-hour record check.** 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 or district rain gauge within 25 km of the site, 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 2% AEP (50-yr) 24-hour depth is then not less than the 1% AEP depth so raised less one contour interval of the plates, 40 mm (all 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 monsoon report of the Meteorological Centre Shimla, a later IMD table or an IMD press release that names the gauge and the day) or in Annex 4.3 of the zone-7 report, which CWC prepared jointly with RDSO, IMD and the Ministry of Surface Transport; 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). IMD's district tables of the heaviest rainfall in the State and its table of station extremes were not obtained for this Manual [TBC], so no record printed in the zone-7 annex yet has the length of its gauge's record confirmed, and none counts until it has. No record therefore raises the plates in the State at present. The records of 2023 that IMD printed as new highest days, among them 185 mm at Rohru, 220.3 mm at Pachhad and 131.3 mm at Manali, whose gauges IMD's report shows to have more than 20 years of record, qualify, and like the other heavy falls of that year, 273.4 mm at Kangra Aero, 254.0 mm at Sujanpur Tira, 250.2 mm at Dharmsala and 250.0 mm at Nahan, they lie below the plates and raise none (IMD, Meteorological Centre Shimla, Monsoon Report 2023). Excluded pending confirmation [TBC]: **600 mm at Dharamshala on 18 July 1967** and **394 mm at Joginder Nagar on 18 August 1954**, which pass every other test but whose gauges' years of record are not confirmed by an IMD table read for this Manual. They are the first records to confirm, Dharamshala first: once its gauge is confirmed to have at least 20 years of record, it raises the 100-year 24-hour depth of sub-area HP-B1 within 25 km of the gauge, in Dharamshala, McLeodganj, Gaggal, Kangra and Palampur, to 600 mm, against a plate value of about 480 mm if the inner contour of the Dharamshala cell is confirmed as 400 mm, and Joginder Nagar's raises Jogindernagar and Baijnath where the plate reading at the site is lower; until then the designer reports both on Form 2-1 beside the design depth. Also excluded pending confirmation: **419 mm at Barauli (Shimla district) on 21 August 1901**, whose gauge has not been located for this Manual and which, if it lies within 25 km of Shimla, would raise the town's 100-year depth by three-quarters or more; **610 mm at Kilba on 27 December 1958 and 559 mm at Sangla on 21 December 1958**, December falls of about 87% and 67% of the annual normal of their gauges in one day, which may be snow measured as water or errors of transcription, until IMD confirms them; the values the zone-7 annex prints for **Una (276 mm, 26 September 1947), Bilaspur (226 mm, 7 August 1971) and Keylong (128 mm, 17 September 1950)**, which IMD's reports of 2023 contradict by giving lower previous records (224 mm on 22 July 1927 at Una, 103.2 mm on 26 July 2012 at Bilaspur Sadar and 78 mm on 28 July 1951 at Keylong) and by calling the falls of 2023 at the Una Rampur and Keylong automatic weather stations (228.5 mm and 83 mm) new records, until IMD states which gauge each value belongs to, although none of them raises a plate; and Kullu's 236 mm (4 October 1888), a record made before 1901, which is below the plate in any case. Until Annex 2A is published, the designer lists on Form 2-1 every record within 25 km of the site, with the tests it passes or fails. The check raises the 24-hour depth and, through (e), the 48- and 72-hour depths, in every sub-area, and in HP-C as a minimum for the study of (i). It does not raise the depths of (f) and (g) for 1 to 18 hours, because the records are daily totals of long monsoon storms against the Dhauladhar, no hourly record of any of them exists, and multiplying Dharamshala's 600 mm by the ratio of (f) would give about 204 mm in 1 hour, nearly three times the largest hour recorded there. The check is made because the plates cannot be relied on in the tail on which floors, storage and spillways depend where the State's wettest gauges have recorded more than their 100-year depth (commentary).

- (i) **Snow-fed catchments and sub-area HP-C.** The zone-7 report states that its relations are not to be used for design floods in the snow-fed area of the zone, and that its recommendations are to be applied with caution where catchments are covered by snow and glaciers (CWC, zone 7). In sub-area HP-C (High and trans-Himalaya), and in any catchment elsewhere with permanent snow or a glacier within it, such as the upper catchments of the Beas, the Parbati, the Ravi and the Sutlej, the design is hazard-first: the design rainfall and design flood are site-specific, the method, data and values are agreed with the Authority and the Jal Shakti Vibhag and recorded on Form 2-1, and they are not less than the values of (c) to (h) for the rain falling on the part of the catchment below the snow [TBC]. For a local catchment wholly below the snow and without a glacier, such as the slopes of a town in HP-C, (c) to (h) apply as in HP-B. No design in HP-C, and no design in any sub-area for a site with a glacier, a glacial lake, a moraine- or landslide-dammed lake or a mapped debris-flow fan in the catchment above it, is complete without a glacial lake outburst flood (GLOF), landslide-lake and debris-flow screening recorded in the drainage report: it identifies the glacial lakes, moraine dams, landslide dams and debris-flow fans upstream, from the inventories of glacial lakes of the State Centre on Climate Change, the glacial lake monitoring of CWC and the landslide inventories and hazard maps of HPSDMA and the State Centre on Climate Change where they exist [TBC], and states whether the site lies on their flow path; where it does, the siting, setback and floor-level rules of Chapters 6 and 7 govern, because no drain is sized to carry a debris flow or an outburst (all set by this Manual). The inventory of 2019 counted 562 glacial lakes in the Sutlej basin, 242 in the Chenab, 93 in the Beas and 37 or 38 in the Ravi (as reported). The disasters of the State's high valleys have been outbursts and debris flows more

than rainfall: on 26 June 2005 the outburst of the Parechu lake, a landslide lake in Tibet, raised the Sutlej by a reported 12–15 m and set the highest levels at Titang, Nathpa and Rampur (as reported; CWC data as transcribed by SANDRP); on 31 July 2024 a debris flow down the Samej khad, where there was no rain gauge, killed 56 people (as reported); and the Kinnaur cell of the plates, about 280–320 mm at 50 years, rests largely on the two doubtful December falls of 1958 excluded under (h).

- (j) **Cloudbursts.** IMD calls a fall of 100 mm or more in one hour over a small area a cloudburst (as quoted; no IMD primary document was found for this Manual [TBC]). No design rule is drawn from the term. No gauge in the State was found in a primary source to have recorded more than 100 mm in an hour: the 100 mm of the Dharampur recording gauge (9 August 1985) equals the threshold (CWC). The counts of cloudbursts published after each monsoon are counts of damage reports, not measurements: for 2023 they are 45 and 27 in two parts of the post-disaster needs assessment and 52 in the district counts that IMD quotes from HPSDMA, and for 2025, 46 or 47 (as reported); IMD's report of the cloudbursts of 31 July 2024 at Samej, Rampur and Padhar leaves the intensity blank, and IMD said that the areas had no gauges, as there were none at Samej, at Bagipul and Rajban, or at Thunag in Seraj on 30 June–1 July 2025 (IMD; as reported). The 1-hour design depths of (f) at 50 and 100 years, about 100–155 mm in HP-A before the climate factor, are of the same order as the threshold, so a burst of that size is within the range for which the major system of Chapter 6 is checked. What a burst does in a steep hill catchment that a design storm does not represent is to bring down boulders, slope debris, felled timber and muck in its first minutes, as on the khads of Seraj in 2023 and 2025 and at the Malana II dam in 2023, which filled with debris and overspilled (as reported). 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 storms of the hills are front-loaded: the zone-7 report puts 73% of a 3-hour storm, and 52% of a 6-hour storm, in its first hour (CWC, zone 7, Annex 4.1).

- (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 not queried at any point in the State for this Manual [TBC]. In sub-area HP-A its present-day values at the site may be reported on Form 2-1 beside the interim values, for comparison only. In HP-B, HP-B1, HP-B2 and HP-C it is not used or reported, because its reanalysis cells were found, in research for the other mountain State of the series, to break down at short durations in the hills, with 50-year 1-hour depths of about one-tenth of the 24-hour depths of the same cells (NIH-DHAARA, queried 10 Nov 2026). Its projected depths are not used under Clause 2.8.4; the ratio of its projected to its present-day depths may be reported as a check on the climate factors of Table 2.2, which apply.

- (n) **IMD Das et al. (2022).** The paper has no panel for any station in Himachal Pradesh. Its nearest panels, for Jammu, Amritsar and the Doon, repeat the generic curve that the paper prints for most of its cities and are not station data. The cross-check of Clause 2.3.3(a) is recorded on Form 2-1 as not available, and the paper is not used as a value, a check or a floor.

- (o) **Earlier design values.** No design storm, return period, runoff coefficient or drain standard was found for the drains of any town in the State. The expert committee whose report the NGT recorded in 2017 found that storm drainage covered about 30% of Shimla, that its drains were "not able to carry the peak flow", that their catchments were "improperly selected" and that they had been built "for longer distances with much lesser gradients than actually required" (NGT, OA 121/2014, 16 November 2017, para 53, quoting the expert committee; the judgment was set aside by the Supreme Court on 11 January 2024 and is cited for the committee's findings only). The drains of Shimla counted as about 67 drains and 42.33 km in 2015 and the 191 drains and nallahs, 55.43 km, built under AMRUT state no design storm (Shimla Municipal Corporation, 2015 and 2022), nor does the proposal of the Jal Shakti Vibhag for storm-water drainage of Una town (₹19.66 crore). Road drains follow IRC:SP:42-2014 (10-year drains and 25- or 50-year culverts on national and State highways; Chapter 6) and

IRC:SP:48. The northern-zone IDF equation of Ram Babu et al. (2006) gives about 129 mm in 24 hours and 77 mm in 1 hour at 50 years, below the Shimla plate value at 24 hours and about half the 270 mm recorded in 24 hours at Dharamshala; one zonal equation cannot represent both the Dhauladhar front and the mid-hill rain shadow, so it is a generalised formula under Clause 2.3.4(a) and is not used. 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 Himachal Pradesh the platform has not yet been shown to meet that purpose. It was not queried at any point in the State for this Manual, and in the hills of the other mountain State of the series its reanalysis cells, of about 12 km, broke down at short durations, giving 50-year 1-hour depths of about one-tenth of their 24-hour depths. A source that has not been checked, and that fails in the same terrain elsewhere, cannot be adopted, so Clause 2.3.6 uses the CWC zone-7 report and the IMD station records until Annex 2A has been done, allows NIH-DHAARA for comparison in the Siwalik foothills only, and does not use it in the hills. Himachal Pradesh is the second mountain State of the series and the first with no plain, and three things set its interim source apart. First, one hill report covers the whole State. The 1(e) line runs just outside the Siwalik front, so no floor of the plains applies, and the State's own gauges carry more weight than anywhere else in the zone: three of the six catchments on which the zone-7 unit hydrograph rests drain the State, the Neogal Khad and the Banu Khad in Kangra and the Chakki Khad, gauged at Pathankot, which drains the Kangra–Chamba hills, and the Neogal and the Banu are the steepest of them; the report's worked example is the Banu Khad; and the report warns that its relations are not to be used without checking them, and not at all in snow-fed areas (CWC, zone 7). The zone-7 ratio of 0.425 at 1 hour is consistent with the recorded hours at the Siwalik front, where the single-storm maxima of the recording gauges give 1-hour ratios of 0.64 at Dharampur and 0.87 at Nahan, from a short record, and is a little above them in the mid-hills, 0.39 at Shimla and 0.42 at Sundernagar; on the Dhauladhar front the ratios are 0.27 at Dharamshala and 0.32 at Dalhousie, because there the daily totals are swollen by orographic monsoon rain (CWC, zone 7, Annex 4.4; maxima of different storms at some gauges). That is why Clause 2.3.6(f) uses the plains ratios on the front's plate, and why (g) keeps 0.34 as the front's lower bound. Shimla sits in a relative low of the plates, about 160–200 mm at 50 years, which its recording gauge supports (127 mm, its largest day of record), so the low is kept, with a floor on the 1-hour depth from the largest hour the gauge recorded. Second, the 24-hour records exceed the plates only on the Dhauladhar front and in Kinnaur. Dharamshala recorded 600 mm on 18 July 1967 and Joginder Nagar 394 mm on 18 August 1954, against 100-year plate values of about 480 mm and 360–440 mm; Kilba and Sangla recorded 610 mm and 559 mm in December 1958, at gauges whose annual normals are 70.3 cm and 83.8 cm; elsewhere the records of 1901–2023, among them the falls of 220–275 mm of July and August 2023 at Una, Nahan, Pachhad, Sujanpur Tira, Dharmsala and Kangra Aero, lie at or below the plates (CWC, zone 7, Annex 4.3; IMD). Clause 2.3.6(h) answers that with a check rather than a new statistic, as the series does elsewhere. Its test of record length keeps a gauge of a few years from setting the depth of a whole town, as in the other editions of the series; IMD's tables of the State, which would confirm record lengths, were not obtained for this Manual, so no record raises a plate yet, and Dharamshala's 600 mm and Joginder Nagar's 394 mm wait for IMD to confirm their gauges, Dharamshala first, because it would raise the 100-year depth of the front to 600 mm; until then the designer reports them on Form 2-1. Its test of plausibility keeps out the December falls of Kilba and Sangla, which would otherwise set the depth of the Baspa and Sutlej valleys and probably drew the closed cell of the plates over Kinnaur, until IMD confirms them, and its test of consistency keeps out the annex values for Una, Bilaspur and Keylong that IMD's own reports contradict. The check stops at 24 hours, because a record day says nothing about its peak hour. Third, the hazards of the high valleys and of the mid-hill slopes are not all rainfall: the outburst of the Parechu lake (2005), the debris flows of Samej (2024) and Seraj (2025), and the slide at Summer Hill in Shimla (2023), whose technical committee named open drainage and the infiltration of water into the debris cover among

its causes, are represented by no design storm, which is why Clause 2.3.6(i) sets a screening and not a depth, and why the hill rules of Chapters 4, 6 and 8 keep water out of slopes. The interim rules for the more frequent AEPs, the 48- and 72-hour depths, the reading of the plates, the sub-area of each town, the ratios of the Dhauladhar front, the 1-hour floors, the record check, the snow-fed and debris-flow rules and durations below 1 hour are set by this Manual. Several points are unresolved. The plate values were read by eye, to about one contour, on a poor scan drawn on a skewed projection, with Plate 10 misregistered; the inner label of the Dharamshala cell cannot be read, the Mandi cell, about 400 mm, is far above any day recorded near Mandi, and the plate at Kullu, about 280–320 mm, is above every day recorded there, 236 mm in 1888 at most (CWC, zone 7, Annex 4.3) [TBC]. The zone-7 report's worked example for the Banu Khad prints a time to peak of 2.5 hours where its own equations give about 3.05 hours, and a loss rate of 0.20 cm/h where its paragraph 3.5 recommends 0.5 cm/h (Chapter 3). The annex values for Una, Bilaspur and Keylong, the 1958 falls in Kinnaur, the location of the Barauli gauge and the record lengths of all the State's gauges are to be obtained from IMD (Clause 2.3.6(h)); the annual normal of Solan is printed as 140.4 cm in the zone-7 report and 737.8 mm in a later study. No storm-drain DPR for any town of the State with its design rainfall analysis was found for this Manual [TBC], so the design basis of the drainage study that Shimla commissioned after the slides of 2023 could not be compared with this clause.

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: Shimla, Solan, Mandi, Dharamshala and Baddi 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. Himachal Pradesh's worst floods have come when days of rain fill the soils, springs and reservoirs and raise the rivers. On 7–11 July 2023 the State received 223 mm in four days, more than five times the normal, under an active monsoon joined by a western disturbance, one of four in that month, and July 2023 brought 448 mm, 75% above normal (IMD; PDNA, 2023). The slides of Shimla on 14–15 August 2023 followed a wet spell that the technical committee traced from April to August (HIMCOSTE-led committee, 2023), and Pong rose from 1,374.20 ft to 1,399.65 ft (about 418.86 m to 426.61 m) between 11 and 15 August 2023, close to its maximum level (as reported). In August and September 2025 the State received 431.3 mm and 205.7 mm, 68% and 71% above normal, and in the first week of September Pong stood about 5 ft above its full reservoir level and Bhakra within a foot of its own (IMD; as reported). The khads and nallahs rise within an hour of a burst, but the landslides, the debris that blocks their culverts and the rivers and reservoirs that hold their outfalls up are set by the whole wet spell, not its peak hour. A rule based only on critical duration, applied to a small site, picks a 1–2 hour storm and misses this failure mode. That is why the long-duration checks are mandatory.

2.6 Sub-daily rainfall

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

2.6.2 Where only daily (24-hour) depths are available for a duration below 24 hours, the sub-daily depth shall be derived using the **ratio set of Annex 2B**. These are duration-to-24-hour ratios calibrated to Himachal Pradesh recording gauges. They shall not be lower than the ratios of the CWC Flood Estimation Report for zone 7 (Western Himalayas), except as Clause 2.3.6 provides for the Dhauladhar front. IMD Das et al. (2022) has no Himachal Pradesh station 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 $P(t) = P(24)\cdot(t/24)^{(1/3)}$ 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 SW 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 zone 7 (Western Himalayas): 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, the 24 hours to 08:30 on 12 July 2021 brought 79.4 mm to Kangra district as a whole, against a normal of 21.2 mm, while Dharamshala town, where a flash flood swept through Bhagsunag that morning, is reported to have received about 230 mm that day (IMD, as reported; the reports of the town's rainfall differ, at 119 mm and 184 mm in the press). On 30 June–1 July 2025 Mandi district averaged 140.7 mm in 24 hours while the floods of Seraj and Thunag fell where there was no gauge at all (as reported). Single storms are patchy at a scale that no cell of about 12 km or district average can show, least of all in the hills, and the annual normals of the gauges run from 309.9 cm at Dharamshala on the Dhauladhar front to 98.4 cm at Kullu and 62.2 cm at Keylong behind it (CWC, zone 7, Annex 4.3). 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. It is at or below published projections for India: Ali and Mishra (2018) project 3-hourly 100-year maxima rising by about 20% at 1.5 °C and 25% at 2.0 °C of warming. No design uplift factor has been adopted in Himachal Pradesh. The State Action Plan on Climate Change, version II (2021–2030), gives none; it reports that annual rainfall and rainy days decreased over 1951–2013 (high confidence) and that the 1-day maximum shows a decreasing trend (low confidence), while it projects annual rainfall to rise by 5.9% (RCP4.5) to 14% (RCP8.5) by mid-century and finds that heavy rainfall and floods "are likely to increase" (Government of Himachal Pradesh, 2021). The observed trends are therefore mixed, but recent extremes have not fallen: in July 2023 Manali, Una, Keylong, Rohru, Pachhad and Nadaun recorded their highest days, new highest levels were set at Gulling, Ropa, Meenus and Ganguwala, Pong received what was reported as its highest inflow since 1974, and the monsoon of 2025 was 39% above normal, the wettest in 29 years (IMD; CWC data as transcribed by SANDRP; as reported). The case for an uplift in the State rests on these events, not on trend statistics. NIH-DHAARA was not queried for the State, so its projected depths could not be compared with its present-day ones (Clause 2.3.6(m)). The factors of Table 2.2 are therefore interim values, not Himachal Pradesh 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 (SW 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.

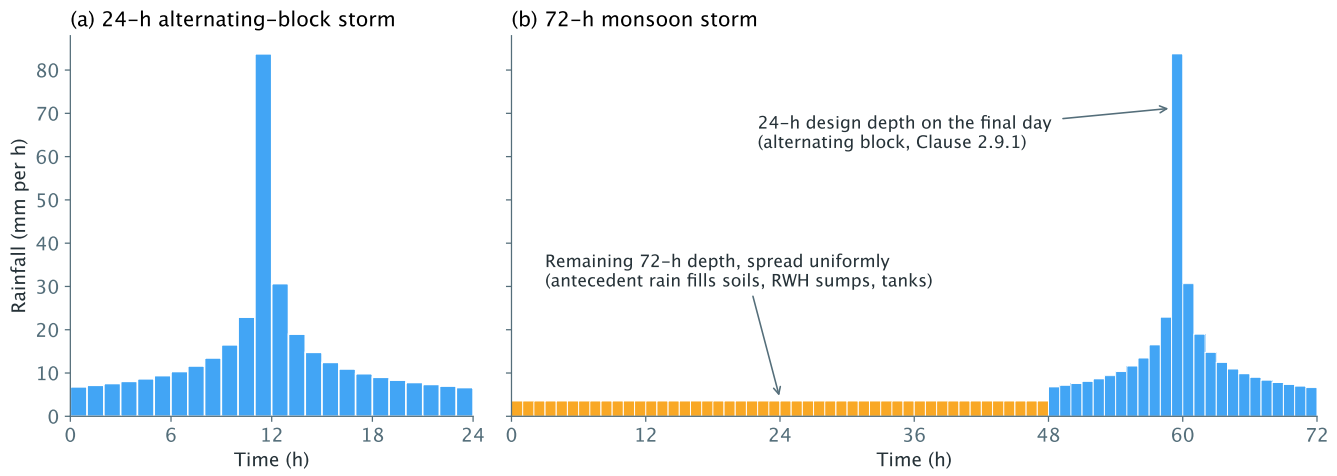

Figure 2.2 — (a) 24-hour alternating-block design storm; (b) 72-hour SW monsoon design storm with the 24-hour design depth on the final day. Illustrative depths only. Original drawing for this Manual. The alternating-block method follows Chow, Maidment & Mays, Applied Hydrology (1988), §14.4.

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

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

> **Commentary.** The alternating-block storm embeds every shorter-duration design intensity in one hyetograph. That makes it conservative and consistent across durations. The 72-hour pattern puts the most intense day last. This reproduces the monsoon sequence of Himachal Pradesh: by the time the largest falls arrive in July and August, or with a western disturbance in September or October, the debris cover of the slopes is saturated and the springs are flowing, the water table of the Balh valley is within a metre or two of the surface, Gobind Sagar, Pong and Pandoh are near their full levels, and the Beas, the Sutlej and the Yamuna are already high. SCS distributions are excluded because they come from US convective and Gulf storm data and have no basis in Himachal Pradesh records.

2.10 Retention rainfall depth

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

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

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

2.11 Design storms for pre- and post-development comparison

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

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

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

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

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

2.11.3 **Flood-sensitive catchments** (as listed in Chapter 4: the catchments of Shimla's nallahs and sinking zones, of Mandi and the Balh valley on the Beas and the Suketi, of Kullu–Bhuntar–Manali on the Beas, of Baddi–Barotiwala–Nalagarh, Una, Paonta Sahib, Dharamshala–Kangra, Rampur Bushahr and Chamba on their rivers and khads, and of the reservoir-backwater towns, 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 July to 30 September at a site in sub-area HP-B (Mid-hills), HP-B1 (Dhauladhar front), HP-B2 (Kullu–Manali inner valley) or HP-C (High and trans-Himalaya) of Annex 2A, including the Balh valley. Use AMC III for every design storm at any time of year in a catchment that drains to Gobind Sagar, the Pong reservoir, the Pandoh reservoir or any other reservoir or barrage pond or its backwater, or to a river reach whose CWC site stands at or above its warning level in the coincident case of Chapter 5 (in Himachal Pradesh, only the Yamuna at Paonta has one). At any other site or time, including the coarse Siwalik valley fills and fans of sub-area HP-A, 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 SW monsoon extremes arrive after weeks of rain. In Himachal Pradesh the ground and the receiving waters, more than the season alone, decide how wet a catchment is. The mid-hill slopes carry thick debris cover over schist, phyllite and slate that lacks primary porosity, so water moves along fractures and the debris saturates; the technical committee on the Shimla slides of 2023 found that "the long-wet spell starting from April to August" had saturated the subsoil before they failed (HIMCOSTE-led committee, 2023), and the springs that run from the slopes show that they drain slowly. In the Balh valley the water table stands 0.27–7.15 m below the surface (CGWB). On the coarse valley fills of the

Siwalik foothills, by contrast, the water table may lie more than 40 m down and the gravels take water fast (transmissivity up to about 2,600 m²/day at Una and 3,336 m²/day at Paonta–Kala Amb; CGWB), although the khads that cross them gather their water from the steep slopes above. This Manual therefore uses AMC III from 1 July to 30 September in the hill sub-areas, HP-B, HP-B1, HP-B2 and HP-C, including the Balh valley; at any time of year where the outfall is Gobind Sagar, Pong, Pandoh or another reservoir backwater, or a river at or above its CWC warning level, because those receiving waters are high only when the catchment is wet; and on the Siwalik valley fills of HP-A only 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 colony draining to a nallah in Shimla 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.

Himachal Pradesh has no coast, so no outfall in the State is tidal and cases (a) and (b) do not arise. The tailwater is the river, khad, nallah, reservoir or tal into which a town drains. For an outfall under river or reservoir backwater, the site storm is combined with the receiving-water level under Clause 5.8.4, which pairs a design event on one side with a 10-yr event on the other in the same way as case (b), and the river and reservoir levels are those of Clause 5.8.2. Only one CWC site in the State has published warning and danger levels: the Yamuna at Paonta Sahib, with a warning level of 383.5 m, a danger level of 384.5 m and a highest level of 384.6 m (5 September 1995), only 0.1 m above the danger level. The other CWC sites in the State monitor levels only and have a highest level and no warning level: the Sutlej at Rampur, 933 m, set by the Parechu outburst flood of 26 June 2005, with a reading of 924.5 m reported for 2023, a conflict to be resolved with CWC [TBC]; the Sutlej at Pandoa, 740.6 m (2005) in one record and 689.6 m (2022) in another, which is not to be used until CWC confirms it [TBC]; the Swan at Ghaluwal, below Una, 367 m, dated 3 June 2017, a date to be verified [TBC]; and the new highest levels of July 2023 on the Spiti at Gulling (3,580.34 m), the Ropa Khad (3,050.85 m), the Meenus Khad (735.3 m), the Pabbar at Meenus (730.35 m) and the Bata at Ganguwala (373.52 m), near Paonta. There is no CWC site on the Beas at Manali, Kullu, Mandi or Pandoh, on the Sutlej at Bilaspur or on the Ravi at Chamba, so the receiving-water level of the towns on those reaches is known only from surveyed flood marks.

The levels of the reservoirs of BBMB are published in feet and are converted here at 0.3048 m per foot: Pong has a full reservoir level of 1,390 ft (423.67 m) and a maximum level quoted as 1,400 ft (426.72 m), 1,410 ft (429.77 m) or 1,421 ft (433.12 m), a conflict to be resolved with BBMB [TBC], and reached 1,399.65 ft (426.61 m) in August 2023 and 1,394.71 ft (425.11 m) on 5 September 2025; Bhakra (Gobind Sagar) has a full reservoir level of 1,680 ft (512.06 m) and reached 1,679 ft (511.76 m) on 4 September 2025; the full reservoir and maximum levels of Pandoh were not found [TBC] (CWC data as transcribed by SANDRP; BBMB levels as reported; none was read in a CWC or BBMB bulletin for this Manual). The khads and nallahs that cross the towns are ungauged; they rise within an hour of a burst and carry boulders and debris, so their levels are known only from surveyed flood marks and the debris lines of 2023 and 2025. These levels are set by rain over catchments upstream, by snowmelt, by outbursts of glacial and landslide lakes and by the releases of Pong, Bhakra, Pandoh, Larji and the other dams, so storage and outfalls are checked for the outfall-closed condition with the local storm falling before, during or after the river peak. No document found in research for this Manual sets a design receiving-water level for the outfalls of any town in the State [TBC], and Chapter 5 sets the interim rule. Every level is stated on a named datum, as Chapter 5 requires; no source found states the datum of the levels quoted here [TBC].

> **Commentary.** Himachal Pradesh has no coast, so no outfall is tidal and there is no storm surge; the coincident load is the level of the rivers, khads and reservoirs that receive the town drains. The coincidence is on record. On 9–11 July 2023, when Una, Nahan and Pachhad recorded 220–250 mm in a day, the Beas submerged the Panchvaktra temple at the Suketi confluence in Mandi, and new highest levels were set on the Ropa Khad, the Spiti at Gulling and the Pabbar and Meenus Khad at Meenus (IMD; CWC data as transcribed by SANDRP; as reported). On 14 August 2023, when Kangra Aero recorded 273.4 mm, Pong received what was reported as its highest inflow since 1974 and rose to 1,399.65 ft by the next day (IMD; as reported). In the hill towns the khads themselves are the receiving waters: they rise within an hour of a burst on the slopes above, while the storm is still falling on the town below. These levels are set by rain over catchments upstream, by snowmelt, by the outburst of glacial and landslide lakes, as on the Sutlej in 2005, and by the releases of the dams, so they give no warning of a local storm that falls while they are high. The levels quoted by different sources differ: the highest level of the Sutlej at Rampur is given as 933 m (2005) and a reading of 924.5 m is reported for 2023, the Sutlej at Pandoa as 740.6 m and 689.6 m, Pong's inflow on 14 August 2023 as 7.3 lakh and 5.13 lakh cusecs, and its maximum level as 1,400, 1,410 and 1,421 ft (as reported), which is why Chapter 5 requires every level to name its source and datum. Because rainfall and surge share a weather cause (in Himachal Pradesh, which has no coast, the counterpart of surge is the stage of the rivers, khads and reservoirs that receive the town drains, raised by the same monsoon systems and western disturbances that bring the heaviest rain to the towns: on 9–11 July 2023 Una, Nahan and Pachhad recorded 220–250 mm in a day while the Beas submerged the Panchvaktra temple at Mandi and new highest levels were set on the Ropa Khad, the Spiti at Gulling and the Pabbar at Meenus, and on 14 August 2023 Kangra Aero recorded 273.4 mm while Pong received what was reported as its highest inflow since 1974, all 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.

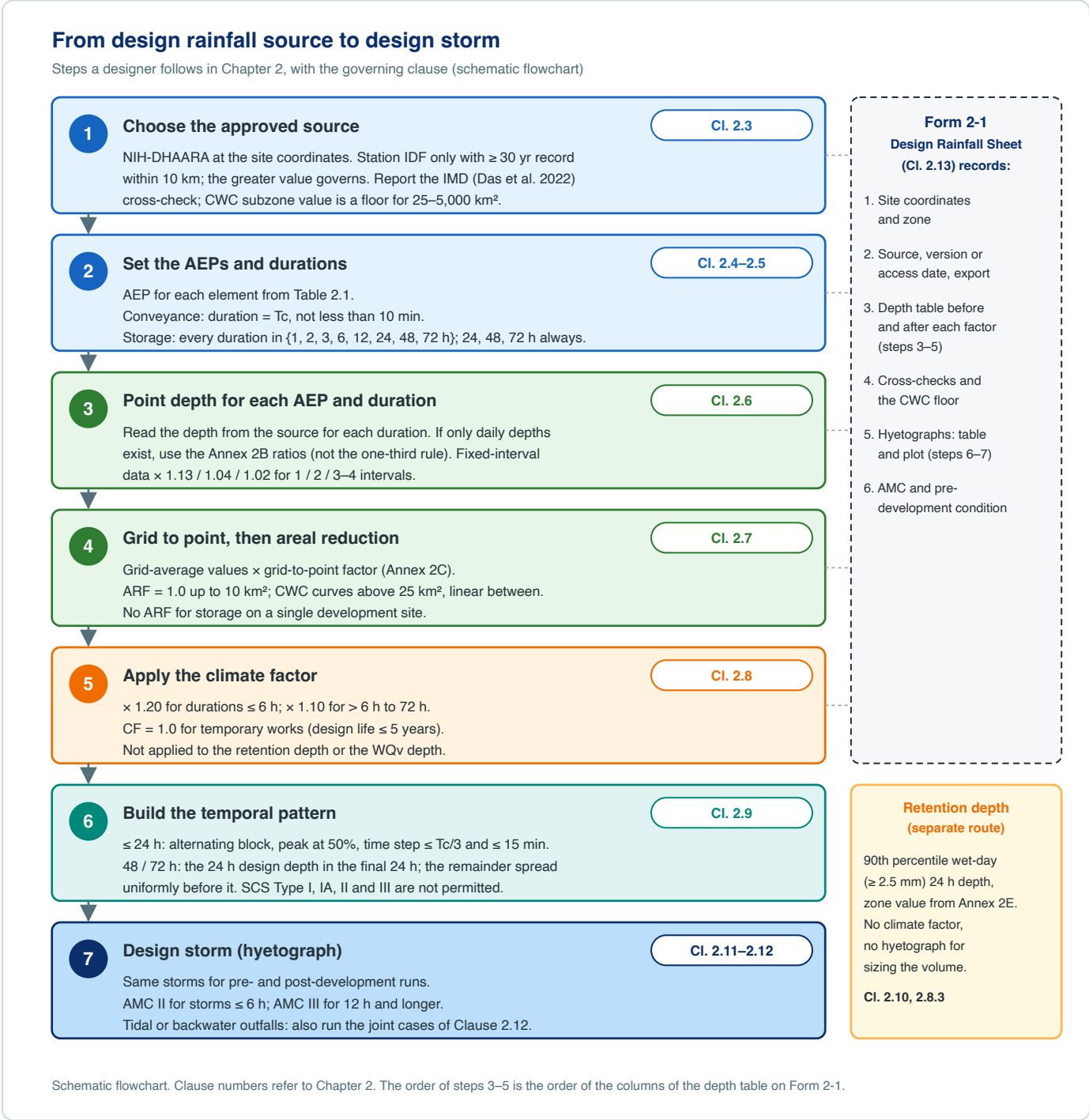

Figure 2.3 — From design rainfall source to design storm: the steps a designer follows (source, AEPs and durations, point depth, grid-to-point and areal reduction, climate factor, temporal pattern, design storm), the clause that governs each step, what Form 2-1 records, and the separate route for the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

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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	Himachal Pradesh temporal patterns (Huff curves)
2E	Retention percentile depths by zone
Form 2-1	Design Rainfall Sheet

CHAPTER 3

Hydrologic Methods

3.1 Purpose and scope

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

- (a) drain, inlet and culvert sizing (Chapter 6);
- (b) retention and detention sizing, and the pre- vs post-development comparison (Chapter 4);
- (c) downstream and tailwater analysis (Chapter 5); and
- (d) waterbody, tank (tal) 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 (tals) 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 Siwalik valley fills and fans, the Balh valley alluvium, the Lesser Himalayan schist, phyllite and slate with their debris cover, and the crystalline, moraine and alpine soils of the high and trans-Himalaya, 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
Retention, detention, any storage; pre- vs post-development comparison	Any size	Hydrograph method; **Rational Method not permitted**	3.8–3.12, 3.14

Purpose	Catchment / condition	Permitted method	Clause
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 zone 7 (Western Himalayas)	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 (tal) 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

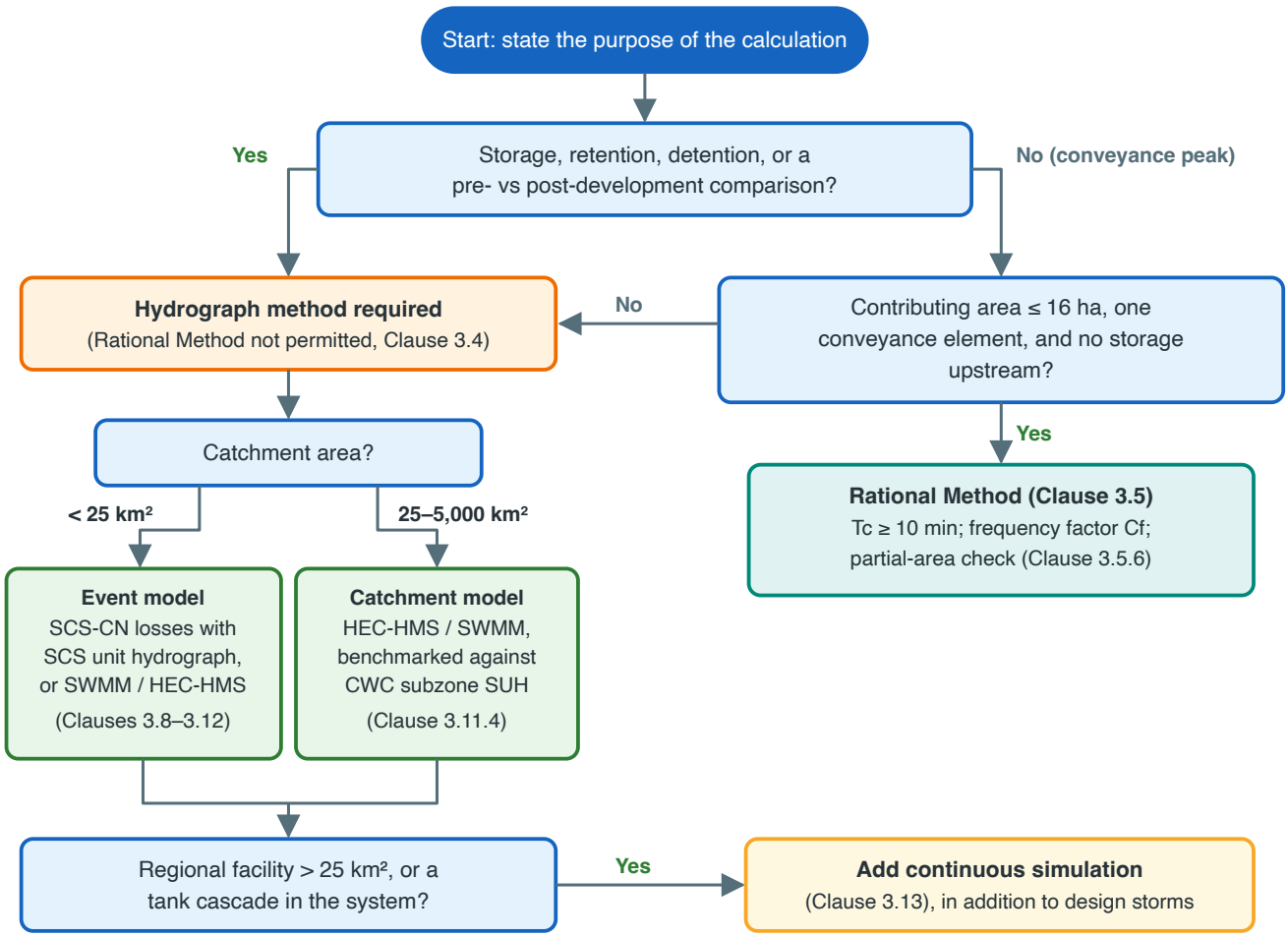

Figure 3.1 — Selection of hydrologic method. Original drawing for this Manual, adapted from KC Metro APWA, Section 5600 Storm Drainage Systems and Facilities, 2011 (§5602.2) and Version 2025.01 (§5603.4, Policy Supplement, 2025).

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 Jal Shakti Vibhag.

> **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 $C \cdot Cf \le 1.0$; 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
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

Surface or land use	C	Source
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 $C = \Sigma(C_j \cdot A_j) / \Sigma A_j$, 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 $\Sigma(C \cdot A)$ 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 Himachal Pradesh's rare storms arrive on wet ground (Clause 2.11.4). The 10-minute minimum Tc matches the minimum design duration of Clause 2.5.1. APWA 2011

> bounds inlet time between 5 and 15 minutes (§5602.7A). The partial-area check follows CPHEEO's treatment of "partial area effect" (CPHEEO 2019, Part A §4.4.1.7). This Manual requires the upper half of each range in 3.5.2 because Indian urban plots are typically more densely covered than the US land uses behind the ASCE ranges.

3.6 Time of concentration

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

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

- (a) **Sheet flow:**

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

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

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

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

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

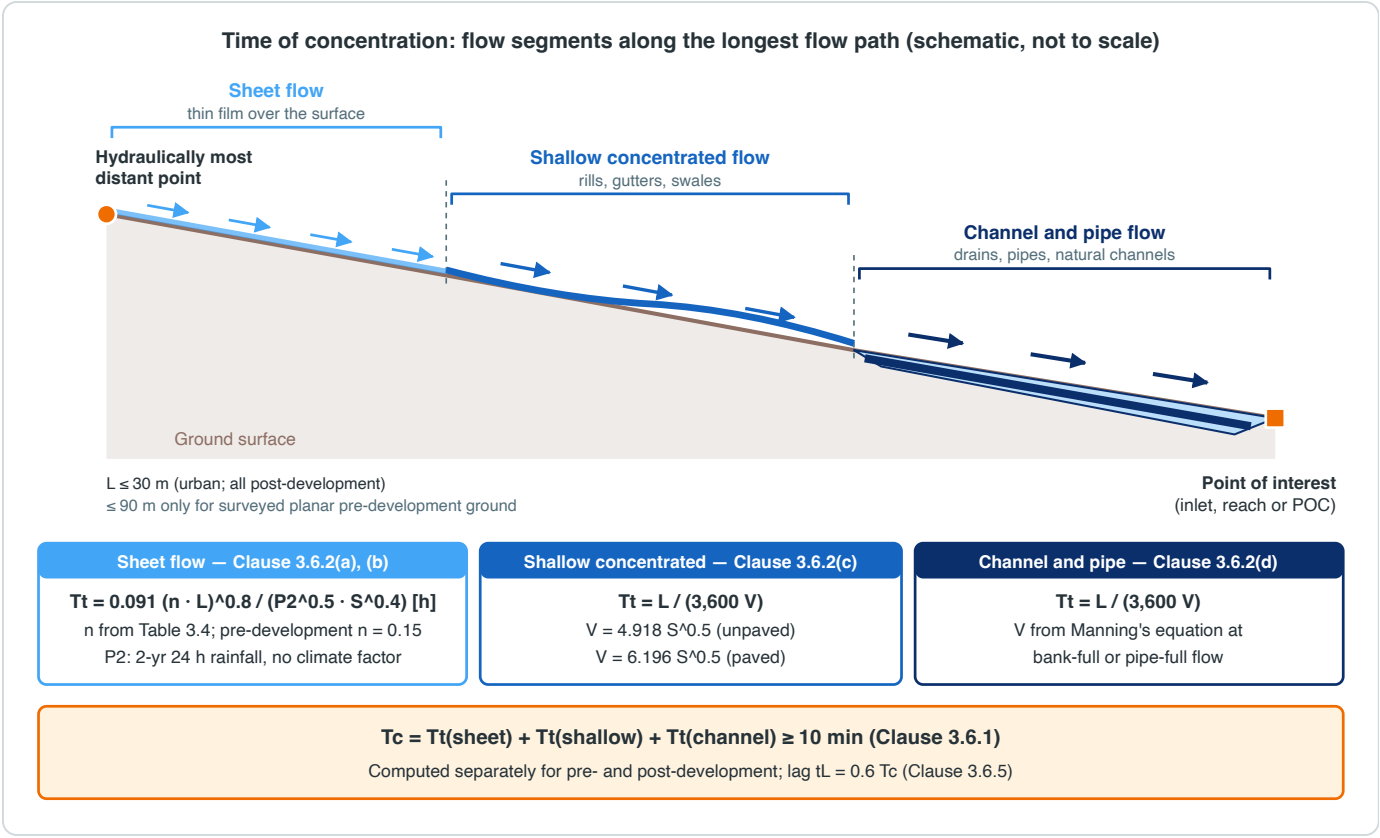

Figure 3.2 — Time of concentration by the NRCS segment method: sheet flow, shallow concentrated flow and channel or pipe flow along the longest flow path, with the travel-time equations and limits of Clause 3.6. Schematic, not to scale. Original drawing for this Manual, adapted from USDA SCS TR-55 (1986),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

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

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

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

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

> tc = 0.0195 L^0.77 S^−0.385

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 Himachal Pradesh Agriculture Department (soil survey) [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 Himachal Pradesh: the valley fills and piedmont fans of the Siwalik valleys of Una, Paonta–Kala Amb and Nalagarh (its upper terraces), HSG A on clean boulder-gravel, and HSG B where a loamy or silty cover lies over the gravels or the ground is compacted urban ground; the central floors of those valleys near their trunk streams, such as the Swan below Una and the lower Sirsa valley, HSG C; the alluvium and terrace deposits of the Balh valley, HSG C, and HSG D for every design storm wherever the seasonal high water table is within about 1 m of the surface, as it is over much of the valley floor in the monsoon; the alluvial terraces of the other valleys, such as the Kangra–Palampur valley and the Beas valley at Kullu, Bhuntar and Manali, HSG B on sandy or gravelly terraces and HSG C on silty ones, and HSG D wherever the seasonal high water table is within about 1 m of the surface; the regolith of the Siwalik sandstone and conglomerate, HSG C, and HSG D on shale or clay; the debris cover, colluvium, slide debris and moraine of the Lesser and Higher Himalaya, HSG D for design, with no infiltration credit on slopes, whatever group the material itself would take; exposed rock (schist, phyllite, slate, quartzite, limestone, granite, gneiss and the like), HSG D; the alpine and trans-Himalayan soils of Lahaul, Spiti and upper Kinnaur, HSG C, and HSG D when frozen; and urban fill, HSG C, and HSG D where it is clayey or compacted. A field infiltration test is required on every site larger than the limits of the simplified method of Clause 4.14.1, at the depth of the proposed facility; on smaller sites, a soil that has not been tested shall be given the less permeable of the groups listed for it. Whether an infiltration practice may be built at all on a hill site is governed by the hill infiltration rule of Clause 4.11, 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 at the edges of the belts, where one site can span two groups: at the foot of the Siwalik fans of Una, Nalagarh and Paonta–Kala Amb, where the boulder gravels pass into finer sediments towards the trunk stream; in the Balh valley and on the river terraces, where a sandy terrace that tests as HSG B lies a metre or two above the water table; on the Siwalik hills, where sandstone, shale and conglomerate alternate; and on hill sites, where a test pit in debris cover can show a high rate that is in fact water entering a slope that cannot take it (Clause 4.11). No HSG map or table for Himachal Pradesh, and no measured infiltration rate for any site in the State, was found during research for this Manual [TBC]: the CGWB's aquifer-mapping reports for the Nalagarh, Paonta–Kala Amb and Balh valleys state that "No infiltration tests have been conducted in previous surveys by CGWB and even this data is not available with state agencies" (NAQUIM). The national assessment says that in the State "Hilly and mountainous parts with steep slopes mainly constitute the run off areas and have low ground water potential", while its aquifers are the unconsolidated and semi-consolidated fills of the valleys, which are assessed valley by valley (CGWB, *Dynamic Ground Water Resources of India 2024*, §7.9). The interim groups follow that geology. The Una valley fill is of pebble, cobble and boulder with sand and clay, coarser towards the hills and finer towards the Swan, with transmissivities of 150–2,600 m²/day and water from 1.45 m above ground (artesian, at Rampur) to 43.20 m below it at Chalet (NAQUIM, Una); the Paonta–Kala Amb valley is of "boulders, pebbles, gravels, sand and variegated clays" in channel, valley-fill and fan deposits, with transmissivities of 211–3,336 m²/day and water 2–42 m below ground (NAQUIM, Sirmour); and the Nalagarh valley fill is 60–100 m of sand, silt, gravel, cobbles and pebbles, with transmissivities of 39–128 m²/day and water from near the surface to more than 35 m below it (NAQUIM, Nalagarh). These are aquifer values, not surface infiltration rates, but they support HSG A–B on the coarse fans. The Balh valley, an intermontane valley of about 101 km² at about 790 m, is of Quaternary alluvium and terrace deposits with transmissivities of only 4.5–70 m²/day and water 0.27–7.15 m below ground (NAQUIM, Mandi), so it is HSG C, and D wherever it is wet. In the mid-hills the rocks of the Jutogh and Shimla groups "lack primary porosity" and are "permeable along the fractures", under a "thick debris cover" (HIMCOSTE-led technical committee on the Shimla landslides, 2023), and the overburden is less than 5 m deep in places and 10–12 m elsewhere (as recorded by the NGT in *Yogindra Mohan Sengupta*, 2017, para 61). The debris would take water fast as a material, but water put into it raises the pore pressure in the slope: the committee on the Shimla slides of July and August 2023 named "over saturation of the sub surface thick debris cover", "Open Drainage systems leading to poor disposal of surface water" and structural depressions acting as "conduits for the infiltration of subsurface water" among their causes, and the expert committee before the NGT found in 2017 that "most of the mass movement" was due to "oversaturation of the overburden materials" and asked for lined drains so that there is "minimum ingress of water into the slope" (NGT judgment of 16 November 2017, para 53, set aside by the Supreme Court on 11 January 2024 and cited here as expert evidence only). That is why debris cover, colluvium, slide debris and moraine are designed as HSG D: the group decides the runoff, and on a slope none of the water is to be put back into the ground. A single group D for the whole State would be conservative for peak flows, but it would deny recharge on the Siwalik valley fills, where the stage of groundwater extraction is the highest in the State, 63.72% in Una district and 57.89% in Solan district (Nalagarh) against 35.48% for the State, although every assessed unit is still safe (CGWB, GWRA 2024). The only regional measure of losses is the design loss rate of the CWC zone 7 report, 0.5 cm/h (5 mm/h) (Annex 3E). It is a φ-index fitted to the floods of whole rural catchments, three of them the Neogal, Banu and Chakki khads of the Kangra–Chamba hills; it shall be used only in rural SUH runs under Clause 3.11.4, not to assign an HSG, not in an urban SCS-CN or SWMM model, and not to size an infiltration practice. The interim groups of Clause 3.7.2, the 1 m water-table threshold for the Balh valley and the river terraces, the treatment of debris cover, colluvium, slide debris and moraine and the rule for untested soil on

small sites are set by this Manual pending a soil-series lookup for Himachal Pradesh. Steep ground matters as much as soil in the hills, where runoff from rock and skeletal soil reaches a channel within minutes; about 90% of Shimla is built on slopes of 45°–60° (NGT expert committee, 2017, as recorded in para 62 of the judgment). The following rules are set by this Manual. (a) On hill streets and nallahs with slopes of 10–60%, Kirpich and similar formulae give times of concentration of 1–5 minutes; Tc shall be found by the segment method of Clause 3.6.2 and shall not be taken below the 10-minute minimum of Clause 3.6.1, which matches the shortest design duration of Chapter 2, and the Kirpich formula, derived from small Tennessee 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, scree, a road cut or a paved hill street shall use the smooth-surface n of Table 3.4 and shall not exceed 30 m. (c) A catchment that runs from a hill flank onto a fan or a valley floor, such as the khads that leave the Siwalik hills onto the fans of Una, Nalagarh–Baddi and Paonta–Kala Amb, the khads of the Dhauladhar onto the Kangra valley, or the side streams of the Beas onto its terraces at Kullu and Manali, shall be split at the break of slope, and the hill sub-area modelled on its own, so that a long, flatter lower reach does not average away the fast response of the hill; channel losses into the gravels of a khad bed shall not be credited in design, because the bed is saturated by the time of the design storm. (d) No method of this chapter predicts debris flow; in steep catchments the design flow is bulked for sediment and debris, and inlets and culverts are protected against blockage, under Chapters 6 and 9.

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

Cover type	HSG A	HSG B	HSG C	HSG D
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 July to 30 September at a site in sub-area HP-B (Mid-hills), HP-B1 (Dhauladhar front), HP-B2 (Kullu–Manali inner valley) or HP-C (High and trans-Himalaya) of Annex 2A, including the Balh valley; AMC III for every design storm at any time of year in a catchment that drains to Gobind Sagar, the Pong reservoir, the Pandoh reservoir or any other reservoir or barrage pond or its backwater, or to a river reach whose CWC site stands at or above its warning level (in Himachal Pradesh, only the Yamuna at Paonta has one); at any other site or time, including the coarse Siwalik valley fills and fans of sub-area HP-A, 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. 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.

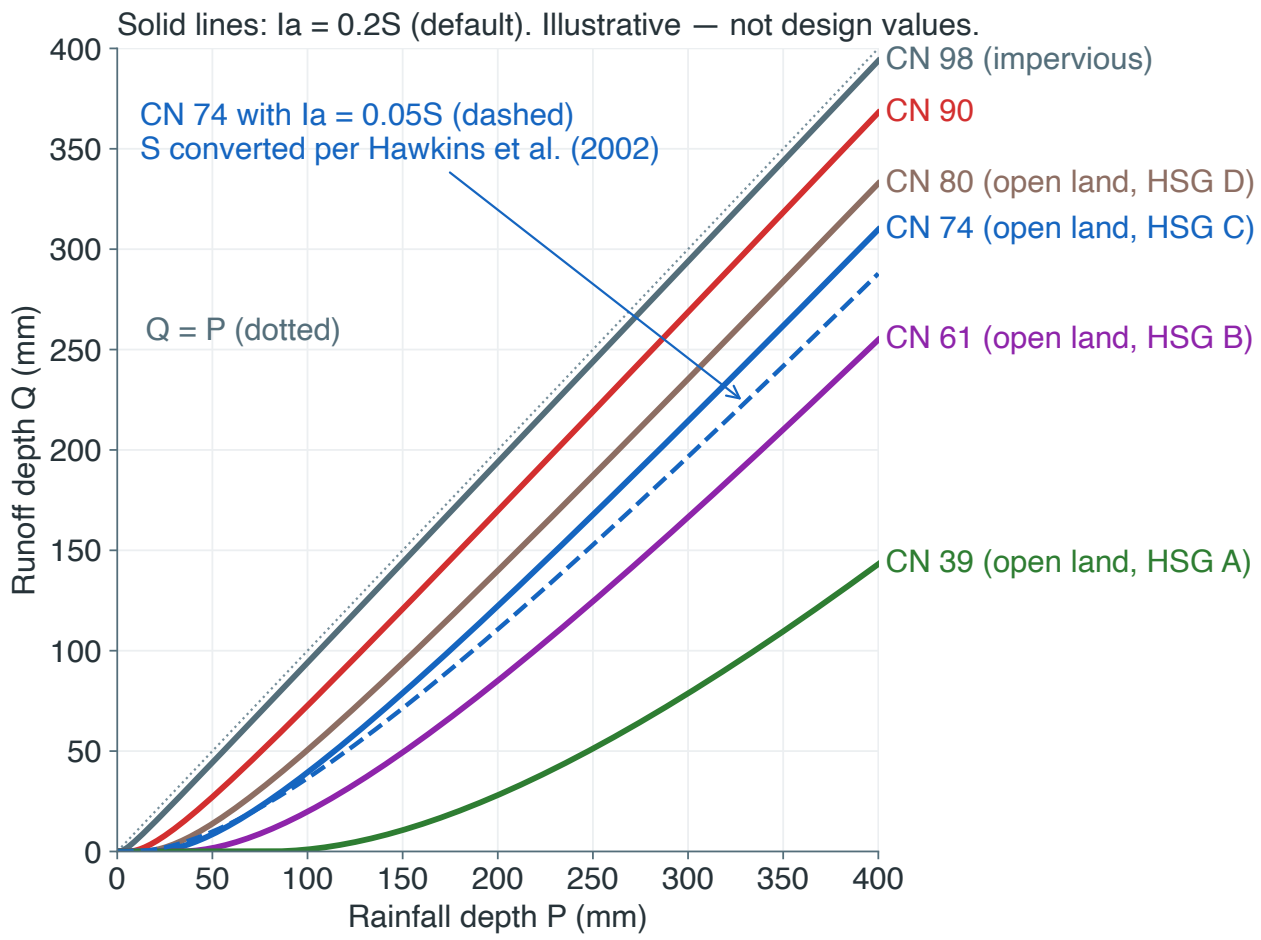

Figure 3.3 — SCS-CN runoff depth versus rainfall depth for selected curve numbers at Ia = 0.2S, with the Ia = 0.05S sensitivity case for CN 74. Original drawing for this Manual, computed from the runoff equation of USDA NRCS, NEH Part 630, Ch. 10 (2004) and USDA SCS TR-55 (1986), and the S-conversion 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 Himachal Pradesh. The AMC conversion equations are the standard NEH-4 relationships as given by Chow, Maidment and Mays (1988, §5.5). Converting only the pervious component follows APWA, which states that "direct conversion of composite antecedent moisture conditions is not appropriate" (KC Metro APWA 5600, 2011, §5602.2C). Converting a composite CN would wrongly lower the CN of the impervious part.

Ia = 0.2S is the original NRCS ratio. Analysis of US rainfall–runoff data found that 0.05S fits better on average (Hawkins et al., 2002; Woodward et al., 2003), and gave the conversion of 3.8.5(b). NRCS has not formally replaced 0.2S, so this Manual keeps it as the default. Figure 3.3 shows why the sensitivity run is needed: for CN 74, the 0.05S case gives **more** runoff for small storms (about 2.0 mm vs 0.5 mm from 25 mm of rain) but **less** for large storms (about 242 mm vs 262 mm from 350 mm). *Illustrative — not design values.* The ratio therefore matters most for retention and water quality volumes, and the default 0.2S is the conservative choice for peak

and detention design. The rule in 3.8.5(c) that the larger retention or water-quality volume governs has no direct precedent; this Manual sets it because the 0.05S case gives more runoff from the small storms that set those volumes.

3.9 Impervious connectivity

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

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

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

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

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

- for directly connected impervious area: $CNc = CNp + (Pimp / 100)(98 - CNp)$;
- 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 SW 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 SW monsoon season (June–September), from site piezometers or trial pits, or from the nearest Central Ground Water Board (CGWB) or Jal Shakti Vibhag 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, tal, 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 some land in Himachal Pradesh is wet in the monsoon, although most of the State is not. The Balh valley, the intermontane valley of the Suketi round Sundernagar and Ner Chowk, is of Quaternary alluvium and terrace deposits with water 0.27–7.15 m below ground (NAQUIM, Mandi, data of 2014–15), and in May 2021 the shallowest level measured in the State, 0.35 m below ground, was in Mandi district (CGWB, Ground Water Year Book 2021–22). The floors of the Siwalik valleys are wet near their trunk streams: in the Una valley wells flow 1.45 m above ground at Rampur, near the Swan, while water stands 43.20 m below ground at Chalet, towards the hills (NAQUIM, Una); in the Paonta–Kala Amb valley water stands 2 m below ground at Nihalgarh and 42 m at Kolar (NAQUIM, Sirmour); and in the Nalagarh valley the post-monsoon water table "intersects the ground surface at the contact between two terraces giving rise to a number of springs" (NAQUIM, Nalagarh). The floodplains and low terraces of the rivers and khads, where the water table follows the river, and the margins of the tals and reservoirs are the other wet land. The coarse fan heads of the same valleys are the opposite case, with water often more than 20 m below ground. In the hills groundwater occurs in weathered rock, fractures and debris cover, and is perched in places: the HIMCOSTE-led technical committee on the Shimla slides of 2023 described the inhabited depression at Cambley Bank as an "ideal site for the retention of sub surface water", and at Krishna Nagar found open drains and springs feeding water into thick unconsolidated material. In January 2025 water stood 2–10 m below ground in most valleys and within 20 m over 86.87% of the monitored area (CGWB bulletin, as reported). No monsoon water-table depths for individual sites in Sundernagar, Mandi, Kullu, Bhuntar or Una, and no map of the seasonal high water table, were obtained [TBC]; Annex 3A is to supply them. Clause 3.10.4 reflects the State's receiving waters, which are rivers and khads with few gauges, reservoirs whose levels are published in feet, and a few tals. Only one CWC site in the State has warning and danger levels, the Yamuna at Paonta (warning 383.5 m, danger 384.5 m, highest 384.6 m on 5 September 1995); the other 29 sites record levels only, among them the Swan at Ghaluwal near Una (highest 367 m, dated 3 June 2017, a date still to be verified) and the Sutlej at Rampur (933 m on 26 June 2005, in the flood from the outburst of the Parechu lake in Tibet) (CWC, as transcribed by SANDRP). There is no CWC site on the Beas at Manali, Kullu, Bhuntar, Mandi or Pandoh, on the Sutlej at Bilaspur or on the Ravi at Chamba. Bilaspur stands on Gobind Sagar, the Bhakra reservoir (full reservoir level 1,680 ft, about 512.06 m), and Dehra and Nagrota Surian on the Pong reservoir (full reservoir level 1,390 ft, about 423.67 m), whose levels BBMB publishes in feet (as reported); a site there drains to a water surface that the operator holds, and Clause 3.10.4(b) applies to the land below the starting level of the reservoir set in the Commentary to Clause 3.12. At Rewalsar the town round the lake, a tal of 2.6 ha with a catchment of 173 ha (State Wetlands Authority, *Major Wetlands of Himachal Pradesh*), drains to a water surface, not to a channel.

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:

> qp = PRF' · A · Q / tp, with PRF' = 0.208 (SI form of the standard peak rate factor 484) tp = Δt / 2 + tL, tL = 0.6 Tc

where qp 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; tp 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 Tc 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 zone 7 (Western Himalayas), which covers the whole State, other than its snow-fed catchments:

- (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 1994; see Chapter 2). They were derived from natural, mostly rural catchments with data that predate the report of 1994 (three of its six gauged catchments drain Himachal Pradesh, the Neogal Khad and

the Banu Khad in Kangra and the Chakki Khad above Pathankot, and were gauged in 1963–67), 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 tals, reservoirs and barrage ponds at their full or maximum level in 3.12.5 because the heaviest rain in Himachal Pradesh falls in the middle and late monsoon and after it, on waterbodies that have taken the earlier rains and are held up for power, irrigation or supply, not drawn down for drainage. July and August carry about 70% of the monsoon normal of 734.4 mm (255.9 mm and 256.8 mm; IMD Meteorological Centre Shimla), and the State's largest recorded falls have come in every month from June to December: 182 mm at Dalhousie on 9–10 June 1971, 600 mm at Dharamshala on 18 July 1967, 419 mm at Barauli (Shimla) on 21 August 1901, 273.4 mm at

Kangra Aero on 14 August 2023, 285 mm at Batheri (Chamba) on 4 October 1955 and 268 mm at Nichar (Kinnaur) on 10 October 1956 (CWC zone 7 report, Annexes 4.3 and 4.4; IMD). The 610 mm and 559 mm recorded at Kilba and Sangla in Kinnaur in December 1958 are doubtful (Chapter 2). The starting levels are as follows. BBMB publishes its levels in feet; they are converted here at 0.3048 m to the foot, and the datum of its gauges has not been found and is to be confirmed [TBC].

- **Pong reservoir (Maharana Pratap Sagar).** Its full reservoir level is 1,390 ft (423.67 m). Its maximum level is given as 1,400 ft (426.72 m) by SANDRP, as 1,410 ft (429.77 m) in the press and as a "technical" 1,421 ft (433.12 m) by SANDRP: the sources conflict, and BBMB's maximum water level is to be confirmed [TBC]. The reservoir rose to 1,399.65 ft (426.61 m) on 15 August 2023 and to 1,394.71 ft (425.11 m) on 5 September 2025 (as reported). Until BBMB confirms its maximum water level, this Manual sets the starting level at 1,421 ft (433.12 m), the highest of the quoted maxima and the tailwater of Clause 5.8.5(c), because a level set too low overstates the storage left for the storm; a designer shall also report the effect of 1,400 ft, almost exactly the level reached in 2023.
- **Gobind Sagar (Bhakra).** Its full reservoir level is 1,680 ft (512.06 m), with an earlier technical limit of 1,690 ft (515.11 m) (BBMB, as quoted by SANDRP). It stood at about 1,678 ft in August 2023 and at 1,679 ft (511.76 m) on 4 September 2025 (as reported). No maximum water level was found [TBC]; it shall be started at 1,690 ft (515.11 m), the higher of its full reservoir level plus 0.5 m (512.56 m) and the earlier technical limit, as the tailwater of Clause 5.8.5(c), with 512.56 m reported as a sensitivity case.
- **Pandoh and the other reservoirs and barrage ponds.** The full and maximum levels of the Pandoh reservoir on the Beas (BBMB) were not found [TBC]. The Kol Dam reservoir on the Sutlej is given as 642 m, Chamera I on the Ravi as 763 m and Karcham Wangtoo on the Sutlej as 1,810 m (as reported); the levels of Larji, Nathpa Jhakri and the other run-of-river ponds were not found [TBC]. Each is started at the maximum water level published by its operator (BBMB, NTPC, NHPC, SJVN, HPSEBL or the project company), or, where none is published, at its full or pond level plus 0.5 m.
- **Tals.** Rewalsar (2.6 ha), Renuka (about 20 ha, fed by 21 seasonal streams) and Khajjiar have no published outlet level, operating rule or level record (State Wetlands Authority, *Major Wetlands of Himachal Pradesh*) [TBC]; they shall be started at their spill or outlet crest level.
- **Village ponds, nauns and baolis.** The small rain-fed ponds of the villages and the spring-fed nauns and baolis are started full from July.

A gated reservoir or barrage 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 July to 15 October in Clause 3.13.5(a) is set by this Manual. It starts after the monsoon has covered the State, whose normal onset date is 25 June (24 June before 2024), with onsets as late as 5 July in 2010 (IMD Meteorological Centre Shimla), so that a late onset or a dry June does not lower the starting level. It ends on 15 October because the monsoon now leaves the State later than its normal withdrawal date of 25 September in most years, in 8 of the 9 years from 2018 to 2026 and as late as 11 October in 2019 (IMD Meteorological Centre Shimla), and because October storms are a real threat: Batheri recorded 285 mm on 4 October 1955, Nichar 268 mm on 10 October 1956, Renuka 246 mm on 12 October 1956 and Kullu 236 mm on 4 October 1888 (CWC zone 7 report, Annex 4.3), and a western disturbance brought heavy rain and snow on 5–7 October 2025, after the monsoon had withdrawn (IMD). Pumps, gates and debris screens stay on standby until 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 July to 15 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.

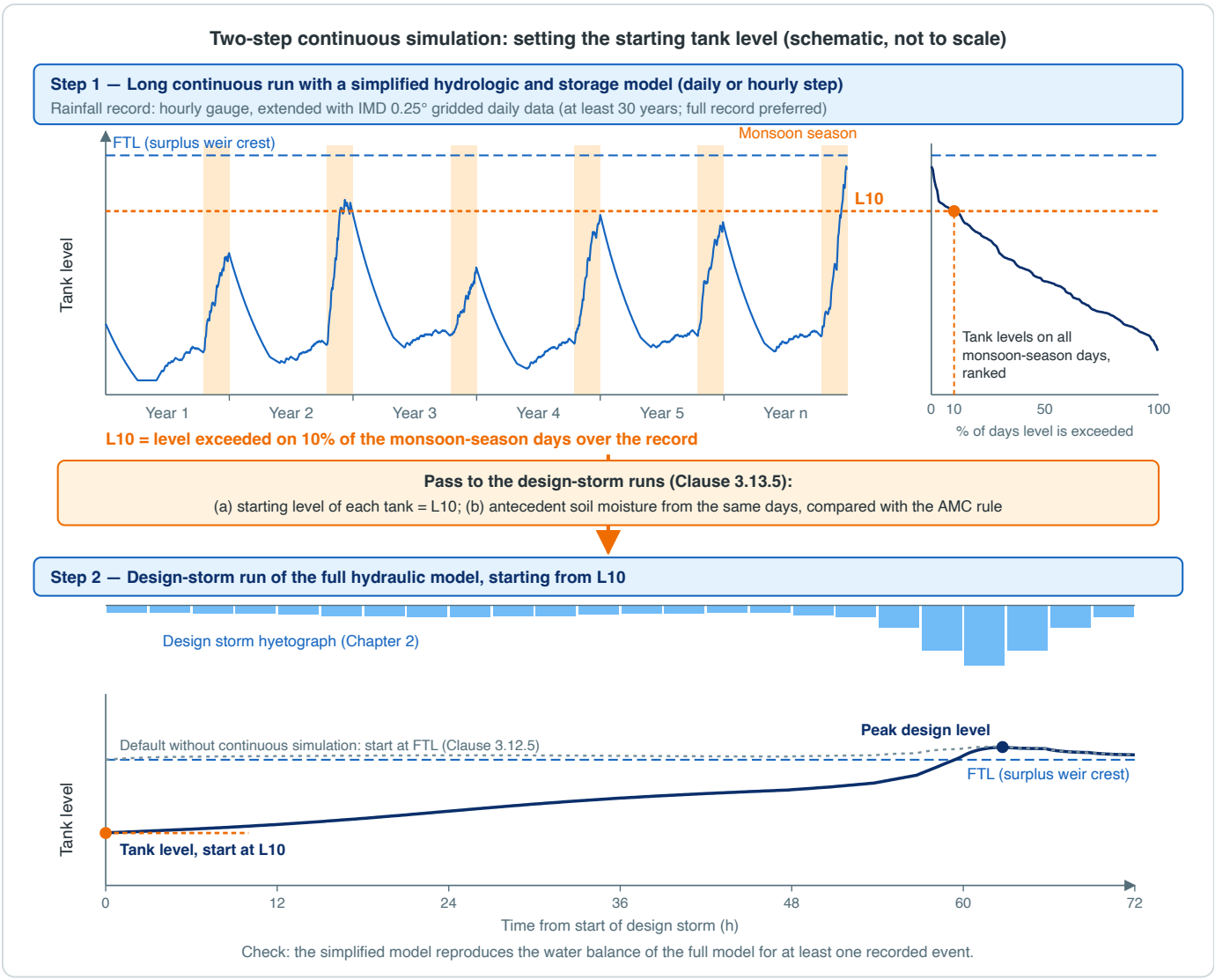

Figure 3.4 — Two-step approach of Clause 3.13.5. Step 1: a long continuous run with a simplified hydrologic and storage model gives the tank level exceeded on 10% of the days from 1 July to 15 October (L10). Step 2: the design storms are run in the full hydraulic model from that starting level, in place 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 Himachal Pradesh. The record length matters less than what the simulation is for. Its main purpose here is to find how full the tanks and soils usually are when a south-west monsoon 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 August 2023, when the Pong reservoir rose from 1,374.20 ft to 1,399.65 ft (about 426.61 m) between 11 and 15 August, 9.65 ft above its full reservoir level, on what was reported as its highest inflow since it began to operate in 1974, and September 2025, when Gobind Sagar stood at 1,679 ft (about 511.76 m), one foot below its full reservoir level, on 4 September and Pong at 1,394.71 ft on 5 September (all as reported).

3.14 Pre- vs post-development comparison procedure

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

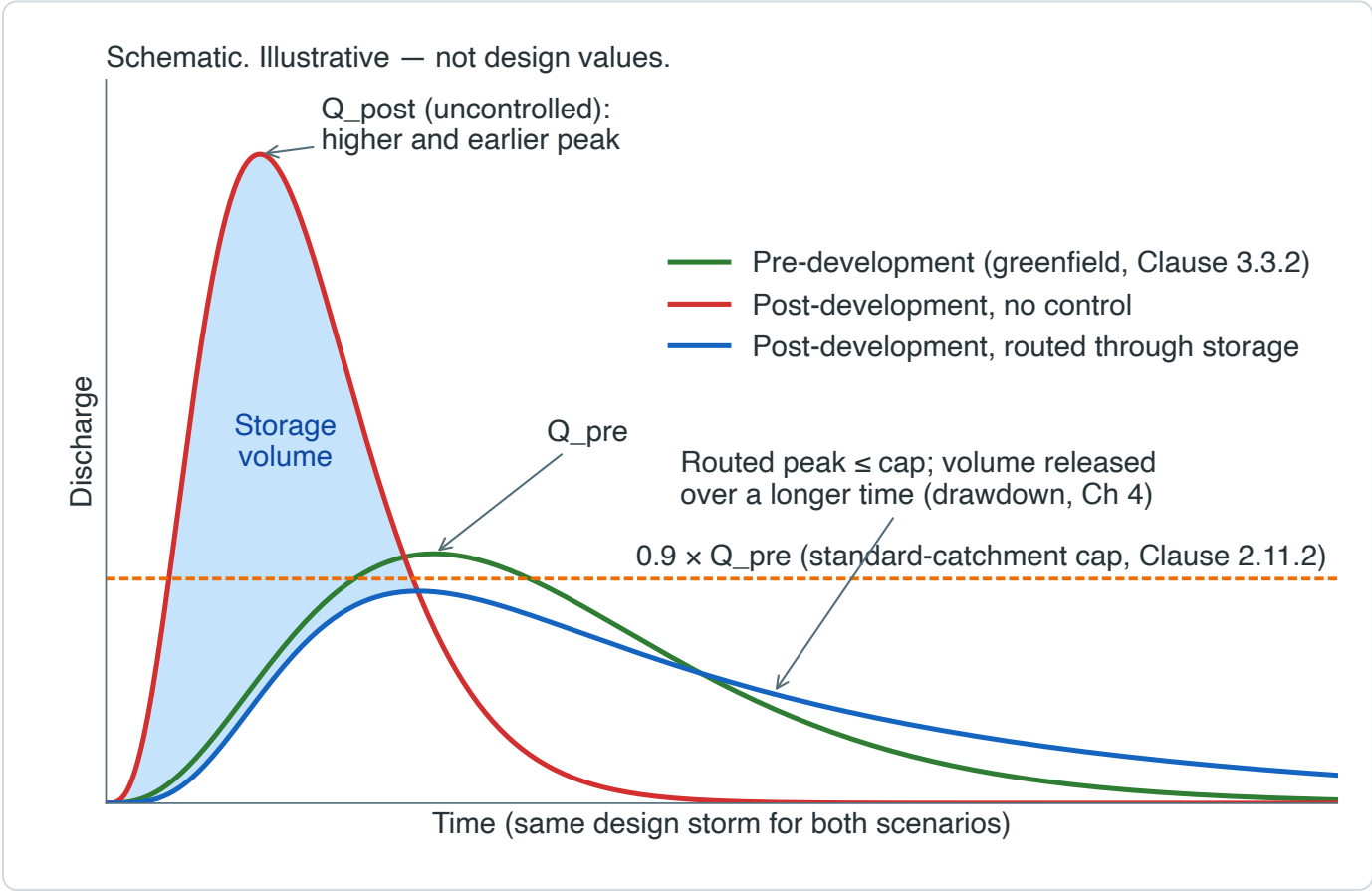

Figure 3.5 — Pre-development, uncontrolled post-development and routed post-development hydrographs for the same design storm. Original drawing for this Manual, adapted from the pre- vs post-development detention concept in CPHEEO, Manual on Storm Water Drainage Systems, Part A §8.5, 2019, and KC Metro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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.15 Model calibration and validation

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

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

3.15.2 **Data.** Calibration shall use observed rainfall (gauges, and radar where available) and observed flows or water levels (Jal Shakti Vibhag gauging sites, SMC or HPSDMA 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 SW monsoon or cyclone event (for example the storm of 9–11 July 2023 (228.5 mm at the Una Rampur AWS on 9 July and 250.0 mm at Nahan on 11 July, IMD), the storm of 14–15 August 2023 (273.4 mm at Kangra Aero and 250.2 mm at Dharamshala on 14 August, IMD), or the storm of 30 June–1 July 2025 over Mandi district (140.7 mm in 24 hours over the district, as reported), 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.

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Annexes and forms

Annex / Form	Content
3A	Himachal Pradesh soil series to HSG lookup; seasonal high water table map
3B	Himachal Pradesh CN calibration and supplementary land covers (terraced fields and orchards, deodar, oak and chir pine forest, slide scars, debris fans and muck dumps, bare rock and scree, alpine pasture and snow, boulder-bed khads, kuhl-fed paddy, tal and reservoir beds)
3C	Benchmark test problems for software acceptance
3D	Peak rate factor study for flat coastal land
3E	CWC SUH parameters for zone 7, 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 (rooftop rainwater collection under Appendix 6 of the TCP Rules 2014, compulsory for every building, existing or proposed, wherever the Himachal Pradesh Town and Country Planning Act 1977 is in operation, with a storage of at least 20 litres per m² of roof-top area and no water supply connection until it is in place; the rules 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 Himachal Pradesh rule found during research for this Manual limits the rate of discharge from a site, and none requires on-site detention or "zero run-off". No Himachal Pradesh document found sets a design storm for any drain. The building rules are the Himachal Pradesh Town and Country Planning Rules 2014, made under the Himachal Pradesh Town and Country Planning Act 1977, which apply statewide wherever the Act is in operation, through Appendix-1 in areas where no Interim Development Plan or Development Plan has been prepared and through the plan's own regulations where one has. The text read is the TCP Department's consolidation to 2022, with the amendments of 2016, 2018 (Second and Third), 2019 (Fourth), 2020 (Fifth) and 2022 (Eighth); the Twelfth Amendment (2024) and the later amendments to the draft Sixteenth Amendment of 2025, published for objections, were not read [TBC], although clause 16 of Appendix-1 still stood on the TCP Department's Appendix-1 page in June 2025. The Act applies in 54 urban local bodies and about 102 notified areas, which hold 21.70% of the State's people but less than 10% of its area (PDNA 2023); most hill settlements lie outside it. The drainage provisions that can be found protect the building, the slope and the watercourse, not the catchment. Appendix-1 sets a maximum slope of 45° for development (cl. 3), defines hilly areas as land above 600 m or with an average slope of 30° (cl. 8), limits a hill cut to 3.50 m with at least 1.00 m between the building and the toe wall (cl. 11), and allows construction "at distance of 3.00 Metre and 5.00 Metre from Nullah and Khud respectively" (cl. 16), without saying whether the distance runs from the bank, the

centreline or the flood level. A new sub-division of land shall keep at least 5% of the scheme "for soak pit etc." (cl. 20(iv)), orient its plots to allow the "natural flow of surface drainage to allow un-obstructed rain water discharge" (cl. 20(v)) and grade its roads at least 1 in 15 (cl. 20(vi)). The appendices for IT parks and real estate add that the distance from the highest flood level along rivers, khuds and nullahs "shall be as delineated in the Interim Development Plans / Development Plans" and that "In other areas, no construction shall be allowed in parcel of land prone to floods". Rule 21(1) requires a geologist's soil investigation report before building "in sliding and sinking zones as defined in the respective Interim Development Plans or Development Plans". The forms require the site plan to show "Existing water bodies like Bauri, Well, Nallah, khud", contours, and the "septic tank, soak pit, rain water harvesting tank"; nothing in the rules bars a soak pit on a slope. Rooftop rainwater storage is compulsory under Appendix 6 (Commentary to Clause 4.11). None of these sets a design storm, a release rate, a detention volume or an overflow path. The Shimla Development Plan 2041 was published on 20 June 2023 according to the Supreme Court (notified on 23 June 2023 according to the press); the Court recorded its rule (§17.2.2.9) that a geologist's soil investigation report is required in sinking and sliding zones and that construction there is refused or conditioned on adverse findings, but its storm-water chapter (§7.5 in the draft of February 2022) was not read [TBC]. The Chopal Development Plan 2041 treats slopes above 45°, flood plains and "areas adjacent to major drainage lines" as non-developable. In July 2025 the press reported new setbacks of 5 m from drains and 7 m from rivers and ravines in place of the 3 m and 5 m of clause 16, with geological and structural reports for urban buildings; the Chief Minister announced that no government building would be built within 150 m of rivers, nullahs and other waterbodies; and in September 2025 the Cabinet was reported to have approved model bye-laws for rural construction that ban building along the banks of rivers and streams. No gazette text of any of these was found, and none is applied in this Manual as a rule [TBC]. The State has no floodplain zoning law and no notified flood line; the post-disaster needs assessment of the 2023 monsoon found that "The lack of well-defined river boundaries in floodplains is a prominent issue in Himachal Pradesh" and called for "comprehensive river boundary mapping and the establishment of floodplain management guidelines" (PDNA 2023). The Himachal Pradesh Minor Canals Act 1976 lets the Government regulate "the flow of water in any river, creek, natural channel or line of natural drainage" and remove obstructions to it (s.43), and makes the obstruction or fouling of a canal, which includes a scheduled kuhl, an offence (s.65); it is the only Himachal Pradesh statute found that names a line of natural drainage. The Himachal Pradesh Ground Water Act 2005 is in force (Commentary to Clause 4.11), and its amendment of 2022 bars any person from releasing "any effluent that contaminates the groundwater" (s.5A). The drain sections of the Himachal Pradesh Municipal Corporation Act 1994 and the Himachal Pradesh Municipal Act 1994 were not read [TBC]. The National Green Tribunal's judgment on Shimla of 16 November 2017 (*Yogindra Mohan Sengupta*, O.A. 121/2014) directed that "All the storm water available as surface run off in all the concretised areas like roads, lanes, platforms and market places should be diverted in such a manner to ensure that such run off does not go in to over burden or flow along hills and depressions, thereby creating over saturation and affecting soil and slope stability" (direction XV), made rainwater harvesting mandatory (XIV) and limited building to slopes of 35° on soil and 45° on rock (XIII); the Supreme Court set the judgment aside on 11 January 2024 (2024 INSC 30), holding that the Tribunal had gone beyond its powers in directing how subordinate legislation should be made, so the directions are cited in this Manual only as expert guidance, not as binding orders. The Supreme Court has since taken up the ecology of the State on its own motion (W.P.(C) 758 of 2025), and the Central Empowered Committee's first report, on hydro-electric projects, roads and tourism construction, was reported in October 2026 (as reported; the orders and the report were not read). The only drainage findings are the Tribunal expert committee's on Shimla: storm drainage covered about 30% of the city, the drains were "not able to carry the peak flow", their "Catchments" were "improperly selected" and they had "much lesser gradients than actually required" (as recorded in the judgment of 2017, para 53). Even the size of Shimla's network is uncertain: a 2015 plan of the Municipal Corporation counts 13 major nallahs and about 67 storm-water drains with about 42.33 km of drains (MC Shimla and UNDP, *Action Plan for Mainstreaming DRR and CCA*, 2015), while the Corporation reports 191 major storm-water drains and nallahs, 55.43 km, built under AMRUT (AMRUT status, 2022); no design basis is stated in either. The Jal Shakti Vibhag's proposal for storm-water drainage of Una town (₹19.66 crore, in the 2023 recovery and reconstruction plan) states none either. Basements are regulated as storeys, not for flooding. A habitable basement counts as a storey (Appendix-1, cl. 22; Appendix 8), parking may be provided in a basement, and an industry on a plot of more than 1,000 m² may build a basement or cellar for its own use (Appendix-2, cl. 4); no Himachal Pradesh rule found restricts basements

in low-lying or flood-prone land, sets a level for a basement ramp or opening, or keeps surface water out of a basement, beyond the geologist's report of Rule 21(1) in sinking and sliding zones. This Manual therefore adds its own requirements for every basement: no detention storage in a habitable basement (Clause 4.10.1); the crest of every basement ramp and the sill of every basement opening at least 0.5 m above the 1% AEP flood level, with basement drainage pumped to the surface drain through a non-return valve (Clauses 6.11.1 and 6.11.4); and no basement in Zone 2 (Clause 7.5.2). In the flood-sensitive catchments of Clause 4.5.3.2, in any catchment notified under Clause 4.5.4, and on the Balh valley, floodplain, tal-margin and reservoir-margin land of Clause 4.12.1, it recommends that no basement be permitted where the 1% AEP flood level stands above the surrounding ground; and in the hills, a basement cut into a slope shall also carry the geotechnical certificate of the hill infiltration 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 TCP Rules leave open and what direction XV described: 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, never onto an unprotected slope or into the overburden. These are the Manual's proposals, not rules of the TCP Rules 2014. This chapter is written so that it can supply, as a technical companion to the TCP Rules 2014, the development plans and the Municipal Acts, the design storm, release rates and storage volumes that they leave open; it has not been adopted for either purpose. In practice many of the State's urban nallahs and khads carry sewage: in 2017 more than half of Shimla's households had no sewer connection (NGT expert committee, as recorded in the judgment, para 53); sewage effluent from the Malyana and Dhalli treatment plants reached the Ashwani Khad intake and caused the outbreak of hepatitis E that began in Shimla in January 2016, after which the supply from the Ashwani Khad was stopped (Bhagra et al., 2017); the CPCB placed the Ashwani Khad, the Bald along Baddi, the Sirsa along Nalagarh and the Sukhna along Parwanoo in Priority I among polluted river stretches (2022 list); Shimla's three treatment plants had an installed capacity of 35.88 MLD but received 18.1 MLD, with 50.8 km of sewer still to be connected by 2039 (Chief Secretary's affidavit of 1 February 2026 in NGT O.A. 735/2023) (Clause 8.9). Retention and detention apply in full on every site whatever the drain carries: every litre a site releases at the peak of a storm takes up capacity in a drain that is already part-filled with sewage. The CPHEEO (2019) manual describes limiting outflow to the pre-development peak as typical practice, but it uses no "shall" and names no storm frequencies (CPHEEO Part A §8.5.1). This chapter turns that description into a development-control requirement.

4.2 Definitions

Term	Meaning in this Manual
Retention	Permanent removal of runoff from the surface drainage system by infiltration, evapotranspiration or reuse, so that the water never reaches the outfall.
Retention depth	The 90th percentile wet-day 24-hour rainfall depth for the site's zone (Clause 2.10, Annex 2E).
Required retention volume (RRV)	The runoff volume from the retention depth over the post-development site (Clause 4.4.2).
Detention	Temporary storage of runoff, released through a controlled outlet at a rate set by Clause 4.5.
Retention credit	The reduction in required detention storage that results from retention practices, determined by routing under Clause 4.4.6. It is **not** the same as the retained volume.
Permissible site discharge (PSD)	The maximum rate at which a site may discharge for a stated AEP, in L/s or L/s/ha.
Site storage requirement (SSR)	The detention storage required per hectare of site under the simplified method of Clause 4.14.

Term	Meaning in this Manual
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 Town and Country Planning Department, through the Director and the officers to whom powers are delegated, in the planning areas and special areas of the Himachal Pradesh Town and Country Planning Act 1977; a Special Area Development Authority or the Baddi Barotiwala Nalagarh Development Authority (BBNDA) in its area; the Municipal Corporation, Nagar Parishad or Nagar Panchayat concerned, where it grants building permission; and HIMUDA for its own colonies [TBC], as applicable).
Tier A / Tier B	Adoption tiers defined in Chapter 1. Tier A: the Shimla Municipal Corporation (SMC) and every approving authority within the Shimla Planning Area; the Municipal Corporations of Dharamshala, Mandi, Solan and Palampur, with the TCP Department in their planning areas; and BBNDA in the Baddi–Barotiwala–Nalagarh area. Tier B: Nagar Parishads and Nagar Panchayats.

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

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

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

4.4 Retention

4.4.1 Requirement

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

- infiltration practices (soakaways, infiltration trenches, permeable pavement with an infiltration base, bioretention);
- rainwater reuse that is drawn down by a demonstrated non-potable demand;
- green roofs and landscape areas that do not drain to the outfall in the retention-depth storm.

The limits of Clause 4.4.4 apply.

4.4.2 Computation of the RRV

> RRV (m³) = 10 × Q_R × A

where:

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

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

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

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

4.4.3 Verification

Retention by infiltration shall be supported by:

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

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

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

it does, Chapter 8 governs.

4.4.4 Limits on retention

4.4.4.1 Infiltration practices shall not be used:

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

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

4.4.5 Drawdown of retention

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

4.4.6 Retention credit: definition and computation

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

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

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

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

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

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

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

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

> Commentary. "Credited against detention" (APWA 5600 2025.01) can be read in two ways. One reading subtracts the retained volume from the detention volume, cubic metre for cubic metre. The other routes the storms with retention in place and sees what detention is still needed. The two readings give very different answers in

Himachal Pradesh, because the mandatory 48- and 72-hour storms (Clause 2.5.2) fill any retention practice on the first day, long before the peak arrives on the last day (Clause 2.9.2). Unless the practice keeps infiltrating during the storm, it is full at the peak and does nothing to reduce the peak storage.

The illustrative example in Clause 4.6.7 shows the size of the effect. A 2 ha site with 552 m³ of retention (no infiltration during the storm) needs 138 m³ less detention for the 24-hour storm. That is a credit of about a quarter of the retained volume. For the 48- and 72-hour storms, which govern, the credit is close to zero. Subtracting the retained volume directly would have under-sized the detention by about 545 m³ (about 19%).

This Manual therefore defines the credit as the result of routing. Retention on fast-draining sandy soils, which keeps infiltrating through a multi-day storm, will earn a real credit. Retention that only fills will earn little. Both outcomes are physically correct. Setting C_R = 0 until Annex 4B exists is a safe default for Tier B, not a judgement that retention has no value: retention is still required for water quality and recharge (Chapter 8).

4.4.7 Preservation credit

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

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

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

4.5 Release-rate criteria

4.5.1 General

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

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

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

4.5.2 Standard catchments

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

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

4.5.3 Flood-sensitive catchments

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

> Q_post(1% AEP, 100-yr) ≤ Q_pre(10% AEP, 10-yr), and Q_post(50% AEP, 2-yr) ≤ Q_pre(50% AEP, 2-yr).

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

4.5.3.2 The flood-sensitive catchments are:

- (a) **Shimla's nallahs and sinking zones**: the catchments of the nallahs of the Shimla Planning Area that drain north to the Sutlej and south to the Ashwani Khad and the Giri, whose steep, debris-laden flows reach the drains within minutes of a burst, and the land of Shimla's two sinking and sliding zones (Commentary to Clause 4.11);
- (b) **Mandi on the Beas and the Suketi**: the land of Mandi town that drains to the Beas and to the Suketi at and above their confluence, and the Balh valley of the Suketi round Sundernagar and Ner Chowk, where the water table is high and the outfalls are flat;
- (c) **Kullu–Bhuntar–Manali on the Beas**: the land of Kullu, Bhuntar and Manali on the valley floor, low terraces and old channels of the Beas and on the fans of its side streams, among them the Sarvari and the Parbati at their confluences;
- (d) **Baddi–Barotiwala–Nalagarh on the Sirsa and the Balad**: the land of the BBNDA area that drains to the Sirsa, the Balad and their nallahs across the Nalagarh valley;
- (e) **Una on the Swan**: the land of Una and the towns of the Una valley that drains to the Swan and its tributaries;
- (f) **Paonta Sahib on the Yamuna and the Bata**: the land of Paonta Sahib that drains to the Yamuna, whose outfalls are held up when the river at Paonta is above its CWC warning level, or to the Bata;
- (g) **Dharamshala–Kangra on the Dhauladhar khads**: the land of Dharamshala, McLeodganj and Kangra that drains to the Manjhi, the Gaj, the Banner and the Bhagsunag nallah and the other khads of the Dhauladhar front;
- (h) **Rampur Bushahr on the Sutlej**: the land of Rampur Bushahr that drains to the Sutlej and to the khads that join it at the town;
- (i) **Reservoir-backwater towns**: the land of Bilaspur that drains to Gobind Sagar, and of Dehra and the other towns on the Pong reservoir that drains to it, below or near the reservoir's starting level of Clause 3.12.5;
- (j) **Chamba on the Ravi**: the land of Chamba town that drains to the Ravi and to the nallahs that cross the town; 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 held up by a river in flood or by a reservoir, such as the Yamuna at Paonta Sahib, the Swan at Una, the Beas at Mandi, Kullu and Bhuntar, the Sutlej at Rampur Bushahr, Gobind Sagar at Bilaspur or the Pong reservoir below Dehra, or that is buried or blocked by the debris of a khad or nallah, for part of the SW monsoon (Chapter 5);

- (d) loss of more than a quarter of the mapped tank and tal 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 Shimla entry follows the nallahs and the slopes. The town drains through 13 major nallahs from the Kufri–Dhalli–Sanjauli–Ridge–Tutu watershed, north to the Sutlej and south to the Yamuna system through the Ashwani Khad and the Giri (MC Shimla and UNDP, 2015); its storm drains covered about 30% of the city in 2017 and were found "not able to carry the peak flow" (expert committee before the NGT, as recorded in the judgment of 2017, para 53); and the slide of 14 August 2023 at Summer Hill and Shiv Bawri, about 230 m long, ran along an old buried stream channel and killed about 20 people, with buildings collapsing at Krishna Nagar the next day (HIMCOSTE-led technical committee, 2023; as reported). The Ashwani Khad below the town is a drinking-water source whose contamination by sewage caused the hepatitis E outbreak of 2016 (Bhagra et al., 2017). The Mandi entry follows the Beas and the Suketi: on 9 July 2023 the Panchvaktra temple at their confluence was submerged to its dome (as reported), Kataula and Pandoh in the district recorded 210.2 mm and 178.0 mm on 23 August 2023 (IMD), the town's sewage treatment works were damaged in the Beas floods of 2025 (Chief Secretary's affidavit in NGT O.A. 735/2023, 2026), and Mandi lies in a closed cell of the CWC zone 7 plate (Annex 3E); the Balh valley upstream has water 0.27–7.15 m below ground (NAQUIM, Mandi). The Kullu–Bhuntar–Manali entry follows the Beas: the post-disaster needs assessment found that "most of the destruction that occurred along the Beas river in Kullu district was mainly due to overflow of the water along the palaeo channels following the old river course along which the developmental activities have taken place" (PDNA 2023); Manali recorded 131.3 mm on 9 July 2023, a new 24-hour record (IMD), Kullu district reported 26 cloudbursts in July 2023 (HPSDMA, as cited by IMD), and the recovery plan lists flash-flood protection for Bhuntar (₹31.23 crore) and works on the Beas at Manali (₹243.37 crore) among its proposals; there is no CWC site on the Beas at Manali, Kullu or Bhuntar. The Baddi–Barotiwala–Nalagarh entry follows the Sirsa and the Balad: a pier of the Baddi–Nalagarh bridge on the Balad collapsed on 23 August 2023 and bridges at Madawala and Dabhota were lost or damaged in July 2023 (as reported), and the CPCB placed the Bald along Baddi and the Sirsa along Nalagarh in Priority I among polluted stretches (2022 list); the Sirsa has no gauge. The Una entry follows the Swan, channelised under the Swan River Flood Management Project (₹922.49 crore in a Rajya Sabha answer of 2024, ₹945.49 crore in a NITI Aayog note of 2020: the sources differ), with no design flood stated in either; the Una Rampur AWS recorded 228.5 mm on 9 July 2023 (IMD), and the Swan at Ghaluwal has a highest recorded level of 367 m (CWC, as transcribed by SANDRP). The Paonta Sahib entry follows the Yamuna, the only river in the State with CWC warning and danger levels (383.5 m and 384.5 m), whose highest level of 384.6 m on 5 September 1995 stands only 0.1 m above the danger level, and the Bata, which set a new highest level of 373.52 m at Ganguwala on 22 July 2023 (CWC, as transcribed by SANDRP). The Dharamshala–Kangra entry follows the Dhauladhar front, the wettest part of the State: Dharamshala recorded 600 mm in a day on 18 July 1967 (CWC zone 7 report, Annex 4.3) and 250.2 mm and Kangra Aero 273.4 mm on 14

August 2023 (IMD), and a flash flood swept through Bhagsunag on 12 July 2021 (as reported). The Rampur Bushahr entry follows the Sutlej, whose highest level at Rampur, 933 m, was set on 26 June 2005 by the outburst of the Parechu lake in Tibet (CWC, as transcribed by SANDRP), and whose flood of 1 August 2000 was reported to have carried away more than 100 people (as reported); and the burst of 31 July 2024 at Samej, in the Rampur area, in which 56 people were reported killed, fell where no gauge recorded it (as reported). The reservoir entry follows Gobind Sagar and Pong, whose levels are set by BBMB and stood near or above their full reservoir levels in 2023 and 2025 (Commentary to Clause 3.12); the High Court has barred muck dumping into Gobind Sagar "and its feeding khuds/nallahas" and ordered action against those who dumped it (CWPIL 31/2023, order of 31 May 2024). The Chamba entry follows the Ravi, which has no CWC site at Chamba; Chuari in Chamba district recorded 234.0 mm on 14 August 2023 (IMD). Solan, Nahan, Hamirpur, Palampur, Sundernagar and Kala Amb are candidates for notification under Clause 4.5.4. The notification triggers in 4.5.4.1 have no direct precedent and are set by this Manual. The 6-month lead time follows the update rule of Clause 2.14.2. Clause 4.16 explains why releases below pre-development are needed at all.

4.5.5 Minimum outlet and short-duration 2-yr checks

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

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

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

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

Commentary. Under AMC II, a greenfield site produces almost no runoff in a 1- or 2-hour, 2-yr storm, because most of the rain is lost to initial abstraction. A pre-development peak of a few litres per second, compared duration by duration, then forces a very small low-flow orifice. That orifice cannot release the 10-yr volume within 48 hours. Checked as if it were outside a flood-sensitive catchment, the illustrative example of Clause 4.6.7 would need a low-flow orifice of about 75 mm to match the 1-hour, 2-yr pre-development peak. 90% drawdown of the 10-yr volume would then take about 84 hours even with a clean orifice, against the 48-hour limit. The 170 mm orifice that meets drawdown with 50% blockage exceeds the 1-hour, 2-yr pre-development peak by about 11 L/s. Clause 4.5.5.2 resolves that conflict in favour of drawdown, because a basin that is still partly full when the next SW 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 tal 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 Jal Shakti Vibhag agreement.

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

> Commentary. Greenfield is the target for all redevelopment, because a dense city only reduces its runoff as it rebuilds. On small, fully built plots in areas such as the Lower Bazaar, Middle Bazaar and Lakkar Bazaar of Shimla, the old town of Mandi, the bazaars of Solan, Kullu and Chamba, or Kotwali Bazaar in Dharamshala, 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 July to 30 September in sub-areas HP-B, HP-B1, HP-B2 and HP-C, including the Balh valley, at all times in catchments draining to Gobind Sagar, Pong, Pandoh or another reservoir, barrage pond or backwater, or a river at or above its CWC warning level, 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 colony draining to a nallah in Shimla. 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: $P(t) = P24 \cdot (t/24)^{0.40}$, 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

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)
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.

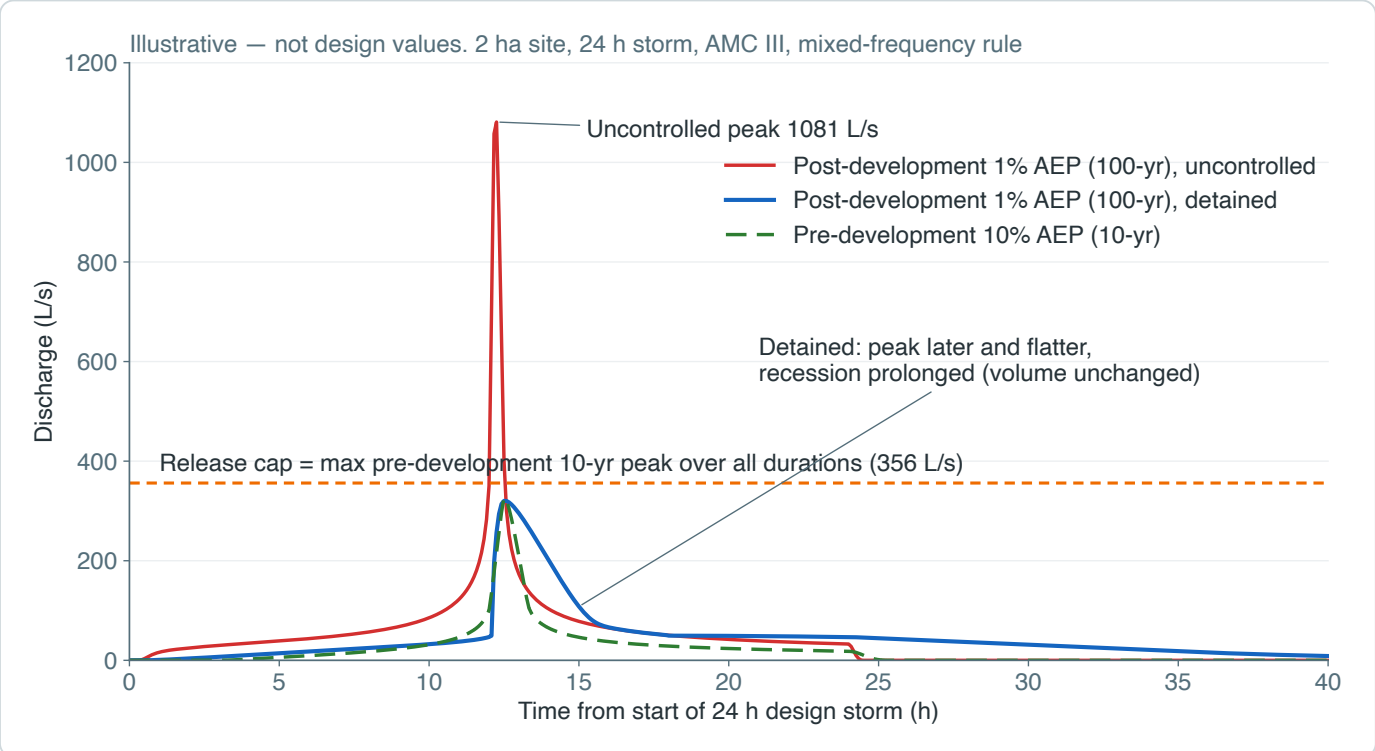


Figure 4.1 — Pre-development 10-yr, post-development 100-yr uncontrolled and detained hydrographs for the 24-hour storm of the illustrative example (Clause 4.6.7). Illustrative — not design values. Original drawing for this Manual, adapted from the pre/post-development hydrograph concept in MARC/KC APWA 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 Himachal Pradesh storage must hold multi-day volumes. It is still short enough that a basin filled by one SW monsoon depression will have most of its volume back before the next, which in July 2023, when four western disturbances (5–11, 13–18, 20–23 and 28–31 July) met an active monsoon and the State received about 448 mm in the month, 75% above its July normal (IMD) 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).

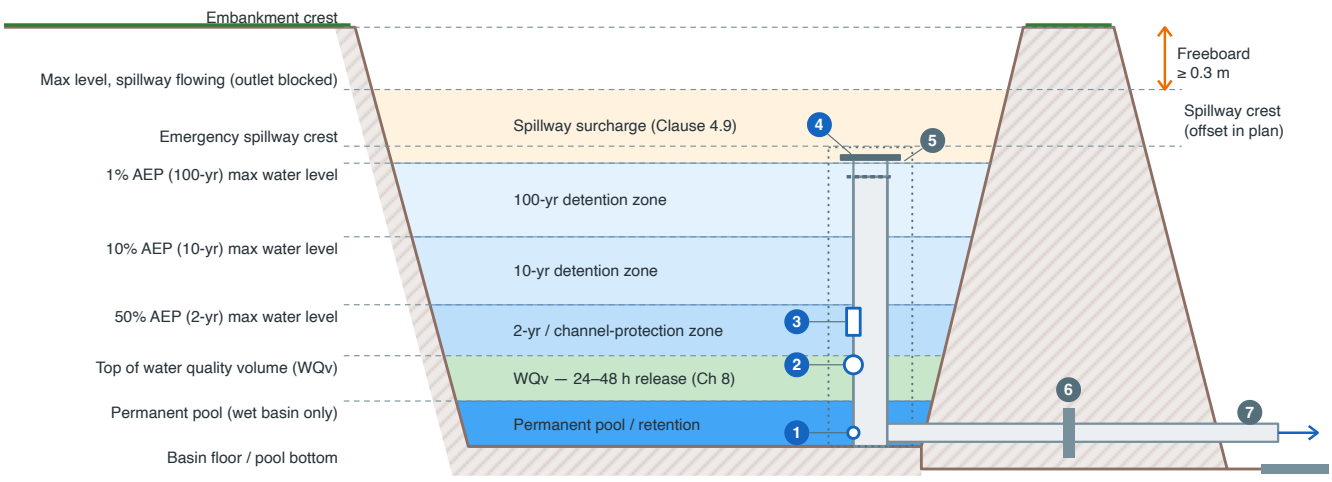
4.8.5 **Outlet barrels.** Outlet barrels through embankments shall:

- 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 TCP Rules 2014, under which a new sub-division of more than five plots keeps at least 10% of the scheme as open or green space and 5% for soak pits and the like (Appendix-1, cl. 20(iii)–(iv)), an IT park keeps 8–12% of its area in parks and tot lots (Appendix-3), and colonies and IT parks put their rainwater storage of 20 L per m² of roof underground in their parks and open spaces. On the Siwalik valley fills of Una, Nalagarh and Paonta–Kala Amb, a detention area graded into the open space below the level of the road keeps it pervious and usable, which is what 4.10.6 requires, and can also infiltrate under Clause 4.11. On a hill site the position is different. Ground on a natural slope of more than 10°, a terrace held up by a retaining wall, land within twice the height of a cut or wall downslope of it, and land in a sinking or sliding zone are not to be used for ponding, because water held there soaks into the slope (hill infiltration rule, Clause 4.11). On such sites, detention is provided in lined tanks, open or closed, with an orifice outlet and an overflow to a lined drain, on rooftops and podiums under 4.10.3 and 4.10.4, or on a level open space only where it stands on rock or on ground that the geotechnical certificate of Clause 4.11 covers; an excavated pond or basin on a slope is not accepted, and the 5% soak-pit area of a hill sub-division is used for lined storage or for the sediment trap ahead of the outfall, not for soak pits. Four kinds of land are not open space for this purpose. A tal, naun, baoli or kuhl on the land is preserved under step 1 of Clause 4.3.1; a tal is modelled as a water surface (Clause 3.3.2(e)) that starts at its spill level (Clause 3.12.5), so only its flood storage above that level can count, and only as Chapter 7 allows, and a kuhl is a canal under the Himachal Pradesh Minor Canals Act 1976 that may not be obstructed or fouled. The strips of 3 m from a nullah and 5 m from a khud of Appendix-1 (cl. 16), the distance from the highest flood level that a development plan delineates, and land "prone to floods" on which the TCP appendices allow no construction are flood land already. Land in the hydraulic corridor of a khad, nallah, tal or river under Chapter 7 is corridor or flood land: water reaches it first, so it is not counted as detention for the development beside it (Chapter 7). And land kept open on purpose, such as the green belts of Shimla, where the development plan allows only limited building and no felling (as recorded by the Supreme Court in 2024), or a mapped spring-recharge area such as the Bohal catchment above Palampur (Clause 4.11), is not graded or paved for detention.

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 SW monsoon season.

4.11.5 **RWH remains mandatory.** Nothing in this chapter reduces the RWH requirement of Appendix 6 of the TCP Rules 2014, any direction under section 15 of the Himachal Pradesh Ground Water (Regulation and Control of Development and Management) Act 2005, the guidelines of the Central Ground Water Authority where they apply, any condition of a planning permission, or any rainwater harvesting rule or direction of an approving authority.

> Commentary. RWH in Himachal Pradesh rests on Appendix 6 of the TCP Rules 2014, "Regulations for collection of rain water". The collection of rain water from roof tops is compulsory wherever the Himachal Pradesh Town and Country Planning Act 1977 is in operation, "For all the buildings existing or proposed for construction in future"; the minimum capacity "shall be worked out @ 20 Liters per square Metre of the roof top area" (cl. (vi)); the stored water is to be used regularly for non-drinking uses, "including fire fighting, landscaping, gardening apart from domestic usages" (cl. (iv)); no water supply connection is given until the system is in place and working (cl. (v)), and a violator is liable to disconnection (cl. (vii)); existing buildings were to install it within eighteen months (cl. (viii)); and storage below ground may be built in the setbacks (cl. (i)). Colonies and IT parks provide the same 20 L per m² of roof underground in their parks and open spaces. A storage of 20 L per m² of roof is 20 mm of rain over the roof, and it is a storage rule, not an infiltration rule: Appendix 6 sets no drawdown, no recharge and no infiltration test, and it requires no recharge on any ground, which suits a State whose built-up land is mostly on slopes. The Himachal Pradesh Ground Water (Regulation and Control of Development and Management) Act 2005 (Act 31 of 2005, amended in 2022 and 2023) adds an enabling power: the Ground Water Authority "may" identify recharge areas and issue rainwater harvesting guidelines, and may direct the construction of rainwater harvesting structures in urban "residential, commercial and other premises having plinth area of 100 square meters or above", building them itself at the owner's cost on default (s.15); the whole State is reported to have been notified under the Act from 19 November 2019 (as reported). The draft Rules of 2006 would exempt from such directions premises of less than 100 m² and "the sinking zones, where construction of rain water harvesting structures would be detrimental to the safety of the building structures in the area" (draft rule 29); the final Rules were not seen, and the exemption is cited as a draft [TBC]. The National Green Tribunal's direction of 2017 that rainwater harvesting be mandatory for all building plans (XIV) was set aside with the rest of its Shimla judgment in 2024 (Commentary to Clause 4.1). No Himachal Pradesh rule found sets a slope, a distance or a soil condition for a soak pit or recharge pit, and Appendix-1 still reserves 5% of a new sub-division "for soak pit etc." (cl. 20(iv)). This Manual credits these structures against its own retention requirement (Clause 4.4) as follows:
>
> - An RWH tank under Appendix 6 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 it is full after the first heavy rain. A tank may also provide detention only if it is built as a combined tank under Clause 4.11.3, with a detention zone above its RWH overflow level that drains through its own orifice; only that zone counts.
> - An RWH tank counts toward the **retention** requirement of Clause 4.4 only to the extent that it is emptied within 72 hours by a continuous non-potable use, such as toilet flushing or washing, demonstrated under Clause 4.4.3; watering a garden is not a continuous use in the monsoon. The tank is then modelled under Clause 4.4.6 like any other retention practice. On hill sites, where infiltration is barred, this storage and reuse is the way retention is provided, and the 20 mm of Appendix 6 is the first part of it.
> - Recharge pits, trenches, shafts and wells count as retention only where they meet Clause 4.11.4: 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. They are also subject to the hill infiltration rule below.

- **Hill infiltration rule.** No deliberate infiltration practice (soakaway, soak pit, recharge pit, shaft or well, infiltration trench, or permeable paving with an exfiltrating base) shall be built or credited: on natural ground sloping more than 10°; in a sinking or sliding zone defined in a Development Plan or Interim Development Plan, including Shimla's two sinking and sliding zones, or on any other mapped landslide or creep zone; on debris cover, colluvium, slide debris or moraine, whatever its slope; or upslope of a cut slope or retaining wall within a distance of 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 the rainwater storage of Appendix 6 of the TCP Rules 2014 (20 L per m² of roof), with overflow to a lined drain that discharges through a sediment trap to a stable natural channel, never onto an unprotected slope. Shimla's two zones are the high sinking-prone area of the Ridge, the Grand Hotel, Lakkar Bazaar, the Central School and the Auckland Nursery School, down to Dhobighat below the Idgah electric substation, and the sliding area of Ladakhi Mohalla, Krishna Nagar, the spurs below the office of the Director of Education and the surroundings of Clarkes Hotel, as identified by the expert committee before the NGT (judgment of 2017, paras 53 and 62) and described in the draft Shimla Development Plan of 2022 (as quoted in the press); the zone maps of the plan as published in 2023 were not read [TBC], and wherever they are wider they govern. In a sinking or sliding zone the geologist's soil investigation report of Rule 21(1) shall also state whether the site's drainage, storage and any infiltration add water to the slope. On these sites, retention is provided by storage and reuse, and detention by lined tanks, not by ponds or basins on the slope (Commentary to Clause 4.10). The 1.0 m groundwater separation of Clause 4.4.3 does not make an infiltration practice acceptable on a slope: perched water and pore pressure in a slope are the hazard, not the depth to the water table.
- **Recharge only on the Siwalik valley fills.** Every one of the ten valley units that the CGWB assesses in the State is safe, with a stage of groundwater extraction of 35.48% for the State in 2024; the highest are Una district (63.72%) and Solan district (57.89%, in the Nalagarh valley), and seven districts, among them Shimla, Kullu and Chamba, have no assessed unit (CGWB, GWRA 2024). Water levels were reported to be falling in the Kangra–Palampur, Indora–Nurpur, Nalagarh, Kullu and Una valleys in August 2025 (as reported). On the valley fills and fans of Una, Paonta–Kala Amb and the upper terraces of Nalagarh, where water stands deep and transmissivities reach 2,600–3,336 m²/day (NAQUIM, Una and Sirmour), and on ground to which the hill infiltration rule does not apply, retention shall be provided by recharge before reuse or detention wherever site tests allow, through a silt trap, a filter and a first-flush diverter ahead of the recharge structure, and with a hydrogeologist's check of the target zone. Recharge is not credited anywhere else in the State unless a hydrogeologist's study approved by the authority shows a deep, stable water table and ground to which the hill infiltration rule does not apply.
- **No recharge credit on wet ground.** In the Balh valley wherever the seasonal high water table is within 1 m of the surface, which it is over much of the valley floor in the monsoon (water 0.27–7.15 m below ground; NAQUIM, Mandi), on the floors of the Siwalik valleys near their trunk streams, where wells near the Swan flow above ground, on the floodplains and low terraces of the rivers and khads, on the margins of the tals and reservoirs, and wherever the seasonal high water table is within the 1.0 m separation of Clause 4.4.3, no recharge or infiltration practice earns retention credit; storage and reuse, detention and conveyance govern there.
- **Springs, nauns and baolis.** About 500 springs have been inventoried in the State in a standard format (NITI Aayog, *Resource Book on Springshed Management in the Indian Himalayan Region*, 2021), and HIMCOSTE is reported to count about 10,512 traditional water sources, of which only 30.41% are recharging properly (as reported). Palampur pays the forest development committee of Bohal to protect the recharge area of the Bohal spring and streams that supply the town (NITI Aayog, 2021); the CGWB advises that a bore well near a spring source in the hills "should be avoided" (NAQUIM, Una and Mandi); and at Krishna Nagar in Shimla the 2023 committee found open drains and springs in the upper catchment feeding water into the slope that failed. The TCP forms require bauris and wells to be shown on the site plan, but no Himachal Pradesh rule found keeps construction back from a spring [TBC]. In the recharge area of a spring, naun or baoli, where it has been mapped, such as the Bohal catchment above Palampur, only clean roof runoff,

passed through a filter, may be infiltrated, and only where the hill infiltration rule allows; road and parking runoff shall not be infiltrated, the area shall not be paved, and no runoff that may be polluted shall be infiltrated upslope of a spring, naun or baoli.

- **Industrial and polluted runoff.** The Ground Water Act bars any person from releasing "any effluent that contaminates the groundwater" (s.5A). Runoff from industrial premises, fuel stations, workshops and the like in Baddi–Barotiwala–Nalagarh, Kala Amb, Paonta Sahib and the industrial areas of Una, where the drains reaching the Sirsa and the Bald carry industrial and sewage loads (Sirsa action plan; CPCB, 2022), shall not be recharged; the hydrogeologist's check of a recharge bore or shaft on the valley fills shall report the nitrate and other contaminants of the target aquifer before it is credited, and untreated runoff shall not be put into a bore or shaft there (Chapter 8).
- **Everywhere,** road and parking runoff shall be recharged only through a surface infiltration practice with a filter, such as a vegetated basin or trench, never directly into a bore or well, and runoff from a nallah or khad that carries sewage, as the nallahs of Shimla above the Ashwani Khad and the drains of Baddi and Nalagarh do in part, shall not be recharged at all.

In the hills, water put into the ground does not stay where it is put. The technical committee on the Shimla slides of July and August 2023 named "Open Drainage systems leading to poor disposal of surface water" among their seven causes, with "over saturation of the sub surface thick debris cover", and found that the slide of 14 August 2023 at Summer Hill and Shiv Bawri, about 230 m long, ran along "the weak plane of the depression which seems to be old buried channel of a dry stream", such depressions being "the conduits for the infiltration of sub surface water in case of metamorphic terrains"; at Navbahar Chowk it found that "Input of rainwater from the road also accelerated the process" (HIMCOSTE-led technical committee, 2023). The expert committee before the NGT had found in 2017 that slides in Shimla were due to "oversaturation of the slope, either by increased rainfall activity or concentrated household disposal", and had asked for lined drains so that there is "minimum ingress of water into the slope" (as recorded in the judgment, paras 53 and 62); the post-disaster needs assessment of 2023 named "blockage of the natural water drainage" among the root causes of the slides and recommended against "disposing of sewage onto slopes" (PDNA 2023). In the Balh valley a recharge pit sits in the water table in the monsoon, and in any town an RWH tank is full after the first heavy rain. Treating RWH as detention would therefore credit storage that does not exist when it is needed. That is why this Manual assumes RWH tanks are full at the start of every storm. Applying the assumption to every season keeps one simple rule. The combined-tank provision (4.11.3) lets an owner build one structure, as long as the detention part is empty when the storm arrives. The hill infiltration rule, the rule that recharge is credited only on the Siwalik valley fills, the bar on recharge credit on wet ground, the spring rules, the industrial-runoff and pre-treatment rules and the road-runoff rule are set by this Manual. No Himachal Pradesh source sets a slope or distance threshold for infiltration: the slopes in the TCP Rules are limits on building (30° for IT parks and in the definition of a hilly area, 45° for development), and the expert committee before the NGT proposed 35° on soil and 45° on rock, also for building. The 10° limit is set by this Manual well below those slopes, 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 Balh valley round Sundernagar and Ner Chowk, where the water table stands 0.27–7.15 m below ground, the floors of the Una, Nalagarh and Paonta–Kala Amb valleys near their trunk streams, where wells near the Swan flow above ground, the floodplains and low terraces of the Beas, the Sutlej, the Ravi, the Yamuna, the Giri and the Swan and of the khads, the margins of Rewalsar, Renuka, Khajjiar and the other tals, the margins and backwaters of Gobind Sagar, the Pong reservoir, the Pandoh reservoir and the other reservoirs and

barrage ponds, and hill sites with perched water, such as the sinking and sliding zones of Shimla, 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 SW monsoon, from:

- (a) site piezometer readings over at least one full June–November season; or
- (b) where (a) is not available, the higher of the CGWB or Jal Shakti Vibhag record for the nearest observation well, plus **0.5 m**, and the design flood level of any adjacent river, khad, nallah, tal or reservoir.

For the flotation check of 4.12.3 at sites in the Balh valley, the river terraces and floodplains, and the tal and reservoir margins, where (a) is not available, the DGWL shall be taken as existing ground level.

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

- (a) the facility shall be watertight (lined or of watertight concrete), and no infiltration credit applies (Clause 4.4.4); or
- (b) if unlined, the volume below the DGWL shall not be counted as detention, and groundwater inflow shall be added to the routed inflow.

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

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

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

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

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

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

> **Commentary.** Himachal Pradesh is landlocked, so the coastal provisions of this clause, the tidal water levels of 4.12.1 and 4.12.3, do not apply in the State, and no saline groundwater was reported in the assessments read for this Manual [TBC], so the exposure provisions of 4.12.5 apply only where a test at the site shows it. Groundwater lies at three kinds of depth. On the coarse fans of the Siwalik valleys it is deep: up to 43.20 m below ground at Chalet in the Una valley (NAQUIM, Una), 42 m at Kolar in the Paonta–Kala Amb valley (NAQUIM, Sirmour) and more than 35 m in the south of the Nalagarh valley (NAQUIM, Nalagarh). In the Balh valley and on the valley floors near the trunk streams it is shallow: 0.27–7.15 m below ground in the Balh valley (NAQUIM, Mandi), 0.35 m in Mandi district in May 2021 (CGWB, Ground Water Year Book 2021–22), and above ground in the wells that flow under artesian pressure near the Swan at Rampur in the Una valley, 1.45 m above ground (NAQUIM, Una). In the hills it occurs in fractures, weathered rock and debris cover, and is perched in depressions such as the one at Cambley Bank in Shimla, which the 2023 committee called an "ideal site for the retention of sub surface water" (HIMCOSTE-led technical committee). The Balh valley, the valley floors near the trunk streams, the floodplains and low terraces of the rivers and khads, the margins of the tals and of the reservoirs and their backwaters, and hill sites with perched water are the wet cases. There an unlined tank fills with groundwater before the storm, and an empty lined tank can float, especially when a river or khad in flood, a reservoir at its full level or a tal at its spill level raises the water table beside it. The design groundwater level of 4.12.1(b) therefore takes the design flood

level of the adjacent river, khad, nallah, tal or reservoir where that is higher than the well record, and in the Balh valley, on the river terraces and floodplains and on the tal and reservoir margins it is taken as existing ground level for the flotation check unless piezometers show otherwise. Where wells near the site flow under artesian pressure, as near the Swan in the Una valley, the tank shall also be checked for uplift with the groundwater at the artesian head measured in the nearest flowing well, which may stand above ground. 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 (hill infiltration rule, Clause 4.11). The June–November monitoring season of 4.12.1(a) is set by this Manual to cover the SW monsoon, which now leaves the State in early October in most years, and the post-monsoon high that the CGWB measures in November: a reading taken in May or June understates the design level. No monsoon water-table depths for individual town sites in Sundernagar, Mandi, Kullu, Bhuntar or Una, and no map of the seasonal high water table of the Balh valley, were obtained [TBC]. The factor of 1.2, the 0.5 m allowance, the "ground level" default for the Balh valley, the river terraces and floodplains and the tal and reservoir margins, and the artesian-head check have no direct precedent; this Manual sets them because no published site-scale seasonal groundwater depths for Himachal Pradesh were found during research.

4.13 Regional detention and fee-in-lieu

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

- (a) a regional detention facility identified in the plan; or
- (b) a fee-in-lieu paid toward restoration of tal 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 SW monsoon. Storage below FTL that is held for irrigation or supply through June to September 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.

Himachal Pradesh has no tank or lake Act, and no tal, lake or reservoir in its towns was found to be operated for flood control under a documented rule. The State Wetlands Authority was constituted on 7 November 2017 under the Wetlands (Conservation and Management) Rules 2017, with HIMCOSTE as its member secretary and secretariat (notification No. STE-E(3)-10/2017-Pt-I), but no wetland in the State was found notified under rule 4 of those Rules [TBC]. The State has three Ramsar sites, Pong Dam Lake (15,662 ha, designated on 19 August 2002), Chandertal (49 ha) and Renuka (20 ha) (both 8 November 2005) (MoEFCC, list of Ramsar sites, 31 January 2024), and two wetlands of national importance, Rewalsar and Khajjiar (State Level Steering Committee on Wetlands, 2017). The State's regional storage is of five kinds: the natural tals, Rewalsar (2.6 ha, in a catchment of 173 ha), Renuka (about 20 ha, fed by 21 seasonal streams) and Khajjiar, with Chandertal in the high Himalaya; the reservoirs, Gobind Sagar behind Bhakra and the Pong and Pandoh reservoirs (BBMB), Kol (NTPC), Nathpa Jhakri (SJVN), Chamera (NHPC), Larji (HPSEBL) and the other hydro-electric ponds; the kuhls, the gravity irrigation channels of Kangra, Mandi and Kullu, which are canals under the Himachal Pradesh Minor Canals Act 1976 where they are listed in its schedules; the springs, nauns and baolis; and the river floodplains, which no law protects. Four points follow:

- A tal on the record may not be a working tal, and a tal in the hills is not a detention basin. No inventory of the tals, ponds, nauns and baolis within the Municipal Corporations, Nagar Parishads and Nagar Panchayats, with their beds, rims and outlets, was found [TBC]. A tal is credited only after a survey shows its bed, rim and outlet, and only for the storage above its spill level; Rewalsar, whose leaking sewage drains are reported to cause eutrophication (State Wetlands Authority, *Major Wetlands of Himachal Pradesh*), offers none, so every site in its catchment provides its full detention on site. A spring-recharge area is not storage for detention (Commentary to Clause 4.11).
- The reservoirs are not spare capacity for a site. They are held for power, irrigation and supply through the monsoon, and their drawdown zones, such as the 80 km² or so of the Pong reservoir between 1,280 and 1,390 ft, fill before the late-monsoon storms; their storage below full level is not credited (Clause 4.13.2(c)); their releases are set by their operators for the whole river; and storm water spilled to a reservoir, or to a river below one, can be relied on only with the written agreement of the operator, BBMB, NTPC, SJVN, NHPC, HPSEBL or the project company, for a stated flow and level.
- A pond or check dam in the bed of a khad or nallah is not regional detention unless it is designed for debris. The streams of the hills and the Siwalik valleys carry boulders, sediment and muck in every large storm, and a basin in their bed fills with debris in one event, as the Malana II pond did in July 2023 (as reported); such a facility is credited only for the storage left after the sediment and debris volume of Chapter 6, with a debris rack or trap at its inlet, a geotechnical check of its bund and abutments, its failure path mapped, and a maintenance budget for clearing it after each large storm (Chapters 9 and 10). A regional facility on a hill slope is also subject to the hill infiltration rule of Clause 4.11. A kuhl is not regional detention either: a storm drain that crosses or discharges to a scheduled kuhl does so only with crossing works under section 46 of the Minor Canals Act and the consent of the body that manages the kuhl, through a screen and a sediment trap, because fouling or obstructing a canal is an offence (s.65).
- No rule dividing natural streams from municipal drains was found [TBC]. Until one is made, this Manual follows the working assignment of Chapter 1: rivers, khads and nallahs outside the limits of a local body, with their beds and banks and the flood-protection and channelisation works on them, such as those on the Swan, as the Jal Shakti Vibhag's; the nallahs, khads and public drains within the limits of a Municipal Corporation, Nagar Parishad or Nagar Panchayat as that body's; drains built under AMRUT or by a Smart City company, or in a scheme of HIMUDA, HPSIDC, BBNDA or a colony developer, as the builder's until

handed over in writing; road drains and cross-drainage as the PWD's, and on national highways NHAI's; sewers as SJPNL's in Shimla and the Jal Shakti Vibhag's elsewhere; scheduled kuhls as the managing body's under the Minor Canals Act; the reservoirs as their operators'; and the Ramsar sites and other wetlands as within the remit of the State Wetlands Authority and the Forest Department (Commentary to Clause 6.9). This is the Manual's working assignment, not a statutory one.

The first point is the basis of condition 4.13.2(c) in Himachal Pradesh. A tal gives flood storage only above its spill level, unless a notified operating rule commits it to be lowered before the SW monsoon. 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
HP-Z1 Siwalik foothills: HP-A Siwalik foothills and outer valleys (Una–Baddi–Nahan–Paonta–Bilaspur–Hamirpur)	A / B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
HP-Z2 Mid-hills: HP-B Mid-hills (Shimla–Solan–Mandi–Chamba–Rampur)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
HP-Z2 Mid-hills: HP-B1 Dhauladhar front (Dharamshala–Kangra–Palampur–Jogindernagar)	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
HP-Z2 Mid-hills: HP-B2 Kullu–Manali inner valley	B / C / D	50% / 70% / 90%	[TBC]	[TBC]	[TBC]	[TBC]	[TBC]
HP-Z3 High and trans-Himalaya: HP-C High and trans-Himalaya (Kinnaur–Lahaul–Spiti; snow-fed)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(i))	—	—	—	—

Worked example (illustrative — not design values).

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

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

Then:

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

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

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

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

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

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

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

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

Table 4.3A — Fixed release coefficients (provisional)

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

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

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

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

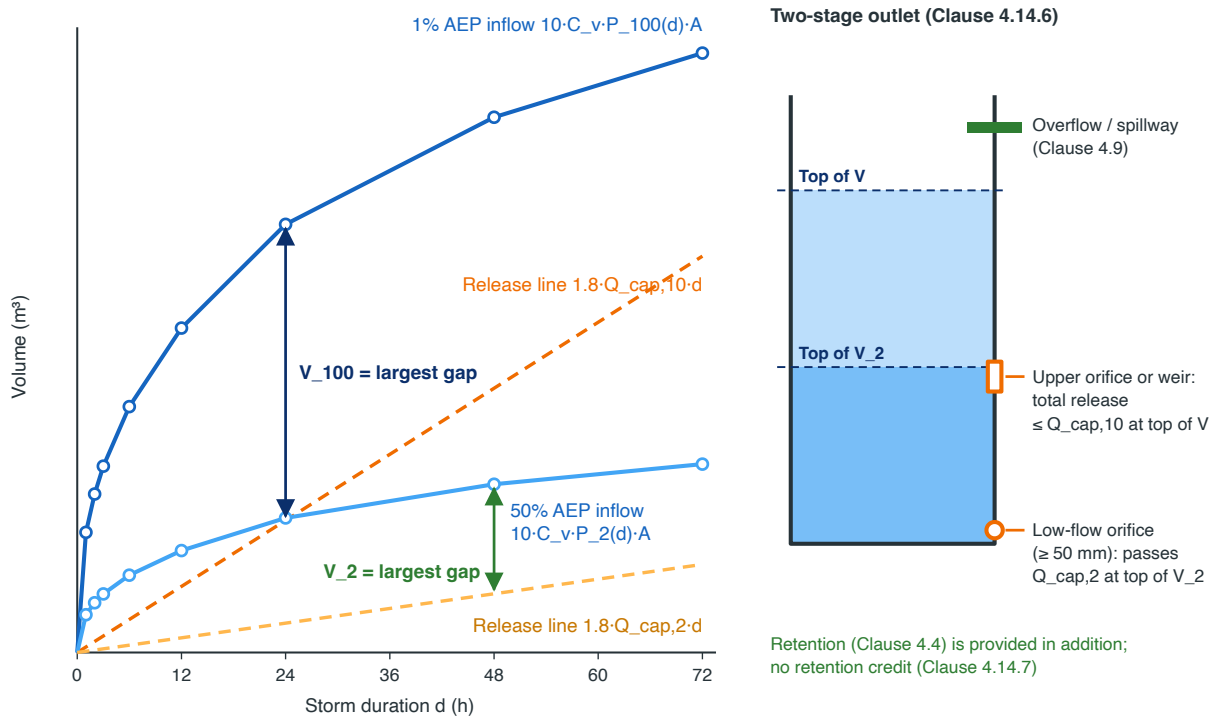
V_2 = max over d of [10 × C_v × P_2(d) × A − 1.8 × Q_cap,2 × d]

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

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

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

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



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

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

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

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

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

Commentary. The fixed-coefficient route follows Singapore, which caps the peak runoff from every development of 0.2 ha or more with one runoff coefficient, C = 0.55, applied to the 10-yr storm (PUB Code of Practice on Surface Water Drainage, 7th ed., cl. 7.1.5, Addendum No. 3, 2025). It is quick to apply and quick to check: the cap needs only the site area, the soil group and two intensities. PUB's 0.55 is not used here, because Singapore's baseline is the existing urban drainage system, while this Manual's baseline is greenfield land (Clause 4.5.1.2). The coefficients of Table 4.3A are set by this Manual from the greenfield curve numbers of Clause 3.3 (CN 39, 61, 74 and 80 for soil groups A to D). They are the ratios of runoff to rainfall that those curve numbers give for 1-hour depths typical of the Siwalik valley fills of Una and Nalagarh, 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 Hindi 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 Himachal Pradesh, the governing failure takes two forms. In the valley towns and on the reservoir shores it is volume with no outlet when a river or reservoir downstream is high. Paonta Sahib drains to the Yamuna, whose CWC warning and danger levels at Paonta are 383.5 m and 384.5 m and whose highest level, 384.6 m on 5 September 1995, stands only 0.1 m above the danger level (CWC, as transcribed by SANDRP); Mandi drains to the Beas and the Suketi, which on 9 July 2023 submerged the Panchvaktra temple at their confluence to its dome (as reported), and to the reach above the Pandoh reservoir, all five of whose gates were opened on 30 June 2025 to pass nearly 44,000 cusecs (about 1,250 m³/s) (as reported); Bilaspur drains to Gobind Sagar, which stood at 1,679 ft (about 511.76 m), a foot below its full reservoir level, on 4 September 2025, and Dehra to the Pong reservoir, which rose to 1,399.65 ft (about 426.61 m), above its full reservoir level of 1,390 ft, on 15 August 2023 (as reported): when the reservoir is at that level, every drain below it discharges to a water surface that cannot fall until BBMB releases. In the hills and on the Siwalik fans the outfall is closed in a different way: by debris. The khads and nallahs rise fast after a burst and carry boulders, sediment, wood and muck that bury outfalls, block culverts and choke the drains behind them; in July 2023 the streams at Thunag were choked with "illegally chopped wood and debris from a road project", and the Malana II pond was "filled with debris and silts causing its overspill" (as reported by SANDRP), and the High Court has acted against the dumping of road muck into Gobind Sagar and its feeding khads (CWPIL 31/2023, order of 31 May 2024). No hourly record of how long a river, reservoir or tal in Himachal Pradesh stays above a town's outfalls was obtained [TBC], the Beas has no CWC site at Manali, Kullu, Bhuntar, Mandi or Pandoh and the Sutlej none at Bilaspur, and no document was found that sets a design river level for an outfall; Chapter 5 sets the design level and the closure to be assumed, and Chapters 6 and 9 the debris and blockage allowances. A perfectly orificed basin behind a closed outfall simply fills. No release-rate rule can fix that; it is handled by the outfall-closed check of Chapter 5.

The response in this Manual is layered:

- release below pre-development (Clause 4.5);

- retain the frequent storms (Clause 4.4);
- route long SW monsoon storms (Clause 4.6.3);
- prefer regional storage in the tal 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 Himachal Pradesh.** Himachal Pradesh is landlocked and mountainous: it has no coast, no tide and no Coastal Regulation Zone, and a monsoon system reaches it only as rainfall, often meeting a western disturbance over the hills, as in July 2023; that rainfall is dealt with in Chapter 2, not as a tidal or surge level. No outfall in the State discharges to the sea, a tidal creek or an estuary, so the provisions of this chapter that depend on tide, storm surge, sea-level rise or a river mouth do not apply in Himachal Pradesh: Clause 5.7 and Annex 5A, cases J1 to J3 of Table 5.2, the tidal lock windows of Clause 5.10.3, the seawater requirement of Clause 5.11.3(a) (gates and seats shall still be of corrosion-resistant materials, and shall resist abrasion by gravel and boulders), and Clause 5.13. They are kept so that the clause numbers of this Manual match its other State editions. In Himachal Pradesh the receiving water is one of five kinds: a river, reached directly, through a gate in a bank or embankment or through a pumping station, such as the Yamuna at Paonta Sahib, the Sutlej at Rampur, the Beas at Kullu and Mandi, the Swan at Una and the Ravi at Chamba, whose level rises and falls within hours in the mountains but is held up for days by long monsoon spells and by the releases of the dams above it; a khad or nallah, such as the nallahs of Shimla and the Ashwani Khad, the Suketi at Mandi, the khads below Dharamshala or the Sirsa and the Balad at Baddi–Nalagarh, ungauged, seasonal and laden with boulders, whose bed rises and falls in a single flood; a reservoir held near its full level, such as Gobind Sagar at Bilaspur, the Pong reservoir and the Pandoh reservoir; a tal (ताल; a pond, lake or tank), such as Rewalsar, Khajjiar or Renuka; or a kuhl (कूहल; a gravity irrigation channel) or canal; 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, a khad or nallah, a reservoir or barrage pond, a tal, a kuhl or canal or a receiving drain, with the river lock of Clause 5.8.5(a) and the closures of Clause 5.8.5(b) to (e) in place of the tidal lock windows.

Commentary. The drains of Himachal Pradesh's towns fail in places that site design does not see, and in five different ways. The first is the river. Paonta Sahib drains to the Yamuna, whose highest recorded level at Paonta, 384.6 m, stands only 0.1 m above its danger level, and to the Bata, which set a new highest level at Ganguwala on 22 July 2023; Rampur drains to the Sutlej, which rose by 12 to 15 m (as reported) when a landslide lake on the Parechu in Tibet burst on 26 June 2005 and set the highest levels at Nathpa and Rampur; and Mandi drains to the Beas at its confluence with the Suketi, where the Panchvaktra temple was submerged to its dome on 9 July 2023 (as reported), at a place where no gauge records the level (CWC data, as copied by SANDRP). The second is the khad and the nallah. Shimla's thirteen major nallahs run north to the Sutlej and south to the Ashwani Khad and the Giri (Municipal Corporation Shimla and UNDP, 2015); none of them is gauged; the expert committee that reported to the National Green Tribunal in 2017 found that the debris of Shimla's slopes "is dumped in the valley or near water channels, obstructing the natural drainage" (*Yogindra Mohan Sengupta*, judgment of 16 November 2017, para 62, set aside by the Supreme Court on 11 January 2024 and cited here only for its committee's findings); and in July 2023 the khads at Thunag were choked with timber and with debris from a road project (as reported). The third is the reservoir: Gobind Sagar holds every drain of Bilaspur, the Pong reservoir took what was reported as its highest inflow since 1974 on 14 August 2023 and rose from 1,374.20 ft to 1,399.65 ft over 11–15 August (as reported), and the releases of Larji and Pandoh raise the Beas at Mandi. The fourth is the tal. Rewalsar, Khajjiar and Renuka receive the drains of the settlements around them and have no published level. The fifth is the kuhl and the canal: the kuhls of Kangra and the other districts are statutory canals under the Himachal Pradesh Minor Canals Act 1976 and intercept the runoff of the slopes above them. The outfalls also belong to one body while the drains above them belong to others: the rivers, khads and flood works are the Jal Shakti Vibhag's, the reservoirs BBMB's, NTPC's, SJVN's, NHPC's or HPSEBL's, the kuhls the Jal Shakti Vibhag's or their beneficiaries', and the drains the Municipal Corporations', the Nagar Parishads' and Nagar Panchayats' and PWD's, and no rule divides them (Chapter 6, Clause 6.9). No document found during research sets a design level for any river, khad, reservoir, tal or kuhl outfall in the State, or a design standard for any town drain. A detention basin that meets every release rate in Chapter 4 still fails if the river it drains to stands above its outfall, if the khad has buried its outlet in boulders, or if the reservoir or tal is full. This chapter makes these failure modes part of the design. Himachal Pradesh has no tidal outfall, so Clause 5.1.4 says which of the chapter's coastal provisions fall away and what takes their place.

5.2 Definitions

Term	Meaning in this Manual
Analysis point	A location on the downstream system where pre- and post-project conditions are compared (Clause 5.3.3).
Contributing catchment	The whole area draining to an analysis point, on and off site.
Major drain	A channel listed as a major drain in the basin plan or Annex 5B, or any river, Jal Shakti Vibhag canal, the nallahs of Shimla that run north to the Sutlej and south to the Ashwani Khad and the Giri, the Suketi and its khads at Mandi, the Manjhi, Gaj, Banner and Neugal khads and the Bhagsunag nala below Dharamshala, Kangra and Palampur, the Sirsa, the Balad and the Sandholi and other nallahs of Baddi–Barotiwala–Nalagarh, the Swan and its tributary khads at Una, the Bata at Paonta Sahib, the side khads of the Beas in the Kullu valley, any kuhl in Schedule I or II of the Himachal Pradesh Minor Canals Act 1976 that receives storm water, the Beas–Sutlej Link, any drain built or held by a Municipal Corporation, a Nagar Parishad or Nagar Panchayat, HIMUDA, BBNDA, HPSIDC, a Smart City company or PWD with an internal width of 1.0 m or more, and every khad, nallah or choe that drains 8 ha or more, or a tidal creek.

Term	Meaning in this Manual
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.
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, tal** 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 tal 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, SMC, HPSDMA or Jal Shakti Vibhag; 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.

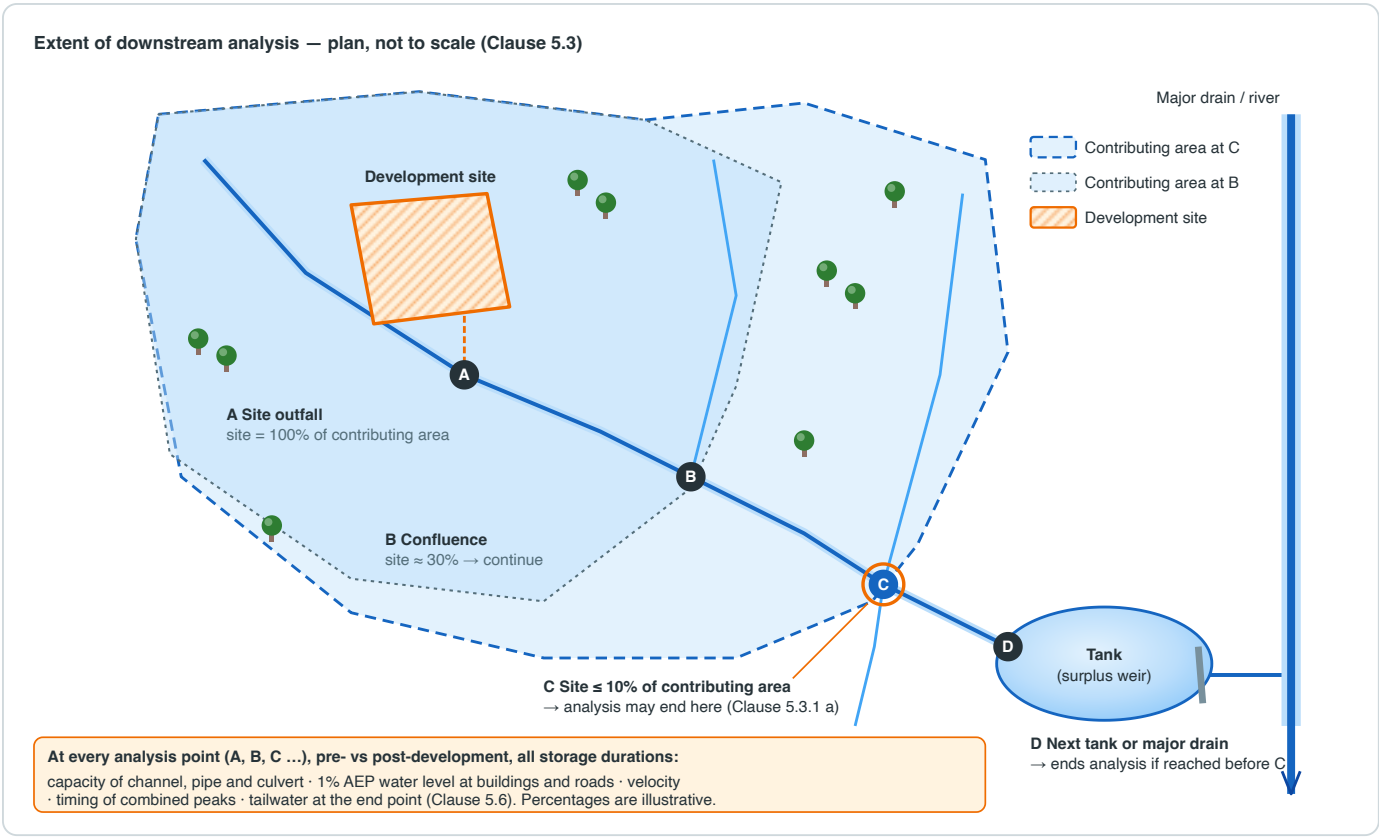


Figure 5.1 — Extent of downstream analysis: analysis points A–D, the contributing area at each point, the 10% point, and the next tal or major drain as an alternative end point. Schematic; percentages are illustrative. Original drawing for this Manual, adapted from the ten-percent rule in the Georgia 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 Himachal Pradesh. In the hill towns, where a colony's drain runs down a nallah to a khad, and the khad to a river many kilometres below, as Shimla's nallahs run to the Ashwani Khad and the Giri on one side of the ridge and to the Sutlej on the other, and on the Siwalik valley floors of Una, Baddi–Nalagarh and Paonta Sahib, where the drains run across the fans to the Swan, the Sirsa and the Balad, and the Yamuna, 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 valley and reservoir-shore towns of Himachal Pradesh, whose outfalls lie below rivers and reservoirs held high for days by monsoon spells and dam releases: the Pong reservoir rose from 1,374.20 ft to 1,399.65 ft over 11–15 August 2023 and then released 1.40 to 1.50 lakh cusec into the Beas for days, and in 2025

it released more than one lakh cusec from 29 August and peaked on 5 September (as reported); and on 9 July 2023 the Beas at Mandi rose over the Panchvaktra temple at its confluence with the Suketi (as reported). 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 Himachal Pradesh, Clause 5.1.4), tidal levels may differ from the open coast. Open-coast levels shall be used unless measured levels over at least one spring–neap cycle, or a calibrated hydrodynamic model, justify a different value. No reduction below open-coast levels shall be taken without such evidence.
- (d) **Interim.** Until Annex 5A is published, the designer shall obtain the values directly from the sources in (a) and record them.

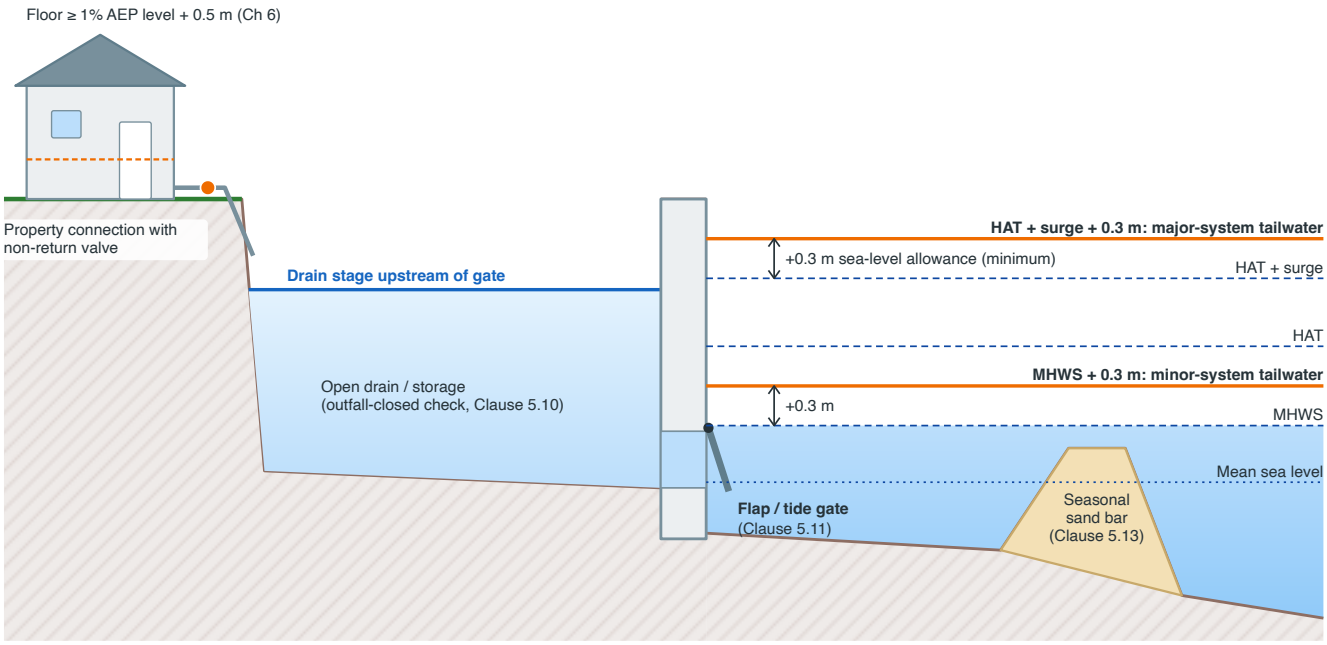
5.7.3 **Storm surge.**

- (a) **Major-system and storage design.** The surge term in "HAT + surge" is the **10% AEP (10-yr) storm surge** for the coastal segment, given in Annex 5A. The 1% AEP surge is used only in the joint case of Clause 2.12(b), with the 10-yr 48-hour storm. That keeps the two cases symmetric, so that a rare rainfall is never paired with a rare surge.
- (b) **Joint case.** The 1% AEP still-water level for Clause 2.12(b) is taken from Annex 5A.
- (c) Until Annex 5A is published, both values shall be taken from a site-specific study using INCOIS, IMD or NCCR surge hindcasts or return-level analyses. The study shall state its source, method and record length.
- (d) Wave set-up shall be added where the outfall faces the open sea without a protected entrance.

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

- (a) **+0.3 m** minimum for every element;
- (b) greater than 0.3 m where the State, a SADA 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.

Tidal outfall — schematic section, not to scale (Clauses 5.6–5.13)



Notes
Levels are diagrammatic. Datums from the current NHO / Survey of India tide tables, reduced to the project datum (Clause 5.7).
Joint case (Clause 2.12 b): 10-yr 48 h storm with the 1% AEP still-water level + 0.3 m. Riverine reaches: see Clause 5.8.
Outfall invert below the 1% still-water level → flap or tide gate required; property connections need non-return valves.

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; Himachal Pradesh has no coast, and the surge term does not arise in the State, which a monsoon system reaches only as rainfall, often meeting a western disturbance over the hills, as in July 2023 (Chapter 2).
>
> Indian tide tables have been published by the Survey of India since the nineteenth century (Survey of India, Tidal Predictions). Current Indian tidal predictions also appear in the NHO's tide tables. One port document describes the current edition as covering 95 Indian ports, based on NHO observations and on data from civil ports, NIO and INCOIS (Adani Ports, Dahej tide table 2025, citing NHO INP-12). INCOIS runs coastal tide gauges and issues storm-surge and swell-surge warnings. None of these is used for design in Himachal Pradesh, which has no coast, and Annex 5A is not prepared for the State (Clause 5.1.4).

5.8 Riverine backwater

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

- the **Yamuna** at **Paonta Sahib** past the **Paonta** gauge, with the **Bata** at **Ganguwala** and the khads and nallahs of the Paonta valley that end in them, and the **Giri** at **Yaswant Nagar**, **Dadahu** and the **Jatton** barrage (Clauses 5.8.3 and 5.8.5(a) and (c));
- the **Sutlej** at **Rampur Bushahr** below the **Nathpa Jhakri** and **Karcham Wangtoo** projects, at **Nathpa** and at **Pandoa** below Shimla, with the nallahs of the north face of Shimla that run to it, and the **Baspa** at **Sangla** (Clauses 5.8.3 and 5.8.5(a) and (c));
- the **Beas** at **Manali**, **Kullu** and **Bhuntar**, below the **Larji** and **Pandoh** dams, and at **Mandi** at its confluence with the **Suketi**, and below the **Pong** dam in the Mand area of **Indora**, with the side khads of the Kullu valley and the **Parbati** (Clauses 5.8.3 and 5.8.5(a) and (c));
- the **Swan** at **Una** and **Ghaluwal**, channelised with its tributaries from Daulatpur to the Gagret bridge (Clause 5.8.5(a) and (b));
- the **Ravi** at **Chamba**, with the **Chamera** reservoir (Clauses 5.8.3 and 5.8.5(a) and (c));
- the **Pabbar** and the **Tons** at **Meenus**, and the **Meenus Khad** (Clause 5.8.5(a));
- the khads and nallahs of the hill and valley towns, among them the thirteen major nallahs of **Shimla**, which drain north to the Sutlej and south to the **Ashwani Khad** and the Giri; the **Suketi** and its khads at Mandi; the **Manjhi**, **Gaj**, **Banner** and **Neugal** khads and the **Bhagsunag** nala below Dharamshala, Kangra and Palampur; the **Sirsa**, the **Balad** and the nallahs of **Baddi–Barotiwala–Nalagarh**; the tributary khads of the Swan at Una; the side khads of the Beas in the Kullu valley; and the choes of the Siwalik hills (Clause 5.8.5(b));
- **Gobind Sagar** (the **Bhakra** reservoir) at **Bilaspur**, the **Pong** reservoir (Maharana Pratap Sagar) at Dehra and the Pong shore, and the **Pandoh**, **Larji**, **Kol**, **Nathpa Jhakri**, **Karcham Wangtoo** and **Chamera** reservoirs and the pond of the **Jatton** barrage (Clause 5.8.5(c));
- **Rewalsar**, **Khajjiar**, **Renuka** and the other tals (Clause 5.8.5(d));
- any **kuhl** in Schedule I or II of the Himachal Pradesh Minor Canals Act 1976, the **Beas–Sutlej Link** of BBMB, any canal of the **Jal Shakti Vibhag**, and any drain or channel of another body that receives storm water (Clause 5.8.5(e)); and
- elsewhere: any river or Jal Shakti Vibhag channel listed in Annex 5B.

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

- (a) Jal Shakti Vibhag 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 on the Sutlej, the Karcham Wangtoo and Nathpa Jhakri projects above Rampur, the Kol dam above Bilaspur and the Bhakra dam below it; on the Beas and its tributaries, the Malana and Parbati projects in the Kullu valley, the Larji and Pandoh dams above Mandi and the Pong dam above Indora; the Chamera dam on the Ravi; and the Jatton barrage on the Giri), 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 **River-locked outfalls, khads and nallahs, reservoirs and dam releases, tals, kuhls, canals and the drains of other bodies, and Jal Shakti Vibhag consent.**

- (a) **River-locked outfalls.** For an outfall to a river directly, through a gate in a bank, a flood wall or an embankment, or through a pumping station, or into a drain that itself discharges in one of those ways, the designer shall identify the body that operates each gate and pumping station, and obtain the sill of each gate, the crest of the bank, wall or embankment, the installed pumping capacity and the operating levels, including the river level at which each gate is closed. Every level shall state its datum and its connection to the gauge datum of the nearest CWC gauge, or of the BBMB or other gauge used, with its operator named.
    - **Design river level.** The river level of Clause 5.8.2 at the outfall shall be, for the major-system cases (Clause 5.8.4(b)), the **1% AEP river level at the outfall**, from a hydraulic model under Clause 5.8.2(b), with the dam releases of item (c). Himachal Pradesh has no floodplain zoning law and no published flood level for any reach of any river (the post-disaster needs assessment of 2023 calls for river-boundary mapping and floodplain management guidelines), so no level is available from a floodplain study [TBC]. The level shall in no case be less than the **highest recorded level** at the nearest CWC gauge on the same river, transferred to the outfall, nor less than the 10% AEP level of this item. The highest levels found during research (Table 5B.1), all from SANDRP's copies of CWC tables and posts, with no datum stated and none read in a CWC site sheet [TBC], are: the Yamuna at Paonta **384.6 m** (5 September 1995); the Bata at Ganguwala **373.52 m** (22 July 2023, above the 372.6 m of 18 August 2019); the Sutlej at Rampur **933 m** (26 June 2005, the flood from the burst of the landslide lake on the Parechu in Tibet), against which a level of 924.5 m for 2023 has also been quoted: the two are in conflict, and 933 m governs until CWC confirms the record [TBC]; the Sutlej at Nathpa **1,451 m** (26 June 2005); the Swan at Ghaluwal **367 m**, dated 3 June 2017, a date to be confirmed with CWC [TBC]; the Giri at Yaswant Nagar **902.9 m** (5 September 1995) and at Dadahu **629.02 m** (18 August 2019); the Tons (Pabbar) at Meenus **730.35 m** and the Meenus Khad **735.3 m** (both 10 July 2023); the Ashni at Gaura **918.2 m** (18 August 2019); the Uhl at Barot **1,832.68 m** (30 August 2016; listed by CWC as the Beas); the Baspa at Sangla **2,515.2 m** (31 July 2017); the Bhaga at Tandi, below Keylong, **2,855.31 m** (13 August 2009); and the Ropa Khad at Ropa **3,050.85 m** and the Spiti at Gulling **3,580.34 m** (9 and 10 July 2023). At **Pandoa**, on the Sutlej below Shimla, the CWC list of 2022 gives **740.6 m** (3 August 2005) and SANDRP's account of July 2023 gives **689.6 m** (1 June 2022) and calls the first "incorrect"; neither shall be used until CWC confirms the level in its site sheet, the reach is treated as a reach with no gauge level under the next item, and the peak of 688.78 m recorded there on 10 July 2023 is a floor (set by this Manual) [TBC]. Where a later flood has exceeded the listed level, the later level governs; five of these

levels were set in July 2023. The recorded level shall be transferred along the river with the water-surface slope of the flood that set it, from the CWC gauge records, or from the model. Until either is available, the recorded level of the nearest gauge upstream applies unchanged at the outfall, except that where the outfall lies between two gauges on the same river, with no tributary joining between them, the level may be interpolated linearly by river distance between the highest recorded levels of the two gauges; and on a mountain river, whose bed falls several metres in a kilometre, a profile of the flood marks of the same flood, surveyed between the gauge and the outfall and tied to a Survey of India benchmark, may be used in place of the unchanged level (set by this Manual).

- **Rivers and reaches with no gauge level.** No CWC site with a published level exists on the Beas at Manali, Kullu, Bhuntar, Mandi or Pandoh, on the Sutlej at Bilaspur, on the Ravi at Chamba, on the Sirsa at Nalagarh, on the Pabbar at Rohru or on the Markanda at Kala Amb; CWC's map of July 2025 shows stations of BBMB named Manali, Bhuntar Beas, Mandi and Pandoh Dam, all marked inactive, with no level found (as copied by SANDRP) [TBC]. On such a reach, and for an outfall upstream of every gauge on its reach, the river level shall be the higher of the level from a model under Clause 5.8.2(b) and the highest flood level surveyed at the outfall from flood marks, including those of July and August 2023, July 2024 and the monsoon of 2025, and from the records of the Jal Shakti Vibhag, the local body or the Deputy Commissioner, with its source stated. Where a level is known only as a gauge reading, the designer shall tie the gauge zero to the project datum and a Survey of India benchmark by levelling. No outfall shall be designed on such a reach without one of these levels (set by this Manual).
- **10% AEP level.** For the cases with the river at its 10% AEP level (Clause 5.8.4(a)), the level shall be taken from the same model or a frequency analysis of the gauge record, and not less than the **danger level** at the nearest CWC gauge, transferred in the same way. The only CWC site in the State with a warning and a danger level is the Yamuna at **Paonta: danger level 384.5 m, warning level 383.5 m**, against a highest recorded level of 384.6 m, only 0.1 m above the danger level (SANDRP's copy of the CWC list of 2022) [TBC]. Every other CWC site in the State is a level-monitoring site with no danger level; there, the 10% AEP case shall use the design river level of this item until a frequency analysis is accepted (all set by this Manual). The datum of every level is to be confirmed for each gauge [TBC].
- **Tailwater.** The tailwater at the outfall shall be the higher of that river level beyond the gate, bank, wall or embankment, and the maximum level in the drain behind it, computed by routing the drain as a closed storage for as long as the river stands above the level behind it, with the inflow of the whole catchment that drains to it, its storage as surveyed in its present condition, net of silt, boulders, debris, encroachment, solid waste and weed, 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), with gravity discharge through the gate only while the river is lower than the level behind it. Pumps shall deliver against the design river level of this item, and every pump, panel and control shall remain operable with the river at that level (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. The outfall-closed check of Clause 5.10 applies with a single lock that lasts for as long as the river stays above the outfall invert, or above the level at which its gate is closed if that is lower, taken from the river model or from the stage record of the nearest CWC gauge in the flood that set the highest recorded level or in a comparable flood, with the releases of item (c), and not less than **72 hours**, or, on a river below a dam or barrage, the time for which the largest recorded release of the dams and barrages above stayed above the flow at which the outfall is closed, from the operator's records, if that is longer (set by this Manual). The lock covers the whole of the 48- and 72-hour storms of Clause 5.10.2, so that storage and pumping handle the full storm volume (Clause 5.9.4) and the drawdown of Clause 5.10.5 is met by pumping until the lock ends. An outfall to a reservoir, or to the pond of the Jatton barrage on the Giri, whose invert is below the level of item (c), is closed for the whole storm. A shorter lock may be used only where the outfall invert is above the 1% AEP river level of this item, or where an analysis of the stage record of a CWC gauge under Clause 5.10.6, including the releases of the dams and barrages above, shows it and the Authority approves it.

    - **Gate failure and breach.** Floor levels and pumped outfalls behind a gate, flood wall or embankment, such as the embankments of the Swan, shall also be checked for the failure of the gate and for a breach of the wall or embankment, with the land and drains behind it filled to the river level beyond it. Below a dam or barrage they shall also be checked for the release that results from a gate failing open.
- (b) **Khads, nallahs and other ungauged hill streams.** For an outfall to a khad (खड्ड; a seasonal hill torrent or ravine stream), a nallah (नाला; a natural drainage channel), a choe or another seasonal hill stream, such as the thirteen major nallahs of Shimla and the Ashwani Khad below them, the Suketi and its khads at Mandi, the Manjhi, Gaj, Banner and Neugal khads and the Bhagsunag nala below Dharamshala, Kangra and Palampur, the Sirsa, the Balad and the Sandholi and other nallahs of Baddi–Barotiwala–Nalagarh, the tributary khads of the Swan at Una, the side khads of the Beas in the Kullu valley, and the khads that come down to Rampur, Chamba, Solan and Nahan, or into a drain that ends in one:
    - **No gauge.** None of these streams has a CWC gauge at a town, except the Bata at Ganguwala below Paonta Sahib and the Ashni at Gaura, and none has a published flood level [TBC]. They are seasonal, steep and boulder-laden: the gauged khads of the State are the steepest in CWC's zone 7, the Neogal falling 84.04 m and the Banu 69.21 m in a kilometre (CWC, 1994); they rise within an hour of a burst of rain, carry gravel, boulders, timber and debris, and raise or scour their beds in a single flood.
    - **Design level.** The tailwater for the major-system and storage cases shall be the highest of: (i) the 1% AEP level at the outfall from a study of the stream, made with a hydrograph method of Chapter 3 for the whole catchment above the outfall, with the rainfall of its sub-area in Annex 2A, the AMC of Clause 3.8.4 and the bulking factor of Clause 6.3.6(b) on the peak flow, and routed through a hydraulic model (Clause 5.8.2(b)) of the channel as surveyed, with the crossings downstream blocked as Clause 6.3.6(c) requires; (ii) the level at the outfall of any flood study of the stream made by or for the Jal Shakti Vibhag, such as the hydraulic modelling for the embankments of the Swan (NITI Aayog, 2020), where it gives one [TBC]; and (iii) the highest flood level surveyed at the outfall from flood marks, such as debris lines, silt and scour marks and the accounts of residents, of the floods of July and August 2023, July 2024 and the monsoon of 2025 or a later flood, and from the records of the Jal Shakti Vibhag, the local body 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, scour and aggradation.** The designer shall survey the bed of the stream at the outfall and for at least 100 m upstream and downstream, and state the range within which the bed has moved, from past surveys, cross-sections, exposed foundations and pipes, and the records of the Jal Shakti Vibhag and the local body. The outfall invert, and the seat of any flap gate on it, shall stand at least **0.5 m above the highest bed level** found in that range within 50 m downstream of the outfall, and the foundation of the outfall structure and its apron shall be taken below the scour depth computed under Chapter 9 (Clause 9.6) for the 1% AEP flow with the bulking factor (set by this Manual).
    - **Siting.** An outfall shall be built into the bank and shall not project into the bed or the active channel, taken for this Manual as the land flooded once in 5 years (set by this Manual). It shall discharge in the direction of the stream's flow, with the bank protection that Chapter 9 requires, and no pipe, interceptor or chamber of the drainage system shall be laid along the bed of the stream. No muck, spoil or excavated material from the works shall be placed in the stream or where a storm can carry it into one (Clause 6.3.6(g)).
    - **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 as long as the level of the stream, computed under item (i) for the coincident cases of Clause 5.8.4, stays above the invert, and, where no hydrograph of the stream has been computed, for the whole storm (Clause 5.9.4) (set by this Manual).
    - **Interceptors and water sources.** An interception and diversion structure on a khad or nallah or its drains (Clause 8.9) shall not raise the design level of this item or reduce the capacity of the drain; it shall stand above that level or be designed to be overtopped without damage. Where the khad is a source of drinking water, such as the Ashwani Khad below Shimla, Clause 8.9 also applies.
- (c) **Reservoirs and dam releases.** For an outfall to a reservoir or barrage pond, directly or through a drain, khad or nallah that ends in it, such as Gobind Sagar, the reservoir of the Bhakra dam on the Sutlej, at Bilaspur; the Pong reservoir on the Beas (Maharana Pratap Sagar) at Dehra and along its shore; the Pandoh and Larji reservoirs on

the Beas; the Kol, Nathpa Jhakri and Karcham Wangtoo reservoirs on the Sutlej; the Chamera reservoir on the Ravi; and the pond of the Jatton barrage on the Giri:

- **Consent.** Storm water shall not be discharged to a reservoir or barrage pond without the written consent of its custodian: BBMB for Bhakra (Gobind Sagar), Pong and Pandoh; NTPC for Kol; SJVN for Nathpa Jhakri; NHPC for Chamera; HPSEBL for Larji; and, for Karcham Wangtoo and the Jatton barrage, the body that operates them, which was not confirmed during research [TBC]. The Pong reservoir is a Ramsar site (Pong Dam Lake, 15,662 ha), where the permission of the State Wetlands Authority and the Forest Department is also required (Chapter 7). An outfall that carries dry-weather flow is dealt with under Clause 8.9.
- **Design level.** The tailwater for the major-system and storage cases shall be the waterbody's **maximum water level (MWL)** as its custodian publishes it, or, where only the full reservoir level (FRL) or maximum pond level is published, **FRL plus the surcharge in its design flood**, computed from the rating of its spillway and gates with the gates operated only as the custodian's written rule provides. Where neither the MWL nor the surcharge has been published, or where the published MWL is not above the FRL, the tailwater is **FRL + 0.5 m** (set by this Manual) [TBC]. For a barrage pond, the tailwater is the higher of that level and the river level of item (a) at the barrage with its gates as operated. In every case it shall be not less than the highest level recorded at the waterbody. The minor-system tailwater is the FRL or maximum pond level, or the level at which the custodian's rule opens the gates if that is higher. The project's discharge shall be included in the level (Clauses 5.3.2 and 5.12.3).
- **Levels in feet.** BBMB publishes the levels of Bhakra and Pong in feet. Every level in feet shall be converted to metres at **1 ft = 0.3048 m** exactly, and the conversion and the datum stated on Form 5-1. No source found states the datum of the feet; this Manual takes them as feet above mean sea level, to be confirmed with BBMB before final design [TBC].
- **The named reservoirs.** Until the custodian confirms the MWL or the design-flood level and its datum, the tailwaters are (set by this Manual) [TBC]: **Gobind Sagar (Bhakra)**, FRL 1,680 ft (512.06 m) and an earlier technical limit of 1,690 ft (515.11 m) reported by BBMB (as copied by SANDRP), with no MWL found and a highest level found of 1,679 ft (511.76 m) on 4 September 2025 (as reported): **515.11 m**, the higher of FRL + 0.5 m (512.56 m) and the reported technical limit; and **Pong**, FRL 1,390 ft (423.67 m), whose maximum level is quoted as 1,400 ft (426.72 m; SANDRP, 2025), 1,410 ft (429.77 m; press) and, as a "technical" limit, 1,421 ft (433.12 m; SANDRP): the three are in conflict, and until BBMB confirms the MWL the tailwater is **433.12 m**, the highest of them; the highest levels found are 1,399.65 ft (426.61 m) on 15 August 2023 and 1,394.71 ft (425.11 m) on 5 September 2025 (as reported). For **Kol**, a reservoir level of 642 m, for **Chamera**, 763 m, and for **Karcham Wangtoo**, 1,810 m, are reported, none confirmed as the FRL (as reported); until the operator confirms it, the tailwater is that level + 0.5 m: **642.5 m**, **763.5 m** and **1,810.5 m** [TBC]. No level on a stated datum was found for **Pandoh**, **Larji**, **Nathpa Jhakri** or the **Jatton** barrage [TBC]; no outfall to any of them shall be designed without the custodian's FRL or pond level and spillway rating in writing, or, until the custodian gives them, the higher of a survey of the crest tied to a Survey of India benchmark and the river level of item (a) (set by this Manual).
- **Closed outfall.** Where the outfall invert is below the design level of this item, the outfall shall be treated as closed for the whole storm (Clause 5.9.4), with storage and pumping handling the full storm volume, unless the custodian's stage record shows the waterbody below the invert at the start of comparable storms and the Authority accepts it. Every reservoir and barrage pond starts every design storm at its FRL or maximum pond level (Clause 7.7.3), and no lowering of a reservoir or pond before a storm and no early or additional gate opening shall be assumed unless the custodian's written operating rule and records show it. The drawdown zone of a reservoir, such as the land between 1,280 ft and 1,390 ft at Pong, is part of the reservoir: no outfall structure, pumping station or storage shall be built in it without the custodian's consent.
- **Rivers below dams and barrages.** For an outfall to a river below a dam or barrage, such as the Beas below Larji and Pandoh, at Mandi, and below Pong in the Mand area of Indora, the Sutlej below Karcham Wangtoo and Nathpa Jhakri at Rampur and below Kol, the Ravi below Chamera, and the Giri below the Jatton barrage, in addition to the cases of Clause 5.8.4, the site design storm (each AEP required) shall be run with the river at the level that results from the largest recorded release of the dams and barrages above, routed to the outfall, with the flow of the catchment below them as it occurred in the same event,

and with the release placed before, during and after the site storm (set by this Manual), until the operator publishes an operating rule that bounds the release [TBC]. The largest recorded releases found are about 1.40 to 1.50 lakh cusec (about 3,960 to 4,250 m³/s) from Pong from 15 August 2023, above which, its chief engineer said, the dam has never released (as reported); 85,000 cusec (about 2,410 m³/s) from Bhakra on 4–5 September 2025 (as reported); and nearly 44,000 cusec (about 1,250 m³/s) from Pandoh, with all five gates open, on 30 June 2025, after a release from Larji (as reported). The largest recorded release of each dam and barrage and its duration shall be obtained from its operator and stated [TBC]. A release, or a release rule, alone shall not be taken to bound the river level: the level shall also be checked for the largest recorded event at the nearest gauge, with the local inflows as they occurred. No attenuation by the storage of Pong, Bhakra or any other reservoir shall be credited to the river below unless the operator's written rule commits that storage to flood control for the event; and no dam or barrage gate shall be assumed to open earlier or wider than the operator's records show. The river level shall not be reduced on the ground that the flood comes from rain that falls outside the town, from snow or glacier melt, or from the burst of a glacial or landslide lake, inside the State or in Tibet, as on the Parechu in 2005, or that the site storm is small.

- (d) **Tals.** For an outfall to Rewalsar, Khajjiar, Renuka or another tal (ताल; a pond, lake or tank), directly or through a drain or stream that ends in it:
    - **Consent.** Storm water shall not be discharged to a tal without the written consent of its custodian. The custodian of each tal was not confirmed during research [TBC]: Renuka is a Ramsar site (20 ha) within a wildlife sanctuary, and Rewalsar and Khajjiar are wetlands of national importance whose action plans are approved by the State Level Steering Committee on Wetlands; until the State names a custodian, the consent of the State Wetlands Authority, the Forest Department and the local body is required (Chapter 7).
    - **Design level.** No level on a stated datum, and no outlet or overflow level, was found for Rewalsar, Khajjiar, Renuka or any other tal [TBC]. Until the custodian gives one, the tailwater is the level at which the tal spills, from its outlet or overflow crest surveyed and tied to a Survey of India benchmark, plus the head over that crest needed to pass the 1% AEP inflow, and not less than the highest level recorded at the tal; the tal starts every design storm at its spill level, and an outfall below the tailwater is closed for the whole storm (Clause 5.9.4) (set by this Manual). Khajjiar, whose water body is fed by streamlets carrying rain and snow-melt water from a catchment of about 6 km², and Renuka, fed by 21 seasonal streams, shall be checked for the snow-melt and the inflow of their whole catchments.
    - **Drains to the tal.** Every drain that discharges to a tal shall pass a debris trap and a sediment trap (Clause 6.3.6(a) and Chapter 8) before it reaches the tal, sized for the bulked flow of Clause 6.3.6(b). No runoff shall be infiltrated on the slopes of the tal's catchment except as Clause 4.11 allows, and no drain that carries sewage shall discharge to a tal (Clause 8.9): at Rewalsar the sewage drains built around the lake are reported to leak at many points and to cause eutrophication (State Wetlands Authority).
- (e) **Kuhls, canals and the drains of other bodies.** Storm water shall not be discharged to a kuhl (कूहल; a gravity irrigation channel) in Schedule I or II of the Himachal Pradesh Minor Canals Act 1976 without the written consent of the Jal Shakti Vibhag and, for a private kuhl in Schedule II, of the Collector after notice to its beneficiaries, who maintain it (ss.46–48 of the Act) (set by this Manual); nor to the Beas–Sutlej Link without the consent of BBMB, or to any other canal without the consent of its operator; nor to a drain of another body, such as a drain of a Municipal Corporation, a Nagar Parishad or Nagar Panchayat, HIMUDA, BBNDA, HPSIDC, a Smart City company, PWD or NHAI, without the written consent of that body. Obstructing a kuhl, or fouling its water, is an offence under s.65 of the Act, and the beneficiaries are required to provide works for the passage of a kuhl across or under a road or a drain (s.46). A drain that crosses a kuhl or canal shall cross by a cross-drainage work built with the consent of the kuhl's or canal's manager, and not discharge into it. 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, including the drains of other bodies and the runoff that the kuhl intercepts from the slope above it, and with its downstream boundary at the river, khad, reservoir or tal level of items (a) to (d); until a design water level is published for a channel, the computed level governs [TBC];

    - the channel shall be taken in its present condition, net of silt, boulders, debris, encroachment, solid waste, weed and obstruction by crossing services and culverts, and with its narrowest section as surveyed, and with any weir that intercepts its dry-weather flow (Clause 8.9) at its crest level; a widening, lining, channelisation, rejuvenation or diversion that has been proposed but not completed, such as the channelisation of the Beas proposed in 2021 or the rejuvenation of Shimla's major nallahs in the draft city development plan, shall not be counted, and a channel designed for a stated return period shall not be taken to carry more than its surveyed section carries; 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.
- (f) **Jal Shakti Vibhag consent; plan, wetland and court lines.** No outfall structure, gate, pumping station or drain shall be built in the bed, bank or floodplain of a river, khad or nallah, in a flood-protection work of the Jal Shakti Vibhag, such as the embankments of the Swan, or in a kuhl, without the consent of the Jal Shakti Vibhag, or of BBMB or the operator of a dam, reservoir or barrage for their structures; the procedure for that consent was not found during research [TBC]. The State has no floodplain zoning law and no notified flood line (Chapter 7). The designer shall also check the outfall against the lines that the building rules, the development plans, the wetland rules and the courts have set, as they stand at the time of design (Chapter 7): the 3.00 m from a nullah and 5.00 m from a khud within which Appendix-1, cl. 16 of the TCP Rules 2014 does not allow construction where no Interim Development Plan or Development Plan has been prepared, a rule that names no line from which the distances are measured; the distance from the highest flood level along rivers, khuds and nullahs "as delineated in the Interim Development Plans / Development Plans", with no construction "in parcel of land prone to floods" in other areas (Appendices 3 and 7); the flood plains and "areas adjacent to major drainage lines" that a development plan treats as non-developable, as the Chopal Planning Area Development Plan 2041 does; the Shimla Development Plan 2041, published on 20 June 2023 according to the Supreme Court (notified on 23 June 2023, as reported), whose storm-water chapter and lines were not read [TBC]; Pong Dam Lake, Renuka and Chandertal, Ramsar sites, and Rewalsar and Khajjiar; the orders of the High Court that no muck be dumped "in Govind Sagar Lake and its feeding khuds/nallahas" (22 May 2023) and that the muck already dumped in the lake, its tributaries and on public land be cleared (*Madan Lal*, CWPIL 31/2023, 31 May 2024), and on the dumping of muck by the contractors of the Kiratpur–Nerchowk four-lane highway near water bodies (*Fourlane Visthapit and Prabhavit Samiti*, CWP 5243/2022, 26 June 2023); and the power of the State under s.43 of the Minor Canals Act to regulate the flow in any "line of natural drainage" and to prohibit or remove an obstruction of it. The distances of 5 m from drains and 7 m from rivers and ravines for buildings, of 150 m from rivers, nullahs and other water bodies for government buildings, and the ban on building along the banks of rivers and streams in the model bye-laws for rural construction, all announced in 2025, are reported in the press only; no gazetted text of any of them was found during research, and they are not applied by this Manual until it is [TBC]. Whether a drain outfall is permitted within each line is to be confirmed with the authority concerned before design [TBC].

No pump, gate, sluice, barrage or dam operation that helps drainage, such as pumping a drain down before a storm, lowering a reservoir, barrage pond or tal before a storm, closing a gate late or opening dam or barrage 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 waterbody or the river (Clause 5.12.3). Pumping shall not be used to move water into a tal, a reservoir, a kuhl or another catchment without the consent of its custodian, or onto a slope.

> **Commentary.** In large continental river basins, a site storm and a river flood are usually treated as roughly independent. That is the basis of tables of coincident frequencies such as FHWA HEC-22 Table 7.3. Himachal Pradesh's rivers break that assumption, because their catchments are small and steep and the storms that fill them fall on the towns at the same time. On 9–11 July 2023, when an active monsoon met a western disturbance, Pachhad recorded 220.3 mm and Nahan 250.0 mm in a day (IMD), the Tons at Meenus and the Meenus Khad set new highest levels on 10 July, and the Ropa Khad and the Spiti set theirs on 9 and 10 July; and on 14 August 2023, when Kangra Aero recorded 273.4 mm and Dharamshala 250.2 mm in a day (IMD), the Pong reservoir took what was reported as the highest inflow since it began to operate in 1974 (IMD; CWC data, as copied by SANDRP;

as reported). The two cannot be treated as independent, and a local storm can fall before, during or after the river peak. Clause 5.8.4 therefore pairs a design event on one side with a 10-yr event on the other, in the same way as Clause 2.12(b). This pairing has no direct precedent. It is more severe than an independence assumption would give.

Clause 5.8.3 reflects the dams above and beside the State's towns. BBMB publishes the levels of its two storage reservoirs in feet. Gobind Sagar, behind the Bhakra dam on the Sutlej, has a full reservoir level of 1,680 ft (512.06 m), and BBMB is reported to have given its earlier technical limit as 1,690 ft (515.11 m); it stood at 1,675.71 ft on 14 August 2023 and at 1,679 ft on 4 September 2025, when it released up to 85,000 cusec (as reported). The Pong reservoir on the Beas has a full level of 1,390 ft (423.67 m), at which its water spreads over about 220 km², against about 125 km² at its minimum level of 1,280 ft (State Wetlands Authority); its maximum level is quoted as 1,400 ft, 1,410 ft and, as a technical limit, 1,421 ft, a conflict that only BBMB can resolve [TBC]. In August 2023 Pong took an inflow reported as 7.3 lakh cusec on 14 August by one account and 5.13 lakh cusec to the morning of that day by another, released about 18,000 cusec until 14 August and then 1.40 to 1.50 lakh cusec, and rose to 1,399.65 ft (as reported); SANDRP has alleged that it was filled too early and released too late, an allegation and not a finding. In 2025 it rose to 1,394.71 ft on 5 September after releasing more than one lakh cusec from 29 August (as reported). The Pandoh dam, which diverts about 9,000 cusec of the Beas to the Sutlej through the Beas–Sutlej Link, opened all five gates and released nearly 44,000 cusec on 30 June 2025, after a release from Larji upstream, and people at Pandoh blamed its releases for the flooding there in July 2023 (as reported); 14 students died in a release from Larji in 2014 (as reported). The spillway of the Kol dam is designed for 16,500 m³/s and that of Nathpa Jhakri for 5,660 m³/s (as reported). No operating rule or release record for any of these dams, no full or maximum level for Pandoh or Larji, and no hourly stage record for any gauge in the State was obtained during research [TBC]; the Chief Secretary is reported to have listed dams, among them Pandoh, that do not meet dam-safety norms, a list that was not obtained (as reported) [TBC]. Until these are available, the largest recorded release applies, with the flow of the catchment below the dam as it occurred in the same event (Clause 5.8.5(c)). The river levels used in this Manual come from SANDRP's copies of CWC data, because the CWC websites refused access during research; their datum and gauge zero are to be confirmed with CWC [TBC].

Clause 5.8.5 is set by this Manual. In Himachal Pradesh the tailwater at a town outfall is set not by the tide but by a river held high by a monsoon spell or by the releases of a dam, by a khad or nallah whose level no one has recorded and whose bed moves, by a reservoir at its full level, by a tal, or by a kuhl or canal, and no document found during research gives a design level for any of them. No design standard for any town drain in the State was found: the expert committee that reported to the National Green Tribunal on Shimla in 2017 found that the city's drains were "not able to carry the peak flow" and that their catchments were "improperly selected", but set no design level (*Yogindra Mohan Sengupta*, judgment of 16 November 2017, para 53; the judgment was set aside by the Supreme Court on 11 January 2024, 2024 INSC 30, and its committee's findings are cited here as expert evidence only). The drainage sections of the State's municipal Acts were not read [TBC]. The State has no floodplain zoning law, and the post-disaster needs assessment of the 2023 monsoon found that "the lack of well-defined river boundaries in floodplains is a prominent issue in Himachal Pradesh" and called for "comprehensive river boundary mapping and the establishment of floodplain management guidelines" (Chapter 7).

The first is the river. Item (a) follows the interim river rule of Uttarakhand, the first mountain State in this series: the design level is the 1% AEP level, and never below the highest level recorded at the nearest CWC gauge. Only one CWC site in Himachal Pradesh, the Yamuna at Paonta, has a warning and a danger level; the other 29 sites in the State, by SANDRP's count of the CWC list of 2022, record levels only, and the Beas, the river of Manali, Kullu and Mandi, has no CWC site with a published level at any town. On the Beas, the Ravi and the Sirsa the design level must therefore come from a model and from flood marks, and item (a) allows a surveyed profile of flood marks in place of the unchanged gauge level on a mountain river, because the bed of such a river falls several metres in a kilometre and a level carried unchanged from a gauge upstream would be several metres too high, or, from a gauge downstream, too low. At Rampur the record of 933 m was set by the Parechu flood of 2005, which came from a landslide lake outside the State and not from rain on the town; item (a) keeps it, because the next such flood will not ask where the town's storm fell, and states the conflicting level of 924.5 m quoted for 2023 [TBC]. At Pandoa the conflict is too large to resolve by taking the higher: the CWC list gives 740.6 m and SANDRP,

which reads the same gauge, says that figure "is incorrect" and gives 689.6 m, so item (a) treats Pandoa as ungauged until CWC confirms its level. The danger level is used as the floor of the 10% AEP level at Paonta because the river's highest recorded level there stands only 0.1 m above it. The rivers of the hills rise and fall within hours, which might seem to justify a shorter lock than in the plains. Item (a) keeps 72 hours for three reasons: no hourly stage record for any gauge in the State was obtained during research [TBC]; the storms that raise the rivers last for days, as on 7–11 July 2023, when the State received 223 mm in four days (post-disaster needs assessment, 2023, citing IMD), and the dams pass a flood for days after it, as Pong did when it released 1.40 to 1.50 lakh cusec from 15 August 2023 and more than one lakh cusec from 29 August 2025 (as reported); and an outfall into a reservoir or barrage pond stays closed for as long as the pond is held, which items (a) and (c) treat as the whole storm. The lock covers the whole of the longest design storm of Clause 2.5.2, so that the site does not rely on the river falling during the storm. A designer who has the stage record of a CWC gauge can justify a shorter lock under Clause 5.10.6, and the mountain rivers are where that analysis is most likely to succeed. Item (a) counts only the permanent pumps less the largest one, for the same reason that Clause 5.12.2(b) requires a standby pump.

The second is the khad and the nallah. Shimla's nallahs, the Suketi at Mandi, the khads below the Dhauladhar and the Sirsa and Balad at Baddi–Nalagarh are ungauged, and no flood study of any of them was found. Item (b) therefore requires the designer to make the study, with the bulking factor of Clause 6.3.6(b), and to survey the flood marks, and takes the higher. A khad's bed is not fixed: it rises with the boulders of one flood and is scoured by the next, and the 2023 monsoon damaged 139.766 km of the State's 610.634 km of sewer pipelines (post-disaster needs assessment, 2023). An outfall set at the present bed level is buried by the first and undermined by the second, so item (b) sets the invert at least 0.5 m above the highest bed level surveyed downstream, a margin set by this Manual for the aggradation that a boulder bed can show in a single flood, and takes the foundation below the computed scour. It keeps outfalls out of the active channel and keeps pipes out of the bed, and forbids the works from leaving muck in the stream, because the High Court has had to bar the dumping of muck in Gobind Sagar and the khads that feed it, and to order the muck already dumped cleared (*Madan Lal*, CWPIL 31/2023).

The third is the reservoir. A reservoir at its full level does not fall for the rest of the season but passes its inflow over its spillway, and its level rises above FRL by whatever head the flood needs. Item (c) therefore takes the MWL, or FRL plus the design-flood surcharge, and treats an outfall below it as closed for the whole storm, which is what Clause 5.9.4 already requires when the tailwater stays above the outfall. BBMB's levels are in feet; item (c) converts them at the exact factor of 0.3048 m and requires the datum to be confirmed. For Pong the maximum level is quoted three ways, 1,400 ft, 1,410 ft and 1,421 ft, and item (c) takes the highest until BBMB confirms the MWL, because a tailwater set too low floods the town while one set too high only costs storage. For Gobind Sagar no MWL was found, and the earlier technical limit of 1,690 ft that BBMB is reported to have given is higher than FRL + 0.5 m, so it is used. Where only a reservoir level is published, FRL + 0.5 m is set as the interim value: it is the freeboard that this Manual uses for floor levels (Clause 6.11.1), and it is a floor, not an estimate of the surcharge, which depends on the spillway and the flood [TBC]. Item (c) also runs the town storm with the river at the largest recorded release because the rain that fills a reservoir and the rain on the town below come from the same monsoon spell (see the Commentary to Clause 5.8.4): on 14 August 2023 Kangra recorded 273.4 mm (IMD) on the day Pong took its record inflow, and the releases that followed raised the Beas through the Mand area of Indora (as reported). It credits no attenuation by Pong or Bhakra, because BBMB has not published an operating rule that commits their storage to flood control, and because the account of 2023 is disputed (as reported).

The fourth is the tal. Rewalsar, Khajjiar and Renuka have no published level and no outlet level, so item (d) uses their surveyed spill level, as Uttarakhand's edition does for its taals. The tals are small, Rewalsar 2.6 ha with a catchment of 173 ha (State Wetlands Authority), and silt and sewage reach them through the same drains, so item (d) requires sediment and debris traps on every drain and keeps sewage out (Clause 8.9).

The fifth is the kuhl, the canal and the drain of another body, and the sixth is the line within which an outfall may be built. The kuhls in the schedules of the Minor Canals Act 1976 are canals in law, managed by the State, a local authority or their beneficiaries, and the Act makes their obstruction or fouling an offence (s.65); a kuhl that runs

across a slope also intercepts the runoff of the land above it, so item (e) asks for consent and computes the kuhl's level with that runoff included. Items (c), (e) and (f) ask for the owner's consent and design level because a design that discharges to a channel, a reservoir or a tal cannot be checked without them. The lines of item (f) decide where an outfall can be built, not its level. The TCP Rules 2014 set 3.00 m from a nullah and 5.00 m from a khud where no development plan exists, and leave the distance from the high flood level to the development plans, but name no line from which either is measured (Chapter 7). The distances announced in 2025, 5 m from drains and 7 m from rivers and ravines, 150 m from rivers for government buildings, and a ban on building along river and stream banks in the rural model bye-laws, were reported in the press, and no gazetted text was found; item (f) reports them and does not apply them.

5.9 Joint-probability cases

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

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

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

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

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

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

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

5.10 Outfall-closed (tide-locked) storage check

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

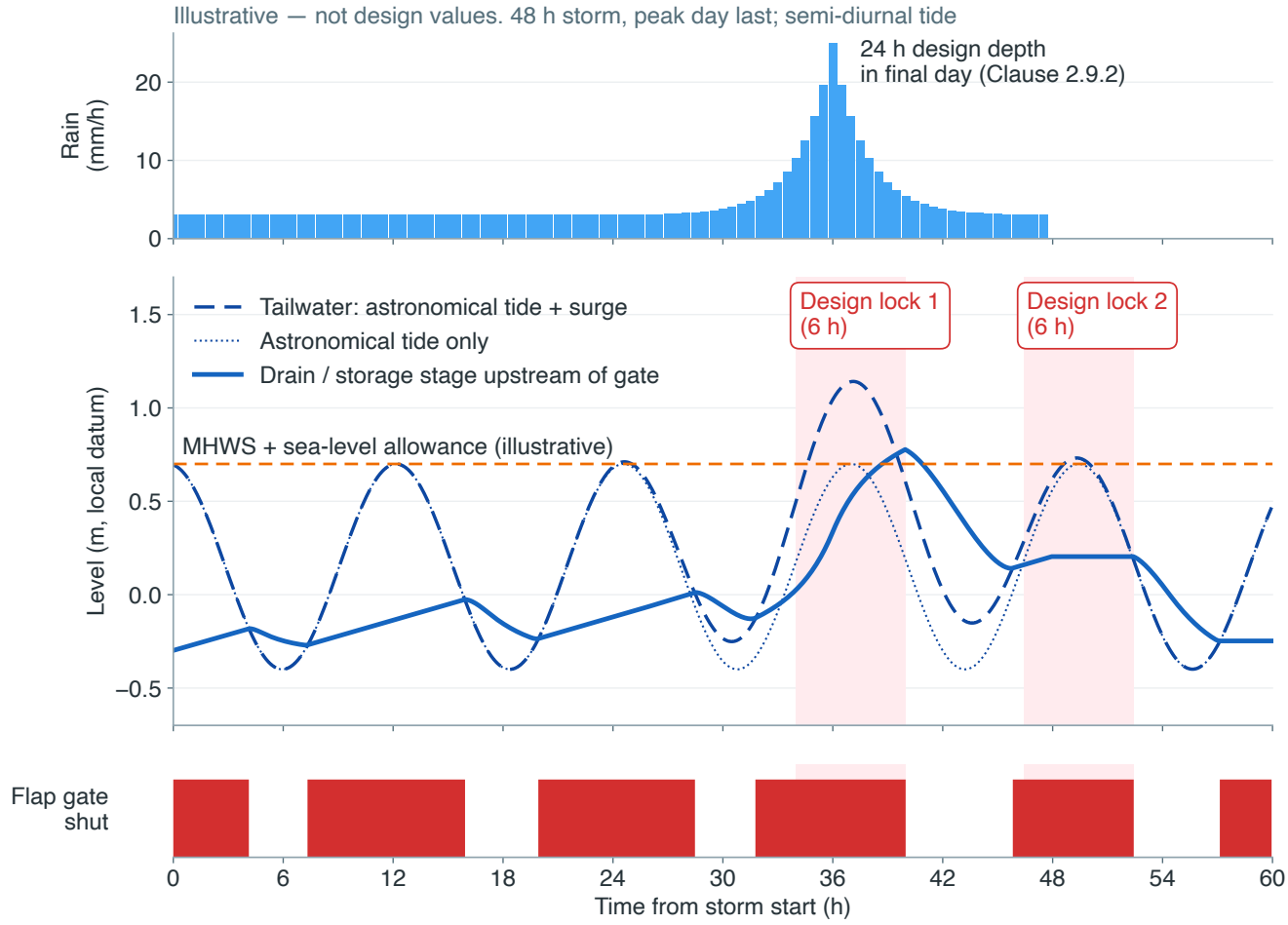


Figure 5.3 — Outfall-closed check: 48-hour storm with the peak day last (Clause 2.9.2), tailwater of astronomical tide plus surge, two 6-hour design lock windows, and the resulting stage upstream of the flap gate. Illustrative — not design values. Original drawing for this Manual, adapted from the tidal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

Commentary. The outfall-closed check is the distinctive Himachal Pradesh requirement in this Manual. In Himachal Pradesh it applies where an outfall is shut not by the tide but by a river held high by a monsoon spell or by the releases of a dam, by a khad or nallah that has risen over the outlet or buried it in boulders, by a reservoir at its full level, or by a tal. The spell of 7–11 July 2023 brought 223 mm to the State in four days, a departure of 436% from normal (post-disaster needs assessment, 2023, citing IMD), and after 15 August 2023 the Pong dam released about 1.40 to 1.50 lakh cusec into the Beas for days (as reported). A river below a dam stays high for as long as the dam passes the flood, a reservoir or tal at its full level stays there for the rest of the monsoon, and a khad in flood can block an outlet with boulders, which is why Clause 5.8.5 replaces the two 6-hour windows described below with a single river lock of at least 72 hours and a closure for the whole storm at a reservoir, tal or khad outfall below its design level. A rate rule cannot help when there is no outlet: an orificed basin behind a closed gate simply fills.

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

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

5.11 Flap gates, tide gates and non-return valves

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

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

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

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

5.11.3 **Construction.**

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

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

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

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

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

- before **15 June** 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 Himachal Pradesh the outfalls do not cross a beach, but many of them end in a river whose level is set by a dam upstream, or in a reservoir held near its full level. In August 2023 the Pong reservoir took an inflow reported as 7.3 lakh cusec on 14 August by one account and 5.13 lakh cusec by another, released about 18,000 cusec until that day and then 1.40 to 1.50 lakh

> cusec (as reported); on 30 June 2025 all five gates of the Pandoh dam were opened, releasing nearly 44,000 cusec, after a release from Larji upstream (as reported); and after the cloudburst of 24 July 2023 the Malana II project filled with debris and silt and overflowed, its gates jammed (as reported). A gate opened in a hurry raises the river below; a gate held shut or jammed raises the reservoir and every outfall that drains to it. The dams are held by BBMB (Bhakra, Pong and Pandoh), NTPC (Kol), SJVN (Nathpa Jhakri), NHPC (Chamera and Parbati) and HPSEBL (Larji), and the drains that reach the rivers and reservoirs below them belong to the Municipal Corporations, the Nagar Parishads and Nagar Panchayats, PWD and the Jal Shakti Vibhag; no rule linking the operation of any of these gates to the levels of the drains was found during research [TBC], and the list of dams, among them Pandoh, that the Chief Secretary is reported to have found in breach of dam-safety norms was not obtained (as reported) [TBC]. A gate and the drains behind it can therefore belong to different bodies. The 15 June inspection date is set ahead of the SW 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 **15 June** 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 Himachal Pradesh: Clause 5.1.4), and any other mouth listed in Annex 5B.

5.13.2 **Assumption at the start of the SW monsoon.** The mouth shall be assumed **closed** by a bar at the start of the June–September season, at the crest level of the most recent pre-monsoon survey. This applies unless the Jal Shakti Vibhag 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 SW 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 Jal Shakti Vibhag 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. Himachal Pradesh has no coast and no river mouth, so Clause 5.13 does not apply in the State (Clause 5.1.4). Its nearest inland counterparts are the boulders, gravel, timber and silt that hill streams leave at an outfall or a gate. After the cloudburst of 24 July 2023 the Malana II project "filled with debris and silts causing its overspill", and its gates jammed (as reported); in the flood of 2005 the silt in the Sutlej at Nathpa Jhakri rose

above 25,000 ppm (International Hydropower Association, case study); Gobind Sagar is reported to have lost between 38% and 47% of its gross storage to silt, by the estimates of IIT Ropar and BBMB (as reported); and the expert committee that reported to the National Green Tribunal in 2017 found Shimla's slope debris dumped "near water channels, obstructing the natural drainage". A flap gate held open or shut by gravel or debris, an outlet buried by a rising bed or left hanging by scour, or a gate that cannot be moved, turns a designed outfall into a dead end or a back-flow path. No written gate-operation rule for the gates of any dam, barrage or tal outlet in the State was found during research [TBC]. Clause 5.8.5 deals with both by setting outfalls above the range of bed movement and by giving no credit for a gate operation or a storage that the operator's records do not show. Clause 5.13.2 has no direct precedent. It puts the burden of proof on showing that the mouth is open rather than assuming it.

5.14 Documentation

Every project subject to this chapter shall submit a **Downstream and Tailwater Report** (Form 5-1). It shall contain:

1. a plan of the analysis extent showing:
    - the site;
    - each analysis point with its contributing catchment area and the site's percentage of it; and
    - the end point and the reason it was chosen (Clause 5.3);
2. the model description:
    - software and version;
    - the network schematic, with survey sources for the drains and crossings;
    - land use and CN for off-site areas;
    - any upstream detention included; and
    - calibration or validation evidence where available;
3. for each analysis point, AEP and duration, the existing and with-project:
    - peak flow;
    - time to peak;
    - maximum water level and velocity; and
    - duration of inundation (Clause 5.4);
4. the comparison against Clause 5.5, with each failure identified and the remedy adopted;
5. the tailwater derivation:
    - tide-table edition and port;
    - MHWS, HAT and MSL relative to chart datum;
    - the datum connection to the Survey of India benchmark and the project datum;
    - surge source and value;
    - SLA; and
    - river levels and their sources (Clauses 5.6 to 5.8);
6. the joint-case table of Clause 5.9 with results;
7. the outfall-closed check (Clause 5.10):
    - storm and lock alignment;
    - stage hydrographs; and
    - the volume balance for each lock window;
8. a schedule of flap gates, tide gates and non-return valves, with certified head–discharge data (Clause 5.11);
9. pumped outfall design, power supply, flood immunity and controls, where provided (Clause 5.12);
10. the sand-bar assumption and supporting Jal Shakti Vibhag 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 site on a nallah draining to the Ashwani Khad in Shimla
Form 5-1	Downstream and Tailwater Report
Form 5-2	Simplified Downstream Statement (small sites)

CHAPTER 6

Minor and Major Drainage Systems

6.1 Purpose and scope

6.1.1 This chapter sets the level of service and the hydraulic criteria for the conveyance system that carries runoff from a development, a road or a public drainage scheme to a receiving waterway, tank or outfall. It covers:

- (a) the dual drainage concept: a minor system and a major system (Clause 6.3);
- (b) design return periods by land use and road class (Clause 6.4);
- (c) street hydraulics: spread, depth and flow hazard (Clause 6.5);
- (d) inlets, including clogging (Clause 6.6);
- (e) pipes and open and covered drains (Clause 6.7);
- (f) hydraulic grade line analysis (Clause 6.8);
- (g) overland flow paths, ponding at sags and building floor levels (Clauses 6.9 to 6.11);
- (h) culverts and road crossings (Clause 6.12); and
- (i) Himachal Pradesh construction-practice requirements for covered drains, silt, solid waste, utilities and desilting access (Clause 6.13).

6.1.2 The detailed hydraulic design of individual structures (culverts, channels, energy dissipators, screens, pumps, gates, manholes) is in Chapter 9. Rainfall is in Chapter 2, runoff methods in Chapter 3, on-site storage in Chapter 4, tailwater in Chapter 5, waterbodies in Chapter 7 and water quality in Chapter 8.

6.1.3 This chapter applies to all public drains, all roads with kerbs or roadside drains, and all private drainage systems in developments that meet the applicability thresholds of Chapter 1. In Tier B local bodies, the simplified procedures and design aids referred to in Chapter 1 may be used for elements serving ≤ 16 ha, but the criteria of this chapter still apply.

Commentary. Himachal Pradesh's drains were not designed against any State or municipal standard: none was found during research, and no document found gives a design return period, runoff coefficient or drain size for any town. The only assessment of a town's drains found is that of the expert committee that reported to the National Green Tribunal on Shimla in 2017: storm drainage covered about 30% of the city, the drains were "not able to carry the peak flow", their catchments were "improperly selected", and they had been laid "with much lesser gradients than actually required" (*Yogindra Mohan Sengupta*, judgment of 16 November 2017, para 53; set aside by the Supreme Court on 11 January 2024, and cited here only for its committee's findings). Shimla's count of its own drains is not settled: about 67 drains with a network of about 42.33 km in 2015 (Municipal Corporation Shimla and UNDP), and 191 major storm-water drains and nallahs, 55.43 km long, built under AMRUT by 2022 (Municipal Corporation Shimla). After the slides of August 2023 the Corporation described its drains as "not built scientifically" and asked SJPNL to commission a study and a detailed project report (as reported), whose result was not found [TBC]; for Una, the Jal Shakti Vibhag has proposed a storm-water drainage scheme of ₹19.66 crore (Recovery and Reconstruction Plan, 2023), with no design basis published. The drains also work in a setting that the plains editions of this Manual do not meet. In the hill towns they collect water from slopes of 45° to 60° that deliver gravel, stones, timber and leaves with every storm, and end in khads and nallahs whose beds move; the technical committee on the Shimla slides of August 2023 named "Open Drainage systems leading to poor disposal of surface water" among their causes (HIMCOSTE-led technical committee, 2023). The road drains of the hills are the drains of the land above them. The drains are also divided among owners: the Municipal

Corporations, Nagar Parishads and Nagar Panchayats, the Smart City companies, HIMUDA, HPSIDC and BBNDA, PWD and NHAI, the Jal Shakti Vibhag and SJPNL all build or hold drains and receiving waters, and no rule divides them (see the Commentary to Clause 6.9). Fixing the rainfall (Chapter 2) is only half the answer. The other half is a second, surface-level system that carries the flows the pipes cannot, without flooding buildings. That is the dual drainage concept of this chapter, taken from Kansas City Metro APWA Section 5600 (5601.8, Levels of Service), which requires every element to have a 1% AEP overflow path.

6.2 Definitions

Term	Meaning in this Manual
Minor system	Inlets, pipes, covered drains and open drains that carry runoff up to the minor design AEP of Table 6.1 without surcharge above the limits of Clause 6.8.
Major system	The surface flow paths (streets, overland flow paths, open channels, floodways and storage) that carry flow above the capacity of the minor system, up to the 1% AEP (100-yr) event.
Overland flow path	A defined surface route, in public land or a recorded easement, that carries major-system flow to a receiving waterway.
Spread (T)	Width of flow in the gutter and carriageway, measured from the face of the kerb.
Sag	A low point on a road or flow path from which water can leave only through an inlet or by ponding to an overflow level. A trapped sag has no surface overflow route.
Clogging factor	The fraction of an inlet's clean hydraulic capacity assumed lost to debris (Clause 6.6.3).
Hydraulic grade line (HGL)	The line joining the free-surface levels in a conduit system, or the piezometric levels where the system is under pressure.
Covered drain	A rectangular drain, usually beside a road, closed by cast-in-situ or precast cover slabs that form a footpath.
Sediment allowance	The depth or area of a drain or pipe assumed filled with silt when its design capacity is computed (Clause 6.7.8).
Check event	An AEP rarer than the design AEP at which the combined minor and major system must still meet the limits of Table 6.2.
High-density area	An area notified as such by the approving authority under Clause 6.4.4.
Class I area	An urban local body with a population of 1 lakh or more (the CPHEEO definition).

6.3 The dual drainage concept

6.3.1 Every drainage system shall be designed as two systems that work together:

- (a) a **minor system** that carries the minor design flow of Table 6.1 below ground or in drains, keeping streets usable and spread within Table 6.2; and
- (b) a **major system** that carries all flow above the minor-system capacity, up to the 1% AEP (100-yr) flow, on the surface without entering buildings and within the depth and hazard limits of Clause 6.5.

6.3.2 **Every element has a 1% path.** Every inlet, sag, pipe, drain, culvert and storage element shall have an identified 1% AEP overland flow path to a receiving waterway, tank or outfall. The path shall be shown on the drainage plan (Clause 6.15).

6.3.3 **Major-system design flow.** The major system at any point shall carry the 1% AEP peak flow less the minor-system capacity at that point. The minor-system capacity used in this subtraction is the capacity of the inlets after the clogging factors of Clause 6.6.3, or the pipe capacity, whichever is less. At sags and at any location used to set building floor levels, the major system shall also be checked with the minor system **fully blocked** (Clause 6.10.3).

6.3.4 **Rainfall and method.** Design flows shall use the rainfall of Chapter 2 (including the climate factor of Clause 2.8) and the methods of Chapter 3:

- (a) the Rational Method only for catchments ≤ 16 ha and a single conveyance element. It shall not be used to accumulate flows down a network whose total catchment exceeds 16 ha;
- (b) a hydrograph method with hydraulic routing (for example SWMM, HEC-HMS with a hydraulic model, or an equivalent 1D/2D model) for networks above 16 ha and for any network with storage, pumping or a tidal outfall;
- (c) a minimum time of concentration of 10 minutes.

6.3.5 **No transfer between catchments.** Neither the minor nor the major system shall divert flow from one natural catchment to another unless the approving authority accepts a catchment-wide study showing no adverse effect.

6.3.6 **Hill catchments: debris, sediment, steep drains and streets, hill roads and sloping sites.** This clause applies to every element of the minor and major systems that receives runoff from a hill catchment, which in this Manual means land in sub-area HP-B, HP-B1, HP-B2 or HP-C of Annex 2A, any catchment whose natural ground slopes more than 10% on average, and any khad, nallah, choe or other seasonal stream that comes down from the hills or runs across the Siwalik valley fills and fans. Such elements shall meet Clauses 6.4 to 6.14 and, in addition (all set by this Manual):

- (a) **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, orchard, terraced or bare slope, or a slide scar), or from a khad, nallah or choe 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 khad or a nallah. 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 May and, in the hill towns, again after the monsoon by 31 October (Chapter 10). The volume of a debris basin is to be set in Chapter 9 [TBC].
- (b) **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 that drains a mapped debris-flow fan, landslide or slide scar, is not designed by a bulking factor: no building, outfall, pumping station or storage shall be placed in the debris-flow path, and the drains are designed for the bulked flow only [TBC].
- (c) **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%.
- (d) **Sediment and minimum velocity.** Drains and pipes that receive flow from a hill catchment, or that run across the Siwalik valley fills and fans of Una, Paonta–Kala Amb and Baddi–Nalagarh, 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).
- (e) **Steep drains and energy dissipation.** 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 (b), with the freeboard of Table 6.7 for steep channels and an energy dissipator at every change to a flatter gradient and at the outlet. No unlined drain shall be laid on a gradient on which the velocity exceeds the limit of Chapter 9 for its bed material.

- (f) **Steep streets.** On a street steeper than 5%, grate-only inlets shall not be used, and inlets shall be placed by the calculation of Clause 6.6.4 with the bypass flows of a steep gutter. On a street steeper than 10%, the flow shall be intercepted by transverse grated channels or kerb inlets at a spacing that keeps the street flow within the limits of Table 6.3 in the check and 1% AEP events. Where the 1% AEP flow cannot be kept within those limits on the carriageway, the excess shall be carried in a lined side channel or stepped drain under item (e), 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.
- (g) **Hill roads as the minor system.** In the hilly area as Appendix-1, cl. 8 of the TCP Rules 2014 defines it (land more than 600 m above mean sea level, or with an average slope of 30°), and on any road elsewhere that crosses a hill catchment, the drainage of a road is the minor system for the land above it as well as for the road. Every road and street there shall have, as works of the road's owner, PWD, NHAI or the local body:
    - (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 khad and nallah, and culverts or scuppers at intervals such that no side drain exceeds its capacity at the design AEP of Table 6.1 with the factors of items (b) and (c);
    - (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, 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;
    - (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 muck, spoil or excavated material from the construction, widening or maintenance of the road placed in or beside a khad, nallah, kuhl or other line of natural drainage, or on a slope from which a storm can carry it into one, and every natural drain or stream that such material has blocked cleared before the monsoon so that the runoff of its catchment reaches the nearest river, khad or nallah.
- (h) **Sloping sites.** 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 (b) and (c), with a 1% AEP flow path that does not pass through or against the building. The space of at least 1.00 m between a building and its toe wall that Appendix-1, cl. 11 of the TCP Rules 2014 requires shall be paved or lined and drained so that water does not stand against the building or soak into the foot of the cut. Both shall discharge to a public drain or a stable natural channel as item (g)(iv) requires, not onto the slope below. Roof and paved-area runoff on such a site follows the hill infiltration rule of Clause 4.11.

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 Shimla 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 Himachal Pradesh, as for Uttarakhand, the first mountain State in this series, because the criteria of this chapter assume clear water on gentle ground. In the hills the water is not clear and the ground is not gentle. The gauged khads of Himachal Pradesh are the steepest in CWC's zone 7, the Neogal falling 84.04 m and the Banu 69.21 m in a kilometre (CWC, 1994); about 90% of Shimla is built on slopes of 45° to 60°, and its slope debris "is dumped in the valley or near water channels, obstructing the natural drainage"; and the expert committee that found this reported that Shimla's drains were "not able to carry the peak flow", that their catchments were "improperly selected", and that they had been "constructed for longer distances with much lesser gradients than actually required" (*Yogindra Mohan Sengupta*, National Green Tribunal, judgment of 16 November 2017, paras 53 and 62; the judgment was set aside by the Supreme Court on 11 January 2024 and its

committee's findings are cited here only as expert evidence). In July 2023 the streams at Thunag were choked with timber and with debris from a road project, and the Malana II project filled with debris and silt and overflowed (as reported); the High Court found muck from the Kiratpur–Nerchowk highway dumped in Govind Sagar and its feeding khads and ordered it cleared (*Madan Lal*, CWPIL 31/2023, 31 May 2024), having earlier asked the Union how NHAI would stop its contractors dumping muck "near water bodies" (*Fourlane Visthapit and Prabhavit Samiti*, CWP 5243/2022, 26 June 2023); and the post-disaster needs assessment of 2023 asked that "all natural drains and streams blocked with dumped spoil" be cleared so that the runoff of each watershed "can safely be disposed of to the nearest river, drain or nala", which is item (g)(vi). The technical committee on the Shimla slides of August 2023 named "Open Drainage systems leading to poor disposal of surface water" among their causes, and at Navbahar Chowk found that the "input of rainwater from the road also accelerated the process" (HIMCOSTE-led technical committee, 2023), which is why items (g)(iv) and (h) keep road and site runoff off unprotected slopes: water discharged onto a slope raises its pore pressure (Chapter 4, Clause 4.11). The same expert committee asked for "proper lined drains on the slopes … so that there is minimum ingress of water into the slope", and the Tribunal's direction XV, that runoff from concretised areas be diverted so that it "does not go in to over burden or flow along hills and depressions", is the nearest the State has come to a sloping-site rule; it was set aside with the rest of the judgment, and item (h) gives the idea a design standard of this Manual's own. IRC:SP:42-2014 (cl. 8.5.1) already treats hill roads differently: their side drains are "normally restricted to 60 cm" in width and lined because "rolling stones cause high friction", "culverts are required at closer intervals compared to those in plain areas", and "stepped chutes/baffles are to be provided where the longitudinal bed slope exceeds critical". No Indian guidance on bulking factors, debris racks or debris basins was found during research [TBC], so each number in Clause 6.3.6 is an interim value with a stated reason, the same as in the Uttarakhand edition. The 1 ha trigger for a debris rack reflects the time of concentration on hill slopes, a few minutes, so that even a small unbuilt slope delivers stones, gravel and leaves to an inlet in the first burst of a storm. The bulking factor of 1.25 is the factor for a flow that carries a fifth of its volume as sediment (bulking factor = 1 / (1 − sediment fraction by volume)): about the most that a drain can carry and still behave as a water flood. A flow with more sediment than that behaves as a debris flow, which no drain can be sized for; the floods at Samej in July 2024 and at Thunag in June and July 2025 were of that kind, and no rain gauge recorded the storm that set off either. That is why item (b) keeps buildings and outfalls out of a debris-flow path rather than sizing a drain for it, and why the factor is to be replaced by a sediment study as soon as one is made [TBC]. The 3.0 m limit in item (c) doubles the core's 1.5 m because boulders and timber block openings that leaves and plastic do not. The 1.0 m/s minimum in item (d) replaces the 0.6 m/s of CPHEEO, which is based on carrying fine sand of 0.09 mm, because hill drains carry gravel. On a 10% street, the hazard limit of 2.0 m/s is reached when sheet flow on a concrete surface is only about 30 mm deep, which is why item (f) takes the flow off steep carriageways. The clause deals with debris at the drain; it does not ask for the concrete channelisation of rivers, which the post-disaster needs assessment found "not advisable in Himalayan Ecology" for the Beas, and which the State told the National Green Tribunal it had recommended dropping because it "may affect the cross drainage and hamper the natural drainage system" (O.A. 735/2023, affidavit of 2024).

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: Shimla, Solan, Mandi, Dharamshala and Baddi core and other high-density areas	10% (10-yr)	1% (100-yr) overland path	This Manual (see Commentary)

Element	Design AEP (return period)	Check event	Basis
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) the Mall, the Ridge, Lower Bazaar and Lakkar Bazaar in Shimla; the old town of Mandi; the bazaars of Dharamshala and McLeodganj; the bazaar of Solan; the industrial area of Baddi; and the bazaars of Kullu and Manali: the older, densely built area within the Municipal Corporation's, Nagar Parishad's or Nagar Panchayat's area, or the industrial area, that the applicable Interim Development Plan or Development Plan under the 1977 planning Act identifies as the core area, old town, bazaar or central business district, with the boundary of each to be confirmed by the local body, TCP and, at Baddi, BBNDA [TBC];
- (b) in every other Municipal Corporation, Nagar Parishad or Nagar Panchayat, the area that the applicable plan identifies as the core area, old town or central business district, the main bazaar of a hill town, and the old village settlements that have been taken into the built-up area; 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

Location	Required hazard class (Table 6.4)	Limits
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.

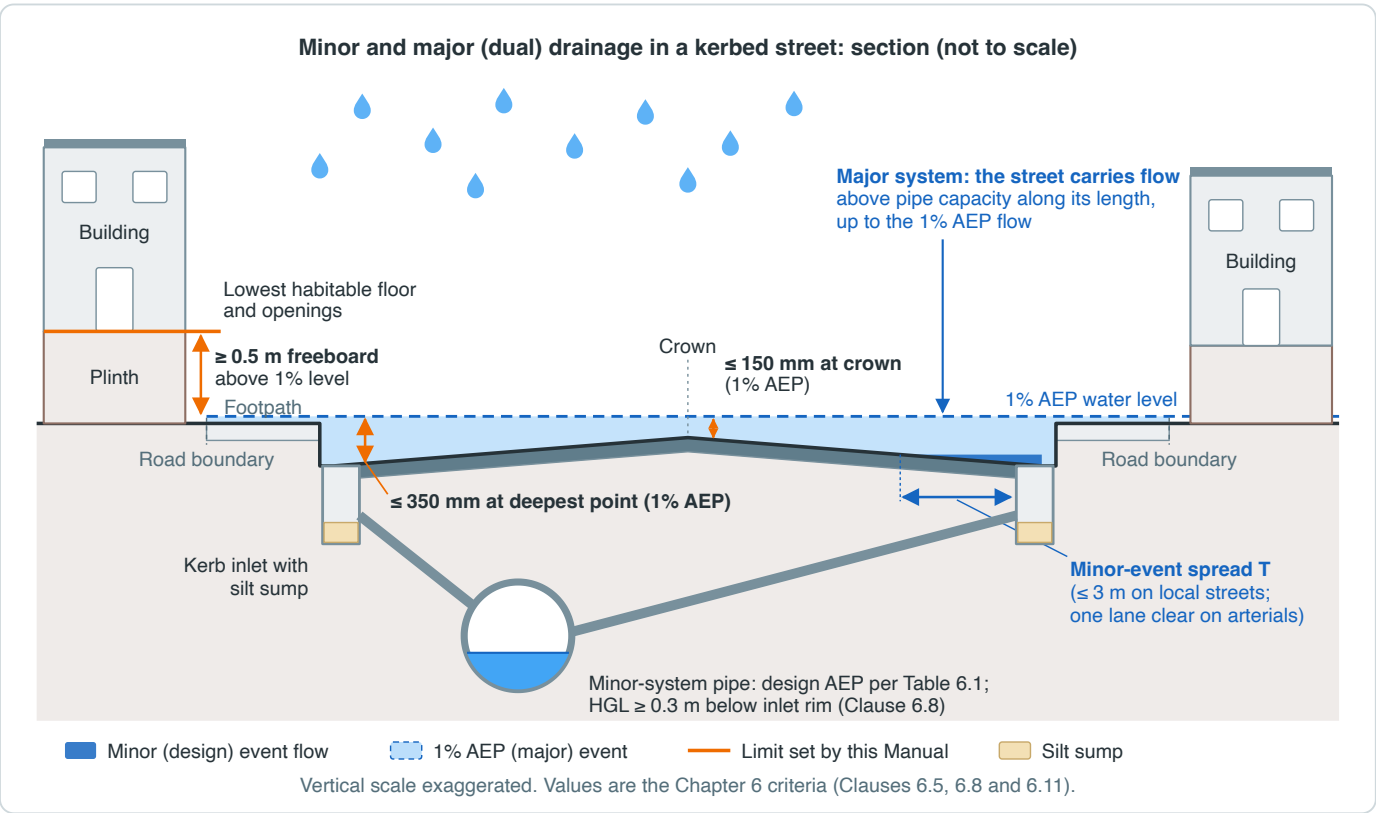


Figure 6.1 — Minor and major drainage in a kerbed street. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5601.8) and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

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 Himachal Pradesh streets, so the 1% event must be treated as a road-closure event on all roads except notified evacuation routes, which must meet H1. The assignment of hazard classes to locations in Table 6.3 has no direct precedent and is set by this Manual.

6.6 Inlets

6.6.1 **Inlet types.** Inlets may be kerb-opening inlets, grate inlets, combination inlets (a grate with a kerb opening) or slotted and trench drains. On public streets:

- (a) kerb-opening or combination inlets shall be used, unless the approving authority accepts grate-only inlets for a specific location;
- (b) inlet openings shall be set at road level, with a gutter depression where practicable, so that water is not held on the carriageway by a raised kerb or footpath;
- (c) grates in carriageways, cycle lanes and footpaths shall be of a bicycle- and pedestrian-safe pattern (Chapter 9, Clause 9.11).

6.6.2 **Inlet capacity.** The clean capacity of inlets on grade and in sags shall be computed by the methods of FHWA HEC-22 (4th edition, 2024), or from tested ratings published by the manufacturer for the exact grate and kerb-opening geometry. The empirical kerb-inlet equations of CPHEEO (2019) Part A §5.6.2 may be used as a cross-check only.

6.6.3 **Clogging factors.** The design capacity of every inlet shall be its clean capacity reduced by the clogging factors of Table 6.5:

Table 6.5 — Inlet clogging factors (share of clean capacity assumed lost)

Inlet type	On grade	In a sag
Grate	50%	50%
Kerb opening	10%	20%
Combination	Apply the grate and kerb factors to each part separately	Apply the grate and kerb factors to each part separately

Design capacity = (1 − clogging factor) × clean capacity.

6.6.4 **Inlet spacing.** Inlets shall be located by a sequential calculation that starts at the top of each gutter run. At each inlet, the intercepted flow is computed, and the bypass flow is added to the gutter flow arriving at the next inlet. Spacing shall be such that the spread limits of Table 6.2 are met everywhere in the minor design event. In addition:

- (a) inlet spacing shall not exceed 30 m on kerbed roads, whatever the calculation gives;
- (b) inlets shall be provided at every sag, immediately upstream of pedestrian crossings and intersections, upstream of bridge decks and superelevation transitions, and at the end of every gutter run;
- (c) bypass flow from the last inlet of a run shall not be passed onto a road of a higher class or into private land.

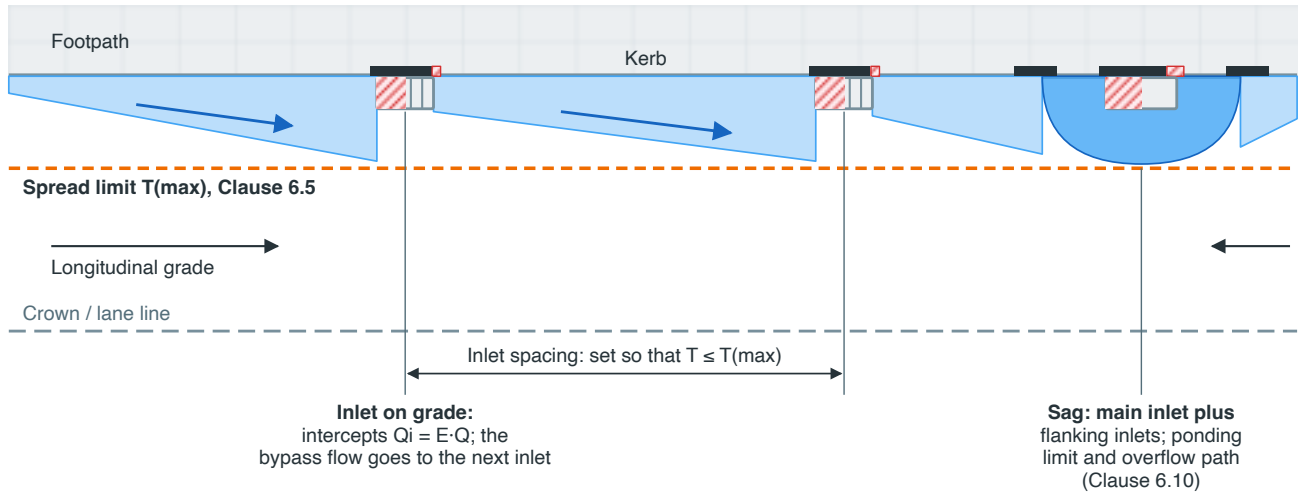
6.6.5 **Sag inlets.** At a sag on a kerbed road:

- (a) the sag inlet's design capacity (after clogging) shall be not less than the total minor design flow arriving at the sag;
- (b) flanking inlets shall be placed on each side of a sag on any road where ponding could spread beyond the Table 6.2 limits, and at every underpass;
- (c) the ponding at the sag shall comply with Clause 6.10.

6.6.6 **Inlet connections.** The pipe connecting an inlet to the main drain shall have a diameter of at least 300 mm and shall be laid at a gradient that gives at least 0.9 m/s at the inlet's design flow.

6.6.7 **Silt sumps.** Every inlet chamber on a public road shall have a silt sump at least 300 mm deep below the invert of its outlet pipe, accessible for cleaning from the surface.

Gutter spread, inlet interception and clogging: plan (not to scale)



Clogging factors (share of clean capacity lost), Clause 6.6

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

Gutter flow spread (minor event)
Ponding at sag
Assumed clogged portion
Kerb opening

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 Himachal Pradesh streets are routinely blinded by plastic and leaves. CPHEEO (2019) Part A shows solid waste dumped in drains as a primary cause of drain failure (Figures 1.2 and 2.1). APWA 5600 (2006) allows only kerb-opening inlets on public streets; Clause 6.6.1(a) is less strict because combination inlets are useful on flat roads. No standard inlet, kerb-channel or covered-drain detail of PWD or of any Municipal Corporation in the State was found during research [TBC]; in Shimla the Municipal Corporation has had to order PWD, CPWD and NHAI to clean the roadside drains and culverts before the monsoon (as reported). 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 Siwalik valley floors of Una, Baddi–Nalagarh and Paonta Sahib and in the Balh valley are flat, which shortens the calculated spacing anyway; on the steep streets of the hill towns gutter flow runs fast and passes inlets by, which Clause 6.3.6(f) 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:

$$V = \frac{1}{n} \cdot R^{2/3} \cdot S^{1/2}; \quad Q = A \cdot V$$

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

Material	Condition	n (CPHEEO)	Minimum design n in this Manual
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 Shimla, Solan, Dharamshala, Mandi, Kullu, Manali, Chamba, Dalhousie, Palampur, Nahan, Rampur Bushahr and Reckong Peo 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
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.

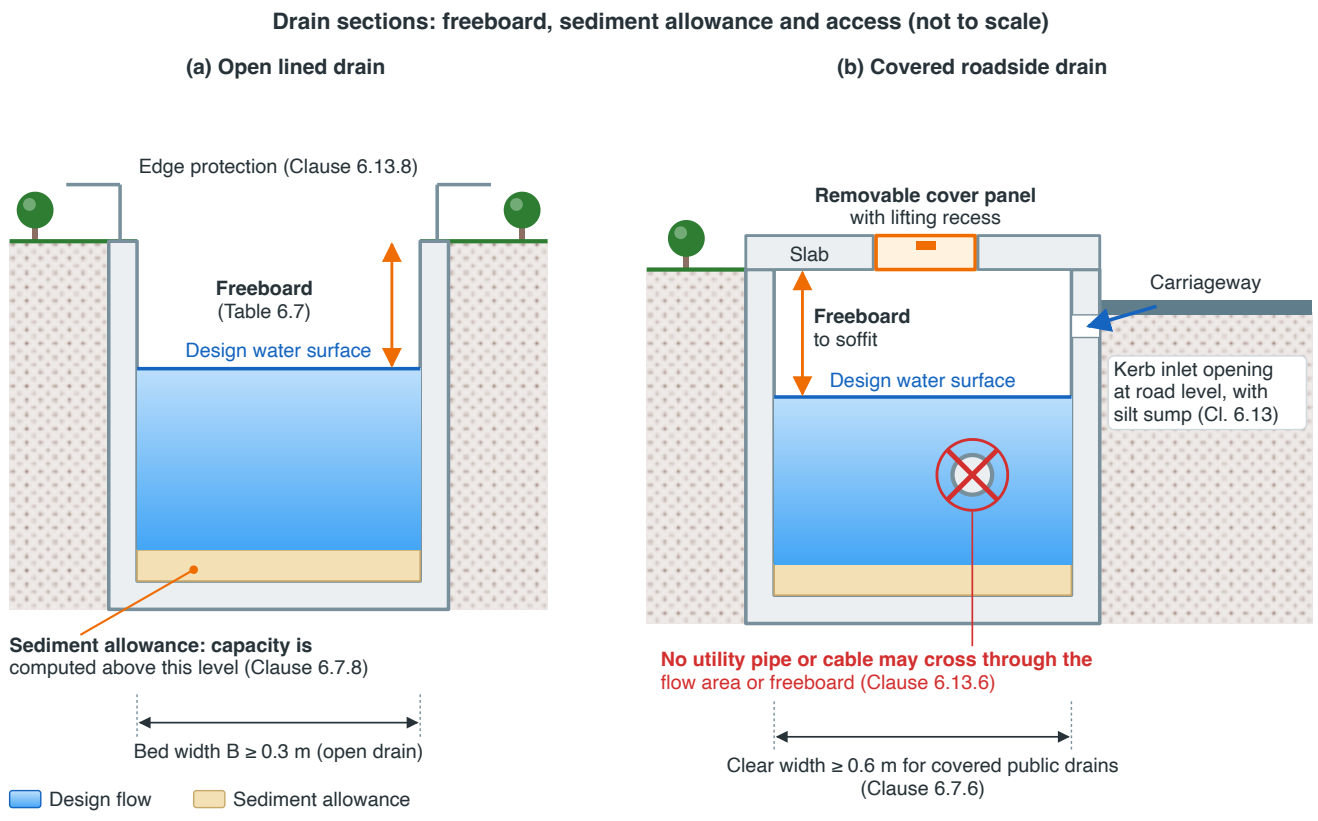


Figure 6.3 — Drain sections: freeboard, sediment allowance and access. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Tables 5.3 and 5.12, and IRC:SP:50-2013.

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 Himachal Pradesh drains carry heavy silt and solid waste. The 0.6 m/s minimum velocity is CPHEEO's (Table 5.2), based on carrying 0.09 mm sand (§5.3.1). The 0.9 m/s value for pipes is stricter, because a silted pipe cannot be cleaned as easily as an open drain. The 3.0 m/s maximum is from CPHEEO Table 5.2 (WPCF/ASCE 1982). The Froude limit of 0.8 is from CPHEEO §5.3, which advises avoiding critical flow because the water surface becomes unstable.

The 0.6 m × 0.6 m minimum for covered drains has no direct precedent and is set by this Manual. A covered drain narrower than this cannot be desilted by hand or by small machines through a cover opening, and silted, inaccessible drains were a recurring finding after the monsoon of 2023 in Shimla, where the Municipal Corporation described its drains as "not built scientifically" and sought the revenue records of century-old drains in order to reopen them (as reported), and in Dharamshala, where drainage is reported to be inadequate despite more than ₹500 crore of Smart City spending (as reported). 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. Shimla'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 Himachal Pradesh many town drains end in a khad or nallah whose bed moves, a river held high by a monsoon spell or a dam release, or a reservoir held near its full level (Clause 5.8.5). Shimla's drains end in nallahs that run to the Ashwani Khad and the Sutlej, and some of them also carry the effluent of the treatment plants at Lalpani, Malyana and Dhalli, which CPCB found discharging "into Nalla leading to Ashwani Khad" (CPCB, interim report in NGT O.A. 735/2023, 2024); Mandi's end in the Beas below the Pandoh dam and in the Suketi, where no gauge records the level; and Bilaspur's end in Gobind Sagar, whose level BBMB keeps in feet. No flood level of any khad or nallah, and no design level of any outfall, was found during research. A drain whose HGL is started from a free outfall, or computed one length at a time without the river, khad or reservoir level, fails in exactly that way. An HGL computed from the outfall, with the tidal tailwater of Chapter 5, exposes those errors at design stage. The MHWS plus 0.3 m starting level is from CPHEEO (2019) Table 6.2. The access-hole method is described in HEC-22 from the 2009 edition onward.

6.9 Major system: overland flow paths, easements and drainage reserves

6.9.1 **Streets as the primary major system.** Streets shall be graded so that the 1% AEP major-system flow is carried along the road reserve to a receiving waterway without being trapped, except at sags designed under Clause 6.10.

6.9.2 **Overland flow paths outside streets.** Where a major-system path leaves the road reserve, it shall be:

- (a) in public land, in the open space of a layout, or in an easement recorded on the layout approval and the title;
- (b) at least as wide as the 1% AEP flow top width plus 0.5 m on each side, and not less than 3.0 m;
- (c) kept free of buildings, compound walls, fences, fill, stored materials and planting that would obstruct flow;
- (d) graded to a continuous fall with no sag that lacks an outlet; and
- (e) within the hazard limits of Table 6.3.

6.9.3 **Compound walls.** A compound wall or fence shall not be built across a mapped overland flow path. Where a wall must cross one, it shall have openings with a total area that passes the 1% AEP flow with a 50% blockage, without raising the upstream water level above the limits of this chapter.

6.9.4 **Access along open drains.** Open drains with a top width of 2 m or more shall have a maintenance access strip at least 3.5 m wide along one bank, connected to a public road at intervals of not more than 500 m.

6.9.5 **Supply channels, surplus courses and tanks.** Tank supply channels and surplus courses are part of the major system and shall be protected under Chapter 7.

6.9.6 **Drainage reserves.** A drainage reserve is a strip of land, including the drain, kept free of buildings so that the drain can be maintained, widened and used as a flood path. A drainage reserve shall be provided:

- (a) along every public drain or channel with an internal width of 1.0 m or more that runs through or along a layout or site being developed or redeveloped;
- (b) along every drain or channel shown in an adopted Basin Stormwater Master Plan (Chapter 11), at the width of the future drain in that plan; and
- (c) along every new public drain with an internal width of 1.0 m or more built by a public body.

6.9.7 **Width.** The reserve shall be not less than the width in Table 6.9, measured from the drain's internal width W. The width is based on the **required** drain size (for a planned drain, the size in the master plan), not the existing size. Where the access strip of Clause 6.9.4 is wider than the margin in Table 6.9, the wider governs.

Table 6.9 — Minimum drainage reserve width (adopted from PUB Singapore)

Internal width of drain, W	Open drain	Closed (covered) drain
1.0 m to 1.2 m	3.0 m	W + 0.6 m
more than 1.2 m to 3.0 m	W + 2.6 m	W + 1.6 m
more than 3.0 m to 4.5 m	W + 3.5 m	W + 1.6 m
more than 4.5 m to 6.0 m	W + 4.5 m	W + 3.0 m
more than 6.0 m to 9.0 m	W + 6.0 m	W + 3.0 m
more than 9.0 m to 25.0 m	W + 7.5 m	W + 3.0 m
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 Jal Shakti Vibhag channel, the reserve is transferred to the Jal Shakti Vibhag.
- (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.

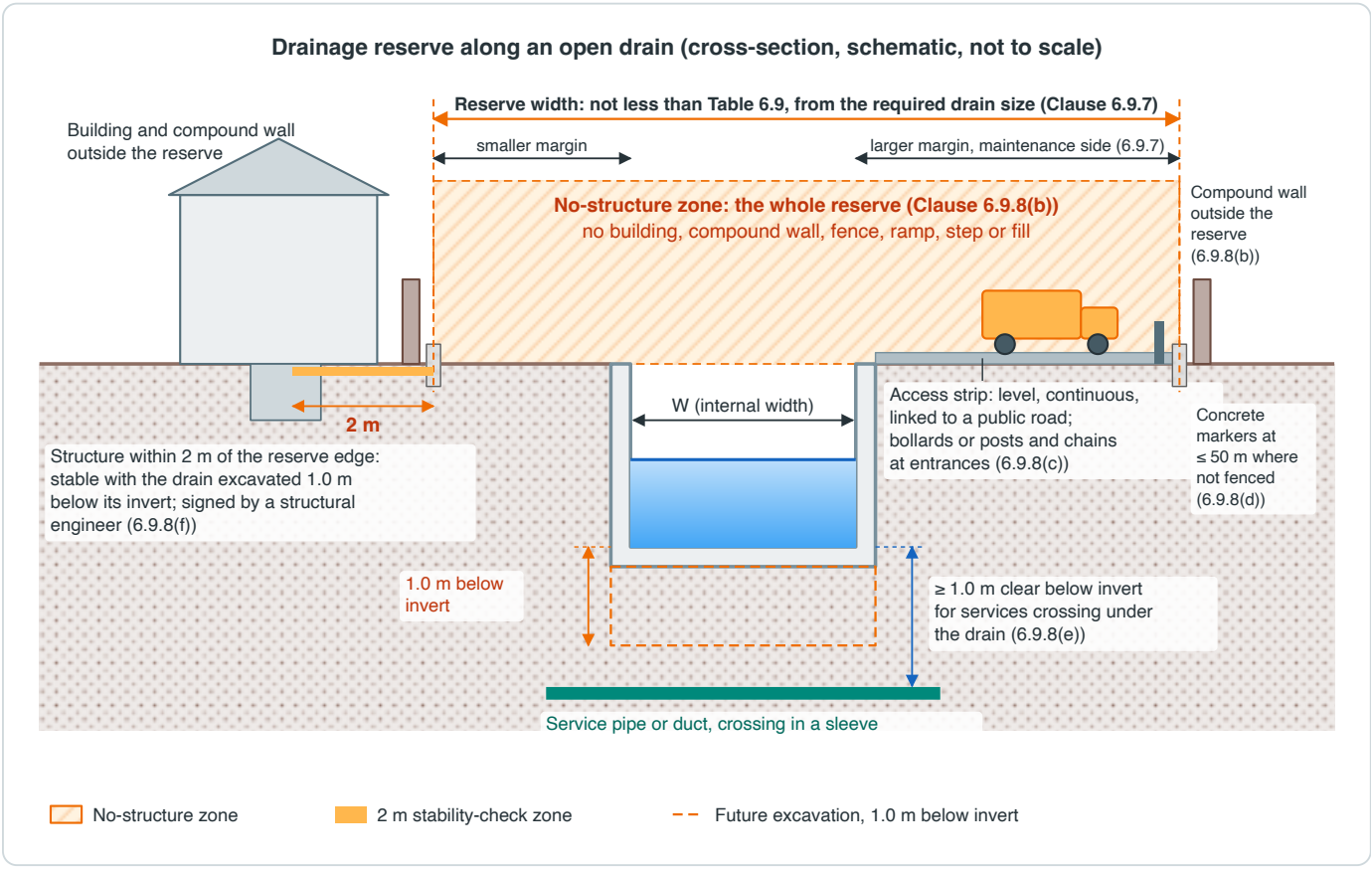


Figure 6.4 — Drainage reserve along an open drain: reserve width from Table 6.9, no-structure zone, access strip on the maintenance side, the 1.0 m service clearance below the invert and the 2 m stability-check zone (Clauses 6.9.6 to 6.9.8). Original drawing for this Manual, adapted from PUB Singapore, 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 Himachal Pradesh, buildings and compound walls are often built up to the edge of a drain, so it cannot be widened or desilted by machine. Reserving the land when a plot is developed or redeveloped is the cheapest time to secure it, because widening later needs land acquisition. Basing the width on the master-plan drain size (6.9.6(b)) protects the land a future drain will need. Himachal Pradesh has short statutory distances from water where no development plan exists, but no reserve width along a drain and no floodplain law. Appendix-1 of the TCP Rules 2014, made under the Himachal Pradesh Town and Country Planning Act 1977, which governs only "areas where land use is frozen and Interim Development Plan or Development Plan has not been prepared", allows construction "at distance of 3.00 Metre and 5.00 Metre from Nullah and Khud respectively" (cl. 16) and names no line, bank, centreline or flood level from which the distances are measured; in planning areas, the distance from the highest flood level along rivers, khuds and nullahs is "as delineated in the Interim Development Plans / Development Plans", and in other areas "no construction shall be allowed in parcel of land prone to floods" (Appendices 3 and 7). A development plan may treat "flood plains and areas adjacent to major drainage lines" as non-developable, as the Chopal Planning Area Development Plan 2041 does. The Shimla Development Plan 2041, published on 20 June 2023 according to the Supreme Court (2024 INSC 30, para 99) and notified on 23 June 2023 according to the press, has a chapter on storm-water drainage in its draft, but its text and its lines were not read [TBC]; the 5 m of the Shimla Interim Development Plan is a distance from the boundary of a green belt, not from a nallah. In 2025 the press reported new distances of 5 m from drains and 7 m from rivers and ravines for buildings, in place of 3 m and 5 m, a rule that no government building be built within 150 m of rivers, nullahs and other water bodies, and model bye-laws for rural construction that ban building along the banks of rivers and streams; no gazetted text of any of these was found during research, and this Manual reports them and does not apply them until it is [TBC]. The State has no floodplain zoning law and no notified flood line. The post-disaster needs assessment of the 2023 monsoon found that "most of the destruction that occurred along the Beas river in Kullu district was mainly due to overflow of the water along the palaeo channels following the old river course along which the developmental activities have taken place", and called for "comprehensive river boundary mapping and the establishment of floodplain management guidelines". The only State power found to protect a line of natural drainage as such is s.43 of the Himachal Pradesh Minor Canals Act 1976, under which the Government may regulate the flow in "any river, creek, natural channel or line of natural drainage" and prohibit or remove an obstruction of it. None of these gives a reserve width along a khad, nallah or 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 the edge of a tal or reservoir is the higher of its full or maximum level and its monsoon water line (Chapter 7, definitions after Clause 7.2); every khad, nallah, choe and kuhl 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; land recorded in the revenue records as a river, khad, nallah or waterbody is part of the channel or waterbody whatever its present use; and an old course of a river, shown on old maps or in the ground as a palaeo-channel, is kept free of building as part of the river's corridor, because that is where the Beas went in 2023 (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(b) (Clause 6.9.7), the access strip of Clause 6.9.4 on the access bank, and, along a river, khad, nallah or choe that drains 8 ha or more, the setbacks of Clause 7.4 measured from its top of bank, with a Zone 1 of at least 15 m; where Appendix-1 of the TCP Rules, a development plan's flood-level line, a gazetted rule or a court sets a wider line, that line applies for as long as it binds (Chapter 7). The corridor is set by this Manual and applies where nothing wider binds. It should be shown in the Interim Development Plans and Development Plans made under the 1977 Act, among them those of Shimla, Kullu, Mandi, Dharamshala and Una, as non-developable land along drainage lines, and checked at planning permission, where the site plan already has to show "Existing water bodies like Bauri, Well, Nallah, khud", rather than made a new NOC.

The reserve matters because the drains of Himachal Pradesh's towns are divided among owners, and no rule divides them. The Municipal Corporations, Nagar Parishads and Nagar Panchayats hold the public drains of their areas under the Himachal Pradesh Municipal Corporation Act 1994 and the Himachal Pradesh Municipal Act 1994, whose drainage sections were not read [TBC]; in Shimla the Corporation's drains run beside a water and sewerage company, SJPNL, over which the Corporation has "limited control" (CAG, Report No. 1 of 2022); the

Smart City companies of Shimla and Dharamshala build drains; HIMUDA approves and builds colonies without the local body, HPSIDC plans the industrial areas, and BBNDA is the development authority of Baddi–Barotiwala–Nalagarh; PWD holds the roads and their drains, culverts and scuppers, which in the hills carry the runoff of the land above them, and NHAI the national highways; the Jal Shakti Vibhag holds the flood-protection works and channelisation of the khads and rivers, such as the Swan, builds the sewers outside Shimla and Solan, and manages the Government kuhls with the local authorities and their beneficiaries; TCP draws the lines of the development plans but builds no drains; and BBMB, NTPC, SJVN, NHPC and HPSEBL hold the dams and reservoirs. Shimla's own count of its drains is not settled: the Corporation reported 13 major nallahs and about 67 drains with a network of about 42.33 km in 2015 (Municipal Corporation Shimla and UNDP), and 191 major storm-water drains and nallahs, 55.43 km long, built under AMRUT by 2022 (Municipal Corporation Shimla); the expert committee before the National Green Tribunal found in 2017 that storm drainage covered about 30% of the city. No rule dividing the khads and natural nallahs from the municipal drains was found during research. For the purposes of this Manual, and until the State issues such a rule [TBC], the drains are assigned as follows: rivers, among them the Beas, the Sutlej, the Yamuna, the Ravi, the Swan, the Sirsa and the Balad, with their beds, banks and floodplains, the khads and nallahs outside the limits of the local bodies, and the flood-protection and channelisation works on any of them, to the **Jal Shakti Vibhag**, with the land as it is recorded, of the Revenue or Forest Department, and the local body keeping the bed free of encroachment within its limits; the natural nallahs, khads and public drains within the limits of a Municipal Corporation, Nagar Parishad or Nagar Panchayat, other than those assigned to the Jal Shakti Vibhag, to that body, in Shimla to SMC; drains built under AMRUT or by a Smart City company to the body that built them until they are handed over in writing, and then to the local body; the drains and storages of a scheme of HIMUDA, HPSIDC, BBNDA or a colony developer to the body that built it until they are handed over in writing; the road drains, catch-water drains, scuppers and cross-drainage of State roads and hill roads to **PWD**, or to the local body that owns the road, of national highways to NHAI or MoRTH, and of border roads to BRO; sewers, interceptors, the interception and diversion of nallahs and treatment plants to SJPNL in Shimla, to the Municipal Corporation in Solan and to the Jal Shakti Vibhag elsewhere (Clause 8.9); kuhls in the schedules of the Minor Canals Act to the Government or local authority that manages them or to their beneficiaries, with the Collector, as the Act provides (ss.43–48); the reservoirs and barrages and their drawdown land to BBMB (Bhakra, Pong and Pandoh), NTPC (Kol), SJVN (Nathpa Jhakri), NHPC (Chamera and Parbati), HPSEBL or HPPCL (Larji and their other projects) and the private operators of the other projects, such as Karcham Wangtoo; springs, nauns and baolis used for supply to the Jal Shakti Vibhag, SJPNL or the local body or panchayat that uses them; and wetlands, among them Pong Dam Lake, Renuka, Chandertal, Rewalsar and Khajjiar, to the State Wetlands Authority, whose secretariat is HIMCOSTE, with the Forest Department (set by this Manual). Under Clause 6.9.8(a), the reserve along a channel assigned to the Jal Shakti Vibhag is transferred to the Jal Shakti Vibhag. Where a channel's status is disputed, the corridor follows the channel and not its name: Shimla's nallahs are at once storm drains, carriers of sewage and the catchment of a drinking-water source, the Ashwani Khad (Clause 8.9). No approved city drainage master plan with a design return period was found for any town in the State, and no design storm for any town drain: the drains of Shimla were found in 2017 to have been laid without one. 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(e) 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 Himachal Pradesh and are one of the most common ways that overland flow paths get blocked. The 50% blockage assumption for wall openings is set to match the grate clogging factor of Clause 6.6.3. The 3.5 m access width is set by this Manual, sized for a small excavator or desilting vehicle. For comparison, APWA 5600 (2006, 5608.4) requires a 15 ft (about 4.6 m) maintenance access strip for detention facilities.

6.10 Ponding at sags and low points

6.10.1 **Minor event.** At every sag, the minor design flow shall be removed by inlets (after clogging) with ponded spread within Table 6.2.

6.10.2 **1% AEP event.** At every sag:

- (a) the ponded depth shall not exceed 350 mm at the deepest point of the carriageway;
- (b) a surface overflow route shall be provided (for example over a lowered kerb and footpath into a designated overland flow path), so that the ponding level cannot rise above the overflow level; and
- (c) building floor levels around the sag shall comply with Clause 6.11.

6.10.3 **Fully-blocked check.** At sags, the 1% AEP ponding level shall also be computed with the minor system fully blocked and all flow leaving by the surface overflow route. Floor levels around the sag shall be set from the higher of the two ponding levels.

6.10.4 **Trapped sags.** Where a sag has no surface overflow route, the inlets and conduits (after clogging) shall carry the 1% AEP flow, and the approving authority shall agree the arrangement.

6.10.5 **Road underpasses.** Underpasses and other trapped sags on public roads shall:

- (a) be drained by a minor system (with pumping under Chapter 9, Clause 9.9, where gravity drainage is not possible) designed for the 2% AEP (50-yr) flow, checked at the 1% AEP flow;
- (b) have flanking inlets at both approaches to intercept flow before it reaches the low point;
- (c) be protected from inflow from surrounding streets by raised approach crests where practicable; and
- (d) have depth markers and automatic warning or closure signals that operate at 150 mm depth on the carriageway.

> Commentary. The fully-blocked check, the trapped-sag rule and the underpass requirements have no direct precedent and are set by this Manual. No record of a flooded road underpass in the State was found during research [TBC]. The roads already act as the major system, and in the hills as its steepest part: the 2023 monsoon damaged more than 8,040 km of the State's roads, about 21% of their length, and the box culverts damaged are to be rebuilt only after a "Drainage Analysis: Assessing the hydraulic requirements for culverts" (Recovery and Reconstruction Plan, 2023), while the technical committee on the Shimla slides of that August found that at Navbahar Chowk the "input of rainwater from the road also accelerated the process" (HIMCOSTE-led technical committee, 2023). 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.

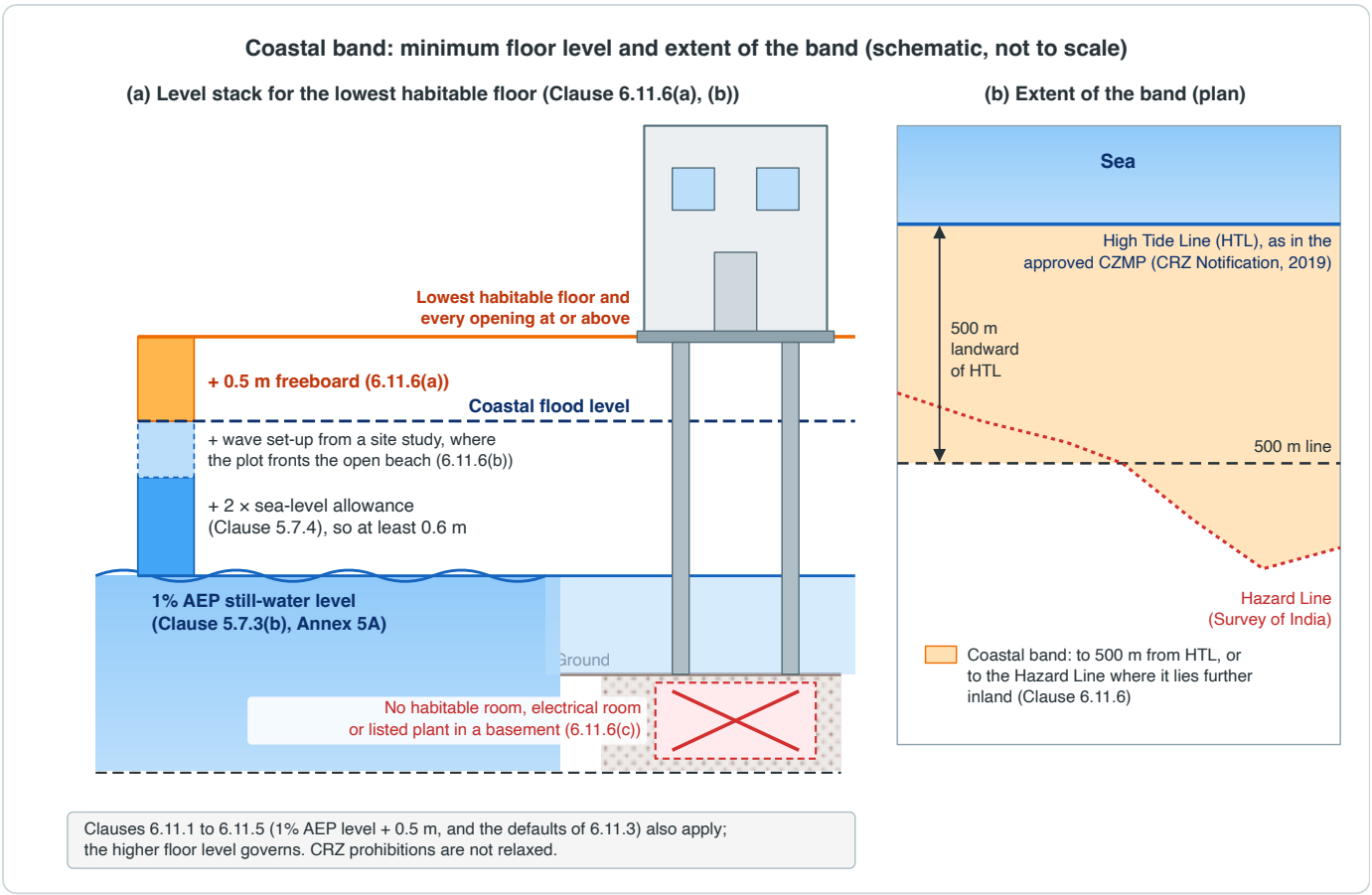


Figure 6.5 — Coastal band: the minimum floor level built up from the 1% AEP still-water level, twice the sea-level allowance, wave set-up where the plot fronts the open beach and 0.5 m freeboard; and the extent of the band, to 500 m from the High Tide Line or to the Hazard Line where it lies further 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. Himachal Pradesh has no coast, no High Tide Line and no Coastal Regulation Zone, so the coastal band is empty in the State and Clause 6.11.6 does not apply there. Clauses 6.11.3 and 6.11.4 matter instead. No plinth-height or basement rule of the TCP Rules 2014 was read for this Manual [TBC]. The only flood-level building rules found are those of the TCP appendices, under which the distance from the highest flood level along rivers, khuds and nullahs is as the development plans delineate it and no construction is allowed on land prone to floods where no plan delineates it, and Appendix-1, which keeps buildings 3.00 m from a nullah and 5.00 m from a khud where no plan exists; none sets a floor level. Clause 6.11.3, which sets the lowest habitable floor and every opening 0.65 m above the road crown where no flood level has been computed, and Clause 6.11.4, which applies the same level, or 0.5 m above the 1% AEP flood level, to the crest of every basement ramp and the sill of every basement opening, are set by this Manual and add to the rules. On a hillside the road crown is not always the right reference: a building below a road takes the road's runoff, and in Shimla buildings along the highways are reported to be required to stand one metre below road level (as reported), so Clause 6.11.2(a) sets their floor and openings from the 1% AEP level of the flow path past them, with the uphill diversion and the drained toe-wall space of Clause 6.3.6(h) in place, and a floor or basement cut into a slope also needs the geotechnical certificate of the hill infiltration rule (Clause 4.11) and, in a sinking or sliding zone, the geologist's soil investigation report of Rule 21(1) of the TCP Rules. Along the rivers, khads and nallahs, near the tals and springs and on the shores of the reservoirs, the lines of Chapter 7 also apply.

6.12 Culverts and road crossings

6.12.1 **Design AEP.** A culvert or bridge that carries a road over a drain or waterway shall pass the design AEP flow of Table 6.1 for that road class without overtopping the road, and with the headwater limits of Chapter 9, Clause 9.4. Where the waterway is a State highway or national highway crossing, the design AEP shall also be not less than that of IRC:SP:42-2014 §7.1.4 for the span. The rarer AEP governs.

6.12.2 **Check event and 1% AEP.** At the check event and at the 1% AEP event, the crossing and the road together shall pass the flow:

- (a) with overtopping depth ≤ 150 mm at the road crown and ≤ 350 mm at the deepest point of the road;
- (b) within the hazard limits of Table 6.3;
- (c) with no overtopping at all of arterial roads that are notified evacuation routes; and
- (d) without raising the 1% AEP flood level at any upstream building or property boundary above the level for the existing condition, unless the affected owners and the approving authority agree.

6.12.3 **Where overtopping is not permitted.** Overtopping in the 1% AEP event is permitted only where the structure span is less than 6 m **and** the 1% AEP peak flow is not more than 7 m³/s, unless a guard rail is installed downstream of the overtopping section. Otherwise, the crossing shall pass the 1% AEP flow without overtopping.

6.12.4 **Blockage check.** The 1% AEP check shall be repeated with a blocked inlet:

- (a) 50% of the inlet area blocked for culverts with a span or diameter below 1.5 m; and
- (b) 20% blocked for larger culverts.

The results of this check shall meet Clause 6.12.2(a) and (d).

6.12.5 **Minimum size.** Culverts under public roads shall be at least 900 mm in diameter, or 900 mm × 900 mm for box culverts.

6.12.6 **Hydraulic design.** Culvert hydraulics, including inlet and outlet control, tailwater, road overtopping and outlet protection, shall follow Chapter 9, Clauses 9.4 and 9.6.

> Commentary. The design AEPs are those of Table 6.1. The overtopping limits are the street-depth limits of Table 6.2. The span and flow threshold in Clause 6.12.3 is the SI conversion of APWA 5600 (2006): overtopping allowed only where the structure span is under 20 ft and the 1% peak is 250 cfs or less, unless a downstream guard fence is installed. IRC:SP:42-2014 (§7.1.4) sets 25-yr for NH/SH culverts up to 2 m span and 50-yr for 2–6 m spans. The blockage percentages in Clause 6.12.4 and the 900 mm minimum size have no direct precedent and are set by this Manual. The 50% value matches the grate clogging factor.

6.13 Himachal Pradesh construction-practice requirements

6.13.1 **Covered roadside drains.** Where a roadside drain is covered by slabs that form a footpath:

- (a) it shall be designed as an open channel with the freeboard of Table 6.7 measured to the soffit of the cover slab, and its HGL shall meet Clause 6.8 measured to the footpath and inlet levels;
- (b) road runoff shall enter through openings in the drain wall at road level (Clause 6.6.1(b)), each with a silt sump (Clause 6.6.7), at the spacing of Clause 6.6.4;
- (c) footpath runoff shall enter through slots or grated openings in the cover, not by ponding on the footpath; and
- (d) the clear section shall meet Clause 6.7.6(c).

6.13.2 **Removable covers and access openings.** Covered drains shall have:

- (a) removable cover panels at not more than **10 m** centres, each at least 0.6 m long and spanning the full clear width, with recessed lifting points, liftable by two workers or by a hand-operated lifting device, and flush with the footpath;
- (b) access chambers with a clear opening of at least 0.6 m × 0.6 m at every junction, bend and change of section, and at not more than **30 m** centres on straight runs; and
- (c) covers rated for the traffic or pedestrian load at their location (Chapter 9, Clause 9.11).

6.13.3 **Silt traps.** In addition to the inlet sumps of Clause 6.6.7, silt trap chambers shall be provided:

- (a) upstream of every culvert under an arterial road;
- (b) upstream of every pump station and detention facility; and
- (c) at every outfall to a tank, river or other waterbody (with the gross pollutant trap required by Chapter 8).

Each silt trap shall be sized to hold the sediment expected between scheduled cleanings, using the sediment yield in Annex 6B, and shall be reachable by a desilting vehicle.

6.13.4 **Garbage and gross pollutant screens.** Screens shall be provided where an open drain enters a covered drain, a pipe or a culvert, and at outfalls under Chapter 8. Each screen shall:

- (a) be designed under Chapter 9, Clause 9.8;
- (b) have a bypass or overflow, so that a fully blinded screen does not flood properties or the road beyond the limits of this chapter; and
- (c) be checked hydraulically with 50% of its area blocked.

6.13.5 **No building over drains.** No structure other than an approved crossing or a removable cover shall be built over a public drain. Shop frontages, ramps and steps that cross a drain shall be removable or shall leave access openings that meet Clause 6.13.2.

6.13.6 **Utilities.** No water main, sewer, power or telecom cable, gas pipe or duct shall be laid along, or pass through, the flow area or freeboard of any drain. A utility that must cross a drain shall:

- (a) cross above the cover soffit or below the drain invert, inside a sleeve; and
- (b) be shown on the drainage plan with its level.

Where an existing utility crossing obstructs a drain, its area shall be deducted from the drain section, with a 50% blockage allowance for the debris it traps, until the utility is relocated. The utility owner shall relocate it when the drain is rebuilt.

6.13.7 **Sewage.** No sewage connection is permitted to a storm drain (Chapter 8). Covered drains shall be built with sealed joints where they run next to sewers.

6.13.8 **Edge protection.** Open drains deeper than 1.0 m beside a footpath, a carriageway or a public open space shall have railings or barriers. Open drains of any depth shall not be left uncovered across a footpath.

6.13.9 **As-built levels.** The as-built invert levels of every public drain, pipe and manhole shall be surveyed and submitted (Chapter 10). Inverts shall be within ±15 mm of design. An HGL re-check shall be submitted where they are not.

6.13.10 **Desilting.** Public drains shall be desilted before the south-west monsoon each year, as set out in Chapter 10.

> Commentary. Clause 6.13 has no direct precedent; this Manual sets it on the basis of Himachal Pradesh practice. Most urban drains in the State are covered roadside drains under footpaths. They are often built with continuous cast-in-situ slabs and few openings, so they cannot be cleaned and fill with silt and solid waste within a season. CPHEEO (2019) notes that uncovered channels "are prone to the dumping of garbage" (Part A, Ch 2), which is why the drains are covered. Covering without access openings simply moves the problem out of sight. NDMA (2010) recommends that pre-monsoon desilting be complete by 31 March. In Himachal Pradesh the south-west monsoon normally sets in on 25 June and withdraws on 25 September (IMD Meteorological Centre Shimla, normals from 2024), but it set in as early as 9 June in 2000 and 13 June in 2021, and it withdrew later than its normal date in eight of the nine years from 2018 to 2026, in October in seven of them (IMD). Western disturbances bring heavy rain after the monsoon has gone: rain and snow were forecast for 5–7 October 2025, after a withdrawal on 26 September (IMD), and the gauges of Batheri and Nichar recorded 285 mm on 4 October 1955 and 268 mm on 10 October 1956 (CWC, 1994). The only directions found are press reports that drains and nallahs be cleaned "before the onset of the monsoon" in Shimla and that the local bodies clean drains, channels and nallahs "in a campaign mode with-in 15 days" (2019) (as reported); no desilting order of the Urban Development Department or of a Municipal Corporation with a completion date was found during research [TBC]. So Clause 6.13.10 refers to the south-west monsoon, and Chapter 10 requires desilting and the clearance of debris from drains, racks, traps and culverts to be complete by 31 May; inlets, debris racks, culverts, flap gates and pumps to be certified ready and test-run by 15 June (Clauses 5.11.5 and 5.12.9), before the earliest recorded onset; standby to continue until 31 October, because of the late withdrawals and the October storms; a second clearance of debris racks, traps and culverts in the hill towns after the monsoon, by 31 October, because every storm in the hills fills them; and inlets in towns above about 1,500 m to be kept clear of snow and ice from December to March. These dates are set by this Manual.
>
> No rule of the TCP Rules 2014 on building over a drain was found, and the drainage sections of the Himachal Pradesh Municipal Corporation Act 1994 and the Himachal Pradesh Municipal Act 1994 were not read [TBC]. Natural drains, khads and nallahs are open channels with a drainage reserve (Clause 6.9), and should not be covered, decked or built over: in Shimla the Municipal Corporation has sought the revenue records of century-old drains in order to reopen them (as reported), and the post-disaster needs assessment of 2023 found that "water channels, which should act as natural outlets, are often encroached upon". Where a drain is covered, Clause 6.13.2 applies to it in full; where it is open beside a footpath or a carriageway, Clause 6.13.8 applies. In the hill towns many drains run beside steps and footpaths on steep ground, where an open drain is a fall hazard and a covered one cannot be cleared of stones without its access openings.

> Clause 6.13.7 is not yet the practice. In January 2016 the Ashwani Khad, a source of Shimla's water, was contaminated by effluent from the Malyana and Dhalli treatment plants, which was followed by an outbreak of hepatitis E, and the supply from it was stopped (Bhagra et al., 2017); in 2022 CPCB put four stretches in the State in its first priority for pollution, the Ashwani Khad, the Bald along Baddi, the Sirsa along Nalagarh and the Sukhna along Parwanoo; and SJPNL is not expected to connect the last 50.8 km of Shimla's sewers before 2039 (Chief Secretary, affidavit in NGT O.A. 735/2023, 1 February 2026). Clause 8.9 sets how dry-weather flow in storm drains is surveyed and intercepted until the connections are removed, including the rule that interception shall not reduce the capacity of the drain (Clause 8.9.5(b)).
>
> The 10 m and 30 m spacings and the ±15 mm tolerance have no direct precedent and are set by this Manual. Clause 6.13.6 responds to the common sight of water mains and cables running through drains. Each one traps debris and reduces the section. Mechanical cleaning through cover openings, rather than manual entry, is assumed throughout, consistent with the Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013.

6.14 Outfalls

6.14.1 Outfalls shall be designed for the tailwater conditions of Chapter 5. Outfalls below the 1% AEP still-water level shall have flap or tide gates or non-return valves (Chapter 5 and Chapter 9, Clause 9.10).

6.14.2 Outfall protection and energy dissipation shall be designed under Chapter 9, Clause 9.6. Outfalls to tanks and waterbodies shall also meet Chapters 7 and 8.

6.15 Submittal requirements

Every conveyance submittal shall include a **Conveyance Design Report** (Form 6-1) containing:

1. a catchment plan showing sub-catchments, the minor system, inlet locations and the major-system overland flow paths for the 1% AEP event (Clause 6.3.2);
2. the land-use and road-class AEP adopted for each element (Table 6.1), and the high-density area status;
3. design flows, with the rainfall sheet of Chapter 2 and the method of Chapter 3;
4. gutter spread, depth and D·V checks for the minor, check and 1% events (Tables 6.2 and 6.3);
5. an inlet schedule with clean capacity, clogging factor, design capacity and bypass flow (Clause 6.6);
6. pipe and drain design tables with n, velocity, sediment allowance and freeboard (Clause 6.7);
7. HGL profiles for the minor and check events, with the tailwater used (Clause 6.8);
8. sag ponding levels, including the fully-blocked check (Clause 6.10);
9. a floor-level schedule for every building (Clause 6.11);
10. culvert and crossing calculations (Clause 6.12 and Chapter 9); and
11. a utilities-crossing schedule and access-opening layout for covered drains (Clause 6.13).

References (chapter)

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Annexes and forms

Annex / Form	Content
6A	Standard inlet types for Himachal Pradesh with capacity curves (on grade and sag)
6B	Sediment yield for silt-trap sizing and calibration of the sediment allowance
6C	Standard drawings: covered roadside drain with removable covers, access chamber, inlet with silt sump
Form 6-1	Conveyance Design Report checklist

CHAPTER 7

Waterbodies, Tals (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 (tal) 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 Himachal Pradesh, with no coast and no tidal water, means the State's three Ramsar sites, Pong Dam Lake, Chandertal and Renuka, the two lakes covered by the national wetland conservation programme, Rewalsar and Khajjiar, any wetland notified under the 2017 Rules (none was found notified), the wetlands of the national atlas larger than 2.25 ha, the drawdown zone of the Pong reservoir, and the spring-fed tals and marshy glades of the hills;
- (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 Himachal Pradesh Town and Country Planning Act, 1977, the TCP Rules 2014 and the Interim Development Plans and Development Plans made under it, the Himachal Pradesh Minor Canals Act, 1976, the Himachal Pradesh Ground Water (Regulation and Control of Development and Management) Act, 2005, the Municipal Acts, the Wildlife (Protection) Act, 1972 (for the sanctuaries at Pong, Renuka and Chandertal), the Wetlands (Conservation and Management) Rules, 2017, or any other law, prohibits.

> Commentary. Himachal Pradesh has no Act for the protection of lakes, tanks, ponds or springs as such, and no floodplain zoning law. Its waterbodies are protected instead by its planning law, by a canal Act that reaches its kuhls and its lines of natural drainage, by its groundwater Act, by the wetland rules and by the courts. The **Himachal Pradesh Town and Country Planning Act, 1977** is applied through the TCP Rules 2014 and through the Interim Development Plans and Development Plans made under it. Where no plan has been prepared, Appendix-1 of the Rules limits development to slopes of 45° (clause 3), limits a hill cut to 3.50 m (clause 11) and allows construction at 3.00 m from a nullah and 5.00 m from a khud (clause 16); in a planning area the distance from the highest flood level along rivers, khads and nullahs is as the plan delineates, and elsewhere "no construction shall be allowed in parcel of land prone to floods" (Appendices 3 and 7); every application for planning permission shows the "Existing water bodies like Bauri, Well, Nallah, khud" on its site plan; and a geologist's soil investigation

report is required before building in the sinking and sliding zones of a plan (Rule 21(1)) (Clause 7.4, Disclosure). The Act reaches only the 54 urban local bodies and about 102 notified areas, with 21.70% of the population and less than 10% of the area of the State (post-disaster needs assessment, 2023); building in the villages is to come under model bye-laws approved by the Cabinet in September 2025, reported to ban building along the banks of rivers and streams, whose text was not found. The **Himachal Pradesh Minor Canals Act, 1976** (Act No. 42 of 1976) makes the kuhls owned or managed by the Government or a local authority (Schedule I) and the listed private kuhls serving more than one beneficiary and at least twenty acres (Schedule II) statutory canals; it lets the Government regulate the flow of water in "any river, creek, natural channel or line of natural drainage" and order an obstruction to be removed (s. 43), requires the beneficiaries to provide works for the passage of a kuhl across a road or a drainage channel (s. 46), and makes it an offence to obstruct a canal or to foul its water (s. 65). It is the only Himachal Pradesh statute found that names a line of natural drainage. The **Himachal Pradesh Ground Water Act, 2005** (Act 31 of 2005, as amended) gives the Ground Water Authority an enabling power over rainwater harvesting and bars the release of effluent that contaminates the groundwater (Chapter 8). The wetlands are the concern of the Himachal Pradesh State Wetlands Authority, constituted on 7 November 2017 with HIMCOSTE as its secretariat (Clause 7.12, Commentary). On flood land the State's own post-disaster needs assessment of 2023 records that "The lack of well-defined river boundaries in floodplains is a prominent issue in Himachal Pradesh" and asks for "comprehensive river boundary mapping and the establishment of floodplain management guidelines"; no floodplain zoning Act and no notified flood line were found. In the towns, drains and nallahs are understood to vest in the local body under the Himachal Pradesh Municipal Corporation Act, 1994 and the Himachal Pradesh Municipal Act, 1994, whose drain sections were not read for this Manual [TBC]. In this chapter **JSV** means the Jal Shakti Vibhag, the former Irrigation and Public Health Department, which holds the State's flood works, such as the channelised Swan in Una, and its water-supply sources and intakes, and runs sewerage outside Shimla and Solan; the State's large reservoirs are held by BBMB and the other dam operators, not by JSV.

This Manual treats every recorded waterbody as drainage infrastructure. Four features set Himachal Pradesh apart. The first is the **khad and the nallah**: the hill torrents and storm channels into which every town on a ridge or slope drains, which carry boulders, debris and muck in flood, which in places carry sewage (Clause 8.9, Commentary), and which in places are a town's water source, as the Ashwani Khad was for Shimla until 2016. The second is the **reservoir**: the State's largest waterbodies are the Pong reservoir and Gobind Sagar behind Bhakra, whose levels are set by BBMB in feet, on whose shores towns such as Bilaspur stand, and into whose feeding khads muck from road works has been dumped (Clause 7.13, Commentary). The third is the **spring**: the naun, the baoli and the chashma, of which about 500 have been inventoried in a standard format (NITI Aayog, 2021), with no rule that keeps building or drains away from them. The fourth is the **kuhl**, the gravity irrigation channel of Kangra and the other valleys, which intercepts and carries hill runoff and is a canal in law. The few natural tals, Renuka, Rewalsar, Khajjiar, Prashar and Dal among them, are small lakes in small catchments, sacred and visited, fed by springs, streamlets and snowmelt, and silting; and the glacial lakes of the high mountains are hazards. This chapter gives the design rules that protect the storage and conveyance of these waterbodies. It does not replace the planning, canal, groundwater, municipal, forest and wetland procedures that record and protect them in law, or the directions of the High Court of Himachal Pradesh, the National Green Tribunal and the Supreme Court.

7.2 Definitions

Term	Meaning in this Manual
Waterbody	A river (such as the Beas, the Sutlej, the Ravi, the Chandra-Bhaga, the Yamuna, the Giri, the Pabbar and the Swan), khad (a hill torrent or ravine stream, perennial or seasonal, such as the Ashwani Khad below Shimla, the Neogal and the Banu Khad in Kangra, the Chakki Khad, and the Balad and the Sirsa in the Nalagarh valley), nallah (a natural drain or storm channel), nali (a street, roadside or house drain), cho (a seasonal Siwalik torrent, such as the streamlets that feed the Pong reservoir from the south), kuhl (a gravity irrigation channel), canal, lake or tal (such as Renuka, Rewalsar, Khajjiar, Prashar and Dal), reservoir or barrage pond (such as the Pong reservoir, Gobind Sagar behind Bhakra, Pandoh, Larji, Kol and Chamera), spring (naun, baoli or chashma) with its recharge area, khatri (a rock-cut seepage tank), wetland (such as the Ramsar sites of Pong Dam Lake, Chandertal and Renuka), glacial or moraine-dammed lake, supply channel or surplus course, perennial or seasonal (as in Chapter 1).
Tank (tal)	A waterbody impounded by an earthen bund, fed by its own catchment and/or a supply channel, with a surplus weir and one or more sluices.
Tank cascade	A chain of tanks in which the surplus or sluice outflow of one tank feeds the next (as in Chapter 3).
Full tank level (FTL)	The crest level of the surplus weir (spillway, overflow or outlet) of a tank, or the permanent crest of its regulating structure. The tank holds water up to FTL without spilling.
Maximum water level (MWL)	The highest water level in a tank when the surplus weir passes the tank's design flood. For this Manual, it is the greater of the level recorded by the Jal Shakti Vibhag 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 (kuhl, nallah, cho or feeder channel)	A channel that brings water from a river, anicut or upstream tank into a tank.
Surplus course	The channel that carries the overflow of a surplus weir to the next tank, a river, a drain or the sea.
Sluice (sluice, sluice gate or regulator)	A controlled outlet through a tank bund, usually to an irrigation channel.
Top of bank	For a channel, the break in slope at the edge of the channel. Where it cannot be identified, the edge of the water surface at the 50% AEP (2-yr) flow.
1% AEP flood extent	The land flooded by the 1% AEP (100-yr) flood with the climate factor of Clause 2.8, from a hydraulic model that meets Chapter 3 and Chapter 5, or from a map adopted by the Authority under Clause 7.3.4.
Floodway	The waterbody and the adjoining land that must be kept free of obstruction to pass the 1% AEP flood without raising the 1% AEP water level by more than **0.1 m** at any point (Clause 7.6.1). For a tank, all land below MWL.
Flood fringe	The part of the 1% AEP flood extent outside the floodway.
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.

Term	Meaning in this Manual
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).

Himachal Pradesh terms. The following terms are used in this chapter in addition to those above (see also Annex 7E):

Term	Meaning in this Manual
Tal (ताल)	A lake, pond or tank: "A pond, a lake or tank" in Joshi's dictionary of the Pahari dialects, and "pond, pool, tank, lake (= tālāb)" in Platts (Annex 7E). In Himachal Pradesh the word, and its forms sar and sarovar in names such as Rewalsar, names the small natural lakes of the hills, such as Rewalsar, Renuka, Khajjiar, Prashar and Dal, most of them fed by springs or streamlets in a small catchment; it is used here for any lake, tank or pond. A tal with a controlled outlet is a tank under Clause 7.2: its outlet gate or regulator is its sluice, and its FTL is the level at which it spills over its outlet with any gate closed, found by survey. A tal with an uncontrolled outlet has its FTL at the crest of that outlet.
Recorded tal	A tal, pond, lake, reservoir, spring or wetland shown in the Revenue records or village maps, on a site plan submitted under the TCP Rules 2014 ("Bauri, Well, Nallah, khud"), in the land use map of an Interim Development Plan or Development Plan, in the records of a Municipal Corporation, Nagar Parishad, Nagar Panchayat or Gram Panchayat, in the national wetland atlas or a list of the Himachal Pradesh State Wetlands Authority, or in a list filed before the High Court of Himachal Pradesh or the National Green Tribunal. A recorded tal 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 tal or reservoir	No Himachal Pradesh rule measures a distance from a lake or reservoir. For this Manual, the boundary of a tal under Clauses 7.3.3 and 7.13.1 is the largest of its Revenue record boundary, its surveyed FTL and the outer edge of its water in the monsoon (July to September) shown by dated imagery or survey of recent years; and the boundary of a reservoir is the higher of its full reservoir level and the highest level its operator states, converted from feet at 1 ft = 0.3048 m and stated to the datum of Clause 7.3.5 (for Pong the operator's maximum is reported as 1,400, 1,410 or 1,421 ft, and the highest governs until BBMB confirms the level). The drawdown land of a reservoir below that level, such as the land between 1,280 and 1,390 ft at Pong, is part of the reservoir. This reading is set by this Manual.
Khad; nallah; nali; cho	A khad (खड्ड; "Khud" in the TCP Rules) is a hill torrent or ravine stream, perennial or seasonal: "A small river" in Joshi, where Hindi dictionaries give only a pit. A nallah (नाला; "Nullah" in the TCP Rules) is a natural drain or storm channel, a nali (नाली) a street, roadside or house drain, and a cho a seasonal Siwalik torrent, as the streamlets that feed the Pong reservoir from the south are "locally called choes" (HP State Wetlands Authority) (Annex 7E). Every khad, nallah or cho that drains 8 ha or more is a natural channel under Clause 7.4.1(b), whatever its name, whether it is dry for most of the year, and whether it is lined, piped or covered. A khad or nallah carries boulders, debris and muck in flood: its inlets and culverts take the debris racks, bulking and blockage of Clause 6.3.6, and its top of bank is the edge of its active boulder bed where that is wider than the edge of the 50% AEP flow. This definition is set by this Manual.
Spring (naun, baoli, chashma); khatri; spring recharge area	A spring is a place where groundwater comes out at the surface. A naun (नौण) is a spring-fed tank or water place ("A place for water" in Joshi; a brick-built tank or well in CDIAL), a baoli or bauri (बावड़ी) in the hills a small spring-fed pool or stone tank rather than the stepped well of the plains, and chashma (चश्मा) a spring (Annex 7E). A khatri is a chamber cut by hand into hard rock to collect the water that seeps through it, found in Hamirpur and the neighbouring parts of Mandi and Kangra (as reported; no dictionary source was found). A spring, naun, baoli or khatri is a waterbody for Clause 7.3, and its Zone 1 under Clause 7.4 is measured from its outlet or the edge of its tank or chamber. Its recharge area is the area upslope from which it is fed, as a hydrogeologist maps it; within that area Clause 8.8.1 limits infiltration, no road runoff, sewage or septic effluent is led into the ground, and no drain is cut that would intercept the flow to the spring. No storm drain or sewer is laid within Zone 1 of a spring except a lined drain below its outlet that carries its overflow away. This definition and these rules are set by this Manual.
Kuhl; line of natural drainage	A kuhl (कूहल) is a gravity irrigation channel that takes water from a khad or stream and carries it along the contour to terraced fields; a kuhl in Schedule I or II of the Himachal Pradesh Minor Canals Act, 1976 is a canal under that Act. A kuhl intercepts and carries hill runoff, so it is part of the drainage system: a kuhl that drains 8 ha or more is a natural channel under Clause 7.4.1(b), and no design under this Manual discharges to a kuhl, or crosses it, unless its capacity and its outlet to a stable channel are shown and the managing body and, for a scheduled kuhl, the Collector have consented (ss. 46 and 65). A line of natural drainage, in the words of section 43 of the Act, is for this Manual every khad, nallah, cho and natural channel, recorded or not; the Act's power to regulate its flow and remove obstructions is the statutory hook for recording every khad, nallah and kuhl of a town, with its owner, in the inventory of Clause 7.3.1.

Term	Meaning in this Manual
Sinking and sliding zones	The zones so defined in an Interim Development Plan or Development Plan, in which a geologist's soil investigation report is required before building (TCP Rule 21(1); Shimla Development Plan, §17.2.2.9), and any other mapped landslide or creep zone. No tal, pond, retention basin or infiltration facility is placed in them (Clause 8.8.1).
Glacial or moraine-dammed lake	A lake held by a glacier, moraine or landslide dam, of which the State Centre on Climate Change counted 562 in the Sutlej basin, 242 in the Chenab, 93 in the Beas and 37 in the Ravi in 2019 (as reported), and such as the landslide lake on the Parechu in Tibet whose burst raised the Sutlej by 12 to 15 m on 26 June 2005 (as reported). It is a waterbody for Clause 7.3 and a hazard to be mapped under Chapter 5; it is **never** a design outfall or design storage, and no drain under this Manual discharges to it. This rule is set by this Manual.

7.3 Inventory and mapping of waterbodies

7.3.1 **Statewide inventory.** The Authority, with the Jal Shakti Vibhag 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 (the Municipal Corporation, Nagar Parishad or Nagar Panchayat (for the drains and nallahs within a town, under the Himachal Pradesh Municipal Corporation Act, 1994 and the Himachal Pradesh Municipal Act, 1994, whose drain sections were not read [TBC]), SJPNL (for Shimla's water sources, intakes and sewers), JSV (for flood works and channelised reaches of the rivers and khads, such as the Swan in Una, for water-supply sources and intakes outside Shimla, and for sewerage outside Shimla and Solan), HPPWD or NHAI (for the drains, catch-water drains and culverts of their roads), the Government, a local authority or the beneficiaries, with the Collector (for a kuhl in Schedule I or II of the Himachal Pradesh Minor Canals Act, 1976), BBMB (for the Pong, Bhakra and Pandoh reservoirs), NTPC, SJVN, NHPC, HPSEBL or another dam operator (for its reservoir and the reach below its dam), the Forest Department (for forest land and the wildlife sanctuaries at Pong, Renuka and Chandertal), the State Government through the Deputy Commissioner and the Tehsildar (for land recorded as water in the Revenue records), the Gram Panchayat (for the nauns, baolis, kuhls and tals of a village), HIMUDA, HPSIDC, BBNDA or a colony developer (for the drains of a scheme until they are handed over), the Himachal Pradesh State Wetlands Authority (for a notified wetland), a private owner, 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) Revenue records and village maps of the Revenue Department, in which rivers, khads, nallahs, kuhls, tals, baolis and land covered by water are recorded; the existing water bodies, "like Bauri, Well, Nallah, khud", that the site plan forms of the TCP Rules 2014 require on every application for planning permission; the land use maps, sinking and sliding zones, non-developable land and distances from the highest flood level along rivers, khads and nullahs of each Interim Development Plan or Development Plan, such as the Shimla Development Plan (published on 20 June 2023); the drains and nallahs in the records of a Municipal Corporation, Nagar Parishad or Nagar Panchayat, and SJPNL's records of Shimla's sources and sewers; the kuhls listed by district and tehsil in Schedules I and II of the Himachal Pradesh Minor Canals Act, 1976; the boundaries of the Ramsar sites at Pong, Chandertal and Renuka and of any wetland notified under the Wetlands (Conservation and Management) Rules, 2017, and the wetlands of the national atlas; BBMB's and the other dam operators' records of reservoir levels and acquired land; the spring inventories (about 500 springs inventoried in a standard format, NITI Aayog, 2021); and the lists of encroachment and muck dumping filed before the High Court of Himachal Pradesh and the National Green Tribunal;
- (b) JSV and Gram Panchayat 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 JSV records use a local or older datum, the conversion to the project datum shall be surveyed and stated.

> **Commentary.** Himachal Pradesh maps no flood lines in law. It has no floodplain zoning Act, and no notified flood line, flood hazard map or 1% AEP map of any town's khads or nallahs was found. The post-disaster needs assessment of 2023 found that "the absence of defined river boundaries hampers effective land-use planning" and that "It becomes challenging to establish setback distances and zoning regulations that account for floodplains and their dynamics", and proposed ₹10 crore for floodplain guidelines; whether any mapping followed was not found. The planning law points to the plans: the distance from the highest flood level along rivers, khads and nullahs is "as delineated in the Interim Development Plans / Development Plans" (TCP Rules 2014, Appendices 3 and 7), and the Chopal Development Plan 2041 treats "flood plains and areas adjacent to major drainage lines" as non-developable; the flood lines of the Shimla Development Plan and the other plans were not read for this Manual. The site plan forms ask for contours and for the "Existing water bodies like Bauri, Well, Nallah, khud", but not for a flood line. The rivers are poorly gauged for this purpose. Of the 30 CWC flood sites listed for the State, only the Yamuna at Paonta has a warning level (383.5 m) and a danger level (384.5 m), with a highest flood level of 384.6 m (5 September 1995); the others record a highest flood level only, such as 933 m for the Sutlej at Rampur, set in the Parechu flood of 26 June 2005 (a reading of 924.5 m in 2023 is also reported), and new highest levels were set in July 2023 at Ropa, Gulling, Meenus and Ganguwala; and there is no CWC site on the Beas at Manali, Kullu, Mandi or Pandoh, on the Sutlej at Bilaspur or on the Ravi at Chamba (all as reported by SANDRP; Chapter 5). The levels of the Pong and Bhakra reservoirs are published by BBMB in feet. No source read

for this Manual states the datum of the CWC levels, of the reservoir levels or of the levels on any plan. The best evidence of flood extent in the towns is therefore on the ground: the flood marks and debris lines of July and August 2023 and of 2025, and the old river courses along which, in Kullu, "most of the destruction" followed (needs assessment, 2023). Clause 7.3.4 lets the Authority adopt flood maps once they exist; until then the Applicant must produce the 1% AEP extent for larger and flood-sensitive sites, with the bulking of Clause 6.3.6 on khads and nallahs and the surveyed flood marks of Clause 5.8.5(b), and a highest flood level delineated in a plan 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 reservoir levels converted from feet at 1 ft = 0.3048 m. 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 (wider lines govern under Clause 7.4.5 where they bind: in a planning area the distance from the highest flood level along rivers, khads and nullahs is as the Interim Development Plan or Development Plan delineates; where no plan has been prepared, Appendix-1, clause 16, of the TCP Rules 2014 allows construction at 3.00 m from a nullah and 5.00 m from a khud, which is narrower than this floor and never governs alone; Himachal Pradesh has no floodplain zoning law; this Manual's 15 m applies to every river, khad, nallah, cho, kuhl, spring and tal where nothing wider binds; 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 approval of JSV for a work on or next to one of its flood works, channelised reaches (such as the Swan), intakes or water-supply sources, the consent of SJPNL for a work in the catchment of one of Shimla's water sources, the permission of the managing body and the Collector for a work that crosses, obstructs or discharges to a kuhl in Schedule I or II of the Himachal Pradesh Minor Canals Act, 1976 (ss. 46 and 65), any notification under section 43 of that Act regulating a line of natural drainage, the views or permission of the Himachal Pradesh State Wetlands Authority or the Forest Department for a work in or next to a Ramsar site, a notified wetland or a wildlife sanctuary, the consent of BBMB, NTPC, SJVN, NHPC, HPSEBL or another dam operator for a work that drains to, or lies next to, one of its reservoirs or the reach below its dam, the distance from the highest flood level along rivers, khads and nullahs delineated in an Interim Development Plan or Development Plan, or a direction of the High Court of Himachal Pradesh, the National Green Tribunal or the Supreme Court (such as the High Court's orders against dumping muck in Gobind Sagar and its feeding khads, listed in the Disclosure to Clause 7.4) 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. Himachal Pradesh has distances from water in its planning rules, but they are the narrowest in this series. Where no Interim Development Plan or Development Plan has been prepared, Appendix-1, clause 16, of the TCP Rules 2014 provides that "The construction shall be allowed at distance of 3.00 Metre and 5.00 Metre from Nullah and Khud respectively", without saying from which line the distance is measured; in a planning area the distance from the highest flood level along rivers, khads and nullahs "shall be as delineated" in the plan (Appendices 3 and 7); and the State has no floodplain zoning law and no notified flood line. Wider distances announced in 2025, 5 m from drains and 7 m from rivers and ravines, no government building within 150 m of rivers and nullahs, and a ban on building along the banks of rivers and streams in rural model bye-laws, were seen only in the press, with no gazetted text. The 15 m floor matters along every nallah and khad, where the rule gives 3 m or 5 m and a hill torrent needs room for the boulders and debris it carries and for the machinery that clears them, and along the kuhls, chos, springs and tals that the rules do not name. 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 Himachal Pradesh flood maps are mostly coarser than US maps, the only level land in a Himachal Pradesh town is usually a river terrace, an old river course, a valley floor such as the Balh valley or the Una and Nalagarh valleys, or the margin of a tal or reservoir (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).

Himachal Pradesh's building rules are the Himachal Pradesh Town and Country Planning Rules, 2014, made under the Himachal Pradesh Town and Country Planning Act, 1977. This Manual read them in the Town and Country Planning Department's consolidation to 2022, with the Appendix-1 title of the Fifth Amendment of 2020; the Twelfth to Fifteenth Amendments (2024–2025) and the draft Sixteenth Amendment published for objections in 2025 were not read, though clause 16 of Appendix-1 still stood on the Department's web page in June 2025. Appendix-1 is the general regulation only "in areas where land use is frozen and Interim Development Plan or Development Plan has not been prepared"; in a planning area the plan's own regulations govern. In Appendix-1, development is limited to slopes of 45° (clause 3), a hill cut to 3.50 m with at least 1.00 m between the building and the toe wall (clause 11), and "The construction shall be allowed at distance of 3.00 Metre and 5.00 Metre from Nullah and Khud respectively" (clause 16); no building may stand within 5.00 m of a forest boundary (clause 18); and a new sub-division keeps 5% of its area for soak pits, orients its plots for the "natural flow of surface drainage" and grades its layout at not less than 1 in 15 (clause 20). Appendices 3 and 7 add that "Distance from the Highest Flood Level (HFL) along Rivers, Khuds and Nullahs shall be as delineated in the Interim Development Plans / Development Plans. In other areas, no construction shall be allowed in parcel of land prone to floods." The 5 m line of the Shimla Interim Development Plan of 1979, as amended in 2000, is kept from the boundary of a green belt, not from a nullah. A stone-crusher policy of 29 June 2021 keeps new crushers 100 m from springs and perennial rivulets and 500 m from lakes, wetlands and reservoirs, and prohibits dumping of waste material in a river water source (as quoted by the HPSPCB before the National Green Tribunal). In 2025 the press reported that buildings must now keep "a minimum distance of 5 metres from drains, and 7 metres from rivers and ravines", where the earlier distances had been 3 and 5 metres (26 July 2025), that no government building would be allowed within 150 m of rivers, nullahs and other water bodies (the Chief Minister, 30 July 2025), and that model bye-laws for rural construction banned building along the banks of rivers and streams (16 September 2025); no notification or gazetted text of any of these was found, and they are reported here, not applied. The rules leave gaps. Clause 16 does not say whether its 3 m and 5 m are measured from the water's edge, the top of the bank or the highest flood level; it does not apply in a planning area, where the plan's line governs; kuhls, chos, springs, baolis, nauns and tals are not named; and no line is tied to a flood level except where a plan delineates the highest flood level. Clause 7.4.7 makes 15 m the floor of Zone 1 everywhere.

Disclosure. Himachal Pradesh **has statutory distances from water, but they are narrow and partial**: where no Interim Development Plan or Development Plan has been prepared, Appendix-1, clause 16, of the TCP Rules 2014 allows construction at **3.00 m from a nullah and 5.00 m from a khud**, from an unstated line; in a planning area the **distance from the highest flood level along rivers, khads and nullahs is as the plan delineates**; and the State has **no floodplain zoning law and no notified flood line**. 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 nallahs, where the rule keeps 3 m; along khads, where it keeps 5 m; and along the kuhls, chos, springs, nauns, baolis and tals that it does not name. So are the setback zones of Clause 7.4, the 1% AEP extent that governs Zone 2, this Manual's reading of the boundary of a tal or reservoir, and the rules on springs, kuhls, sinking zones and glacial lakes (definitions after Clause 7.2). They are **this Manual's proposal, not a statutory width or rule**, and no government body has adopted or endorsed them. The setback is applied as **the larger of the corridor**

and any statutory, plan, court or Tribunal line, so the Manual is **stricter than statute** along nallahs, khads, kuhls, springs and tals, and no less strict anywhere. What exists, and governs wherever it is wider or stricter (Clause 7.4.5), is:

- **Appendix-1, clause 16, of the TCP Rules 2014 (consolidation to 2022).** Construction at 3.00 m from a nullah and 5.00 m from a khud, in areas without an Interim Development Plan or Development Plan. Both are narrower than Zone 1's floor and never govern alone; the Applicant states them on Form 7-1.
- **Interim Development Plans and Development Plans (TCP Rules 2014, Appendices 3 and 7).** The distance from the highest flood level along rivers, khads and nullahs as the plan delineates; elsewhere, no construction in a parcel of land prone to floods; and the plan's non-developable land, such as the "flood plains and areas adjacent to major drainage lines" of the Chopal Development Plan 2041. Where a plan's line is wider than Zone 1 it governs as Zone 1; the lines of the Shimla Development Plan (published on 20 June 2023 according to the Supreme Court; 23 June 2023 in the press) were not read [TBC].
- **The announcements of 2025 (reported, not applied).** 5 m from drains and 7 m from rivers and ravines (TCP, as reported on 26 July 2025); no government building within 150 m of rivers, nullahs and other water bodies (the Chief Minister, as reported on 30 July 2025); and a ban on building along the banks of rivers and streams in model bye-laws for rural construction (the Cabinet, as reported on 16 September 2025). No gazetted text was found, and the reports conflict on the distances. Where any of them is notified it governs as a statutory line under Clause 7.4.5; until then this Manual's 15 m is wider than the first and the others are not applied.
- **Wetlands, Ramsar sites and sanctuaries.** The Ramsar sites of Pong Dam Lake (15,662 ha), Chandertal (49 ha) and Renuka (20 ha), to their boundaries; the wildlife sanctuaries around them; and any wetland notified under the Wetlands (Conservation and Management) Rules, 2017 (none was found notified) (Clause 7.12).
- **Kuhls and lines of natural drainage.** The Himachal Pradesh Minor Canals Act, 1976: no obstruction or fouling of a scheduled kuhl (s. 65), crossing works by the beneficiaries (s. 46), and any notification under section 43 regulating a river, creek, natural channel or line of natural drainage.
- **Courts and custodians.** The High Court's orders against dumping muck in Gobind Sagar and its feeding khads and nallahs (*Madan Lal*, CWPIL 31/2023, orders of 22 May 2023 and 31 May 2024); the lines of BBMB and the other dam operators at their reservoirs; JSV's lines at its flood works. The directions of the National Green Tribunal on Shimla of 16 November 2017 were set aside by the Supreme Court on 11 January 2024 and are cited in this Manual as expert guidance only, never as binding.

This Manual sets 15 m as the floor because the rule gives the nallahs, which carry most of the towns' storm water, only 3 m and the khads only 5 m, measured from an unstated line, and gives the kuhls, chos and springs nothing; because 15 m is above the smallest APWA default stream buffer (12 m) from which Table 7.1 is scaled; and because a khad or nallah needs room for the boulders, debris and muck it carries in flood and for the machinery that clears them. The reasons for the corridor are the record: the needs assessment of 2023 found that "Water channels, which should act as natural outlets, are often encroached upon" and that in Kullu the destruction along the Beas followed the old river courses on which building had taken place; the expert committee before the National Green Tribunal found in 2017 that the debris from Shimla's slopes "is dumped in the valley or near water channels, obstructing the natural drainage"; and the HPSPCB levied environmental compensation for illegal dumping of muck and debris in eight of its regions (reply of 20 February 2024 in NGT O.A. 726/2023). Until a statute, rule, notification, development plan or court adopts it, the 15 m minimum is this Manual's recommended standard, and the statutory, plan, court and Tribunal lines above remain the only legal minimum. Approving authorities should state in each approval which was applied.

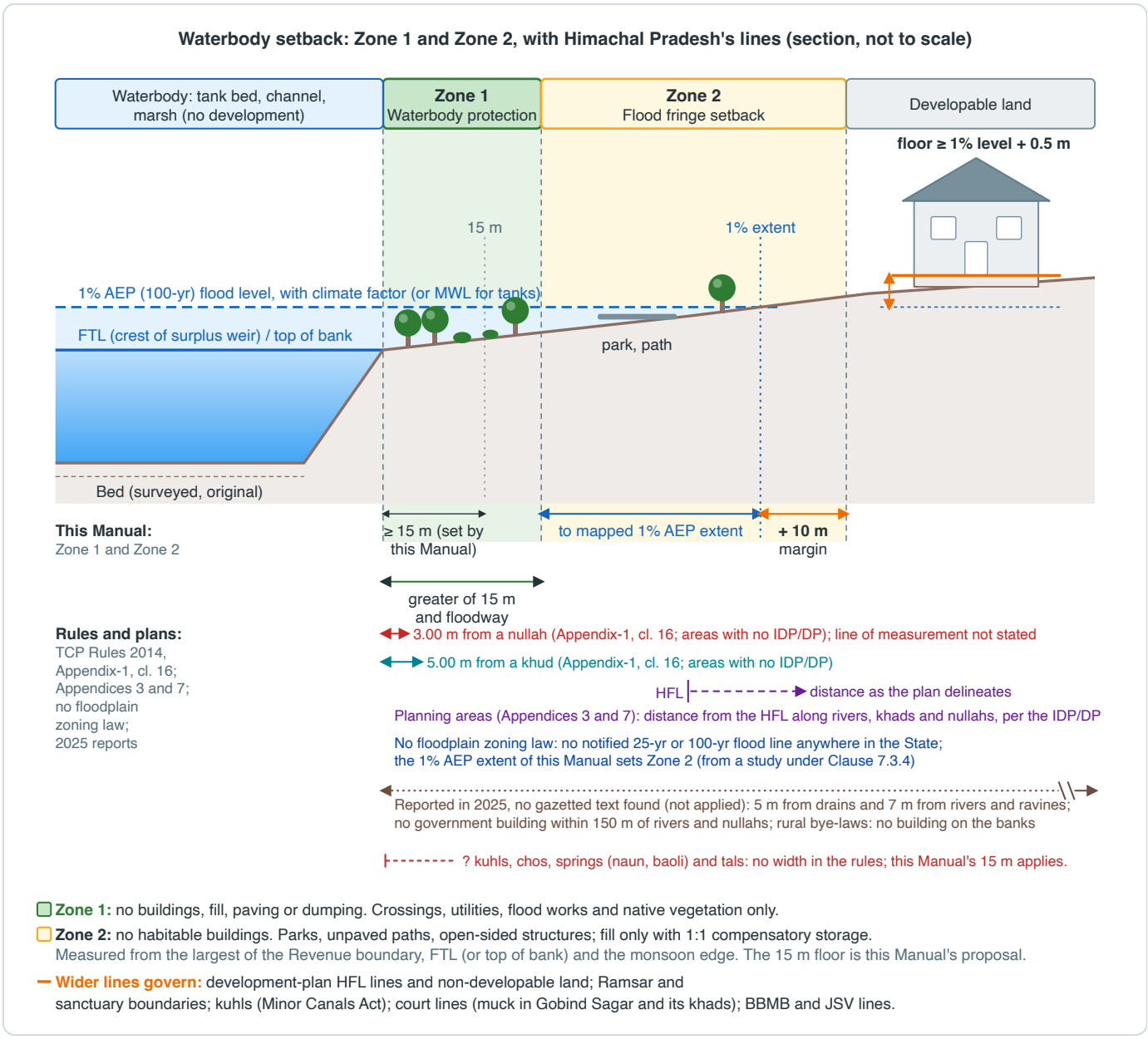

Figure 7.1 — Waterbody setback zones: section through a tank or channel showing FTL, the 1% AEP flood level, the 15 m minimum line, Zone 1 and Zone 2. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 Version 2025.01 and Policy Supplement (MARC, 2025).

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 Himachal Pradesh Town and Country Planning Rules 2014, where the Authority agrees. Zone 1 land shall be handed over to the custodian or kept free of private use, as the Authority decides.

> **Commentary.** The permitted uses follow APWA 2025.01: in Zone 1, only utility and road crossings; in Zone 2, linear utilities, trails and open-sided structures; no clearing, grading, fill or paving in either zone without approval (MARC Supplement, 2025). Clause 7.5.2 adds parks and playgrounds, the uses URDPFI (2015) allows in the 10-year flood zone. The ban on walls in Clauses 7.5.1 and 7.5.3 responds to hill-town 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 valley floors of Una, Nalagarh, Paonta and the Balh valley, the terraces of the Beas at Kullu and Mandi, and the old river courses on which the post-disaster needs assessment of 2023 found building in Kullu, are flat, so a small rise in level spreads flooding over a wide area, and many small encroachments along the same channel add up.
>
> In Himachal Pradesh no building rule measures a distance from a lake or reservoir at all, so the line from which a setback is measured must come from this Manual. The difference matters most at the reservoirs, whose levels swing widely through the year: the water spread of the Pong reservoir is about 125 km² at its minimum level of 1,280 ft and about 220 km² at its maximum of 1,390 ft, so that about 80 km² is a drawdown zone exposed in the dry months (HP State Wetlands Authority), and a line drawn from the edge of the water in May would leave the reservoir's own bed open to building. The natural tals shrink in another way: at Khajjiar, heavy siltation and the deposition of peat have made the water body too shallow, and vegetation has reclaimed some of the old open water (HP State Wetlands Authority), so a line drawn from today's edge would give up the lake's lost area for good. This Manual gives every tal and reservoir a boundary measured from a high level, not from the water's edge on the day of survey: the monsoon edge of a tal and the operator's highest level of a reservoir are part of its boundary (definitions after Clause 7.2), and the foreshore up to MWL is its flood storage. 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 the Beas valley in Kullu and Manali, where the post-disaster needs assessment of 2023 found that most of the destruction along the river followed old river courses on which building had taken place, of Mandi along the Beas, of Una along the Swan, of Baddi and Nalagarh along the Balad and the Sirsa, and of Rampur Bushahr along the Sutlej 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.

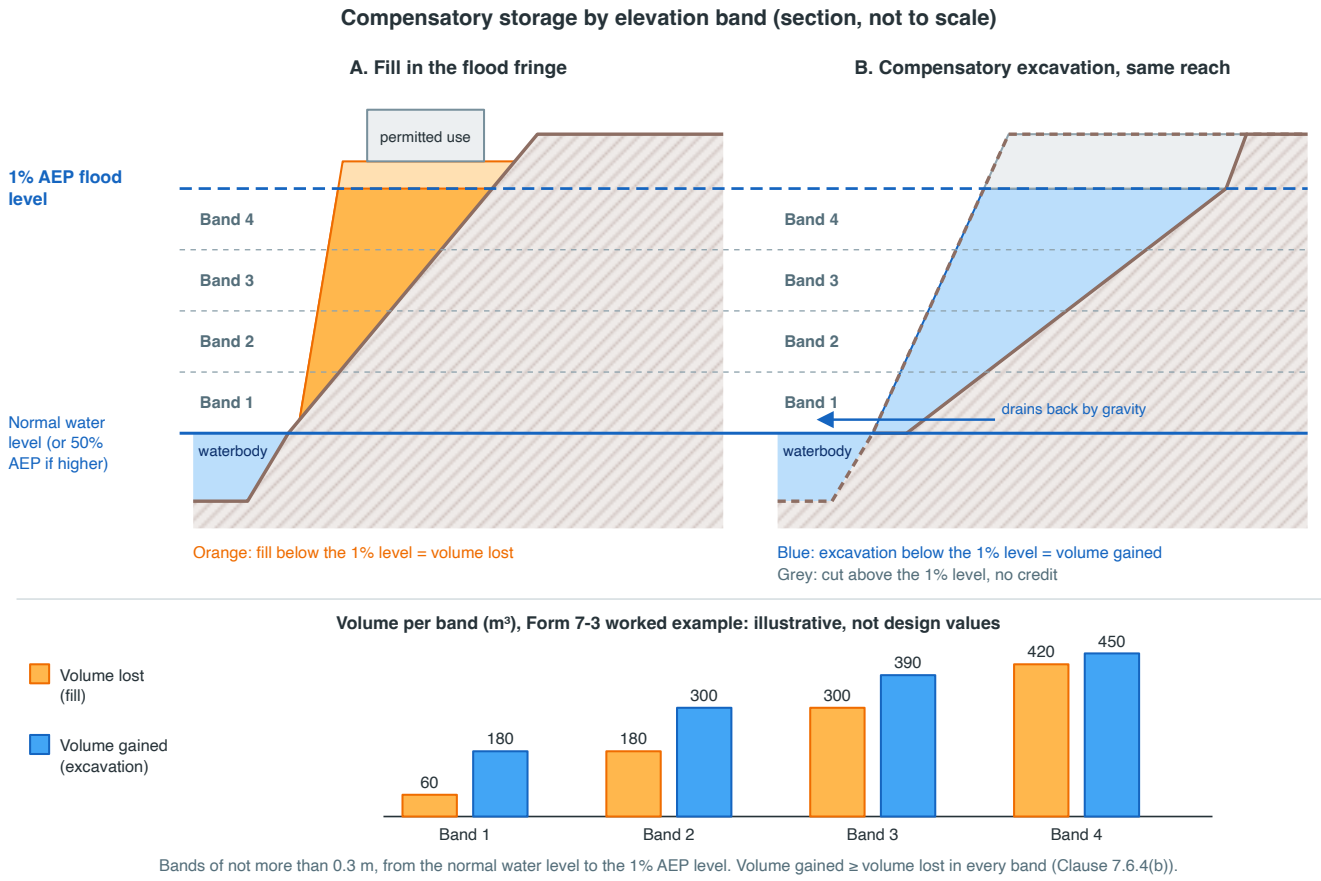

Figure 7.2 — Compensatory storage by elevation band: section through the flood fringe showing fill placed below the 1% AEP flood level and an equal or greater volume excavated within each band of not more than 0.3 m, from the normal water level (or 50% AEP level) up to the 1% AEP level, with the excavation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

Himachal Pradesh has no tank Act, and its storages range from nauns a few metres across to the Pong reservoir, whose water spread grows from about 125 km² at 1,280 ft to about 220 km² at 1,390 ft (HP State Wetlands Authority). The storages that matter for urban drainage are of five kinds. The first is the natural tal: Rewalsar in Mandi district, at about 1,360 m, covers 2.6 ha in a catchment of 173 ha, with a shoreline of about 735 m, and its main source of water is its own springs; Renuka in Sirmaur, of about 20 ha and "the largest natural lake in Himachal", is fed by 21 seasonal streams; and Khajjiar in Chamba district is a water body of about 4,500 m² in a catchment of 6 km², fed by streamlets carrying rain and snowmelt (all HP State Wetlands Authority); Prashar and Dal are smaller lakes for which no data were read. Their outlets are uncontrolled or unrecorded [TBC], so their storage is modelled as an existing feature and not counted unless Clause 7.7.1 is met. The second is the reservoirs and barrage ponds, which are the State's largest waterbodies: the Pong reservoir (full reservoir level 1,390 ft, about 423.67 m) and Gobind Sagar behind Bhakra (full reservoir level 1,680 ft, about 512.06 m), both held by BBMB with their levels in feet, BBMB's Pandoh, NTPC's Kol, NHPC's Chamera and HPSEBL's Larji (as reported); their releases enter a design as inflow and tailwater (Clauses 5.8.3

and 5.8.5(c)), and they are not tanks for these clauses unless their storage is counted. The third is the kuhls and the small village ponds, which are modelled as existing features where they intercept runoff but are never counted as storage, because they are not surveyed, have no controlled outlet and are usually full by the time of the peak storm. The fourth is the springs, nauns, baolis and khatris, which are protected for their water and never counted as storage. The fifth is the glacial and moraine-dammed lakes of the high mountains, which are hazards (definitions after Clause 7.2). These are the waterbodies for which Figure 7.3 and Clause 7.8 matter: in a hill town every nallah ends in a khad and every khad in a river or reservoir, and a spring-fed tal receives the drains of the slopes around it. Any tal or reservoir whose storage is to be counted is subject to Clause 7.7.1 in full, with BBMB, JSV or other custodian, and the custodian of each tal 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.** JSV, or the other custodian, concurs in writing.

Storage in a tank that fails any of (a) to (e) shall not be counted, though the tank shall still be modelled as an existing feature (Chapter 3).

7.7.2 **Modelling.** Tank cascades shall be modelled under Clause 3.12.5 (level-pool routing of each tank, with surplus weir and sluice ratings) and Clause 3.13 (continuous simulation). The whole cascade, from the uppermost tank whose surplus can reach the site or facility to the next river, major drain or sea outfall, shall be modelled together, including, for a hill town, every nallah that falls from the ridge and its slopes to the khad below, every kuhl that the town's drains cross or reach, any spring-fed tal with its inlets and outlet, and the khad itself down to its confluence with the river, whose level sets the tailwater of the nallahs (Clause 5.8.5(b)), 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 JSV'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. Himachal Pradesh's reservoirs have been at or near their full levels in the worst storms. In August 2023 the Pong reservoir rose from 1,374.20 ft to 1,399.65 ft (about 426.61 m) between 11 and 15 August, above its full reservoir level of 1,390 ft, and the outflow, about 18,000 cusecs until 14 August, was then raised to 1.40 to 1.50 lakh cusecs (about 3,960 to 4,250 m³/s); in 2025 Pong peaked at 1,394.71 ft (about 425.11 m) on 5 September and Gobind Sagar at 1,679 ft (about 511.76 m) on 4 September; and on 30 June 2025 all five gates of the Pandoh barrage were reported opened, releasing nearly 44,000 cusecs (all as reported). The natural tals are spring-fed and full through the monsoon, and no record of how long Rewalsar, Renuka or Khajjiar stay at or above their outlet level in a wet spell was obtained for this Manual. The monsoon has also withdrawn later than its normal date of 25 September in eight of the nine years from 2018 to 2026, and storms of western disturbances follow it, as on 5 to 7 October 2025 (IMD), so a late storm finds the reservoirs high. While a tal or reservoir is full, it stores nothing more below FTL, the khads and nallahs that flow into it discharge against its level, and its release adds to the flow in the river below it. A tank cascade passes floods from one tank to the next, so a design that counts storage in one tank and ignores the surplus arriving from the tank above it will overstate the benefit. That is why Clause 7.7.2 requires the whole cascade to be modelled.

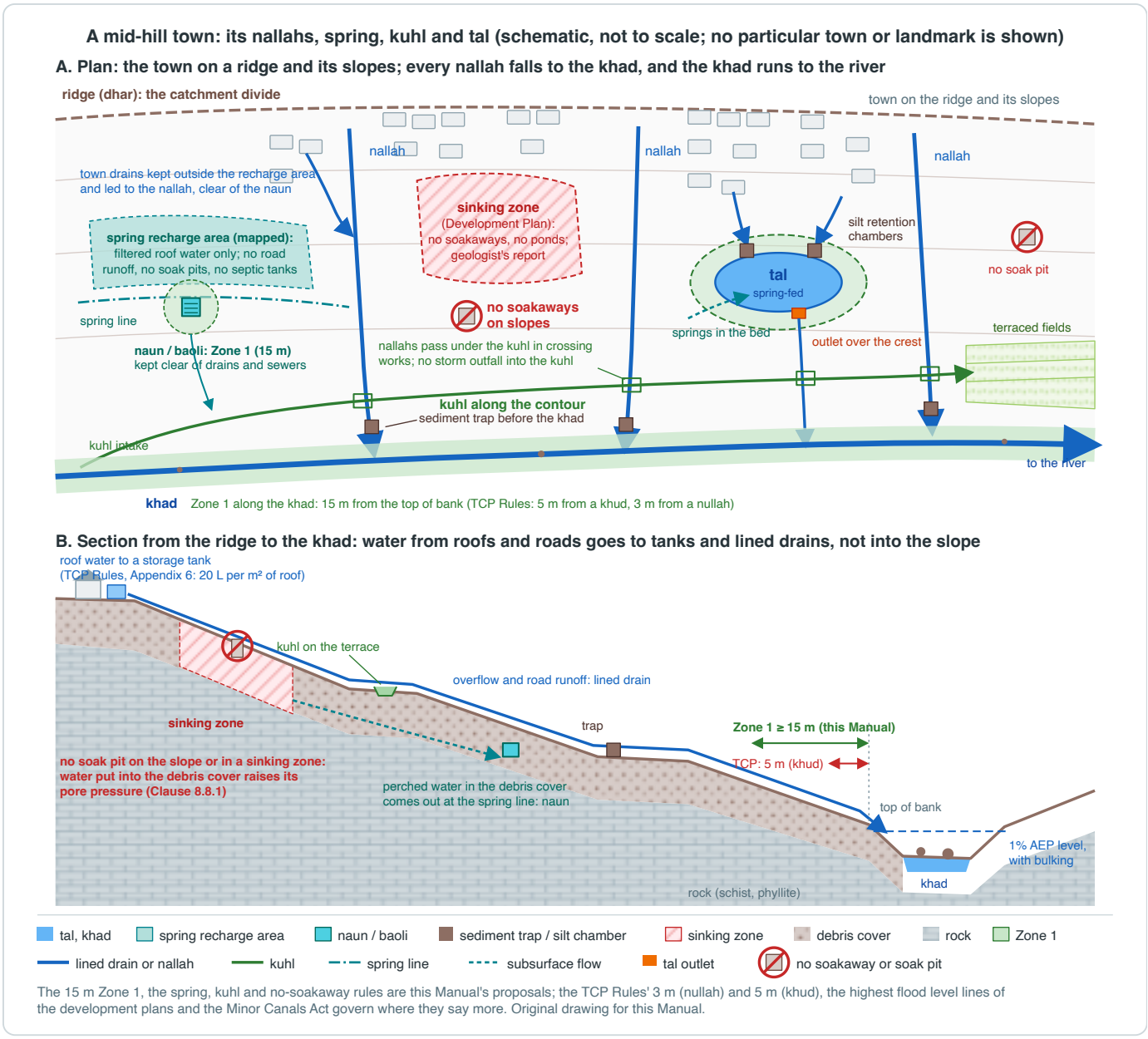

Figure 7.3 — A mid-hill town: its nallahs, spring, kuhl and tal (schematic, not to scale; no particular town, lake or landmark is shown). A: in plan, the town stands on a ridge, the catchment divide, and on the slopes below it, so every drain of the town ends in a nallah and every nallah in the khad at the foot of the slope, which runs to the river and whose level is the nallahs' tailwater (Clause 5.8.5(b)). The nallahs are lined where they pass through the built-up area and each passes a sediment trap before it reaches the khad, because a hill drain carries more silt, gravel and muck than any other load (Clauses 6.3.6 and 8.12). A naun or baoli takes water at the spring line; its Zone 1 (15 m) is kept clear of drains and sewers, and its recharge area upslope, as a hydrogeologist maps it, receives only filtered roof water, with no road runoff, soak pits or septic tanks (Clause 8.8.1). A kuhl leaves the khad upstream and runs along the contour to the terraced fields; the nallahs pass under it in crossing works, and no storm drain discharges into it (definitions after Clause 7.2; Himachal Pradesh Minor Canals Act, 1976, ss. 46 and 65). A small spring-fed tal on a bench receives drains from the slope above only through silt retention chambers, and spills over its outlet crest to the khad. A sinking zone of the Development Plan takes no soakaway and no pond, and no soakaway is placed anywhere on the slopes. Zone 1 along the khad is 15 m from the top of its bank, wider than the 5 m from a khud and 3 m from a nullah of the TCP Rules. B: in section, roof water goes to the storage tank of Appendix 6 of the TCP Rules 2014 (20 L per m² of roof), and its overflow and the road runoff go by a lined drain through a trap to the khad, because water put into the debris cover raises its pore pressure; the spring comes out where perched water in the debris cover meets the rock; the kuhl runs on a terrace; and the khad's 1% AEP level, found with bulking, sets the flood edge from which Zone 2 is measured. The 15 m minimum

and the spring, kuhl and no-soakaway rules are this Manual's proposals; the TCP Rules, the highest flood level lines of the development plans, the Minor Canals Act 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, HPSDMA 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 SW 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 SW 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 SW 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 JSV control, the operating rule shall be JSV's rule. This Manual does not authorise any other body to operate a JSV tank.

> **Commentary.** No tal in Himachal Pradesh was found with a written operating rule, and the natural tals have no gates to operate. The reservoirs are run by their operators to their own rules, which were not read for this Manual. BBMB's full reservoir level for Pong is 1,390 ft (about 423.67 m), but its maximum level is reported as 1,400 ft (about 426.72 m), 1,410 ft (about 429.77 m) and, as a "technical" limit, 1,421 ft (about 433.12 m), and Gobind Sagar's full reservoir level is 1,680 ft (about 512.06 m), with an earlier technical limit of 1,690 ft (about 515.11 m) (all as reported, converted at 1 ft = 0.3048 m). In August 2023 BBMB's Chief Engineer was reported as saying that releases from Pong had never exceeded 1.49 lakh cusecs and that the Beas below could carry 2 lakh cusecs, while a civil-society review alleged that the reservoir had been filled early and released late (an allegation, not a finding); in 2014 a release from the Larji project on the Beas was followed by the deaths of 14 students downstream (as reported); and the needs assessment of 2023 proposed ₹20 crore for a forecast-based dam management system. Without an agreed rule with dates, levels, release rates and a named operator, storage in a tal or reservoir cannot be relied on, and a release made without warning to the towns 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

usually refilled by the early monsoon rain gives no protection in a July or August monsoon burst or cloudburst, often with a western disturbance, as in July and August 2023. The 90% reliability in Clause 7.8.2(c) has no direct precedent and is set by this Manual.

For a natural tal, Clause 7.8.3 is the governing condition: with no controllable outlet, no cushion is assumed, a design that relies on the tal routes the storm through it from its outlet level, and the outflow over the outlet is limited by the khad or nallah below it, which shall be shown to carry it with the debris of Clause 6.3.6. For a reservoir, a design takes the operator's level and release for the storm being checked (Clause 5.8.3), not a drawdown the operator has not agreed to in writing. Most tals have other users: they are sacred places and the centres of their towns' trade, which is why Clause 7.8.2(d) requires the custodian to accept any drawdown.

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 Himachal Pradesh State Pollution Control Board (HPSPCB) 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 May** each year (Chapter 10).

Commentary. No statewide order fixing a date for the pre-monsoon cleaning of drains, nallahs or tals was found; the State's recurring pre-monsoon directions call for "pre-monsoon de-siltation, clearing of water channels, removal of blockages and encroachments from drainage systems and flood plains" without a date (as reported). In the hills the material to be removed is less silt than boulders, debris and muck: Gobind Sagar's storage fell from 9,868 MCM in 1958 to 7,769 MCM in the survey of 2012, with the loss of gross capacity put at 38% by one study and 47% by BBMB (as reported); the State's tals are silting from their catchments, and the works at Rewalsar and Renuka include silt retention chambers, check dams and the cleaning of drains (HP State Wetlands Authority); and the needs assessment of 2023 asked for all natural drains and streams "blocked with dumped spoil" to be cleared. The date of 31 May in this Manual is set by this Manual, before the monsoon's normal onset of 25 June and ahead of the earliest recorded onset, on 9 June 2000 (IMD); because the monsoon now withdraws in October in most years and storms of western disturbances follow it, hill towns also clear debris a second time by 31 October (Chapter 10). Excavation to "increase capacity" is governed by Clause 7.9.3. In a spring-fed tal, such as Rewalsar, whose main source of water is its own springs, deepening can cut the springs off or the silt and clay that hold the water, and this Manual allows no spring-fed tal to be deepened below its original bed or its bed to be lined or cemented. The 31 May 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 Himachal Pradesh precedent.

7.10 Supply channels, surplus courses, inlets and outlets

7.10.1 **Part of the major system.** Supply channels and surplus courses are part of the major drainage system (Chapter 6). They shall be protected as waterbodies, with Zone 1 and Zone 2 setbacks under Clause 7.4.

7.10.2 **No closure or covering.** No supply channel or surplus course shall be closed, filled, diverted, covered, culverted along its length, or converted into a road or a closed drain, except under a design approved by the custodian that keeps or increases its 1% AEP capacity and its access for maintenance.

7.10.3 **Crossings.** Every road, rail, utility or access crossing of a waterbody, supply channel or surplus course shall:

- (a) pass the 1% AEP flow (with the climate factor), or the surplus of the upstream tank at its MWL, whichever is greater, with the freeboard required by Chapter 9;
- (b) not reduce the waterway width at the crossing below the full channel width as recorded in Revenue records or as surveyed, whichever is greater;
- (c) keep the channel bed level and grade; and
- (d) not raise the 1% AEP water level by more than the limit in Clause 7.6.2.

7.10.4 **Capacity.** The design capacity of a surplus course shall be the greater of the surplus weir discharge at MWL and the 1% AEP flow from its own catchment, combined as the cascade model (Clause 7.7.2) shows.

7.10.5 **Protection at structures.** Outlets of surplus weirs and sluices, and drain outfalls into waterbodies, shall have energy dissipation and scour protection designed under Chapter 9, so that the flow leaving them does not erode the bund, the bank or the channel bed.

7.10.6 **Drain outfalls into waterbodies.** A storm drain outfall into a tank, channel or wetland shall:

- (a) have its invert at or above the normal water level of the receiving waterbody, unless the drain is designed for submerged outfall under Chapter 5;
- (b) be located and aligned so that it does not cut through or weaken a tank bund;

- (c) have a gross pollutant trap and first-flush treatment (Chapter 8); and
- (d) not carry sewage or dry-weather flow (Chapter 8).

> Commentary. This Manual protects supply channels and surplus courses as part of the major system. In urban areas they are often the first to be lost. Surplus courses are narrowed by culverts and compound walls, and supply channels are covered and turned into roads, which cuts the tank off from its source or leaves its surplus with nowhere to go. In Himachal Pradesh the drains and nallahs of a town are understood to vest in its Municipal Corporation, Nagar Parishad or Nagar Panchayat, under Municipal Acts whose drain sections were not read for this Manual [TBC], while the khads and rivers lie with JSV for flood works, the road drains with HPPWD and NHAI, and the kuhls with their managing bodies under the Minor Canals Act. No rule or order dividing natural khads and nallahs from municipal drains, or the local bodies' drains from the road drains, was found; Chapter 6 gives this Manual's working assignment. The building rules know the nallah and the khad, but give them only 3 m and 5 m (TCP Rules 2014, Appendix-1, clause 16), and the kuhl and the cho not at all. The record of Shimla shows a network that is old, partial and undersized, and is being concentrated: a municipal and UNDP plan of 2015 counted 13 major nallahs and about 67 drains of 42.33 km, while 191 drains and nallahs of 55.43 km are reported built under AMRUT (the counts conflict); the expert committee before the National Green Tribunal found in 2017 that storm drainage covered about 30% of the city, that the "Carrying capacity of these drains is not sufficient", that their catchments were "improperly selected" and that "drains are constructed for longer distances with much lesser gradients than actually required", so that they were "not able to carry the peak flow"; and the committee on the slides of August 2023 named "Open Drainage systems leading to poor disposal of surface water" among their causes. Elsewhere the response to floods has been to confine the rivers and khads: the Swan in Una was channelised with 16.67 km of embankments in its first phase (NITI Aayog, 2020), and a channelisation of the Beas was prepared in 2021, which the needs assessment of 2023 said "predominantly require[s] concretisation, which is not advisable in Himalayan Ecology", and which the State later told the National Green Tribunal it had recommended dropping "as the channelization may affect the cross drainage and hamper the natural drainage system". The Minor Canals Act gives the Government power to order the removal of an obstruction in any line of natural drainage (s. 43); the TCP rule keeps a building off the first 3 m of a nallah; neither keeps a nallah, khad or kuhl at its recorded width once it has been lined, piped, covered or filled with muck, 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 tal 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 Himachal Pradesh no shared form of storage is required by the building rules: the rainwater harvesting of Appendix 6 of the TCP Rules 2014 is plot-level storage of 20 litres per m² of roof, to be built underground in the parks and open spaces of colonies and IT parks, and the rules have no detention, peak-flow or "zero runoff" rule; the 5% of a new sub-division kept for soak pits (Appendix-1, clause 20(4)) is for wastewater, not storm storage. The plans for Shimla's drains are for conveyance: the draft City Development Plan 2041 of the Municipal Corporation proposes new drains and the rejuvenation of nallahs, with no storage standard (as read), and the storm-water drainage proposed for Una is a drainage work (JSV, ₹19.66 crore). In the hill towns there is little flat land on which a regional pond could be built, and none may be built on a slope where Clause 8.8.1 bars infiltration; a regional facility there is a lined tank or a lined detention structure, not a pond. 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 Himachal Pradesh State Wetlands Authority;
- (b) the State's three Ramsar sites, Pong Dam Lake in Kangra district (Site No. 1211; 15,662 ha; designated on 19 August 2002), Chandertal in Lahaul and Spiti (Site No. 1569; 49 ha; 8 November 2005) and Renuka in Sirmaur (Site No. 1571; 20 ha; 8 November 2005), to their Ramsar boundaries, with the wildlife sanctuaries around them, and any wetland notified under the 2017 Rules;
- (c) Rewalsar and Khajjiar, covered by the national wetland conservation programme, the wetlands of the national atlas larger than 2.25 ha, the drawdown zone of the Pong reservoir between its minimum and maximum levels, and the spring-fed tals, marshy glades and seeps of the hills, within the 1% AEP extent of Clause 7.3.4 (a river or reservoir itself is a waterbody under the rest of this chapter); and
- (d) any other tal, marsh or wetland that the Authority notifies, that the wetland authority lists, or that the High Court of Himachal Pradesh, 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. Himachal Pradesh's wetlands are the concern of the **Himachal Pradesh State Wetlands Authority**, constituted under rule 5(1) of the Wetlands (Conservation and Management) Rules, 2017 by notification No. STE-E(3)-10/2017-Pt-I of 7 November 2017 of the Department of Environment, Science and Technology, chaired by the Minister in charge of that Department, with the Chief Secretary as Vice-Chair, the Secretaries of Urban Development and of Irrigation and Public Health (now JSV) among its members, an expert in hydrology among its non-official members, and HIMCOSTE as Member Secretary, nodal department and secretariat; a State Level Steering Committee on Wetlands under the Chief Secretary, continued in 2017, approves the action plans for the Ramsar sites and for Rewalsar and Khajjiar. The State has three Ramsar sites: **Pong Dam Lake** in Kangra district (Site No. 1211; 15,662 ha; designated on 19 August 2002), **Chandertal** in Lahaul and Spiti (Site No. 1569; 49 ha; 8 November 2005) and **Renuka** in Sirmaur (Site No. 1571; 20 ha; 8 November 2005) (Ministry of Environment, Forest and Climate Change, list of 31 January 2024; Ramsar Sites Information Service); the Authority's booklet gives larger areas, which are those of the sanctuaries and the reservoir, and this Manual uses the Ramsar figures. Rewalsar in Mandi and Khajjiar in Chamba are covered by the national wetland conservation programme. No wetland notified under rule 4 of the 2017 Rules was found, and no count of the State's wetlands in the national atlas was obtained; the Union Ministry has said that the wetlands of the national atlas larger than 2.25 ha are protected under rule 4 whether or not they are notified (office memorandum of 8 March 2022, as quoted). The wetlands that matter to drainage are the small tals in town catchments, which are silting and receiving sewage (Clause 8.9, Commentary): Rewalsar, whose "Sewage drains constructed around the lake are not functioning properly and leaking at many points which are causing eutrophication", and Khajjiar, where "Heavy siltation and deposition of peat has made the water-body too shallow" (HP State Wetlands Authority); and the drawdown zone of the Pong reservoir, whose southern streamlets, the choes, are checked by check dams and walls in the catchment "to reduce the silt load". A drain outfall, desilting, diversion or gate operation in or near a Ramsar site, a notified wetland or a wildlife sanctuary therefore needs the views or permission of the Wetlands Authority or the Forest Department where the Rules or the Wildlife (Protection) Act, 1972 reach it, as well as compliance with this chapter; for the tals, springs and marshy glades they do not reach, this chapter and the planning rules 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 Himachal Pradesh's tals, khads and rivers through the drains (Clause 8.9, Commentary). The CPCB placed the Ashwani Khad, the Bald, the Sirsa and the Sukhna in Priority I in 2022; it found in 2024 that the treatment plants in the catchment of the Ashwani Khad were discharging "into Nalla leading to Ashwani Khad" without a valid consent, and that BBMB's treatment plant at Pandoh was not operating (interim report of 6 May 2024 in NGT O.A. 735/2023); and the leaking sewers round Rewalsar are eutrophying the lake (HP State Wetlands Authority). Clauses 7.10.6(d) and 7.12.3 therefore cannot yet be met by many existing outfalls. In Himachal Pradesh they apply in full to every new outfall, and every existing outfall to a tal, khad, wetland, reservoir or river that carries dry-weather flow comes under the annual survey and the interception of Clauses 8.9.4 and 8.9.5 until its sources are removed. In a tal catchment, every drain that enters the tal also passes a silt retention chamber or sediment trap first (Figure 7.3), as the works at Rewalsar and Renuka already provide, because the tal is the end of the slope's drainage and has no other way to lose the 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. Himachal Pradesh's main controls on building and dumping in its khads, rivers and reservoirs are the planning rules and the courts, and the courts have done most of the work on dumping. In *Madan Lal v. State of Himachal Pradesh* (CWPIL 31/2023) the High Court barred, on 22 May 2023, the dumping of muck "in Govind Sagar Lake and its feeding khuds/nallahas", asked the State on 20 July 2023 what it was doing to stop people dumping muck "on the banks of river or in the valleys", and on 31 May 2024 directed penal action against those who had dumped muck in the lake "or its tributaries/rivulets/khuds or on other forest or public lands" and steps "to clear the muck from the shores of Govind Sagar Lake, its tributaries, forest and all public lands", recording that the figures given for the four-laning of the national highway (6,41,256 m³ of muck, of which 4,08,010 m³ were said to be used and 2,34,080 m³ dumped on private land) were contradicted by the record. In *Fourlane Visthapit and Prabhavit Samiti v. State* (CWP 5243/2022, order of 26 June 2023) the High Court, faced with a payment of ₹8,45,700 for muck dumped in a forest, remarked that it was made "as if the payment of the said money will automatically dissolve the muck and make it disappear in thin air", and asked the Union Ministry how NHAI would stop muck dumping "near water bodies". The HPSPCB has levied environmental compensation for illegal dumping of muck and debris in eight regions, from ₹1,00,000 in Chamba to ₹77,90,000 in Shimla (reply of 20 February 2024 in NGT O.A. 726/2023). On building in flood land, the needs assessment of 2023 found construction "on unstable slopes or floodplains", channels "often encroached upon" and, in Kullu, building along the old river courses of the Beas, and asked for no-building zones along riverbanks. The National Green Tribunal's directions on Shimla of 16 November 2017, which barred new construction in the core and green areas, were set aside by the Supreme Court on 11 January 2024 (*State of Himachal Pradesh v. Yogendera Mohan Sengupta*, 2024 INSC 30), which let the State implement the Shimla Development Plan "subject to what has been observed" and gave the plan no "imprimatur"; and the Supreme Court has since taken up the ecology of the State on its own motion (W.P.(C) 758/2025), referring Shimla's green belts and construction to its Central Empowered Committee, whose first report was reported in October 2026 (all as reported; the orders were not read). A petition on hill cutting and haphazard construction was reported pending before the High Court (CWPIL 13/2021). 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 SW monsoon (by 31 May) 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. The natural tals of Himachal Pradesh are not held by bunds, and village ponds and kuhls are too low to be specified dams, but each outlet work or bund shall be screened under Clause 7.14.1. The dams of the State's reservoirs are specified dams under the Act: among them Kol, 153 m high above the river bed and 167 m above its foundation, Pandoh, 76 m, Karcham Wangtoo, 98 m, and Chamera I, 226 m, as well as Bhakra and Pong (as reported); the needs assessment of 2023 counts 135 dams in the State, and a list of dams that the Chief Secretary was reported to have found in breach of dam-safety norms was not obtained. Where the storage of a tal or reservoir is counted under Clause 7.7, its bund, outlet works or dam is a tank bund for Clause 7.14.2 unless the Act applies. A glacial or moraine-dammed lake is never counted

as storage, but where it lies upstream of a town, its breach path is mapped as a hazard (definitions after Clause 7.2; Chapter 5). 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 Himachal Pradesh the embankments and lakes that matter to the towns are the dams of the hydroelectric and storage projects and the natural dams of the high mountains. On 26 June 2005 a landslide lake on the Parechu in Tibet burst and the Sutlej rose by 12 to 15 m, with a flow of about 2,000 m³/s, and about 5,000 people were evacuated along the river; on 1 August 2000 a flash flood on the Sutlej in Kinnaur and Rampur carried away more than 100 people and over 25 bridges (both as reported; no official account was found). After a cloudburst on 24 July 2023 the reservoir of the Malana II project was reported "filled with debris and silts causing its overspill", with its gates jammed, and the "Bursting of Malana Dam" was listed by IMD among the events of 31 July 2024; releases from Pandoh were blamed by residents for flooding downstream in July 2023, and a civil-society review listed faulty operations at Larji and other projects that year (all as reported). No breach map or emergency action plan for a tal, barrage or reservoir was read for this Manual, and no State plan for urban floods was read. A failed or overtopped bund floods the town below it, a burst lake sends a flood and debris down a khad faster than any warning, and an unannounced release floods the town too, which is why Clause 7.14.3 asks for breach mapping and an emergency action plan for high-hazard embankments. The hazard classes, the breach analysis and the emergency action plan for high-hazard tanks are set by this Manual. They extend the Chapter 4 requirement for detention basins (1% AEP spillway with outlet blocked, 0.2% AEP for high-hazard basins) to tanks that are counted as design storage.

7.15 Submittal requirements

Every drainage report for a development or work under Clause 7.1.2 shall include:

1. the **Waterbody Sheet (Form 7-1)** under Clause 7.3.2, with the setback zones and their basis (mapped extent, hydraulic study or fixed width);
2. the hydraulic study of the 1% AEP extent and floodway, where Clause 7.3.4 requires it;
3. the **Compensatory Storage Calculation (Form 7-3)**, by elevation band, where fill is proposed in the flood fringe;
4. for any tank storage counted: the **Tank Storage Credit Sheet (Form 7-2)**, with the survey, stage–storage curve, operating rule, cascade model results and custodian concurrence of Clause 7.7.1;
5. for any crossing, outfall or work in Zone 1: the custodian's NOC and the hydraulic analysis of Clause 7.6.2 or 7.10.3;
6. for restoration or desilting: the pre-works survey, silt tests and hydrogeological report of Clause 7.9; and
7. for any embankment: the Dam Safety Act screening and hazard class of Clause 7.14.

7.16 Review and update

7.16.1 This chapter shall be reviewed with the rest of the Manual (Chapter 1). The fixed-width table of Clause 7.4.6 shall also be reviewed within 2 years of the Authority adopting 1% AEP flood maps for its area.

7.16.2 Where the Authority adopts new 1% AEP flood maps, they apply to new submittals **6 months** after adoption, unless the Authority notifies otherwise.

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Annexes and forms

Annex / Form	Content
7A	Statewide waterbody GIS layer and inventory fields
7B	Fixed-width setback table (alternative S-3, with Annex 1C)
7C	Template tank operating rule, with flood cushion
7D	Desilting and restoration specification
7E	Glossary of Hindi and Pahari 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 SW 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 Himachal Pradesh towns	Primary control
Gross pollutants (plastics, litter, vegetation)	Streets, markets, open dumping in drains	Source collection; GPTs and screens (Clause 8.10)

Pollutant	Main sources in Himachal Pradesh towns	Primary control
Suspended sediment	Construction sites, unpaved roads and verges, road wear, drain silt	Erosion and sediment control (Clause 8.12); pretreatment; filtration
Oil, grease and fuel	Roads, parking, fuel stations, workshops, bus depots	Oil-grit separators at hotspots; bioretention
Pathogens and organic load (BOD)	Sewage and sullage cross-connections, animal waste	Exclusion and DWF interception (Clause 8.9)
Nutrients (N, P)	Sewage, fertiliser, food waste, detergents	Exclusion; bioretention; wetlands
Heavy metals	Roads, roofs, industrial yards	Filtration; sedimentation

> **Commentary.** Gross pollutants and sewage come first in Clause 8.3 because they dominate the pollution of urban waterbodies in Himachal Pradesh, and because no treatment BMP works for long if they are not removed. CPHEEO (2019) notes that Indian drains carry night soil, urine and food waste (Part A §9.5). In its WSUD procedure it lists TSS, total nitrogen, total phosphorus and gross pollutants as the key pollutants (Part A Ch. 10). AMRUT 2.0 funds the harvesting of rainwater "through storm water drains into water body (which is not receiving sewage/effluent)" (Lok Sabha unstarred question AU1419), which only works if sewage is first kept out of the drains.

8.4 Water quality volume and design flow

8.4.1 **Water quality rainfall depth.** The water quality rainfall depth is:

> $P_{wq} = \max(P_{ret}, P_{3m})$

where:

- P_{ret} = the retention depth for the site's zone (Annex 2E, Clause 2.10), mm; and
- P_{3m} = the 24-hour 3-month ARI depth for the site's zone (Annex 8A), mm.

8.4.2 **Water quality volume.** The WQv shall be computed as:

> $WQv = (P_{wq} / 1000) \times Rv \times A$

where:

- WQv is in m³;
- A = the contributing area, m²;
- $Rv = 0.05 + 0.009 \cdot I$; and
- I = the impervious percentage of the contributing area (0–100), after the connectivity rules of Clause 3.9.

The Rv form above may be used only for sites under 0.5 ha and under the Tier B simplified method (Clause 4.14). This is the same limit as for the retention volume (Clause 4.4.2). For all other sites the WQv shall be computed with the SCS-CN method, as the retention volume is: WQv (m³) = 10 × Q_{wq} × A, where Q_{wq} (mm) is the SCS-CN runoff from P_{wq} for each sub-area and A is in ha.

8.4.3 **Climate factor.** The climate factor of Clause 2.8 shall not be applied to P_wq. P_ret and P_3m are frequency statistics of ordinary rainfall, not AEP design depths.

8.4.4 **WQv met by retention.** The volume retained on site under Chapter 4 counts toward the WQv in full. Where the retained volume is equal to or greater than the WQv, no further treatment is required for that area, except:

- (a) pretreatment of inflows to each retention facility (Clause 8.5.3);
- (b) hotspot controls (Clause 8.8.8); and
- (c) the outfall requirements of Clause 8.10, where the site discharges to a waterbody.

8.4.5 **Water quality design flow.** Flow-through devices (swales, filter strips, oil-grit separators, GPTs) and diversion weirs for off-line BMPs shall be sized for Q_wq. Q_wq shall be computed from the 3-month ARI intensity at the time of concentration of the contributing area:

- (a) by the Rational Method, where Chapter 3 allows it (a single element draining no more than 16 ha); or
- (b) as the peak of a hydrograph method using the 3-month ARI 24-hour depth with the alternating-block pattern of Clause 2.9.1.

8.4.6 **Bypass.** Flows above Q_wq shall bypass flow-through and off-line treatment devices without washing out the material already captured. The bypass shall be part of the minor or major system (Chapter 6).

8.4.7 **Drawdown.** Where the WQv is held in an extended-detention BMP (wet pond, constructed wetland or dry extended-detention basin), it shall be released over **24–48 hours** (Chapter 4).

> Commentary. The WQv depth is the runoff from the 3-month ARI storm or the retention depth, whichever is greater. The 3-month ARI is the Malaysian water quality design storm (MSMA 2, 2012). The Malaysian 2008 checklist gave its depth as about 40 mm and said it captures 90% or more of 24-hour storm runoff volume (DID, 2008). The Himachal Pradesh value must be computed (Annex 8A). Georgia sets its WQv as the runoff from 1.2 inches (about 30 mm), the depth that covers 85% of storms in an average year, and requires 80% removal of the average annual post-development TSS load (GSMM 2016, Vol 1, Standard #4). Kansas City's water quality storm is the 1.37-inch (about 35 mm) event that produces up to 90% of the runoff from all 24-hour storms in a year (MARC BMP Manual, 2012).
>
> The Rv formula is from the MARC/APWA BMP Manual (2012), which computes WQv = P × Rv with Rv = 0.05 + 0.009·I. Rv is used instead of the SCS curve number because the CN method greatly understates runoff from small storms on pervious ground. Not applying the climate factor (Clause 8.4.3) has no direct precedent; this Manual does so because it treats P_wq like the retention depth, as a statistic of ordinary rainfall. Bypass of larger flows and the 24–48 hour drawdown follow Chapter 4; MARC (2012) required at least 40 hours of extended detention of the WQv.
>
> **Illustrative — not design values.** For a 1.0 ha site with 80% impervious cover and an assumed P_wq of 50 mm:
>
> - Rv = 0.05 + 0.009 × 80 = 0.77
> - WQv = (50 / 1000) × 0.77 × 10,000 = 385 m³

8.5 Treatment train and pretreatment

8.5.1 **Treatment train.** Water quality control shall be designed as a treatment train, in the order shown in Figure 8.1:

- (a) **source controls** on the plot: roof runoff to RWH, rain gardens, permeable paving, disconnection of impervious areas, and silt traps at inlets;

- (b) **site controls**: bioretention, swales, filter strips, infiltration, oil-grit separators at hotspots, wet ponds and extended detention; and
- (c) **regional controls**, for public drainage: GPTs and DWF interceptors at outfalls, constructed wetlands at tank inlets, and regional ponds.

8.5.2 A development shall meet the WQv on site, through (a) and (b). Regional controls under (c) may count toward a development's WQv only where a regional facility treating the same runoff has been built under a notified basin plan (Clause 7.11).

8.5.3 **Pretreatment.** Every bioretention cell, infiltration facility, permeable pavement receiving run-on, wet pond and constructed wetland shall have pretreatment at each concentrated inflow. Pretreatment shall be a sediment forebay, grass filter strip, silt trap or proprietary device that holds at least **10% of the WQv** of its contributing area, or that is sized for Q_wq for flow-through devices.

8.5.4 Pretreatment shall be accessible for cleaning without entering or disturbing the main BMP.

> **Commentary.** The treatment train follows CPHEEO (2019, Part A §10.2.3, SuDS treatment train) and CIRIA C753 *The SuDS Manual* (2015). It is also the order of priorities of this Manual: preserve, retain, detain, convey (Chapter 1). The 10% forebay volume has no Indian precedent; it is a common sizing rule for forebays in US manuals. In Himachal Pradesh, unpaved verges, construction sites and drain silt deliver a heavy sediment load. Bioretention and infiltration facilities without pretreatment clog, often within a year or two.

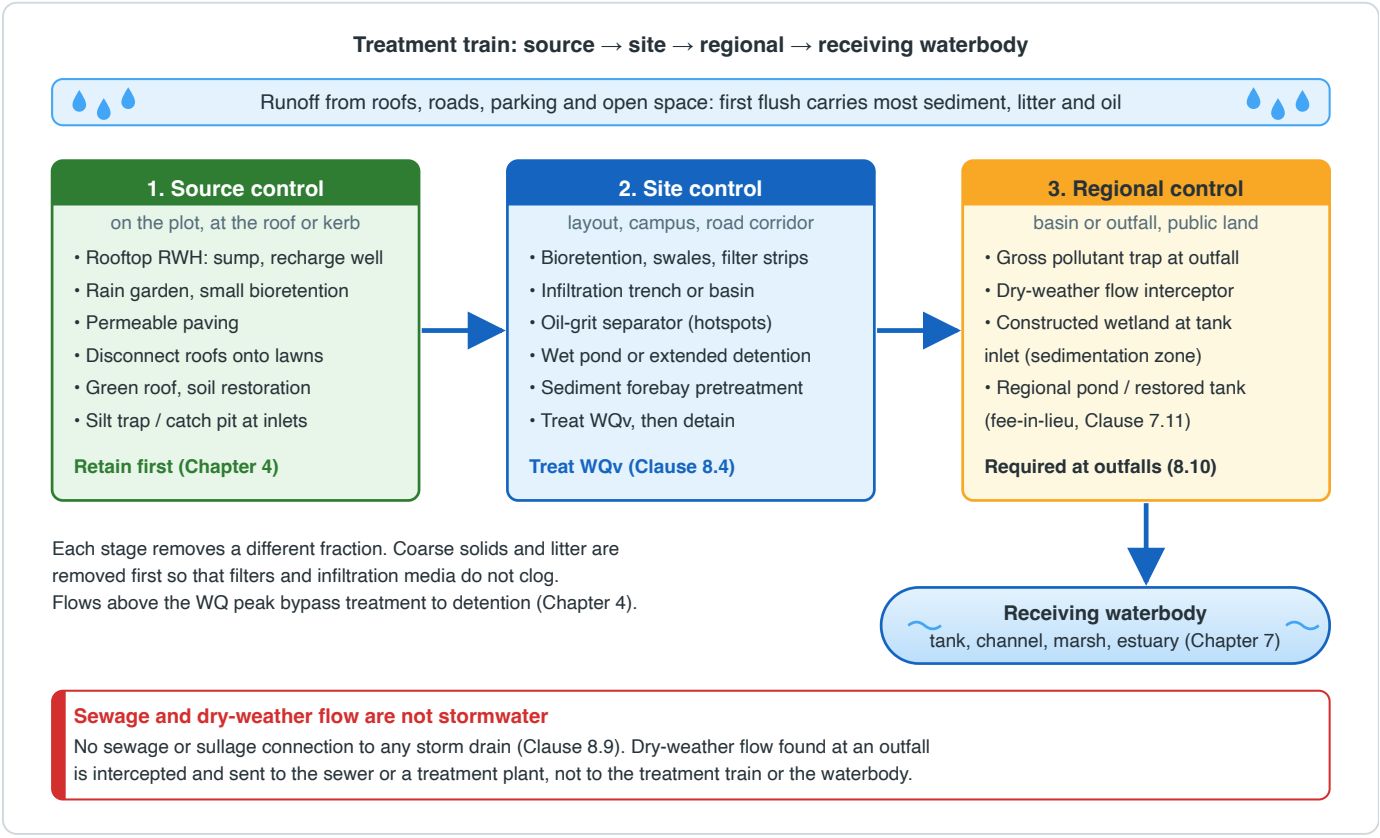


Figure 8.1 — Treatment train: source, site and regional controls before the receiving waterbody, with sewage and dry-weather flow kept out of the system. Original drawing for this Manual, adapted from CIRIA, The SuDS Manual (C753), 2015, and MARC/APWA, Manual of Best Management Practices for Stormwater Quality, 2012.

8.6 BMP selection: Level of Service and Value Rating

8.6.1 **Method.** In Tier A areas, the BMPs for each site shall be selected by the Level of Service (LoS) method of this Clause. In Tier B areas, the simplified route of Clause 8.6.5 may be used.

8.6.2 **Required Level of Service.** For a site that is not redevelopment, the required LoS depends on the change in curve number (ΔCN) from pre- to post-development (Chapter 3):

Table 8.2 — Required Level of Service for sites that are not redevelopment

ΔCN	Impact	Required LoS
17 or more	High	8
7 to 16	Moderate	7
4 to 6	Low	6
1 to 3	Minimal	5

For redevelopment (existing impervious cover of 20% or more of the site), the required LoS shall be taken from Annex 8B.

8.6.3 **Value Rating.** Each BMP treating the WQv has a Value Rating (VR) from Table 8.3. The site's composite VR is the area-weighted average of the VRs of the BMPs serving each part of the site. Treatment trains get a composite VR under Annex 8B. The composite VR shall be equal to or greater than the required LoS.

8.6.4 **Conditions for a Value Rating.** A BMP earns its VR only if:

- (a) it is sized for the WQv (or Q_wq for flow-through devices) of the area credited to it;
- (b) it meets the design requirements of Clause 8.7 and, for infiltration, Clause 8.8; and
- (c) it has pretreatment under Clause 8.5.3.

8.6.5 **Tier B simplified route.** In Tier B areas, the requirement of Clause 8.6.3 is deemed met where the whole WQv of the site is either:

- (a) retained on site under Chapter 4; or
- (b) treated by a bioretention cell, rain garden or infiltration facility designed under Clauses 8.7 and 8.8, with pretreatment.

Table 8.3 — BMP Value Ratings and suitability in Himachal Pradesh

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Siwalik valley fills, fans and river sands	Laterite / hard rock	Balh valley, Siwalik shale or hill colluvium / high water table	Himachal Pradesh notes
Native vegetation (preserved)	9.25	All	High	Suited	Suited	Suited	Counts only for preserved, undisturbed area
Rain garden / infiltration	9.0	Sediment, metals, oil, nutrients	High	Suited if 1.0 m separation met	Conditional (test)	Not suited	Mosquito control: drain within 48 h
Bioretention	8.5	Sediment, metals, oil, nutrients	Medium–high (unlined); low (lined)	Suited	Suited, with underdrain	Lined, with underdrain	Media source and phosphorus content to be specified

BMP	VR (MARC 2012)	Main pollutants removed	Volume reduction / recharge	Siwalik valley fills, fans and river sands	Laterite / hard rock	Balh valley, Siwalik shale or hill colluvium / high water table	Himachal Pradesh notes
Permeable pavement	7.5	Sediment, metals, oil	Medium–high	Suited	Conditional	Lined only	Not where run-on carries heavy silt
Extended detention wetland	7.0	Sediment, nutrients, metals	Low	Conditional (water balance)	Suited	Suited	Good at tank inlets (Clause 7.9.7)
Media / sand filter	6.0	Sediment, metals	Low	Suited	Suited	Suited (lined)	Needs frequent cleaning
Extended wet detention (wet pond)	5.0	Sediment, metals, some nutrients	Low	Conditional (water balance)	Suited	Suited	Dry-season water balance (Clause 8.7.8)
Vegetated filter strip	5.0	Sediment	Low–medium	Suited	Suited	Suited	Mostly as pretreatment
Native vegetation swale	4.0	Sediment, oil	Low–medium	Suited	Suited	Suited	Not where Q_wq velocity is high
Extended dry detention	4.0	Coarse sediment	Low	Suited	Suited	Suited	Combine with detention (Chapter 4)
Proprietary / hydrodynamic devices	3.0–5.0	Coarse sediment, oil, litter	None	Suited	Suited	Suited	VR from verified test data only
Signage (public education)	+0.25	—	—	—	—	—	Added to composite VR

The VR column is from the MARC/APWA BMP Manual (2012), Table 4.4. The suitability columns and notes have no direct precedent and are set by this Manual.

> **Commentary.** The LoS and VR method is from the MARC/APWA Manual of Best Management Practices for Stormwater Quality (2012), Tables 4.2 and 4.4. The VRs combine a water quality score, based on effluent TSS concentrations in the International Stormwater BMP Database, with scores for volume reduction, temperature, and oils and floatables. The method suits Himachal Pradesh for two reasons. It rewards volume reduction and preservation, which also serve recharge. It can also be checked by a reviewer without water quality modelling. Its weakness is that the scores come from US data. Himachal Pradesh stormwater carries more litter and more sewage than the US runoff behind the scores (CPHEEO 2019, §9.5), so this Manual requires GPTs and DWF exclusion separately (Clauses 8.9 and 8.10) and does not let a VR stand in for them.

8.7 BMP design summaries

8.7.1 **General.** Each BMP shall be designed to the requirements below and to Annex 8D (BMP design sheets). The dimensions given are **recommended starting values** where marked; the designer shall justify any departure. Every BMP shall be designed for safe passage of flows above Q_wq (Clause 8.4.6) and shall have access for maintenance (Chapter 10).

8.7.2 **Bioretention and rain gardens** (Figure 8.2).

- (a) Surface ponding depth not more than **300 mm** above the mulch, with an overflow at the maximum ponding level.
- (b) Surface ponding drained within **48 hours**.
- (c) Filter media 600–900 mm deep: an engineered sandy loam with low fines and low phosphorus content (Annex 8D), with a 50–75 mm mulch layer.
- (d) A transition (choker) layer and a gravel drainage layer below the media.
- (e) A perforated underdrain where the design infiltration rate of the native soil (Clause 8.8.4) is below the rate needed to meet (b), or where the cell is lined.
- (f) Unlined cells shall meet the infiltration criteria of Clause 8.8. Cells that cannot meet them, and cells at hotspots, shall be lined.
- (g) Plants: native or naturalised species tolerant of both waterlogging and long dry spells.

8.7.3 **Vegetated swales.**

- (a) Trapezoidal or parabolic section, with side slopes no steeper than 1V:3H.
- (b) Longitudinal slope 0.5% to 4%, with check dams where steeper.
- (c) Flow depth at Q_{wq} not more than the height of the grass, and velocity at Q_{wq} not more than 0.3 m/s.
- (d) The 1% AEP flow (or the bypass) shall not erode the swale (Chapter 9 permissible velocities).
- (e) Where longitudinal slopes are below 1% or the subsoil is poorly drained, an underdrained ("dry") swale with filter media.

8.7.4 **Vegetated filter strips.**

- (a) Receive sheet flow only, with a level spreader where flow arrives concentrated.
- (b) Length in the direction of flow at least 5 m, and slope 1% to 8%.
- (c) Used mainly as pretreatment for bioretention, infiltration and swales.

8.7.5 **Permeable pavement.**

- (a) Run-on from impervious areas not more than twice the permeable area, and no run-on from unpaved or eroding areas.
- (b) Base reservoir of clean, open-graded aggregate, sized to hold its share of the WQv in its voids.
- (c) An open base (infiltrating) only where Clause 8.8 is met; otherwise lined with an underdrain, and then counted as filtration only.
- (d) Structural design for the traffic loading by the road authority's standards.
- (e) Not at hotspots, and not where the surface will be resurfaced with impermeable material.

8.7.6 **Infiltration trenches and basins** (Figure 8.3).

- (a) Pretreatment under Clause 8.5.3 in every case.
- (b) Trenches filled with clean washed aggregate, with a void ratio confirmed by test, wrapped in geotextile on the sides and top, on a sand base.
- (c) An observation well to the base of each trench.
- (d) Storage volume = WQv (or the retention volume of Chapter 4, where greater) held in the voids; emptied within 72 hours at the design infiltration rate.
- (e) An overflow to the minor or major system at grade.
- (f) Not brought into service until the contributing area is stabilised (Chapter 10).

8.7.7 **Wet ponds (extended wet detention).**

- (a) A permanent pool of at least the WQv, plus extended detention of the WQv above the pool, released over 24–48 hours.
- (b) A sediment forebay at each inlet (Clause 8.5.3).
- (c) Length-to-width ratio of the flow path at least 3:1, with no short-circuiting.

- (d) Permanent pool depth 1.0–2.5 m, with a safety bench (Clause 7.9.4).
- (e) A dry-season water balance (Clause 8.7.8).
- (f) The detention storage of Chapter 4 may sit above the extended detention level.

8.7.8 **Water balance for permanent pools.** Wet ponds and wetlands shall be shown, by a monthly water balance using IMD rainfall and pan evaporation, to keep at least 50% of the permanent pool volume (or the minimum wetland depth) through the driest year in 10. They shall not be topped up with groundwater, potable water or sewage. Where the balance fails, a dry extended-detention basin or a constructed wetland with a smaller permanent pool shall be used instead.

8.7.9 **Constructed wetlands.**

- (a) An inlet sedimentation pond (forebay) followed by a shallow vegetated macrophyte zone.
- (b) Extended detention of the WQv above the normal water level, released over 24–48 hours, with an extended detention depth not more than 0.5 m.
- (c) A flow path length-to-width ratio of at least 3:1, with deep zones across the flow path to spread the flow.
- (d) A high-flow bypass so that floods do not scour the macrophyte zone.
- (e) Where built at a tank inlet, the wetland shall sit within the tank's setback but outside its waterspread, and its storage shall not be counted as tank storage.

8.7.10 **Gross pollutant traps.**

- (a) Sized to treat Q_wq, with all flows up to the 1% AEP passing without washing out captured material.
- (b) Capture of gross pollutants down to about 5 mm.
- (c) Head loss included in the hydraulic grade line of the drain (Chapter 9), with the screen assumed **50% blocked**.
- (d) Storage for captured material sized for the cleaning interval of the O&M plan, and not less than the 3-monthly cleaning of Chapter 10.
- (e) Vehicle access for cleaning by suction or grab.

8.7.11 **Oil-grit separators.**

- (a) Required at the hotspots of Clause 8.8.8 that involve fuel or oil: fuel stations, vehicle workshops and washing bays, bus and truck depots, and parking areas of more than 50 spaces.
- (b) Sized for Q_wq, with a high-flow bypass.
- (c) Not to be used as the only treatment: they shall be followed by a filtering BMP where the site needs a VR above 5.

8.7.12 **Silt traps and catch pits.**

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

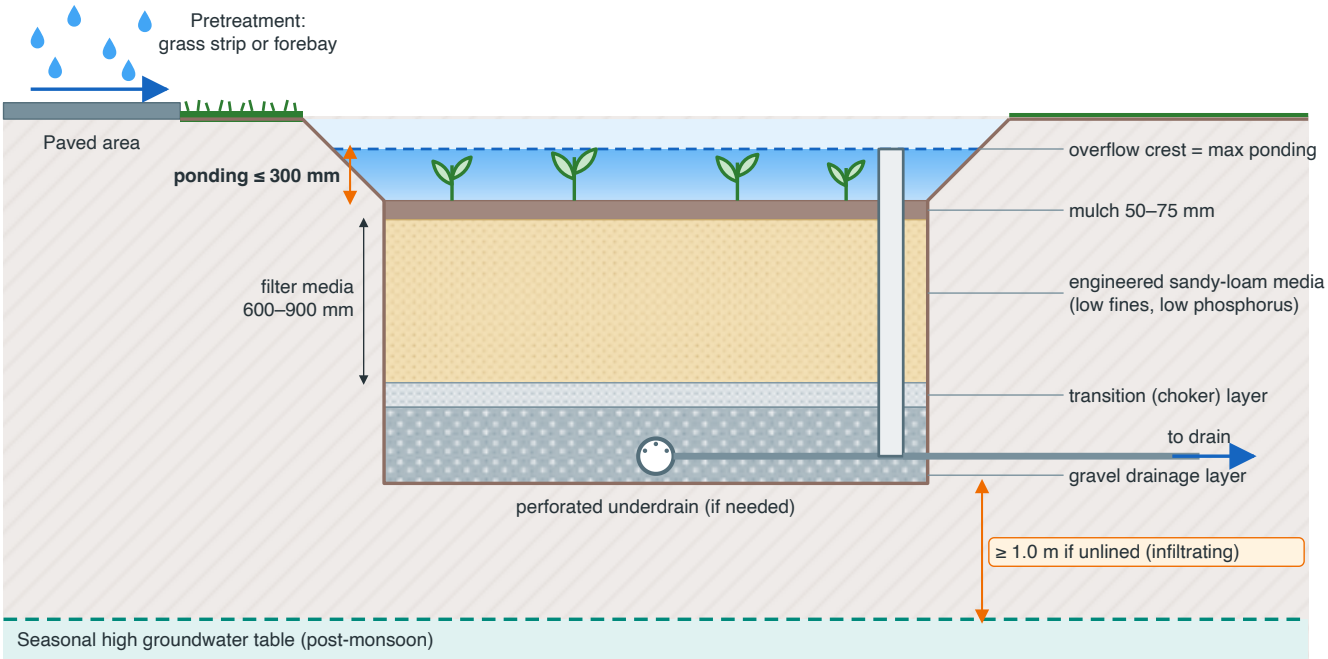
> **Commentary.** The design summaries draw on the MARC/APWA BMP Manual (2012), the Georgia Stormwater Management Manual (2016, Vol 2), CIRIA C753 *The SuDS Manual* (2015) and PUB Singapore's ABC Waters Design Guidelines. The dimensions are typical of those manuals but have not been calibrated in Himachal Pradesh. Three local issues drive changes from the source manuals:
>
> - **Mosquitoes.** Dengue is endemic in Himachal Pradesh. Surface ponding in bioretention and rain gardens must drain within 48 hours (Clause 8.7.2(b)), well inside the time mosquito larvae need to develop. This is consistent with the 24–48 hour WQv drawdown of Clause 8.4.7.
> - **Dry seasons.** Most of Himachal Pradesh's rain falls in the south-west monsoon: the State's monsoon normal is 734.4 mm, from June to September, with 255.9 mm in July and 256.8 mm in August, against 240.7 mm in the pre-monsoon months of March to May and 82.9 mm from October to December, and the

winter brings rain and snow from western disturbances (IMD, Meteorological Centre Shimla). The monsoon now sets in on about 25 June and withdraws on about 25 September (new normal dates, from 2024), but it withdrew later than that in eight of the nine years from 2018 to 2026, and storms of western disturbances follow it, as on 5 to 7 October 2025; above about 1,500 m snow lies through the winter. From October to the monsoon, tals fall and springs weaken unless they are fed, and the HIMCOSTE is reported to find fewer than a third of the State's traditional water sources recharging properly (as reported). In the towns the feed of a drain or pond in the dry months is often sewage, because the nallahs carry it (Clause 8.9, Commentary). A wet pond or constructed wetland whose water balance (Clause 8.7.8) cannot keep its permanent pool through the dry months on its own catchment's runoff is not to be used; in the hill towns, where Clause 8.8.1 bars infiltration on the slopes and there is little flat land, the practical forms are lined bioretention with an underdrain, swales on gentle ground, storage for use, and lined extended dry detention, and above about 1,500 m every BMP is also checked for frost, snow and ice from December to March. Clause 8.7.8 applies to BMPs, which shall not be topped up with sewage; tals, nauns, baolis, khatris, springs and wetlands are waterbodies under Chapter 7 and are not to be used as treatment for a development. Wet ponds that dry out turn into stagnant pools or are used for dumping. Clause 8.7.8 requires a water balance and bans topping up with sewage, which is a common practice for keeping urban ponds "full".

- **Litter and silt.** GPTs and silt traps are treated as essential, not optional, because Himachal Pradesh drains carry heavy litter and silt loads. The 50% blockage factor for screens matches the grate clogging factor of Chapter 6.

The 50-space threshold for oil-grit separators, the 5 mm GPT capture size, the 0.3 m/s swale velocity and the other dimensions in this Clause have no direct precedent and are set by this Manual.

Bioretention cell (rain garden): section, not to scale



Lined version (no infiltration): impermeable liner below the gravel layer. Required at pollution hotspots and wherever the 1.0 m separation to seasonal high groundwater cannot be met.

Dimensions as set in Clause 8.7.2.

Figure 8.2 — Bioretention cell (rain garden) in section: pretreatment, surface ponding, filter media, transition and gravel layers, underdrain, overflow, and the 1.0 m separation to seasonal high groundwater for an unlined cell. Original drawing for this Manual, adapted from MARC/APWA, Manual of Best Management Practices for Stormwater Quality, 2012, and CIRIA, The SuDS Manual (C753), 2015.

8.8 Infiltration and recharge criteria

8.8.1 **Groundwater separation.** An infiltration facility is permitted only where the **seasonal high groundwater table is at least 1.0 m below the base** of the facility. There is no exception in Himachal Pradesh, which has no coastal sand areas (Clause 8.8.9). For this Clause the seasonal high groundwater table is the highest post-monsoon level (September to November), and on a valley floor or terrace the higher of that level and the level at which springs come out where two terraces meet, as they do in the Nalagarh valley after the monsoon (CGWB). Himachal Pradesh needs opposite rules on its valley fills and on its slopes, and Clause 8.8.1 applies with the following. **(i) Recharge on the Siwalik valley fills.** On the coarse valley fills and piedmont fans of Una, Paonta–Kala Amb and the upper terraces of the Nalagarh valley, where the water lies deep (up to 43.20 m below ground in Una and 42 m in the Paonta valley) and the transmissivity is high (150 to 2,600 m²/d in Una and 211 to 3,336 m²/d at Paonta–Kala Amb, CGWB aquifer mapping), recharge, with pretreatment and a hydrogeologist's check, is the first means of meeting retention wherever this Clause is met. Una (63.72%) and Solan (57.89%) are the districts that draw the largest share of their groundwater, though all ten assessed valley units are Safe (CGWB, 2024). **(ii) No infiltration on hill slopes.** The hill infiltration rule of Clause 4.11 applies to every facility under this Chapter: no deliberate infiltration practice (soakaway, soak pit, recharge pit, shaft or well, infiltration trench, unlined bioretention, or permeable paving with an exfiltrating base) shall be built or credited on natural ground sloping more than 10°; in a sinking or sliding zone defined in a Development Plan or Interim Development Plan, including Shimla's two sinking and sliding zones, or on any other mapped landslide or creep zone; on debris cover, colluvium, slide debris or moraine, whatever its slope; or upslope of a cut slope or retaining wall within a distance of 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 the rainwater storage of Appendix 6 of the TCP Rules 2014 (20 L per m² of roof), and its overflow, with all other runoff, is led by a lined drain through a sediment trap to a stable natural channel (or, in a tal catchment, to the tal through a trap), never onto an unprotected slope; the exception for roof water in Clause 8.11.3(c) does not apply, and no infiltration is credited toward retention or the WQv. Water put into a hill slope raises the pore pressure in the debris cover and can carry its fines away: the technical committee on the Shimla slides of August 2023 named "Open Drainage systems leading to poor disposal of surface water" among the causes and found the buried depressions to act as "conduits for the infiltration of sub surface water" (HIMCOSTE-led committee, HPSDMA), the expert committee before the National Green Tribunal asked in 2017 for lined drains on the slopes "so that there is minimum ingress of water into the slope", and the draft Ground Water Rules of 2006 would exempt the sinking zones from rainwater harvesting directions where structures "would be detrimental to the safety of the building structures" (draft; the final rules were not seen). **(iii) No infiltration where the water is within 1 m.** In the Balh valley, where the water table stands 0.27 to 7.15 m below ground (CGWB aquifer mapping), on the central valley floors near the trunk streams, on the low terraces and floodplains of the rivers, and on the margins of tals and reservoirs, no infiltration facility, recharge pit, recharge well or recharge shaft shall receive runoff of any kind where the seasonal high water table is within 1 m of the ground or the ground is waterlogged; the exception for roof water in Clause 8.11.3(c) does not apply there, no infiltration is credited, and retention is met by storage for use and by detention under Chapter 4. Elsewhere on the valley floors this Clause applies on a test at the site. **(iv) Springs, nauns, baolis and khatris.** Himachal Pradesh has no rule that keeps building or drains away from a spring. Within the recharge area of a naun, baoli, khatri or other spring used for drinking water, as a hydrogeologist maps it (such as the recharge area of the Bohal spring, which Palampur's municipal body pays a forest committee to protect under an agreement of 2010), only roof water and runoff that has passed a filtering BMP may be infiltrated, where item (ii) allows any infiltration at all; road runoff, sewage and septic effluent never are; no infiltration facility, soak pit or septic tank is placed within Zone 1 of the spring (Clause 7.4); and no bore well is sunk near a spring source in the hills, as the CGWB advises for the Balh and Una valleys. These rules for springs are set by this Manual. **(v) Quality.** Section 5A of the Himachal Pradesh Ground Water Act, 2005, inserted in 2022, provides that no person shall release any effluent that contaminates the groundwater. No industrial or sewage-laden runoff is led to any recharge structure, and on the valley fills of Baddi–Barotiwala–Nalagarh, Kala Amb, Paonta and Una, where industry stands on the recharge areas, a recharge well or shaft is used only after a check of the groundwater quality at the site and only for roof water or runoff from areas with no industrial use. Where recharge is through a well or shaft into fractured rock or deep gravel, a hydrogeologist's report shall confirm the depth to water, the receiving zone, and that no drinking-water well, spring, naun

or baoli within 30 m will be harmed. The 10° trigger, the distance of twice the wall height, the 1 m limit and these conditions are set by this Manual; no Himachal Pradesh rule on infiltration or soak pits on slopes was found, and the TCP site plan forms simply ask for the soak pit to be shown. 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. Himachal Pradesh has none, so the Clause has no effect in the State; it is kept only so that the clause numbers stay unchanged. The Siwalik valley fills of Una, Paonta–Kala Amb and Nalagarh and the sands and boulders of the river beds are not coastal sand areas: Clause 8.8.1 applies there in full, 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 schist, phyllite, slate, quartzite and limestone of the Lesser Himalaya, as around Shimla, Solan, Mandi and Chamba, the granite and gneiss of the Higher Himalaya, as in Kinnaur and upper Kullu, and the Siwalik sandstone and shale of the outer hills, where groundwater is held in the weathered mantle, joints and fractures and comes out at springs (CGWB); on any slope in these areas the hill limits of Clause 8.8.1 apply first):

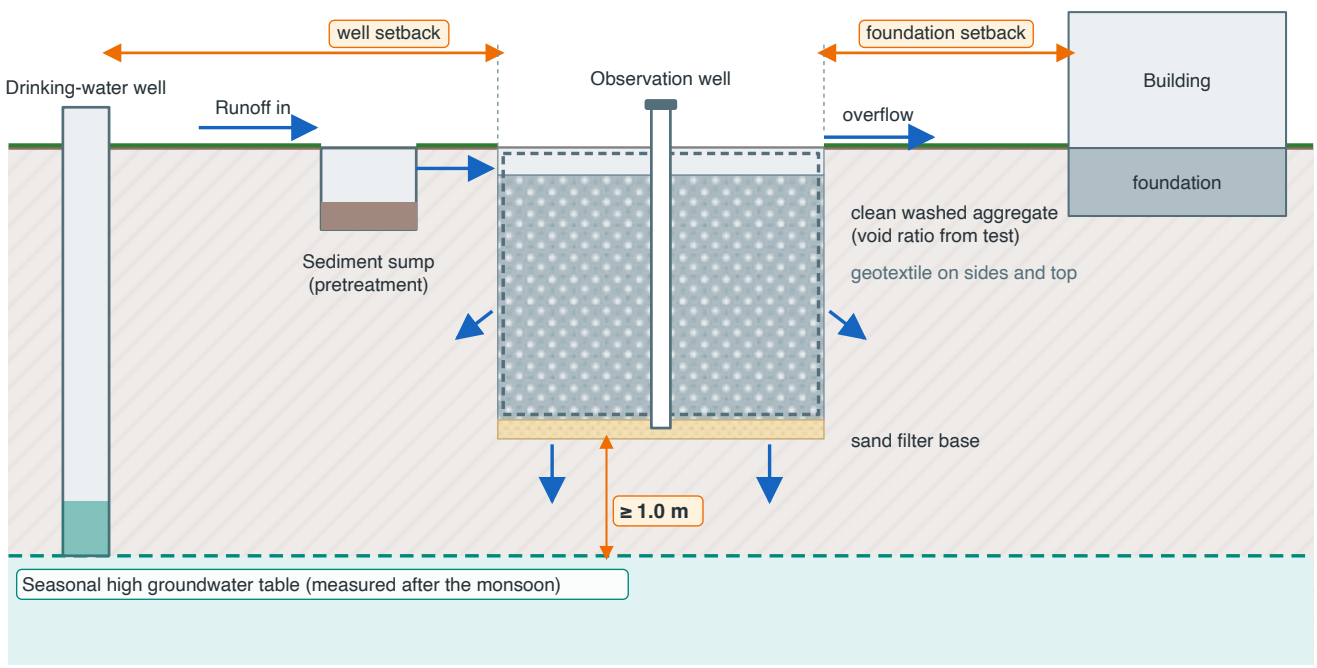
- (a) tests shall be made at the facility base, below any surface crust or hardpan;
- (b) recharge into weathered or fractured rock is permitted only for roof runoff, or for runoff that has passed through a filtering BMP, because fractures give little treatment; and
- (c) infiltration on or above slopes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

8.8.11 **Delta clays and black cotton soils.** In the Balh valley, where the water table stands 0.27 to 7.15 m below ground, the central valley floors of Una and the lower Nalagarh valley near the trunk streams, the silted beds of tals and the margins of reservoirs, the Siwalik shale, and the clayey colluvium and slide debris of the hills, and in expansive black cotton soils:

- (a) infiltration facilities will usually fail Clause 8.8.5 and need not be tested where the soil survey (Chapter 3) shows HSG D; and
- (b) where infiltration is used near buildings on expansive soils, the setback of Clause 8.8.6(a) shall be doubled.

> **Commentary.** The 1.0 m groundwater separation is a core requirement of this Manual. The other values in this Clause (the 1.0 m bedrock separation, test numbers, safety factors, minimum rates and setbacks) are typical of US and UK practice and have no Himachal Pradesh precedent. The well setback in Clause 8.8.6(c) applies to runoff from paved surfaces, not to roof water. Himachal Pradesh RWH practice routes roof water into open wells and recharge wells, and Clause 8.11 keeps that practice.
>
> No map of hydrologic soil groups for Himachal Pradesh, and no measured infiltration rate anywhere in the State, was found: "No infiltration tests have been conducted in previous surveys by CGWB and even this data is not available with state agencies" (CGWB aquifer mapping of the Nalagarh, Paonta and Balh valleys), and every infiltration design needs the tests of Clause 8.8.3. The geology and depths below are from the CGWB's assessments and aquifer-mapping reports. "Hilly and mountainous parts with steep slopes mainly constitute the run off areas and have low ground water potential", while in the valleys "unconsolidated / semi-consolidated formations form potential aquifers", and in the hard rocks water is restricted "to weathered mantle,

joints/fractures, weak planes, bedding planes and limestone caverns" (CGWB, 2024). The Siwalik valley fills are coarse and deep: in the Una valley, pebble, cobble and boulder beds with sand and clay, with the water from artesian at Rampur to 43.20 m below ground and a transmissivity of 150 to 2,600 m²/d; at Paonta and Kala Amb, channel, valley-fill and fan deposits with the water 2 to 42 m down and 211 to 3,336 m²/d; in the Nalagarh valley, 60 to 100 m of sand, silt, gravel and cobbles, where after the monsoon the water table "intersects the ground surface at the contact between two terraces giving rise to a number of springs". The Balh valley round Sundernagar is alluvium and terrace deposits with the water 0.27 to 7.15 m below ground. Shimla stands on the schist, phyllite and slate of the Jutogh and Shimla Groups under a "thick debris cover", in rocks that "lack primary porosity" and are "permeable along the fractures" (HIMCOSTE-led committee, 2023), and the expert committee before the National Green Tribunal found that "approximately 90% Shimla is built on 45º-60º slope" (2017). The State draws 35.48% of its extractable groundwater, and all ten assessed valley units are Safe, Una (63.72%) and Solan (57.89%) drawing the largest shares; Kullu, Shimla, Bilaspur, Hamirpur, Chamba, Kinnaur and Lahaul and Spiti have no assessment unit at all (CGWB, 2024). Older figures that placed Una, Hum or Kala Amb in a critical or over-exploited category are superseded. In the hills the springs are the water supply: about 500 springs have been inventoried in a standard format (NITI Aayog, 2021), the HIMCOSTE is reported to count about 10,512 traditional water sources of which only 30.41% are recharging properly (as reported), Palampur pays a forest committee to protect the recharge area of the Bohal spring that supplies the town (agreement of 2010), and the CGWB advises that a bore well should not be sunk near a spring source in the hills. Water put into a hill slope is a hazard as well as a resource: the committee on the Shimla slides of August 2023 named the "Deposition of thick debris cover on the fragile slopes", "Open Drainage systems leading to poor disposal of surface water" and structural depressions acting as "conduits for the infiltration of subsurface water" among their causes; at Cambley Bank it found the inhabited depression an "ideal site for the retention of sub surface water"; and it did not attribute the failures to sewage. This Manual's interim soil groups follow from these: the Siwalik valley fills and fans A to B, the Balh valley C, and D where the water is within about 1 m, the Siwalik regolith C (D on shale), and the debris cover, colluvium, slide debris and moraine of the hills designed as D with no infiltration credit on slopes (Chapter 3). **The State therefore needs opposite rules on its valley fills and its slopes.** On the coarse Siwalik valley fills, recharge comes first, with pretreatment and a quality check where industry stands on them. On the hill slopes, in the sinking and sliding zones and on the debris cover, no water is put into the ground on purpose, under the hill infiltration rule of Clause 4.11, which Clause 8.8.1 applies. On the Balh valley and the low terraces, where the water is within 1 m, no infiltration is used, and retention is met by storage for use and detention. 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 Himachal Pradesh, which has no coast.



Test infiltration at the proposed base level. Design rate = measured rate ÷ safety factor. Empty within 72 h.
Setback distances and test methods: Clauses 8.8.3 to 8.8.6. Road and parking runoff is never piped into a well.
Sandy coastal soils: high rates, shallow groundwater. Laterite, hard rock: low rates. Delta clay: usually unsuitable.

Figure 8.3 — Infiltration trench in section: pretreatment sump, aggregate-filled trench in geotextile, observation well, overflow, the 1.0 m minimum separation to the seasonal high groundwater table, and setbacks to wells and foundations. Original drawing for this Manual, adapted from the Georgia Stormwater Management Manual, 2016 (Vol 2), and CIRIA, The SuDS Manual (C753), 2015.

8.9 Sewage cross-connections and dry-weather flow

8.9.1 **No sewage in storm drains.** No sewage or sullage (grey water from kitchens, bathrooms and laundries), septic tank effluent, or trade effluent shall be connected to, or discharged into, any storm drain, by any pipe, channel or opening.

8.9.2 **Condition of approval.** Before the completion certificate, the Applicant shall show, by a dye or smoke test witnessed by the Authority or the sewerage agency, that every sewage and sullage outlet on the site discharges to a sewer or to an approved on-site system, and that none discharges to a storm drain. Any existing cross-connection on the site shall be removed as a condition of approval, including on redevelopment and on additions to existing buildings.

8.9.3 **Where no sewer exists.** Where no sewer is available, sewage and sullage shall go to an approved on-site or decentralised treatment system. The treated effluent of such a system may be discharged to a storm drain only with the written consent of the Himachal Pradesh State Pollution Control Board (HPSPCB) 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 SW 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 Himachal Pradesh. It defeats every other measure in this chapter: BMPs designed for stormwater are overloaded, GPTs fill with sludge, and the receiving tanks and channels become sewage lagoons. CPHEEO (2019) notes that Indian drains carry night soil and urine (Part A §9.5). DWF interception (Clause 8.9.5) is an interim measure. It protects the waterbody while the sources are traced and removed, but it can become permanent if the source work is not done, which is why the annual survey and publication of Clause 8.9.4 are required. The annual survey frequency is set by this Manual.
>
> In Himachal Pradesh the nallahs of the towns carry sewage, and some of them feed the towns' water. The expert committee before the National Green Tribunal found in 2017 that Shimla had 13,752 sewer connections against 27,318 domestic and 4,900 commercial water connections, so that more than half of its households were not connected, and that 9.65 MLD was being treated in six plants designed for 35.63 MLD (judgment of 16 November 2017, *Yogindra Mohan Sengupta*, set aside by the Supreme Court on other grounds on 11 January 2024). The Ashwani Khad, which receives the nallahs and treatment plants of Shimla's southern slopes, was also a source of the town's water: its raw water was contaminated with effluent from the Malyana and Dhalli treatment plants, an outbreak of jaundice due to hepatitis E began in January 2016, and the supply from the Ashwani Khad scheme was stopped (Bhagra et al., 2017; the case counts differ between the paper and the press). In 2024 the CPCB found the Lalpani (19.35 MLD), Malyana and Dhalli plants in the Ashwani Khad catchment operating without a valid consent and discharging "into Nalla leading to Ashwani Khad", and every plant it monitored non-complying (interim report of 6 May 2024 in NGT O.A. 735/2023); in August 2025 SJPNL's three plants had an installed capacity of 35.88 MLD of which 18.1 MLD was in use, with 50.8 km of sewer still to be connected by 2039 (annexure to the Chief Secretary's affidavit of 1 February 2026). The CPCB's list of 2022 places four stretches of the State in Priority I: the Ashwani Khad from Matholi to Bhog (BOD 80 mg/L, a figure the State calls an analysis error), the Bald along Baddi (40 mg/L), the Sirsa along Nalagarh (40 mg/L) and the Sukhna along Parwanoo (72 mg/L) (as filed in NGT O.A. 735/2023). In the Sirsa catchment the action plan measures the load of each nallah: the Sandholi Nalla carries 7.34 MLD at a BOD of 56 mg/L, the HPSIDC drain 0.6 MLD at 200 to 230 mg/L, and the outfall of the combined effluent treatment plant 17.5 MLD at 22 mg/L, 385 kg a day (the narrative and the table of the plan disagree on some loads), and the Baddi plant was found discharging without disinfection to a "Drain leading to Sarsa River" (CPCB, 2024); the State holds that the Sirsa's pollution comes mostly from Haryana. No count of tapped and untapped drains for the State was found. In the floods of 2025 the wet wells of the Mandi plant on the Beas were damaged (affidavit of 1 February 2026), and the post-disaster needs assessment of 2023 counted 139.766 km of the State's 610.634 km of sewers damaged and asked that no sewage be disposed of onto slopes. The Municipal Acts were not read for any power to require separate drains for sewage and rain-water [TBC]. Every interceptor on a nallah or khad is a DWF interceptor under Clause 8.9.5, and Clause 8.9.5(b) applies to it in full: it is sized from the measured dry-weather flow of its drain, does not reduce the drain's capacity for the minor and major events or raise the flood level behind it, and passes the storm flow above its capacity on down

the drain, never to the treatment plant or back into the town. On a khad, where a flash flood carries boulders and can destroy it, an interceptor and its chamber are also placed above the 1% AEP flood level of the khad found under Clause 5.8.5(b), or otherwise protected against the scour and debris of that flood (Chapter 9), with the bypass shown to pass it; and in the catchment of a drinking-water intake, such as the Ashwani Khad, every outfall comes first in the survey of Clause 8.9.4 and the programme of Clause 8.10.4. 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 Himachal Pradesh waterbodies, and plastics also block drains and culverts, which links water quality to flooding. The 50% screen blockage matches the grate clogging factor of Chapter 6. Clause 8.10.3(c) warns against fine screens on large drains, which block in the first hour of a storm and cause the flooding they were meant to prevent.

8.11 Rainwater harvesting integration

8.11.1 **RWH mandate continues.** The rainwater harvesting required by the Himachal Pradesh Town and Country Planning Rules 2014 (Appendix 6, which makes the collection of rain water from roof tops compulsory for all buildings, existing and proposed, wherever the Himachal Pradesh Town and Country Planning Act, 1977 is in operation, with a minimum capacity of 20 litres per m² of roof-top area, about 20 mm of rain over the roof, allows the storage below ground in the setbacks, and gives no water supply connection until it is in place; with, in addition, the power of the

Ground Water Authority under section 15 of the Himachal Pradesh Ground Water Act, 2005 to direct rainwater harvesting in urban premises with a plinth area of 100 m² or more) continues to apply, subject to the limits of Clause 8.8.1 (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 SW monsoon (JJAS) 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. Himachal Pradesh's building rules make rainwater harvesting compulsory, but none of them sets a detention rule. Appendix 6 of the TCP Rules 2014 makes "The collection of rain water from the roof tops of the buildings … compulsory" wherever the Town and Country Planning Act, 1977 is in operation, "For all the buildings existing or proposed for construction in future", with existing buildings to comply within eighteen months; it fixes "The minimum capacity of Rain Water Harvesting Structure … @ 20 Liters per square Metre of the roof top area", to be built underground in the parks and open spaces of colonies and IT parks; it allows the storage below ground in the setbacks, for uses "including fire fighting, landscaping, gardening apart from domestic usages"; and "No water supply connection shall be given to any building till Rain Water Harvesting System is put in place". The storage is about 20 mm of rain over the roof, more than in most States of this series, and it is a storage rule, not a recharge rule. Section 15 of the Himachal Pradesh Ground Water Act, 2005 adds an enabling power: the Ground Water Authority "may" identify the areas of recharge and issue guidelines, and in urban areas direct rainwater harvesting in premises with a plinth area of 100 m² or more, building it at the owner's cost on default; the draft Rules of 2006 would exempt from such directions premises of less than 100 m² and "the sinking zones, where construction of rain water harvesting structures would be detrimental to the safety of the building structures in the area" (draft; the

final rules were not seen). The National Green Tribunal's direction of 2017 that rainwater harvesting be mandatory for all building plans, and fitted to old buildings within three months, was set aside with the rest of its directions by the Supreme Court in 2024. Enforcement is through the water connection; no audit of how many tanks were built, or how they are used, was found. The rules set no test of a recharge pit, no protection of the aquifer from road runoff, no storage to be empty before a storm, and no limit on soak pits on slopes, which the site plan forms simply ask to be shown. On the Siwalik valley fills of Una, Paonta–Kala Amb and the upper Nalagarh terraces, recharge may be the main function of harvesting where Clause 8.8.1 allows it (Clause 8.11.2(b)); on hill slopes, in sinking and sliding zones, on debris cover, colluvium and moraine, and on the Balh valley and the low terraces where the water table is within 1 m, harvesting is for storage and use only, and its overflow goes to a lined drain (Clause 8.8.1). RWH serves water supply and recharge. It is usually full, or its soil saturated, by the time a July or August monsoon burst or cloudburst, often with a western disturbance, as in July and August 2023 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 SW monsoon (June to September) is as small as practicable;
- (b) all completed earthworks are stabilised by vegetation, mulch, matting or paving by **31 May**; and
- (c) any area exposed between 15 June 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 SW 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 Himachal Pradesh's 2-year 24-hour depths are high and construction sites are commonly left exposed through the SW monsoon. The 2 ha division between traps and basins, the 31 May stabilisation date, the 10 m stockpile distance and the inspection frequency have no direct precedent and are set by this Manual. The 31 May 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 Himachal Pradesh sediment and muck, not sewage alone, are the dominant pollutants of the hill drains: the slopes are steep and covered with debris, the road and hydroelectric works of the State cut them and leave spoil, and the rivers carry heavy loads (the sediment reaching the Nathpa Jhakri intake on the Sutlej is reported at about 700,000 tonnes a year against a design load of about 430,000, with more than 25,000 ppm in the flood of 2005, and Gobind Sagar is reported to receive about 38 MCM of silt a year, all as reported). Muck from the four-laning of the national highway was dumped in Gobind Sagar and its feeding khads, and the High Court ordered penal action and the clearing of the shores and tributaries (*Madan Lal*, CWPIL 31/2023, 31 May 2024); the HPSPCB has levied environmental compensation for illegal dumping of muck and debris in eight of its regions (2024); the stone-crusher policy of 2021 prohibits the dumping of waste material in a river water source; and the needs assessment of 2023 asked for every natural drain and stream "blocked with dumped spoil" to be cleared "so that the expected runoff from the watershed can safely be disposed of". In the hills 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 8.8.1 bars infiltration, and no spoil, muck or debris from a site is placed in a khad, nallah, kuhl or tal or within its Zone 1; in a tal catchment, a construction site also keeps its sediment out of every drain that reaches the tal.

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 SW monsoon; and
- (b) wet-weather sampling of at least three events each SW 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 Himachal Pradesh programme of stormwater quality monitoring was found during research for this Manual, and CPHEEO (2019) sets no Indian targets. The monitoring in Clause 8.13 is the minimum needed to calibrate Table 8.3 and to show whether DWF interception and source removal are working. The parameter list follows the key pollutants named in CPHEEO's WSUD procedure (TSS, nitrogen, phosphorus and gross pollutants), with BOD and faecal coliform added because of sewage contamination. The monitoring frequencies are set by this Manual.

8.14 Submittal requirements

Every drainage report under this chapter shall include:

1. the **Water Quality Sheet (Form 8-1)**: P_ret, P_3m and P_wq; the WQv and Q_wq for each drainage area; the volume retained under Chapter 4; and the BMP serving each area;
2. for Tier A: the LoS calculation (ΔCN, required LoS) and the composite VR (Clause 8.6);
3. the design of each BMP to Clause 8.7 and Annex 8D, with pretreatment;
4. for infiltration and recharge: the **Infiltration Test Record (Form 8-2)**, the seasonal high groundwater level and its source, the design rate, the drawdown time, and the setbacks of Clause 8.8.6;
5. the sewage and sullage connection plan and the dye or smoke test record of Clause 8.9.2;
6. the GPT and first-flush design for any outfall to a waterbody (Clause 8.10);
7. the RWH layout, separating harvesting, recharge and detention (Clause 8.11); and
8. the ESC plan (Clause 8.12).

8.15 Review and update

8.15.1 This chapter shall be reviewed with the rest of the Manual (Chapter 1). Table 8.3 shall also be reviewed when the calibration programme of Clause 8.13.4 reports, and in any case within 5 years of notification.

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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	Himachal Pradesh BMP performance calibration
8D	BMP design sheets, media specification, plant lists
8E	Erosion and sediment control standard details
Form 8-1	Water Quality Sheet
Form 8-2	Infiltration Test Record

CHAPTER 9

Hydraulic Design of Structures

9.1 Purpose and scope

9.1.1 This chapter sets the hydraulic design methods for the structures used in the minor and major systems (Chapter 6), in retention and detention facilities (Chapter 4), at outfalls (Chapter 5) and at waterbodies (Chapter 7). It covers:

- (a) pipes and box drains (Clause 9.3);
- (b) culverts (Clause 9.4);
- (c) open channels (Clause 9.5);
- (d) energy dissipators, outlet protection and drop structures (Clause 9.6);
- (e) detention outlet structures (Clause 9.7);
- (f) trash racks and screens (Clause 9.8);
- (g) pumps and sumps (Clause 9.9);
- (h) tide gates, flap gates and non-return valves (Clause 9.10);
- (i) inlets and gratings (Clause 9.11);
- (j) manholes, junction chambers and access (Clause 9.12); and
- (k) materials and durability, including coastal and saline exposure (Clause 9.13).

9.1.2 **Structural design is outside the scope of this Manual.** Structures shall be designed structurally to the applicable Indian Standards and IRC codes, for example IS 456 (plain and reinforced concrete), IS 458 (concrete pipes), IRC:SP:13 (small bridges and culverts) and the IRC bridge codes. Where this chapter refers to a structural standard, it does so only for durability (Clause 9.13) or hydraulic performance.

9.1.3 Design flows, design AEPs and level-of-service limits come from Chapters 2 to 7. This chapter does not change them.

> **Commentary.** APWA Section 5600 places most structure hydraulics in its sections on inlets and manholes (5604), enclosed pipe systems (5606), engineered channels (5607) and detention (5608). CPHEEO (2019) spreads them across Chapters 5, 6, 8 and 11. This chapter gathers them in one place and points to the US Federal Highway Administration (FHWA) hydraulic circulars for methods that Indian codes do not cover in enough detail: HDS-5 for culverts, HEC-14 for energy dissipators, HEC-22 for inlets and access holes, and HEC-24 for pump stations. The FHWA editions cited are those listed in the FHWA hydraulics library as of October 2026.

9.2 General requirements

9.2.1 **Tailwater.** Every structure that discharges to a river, khad, nallah, tal or reservoir whose level can rise above the outfall invert shall be analysed with the tailwater conditions of Chapter 5: the non-tidal tailwater of Clause 5.6 for minor- and major-system design; the riverine backwater of Clause 5.8, including the flood released from any dam or barrage upstream, such as Larji and Pandoh on the Beas above Mandi, Malana and the Parbati projects above Bhuntar, Nathpa Jhakri and Karcham Wangtoo on the Sutlej above Rampur, Kol dam above Gobind Sagar, Chamera on the Ravi and the

Dakpathar barrage on the Yamuna above Paonta; the outfall-closed check of Clause 5.10 wherever the receiving water can rise above the outfall invert, which is the case for the drains of Paonta that outfall to the Yamuna and the Bata, for those of Una that outfall to the Swan through its embankments, for those of Mandi that outfall to the Beas and the Suketi, for those of Kullu, Bhuntar and Manali that outfall to the Beas, for those of Baddi and Nalagarh that outfall to the Sirsa and the Balad, for those of Rampur that outfall to the Sutlej, and for the drains of Bilaspur and of the towns on the Pong shore, which end in reservoirs; for an outfall to a reservoir or tal, its maximum water level, or its full reservoir level plus the surcharge in the design flood, as Chapter 5 sets it, or, where neither is published, the full reservoir level plus 0.5 m (set by this Manual), with the levels that BBMB publishes in feet converted at 0.3048 m per foot (Gobind Sagar, full reservoir level 1,680 ft, about 512.06 m; Pong, full reservoir level 1,390 ft, about 423.67 m, with a maximum level quoted as 1,400, 1,410 or 1,421 ft, about 426.72, 429.77 or 433.12 m, of which the highest is used until BBMB states one on a named datum; Pandoh [TBC]) and Rewalsar and the other tals at their outlet levels [TBC]; for an outfall to a khad or nallah that has no gauge, among them the nallahs of Shimla that drain to the Ashwani Khad and the Sutlej and the khads that cross the towns of the Dhauladhar front, the Siwalik fans and the valley floors, the level of the 1% AEP flood in the reach, computed with the sediment and debris allowances of Chapter 6 and checked against surveyed flood marks and the debris lines of 2023 and 2025, with the outfall invert above the highest surveyed bed (Clause 5.8.5(b)); for a river reach without a CWC site, among them the Beas at Manali, Kullu, Mandi and Pandoh, the Sutlej at Bilaspur and the Ravi at Chamba, the flood-mark profile of the reach; the level held in a drain by any sluice, check dam, kuhl head, weir or pumping station downstream of the outfall, taken as a fixed control at its gate-closed level, its weir crest or the start level of its pumps; and the joint case of Clause 2.12. At Paonta the levels are those of the CWC site on the Yamuna, the only site in the State with a warning and a danger level (warning level 383.5 m, danger level 384.5 m, high flood level 384.6 m of 5 September 1995); elsewhere CWC publishes high flood levels only, among them 367 m on the Swan at Ghaluwal (dated 3 June 2017, which needs checking), 933 m on the Sutlej at Rampur (26 June 2005, the Parechu outburst; a 2023 reading of 924.5 m is also quoted, a conflict) and 373.52 m on the Bata at Ganguwala (22 July 2023) (CWC levels as transcribed by SANDRP, as reported; the datum is not stated); readings of a local gauge published in the press, on another zero, are never mixed with them. No document found sets a design river, reservoir, tal, khad or nallah level at any outfall in Himachal Pradesh, and no floodplain line has been notified; until one is published, 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.

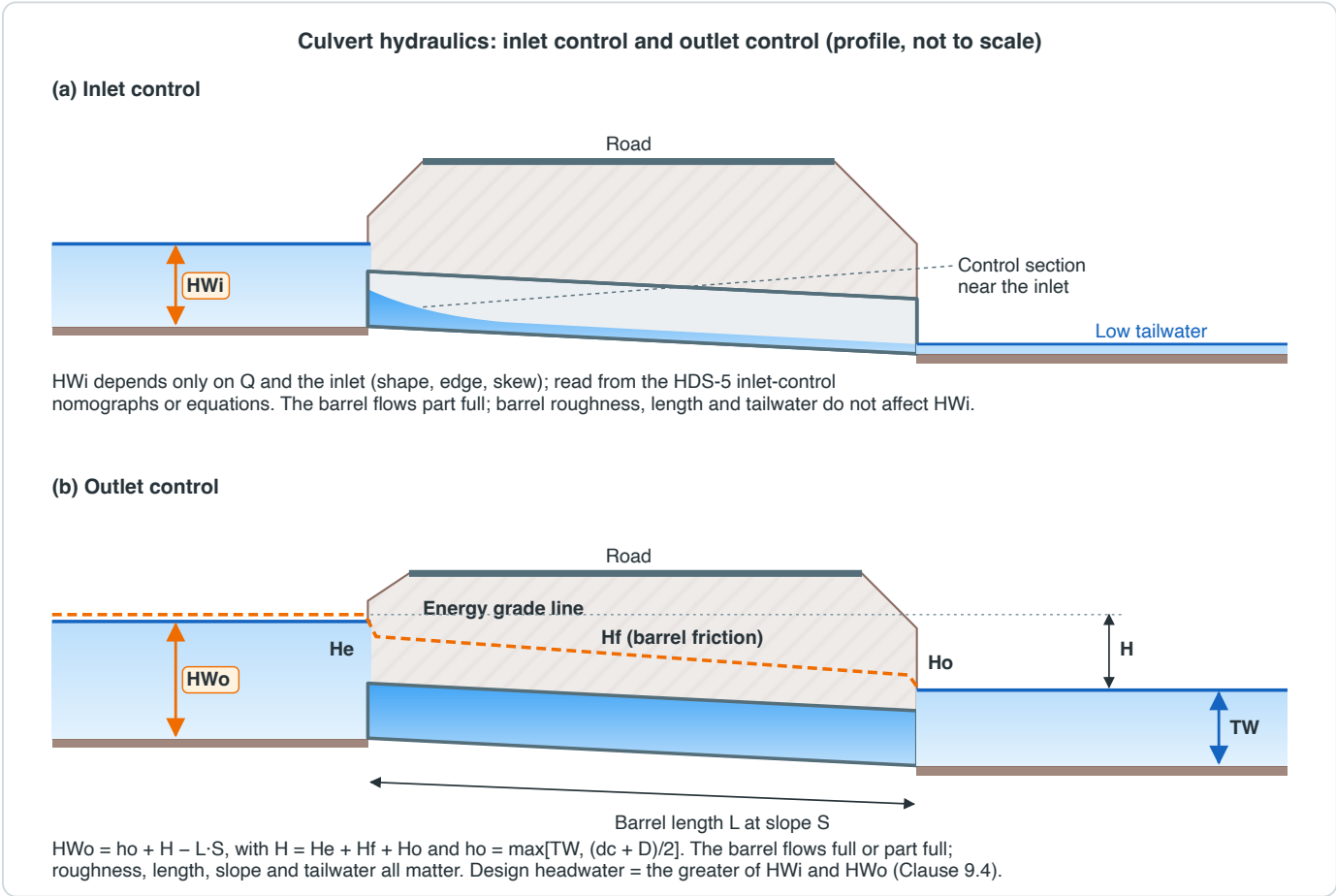

Figure 9.1 — Culvert hydraulics: inlet control and outlet control. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

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 Himachal Pradesh where a road is rebuilt on top of an old culvert, and they hold standing water and silt upstream.

9.5 Open channels

9.5.1 **Flow computation.** Open channels shall be designed by Manning's equation for uniform flow, with the n of Table 6.6. Water levels shall be computed by gradually varied flow (standard step) analysis where tailwater, bridges, culverts, bends or changes of section affect them, which on the drains of Paonta, Una and Mandi that outfall to the Yamuna, the channelised Swan and the Beas below Pandoh, on the drains of Bilaspur and the Pong-shore towns that end in reservoirs whose level BBMB varies through the year, on the flatter drains of the Balh valley, and on the steep nallahs and streets of Shimla, Solan, Mandi, Dharamshala and the other hill towns and the khads of the Siwalik fans, stepped by drop structures and chutes and passing through critical depth at every step, is the normal case.

9.5.2 **Flow regime.** At the design flow, the Froude number shall not exceed 0.8 (CPHEEO 2019, §5.3), unless the channel is designed as a supercritical chute. Flows with a Froude number between 0.8 and 1.2 are not permitted at the design flow in any channel.

9.5.3 **Permissible velocities.** Mean velocity at the design flow shall not exceed the limits of Table 9.2.

Table 9.2 — Maximum permissible mean velocities in channels

Lining or soil	Maximum velocity (m/s)	Source
Concrete lining	3.0	CPHEEO 2019 Table 5.11
Riprap lining	1.8	CPHEEO 2019 Table 5.11
Grassed lining	1.2	CPHEEO 2019 Table 5.11
Stabilised earthen channel (modified natural channel)	2.0, or the critical velocity if less	CPHEEO 2019 §5.10.3
Unlined, fine sand	0.46	Fortier and Scobey (1926), clear water
Unlined, sandy loam	0.53	As above
Unlined, silt loam	0.61	As above
Unlined, firm loam	0.76	As above
Unlined, stiff clay	1.14	As above
Unlined, fine gravel	0.76	As above
Unlined, coarse gravel	1.22	As above

Flexible linings (vegetation, riprap, geosynthetics) may instead be designed by the permissible shear stress method of FHWA HEC-15, *Design of Roadside Channels with Flexible Linings*, 3rd edition (2005).

9.5.4 **Longitudinal slope.** In engineered channels, the longitudinal slope shall not exceed 0.4% for natural linings and 0.2% for concrete linings, unless drop structures (Clause 9.6.6) or a chute are provided (CPHEEO 2019, Table 5.11).

9.5.5 **Freeboard and bends.** Freeboard shall meet Chapter 6, Table 6.7, measured above the water level that includes superelevation at bends. Bend radii shall meet Chapter 6, Clause 6.7.10.

9.5.6 **Side slopes.** Unless a structural or geotechnical design supports a steeper slope:

- (a) unlined earth channels shall have side slopes no steeper than 1V:2H; and
- (b) grassed channels that are mown shall have side slopes no steeper than 1V:3H.

9.5.7 **Low-flow channel.** Channels with a bed width of 3 m or more shall have a defined low-flow channel that carries the dry-weather flow at the self-cleansing velocity of Clause 6.7.3.

9.5.8 **Transitions.** Changes of section shall use gradual transitions. Abrupt expansions and contractions are not permitted in supercritical flow.

9.5.9 **Linings in high groundwater.** Lined channels in areas of high groundwater or tidal influence shall have weep holes with filters, or shall be designed to resist uplift with the channel empty.

9.5.10 **Natural channels.** Natural channels shall be preserved where possible (CPHEEO 2019, §5.10.3 note; Chapter 7). Where a natural channel must be modified, its capacity shall meet the design AEP of Chapter 6 and its velocities shall meet Table 9.2.

> Commentary. The lined-channel velocities and slopes are CPHEEO (2019) Table 5.11 values. The unlined-soil values are the classic Fortier and Scobey (1926) permissible velocities for clear water, as reproduced in Chow (1959). They are given for soils common in Himachal Pradesh (the boulder gravels and coarse sands of the Siwalik valley fills and fans of Una, Nalagarh and Paonta–Kala Amb, the silts and clays of the Balh valley, the clays and sandy loams weathered from the Siwalik sandstones and shales, and the stony debris cover, colluvium and slide debris of the Lesser Himalayan schist, phyllite and slate slopes of Shimla, Solan and Mandi, with moraine in the high valleys, on which the boulders a flow carries, rather than the soil itself, decide what a channel bed must withstand (this Manual's reading)). The ban on Froude numbers between 0.8 and 1.2 extends CPHEEO's advice to avoid critical flow, where the water surface "becomes unstable and wavy" (§5.3). This extension is made by this Manual. The side slopes and the low-flow channel are also set by this Manual, because many Himachal Pradesh urban channels carry sewage-mixed dry-weather flow until the cross-connections of Chapter 8 are removed. A wide flat bed then deposits sludge across its whole width, and a low-flow channel keeps the dry-weather flow concentrated.

9.6 Energy dissipators, outlet protection and drop structures

9.6.1 **When required.** Outlet protection or an energy dissipator shall be provided at every pipe, culvert and channel outlet where the outlet velocity at the design AEP or the 1% AEP exceeds the permissible velocity of the receiving channel in Table 9.2, and at every outlet to an unlined channel, tank or waterbody.

9.6.2 **Method.** Energy dissipators and outlet protection shall be designed by the methods of FHWA HEC-14, *Hydraulic Design of Energy Dissipators for Culverts and Channels*, 3rd edition (2006), selecting the dissipator type by its range of application.

9.6.3 **Riprap aprons.** For a circular outlet discharging to a flat apron, the median riprap size shall be computed with the HEC-14 apron equation:

$$D50 = 0.2 \cdot D \cdot [Q / (g^{0.5} \cdot D^{2.5})]^{(4/3)} \cdot (D / TW)$$

where D50 is the median stone size (m), D is the culvert diameter or rise (m), Q is the design discharge (m³/s), g = 9.81 m/s² and TW is the tailwater depth (m). Where TW is not known, it shall be taken as 0.4D.

Apron length and thickness shall follow the HEC-14 riprap-class table (Table 9.3). The apron width at the outlet shall be at least 3D and shall flare to the downstream channel.

Table 9.3 — Riprap classes and apron dimensions (HEC-14)

Class	D50 (mm)	Apron length	Apron thickness
1	125	4D	3.5 D50
2	150	4D	3.3 D50
3	250	5D	2.4 D50
4	350	6D	2.2 D50
5	500	7D	2.0 D50
6	550	8D	2.0 D50

Source: FHWA HEC-14 (2006), §10.2 and Table 10.1, as reproduced in state-agency design worksheets. Where the computed D50 exceeds Class 6, a riprap basin or a structural stilling basin shall be used.

9.6.4 **Riprap filter and grading.** Riprap shall be placed on a granular filter or a geotextile. Stone shall be angular, durable and graded so that the D50 of Clause 9.6.3 is met.

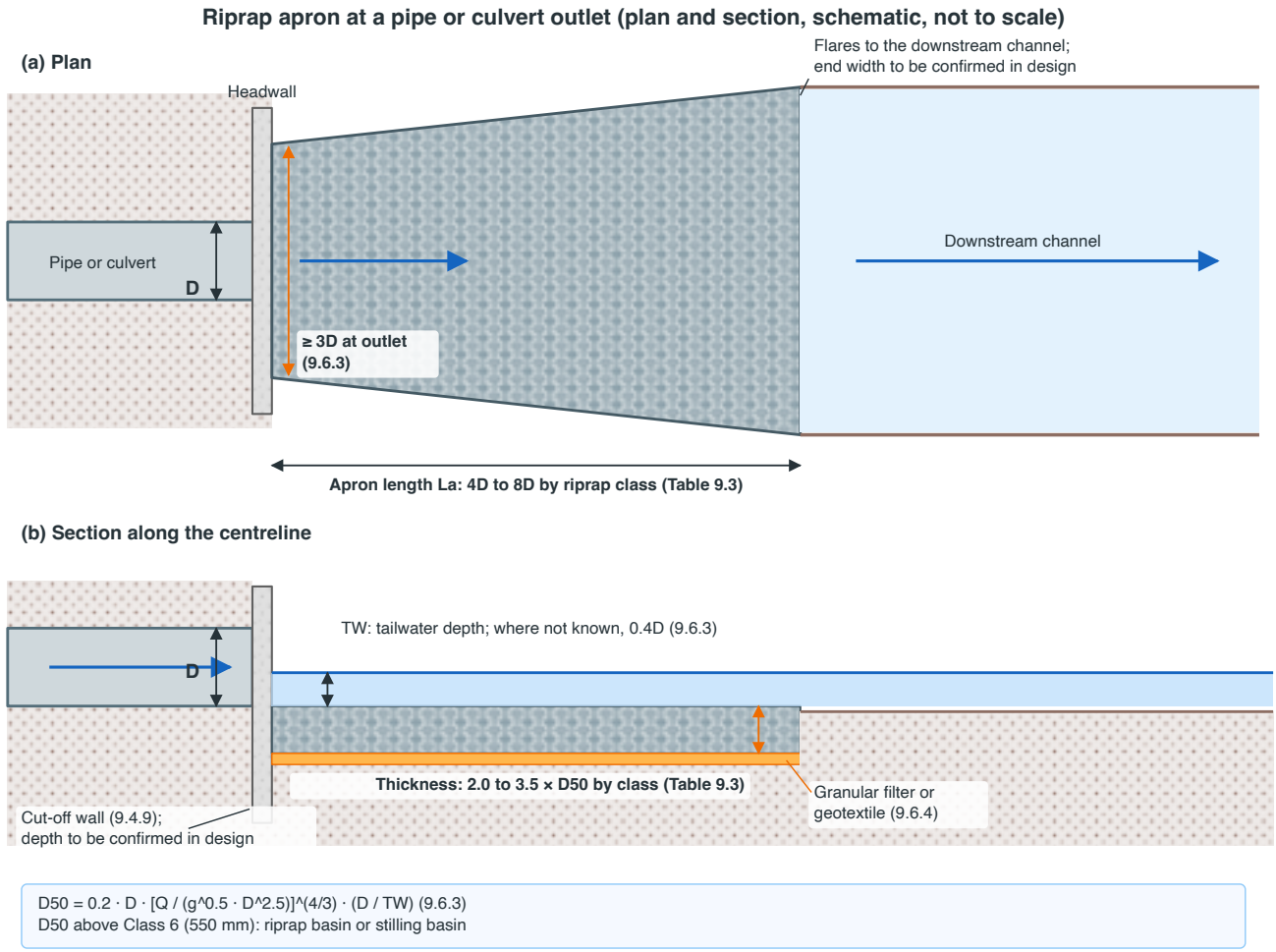

Figure 9.2 — Riprap apron at a pipe or culvert outlet: apron width at least 3D at the outlet, flaring to the downstream channel; length and thickness from Table 9.3; stone on a granular filter or geotextile (Clauses 9.6.3 and 9.6.4). Original drawing for this Manual, adapted from FHWA, Hydraulic Design 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 m³/s.

9.8.7 **Safety.** Racks at the entrance to long conduits shall prevent people from being drawn in. They shall be designed for the hydrostatic load of a fully blocked rack.

> Commentary. CPHEEO (2019, §8.3.1.3) describes pump-station bar screens with a spacing of "approximately 58 mm", built in modules, with an emergency overflow in case of clogging. Clause 9.8.6 follows that approach but links the spacing to the pump's solids-passing size, which varies by pump. The 50% blockage check matches the grate clogging factor of Chapter 6. The Kirschmer equation and its shape factors are standard (Kirschmer 1926, as reproduced in hydraulic handbooks). The rack spacing, area ratio, through-velocity, the 30 m conduit length trigger, the 10× screen area for orifices and the 1 m³/s trigger for mechanical raking have no direct precedent and are set by this Manual.

9.9 Pumps and sumps

9.9.1 **When pumping is used.** Pumping shall be used only where gravity drainage cannot meet the requirements of Chapters 5 and 6, for example at road underpasses (Chapter 6, Clause 6.10.5), basements, low-lying areas and outfalls that are tide-locked under the outfall-closed check of Chapter 5.

9.9.2 **Design inflow and storage.** The station shall be designed with the inflow hydrograph routed through the catchment and any upstream storage. Pump capacity and storage shall be chosen together:

- (a) the station shall meet the design AEP of the element it serves (for underpasses, the 2% AEP with a 1% AEP check);
- (b) where the station serves a tidal outfall, storage plus pumps shall hold the 48 h design volume with the outfall throttled for the tidal-lock duration (default: two consecutive high tides of 6 h each), as required by Chapter 5; and
- (c) the pumps shall be selected for the full range of static head between the lowest sump level against the lowest tailwater, and the highest tailwater (HAT plus surge plus 0.3 m).

9.9.3 **Wet-well volume.** The effective wet-well volume (between the pump-stop and the lowest pump-start level) shall be the greatest of:

- (a) where variable-speed drives and automatic controls are installed, 5 minutes of the minimum inflow (CPHEEO 2019, §8.3.3);

- (b) otherwise, 10 to 15 minutes of the peak inflow, or the volume needed for the pump manufacturer's minimum cycle time, from $V = Q \cdot t$ (CPHEEO 2019, Eq. 8.1); and
- (c) for constant-speed pumps, the volume $V = \Theta \cdot q / 4$ for each pump, where Θ is the minimum cycle time recommended by the motor manufacturer and q is the pump capacity (FHWA HEC-24, 2001).

9.9.4 **Duty and standby.**

- (a) Duty pumps shall be of the same size where practicable (CPHEEO 2019, §8.3.3).
- (b) Standby capacity shall be at least equal to the largest duty pump, and not less than 50% of the number of duty pumps.
- (c) Duty and standby roles shall alternate automatically.

9.9.5 **Pump type.** Pumps shall be solids-handling (non-clog) types suited to stormwater with sand and debris. Axial-flow pumps shall be used only behind a screen that meets Clause 9.8.6, because they cannot handle debris (CPHEEO 2019, §8.3.2).

9.9.6 **Sump and intake design.** Sump geometry, pump spacing, minimum submergence and approach flow conditions shall follow the pump manufacturer's requirements and ANSI/HI 9.8 (Rotodynamic Pumps for Pump Intake Design). A physical hydraulic model study shall be carried out where any pump exceeds 1 m^3/s, or where the sump does not follow standard ANSI/HI 9.8 geometry. The minimum clear space between adjacent pumps or motors is 0.6 m for small and medium units and 1.0 m for large units (CPHEEO 2019, §8.2.5).

9.9.7 **Silt and screens.** A silt trap and a bar screen shall be provided upstream of the wet well (Clause 9.8.6; Chapter 6, Clause 6.13.3).

9.9.8 **Controls and monitoring.**

- (a) Pumps shall be controlled by a primary level sensor (ultrasonic, radar or pressure) with an independent float-switch back-up.
- (b) High-level and pump-fault alarms shall be sent by telemetry to the local body's control room.
- (c) Sump levels, pump run hours and power status shall be logged and kept for at least 5 years.

9.9.9 **Power supply.**

- (a) The station shall have two independent power sources: the grid supply and a standby generator (or a second independent grid feeder) able to run all duty pumps at once (CPHEEO 2019, §2.4.2.3(j)).
- (b) Fuel for at least **72 hours** of continuous operation of all duty pumps shall be stored on site, above the flood level of Clause 9.9.10.
- (c) Changeover to standby power shall be automatic.

9.9.10 **Flood protection of the station.** The floor of the electrical and control room, the generator and the transformer shall be at least 0.5 m above the 1% AEP flood level at the station (Chapter 6, Clause 6.11). Access to the station for maintenance vehicles shall remain usable in the 1% AEP event.

9.9.11 **Discharge.** Each pump shall have its own rising main, or a non-return valve and an isolating valve where mains combine. Rising mains shall discharge into a delivery chamber or outfall fitted with a flap gate or non-return valve under Clause 9.10. Discharge piping shall be sized by a recognised friction formula (CPHEEO 2019, §8.3.9).

9.9.12 **Emergency connections.** Every station shall have a hard-standing area and a quick-coupling connection for mobile pumps to discharge into the delivery chamber.

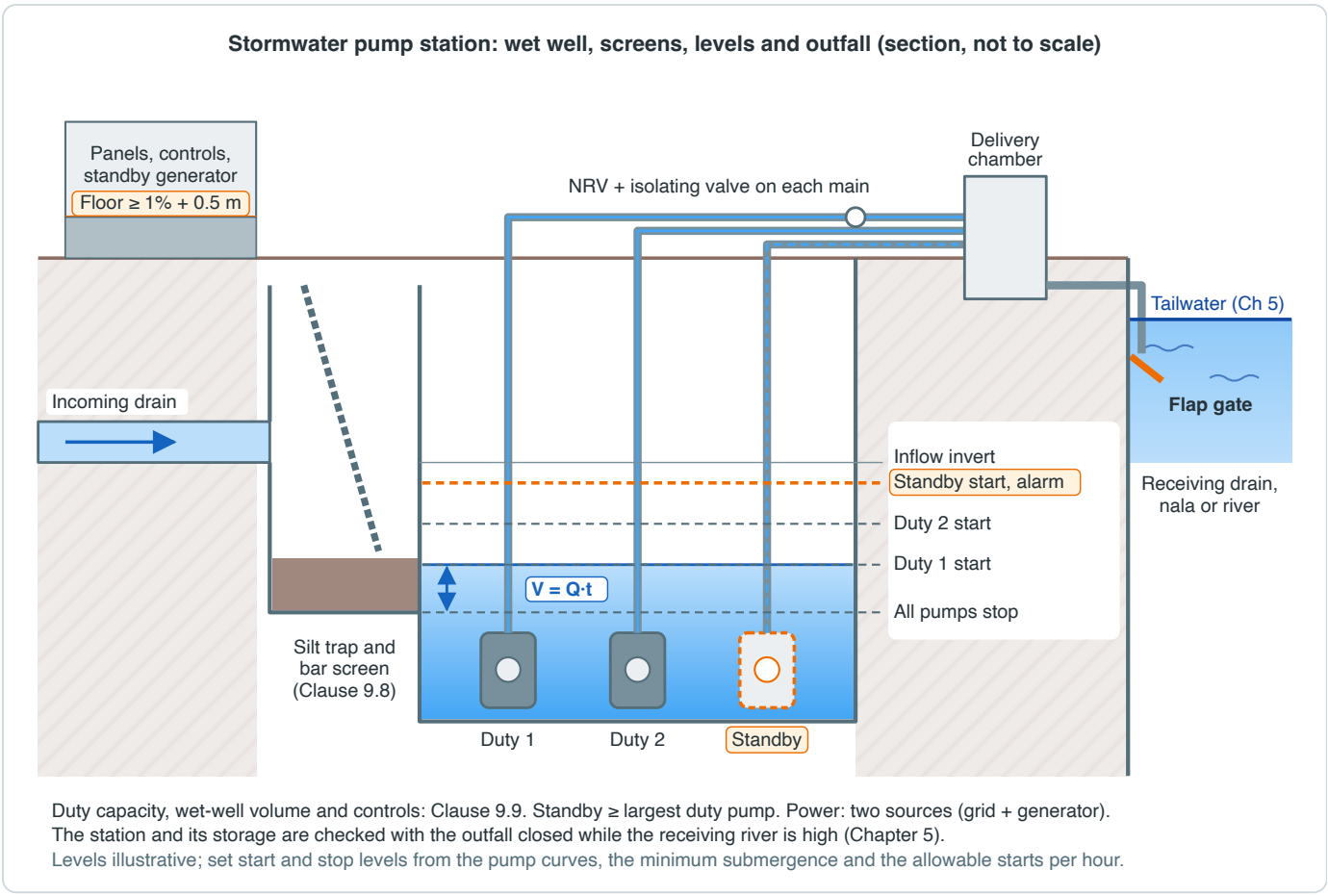

Figure 9.3 — Stormwater pump station: wet well, screens, levels and outfall. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Chapter 8, and FHWA, Highway Stormwater Pump Station Design, HEC-24 (2001).

> **Commentary.** CPHEEO (2019) Chapter 8 covers stormwater pumping: wet-well sizing (§8.3.3), pump types (§8.3.2), trash screens (§8.3.1.3), space requirements (§8.2.5) and the need for generator sets "as standby for emergency operation during failure of electricity" (§2.4.2.3). It recommends standby units of "minimum 50% of the duty pump units". Clause 9.9.4(b) is stricter: the standby must at least equal the largest duty pump, so the station still meets its design duty with its largest pump out of service. This stricter rule is set by this Manual. FHWA HEC-24 (*Highway Stormwater Pump Station Design*, FHWA-NHI-01-007, 2001) is the FHWA pump-station manual. The 72 h fuel storage is set by this Manual to match the 72 h design storm of Chapter 2. The model-study trigger, the telemetry and data-retention requirements, and the emergency connection have no direct precedent and are set by this Manual.

9.10 Tide gates, flap gates and non-return valves

9.10.1 **Where required.** Flap gates, tide gates or non-return valves shall be provided on every outfall whose invert is below the 1% AEP still-water level of the receiving water (Chapter 5).

9.10.2 **Types.** Acceptable devices are:

- (a) hinged flap gates (cast iron, ductile iron, stainless steel, HDPE or composite);
- (b) elastomeric in-line or end-of-pipe check valves (duckbill type); and
- (c) penstocks or sluice gates, manual or motorised, as a secondary closure.

9.10.3 **Secondary closure.** Outfalls of 900 mm or more, and every outfall serving a pumped or storage system, shall have a penstock or stop-log slot upstream of the flap gate so that the gate can be maintained, and as a back-up if the gate jams open.

9.10.4 **Hydraulics.** The head loss through the device in the open position shall be taken from the manufacturer's tested data and included in the HGL (Chapter 6, Clause 6.8.7). Flap gates shall open at a small head difference (CPHEEO 2019, §6.3.10.1).

9.10.5 **Sand and debris.** At beach, estuary and creek outfalls where sand or debris can hold a gate open or shut:

- (a) the gate shall be housed in a chamber with surface access, or elastomeric check valves shall be used; and
- (b) the gate shall be inspected after every high-tide or surge event during the monsoon season (Chapter 10).

9.10.6 **Materials.** Hinges, pins, links and fixings shall be of corrosion-resistant material (CPHEEO 2019, §6.3.10.1). In coastal and tidal locations this means stainless steel grade 316, bronze or a non-metallic material (Clause 9.13).

9.10.7 **Storage behind gates.** Where gates close during a storm, the storage or pumping behind them shall meet the outfall-closed check of Chapter 5.

> Commentary. CPHEEO (2019, §6.3.10.1) describes flap gates and flood gates at outfalls to tidal waters. It notes that "adequate storage may be necessary if pumping is to be avoided during the closure of the gate" and that hinge pins and links "should be of corrosion-resistant materials". Himachal Pradesh has no coast, so no outfall in the State is closed by the tide, and the beach, estuary, tidal and coastal provisions of Clauses 9.6.7, 9.9.2(b), 9.10.5 and 9.13.6, and the coastal and tidal rows of Table 9.5, do not arise; in Clause 9.9.2(c) the highest tailwater is the highest river, reservoir or tal level of Chapter 5. Gates are still required below the 1% still-water level, because some town outfalls end in rivers that floods and dams hold high, and others in reservoirs. Only one CWC site in the State has a warning and a danger level, the Yamuna at Paonta, below the Dakpathar barrage in Uttarakhand (warning level 383.5 m, danger level 384.5 m, and a high flood level of 384.6 m on 5 September 1995, only 0.1 m above the danger level; CWC levels as transcribed by SANDRP, as reported; the datum is not stated); a drain of Paonta that outfalls below these levels is closed for as long as the river stands above its invert, so it needs a flap gate, a penstock and either storage or a pumping station sized under Clause 9.9 and the outfall-closed check of Chapter 5, and the Bata beside the town rose to a new high flood level of 373.52 m at Ganguwala in July 2023 (as reported). At Una the drains outfall to the Swan, which the Jal Shakti Vibhag (then IPH) has channelised, with 16.67 km of embankments between the Jhalera and Santokhgarh bridges in the first phase on modelling by CWPRS (NITI Aayog, 2020), at a cost given as ₹945.49 crore or ₹922.49 crore (the two published figures conflict); no design flood or return period for the embankments has been found, and the CWC site at Ghaluwal monitors levels only, with a high flood level of 367 m dated 3 June 2017 (as reported; the June date needs checking). An outfall through the embankments therefore needs a flap gate and is checked with the Swan at its surveyed 1% AEP level. Bilaspur stands on Gobind Sagar, the reservoir of Bhakra run by BBMB, whose full reservoir level is 1,680 ft (about 512.06 m at 0.3048 m per foot) and which stood at about 1,679 ft on 4 September 2025, with Kol dam (NTPC; reservoir level 642 m) upstream; Dehra and the other towns on the Pong shore drain to Pong (Maharana Pratap Sagar, BBMB), whose full reservoir level is 1,390 ft (about 423.67 m) and whose maximum level is quoted as 1,400, 1,410 or 1,421 ft (about 426.72, 429.77 or 433.12 m; the values conflict), and which rose to 1,399.65 ft in August 2023 and 1,394.71 ft on 5 September 2025 (levels as reported). An outfall to either reservoir is checked against the highest of these levels until BBMB states a maximum water level on a named datum, and below it needs a flap gate and storage, because the reservoir stays high for weeks. Mandi stands on the Beas below Larji (HPSEBL) and Pandoh (BBMB; spillway capacity 9,939 m³/s; full reservoir level not found [TBC]), where all five gates were opened on 30 June 2025 to release nearly 44,000 cusecs (about 1,250 m³/s) and residents blamed the releases for flooding in July 2023; a release from Larji drowned 14 students in 2014 (all as reported). CWC has no site on the Beas at Manali, Kullu, Mandi or Pandoh, on the Sutlej at Bilaspur or on the Ravi at Chamba, so the levels there are surveyed flood marks and modelled levels, with the releases of Larji, Pandoh, Malana and the Parbati projects as an upstream boundary. On the Sutlej the high flood level at Rampur, 933 m, was set by the outburst of the Parechu landslide lake in Tibet on 26 June 2005 (as reported; a

reading of 924.5 m in 2023 is also quoted, a conflict). These dams and barrages are works of BBMB, NTPC, SJVN, NHPC, HPSEBL and other operators, designed to dam-safety standards and not to this chapter, but their reservoir levels and releases are this chapter's boundary conditions, and no release rule, spillway rating or record of gate operation for any of them was found; the PDNA of 2023 proposes a forecast-based dam management system. Most of the State drains steeply. The nallahs and streets of the hill towns fall at 10–60%, about 90% of Shimla being built on slopes of 45°–60° (expert committee before the National Green Tribunal, 2017), and the khads crossing the Siwalik fans of Una, Baddi–Nalagarh and Paonta–Kala Amb at 2–5% (this Manual's reading of the terrain), far beyond the 0.4% and 0.2% of Clause 9.5.4, so drop structures (Clause 9.6.6), stepped channels, baffled chutes and stilling basins (Clauses 9.6.5 and 9.6.6(b)) and supercritical chutes designed under Clause 9.5.2 are the normal case, not the exception. IRC:SP:42-2014 (§8.5.1) says the same of hill roads: their side drains are lined because the slope is high and "rolling stones cause high friction", culverts are needed at closer intervals than on the plains, and stepped chutes or baffles are provided where the bed slope exceeds critical. In Himachal Pradesh the following are set by this Manual for a structure on a drain whose catchment includes an undeveloped hill slope, khad or nallah: (a) a drop or stepped channel shall have each pool shaped to drain dry and reachable by machine, and no single vertical drop shall exceed the 1.5 m of Clause 9.6.6(c); (b) where such a drain enters a pipe, covered drain or culvert, at the catchment size and with the sediment bulking and blockage factors that Chapter 6 sets (Clause 6.3.6), 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 boulders in the bed and not less than that of Clause 9.8.2(a), and a debris basin or sediment trap upstream of the rack; the basin volume shall be estimated from the debris deposited at the site in past floods and a stated debris-yield method, counting every muck dump, slide scar and road cut in the catchment as a source, because no Indian guidance on sizing debris basins was found [TBC]; its spillway shall pass the 1% AEP inflow with the basin full of debris, as for Clause 9.7.6, and it shall have a ramp for the machines that empty it; (c) a culvert shall have a single barrel where possible (Clause 9.4.8(a)), an armoured headwall and apron at the inlet with a deflector against boulders, an invert that follows the bed (Clause 9.4.8(c)), and an outlet protected under Clause 9.6 and led to a stable natural channel, never onto an unprotected slope; (d) every lined drain that receives runoff from unpaved slopes, hill roads, muck dumps or building sites shall have a sediment trap before it joins a public drain, a kuhl, a tal or a reservoir; and (e) a lining in a steep drain shall be designed for the abrasion of the gravel and boulders it carries as well as for the velocity of Table 9.2. The need is shown by the record. The expert committee before the National Green Tribunal found Shimla's drains with catchments "improperly selected", built "for longer distances with much lesser gradients than actually required" and "not able to carry the peak flow", and the debris of hill cutting "dumped in the valley or near water channels, obstructing the natural drainage" (judgment of 16 November 2017, set aside by the Supreme Court on 11 January 2024; its findings are cited here as expert evidence only); the technical committee on the Shimla slides of August 2023 named "Open Drainage systems leading to poor disposal of surface water" among their causes (HIMCOSTE-led committee, HPSDMA); and the PDNA of 2023 found blocked natural drainage among the root causes of the slides, asked that "all natural drains and streams blocked with dumped spoil" be cleared and that hill roads be given catch-water and chute drains, and the State's recovery plan has box culverts rebuilt after an analysis of their hydraulic needs, on roads damaged over more than 8,040 km. Muck-disposal sites are debris sources: the High Court has barred dumping in Gobind Sagar and its feeding khuds and ordered the muck cleared and the violators prosecuted (*Madan Lal v. State*, CWPIL 31/2023, 31 May 2024), and has asked how NHAI will stop its contractors dumping in forests and near water bodies (*Fourlane Visthapit and Prabhavit Samiti v. State*, CWP 5243/2022, 26 June 2023); HPSPCB has levied compensation for illegal dumping in eight regions (2024); and on 19 September 2026 the failure of a valve on the head race tunnel of Parbati II carried muck-dump debris into Palchara village (as reported). No structure of this chapter is designed to pass a debris flow or a glacial-lake outburst: in sub-area HP-C, and on any drain with a glacier, a glacial lake or a mapped debris-flow fan above it, the screening of Clause 2.3.6(i) comes first, and a structure is sited out of the hazard, as the flows at Samej, Bagipul and Rajban in July 2024 and in Seraj and Thunag in 2025 came down channels no drain could have carried, and as the Parechu outburst of 2005 showed on the Sutlej. Screens matter as much as gates, because the drains also carry silt, solid waste and sewage: no sanitary landfill had been built in any of the State's 54 ULBs (CAG, 2021, as reported), and CPCB placed the Ashwani Khad, the Bald (Balad) at Baddi, the Sirsa at Nalagarh and the Sukhna at Parwanoo in Priority I of its polluted river stretches (2022), so a rack on a Himachal Pradesh nallah is checked in the blocked case of Clause 9.8.4. No inventory of the sluices, flap gates, debris racks, sediment traps and pumping stations

on the drains of any Himachal Pradesh town, with their capacities and operating rules, no operating rule for the gates of the State's dams and barrages that is linked to the towns below them, and no design river, reservoir, tal, khad or nallah 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, sluice or penstock that fails, or is jammed open by silt, gravel, boulders, slide debris, muck, solid waste or woody debris, lets a river, reservoir or tal in flood back into the drain network, and one jammed shut blocks it. The khads and nallahs of Himachal Pradesh carry boulders, gravel, slide debris and muck as well as silt, solid waste and sewage: the gates of the Malana II dam were reported jammed after its reservoir filled with debris and silt in the cloudburst of 24 July 2023 (as reported); muck from the four-laning of the Kiratpur–Ner Chowk highway was dumped into Gobind Sagar and its feeding khuds until the High Court barred it and ordered it cleared (*Madan Lal v. State*, CWPIL 31/2023, 31 May 2024); HPSPCB levied environmental compensation on 34 defaulters for illegal dumping of muck and debris in eight regions (reply in O.A. No. 726 of 2023 before the National Green Tribunal, 20 February 2024); and no sanitary landfill had been built in any of the State's 54 ULBs, where waste was dumped in the open (CAG, 2021, as reported), so a gate, its screen and the debris rack above it are exposed to the same load and must be kept clear together; and because Gobind Sagar and Pong can stand near their full reservoir levels for weeks at the end of the monsoon, as in August and September of 2023 and 2025, a gate that leaks or jams can be exposed for the whole of a flood.

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 Himachal Pradesh towns.

9.12 Manholes, junction chambers and access

9.12.1 **Location and spacing.** Manholes shall be provided at the locations and spacings of Chapter 6, Clause 6.7.11 and Table 6.8. Where pipes are too large for a standard manhole, a junction chamber with a riser to the surface shall be used (CPHEEO 2019, §11.3.7.3).

9.12.2 **Minimum internal size.** Manholes shall have at least the internal dimensions of Table 9.4 (CPHEEO 2019, §11.3.7.6):

Table 9.4 — Minimum internal size of manholes

Shape and depth	Minimum internal size
Rectangular, depth below 0.9 m	900 mm × 800 mm
Rectangular, depth 0.9–2.5 m	1,200 mm × 900 mm
Circular, depth above 0.9 m and up to 1.65 m	900 mm diameter
Circular, depth above 1.65 m and up to 2.30 m	1,200 mm diameter
Circular, depth above 2.30 m and up to 6.0 m	1,500 mm diameter
Circular, depth above 6.0 m and up to 9.0 m	1,800 mm diameter

The manhole shall also be large enough to fit the largest pipe connected plus the benching on each side.

9.12.3 **Access openings.** The clear access opening of manholes and access chambers on public drains shall be at least 600 mm, so that cleaning equipment can be lowered.

9.12.4 **Drops.** Where the difference between incoming and outgoing inverts exceeds 0.6 m, a drop connection shall be provided. Below 0.6 m, the difference shall be taken up by adjusting the slope of the incoming pipe or the benching (CPHEEO 2019, §11.3.7.5). The invert drop across a manhole where pipe size changes shall be at least the following fraction of the difference in diameters (CPHEEO 2019, Table 11.6):

- conduits below 400 mm: one-half;
- 400 mm to 900 mm: two-thirds;
- above 900 mm: four-fifths.

9.12.5 **Benching.** Manhole floors shall be benched to at least the crown of the outgoing pipe, with channels shaped to guide flow from each incoming pipe.

9.12.6 **Surcharge.** Manholes on mains where the 1% AEP HGL can rise above the cover (Chapter 6, Clause 6.8.4) shall have bolted, locked or hinged covers designed for that pressure.

9.12.7 **Mechanical cleaning.** Manholes, chambers and covered drains shall be designed for cleaning by machine (suction, jetting, grab or robotic equipment) from the surface. Fixed ladders shall be of corrosion-resistant, encapsulated material where provided.

> **Commentary.** The size and drop requirements are from CPHEEO (2019) Chapter 11. The 600 mm access opening, the benching rule and the bolted covers are set by this Manual. Designing for mechanical cleaning supports the prohibition on hazardous manual cleaning under *The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013*.

9.13 Materials and durability

9.13.1 **Exposure classes.** Concrete structures shall be designed for the exposure class of IS 456: 2000, Table 3. In Himachal Pradesh the minimum classes of Table 9.5 apply unless a site investigation shows a more severe condition:

Table 9.5 — Minimum IS 456 exposure classes for Himachal Pradesh locations

Location	Minimum IS 456 exposure class
Inland drains and structures	Moderate
Drains and structures in the coastal environment, and any drain that carries or may carry sewage-mixed flow	Severe
Structures exposed to sea-water spray, or in contact with saline or aggressive groundwater	Very severe
Structures in the tidal zone	Extreme

9.13.2 **Concrete.** Minimum concrete grade, maximum water–cement ratio, minimum cement content and nominal cover to reinforcement shall be those of IS 456 for the exposure class. For the reader's convenience, IS 456 sets the minimum reinforced-concrete grades as M25 (moderate), M30 (severe), M35 (very severe) and M40 (extreme), and the nominal covers as 30, 45, 50 and 75 mm respectively.

9.13.3 **Aggressive ground.** Groundwater and soil at every structure in coastal and delta areas shall be tested for chlorides and sulphates. Cement type and concrete mix shall be chosen to suit the results under IS 456.

9.13.4 **Sewage-mixed flow.** Pipes and covered drains that carry, or may carry, sewage-mixed flow shall be protected against sulphide (crown) corrosion, by a sacrificial concrete thickness, a corrosion-resistant lining or a non-concrete pipe material.

9.13.5 **Pipes.** Concrete pipes shall comply with IS 458, with the class selected by structural design. Other pipe materials (for example ductile iron, HDPE or structured-wall plastic pipes) shall comply with the applicable Indian Standard and be approved by the approving authority.

9.13.6 **Metalwork.** Within 5 km of the coast, and in all tidal and saline locations:

- (a) fixings, hinges, ladders, handrails and screen frames shall be stainless steel grade 316, or hot-dip galvanised steel with a protective coating, or a non-metallic material; and
- (b) dissimilar metals shall be isolated from each other.

9.13.7 **Masonry.** New public drains in Tier A bodies shall be in reinforced or plain concrete. Brick or stone masonry may be used for drains in Tier B bodies only if it is plastered on the wetted face and meets the n value of Table 6.6.

> **Commentary.** The IS 456 exposure classes and the grade and cover values are quoted from IS 456: 2000 (Tables 3, 5 and 16) for convenience. The standard governs, and designers shall use its current amendment. Assigning Himachal Pradesh locations to exposure classes, the sulphide-corrosion requirement and the ban on new masonry drains in Tier A bodies have no direct precedent and are set by this Manual. Drains that receive sewage cross-connections (a common condition, Chapter 8) generate hydrogen sulphide, which attacks unprotected concrete above the water line.

9.14 Submittal requirements

Every structure design shall be submitted with a **Hydraulic Structures Report** (Form 9-1) containing, as applicable:

1. culvert calculations (HDS-5 or HY-8 output) with HWi, HWo, outlet velocity, tailwater, overtopping and the blockage check;
2. channel water-surface profiles, velocities, Froude numbers and freeboard;
3. outlet protection and dissipator design, with riprap sizing;
4. detention outlet stage–discharge tables and the emergency spillway check;
5. screen and rack design with the 50% blocked check;
6. a pump station design report: inflow hydrograph, storage, pump curves and system curves, wet-well volume, controls, power supply and the Chapter 5 outfall-closed check;
7. gate and valve selection with head-loss data;
8. inlet, grate and cover load classes; and
9. an exposure class and materials statement (Clause 9.13).

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Annexes and forms

Annex / Form	Content
9A	HDS-5 inlet-control coefficients and worked culvert example in SI units
9B	Standard drawings: headwalls, riprap aprons, drop structures, trash racks, detention risers
9C	Pump station design checklist and standard control philosophy

Annex / Form	Content
Form 9-1	Hydraulic Structures Report checklist

CHAPTER 10

Submittals, Review, Operation & Maintenance and Enforcement

10.1 Purpose and scope

10.1.1 This chapter sets out how compliance with this Manual is shown, checked, built, kept working and enforced. It covers:

- (a) the submittal stages and their contents (Clauses 10.3–10.4);
- (b) the compliance calculator (Clause 10.5);
- (c) professional certification and review (Clauses 10.6–10.7);
- (d) construction inspection and as-built certification (Clauses 10.8–10.9);
- (e) maintenance declarations, O&M plans, inspection and access (Clauses 10.10–10.13);
- (f) handover of public assets (Clause 10.14);
- (g) enforcement (Clause 10.15); and
- (h) monitoring, post-event review and data publication (Clauses 10.16–10.17).

10.1.2 This chapter applies to every development and public work to which Chapters 4 and 5 apply under Clause 1.5.2. Clauses 10.3.1 (Stage 0), 10.15 and 10.17 also apply to development that is subject only to Clause 1.5.4.

> Commentary. A criterion that is not checked at approval, built as approved, and maintained afterwards has no effect. In Himachal Pradesh the failure is one of missing criteria and of drains that have not kept up with the towns. No document of the TCP Department, the Urban Development Department, a Municipal Corporation or the Jal Shakti Vibhag stating a design return period, intensity or runoff coefficient for the storm drains of any town was found, and in 2017 Shimla's drains were found to cover about 30% of the city and to be unable to carry the peak flow (Chapter 11). The approval route shapes this chapter. In the 54 ULBs and about 102 other notified areas where the Himachal Pradesh Town and Country Planning Act 1977 operates, which hold about 21.7% of the State's people but less than 10% of its area (PDNA, 2023), building needs planning permission under the TCP Rules 2014 (read here as consolidated to 2022; later amendments up to the Twelfth of 2024 and a draft Sixteenth of 2025 are known only from the press and were not read). The Rules already ask for much of what a drainage submittal needs: a site plan showing "Existing water bodies like Bauri, Well, Nallah, khud", contours, and the septic tank, soak pit and rainwater-harvesting tank; a soil investigation report by a geologist before building in the sliding and sinking zones of a development plan (Rule 21(1); for Shimla, §17.2.2.9 of the Development Plan); roof-top rainwater storage of 20 litres per m² of roof, compulsory for existing and new buildings, without which no water connection is given (Appendix 6); and, where no interim or final development plan exists, a slope of not more than 45°, a hill cut of not more than 3.50 m, construction at 3.00 m from a nullah and 5.00 m from a khud, and sub-divisions laid out for the "natural flow of surface drainage" (Appendix-1, cls. 3, 11, 16 and 20). In planning areas the distance from the high flood level along rivers, khuds and nullahs is as the development plan delineates it, and elsewhere no construction is allowed on land "prone to floods" (Appendices 3 and 7). In the Shimla Planning Area the Shimla Development Plan 2041 governs, published on 20 June 2023 according to the Supreme Court (the press gives 23 June), whose storm-water chapter was not read [TBC]. HIMUDA approves the plans of its colonies without the ULBs, and HPSIDC plans its industrial areas (CAG, Report No. 1 of 2022). Outside these areas, which cover more than 90% of the State, model bye-laws for rural construction approved by the cabinet in September

2025 are reported to send plans to panchayat technical assistants and the Gram Sabha, with TCP approval above 1,000 m² (as reported; text not read). There is no floodplain zoning law, and the PDNA of 2023 asks for river-boundary mapping and floodplain guidelines. The ULBs run their drains under the Himachal Pradesh Municipal Corporation Act 1994 and the Himachal Pradesh Municipal Act 1994, whose drain sections were not read [TBC]. No rule asks for a drainage report, limits peak runoff, requires on-site detention or sets a "zero runoff" condition. 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 application for planning permission, alongside the site plan and the rainwater-harvesting tank that the TCP Rules already require; in a sliding or sinking zone with the geologist's report, which shall then also confirm that no runoff is put into the ground (Clause 8.8.1); at the water connection, which waits for the roof-top storage; and at completion. This chapter is the process.

10.2 Definitions

Term	Meaning in this chapter
Submittal	A set of documents lodged with the Authority at one of the stages of Clause 10.3.
Drainage report	The preliminary (Stage 1) or final (Stage 2) report required by Clause 10.4.
Stormwater facility	Any retention, detention, water quality, conveyance, pumping, gate or outfall element required by this Manual, public or private.
Hold point	A construction stage at which work shall not proceed until the Authority or the certifying professional has inspected it (Clause 10.8).
As-built certificate	The certificate of Clause 10.9 that the facility was built as approved and performs as designed.
Owner	The person or body responsible for a facility under its maintenance declaration, or the ULB for a handed-over asset.
O&M plan	The operation and maintenance plan of Clause 10.11.
Facility register	The public register of facilities of Clause 10.17.

Other terms are defined in Clause 1.4.

10.3 Submittal stages

10.3.1 Submittals shall be made in the following stages, linked to the approval steps of the Himachal Pradesh Town and Country Planning Rules 2014 (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

Stage	Submittal	When	Linked approval
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.

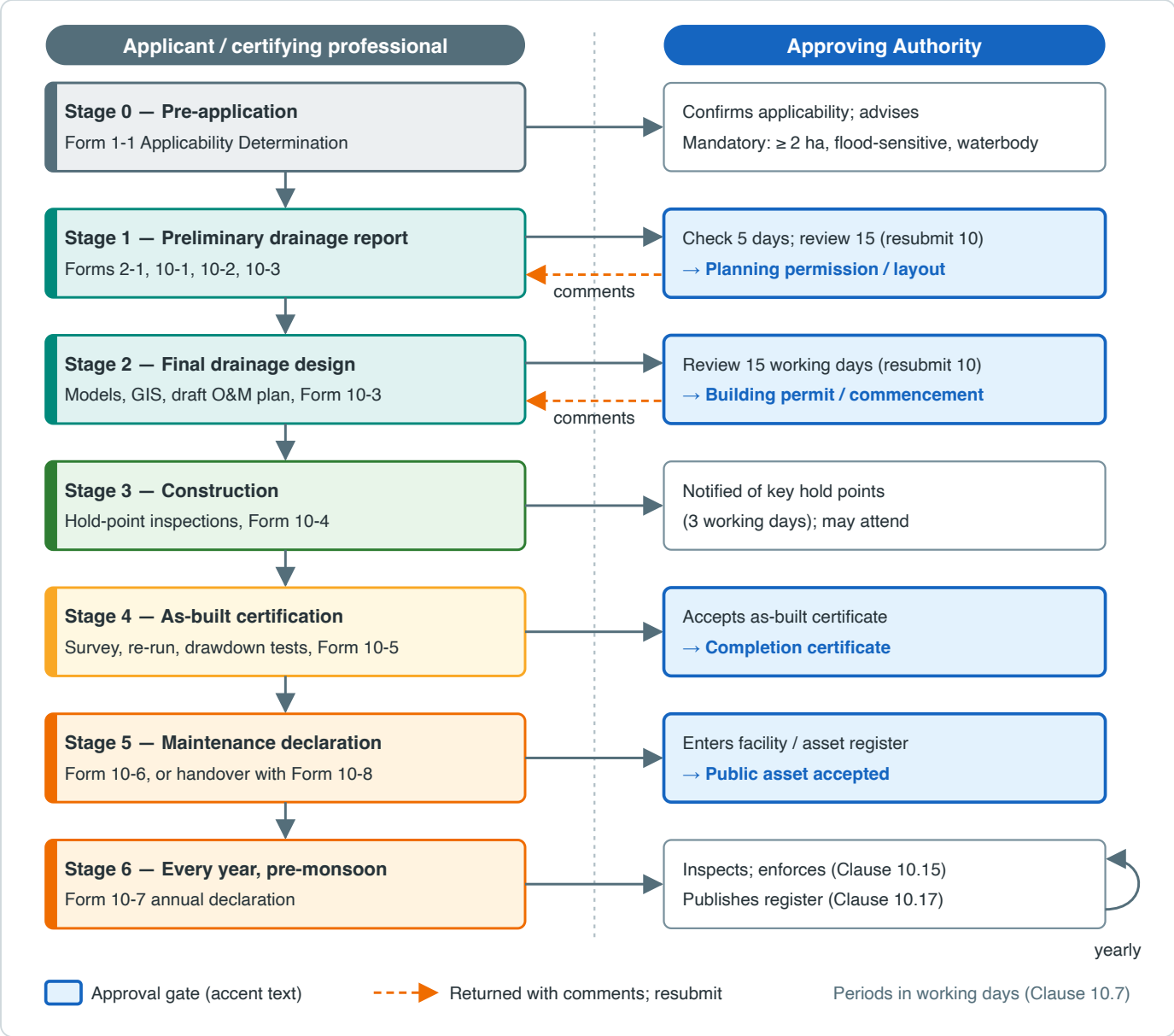

Figure 10.1 — Submittal, review and approval workflow (Clauses 10.3–10.10). Original drawing for this Manual.

> **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 TCP Rules 2014 steps a Himachal Pradesh applicant already follows. Linking Stage 4 to the completion certificate copies the MBBL 2016 RWH model, which requires inspection before the completion certificate (MBBL 2016, §9.6). The 2 ha and 1 ha limits in Clauses 10.3.2 and 10.3.3 have no direct precedent and are set by this Manual.

10.4 Required contents and checklists

10.4.1 **Preliminary drainage report (Stage 1).** The report shall contain at least:

- (a) Form 1-1 and, where applicable, Form 1-2 (Variance / Waiver Request);
- (b) a site plan with existing and proposed levels, impervious areas, and the catchment boundaries draining to and through the site;
- (c) soils (HSG), the seasonal high groundwater table, and infiltration test results or a test plan (Chapter 3);

- (d) the **Design Rainfall Sheet (Form 2-1)**, completed as Clause 2.13 requires;
- (e) the pre-development condition and hydrologic method (Chapter 3);
- (f) how the hierarchy of Clause 1.2 has been applied: areas preserved, retention method, detention concept and conveyance;
- (g) preliminary retention, water quality and detention volumes, and release rates, from the compliance calculator (Clause 10.5);
- (h) the downstream extent and tailwater case (Chapter 5);
- (i) waterbodies, setbacks and the 1% AEP level (Chapters 6 and 7); and
- (j) the land reserved for facilities and maintenance access (Clause 10.13).

10.4.2 **Final drainage design (Stage 2).** The final design shall contain, in addition to updated Stage 1 contents:

- (a) the final calculations for every storage duration of Clause 2.5.2 and every AEP required by Chapter 4, including the outfall-closed check of Chapter 5;
- (b) stage–storage–discharge tables for each facility, and the emergency spillway design (Chapter 4);
- (c) hydraulic design of conveyance elements, inlets and structures (Chapters 6 and 9);
- (d) the water quality design and the first-flush or gross pollutant trap where required (Chapter 8);
- (e) construction drawings, details and specifications of every facility;
- (f) the construction sequence, including protection of retention and infiltration areas from sediment and compaction (Clause 10.8.3);
- (g) the hold-point schedule (Clause 10.8);
- (h) the draft O&M plan (Clause 10.11) and draft maintenance declaration (Clause 10.10);
- (i) the model input files and the GIS data of Clause 10.4.4; and
- (j) the certificates of Clause 10.6.

10.4.3 **Checklist.** Each submittal shall include the **Drainage Report Checklist (Form 10-1)**, showing for each item of Clauses 10.4.1–10.4.2 the page or sheet where it is addressed, or the reason it does not apply. The Authority shall not start technical review of a submittal without a completed Form 10-1.

10.4.4 **Digital submittal.**

- (a) Reports and drawings shall be submitted as searchable PDF.
- (b) Hydrologic and hydraulic models shall be submitted in their native, runnable format (for example SWMM .inp, HEC-HMS or HEC-RAS project files), with the version of the software used.
- (c) Facilities, outfalls, flow paths and catchment boundaries shall be submitted as GIS data (GeoPackage or shapefile) in WGS 84 (EPSG:4326) or the applicable UTM zone (43N for almost all of the State, and 44N east of 78° E, which includes eastern Kinnaur (Karcham, Kalpa, Reckong Peo, Sangla, Chitkul and Pooh), Spiti east of about Kaza and the Dodra Kwar area of Shimla district; Kaza and Nathpa lie within about 0.1° of the meridian, and a project that crosses it uses one zone for all its layers and states which), with attributes as listed in Annex 10B.
- (d) Levels shall be stated relative to a named vertical datum. The relationship to the river datums of the CWC gauges on the receiving rivers, of the reservoir levels of BBMB for Bhakra (Gobind Sagar), Pong and Pandoh (published in feet and converted at 0.3048 m per foot), of the reservoir and pond levels of NTPC, SJVN, NHPC, HPSEBL and the other dam operators, and of the flood marks surveyed on ungauged khads and nallahs used in Chapter 5 shall be stated.

10.4.5 **Summary of forms used in submittals** (Table 10.2):

Table 10.2 — Forms used in submittals

Form	Title	Stage
1-1	Applicability Determination	0 or 1
1-2	Variance / Waiver Request	1
2-1	Design Rainfall Sheet	1, 2

Form	Title	Stage
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. Himachal Pradesh has no notified design return period or design storm for its urban drains, and no document of the TCP Department, the Urban Development Department, a Municipal Corporation, the Jal Shakti Vibhag or a Smart City company stating a return period, a runoff coefficient or a drain standard was found. The expert committee before the National Green Tribunal found that storm drains covered about 30% of Shimla and that their "Carrying capacity … is not sufficient", their catchments "improperly selected" and their gradients "much lesser … than actually required", so that they were "not able to carry the peak flow" (judgment of 16 November 2017, set aside by the Supreme Court in 2024; the findings are cited as expert evidence only); the 191 drains and nallahs, 55.43 km, built in Shimla under AMRUT, the drainage component of the Shimla Smart City proposal, and the Jal Shakti Vibhag's proposal of ₹19.66 crore for storm drainage at Una state no design storm. The rainfall studies do not supply one either: IMD's national IDF study (Das et al., 2022) has no Himachal Pradesh panel, and the northern-zone equation of Ram Babu, Dhyani and Nirmal Kumar (2006) gives a 50-year 24-hour depth of about 129 mm (this Manual's computation), against about 160–200 mm on the CWC plate at Shimla and 270 mm recorded in 24 hours at the Dharamshala self-recording gauge, and is not used. The bursts on record, 100 mm in an hour at Dharampur on 9 August 1985, 84 mm at Nahan in 1980 and 73 mm at Dharamshala in 1975 (CWC Flood Estimation Report, zone 7), and the 24-hour falls, 600 mm at Dharamshala on 18 July 1967 (the same report) and 273.4 mm at Kangra Aero on 14 August 2023 (IMD), exceed anything the drains were built for. The State's design values are therefore those of the CWC Flood Estimation Report for zone 7 (Western Himalayas), which covers the whole State, with the interim provisions of Chapter 2, 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 Himachal Pradesh calculator serves Tier B authorities in particular, where it may be the whole calculation.

10.6 Professional certification

10.6.1 **Who may sign.** Drainage reports and designs shall be prepared and signed by a registered professional (Clause 1.4) competent in hydrology and hydraulics. For any of the following, the signatory shall be a civil engineer **empanelled as a Stormwater Design Professional** by the Authority or TCP:

- (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 TCP 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 TCP Rules 2014 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 TCP list. The empanelled reviewer shall not have worked on the same site. The Authority remains the decision-maker.

10.7.5 **Concurrent clearances.** Where the approval of the Jal Shakti Vibhag for a work on, or a discharge to, a river, khad or flood-protection work in its charge, among them the channelised Swan and its tributaries, the consent of BBMB for a work that drains to Gobind Sagar, Pong or Pandoh, or of NTPC, SJVN, NHPC, HPSEBL or another operator for a work that drains to its reservoir, the consent of the managing body or the Collector for a work that crosses or discharges to a kuhl scheduled under the Himachal Pradesh Minor Canals Act 1976 (s.46), the permission of the Commissioner or Executive Officer to connect to a municipal drain or to build over one (Himachal Pradesh Municipal Corporation Act 1994 and Himachal Pradesh Municipal Act 1994, whose drain sections were not read [TBC]), the no-objection of SJPNL in Shimla, or of the Jal Shakti Vibhag elsewhere, on sewerage, the views of the State Wetlands Authority (HIMCOSTE) or the Forest Department for a work in or next to a Ramsar site, a wetland of national importance such as Rewalsar or Khajjiar, or forest land, the consent of PWD, NHAI or BRO for a discharge to a side drain, catch-water drain or culvert of one of their roads, the consent of BBNDA or HPSIDC in their areas, the consent of the body that owns or runs the receiving drain where that body is not the Authority (for example Shimla Smart City Ltd or Dharamshala Smart City Ltd until its drains are handed over), 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.

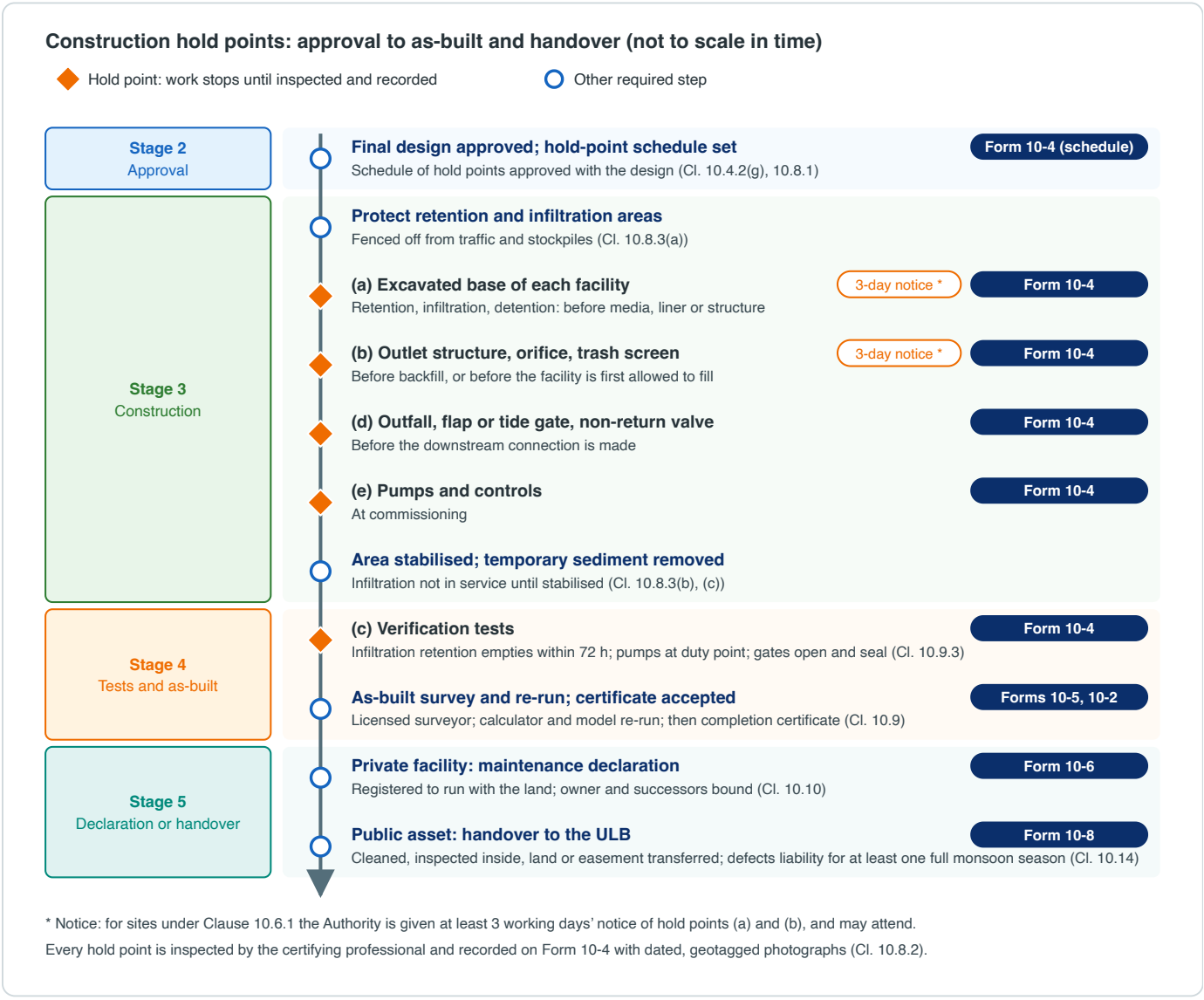

Figure 10.2 — Construction hold points from approval to as-built certification and handover, with the form used at each step (Clauses 10.8–10.10 and 10.14). Hold points are lettered as in Clause 10.8.1. Original drawing for this Manual, adapted from the construction-inspection and maintenance-agreement 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 May** 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 Himachal Pradesh because detention tanks under podiums and in basements are easy to convert to parking or storage once the building is occupied. The 31 May date is set by this Manual to fall before the south-west monsoon (June–September), when most Himachal Pradesh extreme rainfall occurs.

10.11 O&M plans

10.11.1 Every stormwater facility shall have an O&M plan, approved at Stage 2 and finalised at Stage 4. The plan shall include:

- (a) an inventory and a plan drawing of each facility, with design levels, volumes and outlet details;
- (b) routine tasks and their frequency: inspection, debris and sediment removal, vegetation care, screen cleaning;
- (c) the trigger for sediment removal, stated as a depth or a percentage of design volume;
- (d) inspection checklists matching Form 10-7;
- (e) for pumped systems, gates and valves: the operating rules, test schedule, standby power, and actions on a cyclone or heavy-rainfall warning;
- (f) actions to prevent standing water and mosquito breeding, consistent with the drawdown times of Chapter 4;
- (g) safety measures for confined spaces, deep water and public access;
- (h) access routes and equipment needed (Clause 10.13);
- (i) an annual cost estimate and who pays it; and
- (j) the records to be kept, and for how long.

10.11.2 **Public facilities.** For facilities owned by a ULB or department, the O&M plan shall be included in the asset register (Clause 10.14.3) and funded in the annual maintenance budget.

> Commentary. Himachal Pradesh has no dated State order fixing pre-monsoon desilting: the Chief Secretary's directions to clean drains, channels and nallahs, and the Shimla Municipal Corporation's directions to PWD, CPWD and NHAI to keep roadside drains and culverts clean before the monsoon "or face … legal action", are known from the press. The drains are run by several hands: the Municipal Corporations and other ULBs for the municipal drains, the Shimla Municipal Corporation having built its AMRUT drains through its own works wing; PWD, CPWD and NHAI for the road drains and culverts, which carry much of the runoff of the hill towns; SJPNL for water and sewerage in Shimla, over which the Corporation has "limited control"; the Jal Shakti Vibhag for water supply outside Shimla, Solan and Palampur, for sewerage outside Shimla and Solan, and for flood protection, including the channelised Swan; HIMUDA and HPSIDC in their colonies and industrial areas; and the Smart City companies of Shimla and Dharamshala, accountable to the State rather than to the ULBs, whose works are executed by other agencies (CAG, Report No. 1 of 2022). The gates that matter most are run by rules made for other purposes: Bhakra and Pong by BBMB for irrigation and power, Pong releasing about 1.4–1.5 lakh cusecs from 15 August 2023 after its highest inflow on record (as reported); Pandoh, whose five gates were opened together on 30 June 2025 (as reported); and Malana II, whose gates jammed when its reservoir filled with debris in July 2023 (as

reported). No operating rule for any sluice, flap gate or pumping station in a Himachal Pradesh town, linking it to a river stage, a dam release or a rainfall warning, was found in the public domain. Every gate and pump in this Manual needs a written rule for what happens when a warning is issued.

10.12 Inspection frequencies

10.12.1 **Owner inspections.** Owners shall inspect facilities at least as set out in Table 10.3:

Table 10.3 — Minimum owner inspection frequencies

Facility type	Routine	Pre-monsoon (by 31 May)	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 Himachal Pradesh, the pre-monsoon inspection of sluices, flap gates, non-return valves, debris racks, sediment traps, debris basins, culvert inlets and pumped facilities, including the gates on outfalls to Gobind Sagar, Pong, Pandoh and the other reservoirs and tals and on outfalls that the Yamuna at Paonta, the Swan at Una or the Beas at Mandi can close, with the desilting and the clearance of boulders, debris and muck from every drain, inlet, rack, trap, basin and culvert and the pump duty and gate seal tests, shall be completed by **31 May**; inlets, trash and debris racks, culverts, outfall gates and pumped facilities, with their standby generators, shall be certified ready by **15 June**, before the normal onset of 25 June (the earliest recorded onset was 9 June, in 2000), with every gate on an outfall to a river or reservoir operated through its full travel. Pumps, their standby power and the gates shall then be kept on monsoon standby, with the monthly test run, until **31 October**, after the normal withdrawal of 25 September, because the monsoon withdrew later than normal in 8 of the 9 years 2018–2026 and western disturbances bring heavy rain after it, as on 5–7 October 2025, and at an outfall to a river regulated by a dam or barrage upstream, or to a reservoir of BBMB, until the releases have ended and the river at the governing gauge has fallen below its danger level where one is published, if that is later. In the hill towns, and on every drain with an undeveloped hill catchment, every public drain, inlet, debris rack, sediment trap, debris basin and culvert shall be cleared a second time, of the sediment, slide debris and muck of the monsoon, by **31 October**. In towns above about 1,500 m, inlets, gratings, catch-water drains and culvert entrances shall be kept clear of snow and ice from **December to March**, and checked after every snowfall and every winter storm.

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).

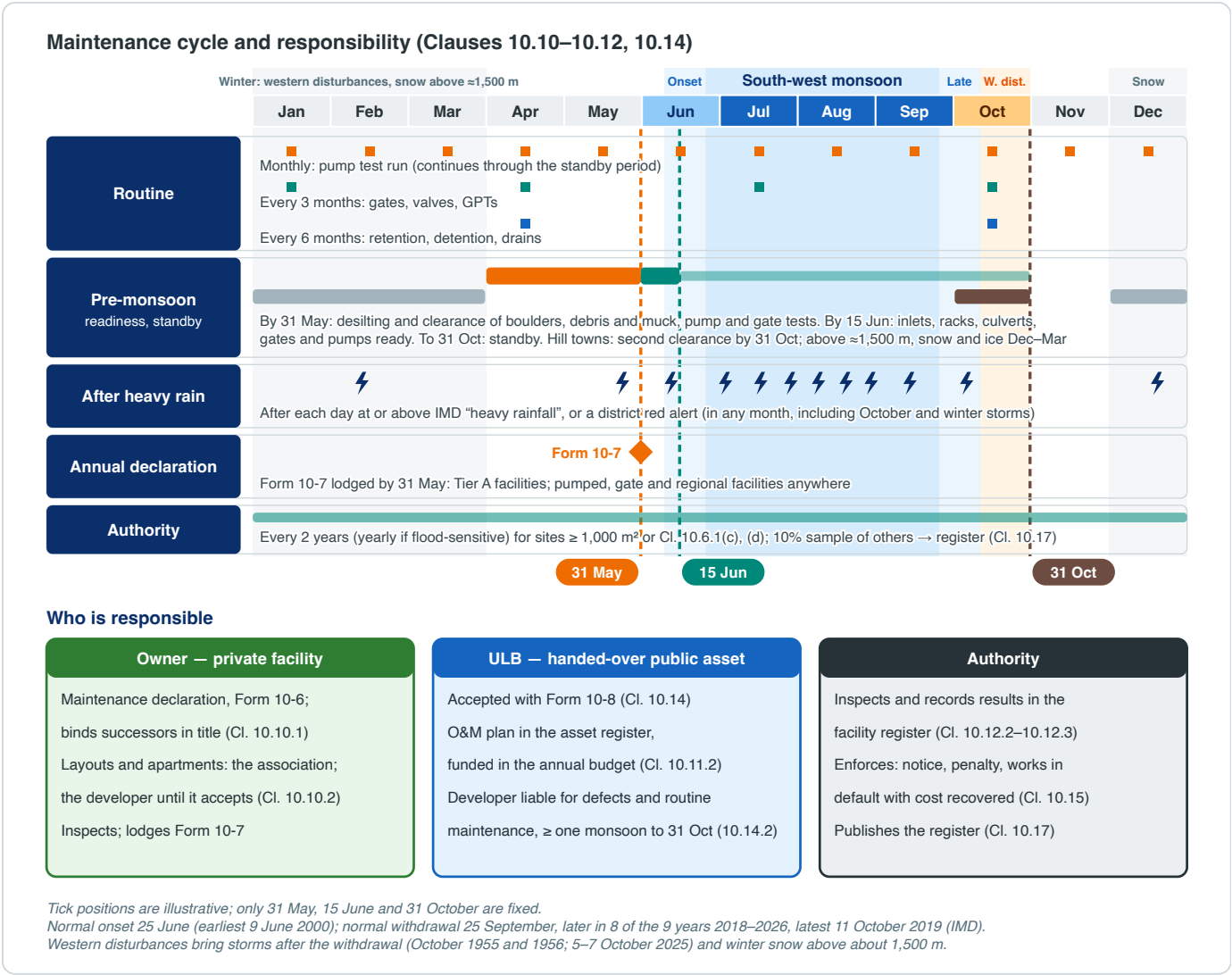

Figure 10.3 — Annual maintenance cycle and who is responsible: routine, pre-monsoon (by 31 May) and post-event inspections, the annual declaration (Form 10-7) and Authority inspections (Clauses 10.10–10.12 and 10.14). Original drawing for this Manual. The timing follows the south-west monsoon (June–September); 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 May deadline is set by this Manual for the onset of the south-west monsoon in the second half of June: the normal onset over Himachal Pradesh is 25 June (IMD normals used from 2024; 24 June before), but the monsoon arrived on 9 June in 2000, 13 June in 2021 and 20 June in 2025 (IMD), and heavy falls come before it, such as 182 mm in 24 hours at the Dalhousie self-recording gauge on 9–10 June 1971 (CWC Flood Estimation Report, zone 7) and the storms reported as cloudbursts in Mandi on 10–13 June 2023 (as reported). No dated State or municipal order fixing a deadline for desilting was found: the Chief Secretary's direction to the ULBs and Panchayati Raj institutions to clean drains, channels and

nallahs "in a campaign mode" within 15 days (2019), the yearly directions on pre-monsoon de-siltation and the removal of blockages, and the Shimla Municipal Corporation's directions to PWD, CPWD and NHAI to clean roadside drains before the onset are all known from the press; this Manual takes 31 May for desilting and the clearance of boulders, debris and muck, the pre-monsoon inspection and the annual declaration. NDMA (2010) sets 31 March for pre-monsoon desilting nationally; this Manual allows until 31 May so that dry-season work can be finished. Inlets, racks, culverts, gates and pumps must in addition be certified ready by 15 June, ten days before the normal onset. The normal withdrawal is 25 September, but the monsoon withdrew later than normal in 8 of the 9 years 2018–2026, as late as 11 October in 2019 (IMD), and western disturbances bring heavy rain and snow after it: 285 mm at Batheri on 4 October 1955, 268 mm at Nichar and 246 mm at Rainka on 10–12 October 1956 and 236 mm at Kullu on 4 October 1888 (CWC Flood Estimation Report, zone 7), and the very heavy rain and first snow of 5–7 October 2025, after the monsoon had withdrawn on 26 September (IMD; as reported); pumps and gates are therefore kept on standby to 31 October (Figure 10.3). Hill drains fill with sediment, slide debris and muck during the season, so in the hill towns a second clearance is made by 31 October. Winter storms bring snow above about 1,500 m, and the Flood Estimation Report lists falls of 610 mm at Kilba and 559 mm at Sangla in December 1958, which this Manual treats as doubtful (Chapter 2), so inlets in the higher towns are kept clear of snow and ice from December to March. The post-event inspections of Table 10.3 cover storms at any time of year.

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 Himachal Pradesh cities make a fixed width hard to apply to every site, so this Manual sets functional requirements. Annex 10C covers maintenance access dimensions.

10.14 Handover of public assets to the ULB

10.14.1 Drains, roads, open space facilities, regional facilities and other stormwater assets that a developer builds for transfer to a ULB shall be handed over only when:

- (a) the as-built certificate (Clause 10.9) has been accepted;

- (b) the facility has been cleaned, and pipes and culverts have been inspected internally (for example by CCTV or manual entry), with the record handed over;
- (c) the land, or an easement over it, has been transferred to the ULB;
- (d) the O&M plan, drawings, GIS data and warranties have been handed over; and
- (e) the **Asset Handover Certificate (Form 10-8)** has been signed by both parties.

10.14.2 **Defects liability.** The developer shall remain responsible for defects and for routine maintenance for a defects liability period that includes at least **one full monsoon season, from 15 June 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 Himachal Pradesh drainage show up only in the first SW 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 Himachal Pradesh Town and Country Planning Rules 2014 are made and from the municipal Acts. The graduated steps are set by this Manual. In Himachal Pradesh the courts and the National Green Tribunal have become the working regulators of the slopes, khads and muck of the hill towns. On Shimla the Tribunal froze new construction in the core and green areas and gave 29 directions, among them that runoff from "all the concretised areas like roads, lanes, platforms and market places" be diverted so that it does "not go in to over burden or flow along hills and depressions" (direction XV) and that rainwater harvesting be mandatory (direction XIV) (*Yogindra Mohan Sengupta v. Union of India*, O.A. No. 121 of 2014, 16 November 2017); the Supreme Court set all its orders aside on 11 January 2024, holding that the Tribunal had "transgressed its limitations", and let the State implement the Shimla Development Plan as published on 20 June 2023 (2024 INSC 30), so the directions are cited in this Manual as expert guidance only. The High Court barred the dumping of muck in Gobind Sagar and "its feeding khuds/nallahas" (22 May 2023) and later directed penal action against the violators and the clearing of the muck from the shores of the lake, its tributaries and public lands within six months (*Madan Lal v. State*, CWPIL 31/2023, 31 May 2024); in another case it observed that a concessionaire's payment of ₹8,45,700 would not make dumped muck "disappear in thin air" (CWP 5243/2022, 26 June 2023). The Tribunal supervises the action plans for the Ashwani Khad and the State's polluted stretches (O.A. No. 735 of 2023; O.A. No. 673 of 2018), and the Supreme Court has taken up the ecology of the State on its own motion (W.P. (C) No. 758 of 2025), with a first report of its Central Empowered Committee reported in October 2026 (as reported; orders not read). The statutes carry limited powers: the TCP Act 1977 deals with unauthorised construction (s.39); the Minor Canals Act 1976 lets the Government regulate the flow in any "line of natural drainage" and order obstructions removed (s.43), and punishes the obstruction or fouling of a kuhl with a fine of up to ₹1,000 (s.65); and the Ground Water Act 2005 lets its Authority direct rainwater harvesting on premises of 100 m² or more (s.15). Rainwater harvesting is enforced through the water connection, which may not be given until the roof-top storage of Appendix 6 of the TCP Rules is in place. The setbacks announced in 2025, 5 m from drains and 7 m from rivers and ravines for buildings, no government building within 150 m of rivers, nullahs and water bodies, and a ban on building along the banks of rivers and streams in model bye-laws for rural areas, are known only from the press, no gazette text was found, and they are not applied in this Manual as rules. 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 level of the receiving river (the Yamuna at Paonta, the only CWC site in the State with warning and danger levels, or the level-monitoring CWC site nearest the town, such as the Swan at Ghaluwal or the Sutlej at Rampur) or of the receiving reservoir or tal, with the level of Gobind Sagar, Pong or Pandoh as BBMB publishes it, converted from feet, and, where it is gauged, at the outfall, each on a named datum, with any reading of a local gauge kept apart from the CWC levels; for an ungauged khad or nallah, and for the Beas at Manali, Kullu and

Mandi, which CWC does not gauge, the flood marks surveyed after the event and the boulders, debris and muck deposited at crossings; the state of every sluice, flap gate, debris rack, sediment trap, debris basin and pumping station on the outfall and on the drain upstream of it, with the volume of debris removed from each, the hours each pump ran and any loss of power; and the gate openings and releases of any dam or barrage that sets the receiving level, such as Larji, Pandoh, Malana, Kol, Bhakra, Pong or the Dakpathar barrage above Paonta;

- (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), HPSDMA, 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. Himachal Pradesh's disasters have been assessed more fully than its town floods. The Post-Disaster Needs Assessment of the monsoon of 2023, prepared with the support of NDMA, put recovery needs at ₹8,667.66 crore, with ₹375 crore for disaster risk reduction, recorded more than 500 deaths, more than 5,400 landslides (5,748 mapped over 45.44 km²) and 83 flash floods, and found that most of the destruction along the Beas in Kullu was "due to overflow of the water along the palaeo channels following the old river course along which the developmental activities have taken place"; its damage totals differ between its tables and its text, and its counts of cloudbursts (45 and 27) differ from the 52 reported by HPSDMA. HPSDMA's technical committees examined the slides of August 2023 in Shimla, Mandi, Kullu, Solan and Hamirpur; the Shimla committee named the saturated debris cover, open drainage and an old buried stream channel among the causes of the Summer Hill slide of 14 August 2023, in which about 20 people died at Shiv Bawri. The CAG found in its audit of flood protection (reported as Report No. 6 of 2017, laid in 2018; number as reported) that only about 11% of the State's estimated 2.31 lakh ha of flood-prone land had been covered by March 2017, that the department had made no scientific assessment of flood-prone areas and no basin-wise plan, that three of the five projects checked had no morphological study and that no robust flood-forecasting system existed (as reported); and in 2025 it reported ₹22.61 crore of the State Disaster Response Fund diverted to inadmissible works in five districts (Report No. 2 of 2025, as reported). The events since, the cloudbursts at Samej, Bagipul and Rajban on 31 July 2024, in which 56 people were reported killed at Samej, and the floods of Seraj and Thunag in Mandi on 30 June–1 July 2025, fell where no gauge recorded the rain (IMD; as reported). No review of any flood in a Himachal Pradesh town, and no record of flood extents, depths or durations kept by any ULB or by HPSDMA, was found, and final tolls for 2023, 2024 and 2025 were not published. NDMA (2010) called for automatic rain gauges at "1 in every 4 sq km" in Class I, II and III cities. Clause 10.16.1 asks only for gauges where they serve design and review. The report and sampling intervals are set by this Manual.

10.17 Data publication

10.17.1 Each Authority shall publish, on a public website, and update at least quarterly:

- (a) a **facility register**: location, type, design volume, release rate, owner, date of as-built acceptance, and the latest inspection result for every facility approved under this Manual;
- (b) a summary of each approved drainage report, with Forms 2-1 and 10-2;
- (c) the register of variances and waivers (Clause 1.10);
- (d) the alternatives adopted under the Policy Supplement (Clause 1.7);

- (e) enforcement actions (Clause 10.15.5); and
- (f) event reports and post-event reviews (Clause 10.16).

10.17.2 The State Stormwater Technical Committee shall publish the compliance calculator, all Annexes, the flood-sensitive catchment maps and the State-level summary of facility registers as open data.

10.17.3 Personal data other than the name of a corporate owner or association shall not be published. Security-sensitive details of critical infrastructure may be withheld, with the reason recorded.

10.17.4 Published data shall be machine-readable (for example CSV and GeoPackage) and released under the Government Open Data Licence – India or an equivalent open licence.

> Commentary. Transparency is a design criterion in its own right here. Some of Himachal Pradesh's drainage records are public: the TCP Rules 2014 as consolidated to 2022 and their appendices on the TCP Department's website; the Chopal and other development plans; the Supreme Court's judgment of 2024 and the Tribunal's of 2017, with the expert committee's findings on Shimla's drains; the Ground Water Act 2005 and the Minor Canals Act 1976; the PDNA of 2023 and the State's recovery plan; HPSDMA's technical committee reports on the slides of 2023; the affidavits and action plans for the polluted stretches filed before the Tribunal; the Shimla Municipal Corporation's disaster-risk plan of 2015 and its AMRUT status reports; the CAG's audits; IMD's monsoon reports for the State; and the State Wetlands Authority's booklet on its major wetlands. Much else could not be found in the public domain: the TCP amendments after 2022, including the draft Sixteenth Amendment of 2025 and any text of the setbacks announced in 2025; the rural model bye-laws; the text of the Shimla Development Plan 2041 and its storm-water chapter and zone maps; the drain sections of the municipal Acts; the design basis of any storm drain, including SJPNL's drainage study for Shimla, the Dharamshala Smart City drains and the Jal Shakti Vibhag's proposal for Una; the design flood of the Swan embankments; CWC's site sheets and gauge datums; the datum of BBMB's reservoir gauges and the maximum water level of Pong; the full reservoir level of Pandoh; the operating rules of the State's dams and barrages; HPSDMA's operating procedures for urban floods; and an inventory of the gates, racks 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, tal 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. Himachal Pradesh's towns have drainage projects and proposals, but no published storm-drainage master plan with a design storm. In Shimla, whose network goes back to drains of the British period whose records the Municipal Corporation has sought from the Revenue Department so that they can be reopened (as reported), the expert committee before the National Green Tribunal found in 2017 that storm drains covered about 30% of the city and could not carry the peak flow, with catchments "improperly selected" and gradients far too flat. The counts of the network conflict: the Corporation's disaster-risk plan of 2015 (with UNDP) gives 13 major nallahs and about 67 storm drains with a total length of about 42.33 km, while its AMRUT reports record 191 major storm drains and nallahs, 55.43 km, built for ₹20.64 crore, probably a different scope; its draft City Development Plan 2041 proposes ₹25.47 crore of new drains and ₹179.00 crore for the rejuvenation of the major nallahs; and after the slides of 2023 the Corporation asked SJPNL for a study by geologists, remote sensing and drones and a project report on its drains, whose output was not found (as reported). In Dharamshala the drainage is reported still inadequate after Smart City spending of more than ₹500 crore (as reported), and no drainage project report was found. In Baddi–Barotiwala–Nalagarh the drains are planned through the action plans for the polluted Sirsa and Balad, which list the loads of the Balad Khad, the Sandholi, Housing Board, Khera, Manpura and HPSIDC drains and the common effluent treatment plant outfall, and a sewerage scheme of ₹33.34 crore for Baddi, but no storm-drainage master plan of BBNDA was found. For the Beas at Mandi and in Kullu–Manali a channelisation project report of 2021, of about ₹1,600 crore, "may reach around Rs. 2000/- crore", but the PDNA of 2023 advised that channelisation "predominantly require[s] concretisation, which is not advisable in Himalayan Ecology" and asked that the proposal be reviewed "with Nature Based Solution Approach", and the State has told the Tribunal that it recommended dropping channelisation because it "may affect the cross drainage and hamper

the natural drainage system" (O.A. No. 735 of 2023, 2024); the recovery plan lists protection works on the Beas at Manali (₹243.37 crore) and against flash floods at Bhuntar (₹31.23 crore). At Una the Swan has been channelised by the Jal Shakti Vibhag with embankments and the treatment of its tributaries (₹945.49 crore or ₹922.49 crore; the figures conflict), with no design return period stated, and a proposal of ₹19.66 crore for storm drainage in Una town awaits funding. No published document sets a design return period for the storm-drain network of any Himachal Pradesh town. This chapter supplies the design storm, levels of service, storage and buffer criteria that such a plan needs, with the design storms of Chapter 2 and the levels of service of Clause 11.6; it has not been adopted by the TCP Department, the Urban Development Department, any Municipal Corporation or other ULB, the Jal Shakti Vibhag, SJPNL, BBNDA, HPSDMA or any other body. A site-level manual cannot fix basin-level problems: lost tank storage, khads and nallahs that carry boulders, slide debris and muck onto towns built on their fans, terraces and old channels, as along the Beas in Kullu in 2023, slopes that open drains saturate, as at Summer Hill and Krishna Nagar in Shimla in 2023, drains that end in reservoirs held high by BBMB or in rivers below dams, nallahs that carry sewage to drinking-water sources, as to the Ashwani Khad in 2016, and single drains split between a Municipal Corporation, PWD, SJPNL, the Jal Shakti Vibhag and a Smart City company, 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 Himachal Pradesh, the second mountain State in the series after Uttarakhand: to towns in three settings, the Siwalik valleys of Una, Baddi–Nalagarh and Paonta, whose drains cross boulder fans to rivers held high by floods or by channel embankments; the mid-hill towns, Shimla, Solan, Mandi, Dharamshala and Chamba among them, built on slopes of 45°–60° where open drains saturate the debris cover and slides decide more than the design storm; and the valley towns of Kullu, Manali and Rampur, on terraces, fans and old river channels below dams and glaciers; to reservoir towns, Bilaspur and the towns of the Pong shore, whose drains end in BBMB's reservoirs, with levels published in feet; to nallahs that are storm drains, sewers and water-source catchments at once, as the Ashwani Khad showed in 2016; to drains run by ULBs, PWD, SJPNL, the Jal Shakti Vibhag and Smart City companies, beside khads that no rule assigns; to a State with its own planning, groundwater and minor canals Acts, but no floodplain law, no flood line and no design return period for the drains of any town; to springs and kuhls that supply and drain the hill towns, and slopes that infiltration can destabilise; and to a monsoon whose worst days, 600 mm at Dharamshala in July 1967 (CWC Flood Estimation Report, zone 7) and the cloudbursts of 2023–2025, fall where few gauges stand, and whose worst floods in the high valleys, Parechu in 2005 and Samej in 2024, were outbursts and debris flows that no drain can carry, so that in the high mountains a BSMP begins with the hazard, not the storm (Clause 11.3.3).

11.2 Definitions

Term	Meaning in this Manual
Basin	The land draining to one outfall to the sea, a river, or a major waterbody, as delineated under Clause 11.3.
Basin Stormwater Master Plan (BSMP)	The plan for one basin prepared under this chapter.
Lead Authority	The body responsible for preparing a BSMP (Clause 11.4).

Term	Meaning in this Manual
Level of service (LoS)	The flood performance a part of the drainage system must achieve, expressed as an AEP and an outcome (Clause 11.6).
Flood hazard map	A map of flood extent, depth, velocity and hazard class (H1–H6, Chapter 6) for a stated AEP and scenario.
Regional facility	A storage, conveyance or outfall work serving more than one development, identified in a BSMP.
Capital Improvement Programme (CIP)	The ranked, costed list of works in a BSMP (Clause 11.8.4).

11.3 Planning unit: the basin, not the ward

11.3.1 BSMPs shall be prepared **by hydrological basin**, not by ward, zone or local-body boundary. Where a basin crosses local-body boundaries, one BSMP shall cover the whole basin.

11.3.2 Basin boundaries shall be delineated from the digital elevation model of Clause 11.5.2, checked against the drain network, road embankments, canals and tank supply channels. Diversions between basins, whether by canal, drain or surplus course, shall be mapped and represented in the model.

11.3.3 No basin delineation has been published for any Himachal Pradesh town. For the urban areas where the evidence identifies them, the basins are at least the following:

- **Shimla, nallahs and sinking zones:** the catchments of the nallahs of the Shimla Planning Area that drain north to the **Sutlej** and south to the **Ashwani Khad** and the Giri, among them the 13 major nallahs of the Corporation's plan of 2015, with the drains of the British period and those built under AMRUT in the 1D network, the two sinking and sliding zones shown, the water intakes and sewage treatment plants on the Ashwani Khad marked, and the 1% AEP level of the ungauged nallahs and khads, with sediment and debris, as the boundary condition;
- **Mandi, Beas and Suketi:** the catchments of Mandi that drain to the **Beas** and the **Suketi** at their confluence, with the releases of **Larji** and **Pandoh** upstream and surveyed flood marks of 2023 and 2025 (the Panchvaktra temple was submerged in July 2023, as reported) as boundary conditions, since CWC has no site there;
- **Kullu, Bhuntar and Manali, Beas:** the catchments of the valley towns and of every side khad that crosses them, including the **Sarvari** at Kullu and the **Parbati** at Bhuntar, with the old channels of the Beas that the floods of 2023 reoccupied mapped, the releases of Malana and the Parbati projects as an upstream boundary, and surveyed flood marks as the river boundary;
- **Dharamshala–Kangra, Dhauladhar khads:** the catchments of the khads that cross Dharamshala, McLeodganj and Kangra, among them the **Manjhi**, the **Gaj**, the **Banner** and the nallah at **Bhagsunag** that flooded on 12 July 2021, with debris racks and basins at the foot of the range and the 1% AEP level with debris as the boundary condition;
- **Baddi–Barotiwala–Nalagarh, Sirsa and Balad:** the catchments that drain to the **Sirsa** and the **Balad** through the Sandholi, Housing Board, Chikni and Ratta khads and the industrial drains, with the effluent plant outfall in the 1D network and the separation of industrial drains from storm drains shown;
- **Parwanoo, Sukhna:** the catchments of Parwanoo that drain to the **Sukhna**, with its sewage loads;
- **Una, Swan:** the catchments of Una that drain to the **Swan** through its embankments, with the level at CWC's **Ghaluwal** site (high flood level 367 m) and the surveyed 1% AEP level of the channelised river as the boundary, and the outfall-closed case a design case;
- **Paonta Sahib, Yamuna and Bata:** the catchments that drain to the **Yamuna** and the **Bata**, with the level at CWC's Paonta site (danger 384.5 m, high flood level 384.6 m) and at Ganguwala (373.52 m) as the boundary and the outfall-closed case a design case;
- **Bilaspur and the Pong shore, reservoirs:** the catchments of Bilaspur that drain to **Gobind Sagar** and of Dehra and the other towns that drain to **Pong**, with the reservoir at the level of Chapter 5, converted from feet, as the boundary, and the khads feeding the reservoir kept free of muck;

- **Rampur Bushahr, Sutlej:** the catchments of the town and its khads, with the high flood level at CWC's Rampur site (933 m, set by the Parechu outburst of 2005; a 2023 reading of 924.5 m conflicts) and a glacial-lake or landslide-lake outburst scenario as boundary conditions; and
- **Chamba, Ravi,** and **other valley towns**: the catchments of the town and of every khad that crosses it, with surveyed flood marks where CWC has no site, and the debris fans, landslide and sinking zones above the town mapped.

Hazard first in the high mountains (set by this Manual). In sub-area HP-C (High and trans-Himalaya; Kinnaur–Lahaul–Spiti; snow-fed) of Annex 2A, and in any basin with a glacier, a glacial lake or a mapped debris-flow fan above it, the BSMP begins with a hazard screening for glacial-lake outbursts, debris flows and landslide dams, made with HPSDMA, the State Centre on Climate Change and CWC's glacial-lake monitoring, and uses site-specific hydrology in place of the zone-7 report (Clause 2.3.6(i)). The State Centre on Climate Change counted 562 glacial lakes in the Sutlej basin, 242 in the Chenab, 93 in the Beas and 37 (38 in another report) in the Ravi in 2019 (as reported), and the outburst of the Parechu lake in Tibet on 26 June 2005 raised the Sutlej by 12–15 m and set the high flood levels at Titang, Nathpa and Rampur (as reported). The hazard zones are shown on the 1% AEP map, no drain, storage or pumping station is sited in them, and no work in the CIP is sized to carry a debris flow or an outburst. Other Tier A bodies, among them Solan, Palampur, Hamirpur and Nahan, shall define their basins in the first BSMP that covers them. Where CWC, BBMB, a dam operator, the Jal Shakti Vibhag, a development plan or a court has a high flood level, a reservoir level, a flood line or an operating rule for a dam, barrage or pumping station, the BSMP shall take its boundary conditions from it and show those levels against its own 1% AEP map.

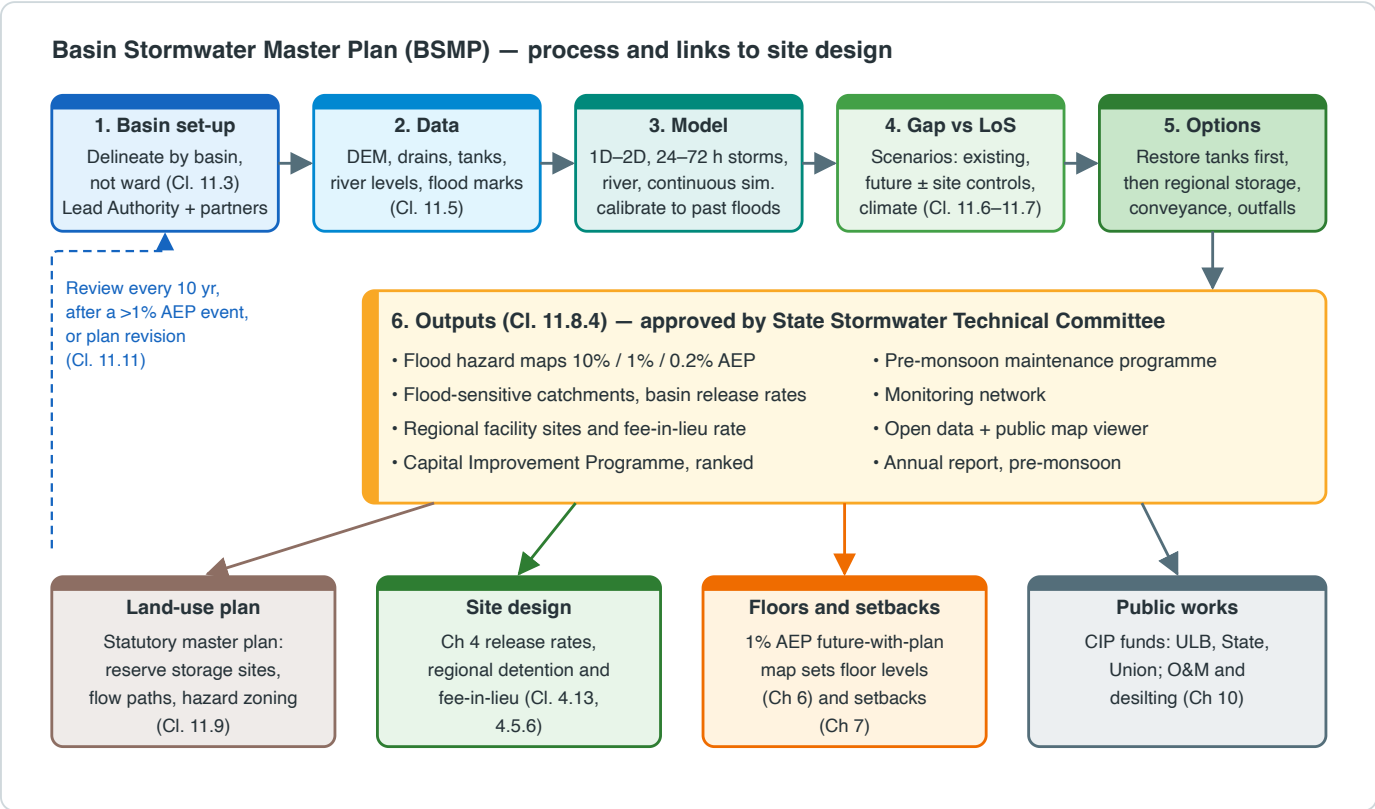


Figure 11.1 — Basin Stormwater Master Plan process and its links to site design. Original drawing for this Manual. The phase structure is adapted from Defra, Surface Water Management Plan Technical Guidance (2010), and Mile High Flood District master planning practice.

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 Himachal Pradesh a single nallah passes through many hands on its way to a river. In Shimla the nallahs are at once storm drains, sewage carriers and the catchments of water sources: the Ashwani Khad, which drains the south of the city to the Giri, took the effluent of the Malyana and Dhalli sewage treatment plants and caused the outbreak of hepatitis E that began in January 2016, after which its water

> intake was shut (Bhagra et al., 2017); the drains in the town are the Municipal Corporation's, its sewers SJPNL's, its road drains PWD's, NHAI's or CPWD's, and the forest slopes above them the Forest Department's; and the drains built under the Smart City Mission are the company's until they are handed over. In Baddi–Barotiwala–Nalagarh the Sirsa, about 54 km long with a catchment of about 550 km², runs 28 km in Himachal Pradesh between reaches in Haryana and Punjab, and its industrial drains, khads and the effluent plant outfall are the concern of BBNDA, HPSIDC, the Jal Shakti Vibhag, HPSPCB and the ULBs. No rule divides the khads and natural nallahs from the municipal drains (as this Manual reads the record); the only State power found to regulate a "line of natural drainage" and order obstructions removed is s.43 of the Minor Canals Act 1976. This clause makes the basin the planning unit, so that one model carries each nallah from its head on the ridge to the river whoever owns each reach, and so that the sewage it carries is separated before it reaches a water source (Chapter 8, Clause 8.9.5).

11.4 Who prepares, and when

11.4.1 **Lead Authority.**

- For the basins of a town with a Municipal Corporation: the **Municipal Corporation** (in Shimla, **SMC**; elsewhere the Municipal Corporations of Dharamshala, Mandi, Solan and Palampur), whose drains are run under the Himachal Pradesh Municipal Corporation Act 1994, jointly with the **TCP Department**, which prepares the interim and final development plans of the planning areas, among them the Shimla Development Plan 2041, into which the BSMP is taken (Clause 11.9); either may prepare the plan as the Urban Development Department directs. In Baddi–Barotiwala–Nalagarh, **BBNDA** is joint Lead Authority with the ULBs in its area. Where a basin extends beyond the ULB or the planning area, the other local bodies, the panchayats and the planning authorities in the basin are partners, and one BSMP covers the whole basin (Clause 11.3.1).
- No order dividing the khads and natural nallahs from the municipal drains, or the drains of the local bodies from the rivers and reservoirs, was found; until one is made, this Manual assigns the reaches within each BSMP as follows, each body being Lead Authority for the reaches and works it owns or runs and for the parts of the CIP on them: the **Jal Shakti Vibhag** for the rivers, khads and nallahs outside ULB limits with their beds, banks and flood-protection and channelisation works, among them the Swan, the Sirsa, the Balad and the Beas, and for the kuhls in its charge; the **Municipal Corporation**, **Nagar Parishad** or **Nagar Panchayat** for the drains and nallahs within its limits; **Shimla Smart City Ltd** and **Dharamshala Smart City Ltd**, **HIMUDA**, **HPSIDC**, **BBNDA** or a colony developer for the drains of their works and schemes, until handed over in writing; **PWD** for the side drains, catch-water drains, scuppers and culverts of the State roads and hill roads, and **NHAI**, CPWD and BRO for theirs, with the muck dumps of their works; **SJPNL** in Shimla and the **Jal Shakti Vibhag** elsewhere for the sewers and treatment plants whose effluent reaches the drains; **BBMB** for Bhakra (Gobind Sagar), Pong and Pandoh, and **NTPC**, **SJVN**, **NHPC**, **HPSEBL** and the other operators for their dams, for their reservoir levels and releases; the **State Wetlands Authority**, with HIMCOSTE as its secretariat, and the Forest Department for Pong Dam Lake, Renuka, Chandertal, Rewalsar, Khajjiar and other wetlands; and **HPSDMA**, with the State Centre on Climate Change, for the mapping of landslide, debris-flow and glacial-lake hazards that a BSMP must show.
- In Tier B bodies: the Lead Authority is named by the Urban Development Department. Basins draining to a common river reach, reservoir or tal may be grouped into one district-level plan.

HPSDMA, the Deputy Commissioner and the State Geologist shall be consulted on every BSMP; BBMB or the dam operator on every BSMP whose basin drains to a reservoir or to a river below a dam; the State Wetlands Authority on every BSMP whose basin drains to a Ramsar site or wetland of national importance; HPSPCB on every BSMP that proposes works on a drain or khad that carries sewage or industrial effluent, among them the Ashwani Khad, the Sirsa, the Balad and the Sukhna; the Collector or the managing body on any work that crosses or discharges to a scheduled kuhl; and, for a basin whose outfall lies on a river shared with a neighbouring State, such as the Sirsa below Nalagarh, the Swan below Una or the Yamuna at Paonta, that State's water resources department, through the Jal Shakti Vibhag.

The Jal Shakti Vibhag 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, tal, pond and marsh under Chapter 7: FTL, MWL, bund level, stage–storage, sluices, surplus weirs, supply channels, encroachment
Rivers and canals	Cross-sections at no more than 200 m spacing and at every structure
Outfalls, rivers, khads, reservoirs and tals	The datum of every level named; outfall invert levels against the warning, danger and high flood levels of the receiving river at the nearest CWC site and its recorded peaks (on the Yamuna at Paonta a warning level of 383.5 m, a danger level of 384.5 m and a high flood level of 384.6 m; elsewhere high flood levels only, such as 367 m on the Swan at Ghaluwal and 933 m on the Sutlej at Rampur, where a reading of 924.5 m is also quoted; CWC levels as transcribed by SANDRP, as reported), with any local gauge kept as a separate series; for the Beas at Manali, Kullu, Mandi and Pandoh, the Sutlej at Bilaspur, the Ravi at Chamba and the ungauged khads and nallahs, surveyed flood marks, the debris lines of 2023 and 2025 and the 1% AEP flood level with its sediment and debris; for outfalls to reservoirs and tals, the maximum water level, full reservoir level and spillway and gate data from BBMB or the operator, converted from feet where BBMB publishes them so (for example Gobind Sagar, full reservoir level 1,680 ft, about 512.06 m; Pong, full reservoir level 1,390 ft, about 423.67 m, with a maximum level quoted as 1,400, 1,410 or 1,421 ft; Kol, reservoir level 642 m), naming which is used, and Rewalsar and the other tals at their outlet levels; the release records of Larji, Pandoh, Malana, the Parbati projects, Nathpa Jhakri, Kol, Bhakra and Pong; the debris-flow fans, landslide zones, muck dumps and glacial lakes above the basin, from HPSDMA, the State Centre on Climate Change and CWC's glacial-lake monitoring where mapped; and the sluices, flap gates, debris racks, sediment traps, debris basins and pumping stations on the outfalls, with their capacities and operating rules

Data	Minimum requirement
Rainfall and levels	All available rain gauges (IMD, including its observatories and stations at Shimla, Dharamshala, Kangra (Gaggal), Mandi, Sundernagar, Una, Solan, Bhuntar, Manali, Kalpa and Keylong and the automatic weather stations reported by the Meteorological Centre Shimla, among them Una Rampur and Kangra Aero; the district and tehsil rain gauges of the State; the self-recording gauges at Shimla, Dharamshala, Dharampur, Nahan, Dalhousie, Sundernagar and Bhuntar used for the CWC Flood Estimation Report for zone 7; the river gauges of CWC; the rain and reservoir records of BBMB at Bhakra, Pong and Pandoh, and of NTPC, SJVN, NHPC and HPSEBL at their dams; and any gauges kept by the Municipal Corporations, the Smart City companies, HPSDMA and the Jal Shakti Vibhag) and water-level records, including those for the 9–11 July 2023 (228.5 mm at Una Rampur AWS on 9 July and 250.0 mm at Nahan on 11 July, IMD, with new high flood levels on the khads of Sirmaur and Kinnaur, as reported), 14–15 August 2023 (273.4 mm at Kangra Aero and 250.2 mm at Dharmsala, IMD, with the slides at Summer Hill and Krishna Nagar in Shimla), 31 July–1 August 2024 (the cloudbursts at Samej, Bagipul and Rajban, where no gauge recorded the rain, as reported), 30 June–1 July 2025 (140.7 mm over Mandi district in 24 hours, with the floods of Seraj and Thunag, as reported) and 5 September 1995 (the Yamuna at Paonta at its high flood level of 384.6 m, CWC as transcribed by SANDRP) 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 Siwalik valley floors of Una, Paonta–Kala Amb and Baddi–Nalagarh and in the Balh valley, where slopes are gentle and, in the Balh, the water table is near the surface, on the fans and river terraces of Kullu, Manali, Mandi and the other valley towns, where a raised road, a muck dump or a low wall can turn the overflow of a khad from one side of a fan to the other, and along the old channels of the Beas that its floods reoccupied in 2023, 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 9–11 July 2023 (228.5 mm at Una Rampur AWS on 9 July and 250.0 mm at Nahan on 11 July, IMD, with new high flood levels on the khads of Sirmaur and Kinnaur, as reported), 14–15 August 2023 (273.4 mm at Kangra Aero and 250.2 mm at Dharmsala, IMD, with the slides at Summer Hill and Krishna Nagar in Shimla), 31 July–1 August 2024 (the cloudbursts at Samej, Bagipul and Rajban, where no gauge recorded the rain, as reported), 30 June–1 July 2025 (140.7 mm over Mandi district in 24 hours, with the floods of Seraj and Thunag, as reported) and 5 September 1995 (the Yamuna at Paonta at its high flood level of 384.6 m, CWC as transcribed by SANDRP) events are the best calibration data Himachal Pradesh has, and much of the evidence is held in photographs, news reports and residents' records that should be collected before it is lost.

11.6 Levels of service

11.6.1 Each BSMP shall adopt the following minimum levels of service. A BSMP may adopt stricter levels.

Table 11.2 — Minimum levels of service

Element	Minimum level of service
Minor system	The design AEP of Chapter 6 (Table 6.1)
Habitable buildings	No flooding above floor level in the 1% AEP (100-yr) event

Element	Minimum level of service
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 tal 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. Himachal Pradesh's storage is in its reservoirs, its few natural lakes, its valley floors and its springs more than in tanks. Pong Dam Lake (Ramsar site, 15,662 ha), Renuka (20 ha) and Chandertal (49 ha) are its Ramsar sites (MoEFCC; the State Wetlands Authority's booklet gives the larger areas of the sanctuaries), and Rewalsar and Khajjiar are wetlands of national importance; Rewalsar, a lake of 2.6 ha in a catchment of 173 ha, is reported eutrophic from leaking sewage drains, and Khajjiar silting from its streamlets (State Wetlands Authority). The State Wetlands Authority was constituted on 7 November 2017 under the Wetlands Rules 2017, with HIMCOSTE as its secretariat, but no wetland has been found notified under Rule 4. Pong's water spread varies from about 125 km² at 1,280 ft to about 220 km² at 1,390 ft (booklet), and Gobind Sagar has lost a large part of its storage to silt, by 38% or 47% depending on the source (as reported). Kuhls, the gravity channels scheduled under the Minor Canals Act 1976, and the nauns and baolis of the hill towns are small stores and carriers of hill runoff; the site plans of the TCP Rules must show every "Bauri, Well, Nallah, khud". The losses are visible in the khads and on the shores: muck dumped into Gobind Sagar and its feeding khuds, which the High Court ordered cleared (2024), and the old channels of the Beas built over in Kullu (PDNA, 2023). No survey of the storage of any tal, or of any floodplain inside a ULB, was found.

11.7 Modelling and scenarios

11.7.1 **Model.** Each BSMP shall use a coupled 1D–2D hydraulic model of:

- the minor system;
- the major (overland) system;
- rivers, canals and tanks; and
- the outfalls.

Methods shall follow Chapter 3. Tidal and river boundaries shall follow Chapter 5.

11.7.2 **Design storms.** The model shall be run for the design storms of Chapter 2, including the 24-, 48- and 72-hour storms, for at least the 50%, 10%, 1% and 0.2% AEPs. Areal reduction shall be applied under Clause 2.7.3.

11.7.3 **Continuous simulation.** Basins with tank cascades shall also be run by continuous simulation (Clause 3.13), using the full IMD gridded daily record where available and at least 30 years, disaggregated by the temporal patterns of Annex 2D. This shows how full the tanks are when the design storms arrive, and how often heavy rain coincides with a

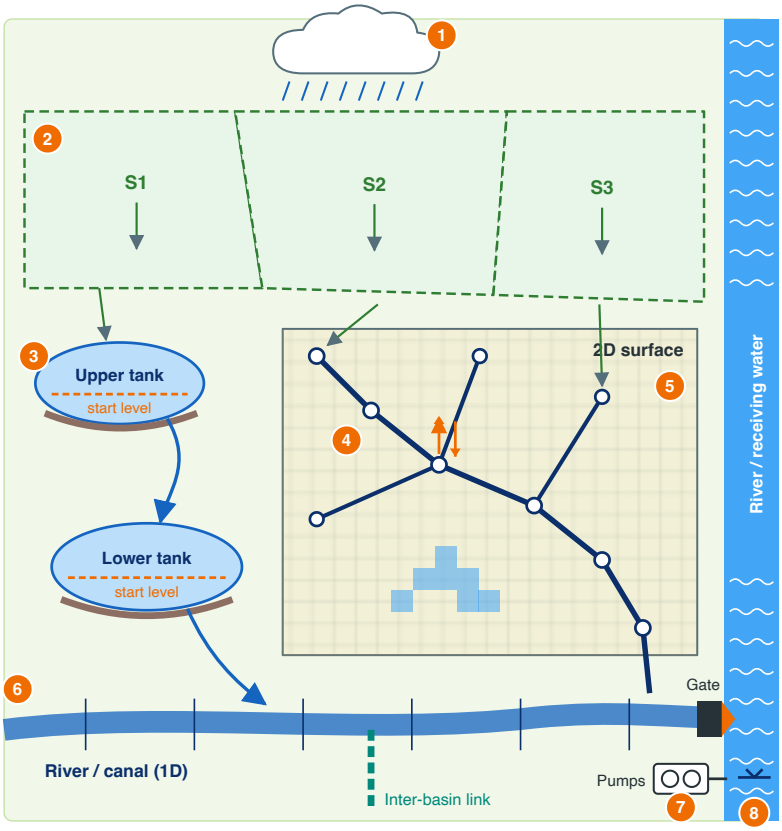
closed outfall. The two-step approach of Clause 3.13.5 may be used: a simplified storage model is run for the whole record, and the coupled 1D–2D model of Clause 11.7.1 is run only for the design storms, starting from the tank levels the continuous run gives. A continuous run of the full 1D–2D model is not required.

11.7.4 **Scenarios.** Each BSMP shall model at least:

- (a) **Existing:** existing land use, network, tanks and outfalls;
- (b) **Future, uncontrolled:** future land use under the statutory master plan, with no site controls;
- (c) **Future, controlled:** future land use with the site controls of Chapter 4;
- (d) **Future, with plan:** scenario (c) plus the works of the CIP; and
- (e) **Climate:** scenarios (a) and (d), with the climate factors of Clause 2.8, used unchanged: no projection of heavy rainfall for Himachal Pradesh has been adopted with a design factor; the State Action Plan on Climate Change (version 2, 2021–2030) projects annual rainfall rising by 5.9% (RCP4.5) to 14% (RCP8.5) by mid-century and says that heavy rainfall and floods are "likely to increase", while it finds decreasing trends in annual rainfall and rainy days (high confidence) and in the 1-day maximum (low confidence) over 1951–2013; and the monsoons of 2023 and 2025 brought new 24-hour records at several stations (IMD, with the conflicts stated in Chapter 2) and new high flood levels on the khads of Sirmaur and Kinnaur (as reported), which is a reason to keep the factors, not to reduce them; in snow-fed basins of sub-area HP-C the climate scenario adds no rainfall factor, and the debris-flow and glacial-lake hazards of Clause 11.3.3 are mapped instead.

11.7.5 **Calibration.** The model shall be calibrated and validated under Clause 3.15, using at least two of the 9–11 July 2023 (228.5 mm at Una Rampur AWS on 9 July and 250.0 mm at Nahan on 11 July, IMD, with new high flood levels on the khads of Sirmaur and Kinnaur, as reported), 14–15 August 2023 (273.4 mm at Kangra Aero and 250.2 mm at Dharmsala, IMD, with the slides at Summer Hill and Krishna Nagar in Shimla), 31 July–1 August 2024 (the cloudbursts at Samej, Bagipul and Rajban, where no gauge recorded the rain, as reported), 30 June–1 July 2025 (140.7 mm over Mandi district in 24 hours, with the floods of Seraj and Thunag, as reported) and 5 September 1995 (the Yamuna at Paonta at its high flood level of 384.6 m, CWC as transcribed by SANDRP) events where data exist.

BSMP model: elements required by Clause 11.7 (schematic, not to scale)



1 **Design rainfall**
Ch. 2 storms incl. 24, 48, 72 h; 50%, 10%, 1%, 0.2% AEP; areal reduction (Cl. 2.7.3, 11.7.2)

2 **Sub-catchments**
Runoff by Ch. 3 methods; land use for each scenario (a)–(e) of Cl. 11.7.4

3 **Tanks and ponds**
Surveyed FTL, MWL, stage–storage, sluices, surplus weirs (Cl. 11.5.1); start level from continuous run (Cl. 3.13.5, 11.7.3)

4 **1D drain network**
Minor system: drains, pipes, culverts with surveyed inverts and silt (Cl. 11.5.1)

5 **2D surface**
Major (overland) system on the DEM, 0.15 m RMSE or better; exchange with 1D at inlets and manholes

6 **Rivers and canals (1D)**
Sections ≤ 200 m apart and at every structure; diversions between basins mapped (Cl. 11.3.2)

7 **Outfall**
Sluices, flap gates and pumps; joint and outfall-closed cases of Ch. 5

8 **Downstream boundary**
River (CWC gauge), reservoir or tal level (MWL or FTL + surcharge), per Ch. 5

Calibrate and validate with at least two major past flood events where data exist (Cl. 11.7.5).

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 tals 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:** tals, tanks, marshes and floodplains, including desilting to the original bed and recovering encroached area (Chapter 7);
2. **Regional retention and detention**, sited by modelling so that releases do not coincide with the main-stem peak (Clause 4.13);
3. **Conveyance** upgrades to drains, canals and culverts;
4. **Outfall works:** flap gates and penstocks on the outfalls to the Yamuna at Paonta, the Swan at Una and the Beas at Mandi, and on the outfalls of Bilaspur and the Pong-shore towns to the reservoirs, with storage or pumping behind them where a river in flood or a reservoir held near its full level can close an outfall; debris racks, sediment traps and debris basins where khads and nallahs from the hills enter the towns, with ramps for the machines that empty them, and the removal of muck dumped in the khads and nallahs; drop structures, chutes, energy dissipators and protected outfalls where steep drains reach a khad or river, never an unprotected slope; screening, and the separation of sewage and industrial effluent, before the outfalls to the Ashwani Khad, the Sirsa, the Balad and the Sukhna; and the release rules of Larji, Pandoh, Bhakra, Pong and the other dams that set the receiving levels, agreed with BBMB and the dam operators;
5. **Property-level protection** where works cannot reach the level of service; and
6. **Non-structural measures:** flood warning (for example IMD district rainfall warnings and nowcasts issued by the Meteorological Centre Shimla, the CWC flood forecast for the Yamuna at Paonta and the river stages at its other sites, notice of releases from Larji, Pandoh, Malana, Kol, Nathpa Jhakri, Bhakra and Pong to the towns downstream, the forecast-based dam management system and early warning that the PDNA of 2023 proposes, and the district emergency operation centres of HPSDMA), 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 groundwater recharge on the Siwalik valley fills of Una, Paonta–Kala Amb and Nalagarh, where the stage of extraction is highest (Una 63.72%, Solan 57.89%; CGWB, 2024), the stability of hill slopes, where water put into debris cover, colluvium or moraine raises the pore pressure, as at Summer Hill and Krishna Nagar in Shimla in 2023, the springs, nauns and baolis that supply the hill towns and their recharge areas, such as that of the Bohal spring above Palampur, the kuhls that carry hill runoff, the high water table of the Balh valley, and the quality of the groundwater, which the Ground Water Act 2005 protects against effluent (s.5A), and of the rivers, khads, reservoirs and tals that the runoff reaches (Chapter 8);
- effect on downstream basins and the receiving river, khad, reservoir, tal or kuhl; 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 many of Himachal Pradesh's town outfalls are closed or limited in the wettest weeks, and because the storage left is on valley floors and in khad beds that the towns are filling. In July 2023 the Bata beside Paonta and the Meenus and other khads of Sirmaur rose to new high flood levels and the Beas submerged the Panchvaktra temple at Mandi, and Gobind Sagar and Pong were held near their full levels in August and September of 2023 and 2025 (as reported). The rivers once spread their floods over wide beds and old channels: the PDNA of 2023 found that the damage along the Beas in Kullu followed the palaeo-channels on which building had taken place, and muck from roads and hydro projects has been dumped into khads and Gobind Sagar (High Court, 2024). Concrete channels alone have not served: the PDNA advised against concreting the Beas and for nature-based solutions, and the expert committee before the Tribunal found Shimla's drains unable to carry the peak flow (2017). On a hill slope storage means a lined tank or a terrace, never a pond that soaks into the slope (Clause 8.8.1), and the roof-top storage of 20 litres per m^2 that the TCP Rules require is the first of it. The storms are large for drains with no stated design basis: the Flood Estimation Report lists 600 mm in a day at Dharamshala (18 July 1967), and 273.4 mm fell at Kangra Aero on 14 August 2023 (IMD). Conveyance upgrades on their own move water faster to an outfall that the Yamuna at Paonta, the Swan at Una or the Beas below Pandoh in flood, or Gobind Sagar, Pong or another reservoir held near its full level, may close, to a khad or nallah whose bed and banks shift with the boulders, slide debris and muck it carries, or to an outfall limited by the capacity of its gate or pumping station. Groundwater in Himachal Pradesh calls for recharge in the valley fills and for restraint on the slopes. The State's stage of extraction was 35.48% in 2024, and all ten assessed valley units were safe, the highest being Una (63.72%) and Solan, for the Nalagarh valley (57.89%); seven districts, Kullu, Shimla, Bilaspur, Hamirpur, Chamba, Kinnaur and Lahaul–Spiti, have no assessment unit (CGWB, 2024). The coarse Siwalik fills of Una, Paonta–Kala Amb and Nalagarh have deep water tables, so recharge there helps; in the Balh valley the water stood 0.3–7 m below ground, so recharge there adds to waterlogging (CGWB). On the hill slopes water put into the ground can bring them down: the committee on the Shimla slides of 2023 found old buried stream channels and structural depressions acting as "conduits for the infiltration of subsurface water", and the draft Ground Water Rules of 2006 exempt sinking zones from rainwater-harvesting directions where structures "would be detrimental to the safety of the building structures". The hill towns depend on springs, nauns and baolis, of which about 500 have been inventoried in a standard format (NITI Aayog, 2021), and Palampur pays the forest committee of Bohal to protect the recharge area of the spring that supplies it (2010). The Ground Water Act 2005 is in force, with an enabling power for rainwater harvesting on premises of 100 m^2 or more (s.15) and a bar on effluent that contaminates groundwater (s.5A). This is why recharge, slope stability, springs, waterlogging and groundwater quality 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 interim and final development plans of the planning areas and special areas notified under the Himachal Pradesh Town and Country Planning Act 1977, among them the Shimla Development Plan 2041 and the development plans of 2041 for the other planning areas, with their regulations and the TCP Rules 2014; the plans of BBNDA, HIMUDA and HPSIDC for their areas; 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. Himachal Pradesh draws few water lines by rule, and no drainage-flood line. Where no development plan exists, Appendix-1 of the TCP Rules 2014 allows construction 3.00 m from a nullah and 5.00 m from a khud, without saying from what line they are measured, and a slope of up to 45°; in planning areas the distance from the high flood level along rivers, khuds and nullahs is as the development plan delineates it, and the Chopal plan of 2041, for example, puts flood plains and land "adjacent to major drainage lines" among its non-developable land; elsewhere no construction is allowed on land "prone to floods" (Appendices 3 and 7). The 5 m buffer of Shimla's interim plan is from the green belts, not from the nallahs. The State has no floodplain zoning law and no notified flood line, and the PDNA of 2023 found that "the lack of well-defined river boundaries in floodplains is a prominent issue in Himachal Pradesh", that the destruction along the Beas in Kullu followed its old channels, built over, and that "there is a pressing need for comprehensive river boundary mapping and the establishment of floodplain management guidelines". The setbacks announced in 2025, 5 m from drains and 7 m from rivers and ravines, 150 m for government buildings, and no building along rural river and stream banks, are press reports without a gazette text and are not applied. These are watercourse lines, not drainage-flood lines: where a development plan draws a high-flood line it governs; elsewhere the hydraulic corridor and setback zones of Chapter 7, with a Zone 1 of at least 15 m, and the TCP lines of 3 m and 5 m apply, whichever is wider, as this Manual's proposal, and old river courses are kept free. A BSMP gives the development plans the 1% AEP drainage-flood map, including the khads and nallahs that no plan yet covers, 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 TCP Rules 2014 already require roof-top rainwater storage of 20 litres per m² of roof for every building and, in colonies and IT parks, underground rainwater storage in the parks and open spaces (Appendix 6), reserve 5% of a new sub-division for soak pits and the like, and ask that plots be laid out for the natural flow of surface drainage (Appendix-1, cl. 20(4)–(5)), 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 a hill slope it is a lined tank or a shallow terrace, never an infiltration basin (Clause 8.8.1). 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 SW monsoon (by 31 May). The report shall show:

- CIP progress;
- the fee-in-lieu ledger (Clause 4.13.4);
- maintenance completed; and
- any flooding against the levels of service.

11.12 Interim arrangements

11.12.1 Until a BSMP is approved for a basin:

- (a) all site criteria of Chapters 4 to 8 apply in full;
- (b) regional detention and fee-in-lieu under Clause 4.13 are not available, except the holding of fees under Clause 4.5.6.3;
- (c) floor levels and setbacks use the best available mapping, and the methods of Chapters 6 and 7 where no mapping exists; and
- (d) public drain projects shall include a basin-level check that their outfall and downstream reaches can take the design flow under the Chapter 5 tailwater cases.

References (chapter)

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Annexes and forms

Annex / Form	Content
11A	BSMP terms of reference template
11B	Basin lists and boundaries for Tier A bodies
11C	Depth–damage curves for Himachal Pradesh building types
11D	BSMP data and model publication standard
Form 11-1	Annual implementation report

ANNEXES TO CHAPTER 1

Policy, Applicability and Adoption

These annexes support Chapter 1. They hold the lists and maps that define where the Manual applies, the model text of the Policy Supplement and of the legal instruments that would give the Manual effect, and the two forms an Applicant files under Chapter 1. The Manual is a draft; it is not adopted by any government or agency: model legal text is offered for consideration by a competent authority and is not in force, and the forms are draft forms. An annex marked "To be prepared" states the data it needs and the rule to use until it is published (Clause 1.11.5).

Annex 1A — List of Tier A authorities, with the boundaries of the Municipal Corporations and of the planning areas and special areas notified under the Himachal Pradesh Town and Country Planning Act, 1977

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)	Shimla Municipal Corporation (SMC)	1.6.1(a)
(b)	Every Approving Authority within the Shimla Planning Area, notified under the Himachal Pradesh Town and Country Planning Act, 1977, including the TCP Department, SMC and the other local bodies and special area authorities in that area	1.6.1(b)
(c)	Every other Municipal Corporation constituted under the Himachal Pradesh Municipal Corporation Act, 1994: Dharamshala, Mandi, Solan and Palampur (as reported [TBC])	1.6.1(c)
(c)	The TCP Department, a SADA or HIMUDA where it grants permission within the area of a Municipal Corporation; and the Baddi Barotiwala Nalagarh Development Authority in its area	1.6.1(c)
—	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 Municipal Corporation, of every Approving Authority within the Shimla Planning Area and of the area of the Baddi Barotiwala Nalagarh Development Authority, with the date from which each is Tier A, and the boundaries of those areas as a map and as a GIS layer. It needs the notified planning areas and special areas and their development plans, among them the Shimla Development Plan 2041 (the TCP Department); the current list and boundaries of the Municipal Corporations, Nagar Parishads and Nagar Panchayats (the Urban Development Department; the CAG counted 54 local bodies in March 2020, and the Municipal Corporations constituted later were not verified for this Manual [TBC]); the areas of BBNDA, the SADAs, HIMUDA and HPSIDC; the sinking and sliding zones of the development plans, which decide where the hill rules of this Manual apply most strictly; and the district and tehsil 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 / Nagar Parishad / Nagar Panchayat / TCP / SADA / BBNDA / HIMUDA / 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 Municipal Corporation, planning-area and special-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)	Shimla's nallahs and sinking zones	The catchments of the nallahs of the Shimla Planning Area that drain north to the Sutlej and south to the Ashwani Khad and the Giri, 13 major nallahs in the count of 2015, and Shimla's two sinking and sliding zones: the high sinking-prone area of Lakkar Bazaar, the Central School and Auckland Nursery School down to Dhobighat, with the Ridge and the Grand Hotel, and the sliding area of Ladakhi Mohalla, Krishna Nagar and the surroundings of Clarkes Hotel (expert committee before the NGT, 2017). About 90% of the city is built on slopes of 45°–60°, its drains were found unable to carry the peak flow (2017), the Summer Hill slide of 14 August 2023 ran along an old buried stream channel, and the nallahs that feed the Ashwani Khad carried the sewage that caused the hepatitis E outbreak of 2016 (HIMCOSTE-led committee, 2023; Bhagra et al., 2017)
(b)	Mandi on the Beas and the Suketi	The land of Mandi town that drains to the Beas and to the Suketi at and above their confluence, and the Balh valley of the Suketi round Sundernagar and Ner Chowk, where the water table stands 0.27–7.15 m below the surface and the outfalls are flat (CGWB). At the confluence the Beas submerged the Panchvaktra temple on 9 July 2023 (as reported); no CWC site measures the Beas at Mandi, and the plate shows a closed cell of about 400 mm at 50 years over the town. The Mandi treatment plant was damaged in the floods of 2025 (Chief Secretary, affidavit before the NGT)

Item	Catchment	Extent as described in Chapter 4
(c)	Kullu–Bhuntar–Manali on the Beas	The land of Kullu, Bhuntar and Manali on the valley floor, low terraces and old channels of the Beas and on the fans of its side streams, among them the Sarvari and the Parbati at their confluences, where the damage of July 2023 was "mainly due to overflow of the water along the palaeo channels following the old river course" (PDNA, 2023); Manali recorded its highest day, 131.3 mm, on 9 July 2023, Kullu district reported 26 cloudbursts that month (IMD), and no CWC site measures the Beas at Manali, Kullu or Bhuntar
(d)	Baddi–Barotiwala–Nalagarh on the Sirsa and the Balad	The land of the BBNDA area that drains to the Sirsa, the Balad and their nallahs across the Nalagarh valley; CPCB placed the stretches of the Bald along Baddi and of the Sirsa along Nalagarh in Priority I for pollution in 2022; a bridge pier on the Balad between Baddi and Nalagarh collapsed on 23 August 2023 (as reported); the Sirsa has no gauge
(e)	Una on the Swan	The land of Una and the towns of the Una valley that drains to the Swan and its tributaries, channelised under the Swan river flood management project (NITI Aayog, 2020); the Swan at Ghaluwal has a CWC highest level of 367 m, and the Una Rampur automatic weather station recorded 228.5 mm on 9 July 2023 (IMD)
(f)	Paonta Sahib on the Yamuna and the Bata	The land of Paonta Sahib that drains to the Yamuna, whose outfalls are held up when the river at Paonta is above its CWC warning level, or to the Bata; Paonta is the only CWC site of the State with warning and danger levels (383.5 m and 384.5 m; highest level 384.6 m, 5 September 1995) and with the Bata at Ganguwala, which set a new highest level of 373.52 m on 22 July 2023 (CWC data as transcribed by SANDRP)
(g)	Dharamshala–Kangra on the Dhauladhar khads	The land of Dharamshala, McLeodganj and Kangra that drains to the Manjhi, the Gaj, the Banner and the Bhagsunag nallah and the other khads of the Dhauladhar front, below the wettest front of the State (annual normal at Dharamshala 309.9 cm; 600 mm in a day on 18 July 1967) (CWC); a flash flood swept through Bhagsunag on 12 July 2021, and Kangra Aero recorded 273.4 mm on 14 August 2023 (IMD; as reported)
(h)	Rampur Bushahr on the Sutlej	The land of Rampur Bushahr that drains to the Sutlej and to the khads that join it at the town; the river's CWC highest level at Rampur, 933 m, was set by the outburst of the Parechu lake on 26 June 2005, when the river rose by a reported 12–15 m; a flash flood of 1 August 2000 was reported to have carried away more than 100 people in Kinnaur and Rampur (CWC data as transcribed by SANDRP; as reported)
(i)	Reservoir-backwater towns	The land of Bilaspur that drains to Gobind Sagar (full reservoir level 1,680 ft, about 512.06 m), and of Dehra and the other towns on the Pong reservoir that drains to it (full reservoir level 1,390 ft, about 423.67 m), below or near the reservoir's starting level of Clause 3.12.5, whose outfalls are held by the operator's levels (BBMB, as reported); the High Court has barred the dumping of muck into Gobind Sagar and its feeding khads (*Madan Lal*, 2024)
(j)	Chamba on the Ravi	The land of Chamba town that drains to the Ravi and to the nallahs that cross the town; no CWC site measures the Ravi at Chamba
(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 (SMC and the Municipal Corporations of Mandi and Dharamshala, the local bodies of Kullu, Manali, Baddi, Nalagarh, Una, Paonta Sahib, Rampur, Bilaspur and Chamba, the TCP Department, BBNDA, Survey of India); the town drains and nallahs with their outfalls and the sewage interceptions on them, with levels on a stated datum (the local bodies, SJPNL, the Jal Shakti Vibhag); the sinking and sliding zones of the development plans (the TCP Department); the flood marks, palaeo-channels and debris lines of 2023 and 2025 along the Beas, the Sutlej, the Swan, the Sirsa and the Ravi (the Jal Shakti Vibhag, HPSDMA, the Deputy Commissioners); the CWC levels at Paonta Sahib, Rampur and Ghaluwal and the levels and release rules of Gobind Sagar, Pong and Pandoh (CWC, BBMB); and the debris-flow fans and landslide inventories above the valley towns (the State Centre on Climate Change, HPSDMA, the Geological Survey of India [TBC]). Solan, Nahan, Hamirpur and Palampur, and the high-valley towns of sub-area HP-C, are candidates for notification under Clause 4.5.4 once their catchment boundaries and flood record are documented [TBC]. The setbacks of the TCP Rules 2014 and of the development plans from nullahs, khads, rivers and the highest flood level, and the wetlands and Ramsar sites, 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
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 Himachal Pradesh Stormwater Design Manual (the Manual) named in each alternative. An alternative applies within the area of an Approving Authority (the Authority) only from the date on which the Authority adopts it under P1.3.

P1.2 **No lower criterion.** No alternative lowers any criterion of the Manual. S-1 and S-2 are simplified methods for meeting the same criterion (Clause 1.7.3(a)).

P1.3 **Adoption.**

- (a) A Tier B authority adopts an alternative by council resolution in the form of Part 3, and sends a copy to the State Stormwater Technical Committee (the Committee) within 30 days of the resolution.
- (b) A Tier A authority adopts an alternative only after the Committee has concurred in writing.
- (c) The Authority publishes the alternatives it has adopted on its website and in the register of Clause 10.17.

P1.4 **Retention.** No alternative replaces the retention requirement (Annex 2E depth), except where fee-in-lieu under S-5 funds equivalent retention in the same basin (Clause 1.7.3(d)).

P1.5 **Tables.** The tables used by S-1, S-2 and S-3 are those issued by the Committee, and are reviewed with Chapter 2 of the Manual (Clauses 1.7.3(e) and 2.14). An alternative that depends on a table cannot be used until that table is issued.

P1.6 **Record.** An Applicant who uses an alternative states it on Form 1-1 and in the drainage report, with the resolution or concurrence under which it was adopted.

Part 2 — The alternatives

S-1 — Design-aid route for storage

S-1.1 *Replaces:* storage sized by a hydrograph method under Chapter 3.

S-1.2 *Alternative:* retention and detention volumes may be taken from the unit-storage tables issued for Annex 4B (m³ per ha, by rainfall zone, hydrologic soil group and impervious fraction) and the compliance calculator, by the method of Clause 4.14.2.

S-1.3 *Eligibility:* sites of 2 ha or less outside flood-sensitive catchments, and of 0.5 ha or less within them (Table 1.2; Clause 4.14.1).

S-1.4 *Conditions:* the post-development imperviousness used shall be that shown on the approved plans; the outlet, spillway, RWH accounting and safety provisions of Clause 4.14.2 apply; the compliance calculator may be the sole calculation (Table 1.1).

S-2 — Permissible site discharge (PSD)

S-2.1 *Replaces:* the release rate $Q_{post}(T) \le 0.9 \times Q_{pre}(T)$ 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 $0.9 \times Q_{pre}$ 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, HPSDMA, or the Jal Shakti Vibhag (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 tal 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 / Nagar Parishad / Nagar Panchayat), dated _____

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

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

- (i) the Himachal Pradesh Stormwater Design Manual and its Policy Supplement have been given effect by _____ (instrument and date);
- (ii) this local body is a Tier B / Tier A authority under Clause 1.6 of the Manual; and

- (iii) for a Tier A authority, the State Stormwater Technical Committee concurred on _____ (reference _____),

resolves:

1. to adopt the following alternatives of the Policy Supplement within its area, under the conditions of Clause 1.7.3 of the Manual:

Table 1C.1 — Alternatives adopted by this resolution

Alternative	Adopted (Yes / No)	Area to which it applies (whole area, or wards / zones)	Applies from (date)
S-1 Design-aid route			
S-2 Permissible site discharge			
S-3 Fixed-width setback			
S-4 Downstream screening checklist			
S-5 Fee-in-lieu			

2. that no adopted alternative shall apply within a flood-sensitive catchment except as the Manual allows (Clause 1.6.5);
3. that a copy of this resolution be sent to the State Stormwater Technical Committee within 30 days;
4. that the adopted alternatives be published on the local body's website and entered in the register of Clause 10.17; and
5. that this resolution be reviewed when the tables of Clause 1.7.3(e) are revised.

Mayor / President: _____ Commissioner / Executive Officer / Secretary: _____ Date: _____

Annex 1D — Model TCP Rules 2014 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 Himachal Pradesh Town and Country Planning Rules 2014 at which the new rule and the conditions would be inserted, and the enabling sections of the Himachal Pradesh Town and Country Planning Act, 1977 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 Himachal Pradesh Town and Country Planning Rules 2014

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

- (1) These rules may be called the Himachal Pradesh Town and Country Planning (Stormwater Management) (Amendment) Rules, _____.
- (2) They shall come into force on the date six months after their publication in the Rajpatra, Himachal Pradesh (Clause 1.11.1).

A.2 **Insertion of a new rule.** After rule [_____] of the building rules made by the Government under the Himachal Pradesh Town and Country Planning Act, 1977, the following rule shall be inserted:

> **Rule [_____]. Stormwater management.**
>
> (1) *Definitions.* In this rule, "the Manual" means the Himachal Pradesh Stormwater Design Manual as notified by the Government, with its annexes and amendments; other words have the meanings given in Clause 1.4 of the Manual.
>
> (2) *Application.* This rule applies to every development for which planning permission, building permit or layout approval is required under these rules.
>
> (3) *Runoff control.* Where a development, over its common plan of development, involves land disturbance of 0.1 ha or more, or new or replaced impervious area of 500 m² or more, the development shall comply with Chapters 4 and 5 of the Manual (retention, detention, downstream and tailwater analysis).
>
> (4) *Provisions for every development.* Every development, whatever its size, shall comply with Clause 1.5.4 of the Manual: no sewage connection to a storm drain; floor levels; waterbody setbacks and the no-fill zone; and no obstruction of a drainage path.
>
> (5) *Exemptions.* A single dwelling on its own plot below the thresholds of sub-rule (3), and linear road resurfacing that adds no impervious area, are exempt from sub-rule (3) but not from sub-rule (4) or the rainwater harvesting provisions of these rules.
>
> (6) *Conditions of approval.* The competent authority shall not grant:
>
> - (a) planning permission or layout approval, unless a preliminary drainage report under the Manual has been accepted;
> - (b) a building permit, or permission to commence, unless the final drainage design has been accepted; or
> - (c) a completion certificate, unless the as-built certificate has been accepted and the maintenance declaration has been registered, or the public assets have been handed over,
>
> for a development to which sub-rule (3) applies (Manual, Clause 10.3).
>
> (7) *Certification.* Drainage reports and designs shall be signed by a registered professional, and, where Clause 10.6.1 of the Manual so requires, by an empanelled Stormwater Design Professional.
>
> (8) *Rainwater harvesting.* Nothing in this rule alters the rainwater harvesting provisions of these rules.
>
> (9) *Variances and waivers.* The competent authority may grant a variance or waiver only on the grounds and by the procedure of Clause 1.10 of the Manual, and shall publish each decision.
>
> (10) *Transition.* Applications filed complete before the commencement of this rule, and Tier B authorities, are governed by Clause 1.11 of the Manual.

Part B — Model ULB bye-law

B.1 **Title and commencement.** These bye-laws may be called the _____ (name of local body) Stormwater Management Bye-laws, _____. They come into force on _____.

B.2 **Adoption of the Manual.** The Himachal Pradesh Stormwater Design Manual, as notified by the Government, applies to:

- (a) every development approved by the local body; and

- (b) every drainage, road, culvert, waterbody and flood-mitigation work executed by the local body, including its own drains and roads (Clause 1.3.1(b)).

B.3 **Public works.** Every detailed project report and contract for a work under B.2(b) shall require compliance with the Manual, from the dates in Clause 1.11 (Clause 1.3.4).

B.4 **Tier and alternatives.** The local body is a Tier _____ authority under Clause 1.6 of the Manual. The alternatives of the Policy Supplement adopted by the local body are listed in the Schedule, with the resolution under which each was adopted.

B.5 **Submittals and review.** Submittals shall be made in the stages of Clause 10.3 of the Manual and reviewed within the periods of Clause 10.7.

B.6 **Maintenance, inspection and enforcement.** Maintenance declarations, inspections, handover of public assets and enforcement shall follow Clauses 10.10 to 10.15 of the Manual.

B.7 **Publication.** The local body shall publish the registers and reports of Clause 10.17 of the Manual.

B.8 **Review.** These bye-laws shall be reviewed whenever the Manual is amended under Clause 1.12.

Table 1D.1 — Schedule: alternatives adopted (layout)

Alternative	Resolution number and date	Committee concurrence (Tier A only)	Applies from	Area

---

Form 1-1 — Applicability Determination

Supports Clauses 1.5.1 to 1.5.9 and 1.6 of Chapter 1, and Clause 10.3 of Chapter 10.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Lodged at the pre-application meeting (Stage 0) or with the preliminary drainage report (Stage 1), as Clause 10.3.2 requires.

Table 1F.1 — Form 1-1: Applicability Determination

No.	Item (clause)	Entry
	A. Applicant and site	
A1	Applicant (owner, developer or department)	_____
A2	Site address and survey numbers	_____
A3	Site coordinates (latitude, longitude)	_____
A4	Approving Authority (Clause 1.4)	_____
A5	Tier of the Authority: A / B (Clause 1.6; Annex 1A)	_____
A6	Approval sought: planning permission / building permit / layout approval / public work (DPR)	_____
A7	Type of development: building / layout / sub-division / road / paving / land-use change / other (Clause 1.4)	_____
A8	Stage at which this form is lodged: Stage 0 / Stage 1 (Clause 10.3)	_____
	B. Coverage (Clause 1.5.1)	
B1	Development requiring approval under the Himachal Pradesh Town and Country Planning Rules 2014 — 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 (TCP Rules 2014, Appendix 6: every building, existing or proposed, where the Himachal Pradesh Town and Country Planning Act, 1977 is in operation) — 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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Lodged with the preliminary drainage report (Clause 1.10.4(a)), with one form for each requirement concerned.

Table 1F.3 — Form 1-2: Variance / Waiver Request

No.	Item (clause)	Entry
	A. Applicant and site	
A1	Applicant	_____
A2	Site address and coordinates	_____
A3	Form 1-1 reference and date	_____
A4	Tier of the Authority: A / B	_____
A5	Site area (ha)	_____
A6	Site in a flood-sensitive catchment: Yes / No	_____
	B. Request	
B1	Type: variance from a numeric requirement (1.10.1) / waiver of Chapter 4 detention (1.10.2)	_____
B2	Clause of the Manual concerned	_____
B3	Value required by the Manual	_____
B4	Value or arrangement proposed	_____
	C. Matters that cannot be varied or waived (Clause 1.10.3) — confirm that the request does not concern any of them	
C1	(a) a sewage connection to a storm drain	Not concerned: _____
C2	(b) the lowest habitable floor level of Chapter 6	Not concerned: _____
C3	(c) a waterbody setback below the Zone 1 minimum of Clause 7.4.7, or fill or construction in the no-fill zone of Chapter 7	Not concerned: _____
C4	(d) retention in a flood-sensitive catchment, except by fee-in-lieu under Clause 1.7	Not concerned: _____
	D. Variance: grounds (Clause 1.10.1(a))	
D1	Site condition: high groundwater table / contaminated soil / rock / site too small for the required facility / other	_____
D2	Evidence (tests, surveys, plans), with references	_____
D3	Options assessed and why each is impracticable	_____
	E. Variance: equal performance or make-up (Clause 1.10.1(b))	
E1	Downstream point used (Chapter 5)	_____
E2	Performance at that point with full compliance and with the variance (peak flows, water levels)	_____

No.	Item (clause)	Entry
E3	Or: shortfall made up by fee-in-lieu or off-site works in the same catchment — volume (m³), works or fee	_____
	F. Waiver of detention: grounds (Clause 1.10.2)	
F1	Site discharges directly to the sea / to a tidal reach with no flood-prone property downstream	_____
F2	Analysis showing that undetained flow does not worsen the outfall-closed condition of Chapter 5 — reference	_____
F3	Retention still provided in full: Yes	_____
	G. Attachments (Clause 1.10.4(a))	
G1	Report certified under Clause 10.6	_____
G2	Preliminary drainage report	_____
	H. Certification and declaration	
H1	Certified by (registered professional; empanelled professional where Clause 10.6.1 applies): name, registration or empanelment number, signature, date	_____
H2	Applicant: name, signature, date	_____
	I. For the Authority (Clause 1.10.4)	
I1	Referred to the State Stormwater Technical Committee (Tier B, site 1 ha or more): Yes / No; date	_____
I2	Decision: granted / granted with conditions / refused	_____
I3	Reasons and conditions	_____
I4	Entry number in the public register (Clause 10.17)	_____
I5	Note: a variance runs with the approval and lapses if the approval lapses (Clause 1.10.4(d))	—
I6	Officer: name, designation, signature, date	_____

ANNEXES TO CHAPTER 2

Design Rainfall and Design Storms

These annexes support Chapter 2. Annexes 2A to 2E will hold the statewide rainfall tables that Chapter 2 refers to: the benchmark checks and zone map, sub-daily ratios, grid-to-point factors, temporal patterns and retention depths. Each needs analysis of NIH-DHAARA and IMD records that has not yet been done for this Manual, so each is marked "To be prepared" and gives its intended layout and the rule to use until it is published (Clause 1.11.5). Form 2-1 is a draft form for the Design Rainfall Sheet that every hydrologic submittal must include (Clause 2.13). The Manual is a draft; it is not adopted by any government or agency.

Annex 2A — NIH-DHAARA vs IMD station and IMD gridded checks at benchmark points; zone map

Supports Clauses 2.3.1 to 2.3.5 of Chapter 2.

To be prepared. This annex will compare, at benchmark points across the State, the NIH-DHAARA design depths with frequency analyses of long IMD daily station records and of IMD gridded daily data (converted to point values with Annex 2C), for 24 hours and longer and for the AEPs of Table 2.1. It will also contain the map of rainfall zones used by Annexes 2B, 2C and 2E and by the Tier B tables of Chapter 4. It needs NIH-DHAARA values at the benchmark coordinates (NIH), IMD daily and recording-gauge station records and IMD gridded rainfall (IMD), State rain-gauge records (the district rain gauges whose readings IMD tabulates for the State, the gauges of the Jal Shakti Vibhag, of BBMB at Bhakra, Pong and Pandoh and of the other dam operators, and the observatory of CSK Himachal Pradesh Krishi Vishvavidyalaya at Palampur [TBC]), and district and basin boundaries (Survey of India, Jal Shakti Vibhag). 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
HP-Z1 Siwalik foothills	The Siwalik hills and the outer valleys along the southern edge of the State, in CWC zone 7, Western Himalayas, about 5–15 km inside its boundary with subzone 1(e) (Clause 2.3.6(b)): Una and Hamirpur districts, the Siwalik parts of Bilaspur, Solan, Sirmaur and Kangra, and the Una (Swan), Nalagarh (Sirsa) and Paonta–Kala Amb valleys; catchments that cross a zone line take the higher zone value	Una (record since at least 1927, IMD); Nahan, Bilaspur and Hamirpur; the Nahan recording gauge used by the CWC zone-7 report (less than five years of data); the Una Rampur automatic weather station; BBMB's gauge at Bhakra	Gauge normals about 110–175 cm (Una 109.4, Bilaspur 128.9, Hamirpur 137.7, Rainka 173.0 cm) (CWC, zone 7, Annex 4.3). FER zone 7 50-yr 24-h about 240–320 mm; 1-h ratio 0.425 (Clause 2.3.6(f)), consistent with the recorded hours at the front (Dharampur 100 mm, Nahan 84 mm). Heavy falls of 9–11 July 2023: Nahan 250.0, Jatton Barrage 238.0, Una Rampur AWS 228.5, R L BBMB (Bilaspur) 224.0, Pachhad 220.3 mm (IMD); Sujanpur Tira 254.0 mm on 14 August 2023
HP-Z1 Siwalik foothills: HP-A Siwalik foothills and outer valleys (Una–Baddi–Nahan–Paonta–Bilaspur–Hamirpur)	Una, Gagret, Amb, Haroli, Hamirpur, Nadaun, Bilaspur, Ghumarwin, Baddi, Barotiwala, Nalagarh, Parwanoo, Nahan, Kala Amb, Paonta Sahib, Indora–Nurpur and Dehra–Jawalamukhi; the Indora–Damtal area near Pathankot may lie in 1(e) [TBC]; boundaries [TBC]	Una; Nahan; Bilaspur; Hamirpur; the Una Rampur automatic weather station	FER zone 7 50-yr 24-h about 280 mm at Una, Bilaspur and Nalagarh–Baddi (a spot above 280 mm near Nalagarh), 240–280 mm at Nahan and Paonta Sahib and about 320 mm at Hamirpur; 100-yr about 320 mm at Una and Nahan. Records: Una 276 mm (26 Sep 1947) and Bilaspur 226 mm (7 Aug 1971) in the zone-7 annex, contradicted by IMD's previous records (224 mm in 1927; 103.2 mm in 2012 at Bilaspur Sadar) and excluded under Clause 2.3.6(h) until IMD confirms them [TBC]; Nahan 250.0 mm (11 Jul 2023); none raises the plates. Coarse valley fills of boulder, cobble and gravel with transmissivity of 150–2,600 m²/day (Una) and 211–3,336 m²/day (Paonta–Kala Amb) and water from artesian to 43 m below ground; Una (63.72%) and Solan (57.89%) the most used groundwater units of the State, both "Safe" (CGWB, 2024). Receiving waters: the Swan (Ghaluwal, highest level 367 m); the Sirsa and the Balad; the Yamuna at Paonta Sahib (warning 383.5 m, danger 384.5 m, highest level 384.6 m, 1995) and the Bata at Ganguwala (373.52 m, 2023); the Markanda at Kala Amb; Gobind Sagar at Bilaspur (full reservoir level 1,680 ft) and Pong for Dehra and Indora (1,390 ft)
HP-Z2 Mid-hills	The Lesser Himalaya and the outer ranges behind the Siwaliks, from Chamba and the Dhauladhar to Shimla, Solan and Rohru, with the Kullu valley, in CWC zone 7 (Clause 2.3.6(b)); catchments that cross a zone line take the higher zone value	Shimla (observatory and recording gauge); Dharamshala (observatory and recording gauge) and Kangra Aero; Mandi (42078) and the Sundernagar recording gauge; Solan (42106) and the Dharampur recording gauge; Dalhousie and Bhuntar recording gauges (less than five years of data); Manali	Gauge normals from 309.9 cm at Dharamshala and 224.5 cm at Joginder Nagar on the Dhauladhar front, through 140.4 cm at Solan and 123.7 cm at Barauli, to 98.4 cm at Kullu (CWC, zone 7, Annex 4.3). FER zone 7 50-yr 24-h from about 160–200 mm at Shimla, a relative low, to closed cells of about 400 mm over Mandi and Dharamshala. Recording-gauge 1-h ratios 0.27 at Dharamshala and 0.32 at Dalhousie on the front, 0.39 at Shimla and 0.42 at Sundernagar in the mid-hills (CWC, zone 7, Annex 4.4). Thick debris cover on schist, phyllite and slate; the sinking and sliding zones of the development plans

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
HP-Z2 Mid-hills: HP-B Mid-hills (Shimla–Solan–Mandi–Chamba–Rampur)	Shimla (the Shimla Planning Area, Theog, Kufri), Solan, Kasauli, Dharampur, Subathu, Chail, Arki, Rajgarh, Mandi, Sundernagar and the Balh valley, Sarkaghat, Rohru, Rampur Bushahr and Chamba; boundaries [TBC]	Shimla; Mandi (42078) and Sundernagar; Solan (42106) and Dharampur; Rohru	FER zone 7 50-yr 24-h about 160–200 mm at Shimla (100-yr about 200–240 mm), 240–280 mm at Solan, Dharampur and Kasauli, a closed cell of about 400 mm over Mandi (taken as 440 mm under Clause 2.3.6(c)), 320–360 mm at Sundernagar and about 200–240 mm at Rohru and Rampur; zone-7 ratios, with the Shimla 1-hour floor of Clause 2.3.6(g). Recording-gauge maxima: Shimla 50 mm in 1 hour (12 Jul 1979) and 127 mm in 24 hours (17–18 Jul 1970); Dharampur 100 mm in 1 hour (9 Aug 1985), 114 mm in 3 hours (12 Aug 1985) and 157 mm in 24 hours; Sundernagar 50 mm in 1 hour (short record) (CWC). Records: Barauli (Shimla district) 419 mm (21 Aug 1901), gauge not located, excluded under Clause 2.3.6(h) [TBC]; Solan 264 mm (21 Aug 1951); Rohru 185 mm and Pachhad 220.3 mm, new highest days of July 2023 (IMD); Shimla automatic weather station 108.5 mm on 14 Aug 2023 (as reported). Jutogh and Shimla Group rocks under thick debris cover, permeable only along fractures; Shimla's two sinking and sliding zones; the Balh valley alluvium with water 0.27–7.15 m below ground (CGWB). Receiving waters: Shimla's nallahs to the Sutlej and to the Ashwani Khad and the Giri; the Beas and the Suketi at Mandi (no CWC site) and Pandoh; the Sutlej at Rampur (highest level 933 m, 2005); the Pabbar at Rohru; the Ravi at Chamba (no CWC site)
HP-Z2 Mid-hills: HP-B1 Dhauladhar front (Dharamshala–Kangra–Palampur–Jogindernagar)	Dharamshala, McLeodganj, Gaggal, Kangra, Palampur, Baijnath, Jogindernagar, and Dalhousie and Banikhet on the same front; boundaries [TBC]	Dharamshala (observatory and recording gauge) and Kangra Aero; Palampur (CSK Himachal Pradesh Krishi Vishvavidyalaya [TBC]); Joginder Nagar; the Dalhousie recording gauge (less than five years of data)	FER zone 7 50-yr 24-h about 320–360 mm at Kangra and Palampur, 320–400 mm at Jogindernagar, and a closed cell at Dharamshala inside the 320 mm line whose inner label, about 400 mm, is illegible [TBC]; the worked example of the zone-7 report, the Banu Khad, reads 320 mm. 1(e) ratios on the zone-7 plate, with the 1-hour floor of 0.34 (Clause 2.3.6(f) and (g)). Recording-gauge maxima at Dharamshala: 73 mm in 1 hour (4 Aug 1975), 123 mm in 3 hours and 187 mm in 6 hours (8 Aug 1978) and 270 mm in 24 hours (13–14 Jul 1976); Dalhousie 59 mm in 1 hour and 182 mm in 24 hours (9–10 Jun 1971) (CWC). Records: Dharamshala 600 mm (18 Jul 1967) and Joginder Nagar 394 mm (18 Aug 1954), excluded under Clause 2.3.6(h) until IMD confirms at least 20 years of record at their gauges [TBC], the first records to confirm (Dharamshala's would raise the 100-yr 24-h depth of HP-B1 near the gauge to 600 mm), and reported on Form 2-1 meanwhile; Kangra Aero 273.4, Dharmsala 250.2 and Palampur 220.0 mm (14 Aug 2023) (IMD). Quaternary alluvium, moraine and boulder fans below the front [TBC]; the Neogal and Banu Khads, the steepest catchments of the zone-7 report. Receiving waters: the Manjhi, the Gaj, the Banner, the Neugal and the Bhagsunag nala to the Beas and Pong

Zone (working name)	Extent (districts, basins)	Representative stations	Notes
HP-Z2 Mid-hills: HP-B2 Kullu–Manali inner valley	Kullu, Bhuntar, Manali, Naggar, Banjar, Aut and Larji, below the snow line; boundaries [TBC]	Bhuntar (recording gauge, less than five years of data) and Manali; Kullu	FER zone 7 50-yr 24-h about 280–320 mm at Kullu and Bhuntar, above every day recorded at Kullu (236 mm, 4 Oct 1888, a record made before 1901), and about 200–240 mm at Manali; zone-7 ratios. Records: Manali 131.3 mm (9 Jul 2023), its highest day (IMD; 105.1 mm on 9 Jul 1971 or 100 mm on 13 Jul 1993 before, in two IMD sources); Bhuntar 38 mm in 24 hours (December 1984, short record) (CWC). Annual normal at Kullu 98.4 cm, but the most cloudbursts reported in the State: 26 in Kullu district in July 2023 (IMD, from HPSDMA). Valley floor, terraces and old channels of the Beas, and debris fans of its side streams; the Samej flood of 31 Jul 2024. Receiving waters: the Beas, with no CWC site at Manali, Kullu or Bhuntar, the Parbati, the Sarvari and the side khads; the releases of Larji, Malana and the Parbati projects
HP-Z3 High and trans-Himalaya	The High Himalaya and the trans-Himalaya, whose snow-fed catchments the zone-7 report excludes (Clause 2.3.6(i)); hazard-first, with mandatory GLOF, landslide-lake and debris-flow screening; catchments that cross a zone line take the higher zone value	Kalpa and Keylong (and the Keylong automatic weather station); Kaza; CWC level sites on the Sutlej, the Spiti, the Chandra and the Bhaga	Gauge normals 62.2 cm at Keylong, 70.3 cm at Kilba and 83.8 cm at Sangla (CWC, zone 7, Annex 4.3). FER zone 7 50-yr 24-h about 120–160 mm in Lahaul and Spiti; a closed cell of about 280–320 mm over the Baspa valley in Kinnaur that rests largely on the doubtful falls of December 1958. Snow, rain on snow and snowmelt
HP-Z3 High and trans-Himalaya: HP-C High and trans-Himalaya (Kinnaur–Lahaul–Spiti; snow-fed)	Reckong Peo, Kalpa, Sangla, Chitkul, Pooh and Nichar in Kinnaur; Keylong and Udaipur in Lahaul; Kaza and Tabo in Spiti; Pangi, the high villages of Bharmour and Dodra Kwar; and every catchment elsewhere with permanent snow or a glacier; projects east of 78° E (eastern Kinnaur, Spiti east of about Kaza, Dodra Kwar) lie in UTM zone 44N; boundaries [TBC]	Kalpa; Keylong	Zone-7 relations not used for snow-fed catchments; site-specific hydrology and a GLOF, landslide-lake and debris-flow screening (Clause 2.3.6(i)). Records: Kilba 610 mm (27 Dec 1958) and Sangla 559 mm (21 Dec 1958), excluded under Clause 2.3.6(h) until IMD confirms them; Keylong 128 mm (17 Sep 1950) in the zone-7 annex, against 78 mm (1951) and 83 mm (9 Jul 2023, automatic weather station) given by IMD as its records, excluded until IMD confirms which gauge each belongs to; Nichar 268 mm (10 Oct 1956) (CWC; IMD). Alpine soils of 0.3–0.6 m over debris or moraine, frozen in winter. Glacial lakes: 562 in the Sutlej basin, 242 in the Chenab, 93 in the Beas and 37 or 38 in the Ravi (2019 inventory, as reported). Events not driven by rain at the gauges: the Parechu outburst flood on the Sutlej (26 Jun 2005). Receiving waters: the Sutlej (Khab, Titang, Nathpa), the Spiti (Gulling, 3,580.34 m in July 2023), the Chandra and the Bhaga, the Baspa and the Ropa Khad (3,050.85 m in July 2023); the reservoirs of Karcham Wangtoo and Nathpa Jhakri

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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 Himachal Pradesh are those of Clause 2.3.6: the CWC Flood Estimation Report ratios for the site's sub-area in Table 2B.1 (zone 7 in HP-A, HP-B, HP-B2 and the local catchments of HP-C; 1(e), on the zone-7 plate depth, in HP-B1), with the 1-hour floors of Clause 2.3.6(g) in HP-B1 and in the Shimla Planning Area, applied to the 24-hour depth before the record check of Clause 2.3.6(h) (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
HP-Z1 (HP-A Siwalik foothills and outer valleys), HP-Z2 (HP-B Mid-hills; HP-B2 Kullu–Manali inner valley) and HP-Z3 (the local catchments of HP-C below the snow)	CWC FER zone 7, 10-yr basis, nine recording gauges (interim design ratios, Clause 2.3.6(f); 2-h value interpolated on logarithmic axes)	0.425		0.600	0.725	0.845	1.00
HP-Z2 (HP-B1 Dhauladhar front, on the zone-7 plate)	CWC FER 1(e), 50-yr (interim design ratios, Clause 2.3.6(f))	0.34	0.475	0.56	0.68	0.84	1.00
HP-Z2 (HP-B1), every AEP	1-hour floor of Clause 2.3.6(g)(i), set by this Manual (also binds a station IDF)	0.34					
HP-Z2 (HP-B): Shimla Planning Area, every AEP	1-hour floor of Clause 2.3.6(g)(ii), set by this Manual: 50 mm × P24(T) / P24(10-yr), not a fixed ratio						
HP-Z2 (HP-B1): Dharamshala	CWC FER zone 7, Annex 4.4: the recording-gauge maxima as ratios to the 24-h maximum of the same record (separate storms: 1 h on 4 Aug 1975, 3 and 6 h on 8 Aug 1978, 12 h on 24–25 Jul 1980, 24 h on 13–14 Jul 1976; comparison only)	0.27		0.46	0.69	0.76	1.00
HP-Z2 (HP-B1): Dalhousie	CWC FER zone 7, Annex 4.4: recording-gauge maxima of 9–10 Jun 1971, a record of less than five years (comparison only)	0.32		0.66	0.70	0.73	1.00
HP-Z2 (HP-B): Shimla	CWC FER zone 7, Annex 4.4: recording-gauge maxima (separate storms: 1 and 3 h on 12 Jul 1979, 6 to 24 h on 17–18 Jul 1970; comparison only)	0.39		0.68	0.81	0.83	1.00
HP-Z2 (HP-B): Sundernagar	CWC FER zone 7, Annex 4.4: recording-gauge maxima of 1982–85, a record of less than five years (separate storms; comparison only)	0.42		0.57	0.60	0.67	1.00

Zone	Source	1 h	2 h	3 h	6 h	12 h	24 h
HP-Z2 (HP-B): Dharampur (Solan)	CWC FER zone 7, Annex 4.4: recording-gauge maxima (separate storms: 1 h on 9 Aug 1985, 3 to 12 h on 12 Aug 1985, 24 h on 28–29 Jun 1978; comparison only)	0.64		0.73	0.79	0.88	1.00
HP-Z1 (HP-A): Nahan	CWC FER zone 7, Annex 4.4: recording-gauge maxima of 1–2 Aug 1980, a record of less than five years (comparison only)	0.87		0.89	0.92	1.00	1.00
HP-Z2 (HP-B2): Bhuntar	CWC FER zone 7, Annex 4.4: recording-gauge maxima of 1984–85, a record of less than five years, the 24-h maximum a December storm (separate storms; comparison only)	0.50		0.53	0.53	0.71	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 Jal Shakti Vibhag and BBMB, and the district rain gauges of the State whose records IMD tabulates [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 Himachal Pradesh no gridded product was compared with gauges for this Manual: NIH-DHAARA was not queried at any point in the State [TBC], and in the hills of the other mountain State of the series its reanalysis cells, of about 12 km, gave 50-year 1-hour depths of about one-tenth of their 24-hour depths. The averages that IMD publishes for districts after a storm show the size of the gap between an area value and a point: on 12 July 2021 Kangra district averaged 79.4 mm in 24 hours while Dharamshala town is reported to have received about 230 mm (IMD; as reported), and on 30 June–1 July 2025 Mandi district averaged 140.7 mm while the floods of Seraj fell where there was no gauge (as reported). Within a few tens of kilometres the gauge normals change several-fold, from 309.9 cm a year at Dharamshala to 137.7 cm at Hamirpur and 98.4 cm at Kullu (CWC, zone 7, Annex 4.3). 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 Himachal Pradesh until this annex and Annex 2A are published, and NIH-DHAARA is not used at all in the hills (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 — Himachal Pradesh temporal patterns (Huff curves)

Supports Clauses 2.9.3 and 2.9.4 of Chapter 2, and Clause 11.7.3 of Chapter 11.

To be prepared. This annex will give dimensionless time-distribution (mass) curves of Himachal Pradesh storms, in the form introduced by Huff (1967), by zone, storm-duration class and quartile, at stated probability levels. It needs storm hyetographs from recording gauges and automatic weather stations (IMD, its automatic weather stations and automatic rain gauges in the State, under the Meteorological Centre Shimla, and any recording gauges of the Jal Shakti Vibhag, HPSDMA, BBMB and the Smart City companies of Shimla and Dharamshala [TBC]), separated into independent storms by a stated rule, and the storms recorded by the recording gauges of the CWC zone-7 report at Dharamshala (4 August 1975, 13–14 July 1976 and 8 August 1978), Dharampur (9 and 12 August 1985), Shimla (17–18 July 1970 and 12 July 1979) and Dalhousie (9–10 June 1971), the storms of 9–11 July and 14 August 2023, the Samej–Bagipul storm of 31 July 2024 and the Seraj storm of 30 June–1 July 2025 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 Jal Shakti Vibhag and BBMB, and the district rain gauges of the State whose records IMD tabulates [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
HP-Z1 Siwalik foothills					
HP-Z2 Mid-hills					
HP-Z3 High and trans-Himalaya					

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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. One sheet for each hydrologic submittal. The steps follow Figure 2.3 of Chapter 2.

Table 2F.1 — Form 2-1: site, source and storms

No.	Item (clause)	Entry
	A. Site (Clause 2.13, item 1)	
A1	Project and site	_____
A2	Site coordinates (latitude, longitude, decimal degrees)	_____
A3	Rainfall zone (Annex 2A, or as agreed with the Authority)	_____
A4	Contributing catchment area (km²) (Clause 2.7)	_____
A5	Design life: more than 25 years / temporary works, 5 years or less (Clause 2.8.2)	_____
A6	Outfall under tidal or river backwater influence: Yes / No (Clauses 2.5.3, 2.12)	_____
	B. Source (Clauses 2.3, 2.3.5; item 2)	
B1	NIH-DHAARA: version or access date	_____
B2	Coordinates queried	_____
B3	Screenshot or export of the values extracted attached: reference	_____
B4	Station IDF used (Clause 2.3.2): No / Yes — station, ID, distance from site (km)	_____
B5	Station IDF: years of recording-gauge data (30 or more); published or approved by	_____
B6	Station IDF: change of terrain or coastal exposure between gauge and site: None / describe	_____
	C. AEPs and durations (Clauses 2.4, 2.5)	
C1	Elements designed and their AEPs (Table 2.1)	_____
C2	Conveyance: Tc and design duration (not less than 10 min) (Clause 2.5.1)	_____
C3	Storage: durations checked from {1, 2, 3, 6, 12, 24, 48, 72 h}; 24, 48 and 72 h included (Clause 2.5.2)	_____
C4	Critical duration found for each storage element	_____
	D. Conversions	
D1	Sub-daily depths: read directly / from Annex 2B ratios / from ratios agreed with the Authority (Clauses 2.6.1, 2.6.2)	_____
D2	Fixed-interval factor applied: none (true-interval source) / 1.13 / 1.04 / 1.02 (Clause 2.6.3)	_____
D3	Grid-to-point factor: not needed (point source) / Annex 2C / agreed value (Clause 2.7.1)	_____
D4	ARF: 1.0 (10 km² or less; single-site storage) / CWC curve / interpolated (Clauses 2.7.2–2.7.4)	_____
D5	Climate factor: 1.20 (≤ 6 h) and 1.10 (> 6–72 h) / 1.0 temporary works / projected depths under Clause 2.8.4	_____
	E. Cross-checks (Clause 2.3.3; item 4)	
E1	IMD Das et al. (2022) values for 1–24 h: reported in Table 2F.2	_____

No.	Item (clause)	Entry
E2	CWC zone 7 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 July–30 September in sub-areas HP-B, HP-B1, HP-B2 and HP-C (including the Balh valley), whatever its duration, and at any time in catchments draining to Gobind Sagar, Pong, Pandoh or another reservoir, barrage pond or backwater, or a river at or above its CWC warning level; 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 — Himachal Pradesh soil series to HSG lookup; seasonal high water table map

Supports Clauses 3.7 and 3.10 of Chapter 3.

To be prepared. This annex will contain (a) a lookup from each soil series mapped in Himachal Pradesh to its hydrologic soil group (HSG), in both the drained and the undrained state, and (b) a map of the depth to the seasonal high groundwater table in the south-west monsoon (June–September). It needs NBSS&LUP and Himachal Pradesh Agriculture Department (soil survey) [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 Jal Shakti Vibhag, supplemented by piezometers in the Balh valley round Sundernagar and Ner Chowk, where the water table stands 0.27–7.15 m below ground, the floors of the Una, Nalagarh and Paonta–Kala Amb valleys near the Swan, the Sirsa, the Yamuna and the Bata, where wells near the Swan flow above ground, the floodplains and low terraces of the Beas at Kullu, Bhuntar and Mandi and of the other rivers, the margins of Rewalsar, Renuka and the other tals, the margins of Gobind Sagar at Bilaspur and of the Pong reservoir, and hill towns with perched water on unstable slopes, such as the sinking and sliding zones of Shimla. 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 June–September record	Highest June–September level below ground (m)	Within 0.6 m of ground (Clause 3.10.1)?	Data source

Annex 3B — Himachal Pradesh CN calibration and supplementary land covers (terraced fields and orchards, deodar, oak and chir pine forest, slide scars, debris fans and muck dumps, bare rock and scree, alpine pasture and snow, boulder-bed khads, kuhl-fed paddy, tal and reservoir beds)

Supports Clauses 3.8 and 3.15 of Chapter 3.

To be prepared. This annex will contain (a) curve numbers calibrated against observed rainfall and runoff in Himachal Pradesh catchments, compared with the TR-55 values of Table 3.5, and (b) curve numbers for land covers that Table 3.5 does not list: the terraced fields of the hill slopes, whose risers and bunds hold water on each terrace until it overtops, including the paddy terraces fed by kuhls in Kangra, Mandi and Kullu; the apple and other orchards of the Shimla hills, Kullu and Kinnaur, often on terraces with weeded or grassed floors; the deodar and oak forest of the mid-hills, with deep litter, and the chir pine forest of the lower hills, whose needle litter sheds water; the fresh scars, slide debris and debris fans of landslides and debris flows, and the cut slopes and muck dumps of hill roads and hydro-electric projects; bare rock, scree and the skeletal soils of the steep hills; the alpine pastures and the snow and frozen ground of the high and trans-Himalaya; the wide boulder beds of the khads of the Siwalik valleys, such as the Swan, the Sirsa, the Balad and the Bata, which lose flow to the gravels until the bed is saturated; and the beds of tals and reservoirs that are dry or drawn down at the start of a storm, such as the drawdown zone of the Pong reservoir, about 80 km² between 1,280 and 1,390 ft, and the margins of Gobind Sagar. It needs paired rainfall–runoff records for small gauged catchments of known cover and soil, from Jal Shakti Vibhag 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)
Terraced fields of the hill slopes, with the riser height recorded (cultivated or abandoned); kuhl-fed paddy terraces						
Apple or other orchard, with the floor recorded (weeded, grassed or mulched; terraced or not)						
Deodar or oak forest of the mid-hills, with deep litter						
Chir pine forest of the lower hills, with needle litter						

Cover type	HSG A	HSG B	HSG C	HSG D	Ia ratio	Basis (catchments, events, years)
Fresh landslide scar, slide debris or debris fan; hill-road cut slope; road or project muck dump						
Bare rock, scree and skeletal soil of steep slopes						
Alpine pasture; snow or frozen ground at the start of the storm						
Boulder bed of a khad of the Siwalik valleys (Swan, Sirsa, Balad, Bata and the like), dry at the start of the storm						
Tal or reservoir bed dry or drawn down at the start of the storm (Pong drawdown zone; Gobind Sagar margins)						
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**

Step	Calculation	Result
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**
(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

Time (min)	Inflow I (m³/s)	Outflow O (m³/s)	Storage (m³)	Stage (m)
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
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 Himachal Pradesh.** Himachal Pradesh is landlocked and mountainous, 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 Balh valley, the floors of the Siwalik valleys and the tal and reservoir margins are flat in places but are not coastal plain; their slow response is represented by storage and backwater (Clauses 3.10.4 and 3.12.4), not by a lower peak rate factor, while the hills and the khads 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 zone 7, with worked example

Supports Clauses 3.4.3 and 3.11.4 of Chapter 3.

To be prepared. This annex will tabulate, for CWC zone 7 (Western Himalayas), the regression relationships for the synthetic unit hydrograph parameters, the design storm duration, loss rate, base flow, areal reduction and time distribution, each with its reference to the Flood Estimation Report, and a worked example for one catchment. It needs the one CWC Flood Estimation Report that covers Himachal Pradesh, the Western Himalayas zone 7 report (No. WH/22/1994, November 1994), which covers every town of the State, from Una, Nalagarh, Baddi, Parwanoo, Nahan and Paonta Sahib on the Siwalik front, about 5–15 km inside its southern boundary with subzone 1(e), to Shimla, Solan, Mandi, Sundernagar, Bilaspur, Hamirpur, Dharamshala, Kangra, Palampur, Chamba, Kullu, Manali and Rampur Bushahr, but whose relationships are not to be used in its snow-fed catchments in Kinnaur, Lahaul and Spiti, Pangi and the upper valleys of the Beas, the Ravi and the Sutlej (see the References of Chapter 3); with the zone 7 areal reduction factors for areas above 300 km² and for 24 hours, the cell labels of Plates 8, 9 and 10 at Dharamshala, Mandi, Kullu and Kinnaur, which are not legible on the copy read, the loss rate of the worked example (the Banu Khad in Kangra), printed as 0.20 cm/h against the 0.5 cm/h the report recommends, the time to peak of the same example, printed as 2.5 h against about 3.05 h from its own equations, and the position of the boundary with subzone 1(e) near Indora and Damtal, where the Beas leaves the State, still to be confirmed on the report's page images and index maps [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	Zone 7 (Western Himalayas) relationship
Time from centre of unit rainfall to peak	tp	h	tp = 2.498 (L·Lc/S)^0.156 (printed with S, not √S; see the note)
Peak discharge per unit area	qp	m³/s per km²	qp = 1.048 tp^−0.178
Width of UH at 50% of peak	W50	h	W50 = 1.954 (L·Lc/S)^0.099
Width of UH at 75% of peak	W75	h	W75 = 0.972 (L·Lc/S)^0.124
Width of rising limb at 50% of peak	WR50	h	WR50 = 0.189 W50^1.769

Parameter	Symbol	Unit	Zone 7 (Western Himalayas) relationship
Width of rising limb at 75% of peak	WR75	h	WR75 = 0.419 W75^1.246
Base width of UH	TB	h	TB = 7.845 tp^0.453
Unit duration	tr	h	1
Design storm duration	TD	h	TD = 1.1 tp (it gave the highest peak on all the gauged catchments)
Design loss rate	—	mm/h	5 (printed "0.5 cm/hr"; the observed modal value of 0.6 cm/h was judged "on higher side", and "Designers can modify this value as per local conditions"); the worked example uses 0.20 cm/h "as recommended in para 3.5", which conflicts with para 3.5 [TBC]; not for snow-fed areas
Design base flow	—	m³/s per km²	0.05 (27 of 45 events in the range 0.00–0.10)
Ratio of t-hour to 24-hour rainfall	—	—	10-yr, from 9 self-recording gauges: 1 h 0.425; 3 h 0.600; 6 h 0.725; 9 h 0.790; 12 h 0.845; 15 h 0.895; 18 h 0.935; 24 h 1.000
Time distribution of rainfall	—	cumulative fraction by hour	3-h storm 0.73, 0.92, 1.00; 6-h storm 0.52, 0.69, 0.82, 0.91, 0.97, 1.00; 12-h storm 0.34, 0.49, 0.60, 0.67, 0.74, 0.81, 0.86, 0.90, 0.94, 0.96, 0.98, 1.00; 24-h storm 0.17, 0.27, 0.36, 0.43, 0.48, 0.53, 0.58, 0.63, 0.67, 0.70, 0.73, 0.76, 0.79, 0.82, 0.84, 0.86, 0.88, 0.90, 0.92, 0.94, 0.96, 0.98, 0.99, 1.00
Conversion of 1-day to 24-hour rainfall	—	factor	1.15
Areal reduction factor	ARF	% of point rainfall	Annex 4.2: 50 km², 94.00 at 1 h, 96.40 at 3 h, 97.70 at 6 h, 98.25 at 12 h; 100 km², 89.00, 92.90, 95.40, 96.50; 200 km², 80.75, 86.20, 89.80, 93.50; 300 km², 74.25, 80.00, 86.20, 90.50; the worked example uses 0.926 for 3 hours at 103.6 km²; the 24-hour column and the rows above 300 km² (to 2,000 km²) not read [TBC]. The storms analysed were centred on the self-recording gauges at Dehradun (14) and Dharampur in Solan district (3)
50-yr 24-hour point rainfall at Himachal Pradesh towns (100-yr in brackets)	—	mm	Plate 9 (Plate 10), read by eye within about one contour: Shimla about 160–200 (200–240), in a relative low, with a closed cell below 180 just north-east of the town; Solan, Dharampur and Kasauli about 240–280 (about 280); Nahan and Paonta Sahib about 240–280 (Nahan about 320); Una about 280 (about 320); Nalagarh, Baddi and Parwanoo about 280; Bilaspur about 280; Hamirpur about 320; Kangra and Palampur about 320–360; Dharamshala and Mandi in closed cells above 320 whose inner labels, probably 400, are not legible on the copy read [TBC]; Kullu and Bhuntar about 280–320, above every value recorded at Kullu [TBC]; Manali about 200–240; Rampur Bushahr about 200 (about 240–280); Reckong Peo on the 280 ring of a Kinnaur cell that rests on doubtful records [TBC]; Keylong and Kaza about 120–160, snow-fed
Gauged catchments in Himachal Pradesh	—	—	3 of the 6 used, all in the Kangra–Chamba hills: the Neogal Khad at railway bridge 821 on the line to Jogindernagar (151.98 km²; L 21.35 km, Lc 12.00 km, S 84.04 m/km; 1966); the Banu Khad at bridge 629 on the Pathankot–Jogindernagar line (103.60 km²; L 21.32 km, Lc 11.58 km, S 69.21 m/km; 1963–66), the report's worked example; and the Chakki Khad at bridge 232 on the Jalandhar–Pathankot line (657.86 km²; L 51.49 km, Lc 24.13 km, S 9.90 m/km; 1963–67), whose bridge is in Punjab and whose catchment lies mainly in Kangra and Chamba; the Bannar Khad at bridge 357 on the Pathankot–Jogindernagar line (170.00 km², 1962–65) was listed but not used
Catchment area for which the relationships apply	A	km²	25–1,000; not in snow-fed catchments

Parameter	Symbol	Unit	Zone 7 (Western Himalayas) relationship
Report reference	—	—	§§3.3–3.6, Annexes 3.1 and 3.2, §4.4.2, Annexes 4.1 to 4.4, worked example (pp. 24–26), Plates 8–10

Note: relationships as printed in the CWC zone 7 report (References of Chapter 3), read from a scanned copy and checked against the page images except where marked. L is the length of the main stream in km, Lc the length to the point nearest the catchment centroid in km, S the equivalent slope in m/km and A the catchment area in km². Zone 7 relates tp to L·Lc/S, printed without the square root that most subzone reports use, and the printed equations reproduce the report's own unit hydrograph only in that form. **Coverage.** The report was written for Jammu and Kashmir, Punjab, Himachal Pradesh and Uttar Pradesh, over a zone of 322,170 km² that takes in the hill basins of the Indus system (the Jhelum, the Chenab, the Ravi, the Beas and the Sutlej, 272,575 km²) and of the Yamuna and the Ganga, and its rainfall analysis drew on 13 districts of Himachal Pradesh. All of Himachal Pradesh is in zone 7. On Plates 9 and 10 of the subzone 1(e) report, the boundary between the two reports runs along the Siwalik front outside the State, so that Una (about 12 km), Nalagarh (about 8 km), Baddi, Parwanoo and Nahan (about 5 km) and Paonta Sahib (about 14 km) lie inside zone 7 (NEER's reading, within about 5 km); whether the Indora–Damtal area, where the Beas leaves the State, lies in 1(e) was not resolved [TBC]. The 1(e) report is not used for design in the State; at the southern edge its plates may be read only for comparison. **Basis.** The unit hydrograph rests on only six catchments of 44–658 km² (five railway bridges and the Sewa hydro-electric project in Jammu and Kashmir), with 2–5 years of record each in 1962–67 and 45 flood events, all near the southern edge of the zone: about 1% of it. Three of the six drain Himachal Pradesh, and the Neogal Khad (84.04 m/km) and the Banu Khad (69.21 m/km) are the steepest of them, so the relationships are better grounded for the khads of the Kangra–Palampur valley than for any other part of the zone. For the gauged catchments the printed relationships give L·Lc/S = 3.05, tp ≈ 3.0 h, qp ≈ 0.86 m³/s per km², TB ≈ 13 h and TD ≈ 3.3 h for the Neogal Khad, and L·Lc/S = 125.5, tp ≈ 5.3 h, qp ≈ 0.78 m³/s per km², TB ≈ 17 h and TD ≈ 5.8 h for the Chakki Khad (NEER's computation; yardsticks, not design values). The report itself warns that a design flood computed from these relations is not to be used "without verifying the results on the basis of alternate methods", and that the relations are "not to be utilised for computation of design flood in the snow fed area of the zone". **Worked example.** The example, the Banu Khad at bridge 629 (103.60 km², L 21.32 km, Lc 11.58 km, S 69.21 m/km), was checked for this Manual against its own equations. It prints tp = 2.5 h, while the equations give L·Lc/S = 3.57 and tp ≈ 3.05 h; the printed qp (0.86 m³/s per km²), TB (13.0 h) and unit-hydrograph peak (89.02 m³/s) agree with 3.05 h, not with 2.5 h, which would give qp ≈ 0.89, so the 2.5 h is a misprint. With the 50-yr 24-hour point rainfall of 32.00 cm read from Plate 9, the 3-hour ratio of 0.600 and an ARF of 0.926, the areal rainfall is 17.78 cm, distributed as 12.98, 3.38 and 1.42 cm over three hours. The example then applies a loss of 0.20 cm/h, "as recommended in para 3.5", where para 3.5 recommends 0.5 cm/h; the printed 50-yr peak of 1,365.22 m³/s, about 13.2 m³/s per km², follows from the 0.20 cm/h loss (89.02 × 12.78 + 56.50 × 3.18 + 35.00 × 1.22 + 5.18 m³/s of base flow), and with 0.5 cm/h the same unit hydrograph gives about 1,311 m³/s, about 4% lower (NEER's recomputation). This Manual uses 0.5 cm/h and reads tp from the equations [TBC]. The value of 32.00 cm used at the Banu Khad agrees with the reading of about 320–360 mm at Kangra and Palampur above. **Use in the State.** The gauged catchments have slopes of 9.9–84 m/km; the urban hill catchments of Shimla, Solan, Dharamshala and the wards of Mandi are far steeper and far smaller than 25 km², and are designed by the methods of Clause 3.4 with the rules for steep ground of the Commentary to Clause 3.7. The SUH applies to the rural khads of 25–1,000 km² that enter the towns, such as the Manjhi, the Gaj, the Banner and the Neugal in the Kangra–Dharamshala valley, the Suketi at Mandi and in the Balh valley, the Sarvari at Kullu, the tributaries of the Swan at Una, the Sirsa (about 550 km² in all) and the Balad at Nalagarh and Baddi, the Markanda at Kala Amb and the Bata and the lower Giri near Paonta Sahib. In sub-area HP-C (High and trans-Himalaya) the zone 7 SUH does not apply: catchments with snow or glacier cover, in Kinnaur, Lahaul and Spiti, Pangi and the upper valleys of the Beas, the Ravi and the Sutlej, require a site-specific hydrological study, and no design there is complete without the glacial-lake-outburst, landslide-lake and debris-flow screening of Clause 2.3.6(i). Where a city catchment lies within the range, the SUH is computed only as the benchmark of its natural condition (Clause 3.11.4), and the catchment itself is designed by the methods of Clause 3.4 with the design rainfall of Chapter 2. The Sutlej, the Beas, the Ravi and the Yamuna are far larger than the catchments of the report and are outside Clause 3.11.4 (Clause 3.4.5); below Bhakra, Pong, Pandoh, Larji, Kol, Nathpa Jhakri and Chamera the flood is set by releases (Chapter 5). The design loss rate of 5 mm/h is a φ-index fitted to the monsoon floods of whole rural catchments; it is used only in rural SUH runs, is not a soil infiltration capacity and is not used to assign HSG (Clause 3.7), in urban SCS-CN or SWMM models, or to size infiltration practices (Chapter 4). The ratios are not to be used to

derive intensities for durations shorter than the TD of the SUH (Chapter 2): with the zone 7 ratio of 0.425 the 50-yr 1-hour depth is about 68–85 mm at Shimla, about 102–119 mm at Solan and Dharampur and more than 136 mm at Dharamshala, against largest recorded 1-hour falls of 50 mm at Shimla (12 July 1979), 100 mm at Dharampur (9 August 1985) and 73 mm at Dharamshala (4 August 1975) (Annex 4.4 of the report); Clause 2.3.6 deals with the difference. At 24 hours the plates are exceeded at Dharamshala, which recorded 600 mm on 18 July 1967 and 270 mm on its self-recording gauge on 13–14 July 1976, and are matched elsewhere, as at Kangra Aero (273.4 mm on 14 August 2023), Nahan (250.0 mm on 11 July 2023) and Una (276 mm on 26 September 1947 in the report's annex) (IMD; Annex 4.3 of the report), so the plate values are a floor under Clause 2.3.3, not a ceiling; the 610 mm and 559 mm recorded at Kilba and Sangla in December 1958 are doubtful, and Clause 2.3.6(h) decides which records count.

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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. One form per submittal. Attach the documents listed in Section H.

A. Project

Table 3F.1 — Form 3-1: project

Field	Entry
A1. Project name and applicant	
A2. Location (village or ward, survey numbers, district)	
A3. Site area (ha) and number of points of comparison (POCs)	
A4. Catchment class: standard (Clause 2.11.2) or flood-sensitive (Clause 2.11.3)	
A5. Design Rainfall Sheet reference (Form 2-1)	

B. Method and software (Clauses 3.4, 3.11, 3.12, 3.16)

Table 3F.2 — Form 3-1: method and software

Field	Entry
B1. Purpose of each calculation (conveyance, storage, comparison, catchment study)	
B2. Contributing area for each purpose (ha or km²)	
B3. Method used and the row of Table 3.1 that permits it	
B4. Reason for the choice of method	
B5. Software and version; engine and version for packages built on SWMM or HEC (Clause 3.16.1, 3.16.2)	
B6. For other software: benchmark results of Annex 3C attached (Table 3C.7) and the 5% comparison of Clause 3.16.2	
B7. Runoff transform (Clause 3.11.1)	
B8. Computation interval Δt (h), with 0.133 Tc of the smallest sub-area and the hyetograph time step (Clause 3.11.3(a))	
B9. Storage routing and channel routing methods (Clauses 3.12.1, 3.12.2)	
B10. Dynamic-wave routing required? If yes, which condition of Clause 3.12.4	
B11. CWC SUH benchmark required (25–5,000 km², Clause 3.11.4)? Result reference	
B12. Continuous simulation required (Clause 3.13.1)? Record used and starting tank levels (Clause 3.13.5)	
B13. Calibration required (Clause 3.15.1)? Calibration report reference	

C. Soils and groundwater (Clauses 3.3.3(b), 3.7, 3.10)

Table 3F.3 — Form 3-1: soils and groundwater

Field	Entry
C1. HSG source map, scale and lookup used (Clause 3.7.1, Annex 3A) or NEH Part 630, Ch. 7 assignment (Clause 3.7.2)	
C2. Infiltration tests: number, locations, depths, results (Clause 3.7.3)	
C3. Seasonal high water table: depth below ground and source (Clause 3.10.2)	
C4. Areas within 0.6 m assigned HSG D (Clause 3.10.1)	
C5. Disturbed pervious areas and HSG downgrade applied (Clause 3.3.3(b))	

D. Parameters by sub-area and condition (Clauses 3.3, 3.5, 3.8, 3.9; Clause 3.17 item 4)

Table 3F.4 — Form 3-1: parameters by sub-area and condition

Sub-area	Condition (pre / post)	Area (ha)	Impervious: roofs / paved / roads (ha)	DCIA (ha)	Disconnected (ha)	HSG	CN, AMC II	CN, AMC III (pervious part)	C and Cf (if Rational)	Tc (min)

E. Time of concentration worksheet (Clause 3.6)

One worksheet per sub-area and condition.

Table 3F.5 — Form 3-1: time of concentration worksheet

Segment	Flow type	Surface and n (Table 3.4)	L (m)	S (m/m)	P2 (mm)	V (m/s)	Tt (min)
1	Sheet					—	
2	Shallow concentrated				—		
3	Channel or pipe				—		
	Tc (not less than 10 min)						

E1. Is the post-development Tc shorter than the pre-development Tc? If not, explain (Clause 3.6.6): _____

F. Rainfall and losses (Clauses 3.8.4, 3.8.5, 3.11.5, 3.12, 3.3.5)

Table 3F.6 — Form 3-1: rainfall, losses and starting levels

Field	Entry
F1. AEPs and durations run; climate factor applied (Chapter 2)	
F2. AMC used for each duration (Clause 3.8.4)	
F3. Ia ratio for design runs; Ia = 0.05S sensitivity run made (Clause 3.8.5)	
F4. Peak rate factor used; if lower than 484, the Annex 3D value and the land it applies to (Clause 3.11.5)	
F5. Starting water level of each tank or waterbody, and its basis (Clauses 3.12.5, 3.13.5)	

Field	Entry
F6. Off-site run-on: land use assumed for conveyance and for the comparison (Clause 3.3.5)	
F7. Incidental storage counted? If yes, the authority's acceptance (Clause 3.12.3)	

G. Departures

Table 3F.7 — Form 3-1: departures from Chapter 3

No.	Clause departed from	Value used in place of the Chapter 3 value	Justification
1			
2			

H. Attachments (Clause 3.17)

Table 3F.8 — Form 3-1: attachments

Item	Attached (yes / no / not applicable)	Reference
H1. Catchment maps, pre- and post-development, with sub-areas, Tc flow paths, POCs and off-site run-on		
H2. HSG map, water-table data and infiltration test results		
H3. Parameter tables (Section D) and Tc worksheets (Section E)		
H4. Design Rainfall Sheet (Form 2-1) and hyetographs		
H5. Hydrograph tables and plots; stage–storage and stage–discharge tables; routed outflows; peak water levels		
H6. Form 3-2 for each POC		
H7. Calibration report (Clause 3.15)		
H8. Native model input and output files (Clause 3.16.4)		

I. Statement by the responsible engineer (Clause 3.17 item 10)

I state that the methods and parameters of Chapter 3 of the Himachal Pradesh Stormwater Design Manual (Draft v1.0) have been used in this submittal, and that every departure is listed and justified in Section G.

Table 3F.9 — Form 3-1: statement by the responsible engineer

Field	Entry
Name	
Qualification and registration number	
Organisation	
Signature	
Date	

Form 3-2 — Pre- vs Post-Development Comparison

Supports Clauses 3.8.5, 3.11.5 and 3.14 of Chapter 3.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. One form for each point of comparison (POC). Flows in m³/s, volumes in m³.

A. Point of comparison (Clause 3.14.2)

Table 3F.10 — Form 3-2: point of comparison

Field	Entry
A1. POC identifier and location	
A2. Area draining to the POC: site (ha) and off-site run-on (ha)	
A3. Off-site run-on passes through site storage? (Clause 3.14.2(c))	
A4. Catchment class: standard (Clause 2.11.2) or flood-sensitive (Clause 2.11.3)	
A5. Tailwater applied, including joint cases of Clause 2.12 (Clause 3.14.9(c))	
A6. Flood-sensitive only: largest 10% AEP pre-development peak over all durations, the cap of Clause 2.11.3 (Clause 3.14.7)	
A7. Flood-sensitive only: 50% AEP pre-development peak at the pre-development critical duration (Clause 2.11.3)	

B. Peak flows (Clauses 3.14.7–3.14.10)

Limit: standard catchments 0.9 × Q_pre for the same AEP and duration (Clause 3.14.10(a)); flood-sensitive catchments the caps A6 (for 1% AEP) and A7 (for 50% AEP) (Clause 3.14.10(b)).

Table 3F.11 — Form 3-2: peak flows by AEP and duration

AEP	Duration (h)	AMC	Q_pre	Q_post, uncontrolled	Q_post, routed	Limit	Met?
50% (2-yr)	1	II					
50% (2-yr)	2	II					
50% (2-yr)	3	II					
50% (2-yr)	6	II					
50% (2-yr)	12	III					
50% (2-yr)	24	III					
50% (2-yr)	48	III					
50% (2-yr)	72	III					
10% (10-yr)	1	II					
10% (10-yr)	2	II					
10% (10-yr)	3	II					
10% (10-yr)	6	II					

AEP	Duration (h)	AMC	Q_pre	Q_post, uncontrolled	Q_post, routed	Limit	Met?
10% (10-yr)	12	III					
10% (10-yr)	24	III					
10% (10-yr)	48	III					
10% (10-yr)	72	III					
1% (100-yr)	1	II					
1% (100-yr)	2	II					
1% (100-yr)	3	II					
1% (100-yr)	6	II					
1% (100-yr)	12	III					
1% (100-yr)	24	III					
1% (100-yr)	48	III					
1% (100-yr)	72	III					

C. Volumes and storage (Clauses 3.14.8–3.14.10)

Table 3F.12 — Form 3-2: volumes and storage

AEP	Governing duration (h)	Runoff volume, pre	Runoff volume, post uncontrolled	Retention volume	Detention storage required	Peak water level in storage (m)
50% (2-yr)						
10% (10-yr)						
1% (100-yr)						

C1. Governing duration for storage, and the 24, 48 and 72 h results (Clause 3.14.10): _____

D. Sensitivity runs (Clauses 3.8.5, 3.14.11)

Table 3F.13 — Form 3-2: sensitivity runs

Run	Governing storm (AEP, duration)	Change in Q_post, routed (%)	Change in required storage (%)	Retention volume or WQv governing (Clause 3.8.5(c))
Ia = 0.05S				
Standard peak rate factor (only where a lower factor is used)				—

E. Associated checks (Clause 3.14.12)

Table 3F.14 — Form 3-2: associated checks

Check	Result	Reference in submittal
Drawdown times (Chapter 4)		
Minimum orifice and trash screen (Chapter 4)		
Emergency spillway (Chapter 4)		
Outfall-closed storage check (Chapter 5)		
Downstream analysis (Chapter 5)		

F. Statement by the responsible engineer

I state that this comparison has been made by the procedure of Clause 3.14, with the same design storms in the pre- and post-development runs, and that no runoff has been diverted from one natural catchment to another to meet the criterion (Clause 3.14.2(b)).

Table 3F.15 — Form 3-2: statement by the responsible engineer

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 4

Site Runoff Control: Retention and Detention

These annexes support Chapter 4. Annex 4C is a complete Tier A worked example with routing tables, built on the illustrative example of Clause 4.6.7. Annex 4B sets out the structure of the Tier B tables, the provisional fixed release coefficients and a standard orifice table computed from the Chapter 4 orifice equation; the values that need NIH-DHAARA depths are still to be derived. Annex 4A needs GIS and groundwater data that this draft does not yet contain; it gives the intended layout and the interim rules of Chapter 4. Forms 4-1 to 4-3 are the submittal forms required by Clause 4.17. They are draft forms and have no statutory status.

Annex 4A — Flood-sensitive catchment boundaries (GIS); shallow-groundwater zone map

Supports Clauses 4.5.3, 4.5.4 and 4.12 of Chapter 4.

4A.1 **Flood-sensitive catchment boundaries.** The catchments are those listed in Clause 4.5.3.2, with any catchment notified under Clause 4.5.4. Their maps and GIS layer are the same data set as Annex 1B, which lists the catchments and gives the attribute layout of the layer. The two annexes shall be issued together.

4A.2 **Shallow-groundwater zone map.** This map shows the areas where Clause 4.12 applies: the Balh valley round Sundernagar and Ner Chowk, where the water table stands 0.27–7.15 m below ground, the floors of the Una, Nalagarh and Paonta–Kala Amb valleys near their trunk streams, where wells near the Swan flow above ground, the floodplains and low terraces of the Beas, the Sutlej, the Ravi, the Yamuna, the Giri and the Swan and of the khads, the margins of Rewalsar, Renuka, Khajjiar and the other tals, the margins and backwaters of Gobind Sagar, the Pong reservoir, the Pandoh reservoir and the other reservoirs and barrage ponds, and hill sites with perched water, such as the sinking and sliding zones of Shimla, 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 SW monsoon. It needs basin and sub-basin boundaries from a digital elevation model and the drainage network (Jal Shakti Vibhag, NRSC, Survey of India), the flood-protection and channelisation works of the Jal Shakti Vibhag on the Swan and other khads, with their design levels, the levels of Gobind Sagar, the Pong reservoir and the Pandoh reservoir from BBMB and of the Kol, Nathpa Jhakri, Chamera, Larji and other reservoirs from their operators, converted to metres where they are published in feet, the flood-prone land, flood plains and land along major drainage lines shown as non-developable in the Interim Development Plans and Development Plans of the TCP Department, with the sinking and sliding zones they define, the kuhls in Schedules I and II of the Himachal Pradesh Minor Canals Act 1976, the Ramsar sites (Pong Dam Lake, Renuka and Chandertal) and other wetlands within the remit of the State Wetlands Authority, among them Rewalsar and Khajjiar, the landslide inventory of the State Centre on Climate Change and the glacial-lake inventories of HIMCOSTE, town boundaries (the TCP Department for the planning areas and special areas, the Urban Development Department, the Municipal Corporations, Nagar Parishads and Nagar Panchayats, BBNDA and HIMUDA), flood maps held by HPSDMA, observation-well records of the CGWB and the Jal Shakti Vibhag, and the extent of the Siwalik valley fills and fans, the Balh valley alluvium and the river terraces, the Siwalik rock, the debris cover, colluvium, slide debris, moraine and exposed rock of the hills, and the alpine soils of the high and trans-Himalaya, with the slopes of more than 10° to which the hill infiltration rule of Clause 4.11 applies from soil survey maps (NBSS&LUP, the Himachal Pradesh Agriculture Department (soil survey) [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 June–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, khad, nallah, tal or reservoir (Clause 4.12.1(b)). For the flotation check in the Balh valley, the river terraces and floodplains, and the tal and reservoir margins without piezometer readings, the design groundwater level is existing ground level (Clause 4.12.1).

Table 4A.1 — Attributes of the shallow-groundwater zone layer (layout)

Field	Content	Unit or format
zone_id	Unique identifier	text
zone_class	Balh valley (Sundernagar–Ner Chowk); Siwalik valley floor near a trunk stream (Una–Swan, Nalagarh–Sirsa, Paonta–Kala Amb or other); river floodplain or low terrace (Beas, Sutlej, Ravi, Yamuna, Giri, Swan or a khad); tal margin (Rewalsar, Renuka, Khajjiar or other); reservoir or barrage-pond margin or backwater (Gobind Sagar, Pong, Pandoh, Kol or other); perched water on a hill slope (a Shimla sinking or sliding zone or other); other area with groundwater within 3 m of the surface (Clause 4.12.1)	text
shgw_depth_m	Seasonal high groundwater depth below ground, SW 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 (m³/ha), standard	SSR (m³/ha), flood-sensitive
HP-Z1 Siwalik foothills: HP-A Siwalik foothills and outer valleys (Una–Baddi–Nahan–Paonta–Bilaspur–Hamirpur)	A / B / C / D	50% / 70% / 90%	—	—	—	—	—
HP-Z2 Mid-hills: HP-B Mid-hills (Shimla–Solan–Mandi–Chamba–Rampur)	B / C / D	50% / 70% / 90%	—	—	—	—	—
HP-Z2 Mid-hills: HP-B1 Dhauladhar front (Dharamshala–Kangra–Palampur–Jogindernagar)	B / C / D	50% / 70% / 90%	—	—	—	—	—
HP-Z2 Mid-hills: HP-B2 Kullu–Manali inner valley	B / C / D	50% / 70% / 90%	—	—	—	—	—

Zone (Annex 2A)	HSG	Imperviousness	PSD 2-yr (L/s/ha)	PSD 100-yr (L/s/ha), standard	PSD 100-yr (L/s/ha), flood-sensitive	SSR (m³/ha), standard	SSR (m³/ha), flood-sensitive
HP-Z3 High and trans-Himalaya: HP-C High and trans-Himalaya (Kinnaur–Lahaul–Spiti; snow-fed)	—	—	Not tabulated: Clause 4.6 applies (Clause 2.3.6(i))	—	—	—	—

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

Permissible discharge (L/s)	H = 0.5 m	H = 1.0 m	H = 1.5 m	H = 2.0 m
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 colony draining to a nallah in Shimla; 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 nallah draining to the Ashwani Khad in Shimla 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

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)
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
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

Stage h (m)	Storage (m³)	Stage 1, 170 mm (L/s)	Stage 2, 460 mm (L/s)	Total (L/s)
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

Item	Requirement	Value	Result
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 nallah draining to the Ashwani Khad in Shimla (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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. One form for each site. Where the site drains to more than one outfall, complete Sections E to J for each outfall (Clause 4.5.1.3). Tier B sites using Clause 4.14.2 attach Form 4-2 in place of Sections F and G; sites using the fixed-coefficient route attach Form 4-3 in place of Sections F and G (Clause 4.17).

A. Site and route

Table 4F.1 — Form 4-1: site and route

Field	Entry
A1. Project name and applicant	
A2. Location (village or ward, survey numbers, district)	
A3. Approving Authority and tier (Tier A / Tier B)	
A4. Site area, land disturbance and new or replaced impervious area (ha, ha, m²) (Clause 4.1.2)	
A5. Number of outfalls (Clause 4.5.1.3)	
A6. Sizing route: full method (Clause 4.6) / Tier B tables (Clause 4.14.2) / fixed-coefficient route (Clause 4.14.3)	
A7. Constrained redevelopment route used (Clause 4.5.6)? If yes, attach the Constraint Statement, the existing-condition model and the shortfall and fee computation	

B. Inputs (Clause 4.17, item 1)

Table 4F.2 — Form 4-1: inputs

Field	Entry
B1. Design Rainfall Sheet reference (Form 2-1)	
B2. Hydrologic Calculation Summary reference (Form 3-1)	
B3. HSG of each sub-area and the tests that confirm it (Clause 4.6.2, step 1)	
B4. Pre-development condition and CN (Clause 4.5.1.2)	
B5. Post-development CN of each sub-area, and Tc pre and post	
B6. Routing method and software, with version; time step (Clauses 4.6.1, 4.6.2)	

C. Order of measures (Clause 4.3.1; Clause 4.17, item 2)

Table 4F.3 — Form 4-1: order of measures

Step	What the design does	Why this step cannot do more
1. Preserve		
2. Retain		

Step	What the design does	Why this step cannot do more
3. Detain		
4. Convey		

D. Retention (Clause 4.4; Clause 4.17, items 3 and 4)

Table 4F.4 — Form 4-1: retention

Field	Entry
D1. Retention depth P_R (mm) and zone (Annex 2E)	
D2. Runoff depth Q_R (mm) by sub-area and RRV (m³) (Clause 4.4.2)	
D3. Retention practices and volume provided (m³)	
D4. Infiltration tests: number, locations and depths, measured rates (mm/h) (Clause 4.4.3(a))	
D5. Design infiltration rate (mm/h), not more than half the measured rate (Clause 4.4.3(b))	
D6. Seasonal high groundwater depth below the base of each practice (m), at least 1.0 m (Clause 4.4.3(c))	
D7. Reuse demand calculation, where retention is by reuse (Clause 4.4.3)	
D8. Retention drawdown time (h), not more than 72 h (Clause 4.4.5)	
D9. Shortfall in RRV (m³), if any, treated as WQv (Clause 4.4.4.2)	
D10. Governing storage without and with retention, and the retention credit (m³) (Clause 4.4.6)	
D11. Preservation credit areas and covenant reference (Clause 4.4.7)	

E. Release criteria (Clause 4.5; Clause 4.17, item 5)

Table 4F.5 — Form 4-1: release criteria

Field	Entry
E1. Catchment class: standard (Clause 4.5.2) or flood-sensitive (Clause 4.5.3), with the Annex 4A map extract	
E2. Release caps by AEP (L/s), and the duration that sets each cap	
E3. Clause 4.5.5 used (50 mm orifice deemed to comply, or the short-duration 2-yr relief)? Report any 2-yr exceedance	

F. Results (Clause 4.6; Clause 4.17, item 6)

Complete one row for each duration, in the format of Table 4.2. Mark the governing case for storage, for each outlet stage and for the spillway (Clause 4.6.2, step 12).

Table 4F.6 — Form 4-1: results by duration (L/s; m³)

Duration (h)	2-yr pre	2-yr post, detained	10-yr pre	10-yr post, detained	100-yr post, uncontrolled	100-yr post, detained	100-yr storage used
1							
2							

Duration (h)	2-yr pre	2-yr post, detained	10-yr pre	10-yr post, detained	100-yr post, uncontrolled	100-yr post, detained	100-yr storage used
3							
6							
12							
24							
48							
72							

G. Facility, drawdown and outlet (Clauses 4.7, 4.8, 4.10; Clause 4.17, items 7 to 9)

Table 4F.7 — Form 4-1: facility, drawdown and outlet

Field	Entry
G1. Facility type (Clause 4.10) and storage provided (m^3)	
G2. Stage–storage and stage–discharge tables and plots; inflow and outflow hydrographs for the governing cases (attach)	
G3. 10-yr drawdown: time to release 90% of the maximum stored volume (h), with the low-flow orifice 50% blocked (Clauses 4.7.1, 4.8.3)	
G4. WQv release time (h), 24 to 48 h (Clause 4.7.2)	
G5. Tidal outfall: drawdown with the tidal tailwater, and any pumped drawdown (Clause 4.7.4)	
G6. Each outlet stage: type, size (mm), invert level (m)	
G7. Trash racks: clear bar spacing (mm) and open area (m^2) (Clause 4.8.3)	
G8. Anti-vortex devices (Clause 4.8.4); outlet barrel diameter and seepage control (Clause 4.8.5); isolation (Clause 4.8.6)	
G9. Proprietary devices: certified head–discharge curve and minimum clear opening (Clause 4.6.5.3)	

H. Spillway, freeboard and embankment (Clause 4.9; Clause 4.17, item 10)

Table 4F.8 — Form 4-1: spillway and freeboard

Field	Entry
H1. Hazard classification, with reasons (Clause 4.9.2)	
H2. 1% AEP peak inflow (L/s); 0.2% AEP peak inflow for high-hazard facilities (L/s)	
H3. 1% AEP maximum water level with the outlet working (m); spillway crest level (m) (Clause 4.9.3)	
H4. Spillway or overflow route: type, dimensions, maximum level with the outlet blocked (m)	
H5. Freeboard to the embankment crest or wall top (m), at least 0.3 m (Clause 4.9.1)	
H6. Spillway location and discharge path (Clause 4.9.4)	
H7. Embankment height (m); geotechnical report where more than 2 m (Clause 4.9.6)	

I. RWH accounting, groundwater and flotation (Clauses 4.11, 4.12; Clause 4.17, items 11 and 12)

Table 4F.9 — Form 4-1: RWH, groundwater and flotation

Field	Entry
I1. RWH storage provided (m³), assumed full at the start of every storm (Clause 4.11.2)	
I2. Combined RWH and detention tanks: zone levels and the detention orifice level (Clause 4.11.3); attach tank sections	
I3. Design groundwater level and its basis (Clause 4.12.1)	
I4. Lined or unlined storage; volume below the design groundwater level not counted (Clause 4.12.2)	
I5. Flotation factor of safety, at least 1.2 (Clause 4.12.3)	

J. Downstream, tailwater, safety and maintenance (Clause 4.17, items 13 and 14)

Table 4F.10 — Form 4-1: downstream, tailwater, safety and maintenance

Field	Entry
J1. Downstream and Tailwater Report (Form 5-1) or Simplified Downstream Statement (Form 5-2) reference	
J2. Tailwater used in routing, and flap gate where tailwater governs (Clause 4.6.6)	
J3. Public access, depths in the 10% and 1% AEP storms, slopes, fencing, grates, signs and depth markers (Clause 4.15)	
J4. Draft maintenance declaration reference (Chapter 10)	

K. Statement by the registered professional (Clause 10.6)

I state that this report has been prepared under Chapter 4 of the Himachal Pradesh Stormwater Design Manual (Draft v1.0), that the results reported are reproduced by the models submitted, and that every departure from Chapter 4 is listed with its reason. The Professional Design Certificate (Form 10-3) is attached.

Table 4F.11 — Form 4-1: statement by the registered professional

Field	Entry
Name	
Qualification and registration number	
Empanelment number, where Clause 10.6.1 requires it	
Organisation	
Signature	
Date	

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0.

Form 4-2 — Tier B Site Sheet

Supports Clauses 4.4.6.3, 4.14.1 and 4.14.2 of Chapter 4.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. This sheet replaces items 6 and 7 of the Site Runoff Control Report (Form 4-1) for Tier B sites using Clause 4.14.2. It can be used only after Table 4.3 is published in Annex 4B; until then, Tier B sites use Clause 4.6 or, for sites of 1 ha or less, the fixed-coefficient route (Clauses 4.14.1 and 4.14.3).

A. Eligibility (Clause 4.14.1)

Table 4F.12 — Form 4-2: eligibility

Field	Entry
A1. Local body (Tier B)	
A2. Site area A (ha): 2 ha or less outside flood-sensitive catchments; 0.5 ha or less inside them	
A3. Catchment class: standard or flood-sensitive (Annex 4A)	

B. Table 4.3 values (Clause 4.14.2, step 1)

Table 4F.13 — Form 4-2: values read from Table 4.3

Field	Entry
B1. Rainfall zone (Annex 2A)	
B2. Hydrologic soil group	
B3. Post-development imperviousness (%)	
B4. PSD 2-yr (L/s/ha)	
B5. PSD 100-yr (L/s/ha), for the catchment class	
B6. SSR (m³/ha), for the catchment class	

C. Storage and release (Clause 4.14.2, steps 2 and 3)

Table 4F.14 — Form 4-2: storage and release

Line	Quantity	Computation	Value
C1	RRV provided (m³)	Clause 4.4	
C2	C_R	Annex 4B; 0 until published	
C3	V_credit (m³)	C2 × C1 (Clause 4.4.6.3)	
C4	Required storage V (m³)	B6 × A − C3	
C5	Storage provided (m³)	From drawings	
C6	Q_PSD,2 (L/s)	B4 × A	

Line	Quantity	Computation	Value
C7	Q_PSD,100 (L/s)	B5 × A	

D. Outlet and other provisions (Clause 4.14.2, steps 4 and 5)

Table 4F.15 — Form 4-2: outlet and other provisions

Field	Entry
D1. Low-flow orifice: diameter (mm) from the Annex 4B outlet table, head (m), at least 50 mm	
D2. Upper control: type, size and level	
D3. Spillway or overflow (Clause 4.9)	
D4. RWH accounting (Clause 4.11)	
D5. Safety provisions (Clause 4.15)	

E. Statement

I state that the values above are taken from Annex 4B for the site's zone, soil group, imperviousness and catchment class, and that the storage and outlets shown on the drawings match them.

Table 4F.16 — Form 4-2: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0.

Form 4-3 — Fixed-coefficient Route Sheet (Clauses 4.14.3 to 4.14.7)

Supports Clauses 4.14.3 to 4.14.7 of Chapter 4.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. This sheet replaces items 6 and 7 of the Site Runoff Control Report (Form 4-1) for sites using the fixed-coefficient route. Complete it for each point where runoff leaves the site (Clause 4.14.4). Figure 4.3 shows the method.

A. Eligibility (Clause 4.14.3)

Table 4F.17 — Form 4-3: eligibility

Check	Yes / No
A1. Site area 1 ha or less	
A2. The design does not count tank or waterbody storage (Clause 4.14.3(a))	
A3. No part of the site lies within a waterbody setback (Clause 4.14.3(b))	
A4. The site does not drain to a tank cascade whose storage is counted in a downstream design (Clause 4.14.3(c))	

B. Release caps (Clause 4.14.4)

Table 4F.18 — Form 4-3: release caps

Line	Quantity	Source or computation	Value
B1	Site area A (ha)	Survey	
B2	Area of each hydrologic soil group (ha)	Clause 3.7	
B3	C_10 and C_2, area-weighted	Table 4.3A	
B4	i_10 and i_2 (mm/h), 15-minute duration, with the climate factor	Form 2-1; Clause 2.8	
B5	Q_cap,10 (L/s)	2.78 × C_10 × i_10 × A	
B6	Q_cap,2 (L/s)	2.78 × C_2 × i_2 × A	
B7	Discharge of a 50 mm orifice at the corresponding stage (L/s), where a cap is smaller (Clause 4.5.5.1)	Orifice equation, Clause 4.6.5.2	

C. Volumetric coefficient (Clause 4.14.5)

Table 4F.19 — Form 4-3: volumetric coefficient C_v

Line	Quantity	Value
C1	Composite C of Table 3.2 (upper half of each range)	
C2	Cf of Table 3.3 for the 1% AEP	
C3	C_v for durations below 12 h (C1 × C2)	
C4	C_v for durations of 12 h or more, with C for every pervious surface not less than 0.50	

D. Storage (Clause 4.14.5)

For each duration: inflow = 10 × C_v × P(d) × A (m³); release = 1.8 × Q_cap × d (m³); difference = inflow − release. V_100 and V_2 are the largest differences; V is the larger of the two.

Table 4F.20 — Form 4-3: storage by duration

d (h)	P_100(d) (mm)	100-yr inflow (m³)	1.8 × Q_cap,10 × d (m³)	100-yr difference (m³)	P_2(d) (mm)	2-yr inflow (m³)	1.8 × Q_cap,2 × d (m³)	2-yr difference (m³)
1								
2								
3								
6								
12								
24								
48								
72								

Table 4F.21 — Form 4-3: storage required and provided

Line	Quantity	Value
D1	V_100 (m³) and governing duration	
D2	V_2 (m³) and governing duration	
D3	V = larger of D1 and D2 (m³)	
D4	Storage provided (m³)	

E. Outlet, retention and other checks (Clauses 4.14.3, 4.14.6, 4.14.7)

Table 4F.22 — Form 4-3: outlet, retention and other checks

Field	Entry
E1. Low-flow orifice: diameter (mm) and invert; discharge (L/s) with the storage holding V_2 full, not more than Q_cap,2	
E2. Upper orifice or weir: size and level; total release (L/s) at the top of V, not more than Q_cap,10	
E3. Retention volume of Clause 4.4 provided in addition to V (m³); no retention credit taken	
E4. Drawdown (Clause 4.7), trash racks (Clause 4.8), spillway (Clause 4.9): reference to Form 4-1 Sections G and H	
E5. Downstream and tailwater checks (Chapter 5) and water quality (Chapter 8): references	

F. Statement

I state that the site meets the eligibility conditions of Clause 4.14.3 and that the caps, storage and outlets above have been computed by Clauses 4.14.4 to 4.14.7.

Table 4F.23 — Form 4-3: statement

Field	Entry
Name	
Qualification and registration number	
Signature	
Date	

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 5

Downstream and Tailwater Analysis

These annexes support Chapter 5. Annex 5C is a worked example of the outfall-closed check of Clause 5.10, for the illustrative facility of Annex 4C. Annexes 5A and 5B need tidal, surge, survey and river data that this draft does not yet contain; each lists what the chapter already sets, gives the intended layout and states the interim rule of Chapter 5 that applies until it is published. Forms 5-1 and 5-2 are the submittal forms required by Clause 5.14. They are draft forms and have no statutory status.

Annex 5A — Tidal datums (MSL, MHWS, HAT vs CD and Survey of India datum), surge allowances and 1% still-water levels by coastal segment

Supports Clauses 5.7, 5.9, 5.10, 5.11 and 5.12 of Chapter 5.

5A.1 Table 5A.1 shows how the values of this annex enter the design tailwater levels of Table 5.1. The sea-level allowance is set by Clause 5.7.4 and does not depend on this annex.

Table 5A.1 — Use of the Annex 5A values in the design tailwater (Table 5.1)

Design case	Tailwater	Annex 5A values used	Chapter value
Minor-system design	MHWS + SLA	MHWS	SLA ≥ +0.3 m (Clause 5.7.4)
Major-system and storage design	HAT + surge + SLA	HAT; 10% AEP surge (Clause 5.7.3(a))	SLA ≥ +0.3 m
Joint case (Clause 2.12(b))	1% AEP still-water level + SLA	1% AEP still-water level (Clause 5.7.3(b))	SLA ≥ +0.3 m
Datum conversion	Chart datum to project datum	Offset from chart datum to the Survey of India datum (Clause 5.7.2(b))	—

Not prepared for Himachal Pradesh. Himachal Pradesh has no coast, so no outfall in the State has a tidal tailwater, and this annex has no Himachal Pradesh content (Clause 5.1.4). Its tables are kept, empty, so that the annex and table numbers match the other editions of this Manual. Rows F1 to F7 of Form 5-1 are entered as "not applicable", and the tailwater is derived under rows F8 to F10; for an outfall to a khad or nallah, row F10 records the study, the flood marks and the bed survey of Clause 5.8.5(b), and for an outfall to Gobind Sagar or the Pong reservoir, the conversion of BBMB's levels from feet of Clause 5.8.5(c).

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
Yamuna at Paonta Sahib, past the Paonta gauge; the Bata at Ganguwala and the khads of the Paonta valley	Sirmaur	Riverine outfall reach and major drains; design river level not below the transferred 384.6 m (Paonta, 5 September 1995) and 373.52 m (Ganguwala, 22 July 2023); 10% AEP not below the danger level 384.5 m (warning 383.5 m), the only danger level in the State; datum [TBC]	5.2, 5.8.1, 5.8.5
Giri at Yaswant Nagar and Dadahu; the Jatton barrage	Sirmaur	Riverine outfall reach; design river level not below the transferred 902.9 m (Yaswant Nagar, 5 September 1995) and 629.02 m (Dadahu, 18 August 2019); barrage pond level and operator not found [TBC]	5.8.1, 5.8.3, 5.8.5
Sutlej at Rampur Bushahr, Nathpa and Pandoa, below the Karcham Wangtoo and Nathpa Jhakri projects; the Baspa at Sangla	Shimla, Kinnaur	Riverine outfall reach; design river level not below the transferred 933 m (Rampur, 26 June 2005; 924.5 m quoted for 2023: conflict [TBC]), 1,451 m (Nathpa) and 2,515.2 m (Sangla); Pandoa 740.6 m or 689.6 m: conflict, treated as ungauged with the 2023 peak of 688.78 m as a floor [TBC]; releases included; glacial-lake and landslide-lake bursts (Parechu, 2005) not excluded	5.8.1, 5.8.3, 5.8.5
Nallahs of Shimla draining north to the Sutlej and south to the Ashwani Khad and the Giri; the Ashwani Khad	Shimla	Nallahs and major drains; ungauged; 1% AEP study with bulking and flood marks; outfall at least 0.5 m above the highest surveyed bed level; no outfall in the active channel; the Ashwani Khad a drinking-water source (Clause 8.9)	5.2, 5.8.1, 5.8.5
Beas at Manali, Kullu and Bhuntar, with the side khads of the Kullu valley and the Parbati	Kullu	Riverine outfall reach and khads; no CWC site with a published level (BBMB stations shown inactive) [TBC]; modelled or surveyed flood level required; palaeo-channels kept free (Chapter 6, Clause 6.9)	5.2, 5.8.1, 5.8.5
Beas at Mandi and its confluence with the Suketi, below the Larji and Pandoh dams; the Suketi and its khads	Mandi	Riverine outfall reach, khads and major drains; no CWC site with a published level [TBC]; modelled or surveyed flood level required; Larji and Pandoh releases included (44,000 cusec from Pandoh on 30 June 2025)	5.2, 5.8.1, 5.8.3, 5.8.5
Beas below the Pong dam, in the Mand area of Indora	Kangra	Riverine outfall reach; no CWC site with a published level [TBC]; Pong releases included (1.40–1.50 lakh cusec in August 2023)	5.8.1, 5.8.3, 5.8.5

Water body	Region	Listed as	Clause
Manjhi, Gaj, Banner and Neugal khads; the Bhagsunag nala	Kangra	Khads and major drains below the Dhauladhar; ungauged; 1% AEP study with bulking and flood marks (the flash flood of 12 July 2021 at Bhagsunag)	5.2, 5.8.1, 5.8.5
Sirsa and Balad, and the Sandholi, Housing Board and other nallahs of Baddi–Barotiwala–Nalagarh	Solan	Khads and major drains; no gauge level found [TBC]; 1% AEP study with bulking and flood marks; industrial and sewage flows dealt with under Clause 8.9	5.2, 5.8.1, 5.8.5
Swan at Una and Ghaluwal and its tributary khads	Una	Riverine outfall reach and khads; design river level not below the transferred 367 m (Ghaluwal; dated 3 June 2017, to be confirmed [TBC]); the channelisation's design levels to be obtained from the Jal Shakti Vibhag [TBC]; embankment breach check	5.2, 5.8.1, 5.8.5
Ravi at Chamba; the Chamera reservoir	Chamba	Riverine outfall reach and reservoir; no CWC site with a published level [TBC]; Chamera tailwater 763.5 m (reported level of 763 m + 0.5 m) [TBC]; NHPC's consent	5.8.1, 5.8.3, 5.8.5
Gobind Sagar (Bhakra reservoir) at Bilaspur, and its feeding khads and nallahs	Bilaspur	Reservoir outfalls; tailwater 515.11 m (1,690 ft, the reported earlier technical limit; FRL 1,680 ft = 512.06 m) [TBC]; levels in feet converted at 0.3048; BBMB's consent; no muck in the lake or its feeding khads (High Court, CWPIL 31/2023)	5.8.3, 5.8.5
Pong reservoir (Maharana Pratap Sagar; Pong Dam Lake, a Ramsar site) at Dehra and the Pong shore	Kangra	Reservoir outfalls; tailwater 433.12 m (1,421 ft, the highest of the conflicting maximum levels 1,400, 1,410 and 1,421 ft; FRL 1,390 ft = 423.67 m) [TBC]; BBMB's consent and the State Wetlands Authority's permission; drawdown zone part of the reservoir	5.8.3, 5.8.5
Pandoh, Larji, Kol, Nathpa Jhakri and Karcham Wangtoo reservoirs	Mandi, Kullu, Bilaspur, Kinnaur	Reservoir outfalls; Kol 642.5 m and Karcham Wangtoo 1,810.5 m (reported levels + 0.5 m) [TBC]; no level found for Pandoh, Larji or Nathpa Jhakri [TBC]; the custodian's consent	5.8.3, 5.8.5
Rewalsar, Khajjiar and Renuka	Mandi, Chamba, Sirmaur	Tal outfalls; no level found [TBC]; spill level plus head; custodian [TBC]; Renuka a Ramsar site; debris and sediment traps; no sewage	5.8.5
Kuhls in Schedules I and II of the Minor Canals Act 1976; the Beas–Sutlej Link; canals of the Jal Shakti Vibhag; drains of Municipal Corporations, Nagar Parishads and Nagar Panchayats, HIMUDA, BBNDA, HPSIDC, Smart City companies, PWD and NHAI 1.0 m wide or more	Himachal Pradesh	Major drains; owner's consent (Jal Shakti Vibhag and, for a Schedule II kuhl, the Collector; BBMB for the Link), design water level and flap gate	5.2, 5.8.5
Bhakra, Pong, Pandoh and Larji dams; the Kol, Nathpa Jhakri, Karcham Wangtoo, Chamera, Malana and Parbati projects; the Jatton barrage	Sutlej, Beas, Ravi, Giri	Releases and gate operation to be included in river levels (operating rules and release records [TBC])	5.8.3, 5.8.5
River mouths subject to sand-bar closure	None in Himachal Pradesh	Not applicable (Clause 5.1.4)	5.13.1

To be prepared. This annex will list and map (a) the major drains of each basin plan, (b) the riverine outfall reaches where backwater shall be modelled, with their upstream and downstream limits and the source of their design flood levels, and (c) the river mouths and creek inlets subject to seasonal sand-bar closure, with the most recent pre-monsoon bar crest levels and any Jal Shakti Vibhag mouth-maintenance programme. It needs Jal Shakti Vibhag river and canal records, design and recorded flood levels, reservoir operating rules, mouth-condition, dredging and bar-cutting records and pre-monsoon bar surveys (Jal Shakti Vibhag), the drain inventories of SMC 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, Jal Shakti Vibhag canal, the nallahs of Shimla that run north to the Sutlej and south to the Ashwani Khad and the Giri, the Suketi and its khads at Mandi, the Manjhi, Gaj, Banner and Neugal khads and the Bhagsunag nala below Dharamshala, Kangra and Palampur, the Sirsa, the Balad and the Sandholi and other nallahs of Baddi–Barotiwala–Nalagarh, the Swan and its tributary khads at Una, the Bata at Paonta Sahib, the side khads of the Beas in the Kullu valley, any kuhl in Schedule I or II of the Himachal Pradesh Minor Canals Act 1976 that receives storm water, the Beas–Sutlej Link, any drain built or held by a Municipal Corporation, a Nagar Parishad or Nagar Panchayat, HIMUDA, BBNDA, HPSIDC, a Smart City company or PWD with an internal width of 1.0 m or more, and every khad, nallah or choe 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 Himachal Pradesh) are assumed closed at the start of the SW monsoon unless the Jal Shakti Vibhag 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	Jal Shakti Vibhag 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	Jal Shakti Vibhag 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 site on a nallah draining to the Ashwani Khad in Shimla

Supports Clauses 5.9, 5.10, 5.11 and 5.12 of Chapter 5 and Clause 4.6.6 of Chapter 4.

Illustrative — not design values. This example applies the outfall-closed check of Clause 5.10 to the revised detention facility of Annex 4C. The site, its levels and its receiving drain are invented to show the method. No tidal level is used: the tide enters only through the illustrative statements in Table 5C.1 about whether the receiving drain is above or below the site outlet.

Inputs

5C.1 The site is the 2.0 ha flood-sensitive site of Annex 4C. It discharges through its own outlet chamber and a flap gate to a public storm drain that joins a nallah running to the Ashwani Khad below Shimla, whose level rises when the nallah runs full and when the khad is in flood, as in the storms of July and August 2023, 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 Himachal Pradesh an outfall to a khad or nallah whose invert is below its design level is closed for as long as the computed level of the stream stays above it, or for the whole storm where no hydrograph of the stream has been computed, a river-locked outfall has a single lock of at least 72 hours, and an outfall below the design level of a reservoir or tal is closed for the whole storm, under Clause 5.8.5, so in each of those cases the facility must store or pump 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 nallah would also need the debris rack and the bulking factor of Clause 6.3.6 and an invert above the range of bed movement of Clause 5.8.5(b); and on a slope in Shimla the facility itself would be a lined tank, not an infiltrating basin (Clause 4.11).

Table 5C.1 — Inputs (Illustrative — not design values)

Item	Value	Basis
Facility	Revised facility of Annex 4C: 2,500 m² plan area, vertical walls; 170 mm orifice at the floor; 460 mm orifice, invert 0.53 m	Annex 4C, Table 4C.14
Storm	1% AEP, 48 h, peak day last, AMC III; 72 h also run	Clause 5.10.2
Inflow	Post-development 1% AEP hydrographs of Annex 4C (48 h: 8,420 m³; 72 h: 9,468 m³)	Annex 4C
Receiving drain levels at the connection, J1, J2 and J3	Below the site outlet invert (from the drain owner's model)	Illustrative input
Receiving drain during each lock window	Backs up above the site outlet invert, so the site cannot discharge	Illustrative input; Clause 5.10.3(b)
Flap gate on the site outlet	Set 0.15 m below the orifice inverts in the outlet chamber, so that outside the lock windows its opening head and head loss do not affect the orifice control	Illustrative input; to be confirmed from the certified curve (Clause 5.11.2)
Lock windows	Two of 6 h each, starts 12.4 h apart (semi-diurnal tide)	Clause 5.10.3(a)
Pumps	None	—

5C.2 **Cases of Table 5.2.** Because the receiving drain stays below the site outlet in J1, J2 and J3 (Table 5C.1), those cases give the free-outfall results of Annex 4C: in J2 the 1% AEP maximum water level is **1.17 m** (2,913 m³), and in J3 (10% AEP, 48 h) it is 0.77 m. R1 and R2 do not apply, because the site does not drain to a river. J4, the outfall-closed check, is worked below.

Lock windows (Clause 5.10.3)

5C.3 The peak 1-hour block of the final 24 hours of the 48-hour storm is 35:35–36:35 h, with 98.2 mm (the 1-hour depth of Table 4C.2). Two runs are made:

- **Run A:** the first window is centred on that block: 33:05–39:05 h; the second starts 12.4 h later: 45:29–51:29 h.
- **Run B:** the first window starts at that block: 35:35–41:35 h; the second: 47:59–53:59 h.

For the 72-hour storm, every time is 24 h later.

5C.4 Gravity discharge is zero inside each window. Outside the windows the outlet discharges through the orifices of Table 4C.10. The routing is the same level-pool routing as in Annex 4C.

Results

Table 5C.2 — Outfall-closed check results (Illustrative — not design values)

Storm	Run	Lock windows (h:min)	Maximum stage (m)	Maximum storage (m³)	Time of maximum (h:min)	Largest release after a window (L/s)
1% AEP, 48 h	A	33:05–39:05; 45:29–51:29	2.01	5,019	39:05	566
1% AEP, 48 h	B	35:35–41:35; 47:59–53:59	**2.10**	**5,238**	41:35	584
1% AEP, 72 h	A	57:05–63:05; 69:29–75:29	2.00	5,012	63:05	565
1% AEP, 72 h	B	59:35–65:35; 71:59–77:59	2.09	5,233	65:35	584

Run B of the 48-hour storm governs. The first window closes the outlet just as the storm peak arrives, so the whole peak is stored. The second window arrives when the facility has drained to about 0.7 m, below the Stage 2 orifice, and adds little.

5C.5 **Volume balance (Clause 5.10.4).** Table 5C.3 gives the balance for Run B. The outflow in each period is found by continuity: outflow = storage at start + inflow − storage at end.

Table 5C.3 — Volume balance, 1% AEP 48-hour storm, Run B (Illustrative — not design values)

Period (h:min)	Inflow (m³)	Gravity outflow (m³)	Pumped (m³)	Storage at start (m³)	Storage at end (m³)
0:00–35:35, before window 1	3,817	2,213	0	0	1,604
35:35–41:35, window 1	3,634	0	0	1,604	5,238
41:35–47:59, between windows	941	4,423	0	5,238	1,756
47:59–53:59, window 2	28	0	0	1,756	1,784
After 53:59	0	1,784	0	1,784	0
Total	8,420	8,420	0	—	—

Check for window 1: V_{inflow} = 3,634 m³ ≤ $V_{storage\ available} + V_{pumped} + V_{gravity}$ = (5,238 − 1,604) + 0 + 0 = 3,634 m³. The facility therefore needs **5,238 m³** of storage, which the routing confirms.

Table 5C.4 — Stage hydrograph, 1% AEP 48-hour storm, Run B (Illustrative — not design values)

Time (h)	Inflow (L/s)	Outlet	Outflow (L/s)	Stage (m)	Storage (m³)
24	20	Open	18	0.18	445
28	39	Open	24	0.25	621
32	59	Open	32	0.36	906
34	85	Open	37	0.47	1,166
36	286	Closed	0	0.78	1,944
38	106	Closed	0	1.73	4,321
40	66	Closed	0	1.96	4,904
42	51	Open	529	1.79	4,472
44	42	Open	204	0.87	2,181
46	37	Open	49	0.74	1,854
48	33	Open	47	0.70	1,756
50	0	Closed	0	0.71	1,784
54	0	Closed	0	0.71	1,784
56	0	Open	43	0.58	1,459
60	0	Open	32	0.37	921
66	0	Open	16	0.16	397
72	0	Open	7	0.06	162

Assessment

5C.6 **Clause 5.10.4(a).** The facility of Annex 4C reaches 1.17 m in J2, and its spillway crest is at 1.35 m (Annex 4C). In the outfall-closed check the stage reaches 2.10 m, so the spillway would operate. **The facility of Annex 4C fails the check.**

5C.7 **Remedy.** Pumping (Clause 5.12) does not help here: during the lock windows the receiving drain is itself closed, and pumping into it would raise its level, which Clause 5.12.3 does not permit. The remedy is more storage. Keeping the plan area of 2,500 m² and the outlets of Annex 4C:

- the facility must hold 5,238 m³, to a stage of **2.10 m**;
- the spillway crest is set above that stage, with the 0.15 m clearance recommended in Clause 4.9.3: **2.25 m**;
- with the 4.0 m spillway of Annex 4C (head 0.30 m), the maximum level with the spillway flowing is 2.55 m, and with 0.3 m freeboard the top of the walls is at least **2.85 m** above the floor.

The outfall-closed check therefore governs the storage: 5,238 m³ against 2,913 m³ from the release-rate checks, about 80% more. A larger plan area would make the facility shallower; the outlet, caps and drawdown would then have to be re-checked, because the stage–discharge relationship changes.

5C.8 **Release after the lock.** When the first window ends, the stored water is released under a head of about 2 m, at up to 584 L/s. This is above the 100-yr cap of 356 L/s. Clause 5.10.4 allows this, because the release reaches a drain that has itself just reopened, and requires it to be included in the J4 run of the downstream analysis (Clauses 5.4 and 5.9) and reported on Form 5-1, Section H.

5C.9 **Drawdown after the storm (Clause 5.10.5).** The J1 tidal curve stays below the site outlet (Table 5C.1), so the drawdown of Annex 4C applies: 45.3 h for 90% of the 10-yr storage with the low-flow orifice 50% blocked, within the 48-hour limit of Clause 4.7. In Run B, 90% of the maximum J4 storage is released 22.6 h after the maximum.

5C.10 **Other requirements.**

- The flap gate on the site outlet is inspected and operated before 15 June 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 Balh valley, the river terraces and floodplains, and the tal and reservoir margins without piezometer readings that level is existing ground level (Clauses 4.12.1 and 4.12.3).
- The fence and signs of Annex 4C apply to the deeper facility (Clause 4.15).

Table 5C.5 — Summary (Illustrative — not design values)

Item	Value
Governing case	J4, 1% AEP 48-hour storm, Run B (first window starting at the peak 1-hour block)
Storage required	5,238 m³ (Annex 4C release-rate design: 2,913 m³)
Maximum stage	2.10 m, with 2,500 m² plan area
Spillway crest	2.25 m
Top of walls	≥ 2.85 m above the floor
Largest release after a lock window	584 L/s, to be included in the downstream J4 run
Drawdown	Annex 4C result applies: 45.3 h with the low-flow orifice 50% blocked

Form 5-1 — Downstream and Tailwater Report

Supports Clauses 5.3 to 5.14 of Chapter 5.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. One report for each project. Sites of less than 0.5 ha that meet Clause 5.3.4 may submit Form 5-2 instead, where the Authority accepts it. Attach the plans, model files and hydrographs referred to.

A. Project

Table 5F.1 — Form 5-1: project

Field	Entry
A1. Project name, applicant and location	
A2. Project type: site under Chapter 4; drainage project under Chapter 6; regional detention or tank restoration (Clause 5.1.2)	
A3. Site or project area (ha) and outfalls	
A4. Site Runoff Control Report reference (Form 4-1), where applicable	

B. Extent of the analysis (Clause 5.3; Clause 5.14, item 1)

Table 5F.2 — Form 5-1: analysis points

Point	Location	Type (Clause 5.3.3 (a) to (e))	Contributing catchment (ha)	Project area as % of it

Table 5F.3 — Form 5-1: end point

Field	Entry
B1. End point and reason: 10% point, tank or tal, or major drain or the sea (Clause 5.3.1 (a) to (c))	
B2. Where the end point is a tank or tal: 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. River-locked outfalls, khads and nallahs, reservoir, barrage-pond and tal outfalls, rivers below dams and barrages, and kuhls, canals or drains of other bodies: operator of each gate and pumping station identified, gate sills, bank, wall or embankment crest, installed capacity, operating levels and gate-closing level obtained, with every level tied to the datum of the nearest CWC gauge or of the named gauge used; 1% AEP river level at the outfall from a model, with the dam releases, and not below the highest recorded level at the nearest CWC gauge transferred to the outfall (384.6 m at Paonta, 373.52 m at Ganguwala, 933 m at Rampur, 367 m at Ghaluwal, and the other levels of Clause 5.8.5(a); Pandoa treated as ungauged until CWC confirms its level), with the profile or flood-mark survey used, or, where no gauge level exists (the Beas at Manali, Kullu, Mandi and Pandoh, the Ravi at Chamba and other reaches), a modelled or surveyed flood level and its source; 10% AEP river level, not below the CWC danger level transferred where one exists (384.5 m at Paonta); drain behind the gate routed with its whole catchment and present storage, pumping confirmed available (permanent pumps only, not more than installed capacity less the largest pump), pumps operable at the design river level; single river lock of not less than 72 hours, or the duration of the largest recorded release below a dam or barrage if longer, and its source, and closure for the whole storm below a reservoir or barrage pond level; gate-failure and breach checks; for a khad or nallah, the 1% AEP study with the bulking and blockage of Clause 6.3.6, the surveyed flood marks and their sources, any Jal Shakti Vibhag flood study, the bed survey and range of bed movement, the invert at least 0.5 m above the highest surveyed bed level and the scour depth of the foundation; for a reservoir or barrage pond, custodian's consent, MWL or FRL plus design-flood surcharge (FRL + 0.5 m where neither is published), every level in feet converted at 1 ft = 0.3048 m with its datum stated (Gobind Sagar 515.11 m; Pong 433.12 m, the highest of the conflicting maximum levels), not below the highest recorded level, outfall below it treated as closed for the whole storm, waterbody starting at FRL or pond level, no gate operation or reservoir attenuation credited without the custodian's written rule; for an outfall below a dam or barrage, the design storm with the largest recorded release, placed before, during and after the storm; for Rewalsar, Khajjiar, Renuka or another tal, the custodian's consent, the surveyed spill level plus head, and the debris and sediment traps before the tal; for a kuhl, the consent of the Jal Shakti Vibhag (and of the Collector for a Schedule II kuhl), its level computed with the runoff it intercepts; for a canal, the operator's consent; Jal Shakti Vibhag consent, and the TCP Rules, development-plan, wetland and court lines checked; owner's consent, permitted rate, design water level or computed channel level, and flap gate (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				
J4				
R1				
R2				

H. Outfall-closed check (Clause 5.10; Clause 5.14, item 7)

Table 5F.9 — Form 5-1: outfall-closed check

Field	Entry
H1. Reason the check applies (Clause 5.10.1)	
H2. Storm: AEP, 48 h and 72 h, AMC III (Clause 5.10.2)	
H3. Lock duration and basis: default of two 6-hour windows, or site study (Clause 5.10.6); extension for sand-bar closure (Clause 5.13.5)	
H4. Lock windows of the two runs (start and end times) (Clause 5.10.3(d))	
H5. Maximum stage in each facility, against its 1% AEP maximum water level (Clause 5.10.4(a))	
H6. Maximum stage in the minor and major systems, against the Chapter 6 limits (Clause 5.10.4(b))	
H7. Property connections: surcharge level, or non-return valves fitted (Clause 5.10.4(c))	
H8. Stage hydrographs (attach)	
H9. Drawdown after the storm under the J1 tidal curve, and pumping where needed (Clause 5.10.5)	

Table 5F.10 — Form 5-1: volume balance for each lock window (Clause 5.10.4)

Period	Inflow (m^3)	Gravity outflow (m^3)	Pumped (m^3)	Storage at start (m^3)	Storage at end (m^3)
Before window 1					
Window 1					
Between windows					
Window 2					
After window 2					

I. Gates and valves (Clause 5.11; Clause 5.14, item 8)

Table 5F.11 — Form 5-1: schedule of flap gates, tide gates and non-return valves

Location	Type	Size (mm)	Invert (m, project datum)	Certified head–discharge data (reference)	Stop-log or penstock (outfalls > 600 mm)

J. Pumped outfalls (Clause 5.12; Clause 5.14, item 9)

Table 5F.12 — Form 5-1: pumped outfalls

Field	Entry
J1. Reason pumping is needed (Clause 5.12.1)	
J2. Duty capacity (m^3/s) at the static head for the J2 tailwater; standby capacity (Clause 5.12.2)	
J3. Effect on the receiving water level (Clause 5.12.3)	

Field	Entry
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 Jal Shakti Vibhag 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 15 June and after closure events (Clause 5.11.5)	
L2. Pump test runs before 15 June (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 Himachal Pradesh Stormwater Design Manual (Draft v1.0), that the results reported are reproduced by the models submitted, and that every departure from Chapter 5 is listed with its reason. The Professional Design Certificate (Form 10-3) is attached.

Table 5F.15 — Form 5-1: statement by the registered professional

Field	Entry
Name	
Qualification and registration number	
Empanelment number, where Clause 10.6.1 requires it	
Organisation	
Signature	
Date	

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0.

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

Supports Clause 5.3.4 of Chapter 5.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. For sites of less than 0.5 ha. The Authority may accept this statement in place of the full analysis only where every answer in Section B is "Yes". Otherwise submit Form 5-1.

A. Site

Table 5F.16 — Form 5-2: site

Field	Entry
A1. Project name, applicant and location	
A2. Site area (ha), less than 0.5 ha	
A3. Receiving public drain: name or reference, type and size	
A4. Site Runoff Control Report reference (Form 4-1)	

B. Conditions (Clause 5.3.4)

Table 5F.17 — Form 5-2: conditions

Condition	Yes / No	Evidence
B1. The receiving public drain has documented capacity for its minor-system design flow (Chapter 6)		
B2. No flood-prone location is recorded within 500 m downstream of the site outfall. Records checked: local body, SMC, HPSDMA, Jal Shakti Vibhag (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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 6

Minor and Major Drainage Systems

These annexes support Chapter 6. Annex 6A (standard inlets and their capacity curves) and Annex 6B (sediment yield) need test and survey data that are not yet available; each states what it will contain and the interim rule to use until it is published. Annex 6C gives standard drawings that carry only the dimensions Chapter 6 and Chapter 9 already set; every other dimension is marked "to be confirmed in design". Form 6-1 is a draft form: it lists what Clause 6.15 requires and does not add to it.

Annex 6A — Standard inlet types for Himachal Pradesh with capacity curves (on grade and sag)

Supports Clauses 6.6.1 to 6.6.7 of Chapter 6 and Clause 9.11 of Chapter 9.

To be prepared. This annex will contain a short list of standard inlet types for Himachal Pradesh streets (kerb-opening, grate and combination inlets, including the road-level wall opening into a covered drain) and, for each type, capacity curves on grade and in a sag. It needs a fixed set of standard inlet geometries agreed with the road-owning agencies, and rating tests of those geometries (laboratory or full-scale), or HEC-22 calculations for each geometry checked against tests (data and likely sources: Public Works Department (PWD), NHAI and Shimla Municipal Corporation standard details, IIT Mandi, NIT Hamirpur, NIH Roorkee 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

Item	Requirement	Clause
Grate pattern	Openings parallel to the direction of travel not wider than 25 mm	9.11.3(a)
Load class	D400 in carriageways and medians; C250 within 0.5 m of the kerb; B125 in footpaths and cycle tracks (or the equivalent IS class)	9.11.2
Connection pipe	At least 300 mm diameter; gradient giving at least 0.9 m/s at the inlet's design flow	6.6.6
Silt sump	At least 300 mm deep below the outlet pipe invert, cleanable from the surface	6.6.7, 9.11.6

The intended layout of the annex is given in Tables 6A.2 to 6A.4.

Table 6A.2 — Register of standard inlet types (layout)

Type code	Description	Grate size or kerb opening (mm)	Gutter depression (mm)	Load class	Standard drawing
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Table 6A.3 — Capacity on grade (layout; one table per inlet type)

Cross slope Sx (m/m)	Longitudinal slope SL (m/m)	Gutter flow Q (L/s)	Spread T (m)	Clean intercepted flow (L/s)	Design intercepted flow after clogging (L/s)	Bypass flow (L/s)
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

Table 6A.4 — Capacity in a sag (layout; one table per inlet type)

Ponded depth at the inlet (mm)	Clean capacity (L/s)	Clogging factor (Table 6.5)	Design capacity (L/s)	Flow regime (weir, orifice or transition)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Annex 6B — Sediment yield for silt-trap sizing and calibration of the sediment allowance

Supports Clauses 6.7.4, 6.7.8, 6.13.3 and 6.13.10 of Chapter 6.

To be prepared. This annex will contain sediment yields for urban drains in Himachal Pradesh, by land use and drain type, for sizing the silt traps of Clause 6.13.3, and a calibration of the sediment allowance of Clause 6.7.8 against measured silt depths. It needs desilting records (volume or mass removed per drain length and per catchment area, with dates), silt-depth surveys before and after the south-west monsoon, and catchment land-use and soil data (data and likely sources: desilting records of Shimla Municipal Corporation and other urban local bodies, Jal Shakti Vibhag records for channels, land cover from NRSC, soils from the Himachal Pradesh soil survey and NBSS&LUP, rainfall from IMD). Until it is published, size each silt trap from the designer's stated estimate of the sediment expected between scheduled cleanings, based on the desilting records of the same drain or of similar drains in the same local body, and state the cleaning interval assumed; the interval shall not be longer than the yearly pre-monsoon desilting of Clause 6.13.10. Inlet silt sumps remain at least 300 mm deep (Clause 6.6.7), and the sediment allowance of Clause 6.7.8 applies unchanged.

The intended method is a simple volume balance, with every term to be stated in the design:

$$V_{trap} = Y \cdot A \cdot t_c$$

where V_{trap} is the sediment storage volume of the trap below its outlet invert (m^3), Y is the sediment yield for the catchment's land use and drain type (m^3/ha per year, from Table 6B.2 once published), A is the catchment area draining to the trap (ha), and t_c is the scheduled cleaning interval (years). The annex will state whether a safety margin is added.

Table 6B.1 — Sediment allowances already set by Chapter 6 (provisional, to be calibrated)

Element	Sediment allowance at the invert	Clause
Open and covered drains	Greater of 75 mm and 10% of the clear internal depth	6.7.8(a)
Pipes of 600 mm diameter or more	5% of the internal diameter	6.7.8(b)
Pipes below 600 mm	No allowance; minimum velocity of Clause 6.7.3(a) applies	6.7.8(c)
Drains and pipes that cannot reach the minimum velocity	Allowance doubled; mechanical desilting access provided	6.7.4(b), (c)
Inlet silt sumps	At least 300 mm below the outlet pipe invert	6.6.7

Table 6B.2 — Sediment yield by land use and drain type (layout)

Land use or catchment type	Drain type	Sediment yield Y (m^3/ha per year)	Bulk density (t/m^3)	Local body and records used	Years of record
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Table 6B.3 — Calibration of the sediment allowance (layout)

Drain or pipe ID	Clear internal depth or diameter (mm)	Allowance under Clause 6.7.8 (mm)	Measured silt depth before pre-monsoon desilting (mm)	Measured silt depth at the end of the monsoon (mm)	Ratio of measured to allowance
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Annex 6C — Standard drawings: covered roadside drain with removable covers, access chamber, inlet with silt sump

Supports Clauses 6.6, 6.7.6 to 6.7.10 and 6.13 of Chapter 6, and Clauses 9.11 and 9.12 of Chapter 9.

The drawings below are schematic standard drawings. They show only the dimensions that Chapter 6 and Chapter 9 set. Wall and slab thicknesses, reinforcement, concrete grade and cover, chamber plan sizes and frame details are to be confirmed in design: they come from the structural design (Clause 9.1.2) and the exposure class of Clause 9.13. Table 6C.1 lists the dimensions shown and their source clauses.

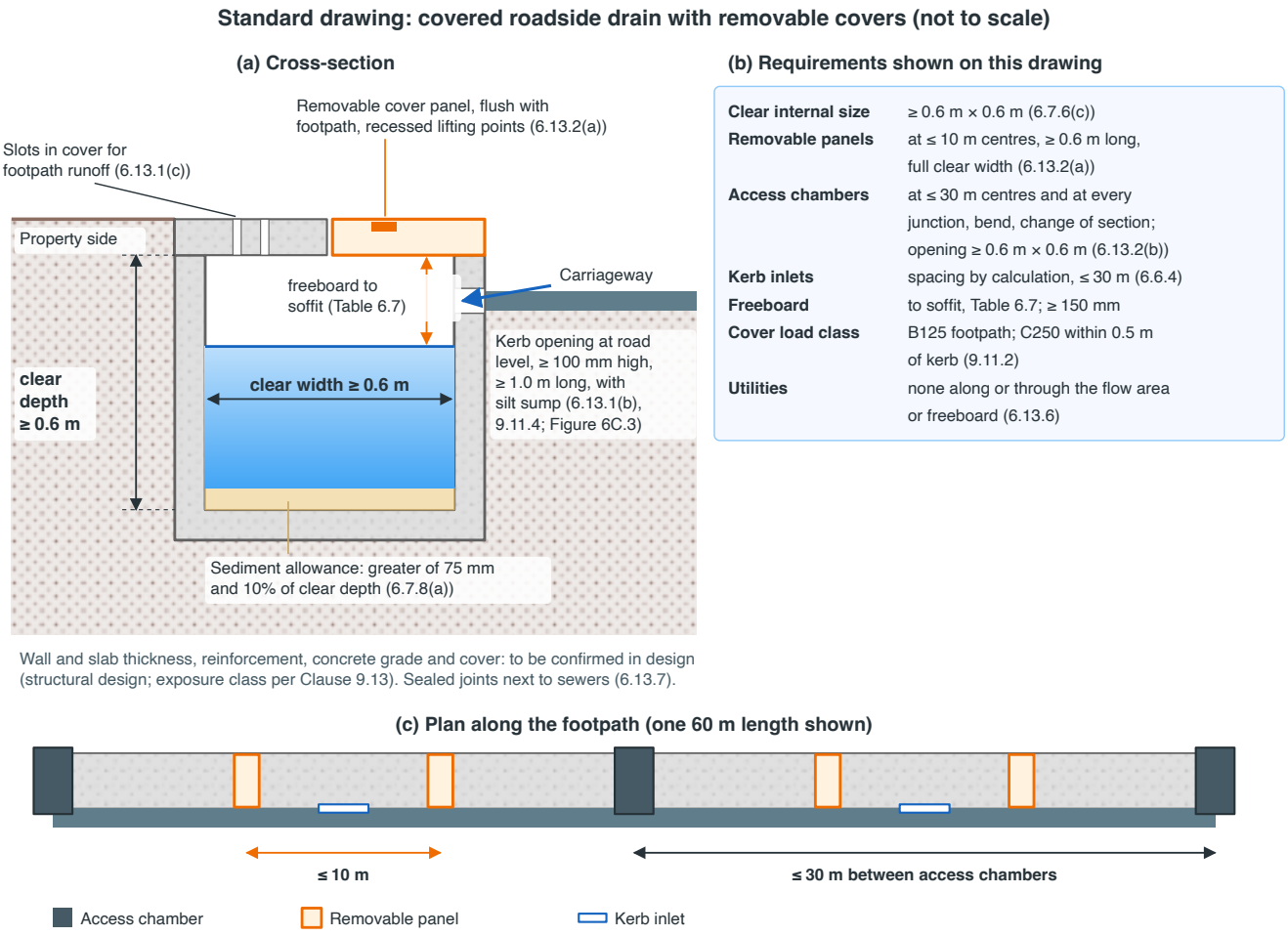

Figure 6C.1 — Standard drawing: covered roadside drain with removable covers, kerb inlets at road level, footpath slots, freeboard to the soffit and sediment allowance, with a plan of cover panels and access chambers along the footpath. Original drawing for this Manual, adapted from CPHEEO, Manual on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

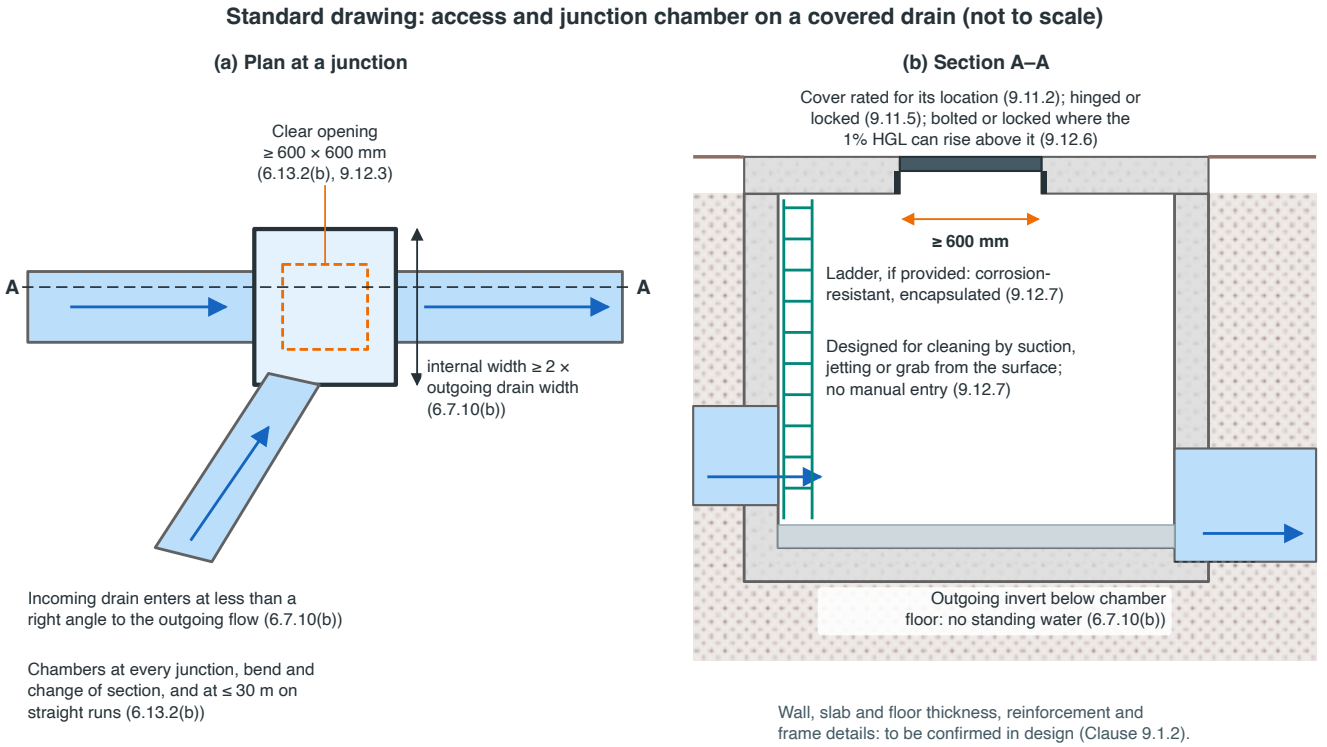

Figure 6C.2 — Standard drawing: access and junction chamber on a covered drain, with the clear opening, junction width, entry angle of the incoming drain, outgoing invert below the chamber floor, and cover requirements. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage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

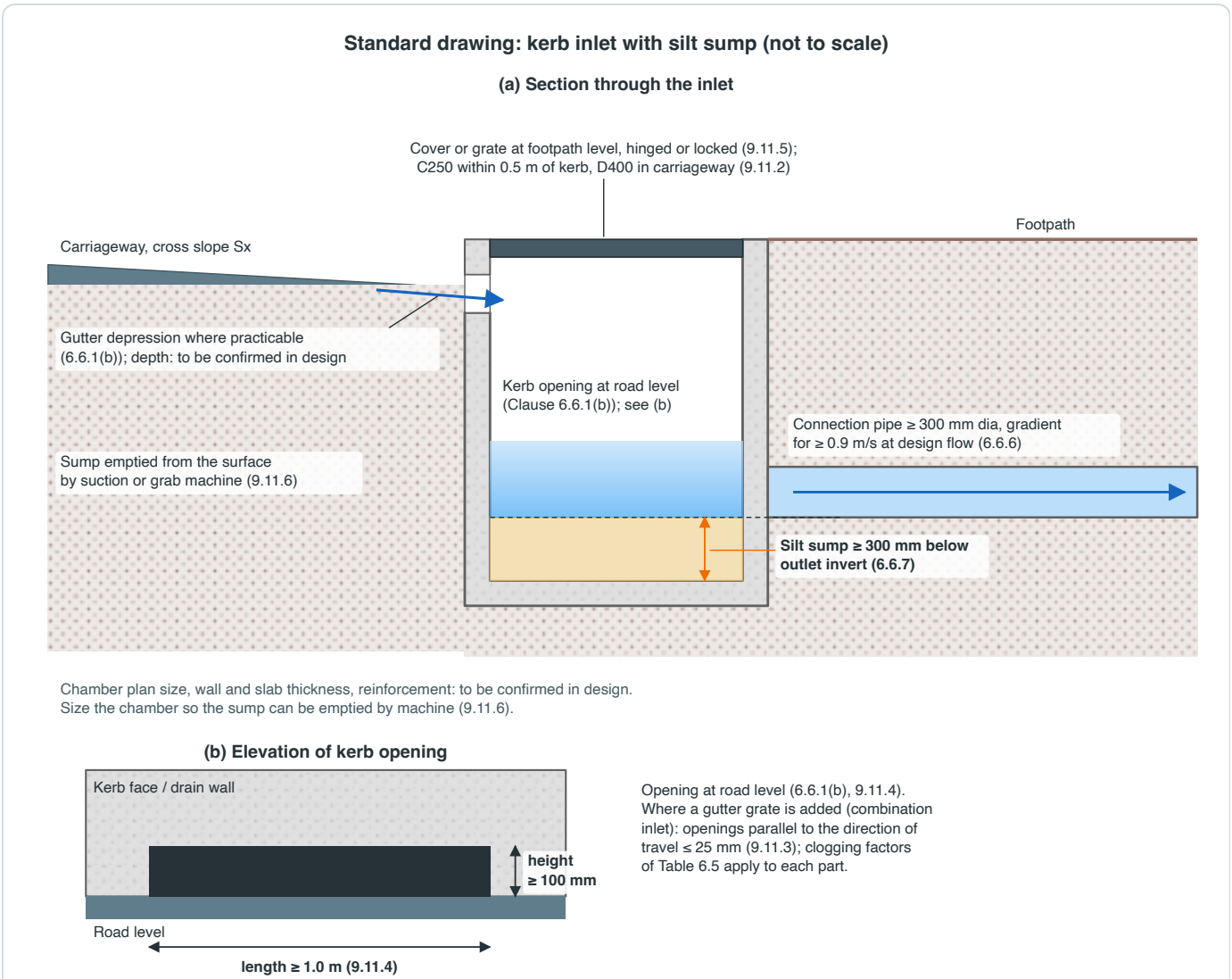

Figure 6C.3 — Standard drawing: kerb inlet at road level with silt sump, connection pipe and cover, and an elevation of the kerb opening. Original drawing for this Manual, adapted from CPHEEO, Manual on Storm Water Drainage Systems (2019), Figure 5.9, and FHWA, HEC-22 Urban Drainage Design Manual (4th ed., 2024).

Table 6C.1 — Dimensions on the standard drawings and their source clauses

Drawing	Item	Dimension or rule	Clause
6C.1	Clear internal size of a covered public drain	At least 0.6 m wide and 0.6 m deep	6.7.6(c)
6C.1	Freeboard to the cover soffit	Table 6.7; not less than 150 mm for any roadside drain	6.7.9, 6.13.1(a)
6C.1	Sediment allowance	Greater of 75 mm and 10% of clear depth	6.7.8(a)
6C.1	Removable cover panels	At not more than 10 m centres; each at least 0.6 m long and spanning the full clear width; recessed lifting points; flush with the footpath	6.13.2(a)
6C.1	Footpath runoff	Through slots or grated openings in the cover	6.13.1(c)
6C.1	Kerb inlets	Openings in the drain wall at road level, each with a silt sump; spacing by calculation, not more than 30 m	6.13.1(b), 6.6.4
6C.1, 6C.2	Access chambers	At every junction, bend and change of section, and at not more than 30 m centres on straight runs	6.13.2(b)

Drawing	Item	Dimension or rule	Clause
6C.2	Clear access opening	At least 0.6 m × 0.6 m (600 mm)	6.13.2(b), 9.12.3
6C.2	Junction chamber	Internal width at least twice the outgoing drain width; incoming drains at less than a right angle; outgoing invert below the chamber floor	6.7.10(b)
6C.2	Covers	Load class for the location; hinged or locked; bolted or locked where the 1% AEP HGL can rise above the cover	9.11.2, 9.11.5, 9.12.6
6C.2	Cleaning	By machine from the surface; ladders, where provided, corrosion-resistant and encapsulated	9.12.7
6C.3	Kerb opening	At road level; clear height at least 100 mm; length at least 1.0 m	6.6.1(b), 9.11.4
6C.3	Silt sump	At least 300 mm below the outlet pipe invert; emptied by suction or grab machine	6.6.7, 9.11.6
6C.3	Connection pipe	At least 300 mm diameter; at least 0.9 m/s at the design flow	6.6.6
6C.3	Grate in a combination inlet	Openings parallel to travel not wider than 25 mm; Table 6.5 clogging on each part	9.11.3, 6.6.3
All	Wall and slab thickness, reinforcement, concrete grade and cover, chamber plan size, gutter depression depth	To be confirmed in design	9.1.2, 9.13

Form 6-1 — Conveyance Design Report checklist

Supports Clause 6.15 of Chapter 6.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Not for statutory use.

Attach this checklist to the front of the Conveyance Design Report. For each item, enter Yes, No or Not applicable, and the drawing or page where it is shown.

Section A — Project

Table 6F.1 — Form 6-1, Section A: project

Field	Entry
Project name and location	_____
Local body, and Tier A or Tier B (Chapter 1)	_____
Applicant	_____
Designer (name and registration)	_____
Total catchment area served (ha)	_____
High-density area status for the 10% AEP minor system (Clause 6.4.4)	_____
Within the coastal band of Clause 6.11.6 (Yes / No)	_____
Date and revision	_____

Section B — Contents required by Clause 6.15

Table 6F.2 — Form 6-1, Section B: contents required by Clause 6.15

No.	Item	Clause	Provided (Yes / No / NA)	Drawing or page
1	Catchment plan: sub-catchments, minor system, inlet locations and the 1% AEP major-system overland flow paths	6.3.2		
2	Land-use and road-class AEP adopted for each element, and the high-density area status	Table 6.1, 6.4.4		
3	Design flows, with the rainfall sheet of Chapter 2 and the method of Chapter 3	6.3.4		
4	Gutter spread, depth and D·V checks for the minor, check and 1% events	Tables 6.2, 6.3		
5	Inlet schedule: clean capacity, clogging factor, design capacity and bypass flow	6.6		
6	Pipe and drain design tables: n, velocity, sediment allowance and freeboard	6.7		
7	HGL profiles for the minor and check events, with the tailwater used	6.8		
8	Sag ponding levels, including the fully-blocked check	6.10		
9	Floor-level schedule for every building	6.11		
10	Culvert and crossing calculations (with Form 9-1)	6.12, Chapter 9		

No.	Item	Clause	Provided (Yes / No / NA)	Drawing or page
11	Utilities-crossing schedule and access-opening layout for covered drains	6.13		

Section C — Design basis

Table 6F.3 — Form 6-1, Section C: design basis

Field	Entry	Clause
Minor-system design AEP adopted	_____	Table 6.1
Road class(es) and design / check AEPs for road drainage and crossings	_____	Table 6.1, 6.4.2
Rainfall source and climate factor applied	_____	6.3.4, Chapter 2
Method: Rational Method (catchment ≤ 16 ha, single element) or hydrograph method with routing	_____	6.3.4(a), (b)
Minimum time of concentration used (not less than 10 min)	_____	6.3.4(c)
Tailwater at the outfall for the HGL (MHWS + 0.3 m at tidal outfalls, or the receiving level)	_____	6.8.2
Any transfer of flow between natural catchments (none unless accepted under 6.3.5)	_____	6.3.5

Section D — Compliance checks

Table 6F.4 — Form 6-1, Section D: compliance checks

No.	Check	Limit	Clause	Complies (Yes / No / NA)
D1	Every inlet, sag, pipe, drain, culvert and storage element has a 1% AEP overland path	Shown on plan	6.3.2	
D2	Major-system flow = 1% AEP peak less the clogged minor-system capacity	Computed at each point	6.3.3	
D3	Spread in the minor event	Table 6.2	6.5.2	
D4	Depth in the check and 1% events	≤ 150 mm at the crown; ≤ 350 mm at the deepest point	Table 6.2	
D5	Flow hazard (D·V) by location	Table 6.3	6.5.3	
D6	Inlet clogging factors applied	Table 6.5	6.6.3	
D7	Inlet spacing on kerbed roads	≤ 30 m	6.6.4(a)	
D8	Sag inlet design capacity ≥ minor design flow arriving; flanking inlets where required	—	6.6.5	
D9	Inlet connection pipes and silt sumps	≥ 300 mm dia, ≥ 0.9 m/s; sump ≥ 300 mm	6.6.6, 6.6.7	
D10	Manning's n not less than the minimum design values	Table 6.6	6.7.2	
D11	Minimum velocity at the minor design flow	0.6 m/s drains; 0.9 m/s pipes	6.7.3(a)	
D12	Maximum velocity and Froude number	3.0 m/s lined drains and pipes; Fr ≤ 0.8	6.7.3(b), (d)	

No.	Check	Limit	Clause	Complies (Yes / No / NA)
D13	Where minimum velocity cannot be met: velocity reported, sediment allowance doubled, desilting access provided	—	6.7.4	
D14	Pipes sized for pipe-full capacity, not the 0.95-depth peak	—	6.7.5	
D15	Minimum sizes	Pipes 300 mm (450 mm public mains); open drain bed 0.3 m; covered public drains 0.6 m × 0.6 m	6.7.6	
D16	Cover to pipes; flotation check where groundwater is within 1 m of the crown	≥ 0.6 m; ≥ 0.9 m under carriageways	6.7.7	
D17	Sediment allowance in capacity	6.7.8 values	6.7.8	
D18	Freeboard, including superelevation at bends	Table 6.7	6.7.9	
D19	Bend radii and junction sumps	6.7.10	6.7.10	
D20	Manhole spacing on straight runs	Table 6.8	6.7.11	
D21	HGL below inlet rims and manhole covers in the minor event	≥ 0.3 m	6.8.3	
D22	Manholes that can surcharge above ground: bolted or locked covers	—	6.8.4	
D23	Soffits matched or outgoing soffit lower; outgoing invert not above the lowest incoming invert	—	6.8.6	
D24	Gate and valve losses included in the HGL; non-return valves on private connections where required	—	6.8.7, 6.8.8	
D25	Overland flow paths outside streets: width, tenure, no obstruction, continuous fall	≥ 1% top width + 0.5 m each side, ≥ 3.0 m	6.9.2	
D26	Compound walls across mapped flow paths: openings pass the 1% flow at 50% blockage	—	6.9.3	
D27	Access strip along open drains with top width ≥ 2 m	≥ 3.5 m, linked to a road at ≤ 500 m	6.9.4	
D28	Drainage reserve where required: width, separate plot, no structures, markers, services, 2 m stability check	Table 6.9	6.9.6–6.9.8	
D29	Sag ponding in the 1% event, overflow route, and fully-blocked check	≤ 350 mm at the deepest point	6.10.2, 6.10.3	
D30	Trapped sags and road underpasses	6.10.4, 6.10.5	6.10.4, 6.10.5	
D31	Floor levels	≥ 1% AEP level + 0.5 m; defaults of 6.11.3 where no level is computed	6.11.1–6.11.3	
D32	Basements and building services	6.11.4, 6.11.5	6.11.4, 6.11.5	
D33	Coastal band: floor ≥ 1% still-water level + 2 × SLA (+ wave set-up where applicable) + 0.5 m; no basement rooms or plant	—	6.11.6	
D34	Culverts: design AEP, overtopping, 50% / 20% blockage check, minimum size	≥ 900 mm	6.12	

No.	Check	Limit	Clause	Complies (Yes / No / NA)
D35	Covered drains: removable panels and access chambers	≤ 10 m; ≤ 30 m	6.13.1, 6.13.2	
D36	Silt traps, screens with bypass and 50% blockage check	—	6.13.3, 6.13.4	
D37	No building over drains; no utilities in the flow area or freeboard; existing crossings deducted with 50% blockage	—	6.13.5, 6.13.6	
D38	No sewage connections; sealed joints next to sewers; edge protection on open drains deeper than 1.0 m	—	6.13.7, 6.13.8	
D39	Outfalls: tailwater, flap gates or non-return valves below the 1% still-water level, outlet protection	—	6.14	

Section E — Variances

Table 6F.5 — Form 6-1, Section E: variances

Clause	Requirement not met	Reason and proposed alternative	Approved by and date
_____	_____	_____	_____

Section F — Signatures

The report shall be prepared and signed by a registered professional, and the Professional Design Certificate (Form 10-3) attached (Clauses 10.6.1 and 10.6.3 of Chapter 10). Where a structure stands within 2 m of the edge of a drainage reserve, the stability design shall also be signed by a qualified structural engineer (Clause 6.9.8(f)).

Table 6F.6 — Form 6-1, Section F: signatures

Role	Name	Registration or empanelment no.	Signature	Date
Designer	_____	_____	_____	_____
Structural engineer (Clause 6.9.8(f), where applicable)	_____	_____	_____	_____

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 7

Waterbodies, Tals (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 Hindi and Pahari 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 Jal Shakti Vibhag and the Revenue Department. It needs the Revenue records and village maps of the Revenue Department, in which rivers, khads, nallahs, kuhls, tals, baolis and land covered by water are recorded; the existing water bodies, "like Bauri, Well, Nallah, khud", that the site plan forms of the TCP Rules 2014 require on every application for planning permission; the land use maps, sinking and sliding zones, non-developable land and distances from the highest flood level along rivers, khads and nullahs of each Interim Development Plan or Development Plan, such as the Shimla Development Plan (published on 20 June 2023); the drains and nallahs in the records of a Municipal Corporation, Nagar Parishad or Nagar Panchayat, and SJPNL's records of Shimla's sources and sewers; the kuhls listed by district and tehsil in Schedules I and II of the Himachal Pradesh Minor Canals Act, 1976; the boundaries of the Ramsar sites at Pong, Chandertal and Renuka and of any wetland notified under the Wetlands (Conservation and Management) Rules, 2017, and the wetlands of the national atlas; BBMB's and the other dam operators' records of reservoir levels and acquired land; the spring inventories (about 500 springs inventoried in a standard format, NITI Aayog, 2021); and the lists of encroachment and muck dumping filed before the High Court of Himachal Pradesh and the National Green Tribunal; the JSV and Gram Panchayat 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 JSV records, with local name	7.3.1(a)
WB_NAME_HI	Text	Hindi script	Yes	Name in Hindi	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, tehsil 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	JSV 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)
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 JSV datum	7.3.5

Field	Type	Unit / domain	Required	Content	Clause
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; khad (hill torrent); nallah (natural drain or storm channel); nali (street, roadside or house drain); cho (seasonal Siwalik torrent); kuhl (irrigation channel; scheduled or not); canal; lake or tal; reservoir or barrage pond (with its drawdown zone); spring (naun, baoli or chashma) and its recharge area; khatri (rock-cut seepage tank); wetland; glacial or moraine-dammed lake; supply channel; surplus course	7.2
CUSTODIAN	Municipal Corporation, Nagar Parishad or Nagar Panchayat (Municipal Acts, 1994 [TBC]); SJPNL (Shimla sources and sewers); JSV (division); HPPWD or NHAI (road drains and culverts); Government, local authority or beneficiaries with the Collector (scheduled kuhl, Minor Canals Act, 1976); BBMB, NTPC, SJVN, NHPC, HPSEBL or other dam operator; Forest Department (forest land; wildlife sanctuary); State Government through the Deputy Commissioner or Tehsildar; Gram Panchayat; HIMUDA, HPSIDC, BBNDA or developer (until handed over); Himachal Pradesh State Wetlands Authority (wetland); private owner; 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)
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 JSV control, the operating rule is JSV'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, tehsil, district].
2. Custodian: [JSV division / ULB / Gram Panchayat / 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

Period	Target level (m)	Upper limit (m)	Lower limit (m)	Purpose
[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 SW 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 HPSDMA red alert	IMD, HPSDMA	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 SW monsoon (15 June to 31 October) the operator shall record daily: the tank level, every release (time, rate and duration), and every gate setting. Outside the SW 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 SW monsoon (by 31 May) 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 Himachal Pradesh State Pollution Control Board (HPSPCB) 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 Himachal Pradesh State Pollution Control Board (HPSPCB) 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 May**. No excavation shall be left open, and no sluice or weir left dismantled, during the SW 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 May)	As-built survey, stage–storage curve, silt disposal record	7.9.8, 7.7.1(b)

Annex 7E — Glossary of Hindi and Pahari waterbody terms and regional variants

Supports Clause 7.2 and Clause 7.3 of Chapter 7.

The terms below are Hindi words, and Pahari words where they are in use, for waterbodies, springs, channels and land in Himachal Pradesh, given in Devanagari and, where Platts gives it, Urdu script. Many of them appear in the names of lakes, streams and places (Rewalsar, Ashwani Khad, Banu Khad, Sikandara Dhar). The name used in the Revenue, JSV, municipal or SJPNL 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 confirmed in Tika Ram Joshi, *A Dictionary of the Pahari Dialects as Spoken in the Punjab Himalayas* (1911), the only Pahari dictionary checked; in J. T. Platts, *A Dictionary of Urdu, Classical Hindi, and English* (1884), or Syamasundara Dasa, *Hindi Shabdasagara* (1965–1975), both as served by the Digital South Asia Library, with the page shown there; or in R. L. Turner, *A Comparative Dictionary of the Indo-Aryan Languages* (CDIAL, 1962–1966), by entry number. **Two cautions apply.** Joshi's dictionary was read in a poor OCR copy, and its page numbers, taken from the printed running heads, may be one page out (±1); some headwords and accents are lost. The CDIAL entry numbers were taken from web summaries, not from the dictionary pages, and are to be checked on the Digital South Asia Library before this annex is relied on. Meanings are the dictionaries' English glosses, or a translation of their Hindi, and modern usage may be narrower or wider. Every term whose meaning or regional use was not confirmed in a dictionary is in Table 7E.4. The list is to be extended by the State Stormwater Technical Committee, with modern Revenue, JSV and municipal usage and with other Pahari dictionaries.

The Manual's term for a lake, tank or pond in Himachal Pradesh is **tal (ताल)**: it is the only candidate found with a water sense in all four sources, Joshi records it in the hill dialects, and it covers both natural lakes and built tanks. Because ताल also means rhythm and the palm of the hand, it is glossed on first use as "tal (pond, lake or tank)". **Naun (नौण)** and **baoli (बावड़ी)** are used, always glossed, only for spring-fed sources; and an engineered detention basin is not called a tal, naun or baoli: it is a detention pond, with the local word in brackets where that helps. The romanised "talab" is avoided, because in Joshi *talab* is a salary.

Table 7E.1 — Waterbodies

Term	Meaning	Source of the term	Manual term (Clause 7.2)
ताल / تال (tāl; tal)	"A pond, a lake or tank" (Joshi, marked as Hindi); "pond, pool, tank, lake (= tālāb)" (Platts, second sense; the first is the palm and musical time); in CDIAL, Western Pahari *tāl* "pond"	Joshi, p. 238; Platts, p. 306; CDIAL 5742	Tal (lake, tank or pond), see the definitions after Clause 7.2
सर, सरोवर / سروور (sar, sarovar)	सर: "a large sheet of water, lake, pond"; सरोवर: "तालाब । पोखरा । झील । ताल ।", a tank, a pond, a lake	Platts, pp. 648 and 658; Shabdasagara, p. 5003	In names only, such as Rewalsar; a tal for this chapter

Term	Meaning	Source of the term	Manual term (Clause 7.2)
झील / جھیل (jhīl; jheel)	"A pool, a shallow lake; a marsh, morass, swamp"; in the Shabdasagara, a very large natural waterbody surrounded by land, some fed by springs in their own bed	Platts, p. 411; Shabdasagara, p. 1848	A tal; a marsh under Clause 7.12 where it is one
कुंड (kuṇḍ; kund)	"A pool, a deep hole in a stream" (Joshi); in the Shabdasagara, "छोटा बँधा हुआ जलाशय । बहुत छोटा तालाब ।", a small embanked waterbody, a very small tank	Joshi, p. 199; Shabdasagara, p. 964	A pool in a khad, or a small tank; a waterbody for Clause 7.3
नौण (nauṇ; naun)	"A place for water" (Joshi; headword lost in the OCR, its place in the alphabet fits *nauṇ*); in CDIAL, Western Pahari *nauṇ* "brick-built tank, well" and Punjabi of Kangra *nauṇ* "artificial reservoir, spring". Platts and the Shabdasagara have no water sense	Joshi, p. 211; CDIAL 13790a and 13783a	Spring (naun), see the definitions after Clause 7.2
बावड़ी, बाउड़ी / باولي (bāoṛī, bāolī; baoli, bauri)	"A water pool" (Joshi, *Báori*, from Sanskrit *vāpī*); in Platts (बावली), "A large masonry well, generally with winding steps down to the water"; in CDIAL, Western Pahari "tank, stone-built reservoir fed by a spring, spring". In the hills a small spring-fed pool or stone tank, in the plains a step-well; the TCP site plan forms ask for every "Bauri" to be shown	Joshi, pp. 126 and 128; Platts, p. 128; CDIAL 11529; TCP Rules 2014, forms	Spring (baoli), see the definitions after Clause 7.2
खाल (khāl); डाबर (dábr)	"a tank, a pond" and "small pond or tank" (Joshi; OCR poor)	Joshi, pp. 191 and 146	Local only; a tal for this chapter, always glossed

Table 7E.2 — Springs, streams and channels

Term	Meaning	Source of the term	Manual term (Clause 7.2)
चश्मा (caśmā; chashma)	"पानी का सोता, स्रोत", a spring, a source (also spectacles)	Shabdasagara, p. 1494	Spring (chashma), see the definitions after Clause 7.2
सोत, सोता / سوت (sot, sotā)	"A stream, rill, rivulet; current, channel; a spring, source (of a river)"; in the Shabdasagara, a small stream that flows or comes out steadily, a spring	Platts, p. 693; Shabdasagara, p. 5294	Spring or rill; a spring for this chapter
धारा / دھارا (dhārā; dhara)	"A line of descending fluid, a stream, current …, a channel, a water-course; a torrent"; in the Shabdasagara, also a spring. In legal Hindi धारा also means a section of an Act	Platts, p. 538; Shabdasagara, p. 2457	A spring spout or stream; not used as a defined term
खड्ड (khaḍḍ; khad, khud)	"Khad, n.m. A ditch (also khadd)" and "Khád, n.f. A small river" (Joshi); Platts gives खड्डा only as a pit, a hollow; in CDIAL, *khaḍḍa* "hole, pit", with "valley" in Bashkarik. The stream sense is found only in Joshi. The TCP Rules write "Khud"	Joshi, p. 190; Platts, p. 873; CDIAL 3790; TCP Rules 2014, Appendix-1, clause 16	Khad (hill torrent; a natural channel), see the definitions after Clause 7.2
नाला / نالا (nālā; nala, nallah)	"A watercourse; channel (for water), a ravine; a rivulet, brook, canal; a drain, gutter" (Platts); in the Shabdasagara, a channel by which rain-water goes to a river; in Joshi, a waterfall, a spring or a small river. The TCP Rules write "Nullah"	Platts, p. 1117; Shabdasagara, p. 2596; Joshi, p. 210	Nallah (natural drain or storm channel)
नाली / نالي (nālī; nali)	"a drain; … a small watercourse" (Platts); "A small rivulet" (Joshi)	Platts, p. 1117; Joshi, p. 210	Nali (street, roadside or house drain)
कूहल (kūhal; kuhl)	Not a Joshi headword (nearest, "Gül or Kül, n.f. A small channel"); in CDIAL, under *kulyā́* "small river, canal, ditch", Lahnda *kūhl* "watercourse", Punjabi *kūlh, kūhul* "brook, canal" and Western Pahari *kull* "natural or artificial stream"; in the Shabdasagara, कुल्या "a canal; a small river; a drain". The Minor Canals Act uses "kuhls". Platts's कूल is a bank or slope and is not used	CDIAL 3352; Joshi, p. 169; Shabdasagara, p. 1008; Himachal Pradesh Minor Canals Act, 1976	Kuhl (gravity irrigation channel), see the definitions after Clause 7.2

Table 7E.3 — Land and structures

Term	Meaning	Source of the term	Use in this Manual
धार / دھار (dhār; dhar)	"(1) The uppermost part of a roof. (2) A peak" (Joshi); "a line or chain (of mountains)", and also "flowing, stream" (Platts)	Joshi, p. 153; Platts, p. 538	A ridge or crest, and so a catchment divide; always glossed, because Hindi readers take धार as a stream
घराट (ghrāṭ; gharat)	A water mill (Joshi, *Ghrát*); not found in Platts or the Shabdasagara	Joshi, p. 166	The channel of a gharat on a khad is a supply channel for Clause 7.10
पनिहार (panihār; panihar)	"The water-place of a village" (Joshi, *Panhair*); in Hindi पनहरा is a water-carrier	Joshi, p. 217; Shabdasagara, p. 2811	A village water source; a spring for this chapter where it is one

Table 7E.4 — Terms not yet verified

These terms or senses are in use but were not confirmed in a dictionary during research for this Manual. They shall not be used in a record or a drawing as defined terms until verified.

Term	Reported meaning or use	Status
खात्री (khātrī; khatri)	A chamber cut by hand into hard rock to collect seepage water, with a capacity reported at tens of thousands of litres, in Hamirpur and the neighbouring parts of Mandi and Kangra	Sourced only to non-dictionary reports (Rajan, *The Tribune*, 2011, on the khatris of Bamsan; a CGWB district brochure for Hamirpur, seen only as a search summary); not found in Joshi; not checked in Platts, the Shabdasagara or CDIAL; used in this Manual only with this gloss
कोहली (kohli)	The overseer of a kuhl, who runs its distribution and its upkeep for the irrigators	Sourced only to Baker (2005), *The Kuhls of Kangra*; not found in Joshi, Platts or the Shabdasagara, and not named in the Minor Canals Act as read
cho, choe	A seasonal Siwalik torrent, as the southern streamlets of the Pong reservoir, "ephemeral in nature and locally called choes"	HP State Wetlands Authority booklet; Platts's चोआ (p. 447) is only a cross-reference, with no meaning confirmed
CDIAL entries 3352, 3790, 5742, 11529, 13783a, 13790a	As cited in Tables 7E.1 and 7E.2	Entry numbers from web summaries; to be checked on the Digital South Asia Library
छुड्डू (chhrudu) and other Pahari spring words	A small spring	Not found as a headword in Joshi (an entry "A spring of water" on p. 141 has lost its headword); unsourced
Pahari forms of tal, nallah and the other terms in the dialects of Kangra, Mandi, Kullu, Chamba, Shimla and Sirmaur	Regional words and spellings	Not checked beyond Joshi (1911)

The Manual uses the terms in the last column of Tables 7E.1 and 7E.2, the land terms of Table 7E.3, and the Himachal Pradesh 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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. One sheet per waterbody. Attach the plan of Clause 7.3.2 at 1:1,000 or larger.

Table 7F.1 — Form 7-1, Section A: Project and waterbody

No.	Field	Entry	Clause
A1	Project name and Authority file number	_____	—
A2	Waterbody name (English and Hindi) 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 records and village maps, TCP site plan (bauri, well, nallah, khud), IDP/DP land use, HFL lines and sinking/sliding zones, municipal drain and SJPNL records, Minor Canals Act kuhl schedules, Ramsar and wetland boundaries, BBMB and dam-operator records, spring inventories, court and NGT lists □; JSV / Gram Panchayat 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 JSV 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 (JSV record or 1% AEP computed)	_____	7.2
B3	TBL, lowest point (tanks), m	_____	7.3.1(d)
B4	1% AEP flood level, m, and source (adopted map / hydraulic study / not available)	_____	7.3.4
B5	Drainage area at the site (channels), ha	_____	7.4.1(b)
B6	Supply channels, surplus courses, sluices and surplus weirs shown on plan (yes / no)	_____	7.3.2
B7	Known encroachments, with date recorded	_____	7.3.1(g)

Table 7F.3 — Form 7-1, Section C: Setback

No.	Field	Entry	Clause
C1	Basis of setback: mapped extent / hydraulic study / fixed width (Annex 7B)	_____	7.15(1)
C2	Is a hydraulic study required under Clause 7.3.4 (a) / (b) / (c)?	_____	7.3.4
C3	Floodway outer edge, m from FTL or top of bank, and how delineated	_____	7.6.1
C4	Zone 1 width, m (greatest of 15 m, floodway edge, MWL contour)	_____	7.4.3

No.	Field	Entry	Clause
C5	Zone 2 width, m (to 1% AEP extent + 10 m, or 10 m)	_____	7.4.4
C6	Wider statutory or approval setback, if any, and its source	_____	7.4.5
C7	Setback applied: Manual standard / a wider statutory, plan or approval line: the distance from the highest flood level along rivers, khads and nullahs delineated in an Interim Development Plan or Development Plan; non-developable land of a development plan (flood plains and land adjacent to major drainage lines); the 3.00 m (nullah) and 5.00 m (khud) of Appendix-1, clause 16, of the TCP Rules 2014, where no plan exists (narrower than Zone 1; stated, never governing alone); the boundary of a Ramsar site, a wildlife sanctuary or a notified wetland; a kuhl or line of natural drainage regulated under the Himachal Pradesh Minor Canals Act, 1976; a court or Tribunal line (such as the High Court's orders on muck in Gobind Sagar and its feeding khads); a BBMB, JSV, NTPC, SJVN, NHPC or HPSEBL 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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. One sheet per tank whose storage is counted. Storage that fails any item in Section B shall not be counted (Clause 7.7.1).

Table 7F.5 — Form 7-2, Section A: Tank and scheme

No.	Field	Entry	Clause
A1	Tank name and inventory ID (Annex 7A); custodian	_____	7.3.1
A2	Scheme in which storage is counted: basin plan / regional facility / fee-in-lieu (S-5)	_____	7.7.1, 7.11
A3	Cascade modelled: uppermost tank _____ to outfall _____	_____	7.7.2
A4	Datum	_____	7.3.5

Table 7F.6 — Form 7-2, Section B: Conditions for counting storage

No.	Condition	Date / reference	Met (yes / no)	Clause
B1	FTL, MWL, TBL, weir crest and length, sluice sills surveyed within the previous 5 years	_____	_____	7.7.1(a)
B2	Stage–storage curve from a bathymetric and topographic survey within 5 years or after the last desilting, whichever is later	_____	_____	7.7.1(b)
B3	Documented operating rule agreed with the custodian (Annex 7C)	_____	_____	7.7.1(c), 7.8
B4	Weir, sluices and bund under an O&M plan; latest pre-monsoon inspection found them serviceable	_____	_____	7.7.1(d), 7.14.4
B5	Custodian's written concurrence	_____	_____	7.7.1(e)

Table 7F.7 — Form 7-2, Section C: Levels and creditable volume

No.	Item	Value	Clause
C1	Starting level: FTL, or cushion level under a rule meeting Clause 7.8.2, m	_____	7.7.3
C2	If a cushion is used: controllable outlet (type) and drawdown time, h	_____	7.8.2(a)
C3	If a cushion is used: reliability from continuous simulation, % of SW 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; JSV 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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0.

Method

1. Fix the **lower limit**: the normal water level of the waterbody, or the 50% AEP (2-yr) level where higher (Clause 7.6.4(b)).
2. Fix the **upper limit**: the 1% AEP flood level (with the climate factor).
3. Divide the range into **bands of not more than 0.3 m**. The top band may be thinner.
4. For each level z at a band boundary, measure on plan:
    - A_fill(z): the area of the fill footprint where existing ground is below z; and
    - A_cut(z): the area of the excavation where finished ground is below z and existing ground was above z (new flooded area).
5. For each band, by the average end-area method: V = (A(z_bottom) + A(z_top)) / 2 × band thickness. Do this for fill (volume lost) and for excavation (volume gained).
6. **Check each band:** volume gained ≥ volume lost. A surplus in one band does not make up a shortfall in another (Clause 7.6.4(b)).
7. Check the other conditions of Clause 7.6.4(c) to (f) in Section C.

Figure 7.2 in Chapter 7 shows the method.

Table 7F.10 — Form 7-3, Section A: Levels

No.	Field	Entry	Clause
A1	Waterbody, reach, and inventory ID	_____	7.6.4(c)
A2	Normal water level, m; 50% AEP level, m; lower limit (the higher), m	_____	7.6.4(b)
A3	1% AEP flood level with climate factor, m (upper limit)	_____	7.6.4(b)
A4	Band thickness, m (≤ 0.3) and number of bands	_____	7.6.4(b)
A5	Datum	_____	7.3.5

Table 7F.11 — Form 7-3, Section B: Band-by-band balance

Band	From (m)	To (m)	A_fill bottom (m²)	A_fill top (m²)	Volume lost (m³)	A_cut bottom (m²)	A_cut top (m²)	Volume gained (m³)	Gained ≥ lost?
1	_____	_____	_____	_____	_____	_____	_____	_____	_____
2	_____	_____	_____	_____	_____	_____	_____	_____	_____
3	_____	_____	_____	_____	_____	_____	_____	_____	_____
4	_____	_____	_____	_____	_____	_____	_____	_____	_____
Total					_____			_____	

Add rows as needed.

Table 7F.12 — Form 7-3, Section C: Other conditions

No.	Condition	Met (yes / no) and evidence	Clause
C1	Fill is in the flood fringe, not the floodway, and for a permitted use	_____	7.6.2, 7.6.3
C2	Excavation is in the same reach of the same waterbody, hydraulically connected, and not further downstream than the fill	_____	7.6.4(c)
C3	Excavation drains by gravity as the flood recedes; no pumping; no permanent pool below normal water level	_____	7.6.4(d)
C4	Excavation built before, or at the same time as, the fill	_____	7.6.4(e)
C5	Covenant or handover so that it is never filled (reference)	_____	7.6.4(f)
C6	Not counted as detention or retention under Chapter 4	_____	7.6.5
C7	Signature of designer (Clause 10.6) and date	_____	10.6

Worked example

Illustrative — not design values. A site in the flood fringe of a channel needs a fill pad for a permitted Zone 2 use (Clause 7.5.2). The inputs are assumed.

- Normal water level 10.00 m; 50% AEP level 9.80 m. Lower limit = 10.00 m (the higher).
- 1% AEP flood level 11.20 m. Range 1.20 m, so four bands of 0.30 m.
- The fill footprint is 1,600 m². Existing ground across the footprint rises evenly from 10.00 m to 11.20 m, so the area of footprint below each level is: 0 m² at 10.00 m; 400 m² at 10.30 m; 800 m² at 10.60 m; 1,200 m² at 10.90 m; 1,600 m² at 11.20 m.
- The excavation is a graded cut beside the channel, with its floor at 10.00 m. The new flooded area below each level (first trial) is: 300 m² at 10.00 m; 900 m² at 10.30 m; 1,100 m² at 10.60 m; 1,500 m² at 10.90 m; 1,500 m² at 11.20 m.

Step 1 — volume lost, band by band (V = average area × 0.3 m):

- Band 1: (0 + 400) / 2 × 0.3 = 60 m³
- Band 2: (400 + 800) / 2 × 0.3 = 180 m³
- Band 3: (800 + 1,200) / 2 × 0.3 = 300 m³
- Band 4: (1,200 + 1,600) / 2 × 0.3 = 420 m³
- Total: 960 m³

Step 2 — volume gained, first trial:

Table 7F.13 — Worked example: first trial (illustrative)

Band	From (m)	To (m)	Volume lost (m³)	A_cut bottom (m²)	A_cut top (m²)	Volume gained (m³)	Gained ≥ lost?
1	10.00	10.30	60	300	900	180	Yes
2	10.30	10.60	180	900	1,100	300	Yes
3	10.60	10.90	300	1,100	1,500	390	Yes
4	10.90	11.20	420	1,500	1,500	450	Yes
Total			960			1,320	

Every band passes. Note that a simple total balance would hide a failure if, for example, the cut were made deeper and narrower: suppose the designer instead offers a cut with new flooded areas of 1,400 m² at 10.00 m, 1,400 m² at 10.30 m, 1,000 m² at 10.60 m, 600 m² at 10.90 m and 200 m² at 11.20 m.

Table 7F.14 — Worked example: deeper, narrower cut (illustrative)

Band	From (m)	To (m)	Volume lost (m³)	A_cut bottom (m²)	A_cut top (m²)	Volume gained (m³)	Gained ≥ lost?
1	10.00	10.30	60	1,400	1,400	420	Yes
2	10.30	10.60	180	1,400	1,000	360	Yes
3	10.60	10.90	300	1,000	600	240	**No**
4	10.90	11.20	420	600	200	120	**No**
Total			960			1,140	

The total gained (1,140 m³) exceeds the total lost (960 m³), but bands 3 and 4 are short by 60 m³ and 300 m³. The surplus low down cannot be counted against them: the low storage fills early in every flood and is not available when the fill takes away storage near the peak. This design fails Clause 7.6.4(b) and must be regraded so that the upper bands gain at least as much as they lose, as in the first trial.

ANNEXES TO CHAPTER 8

Water Quality and Recharge

These annexes support Chapter 8. They give the layout of the water quality rainfall tables, the Level of Service and Value Rating method in detail, the layout of the BMP calibration programme, design sheets for each BMP, standard details for construction erosion and sediment control, and the two forms that Clause 8.14 requires. Annexes 8A and 8C need data that are not yet available; they say so and give the rule to use in the meantime. The forms are draft forms.

Annex 8A — 3-month ARI 24-hour depth and IDF by zone

Supports Clauses 8.2, 8.4.1 and 8.4.5 of Chapter 8.

To be prepared. This annex will contain, for each rainfall zone of Chapter 2, the 24-hour 3-month ARI depth P_3m and the 3-month ARI intensity–duration relationship used for Q_wq. It needs long-term daily and sub-daily rainfall records (IMD station and gridded data, with NIH as the Chapter 2 primary source), analysed as a partial-duration series. Until it is published, the designer shall compute P_3m from the longest available daily record for the site's zone, as the 24-hour depth equalled or exceeded on average four times a year (Clause 8.2), state the record, its length and the method on the Water Quality Sheet (Form 8-1), and use P_wq = max (P_ret, P_3m) (Clause 8.4.1). The climate factor is not applied (Clause 8.4.3).

8A.1 Method to be used in preparing the annex

- (a) Use daily records of at least 30 years where available (as for station IDF in Chapter 2).
- (b) Form the partial-duration series of 24-hour depths, with independent events separated by at least one dry day.
- (c) Choose the threshold so that the number of events above it averages four per year; P_3m is that threshold.
- (d) Derive the 3-month ARI intensities for durations from 10 minutes to 24 hours from sub-daily records, or by the Chapter 2 method of scaling from the daily value, stating which.
- (e) Do not apply the climate factor (Clause 8.4.3).

Table 8A.1 — Water quality rainfall depths by zone (layout)

Zone (Chapter 2)	Representative stations or grid	Record (years)	P_ret, Annex 2E (mm)	P_3m (mm)	P_wq = max (mm)
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Table 8A.2 — 3-month ARI intensity by duration (layout)

Zone	10 min (mm/h)	15 min (mm/h)	30 min (mm/h)	1 h (mm/h)	2 h (mm/h)	6 h (mm/h)	24 h (mm/h)
_____	_____	_____	_____	_____	_____	_____	_____

Zone	10 min (mm/h)	15 min (mm/h)	30 min (mm/h)	1 h (mm/h)	2 h (mm/h)	6 h (mm/h)	24 h (mm/h)
_____	_____	_____	_____	_____	_____	_____	_____

Annex 8B — Redevelopment LoS table and treatment-train composite VR

Supports Clauses 8.6.2 to 8.6.5 of Chapter 8.

8B.1 Required Level of Service for redevelopment

To be prepared. This part will give the required Level of Service for redevelopment sites (existing impervious cover of 20% or more of the site, Clause 8.6.2). The MARC/APWA BMP Manual (2012, Table 4.3) sets the redevelopment LoS from the percentage of impervious cover within the disturbed area; the Himachal Pradesh values need to be set by the State Stormwater Technical Committee and checked against local redevelopment cases. Until it is published, the required LoS for a redevelopment site is **6** for the disturbed area. Where Table 8.2, applied to the change in CN from the existing condition to post-development, gives a higher LoS, that higher LoS applies. This interim value is set by this Manual. A redevelopment site that retains its whole WQv on site under Chapter 4 needs no further treatment for that area, apart from pretreatment, hotspot controls and the outfall requirements (Clause 8.4.4).

Table 8B.1 — Required LoS for redevelopment (layout)

Existing impervious cover within the disturbed area (%)	Change in impervious cover	Required LoS
_____	_____	_____
_____	_____	_____
_____	_____	_____

8B.2 Composite Value Rating: area-weighted method

The composite VR of a site is the area-weighted average of the VRs of the BMPs serving each part of the site (Clause 8.6.3):

$$VR_{site} = \Sigma (A_i \times VR_i) / \Sigma A_i + VR_{signage}$$

where:

- A_i = the area of part i of the site, ha;
- VR_i = the Value Rating (Table 8.3) of the BMP serving part i, which counts only if the BMP meets Clause 8.6.4 for the whole of A_i;
- ΣA_i = the whole site area: every part of the site is assigned to one BMP, or to preserved native vegetation; a part served by no BMP is entered with $VR_i = 0$; and
- $VR_{signage} = 0.25$ where public education signage is provided (Table 8.3), otherwise 0.

The site complies where $VR_{site} \geq$ required LoS (Clause 8.6.3).

Illustrative — not design values. A 1.0 ha site that is not redevelopment, with ΔCN = 18. Required LoS = 8 (Table 8.2).

Table 8B.2 — Worked example: composite VR (illustrative)

Part	Area A_i (ha)	BMP	VR_i (Table 8.3)	A_i × VR_i
Roofs and paving draining to bioretention	0.60	Bioretention	8.5	5.100
Car park	0.25	Permeable pavement	7.5	1.875
Preserved strip along boundary	0.15	Native vegetation (preserved)	9.25	1.388
Total	1.00			8.363

- Area-weighted VR = 8.363 / 1.00 = 8.36
- Signage provided: + 0.25
- VR_site = 8.61 ≥ 8. The site complies.

Without the permeable pavement (car park draining untreated, VR = 0): (5.100 + 0 + 1.388) / 1.00 + 0.25 = 6.74 < 8. The site would not comply.

8B.3 Treatment trains

To be prepared. This part will give the composite VR of BMPs in series (a treatment train), following the approach of the MARC/APWA BMP Manual (2012, Table 4.6), with values to be confirmed for Himachal Pradesh by the calibration programme of Clause 8.13.4 (Annex 8C). Until it is published, each part of the site is credited with the VR of one BMP in the train that meets Clause 8.6.4 for that part, normally the last BMP before discharge, and no extra credit is given for BMPs in series. Pretreatment devices, silt traps and oil-grit separators upstream of the credited BMP earn no VR of their own (Clauses 8.6.4(c), 8.7.11(c) and 8.7.12(c)).

Table 8B.3 — Composite VR of treatment trains (layout)

First BMP	Second BMP	Composite VR	Conditions
_____	_____	_____	_____
_____	_____	_____	_____

Annex 8C — Himachal Pradesh BMP performance calibration

Supports Clauses 8.6.3, 8.13 and 8.15.1 of Chapter 8.

To be prepared. This annex will report the BMP performance calibration programme of the State Stormwater Technical Committee (Clause 8.13.4): measured inflow and outflow concentrations and volumes for BMPs built in Himachal Pradesh, and the revised Value Ratings that follow from them. It needs wet-weather monitoring of BMPs over several SW 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

The lists below are **indicative**. They name species that are native or long naturalised in Himachal Pradesh or the western Himalaya and its foothills and known to tolerate both wet and dry periods, or, where marked, dry ground or the hills only; no Himachal Pradesh source on planting for stormwater was researched for this Manual, though the State Wetlands Authority records *khair*, *shisham*, *kachnar* and chir pine around Rewalsar, and chir pine, ban oak and deodar around Khajjiar. Hindi or Urdu names are given only where J. T. Platts, *A Dictionary of Urdu, Classical Hindi, and English* (1884, as served by the Digital South Asia Library), gives the name for the species or plant named, with its page; a dash means none was confirmed. Platts often uses older botanical names, which are given in the notes. No Pahari name was checked. Final selection shall be confirmed with a horticulturist or the State Forest Department for the site's altitude, soil and water table. Three settings need different plants: the Siwalik valleys of Una, Nalagarh, Paonta and Kala Amb below about 1,000 m, where the lists below apply as in the plains States; the Balh valley and the river terraces, where the ground stands wet in the monsoon; and the hill towns, where frost and snow from December to March rule out tender species, where bioretention on a slope is lined (Clause 8.8.1), and where planting on banks, cut slopes, muck dumps and the margins of khads and nallahs is chosen first to bind soil.

Table 8D.13 — Indicative plants for bioretention, swales and filter strips

Use	Botanical name	Hindi / Urdu name	Notes
Swales, filter strips, bioretention edges, cut-slope and bank toes	*Chrysopogon zizanioides* (vetiver)	ख़स / خس (khas)	Deep-rooted clump grass; tolerates flooding and drought; binds soil on side slopes and drain banks; below about 1,000 m. Platts: "A fragrant grass, *Andropogon muricatum* (from the roots of which *taṭṭīs* are made)" (p. 489), an older name of this species
Swales and filter strips (turf)	*Cynodon dactylon* (Bermuda grass)	दूब / دوب (dūb)	Low turf; tolerates drought, traffic and short flooding. Platts: "Bent grass, panic grass, *Panicum dactylon*, or *Cynodon dactylon*" (p. 531)
Swales and banks on the Siwalik valley floors and river terraces	*Saccharum spontaneum*	कास / کاس (kās)	Native tall grass of river sands; binds banks; cut back where it would obstruct a channel. Platts: "A species of grass, of which ropes, &c. are made, *Saccharum spontaneum*" (p. 801)
Trees beside swales and channels in the Siwalik valleys	*Dalbergia sissoo*	शीशम / شیشم (śīśam)	Riverine tree of the foothills, recorded around Rewalsar. Platts: "The tree *Dalbergia sisu*, and its wood" (p. 740)
Trees beside channels and wet ground, up to the middle hills	*Ficus racemosa* (syn. *F. glomerata*)	गूलर / گولر (gūlar)	Native fig of stream banks. Platts: "The wild fig, *Ficus glomerata*" (p. 926). Keep roots clear of underdrains, pipes and walls
Trees beside bioretention and swales, up to the middle hills	*Toona ciliata* (toon)	तून / تون (tūn)	Native; grows along streams. Platts: "The tree *Cedrela toona* and its wood" (p. 344), an older name of this species
Trees on dry banks and swale edges (not in the wet zone)	*Bauhinia variegata*	कचनार / کچنار (kaćnār)	Native; recorded around Rewalsar; for dry banks and the upper edges of swales. Platts: "The mountain ebony, *Bauhinia variegata*" (p. 819)
Banks of khads and nallahs in the hills (live staking)	*Salix* spp. (willow)	बेद / بید (bed)	Willows root from cuttings and bind wet banks; keep out of the waterway where they would obstruct flow. Platts: "A species of willow" (p. 207); the species was not confirmed
Moist slopes and stream banks in the hills	*Alnus nepalensis* (Himalayan alder)	—	Native of moist hill slopes and stream banks; grows fast on disturbed ground and on slide scars. No name in Platts
Slopes above spring recharge areas and drain banks in the hills (not in the wet zone)	*Quercus leucotrichophora* (syn. *Q. incana*) (ban oak)	बाँज / بانجھ (bāṅj)	Native broadleaf of the outer Himalaya, recorded around Khajjiar; for upland margins, spring recharge areas and slopes, not for bioretention cells. Platts: "The tree *Quercus incana*, or *dilatata* (common in the outer Himalaya …)" (p. 126)

Use	Botanical name	Hindi / Urdu name	Notes
Bioretention (flowering, wet zones), below about 1,000 m	*Canna indica*	—	Naturalised; tolerates waterlogging; widely used in constructed wetlands in India; not frost-hardy

Table 8D.14 — Indicative plants for constructed wetlands and wet ponds

Zone	Botanical name	Hindi / Urdu name	Notes
Shallow macrophyte zone	*Typha* spp. (e.g. *T. domingensis*, syn. *T. angustata*)	—	Native; spreads quickly and needs periodic harvesting. It is listed among the weeds invading the open water of Khajjiar (HP State Wetlands Authority), so it is never planted in or near a tal. No Hindi name was confirmed in Platts
Shallow macrophyte zone	*Phragmites karka*	नल / نل (nal); नरसल / نرسل (narsal)	Native reed; vigorous; its "profuse aggregation" at Rewalsar is a concern for the lake (HP State Wetlands Authority), so it is kept out of tals, nallahs and channels where it would obstruct flow. Platts: "A species of reed, *Amphidonax karka*, or *Arundo karka*" (p. 1152) and "A large species of reed, *Arundo karka*" (p. 1132)
Shallow macrophyte zone	*Canna indica*	—	As Table 8D.13; Siwalik valleys only
Open water and deep zones (Siwalik valleys only)	*Nelumbo nucifera* (lotus)	कमल / کمل (kamal)	Native; for permanent pools only. Platts: "The lotus, *Nelumbium speciosum*" (p. 849)

Wet ponds and constructed wetlands are not used on hill slopes, where Clause 8.8.1 bars infiltration and there is little flat land (Clause 8.7, Commentary); the plants of this table are for the Siwalik valleys and the valley floors, and none of them is planted in a natural tal, whose weeds are already a problem.

Table 8D.15 — Species not to be planted

Botanical name	Hindi / Urdu name	Reason
Eichhornia crassipes (water hyacinth)	—	Invasive; chokes ponds, tals, nallahs and screens
Lantana camara	—	Invasive on forest edges, the Siwaliks and drain banks; not for swales or banks
Ageratina adenophora (syn. *Eupatorium adenophorum*)	—	Invasive on hill slopes, road cuts and stream banks; not for slopes or banks
Prosopis juliflora	—	Invasive on embankments and drain banks in the Siwalik valleys
Ipomoea carnea	—	Invasive in ponds and channels; obstructs flow

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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 SW 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

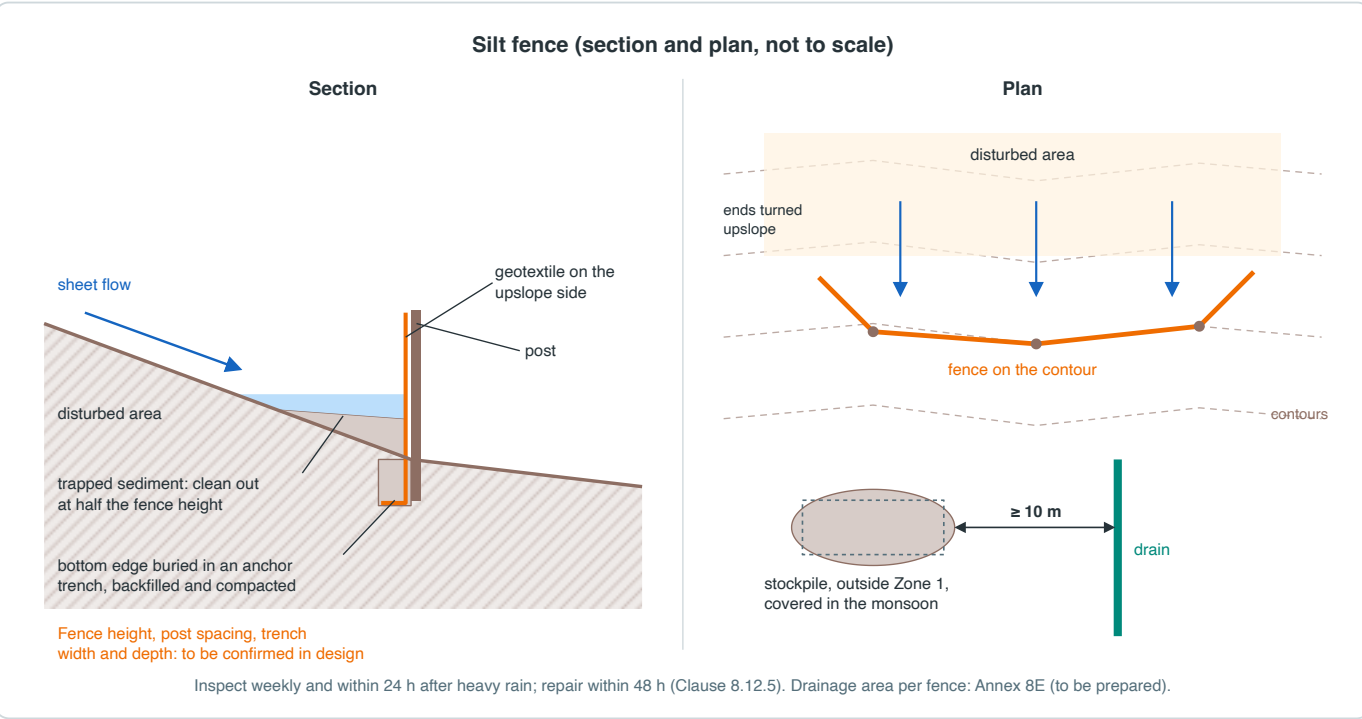


Figure 8E.1 — Silt fence: section showing geotextile on posts with the bottom edge buried in an anchor trench on the upslope side, and plan showing the fence on the contour with returns at the ends. Dimensions not set by the Manual are to be confirmed in design. Original drawing for this Manual, adapted 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 Himachal Pradesh rainfall. Until they are published, the following interim limits apply, taken from common US practice (US EPA, Stormwater Best Management Practice fact sheet: Silt Fence):

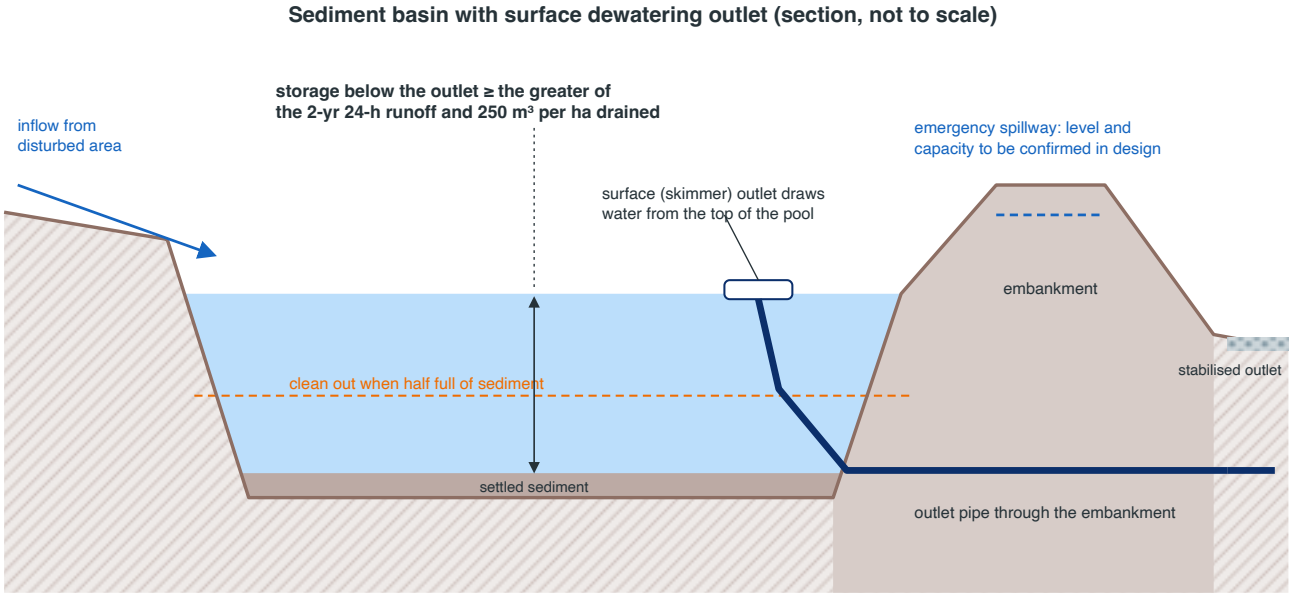
- drainage area: not more than **0.1 ha per 30 m** of fence;
- slope length above the fence: not more than 30 m on slopes under 2%, 23 m at 2–5%, 15 m at 5–10%, 8 m at 10–20% and 5 m steeper than 20%;
- wherever flow arrives concentrated, or a limit cannot be met, a sediment trap (Figure 8E.2) is used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

The designer shall show the drainage area and slope length served by each fence on the ESC plan.

Notes:

1. Place along the contour at the downslope edge of the disturbed area, never across a concentrated flow path.
2. Turn the ends upslope so that water cannot run round them.
3. Inspect weekly and within 24 hours after every heavy-rainfall event; repair within 48 hours; remove sediment when the deposit reaches half the fence height (Clause 8.12.5).
4. Remove only after the area draining to it is stabilised (Clause 8.12.6).
5. Stockpiles: outside Zone 1, at least 10 m from any drain, and covered during the SW 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

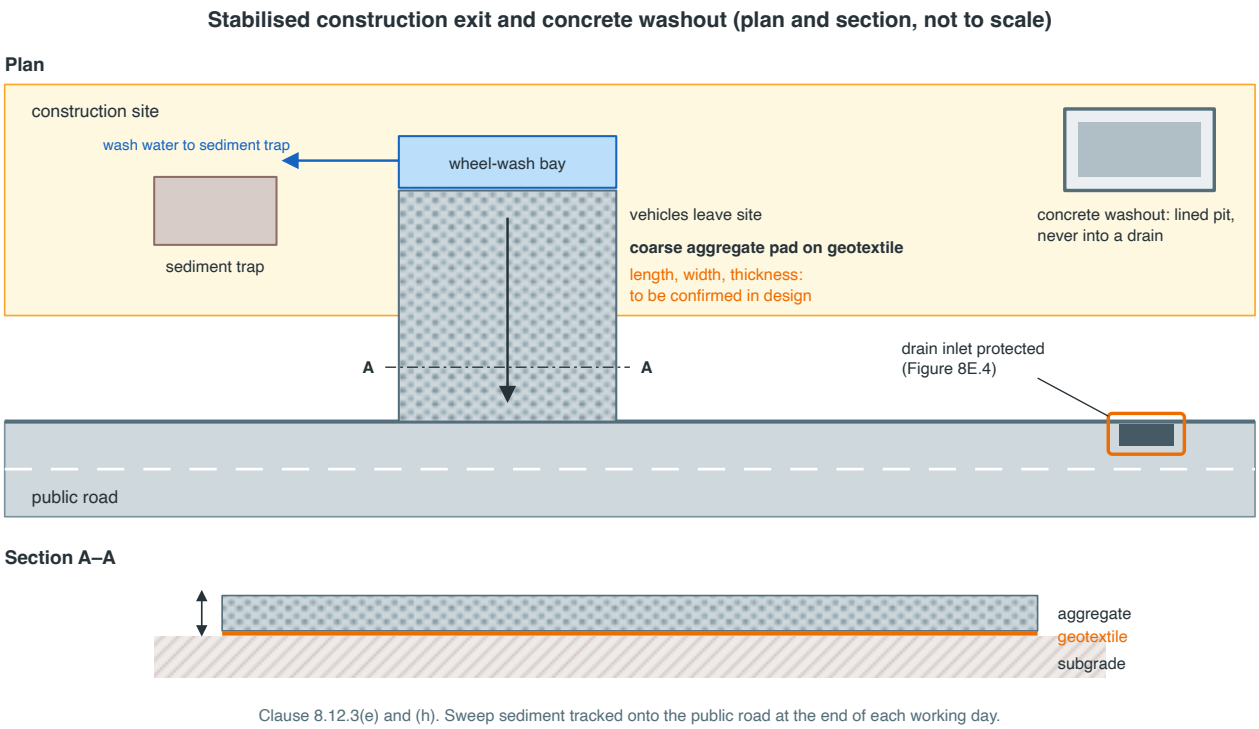


Figure 8E.3 — Stabilised construction exit: plan and section showing a coarse aggregate pad on geotextile between the site and the public road, a wheel-wash bay draining to a sediment trap, and a lined concrete washout pit. Dimensions not set by the Manual are to be confirmed in design. Original drawing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

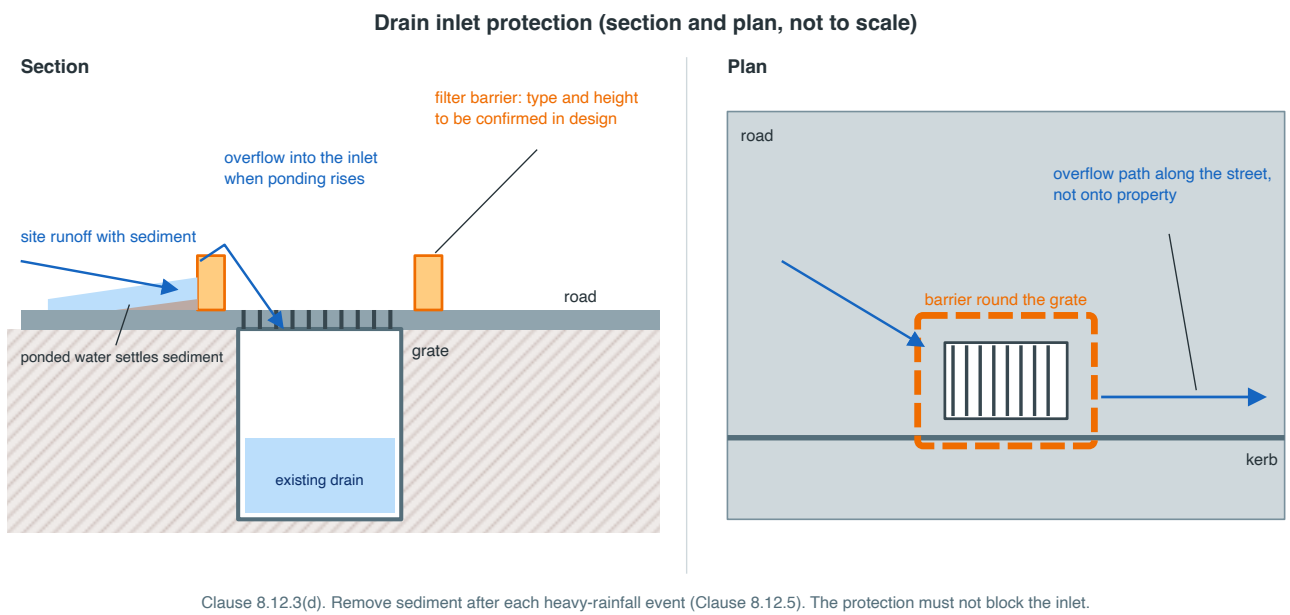


Figure 8E.4 — Inlet protection at an existing drain inlet: a filter barrier around a grate or kerb inlet, with an overflow path so that ponding does not flood the road or property. Original drawing for this Manual, adapted from US EPA, NPDES Construction General Permit (2022), and CIRIA, The SuDS Manual (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 May
Area cleared between 15 June and 31 October	Sediment controls in place before clearing
Area exposed in the SW 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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0.

Table 8F.1 — Form 8-1, Section A: Site and rainfall

No.	Field	Entry	Clause
A1	Project name and Authority file number	_____	—
A2	Tier (A / B) and site area, ha	_____	8.6.1
A3	Rainfall zone (Chapter 2)	_____	8.4.1
A4	P_ret, mm (Annex 2E)	_____	8.4.1
A5	P_3m, mm (Annex 8A, or the interim calculation: record, years, method)	_____	8.4.1
A6	P_wq = max (P_ret, P_3m), mm (no climate factor)	_____	8.4.1, 8.4.3
A7	WQv method: SCS-CN, or Rv (sites < 0.5 ha and Tier B simplified method only)	_____	8.4.2
A8	Redevelopment (existing impervious ≥ 20%)?	_____	8.6.2

Table 8F.2 — Form 8-1, Section B: Water quality volume and flow by drainage area

Area ID	Area (ha)	Impervious I (%)	Q_wq runoff depth (mm) or Rv	WQv (m^3)	Q_wq (m^3/s)	Volume retained, Chapter 4 (m^3)	WQv not retained (m^3)	BMP serving the area	Pretreatment
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Total	_____			_____		_____	_____		

Table 8F.3 — Form 8-1, Section C: Level of Service and Value Rating (Tier A)

No.	Field	Entry	Clause
C1	CN pre-development; CN post-development; ΔCN	_____	8.6.2
C2	Required LoS (Table 8.2, or Annex 8B for redevelopment)	_____	8.6.2
C3	Composite VR (Annex 8B calculation attached)	_____	8.6.3
C4	Composite VR ≥ required LoS?	_____	8.6.3
C5	Tier B: route used under Clause 8.6.5 (a) retained on site / (b) bioretention, rain garden or infiltration	_____	8.6.5

Table 8F.4 — Form 8-1, Section D: Other submittals (Clause 8.14)

No.	Item	Attached (yes / no / not applicable)	Clause
D1	BMP designs to Clause 8.7 and Annex 8D, with pretreatment	_____	8.14(3)

No.	Item	Attached (yes / no / not applicable)	Clause
D2	Infiltration Test Record (Form 8-2), seasonal high groundwater level and source, design rate, drawdown time, setbacks	_____	8.14(4)
D3	Sewage and sullage connection plan; dye or smoke test record	_____	8.9.2, 8.14(5)
D4	GPT and first-flush design for any outfall to a waterbody	_____	8.10, 8.14(6)
D5	RWH layout separating harvesting, recharge and detention	_____	8.11, 8.14(7)
D6	ESC plan	_____	8.12, 8.14(8)
D7	Hotspot controls, where Clause 8.8.8 applies	_____	8.8.8

Table 8F.5 — Form 8-1, Section E: Prepared by

Field	Entry
Name, registration and empanelment number (Clause 10.6)	_____
Signature and date	_____

Form 8-2 — Infiltration Test Record

Supports Clauses 8.8.1 to 8.8.7 and 8.11.4 of Chapter 8.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. One record per facility. Attach a plan showing the test locations, and the readings for each test.

Table 8F.6 — Form 8-2, Section A: Facility

No.	Field	Entry	Clause
A1	Project and facility ID; facility type	_____	8.8.3
A2	Infiltration base area (m²) or trench length (m)	_____	8.8.3(c)
A3	Proposed base level of the facility, m (datum)	_____	8.8.3
A4	Runoff source: roof only / paved surfaces / mixed; hotspot (yes / no)	_____	8.8.6, 8.8.8
A5	Ground setting: sandy coastal / laterite or hard rock / delta clay or black cotton / other	_____	8.8.9–8.8.11

Table 8F.7 — Form 8-2, Section B: Tests

Test no.	Location (grid ref.)	Date	Method: double-ring (ASTM D3385) / falling-head borehole or trial-pit soakage (e.g. BRE Digest 365)	Test level, m	Groundwater level at time of test, m	Measured rate (mm/h)
1	_____	_____	_____	_____	_____	_____
2	_____	_____	_____	_____	_____	_____
3	_____	_____	_____	_____	_____	_____

Minimum number of tests: 2 per facility, and 1 per 100 m² of base area or per 50 m of trench (Clause 8.8.3(c)).

Table 8F.8 — Form 8-2, Section C: Design rate and drawdown

No.	Item	Entry	Clause
C1	Number of tests made; number required	_____	8.8.3(c)
C2	Highest and lowest measured rates; ratio (highest ÷ lowest)	_____	8.8.4
C3	Safety factor: 2.0 (tests meet 8.8.3(c) and ratio ≤ 2) or 3.0	_____	8.8.4
C4	Design rate = measured rate used ÷ safety factor, mm/h (state which measured rate was used)	_____	8.8.4
C5	Category: ≥ 13 mm/h full infiltration / 3–13 mm/h partial with underdrain / < 3 mm/h no credit	_____	8.8.5
C6	Depth of water to infiltrate, mm; drawdown time = depth ÷ design rate, h (≤ 72 h)	_____	8.8.7

Table 8F.9 — Form 8-2, Section D: Separation and setbacks

No.	Item	Entry	Clause
D1	Seasonal high groundwater level, m, and its source (Clause 3.10.2)	_____	8.8.1
D2	Separation from facility base to seasonal high groundwater, m (≥ 1.0; ≥ 0.5 for roof-only runoff in notified coastal sand with mounding check)	_____	8.8.1, 8.8.9(d)

No.	Item	Entry	Clause
D3	Depth to bedrock or impermeable layer below base, m (≥ 1.0 unless Clause 8.8.10)	_____	8.8.2
D4	Distances to: foundations / basement / property boundary / drinking-water well or borewell / septic tank or soak pit / crest of slope steeper than 1V:3H, m	_____	8.8.6
D5	Expansive soils: foundation setback doubled?	_____	8.8.11(b)

Table 8F.10 — Form 8-2, Section E: Declaration

Field	Entry
Tester: name, qualification in geotechnical testing, organisation	_____
I certify that the tests were made at the stated locations and levels, by the stated methods, and that the readings attached are complete. Signature and date	_____
Designer (Clause 10.6): name and signature	_____

ANNEXES TO CHAPTER 9

Hydraulic Design of Structures

These annexes support Chapter 9. Annex 9A gives the FHWA HDS-5 inlet-control equations in SI units, with published coefficients for common inlets, and a full worked culvert example. Annex 9B gives standard drawings that carry only the dimensions Chapter 9 and Chapter 6 already set; every other dimension is marked "to be confirmed in design". Annex 9C is a pump station design checklist with a standard control philosophy drawn from Clause 9.9. Form 9-1 is a draft form: it lists what Clause 9.14 requires and does not add to it.

Annex 9A — HDS-5 inlet-control coefficients and worked culvert example in SI units

Supports Clauses 9.4.1 to 9.4.7 of Chapter 9 and Clause 6.12 of Chapter 6.

9A.1 Inlet-control equations

FHWA *Hydraulic Design of Highway Culverts*, HDS-5, 3rd edition (2012), Appendix A, gives three inlet-control equations. In SI units:

> Unsubmerged, Form 1: HWi/D = Hc/D + K · [Ku · Q / (A · D^0.5)]^M + Ks · S

> Unsubmerged, Form 2: HWi/D = K · [Ku · Q / (A · D^0.5)]^M

> Submerged: HWi/D = c · [Ku · Q / (A · D^0.5)]² + Y + Ks · S

where HWi is the headwater depth above the inlet invert under inlet control (m), D is the interior height (rise) of the barrel (m), Hc is the specific head at critical depth, dc + Vc²/2g (m), Q is the discharge (m³/s), A is the full cross-sectional area of the barrel (m²), S is the barrel slope (m/m), K, M, c and Y are the constants of Table 9A.1, Ku = 1.811 in SI units (1.0 in US units), and Ks is the slope correction: −0.5, or +0.7 for mitred inlets.

Which equation applies depends on X = Ku · Q / (A · D^0.5):

- X ≤ 3.5: unsubmerged equation (Form 1 or Form 2 as listed in Table 9A.1);
- X ≥ 4.0: submerged equation;
- 3.5 < X < 4.0 (transition): use FHWA HY-8, which implements the HDS-5 transition. Where a hand calculation is used, take the higher of the unsubmerged and submerged results. This is a conservative simplification made by this annex, not an HDS-5 rule.

Table 9A.1 — HDS-5 inlet-control coefficients for common inlets

Barrel	Inlet edge	Form	K	M	c	Y
Circular concrete	Square edge with headwall	1	0.0098	2.0	0.0398	0.67
Circular concrete	Groove (socket) end with headwall	1	0.0018	2.0	0.0292	0.74
Circular concrete	Groove (socket) end projecting	1	0.0045	2.0	0.0317	0.69
Circular corrugated metal	Headwall	1	0.0078	2.0	0.0379	0.69
Circular corrugated metal	Mitred to slope	1	0.0210	1.33	0.0463	0.75
Circular corrugated metal	Projecting	1	0.0340	1.50	0.0553	0.54
Rectangular box	Wingwalls flared 30° to 75°	1	0.026	1.0	0.0347	0.81
Rectangular box	Wingwalls flared 90° and 15°	1	0.061	0.75	0.0400	0.80
Rectangular box	Wingwalls at 0° (extensions of the sides)	1	0.061	0.75	0.0423	0.82
Rectangular box	90° headwall with 19 mm (3/4 in) chamfers	2	0.515	0.667	0.0375	0.79
Rectangular box	90° headwall with 45° bevels	2	0.495	0.667	0.0314	0.82
Rectangular box	90° headwall with 33.7° bevels	2	0.486	0.667	0.0252	0.865

Source: FHWA HDS-5 (2012), Appendix A, Table A.1 (the coefficients are dimensionless and apply in SI units with Ku = 1.811). The values were checked against HIF-12-026, Table A.1 (chart and scale numbers 1/1–1/3, 2/1–2/3, 8/1–8/3 and 10/1–10/3). Where a later edition of HDS-5 differs, the later table governs. Entrance loss coefficients for outlet control are in Table 9.1 of Chapter 9.

9A.2 Worked example: pipe culvert under a collector road

Illustrative — not design values. The inputs below are invented to show the method; the results are not design values for any site.

Inputs.

Table 9A.2 — Inputs for the worked example

Item	Value	Source
Road class	Collector; design AEP 4% (25-yr), check event 2% (50-yr), and the 1% AEP check	Table 6.1, Clause 6.12.2
Design flow, 4% AEP	1.80 m³/s (including the climate factor)	Illustrative
Check flow, 2% AEP	2.20 m³/s	Illustrative
1% AEP flow	3.00 m³/s	Illustrative
Barrel	One 1,200 mm RCC pipe with collar joints, n = 0.015	Table 6.6
Inlet	Square edge with headwall: ke = 0.5; K = 0.0098, M = 2.0, c = 0.0398, Y = 0.67, Form 1	Tables 9.1 and 9A.1
Length and slope	L = 20.0 m; S = 0.005 (inlet invert 20.00 m, outlet invert 19.90 m, local datum)	Illustrative
Road levels at the inlet	Shoulder edge 22.00 m; lowest point of the road crest 22.10 m	Illustrative
Tailwater above the outlet invert, TW	0.60 m at 1.80 m³/s; 0.70 m at 2.20 m³/s; 0.85 m at 3.00 m³/s (normal depth in the downstream channel)	Illustrative; Clause 9.4.4
Receiving channel	Unlined sandy loam	Table 9.2

Minimum size: 1,200 mm ≥ 900 mm (Clause 6.12.5). The span is below 1.5 m, so the blockage check uses 50% of the inlet area blocked (Clause 6.12.4(a)).

Step 1 — Barrel properties. A = π · 1.2² / 4 = 1.131 m²; full-barrel hydraulic radius R = D/4 = 0.300 m; D^0.5 = 1.095.

Step 2 — Critical depth. For each flow, dc is found by trial from the critical-flow condition for a circular section, $Q^2 \cdot T / (g \cdot Ac^3) = 1$, where Ac and T are the flow area and top width at depth dc.

Table 9A.3 — Critical depth and specific head (D = 1.2 m)

Q (m³/s)	dc (m)	Ac (m²)	T (m)	Vc = Q/Ac (m/s)	Hc = dc + Vc²/2g (m)	Hc/D
1.80	0.737	0.728	1.168	2.471	1.048	0.873
2.20	0.817	0.820	1.119	2.683	1.184	0.987
3.00	0.952	0.962	0.972	3.118	1.447	1.206

Step 3 — Headwater under inlet control. X = 1.811 · Q / (1.131 × 1.095) = 1.462 · Q.

Table 9A.4 — Inlet-control headwater

Q (m³/s)	X	Equation	HWi/D	HWi (m)
1.80	2.631	Unsubmerged, Form 1: 0.873 + 0.0098 × 2.631² − 0.5 × 0.005 = 0.873 + 0.068 − 0.003	0.939	1.127
2.20	3.216	Unsubmerged, Form 1: 0.987 + 0.0098 × 3.216² − 0.003 = 0.987 + 0.101 − 0.003	1.085	1.302
3.00	4.385	Submerged: 0.0398 × 4.385² + 0.67 − 0.003 = 0.765 + 0.67 − 0.003	1.433	1.719

Step 4 — Headwater under outlet control (Clause 9.4.3). The friction term is 19.63 · n² · L / R^1.33 = 19.63 × 0.015² × 20.0 / 0.300^1.33 = 0.0883 / 0.2016 = 0.438, so H = (1 + 0.5 + 0.438) · V²/2g = 1.938 · V²/2g. L · S = 20.0 × 0.005 = 0.100 m.

Table 9A.5 — Outlet-control headwater

Q (m³/s)	V = Q/A (m/s)	V²/2g (m)	H (m)	(dc + D)/2 (m)	TW (m)	ho (m)	HWo = ho + H − L·S (m)
1.80	1.592	0.129	0.250	0.969	0.60	0.969	1.119
2.20	1.945	0.193	0.374	1.009	0.70	1.009	1.283
3.00	2.653	0.359	0.695	1.076	0.85	1.076	1.671

Step 5 — Governing headwater (Clause 9.4.1): the greater of HWi and HWo.

Table 9A.6 — Governing headwater and checks

Event	Q (m³/s)	HWi (m)	HWo (m)	Control	HW (m)	HW level (m)	HW/D
Design, 4% AEP	1.80	1.127	1.119	Inlet	1.127	21.13	0.94
Check, 2% AEP	2.20	1.302	1.283	Inlet	1.302	21.30	1.09
1% AEP	3.00	1.719	1.671	Inlet	1.719	21.72	1.43

Step 6 — Headwater limits at the design AEP (Clause 9.4.5):

- (a) HW/D = 0.94 ≤ 1.2. Complies.
- (b) HW level 21.13 m ≤ shoulder edge 22.00 m − 0.30 m = 21.70 m. Complies.

- (c) Water levels at upstream buildings and property boundaries are compared with the existing condition under Clause 6.12.2(d). This needs the upstream survey and is not shown here.

Step 7 — Road overtopping (Clauses 6.12.2, 6.12.3 and 9.4.6). The 1% AEP headwater level, 21.72 m, is below the lowest road crest, 22.10 m, so the road is not overtopped in the check or 1% AEP events. Had the headwater exceeded the crest, the overtopping flow Qr = Cd · L · h^1.5 (Cd ≤ 1.66) would be balanced with the culvert flow at a common headwater, and the overtopping depth checked against Clause 6.12.2(a).

Step 8 — Outlet velocity (Clause 9.4.7). Under inlet control, the outlet velocity is the velocity at normal depth in the barrel. The barrel's full-flow capacity is (1/n) · A · R^(2/3) · S^0.5 = (1/0.015) × 1.131 × 0.448 × 0.0707 = 2.39 m³/s.

- 1.80 m³/s: normal depth 0.778 m, outlet velocity 2.32 m/s.
- 2.20 m³/s: normal depth 0.908 m, outlet velocity 2.40 m/s.
- 3.00 m³/s: above the full-flow capacity, so the barrel flows full at the outlet; velocity = Q/A = 2.65 m/s.

The receiving channel is unlined sandy loam, with a permissible velocity of 0.53 m/s (Table 9.2), so outlet protection is required (Clause 9.6.1). All barrel velocities are below 3.0 m/s (Clause 6.7.3(b)).

Step 9 — Riprap apron (Clause 9.6.3; Figure 9.2). D50 = 0.2 · D · [Q / (g^0.5 · D^2.5)]^(4/3) · (D/TW), with g^0.5 · D^2.5 = 3.132 × 1.577 = 4.941.

Table 9A.7 — Riprap apron sizing

Q (m³/s)	TW (m)	Q / (g^0.5 · D^2.5)	[ ]^(4/3)	D50 (m)
1.80	0.60	0.364	0.260	0.2 × 1.2 × 0.260 × 2.00 = 0.125
2.20	0.70	0.445	0.340	0.2 × 1.2 × 0.340 × 1.71 = 0.140
3.00	0.85	0.607	0.514	0.2 × 1.2 × 0.514 × 1.41 = 0.174

Clause 9.4.7 requires the outlet to be protected for the design AEP and the 1% AEP, so the apron is sized here for the largest D50, 0.174 m. From Table 9.3, Class 2 (D50 = 150 mm) is too small, so **Class 3** (D50 = 250 mm) is used:

- apron length 5D = 5 × 1.2 = 6.0 m;
- apron thickness 2.4 × D50 = 2.4 × 0.25 = 0.60 m;
- apron width at the outlet at least 3D = 3.6 m, flaring to the downstream channel;
- stone placed on a granular filter or geotextile (Clause 9.6.4).

Step 10 — Blockage check (Clause 6.12.4(a)). Steps 3 to 7 are repeated for the 1% AEP flow with 50% of the inlet area blocked, and the results must meet Clause 6.12.2(a) and (d). This Manual does not yet set a standard way of representing a partly blocked inlet, so this check is carried out in HY-8 or by a method agreed with the Approving Authority. It is not worked here.

Table 9A.8 — Summary of the worked example (Illustrative — not design values)

Check	Result	Clause
Minimum size	1,200 mm ≥ 900 mm	6.12.5
Design HW/D	0.94 ≤ 1.2	9.4.5(a)
Design HW below shoulder edge	21.13 m ≤ 21.70 m	9.4.5(b)
Overtopping in the check and 1% events	None (21.72 m < 22.10 m)	6.12.2, 9.4.6
Outlet protection	Class 3 riprap apron, 6.0 m long, 0.60 m thick, 3.6 m wide at the outlet	9.6.1, 9.6.3
Blockage check	To be run in HY-8 or by an agreed method	6.12.4

Annex 9B — Standard drawings: headwalls, riprap aprons, drop structures, trash racks, detention risers

Supports Clauses 9.4, 9.6, 9.7 and 9.8 of Chapter 9.

The drawings below are schematic standard drawings. They show only the dimensions and rules that Chapter 9 and Chapter 6 set. Structural dimensions, reinforcement, foundations and fixings are to be confirmed in design (Clause 9.1.2). The riprap apron standard drawing is Figure 9.2 of Chapter 9, with dimensions from Table 9.3; it is not repeated here. Table 9B.1 lists the dimensions shown and their source clauses.

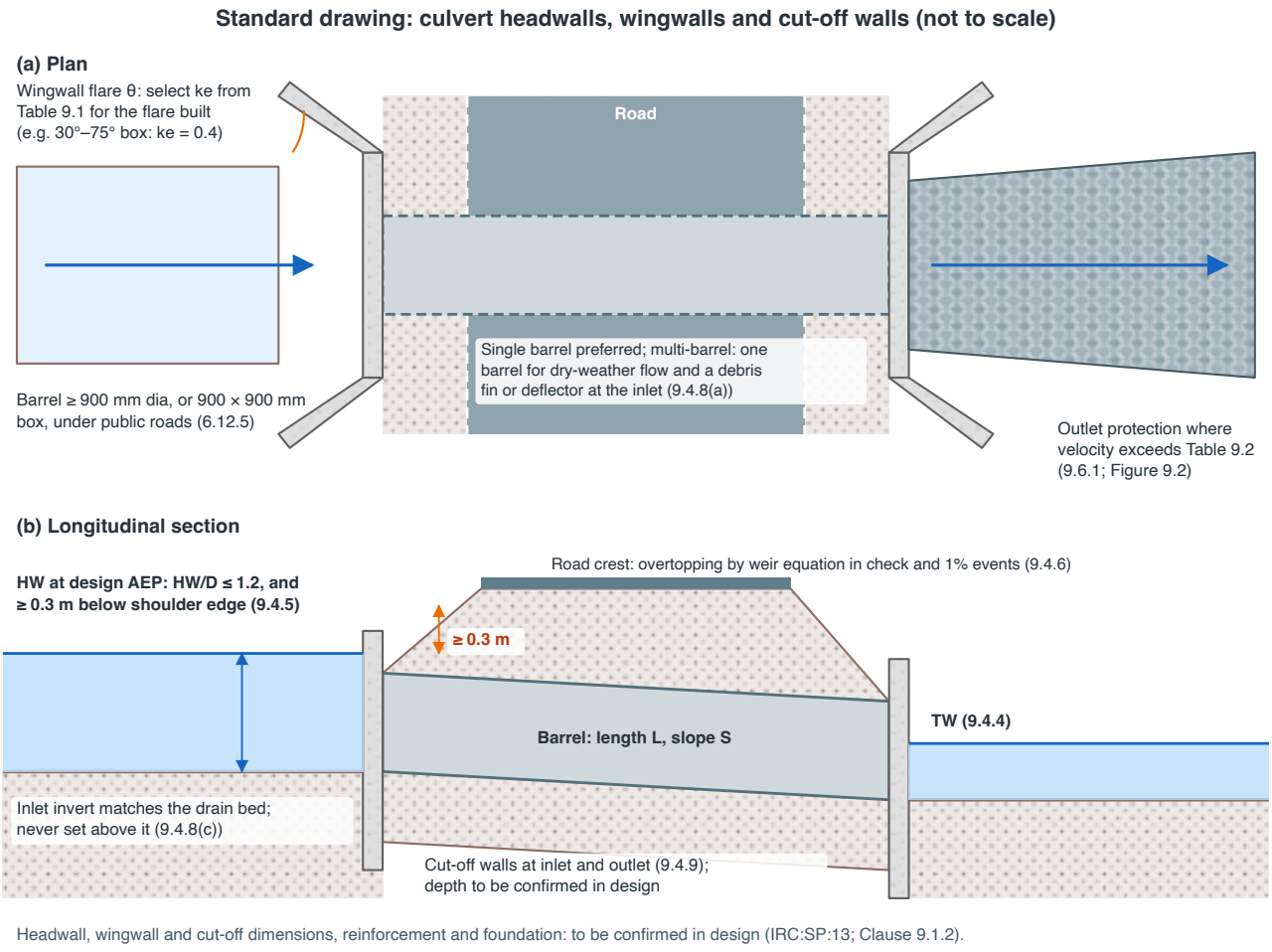


Figure 9B.1 — Standard drawing: culvert headwalls, wingwalls and cut-off walls, in plan and long section, with the headwater limits, invert rule and debris provisions. Original drawing for this Manual, adapted from FHWA, Hydraulic Design of Highway Culverts, HDS-5 (3rd ed., 2012).

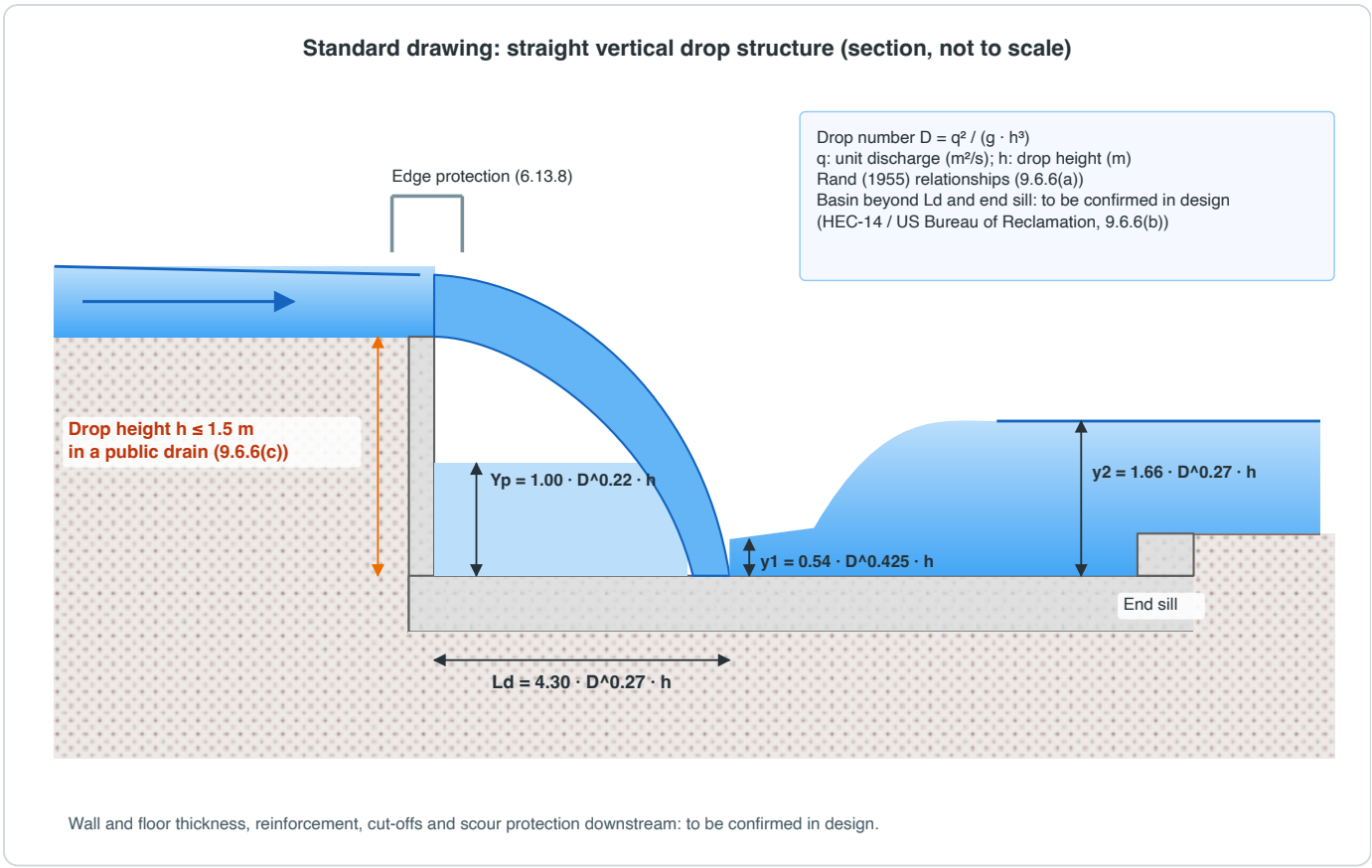


Figure 9B.2 — Standard drawing: straight vertical drop structure with the Rand (1955) pool geometry and the 1.5 m height limit. Original drawing for this Manual, adapted from Chow, Open-Channel Hydraulics (1959), and FHWA, HEC-14 (3rd ed., 2006).

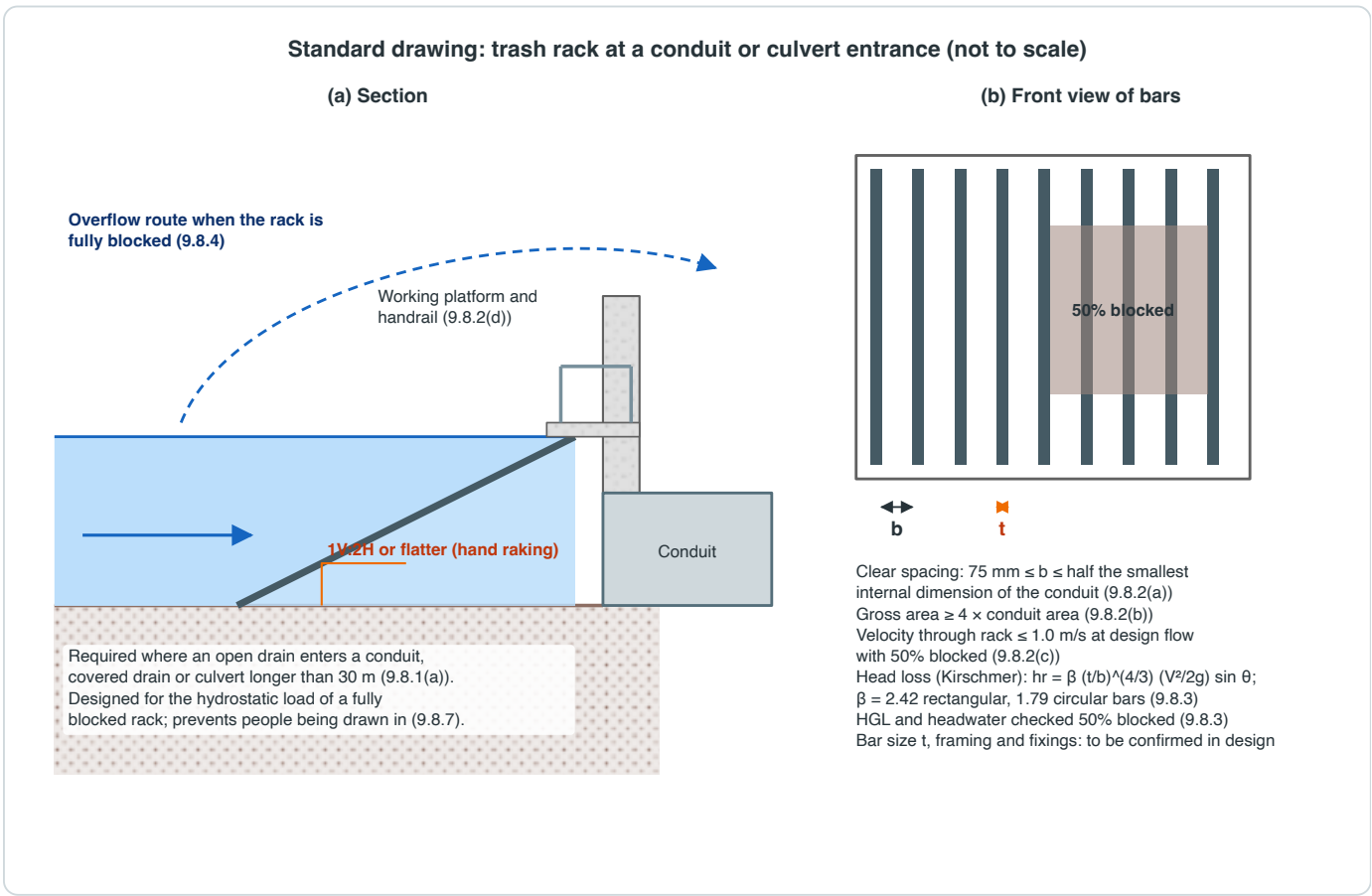


Figure 9B.3 — Standard drawing: trash rack at a conduit or culvert entrance, in section and front view, with bar spacing, area, velocity, slope and overflow requirements. Original drawing for this Manual, adapted from CIRIA, Culvert, screen and outfall manual, C786 (2019), and CPHEEO, Manual on Storm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

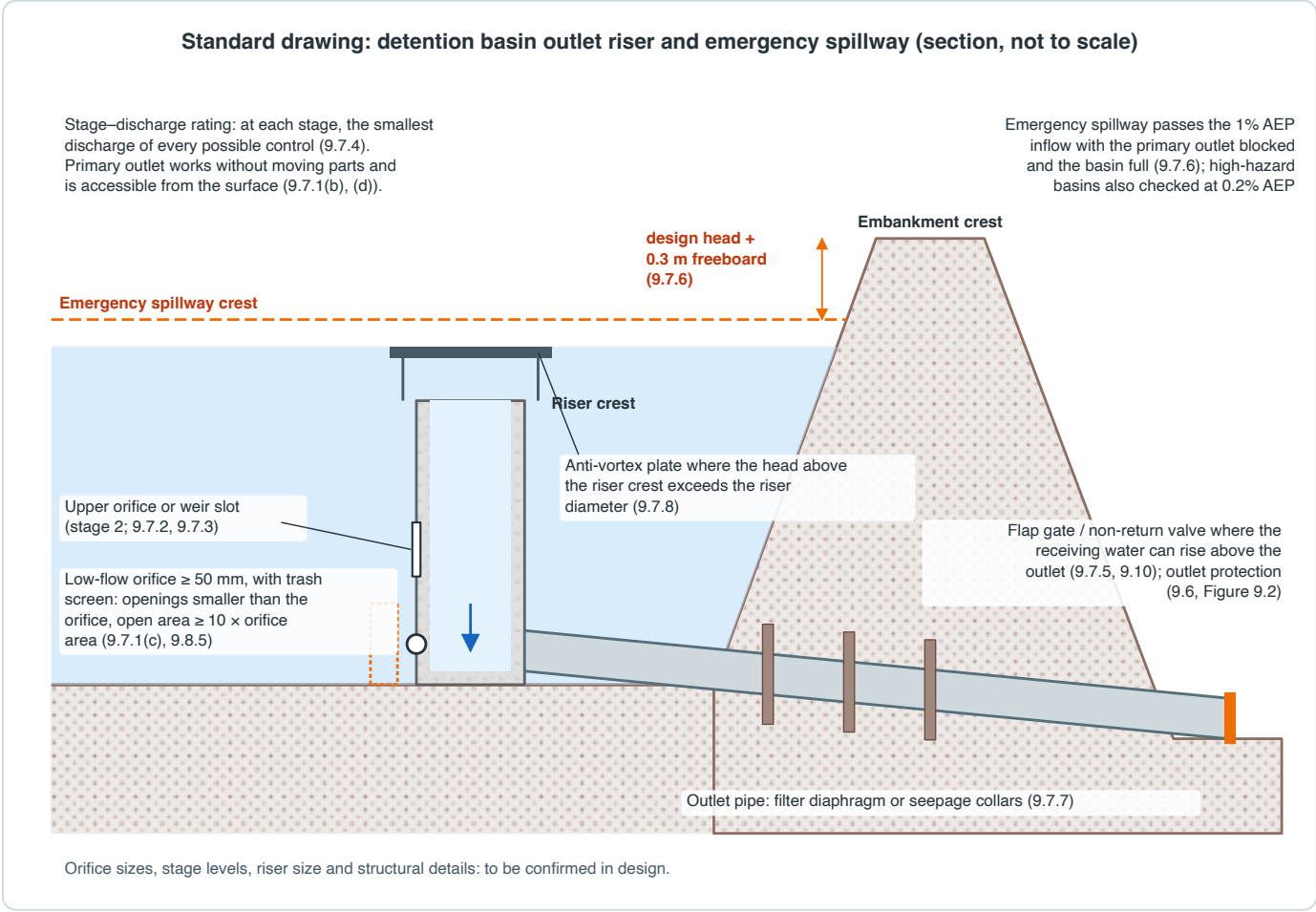


Figure 9B.4 — Standard drawing: detention basin outlet riser with low-flow orifice and screen, upper stage, anti-vortex plate, outlet pipe through the embankment, flap gate and emergency spillway. Original drawing for this Manual, adapted from Kansas City Metro APWA, Section 5600 (2006, 5608.4).

Table 9B.1 — Dimensions and rules on the standard drawings and their source clauses

Drawing	Item	Dimension or rule	Clause
9B.1	Minimum culvert size under public roads	900 mm diameter, or 900 mm × 900 mm box	6.12.5
9B.1	Headwater at the design AEP	HW/D ≤ 1.2; at least 0.3 m below the shoulder edge at the upstream face	9.4.5
9B.1	Entrance loss coefficient	From Table 9.1 for the inlet built (for example 0.4 for a box with wingwalls at 30°–75°)	9.4.3
9B.1	Inverts	Match the drain bed; never above it	9.4.8(c)
9B.1	Multi-barrel culverts	Avoided in debris-prone drains; where used, one barrel for dry-weather flow and a debris fin or deflector	9.4.8(a)
9B.1	Headwalls, wingwalls, cut-off walls	Required; dimensions to be confirmed in design	9.4.9
9B.1	Road overtopping	Qr = Cd · L · h^1.5, Cd ≤ 1.66	9.4.6
Figure 9.2	Riprap apron	Width at the outlet ≥ 3D, flaring to the channel; length and thickness from Table 9.3; filter or geotextile	9.6.3, 9.6.4

Drawing	Item	Dimension or rule	Clause
9B.2	Single vertical drop in a public drain	Height h ≤ 1.5 m; edge protection	9.6.6(c), 6.13.8
9B.2	Pool geometry	D = q²/(g h³); Ld/h = 4.30 D^0.27; Yp/h = 1.00 D^0.22; y1/h = 0.54 D^0.425; y2/h = 1.66 D^0.27	9.6.6(a)
9B.2	Basin beyond Ld, end sill	To be confirmed in design (HEC-14 or US Bureau of Reclamation)	9.6.6(b)
9B.3	Where required	Where an open drain enters a conduit, covered drain or culvert longer than 30 m	9.8.1(a)
9B.3	Clear bar spacing b	Not less than 75 mm and not more than half the smallest internal dimension of the conduit	9.8.2(a)
9B.3	Gross rack area	At least 4 times the conduit area	9.8.2(b)
9B.3	Velocity through the rack	Not more than 1.0 m/s at the design flow with 50% blocked	9.8.2(c)
9B.3	Inclination	No steeper than 1V:2H where raked by hand; working platform and handrail	9.8.2(d)
9B.3	Head loss and blocked check	Kirschmer equation; HGL and headwater checked with 50% blocked	9.8.3
9B.3	Overflow and safety	Overflow route for a fully blocked rack; designed for the full hydrostatic load	9.8.4, 9.8.7
9B.4	Low-flow orifice	Not smaller than 50 mm; trash screen with openings smaller than the orifice and open area at least 10 times the orifice area	9.7.1(c), 9.8.5
9B.4	Orifice and weir flow	Q = Cd · A · (2gh)^0.5, Cd = 0.60 sharp-edged; weir coefficients of Clause 9.7.3	9.7.2, 9.7.3
9B.4	Stage–discharge rating	Smallest discharge of every possible control at each stage	9.7.4
9B.4	Anti-vortex plate	Where the design head above the riser crest exceeds the riser diameter	9.7.8
9B.4	Outlet pipe through the embankment	Filter diaphragm or seepage collars; flared or headwalled inlet	9.7.7
9B.4	Flap gate or non-return valve	Where the receiving water can rise above the outlet	9.7.5, 9.10
9B.4	Emergency spillway	Passes the 1% AEP inflow with the primary outlet blocked and the basin full, with 0.3 m freeboard to the embankment crest; 0.2% AEP check for high-hazard basins	9.7.6
All	Structural dimensions, reinforcement, foundations, bar sizes, orifice sizes and stage levels	To be confirmed in design	9.1.2

Annex 9C — Pump station design checklist and standard control philosophy

Supports Clauses 9.8.6, 9.9 and 9.10 of Chapter 9, with Clause 6.10.5 of Chapter 6 and the outfall-closed check of Chapter 5.

9C.1 Design checklist

Submit this checklist with the pump station design report of Clause 9.14, item 6.

Table 9C.1 — Pump station design checklist

No.	Item	Requirement	Clause	Provided (Yes / No / NA)
1	Need for pumping	Gravity drainage cannot meet Chapters 5 and 6; reason stated	9.9.1	
2	Inflow	Inflow hydrograph routed through the catchment and any upstream storage	9.9.2	
3	Design standard	Design AEP of the element served; for underpasses, 2% AEP with a 1% AEP check	9.9.2(a), 6.10.5(a)	
4	Tidal outfall	Storage plus pumps hold the 48 h design volume with the outfall throttled for the tidal-lock duration (default two high tides of 6 h each)	9.9.2(b), Chapter 5	
5	Head range	Pumps selected from the lowest sump level against the lowest tailwater to the highest tailwater (HAT + surge + 0.3 m); pump and system curves submitted	9.9.2(c), 9.14	
6	Wet-well volume	Greatest of: 5 min of minimum inflow (variable speed and automatic control); 10 to 15 min of peak inflow, or the manufacturer's minimum cycle volume; $V = \Theta \cdot q / 4$ for each constant-speed pump	9.9.3	
7	Duty pumps	Same size where practicable	9.9.4(a)	
8	Standby	At least equal to the largest duty pump, and not less than 50% of the number of duty pumps	9.9.4(b)	
9	Alternation	Duty and standby roles alternate automatically	9.9.4(c)	
10	Pump type	Solids-handling (non-clog); axial-flow only behind a screen meeting Clause 9.8.6	9.9.5	
11	Sump and intake	Manufacturer's requirements and ANSI/HI 9.8; clear space 0.6 m (small and medium) or 1.0 m (large units)	9.9.6	
12	Model study	Physical model where any pump exceeds 1 m^3/s or the sump departs from ANSI/HI 9.8 geometry	9.9.6	
13	Silt trap and screen	Upstream of the wet well; screen spacing smaller than the pumps' solids size; removable modules; mechanical raking where inflow exceeds 1 m^3/s	9.9.7, 9.8.6	
14	Screen overflow	Overflow route when the screen is fully blocked	9.8.4	
15	Level control	Primary level sensor (ultrasonic, radar or pressure) with an independent float-switch back-up	9.9.8(a)	
16	Alarms	High-level and pump-fault alarms by telemetry to the local body's control room	9.9.8(b)	
17	Records	Sump levels, pump run hours and power status logged and kept at least 5 years	9.9.8(c)	
18	Power sources	Grid supply plus a standby generator or second independent feeder able to run all duty pumps at once	9.9.9(a)	
19	Fuel	At least 72 h of all duty pumps, stored above the flood level of Clause 9.9.10	9.9.9(b)	
20	Changeover	Automatic changeover to standby power	9.9.9(c)	
21	Flood protection	Electrical and control room floor, generator and transformer at least 0.5 m above the 1% AEP flood level; vehicle access usable in the 1% AEP event	9.9.10	
22	Discharge	Separate rising mains, or a non-return and an isolating valve where mains combine; delivery chamber or outfall with a flap gate or non-return valve; mains sized by a recognised friction formula	9.9.11	

No.	Item	Requirement	Clause	Provided (Yes / No / NA)
23	Gates	Flap or tide gate on outfalls below the 1% AEP still-water level; penstock or stop-log slot upstream for outfalls of 900 mm or more and every pumped outfall; head loss from tested data	9.10.1, 9.10.3, 9.10.4	
24	Sand and debris at the outfall	Gate in a chamber with surface access, or elastomeric check valves, at beach, estuary and creek outfalls	9.10.5	
25	Emergency connection	Hard-standing and quick-coupling connection for mobile pumps into the delivery chamber	9.9.12	
26	Materials	Exposure class of Clause 9.13; stainless steel grade 316, galvanised and coated steel, or non-metallic fixings within 5 km of the coast	9.13	
27	Design life	At least 50 years for civil works and 25 years for mechanical and electrical equipment	9.2.4	
28	Underpass stations	Depth markers and automatic warning or closure signals at 150 mm depth on the carriageway	6.10.5(d)	
29	Certification	Designed by an empanelled professional and checked by an independent empanelled professional	10.6.1(d), 10.6.4	

9C.2 Standard control philosophy

This is the standard control philosophy for a stormwater pump station designed under Clause 9.9. The designer adapts it to the station and submits it with the design report. Items marked "recommended" are good practice that Chapter 9 does not require; all others restate a clause.

Table 9C.2 — Control levels (values to be set in design)

Level	Rule for setting it	Clause
Pump stop	Not below the minimum submergence required by the pump manufacturer and ANSI/HI 9.8	9.9.6
Duty pump 1 start	Above the pump-stop level by at least the effective wet-well volume of Clause 9.9.3	9.9.3
Duty pumps 2, 3 … start	Staged above duty pump 1 start; spacing to be confirmed in design	9.9.2
High-level alarm	Above the highest duty-pump start level; to be confirmed in design	9.9.8(b)
Float back-up high	Independent float; starts the duty pumps	9.9.8(a)
Float back-up low	Independent float; stops the pumps	9.9.8(a)

1. **Normal (automatic) operation.** As the wet-well level rises to the duty pump 1 start level, the lead pump starts. If the level keeps rising, each further duty pump starts at its start level. The pumps stop when the level falls to the pump-stop level. The primary level sensor controls this sequence (Clause 9.9.8(a)).
2. **Duty rotation.** The lead pump changes automatically, after each pump-down cycle or by run hours as set in the design, so that duty and standby roles alternate and wear is shared (Clause 9.9.4(c)).
3. **Pump fault.** A pump that trips or fails to start is locked out. The next available pump, including the standby pump, takes its place, and a pump-fault alarm is sent by telemetry (Clauses 9.9.4(b) and 9.9.8(b)).
4. **Level-sensor failure.** If the primary sensor fails, or disagrees with the float switches, control passes to the independent float back-up: at the float-high level the duty pumps run, and at the float-low level they stop. An alarm is sent (Clause 9.9.8(a), (b)).
5. **Power failure.** Supply changes over automatically to the standby generator or second feeder (Clause 9.9.9(c)). Recommended: pumps restart one at a time after changeover, to limit the starting load on the generator.

6. **High level.** At the high-level alarm level an alarm is sent by telemetry to the local body's control room (Clause 9.9.8(b)). At an underpass, the warning or closure signals operate at 150 mm depth on the carriageway (Clause 6.10.5(d)).
7. **Outfall and gates.** Rising mains discharge to a delivery chamber or outfall fitted with a flap gate or non-return valve (Clause 9.9.11). Flap gates open and close under head difference without control action. The upstream penstock or stop logs are closed only for maintenance, or if the flap gate jams open (Clause 9.10.3). Recommended: penstock position is shown at the control panel and logged.
8. **Tide-locked operation.** Where the outfall is tide-locked, storage and pumping together hold the 48 h design volume for the tidal-lock duration (Clause 9.9.2(b) and Chapter 5). Where the station also has a gravity outfall, gravity discharge resumes through the flap gate when the tide falls.
9. **Screens.** Mechanically raked screens (required where inflow exceeds 1 m³/s, Clause 9.8.6) are run automatically. Recommended: raking is started by a timer and by the level difference across the screen, with an alarm when the difference stays high.
10. **Manual operation.** Recommended: each pump has a hand–off–auto selector at the panel, and the float back-up high-level start remains active in hand mode.
11. **Mobile pumps.** When fixed pumps are out of service or overwhelmed, mobile pumps discharge into the delivery chamber through the quick-coupling connection (Clause 9.9.12).
12. **Records.** Sump levels, pump run hours and power status are logged and kept for at least 5 years (Clause 9.9.8(c)). Recommended: alarms, pump starts and stops, and changeovers are logged as well.
13. **Testing.** The controls, floats, alarms, telemetry, changeover and generator are tested in the pre-monsoon inspection of Chapter 10 (Clause 10.12), and the results reported in the Annual Maintenance Declaration (Form 10-7; Clause 10.10.3).

Form 9-1 — Hydraulic Structures Report checklist

Supports Clause 9.14 of Chapter 9.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Not for statutory use.

Attach this checklist to the front of the Hydraulic Structures Report. For each item, enter Yes, No or Not applicable, and the drawing or page where it is shown.

Section A — Project

Table 9F.1 — Form 9-1, Section A: project

Field	Entry
Project name and location	_____
Local body, and Tier A or Tier B (Chapter 1)	_____
Applicant	_____
Designer (name and registration)	_____
Structures covered (culverts, channels, dissipators, outlets, screens, pumps, gates, inlets, manholes)	_____
Tailwater conditions used: MHWS, HAT + surge, sea-level allowance, joint case (Clause 9.2.1)	_____
Date and revision	_____

Section B — Contents required by Clause 9.14

Table 9F.2 — Form 9-1, Section B: contents required by Clause 9.14

No.	Item	Clause	Provided (Yes / No / NA)	Drawing or page
1	Culvert calculations (HDS-5 or HY-8 output) with HWi, HWo, outlet velocity, tailwater, overtopping and the blockage check	9.4, 6.12		
2	Channel water-surface profiles, velocities, Froude numbers and freeboard	9.5		
3	Outlet protection and dissipator design, with riprap sizing	9.6		
4	Detention outlet stage–discharge tables and the emergency spillway check	9.7		
5	Screen and rack design with the 50% blocked check	9.8		
6	Pump station design report: inflow hydrograph, storage, pump and system curves, wet-well volume, controls, power supply and the Chapter 5 outfall-closed check (with Annex 9C)	9.9		
7	Gate and valve selection with head-loss data	9.10		
8	Inlet, grate and cover load classes	9.11		
9	Exposure class and materials statement	9.13		

Section C — Compliance checks

Table 9F.3 — Form 9-1, Section C: compliance checks

No.	Check	Limit	Clause	Complies (Yes / No / NA)
C1	Climate factor included in design flows	Clause 2.8	9.2.2	
C2	Blocked condition checked where debris can block; safe overflow route	—	9.2.5	
C3	Pipes and box drains: design n (box drains ≥ 0.015); supercritical pipes: jump located in a structure, air venting	—	9.3.1, 9.3.4	
C4	Pipe size does not decrease downstream; joins only at manholes or junction chambers; no change of direction over 90°	—	9.3.5	
C5	Culvert design headwater = greater of HWi and HWo	—	9.4.1	
C6	Culvert headwater at the design AEP	HW/D ≤ 1.2; ≥ 0.3 m below shoulder edge	9.4.5	
C7	Road overtopping weir coefficient	Cd ≤ 1.66	9.4.6	
C8	Culvert inverts match the drain bed; headwalls, wingwalls and cut-off walls	—	9.4.8(c), 9.4.9	
C9	Channel Froude number at the design flow	≤ 0.8; none between 0.8 and 1.2	9.5.2	
C10	Channel velocity	Table 9.2	9.5.3	
C11	Channel slope in engineered channels	≤ 0.4% natural, ≤ 0.2% concrete, or drops / chute	9.5.4	
C12	Side slopes; low-flow channel where bed width ≥ 3 m; uplift or weep holes	—	9.5.6, 9.5.7, 9.5.9	
C13	Outlet protection where outlet velocity exceeds Table 9.2	Table 9.3 apron, or basin	9.6.1, 9.6.3	
C14	Single vertical drop height	≤ 1.5 m	9.6.6(c)	
C15	Detention primary outlet: no moving parts; minimum orifice	≥ 50 mm with screen	9.7.1	
C16	Emergency spillway	1% AEP, outlet blocked, basin full, 0.3 m freeboard; 0.2% AEP for high-hazard basins	9.7.6	
C17	Outlet pipe through embankment; anti-vortex plate where needed	—	9.7.7, 9.7.8	
C18	Conduit-entrance racks	Spacing 75 mm to half the smallest conduit dimension; area ≥ 4×; ≤ 1.0 m/s at 50% blocked	9.8.2	
C19	Detention orifice screens	Openings smaller than the orifice; open area ≥ 10×	9.8.5	
C20	Pump station	Annex 9C checklist complete	9.9	
C21	Gates on outfalls below the 1% AEP still-water level; secondary closure; corrosion-resistant fittings	—	9.10	
C22	Grate load classes, parallel openings ≤ 25 mm, kerb openings ≥ 100 mm × 1.0 m, locked covers	—	9.11	
C23	Manhole sizes (Table 9.4), 600 mm access openings, drops, benching, surcharge covers	—	9.12	

No.	Check	Limit	Clause	Complies (Yes / No / NA)
C24	Exposure class (Table 9.5); chloride and sulphate tests in coastal and delta areas; sulphide protection; metalwork within 5 km of the coast	—	9.13	

Section D — Variances

Table 9F.4 — Form 9-1, Section D: variances

Clause	Requirement not met	Reason and proposed alternative	Approved by and date
_____	_____	_____	_____

Section E — Signatures

The report shall be prepared and signed by a registered professional, and the Professional Design Certificate (Form 10-3) attached (Clauses 10.6.1 and 10.6.3 of Chapter 10). For a facility with an embankment, a high-hazard basin, a pumped facility, a tide gate or a regional facility, the signatory shall be an empanelled Stormwater Design Professional, and a second, independent empanelled professional shall sign as checker (Clauses 10.6.1(c), (d) and 10.6.4).

Table 9F.5 — Form 9-1, Section E: signatures

Role	Name	Registration or empanelment no.	Signature	Date
Designer	_____	_____	_____	_____
Independent checker (Clause 10.6.4, where applicable)	_____	_____	_____	_____

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0.

ANNEXES TO CHAPTER 10

Submittals, Review, Operation & Maintenance and Enforcement

These annexes support Chapter 10. They give the specification and user-guide outline of the compliance calculator, the GIS data specification, the maintenance access dimensions that the Manual sets, model O&M plans for each facility type, model empanelment criteria, and the eight forms that Chapter 10 requires. The Design Rainfall Sheet (Form 2-1) is in the annexes to Chapter 2. The forms are draft forms. The model texts are for consideration by a competent authority and are not in force.

Annex 10A — Compliance calculator and user guide

Supports Clauses 10.4.1(g), 10.5 and 10.9.1(b) of Chapter 10.

> **Status.** The compliance calculator does not exist yet. Clause 10.5.1 requires the State Stormwater Technical Committee to issue and maintain it. This annex is the specification the calculator shall meet and the outline of its user guide. Until the calculator is issued, the designer completes Form 10-2 by hand from the calculations of Chapters 4, 5 and 8, enters "not issued" as the calculator version, and attaches the calculations.

10A.1 General requirements

The calculator shall:

- (a) be a spreadsheet or web tool, published free of charge with its user guide and the source of every table in it (Clause 10.5.4);
- (b) print its version number and release date on every output page and every exported file (Clause 10.5.3);
- (c) keep a public version log. A new version applies to new submittals 6 months after release; a submittal keeps one version from Stage 1 to Stage 4 unless the Applicant elects a later one (Clause 10.5.3);
- (d) work for one site at a time, with one or more drainage areas, each draining to its own outfall (Clause 4.5.1.3);
- (e) never apply a value that the Manual has not published. Where a table it needs has not been issued (for example Table 4.3 of Annex 4B, or the S-2 discharge tables of Annex 1C), the calculator shall show that route as "not available" rather than estimate the value; and
- (f) export its inputs and results as a machine-readable file (CSV or JSON) as well as Form 10-2, so that the Authority can load them into the facility register (Clause 10.17.1(b)).

10A.2 Inputs

Table 10A.1 — Calculator inputs

No.	Input	Unit	Source
I1	Authority, tier (A or B) and file number	—	Clause 1.6

No.	Input	Unit	Source
I2	Site area; land disturbance area	ha	Clause 1.5.2
I3	New impervious area; replaced impervious area; existing impervious area before demolition	m²	Clauses 1.5.2, 1.5.6, 4.5.6.1
I4	Development type: new, redevelopment, linear public work, single dwelling	—	Clauses 1.5.6–1.5.8
I5	Flood-sensitive catchment (yes / no), and basin with an approved BSMP (yes / no)	—	Clauses 4.5.3, 4.13, 11.12
I6	Rainfall zone	—	Annex 2A
I7	Retention depth P_R; 3-month ARI 24-hour depth P_3m	mm	Annexes 2E, 8A
I8	Design rainfall depths by duration (1–72 h) and AEP, with the climate factor, as recorded on Form 2-1	mm	Clauses 2.5, 2.8, 2.13
I9	15-minute intensities i_10 and i_2, with the climate factor (fixed-coefficient route only)	mm/h	Clause 4.14.4
I10	Drainage areas: for each, area, land cover, impervious percentage, HSG and curve number, pre- and post-development	ha, %, —	Clauses 3.3, 3.7, 3.9
I11	Areas preserved under a registered covenant	ha	Clause 4.4.7
I12	Seasonal high groundwater depth below the base of each retention practice	m	Clauses 4.4.3(c), 8.8
I13	Measured infiltration rate at each practice	mm/h	Clause 4.4.3
I14	Retention volume provided, by practice; reuse demand where retention is by reuse	m³, m³/d	Clauses 4.4.3, 4.4.5
I15	Route: full hydrograph method (Clause 4.6); design-aid S-1 (Clause 4.14.2); PSD S-2 (Clause 1.7); fixed-coefficient (Clause 4.14.3); constrained redevelopment (Clause 4.5.6)	—	Clauses 1.7, 4.5.6, 4.6, 4.14
I16	For the full method: model results for each AEP and duration — pre- and post-development peaks, storage used, retention credit found by routing	m³/s, m³	Clauses 4.4.6.2, 4.6
I17	Outlet: low-flow orifice diameter or least slot dimension; drawdown times from routing	mm, h	Clauses 4.7, 4.8.2
I18	Outfall: tidal or non-tidal; outfall-closed check result	—	Chapter 5
I19	Fee-in-lieu unit rate notified for the basin, where the route applies	₹/m³	Clause 4.13.3
I20	Stage of submittal (1, 2 or 4) and, at Stage 4, the as-built values of I14, I16 and I17	—	Clauses 10.5.2, 10.9.1(b)

10A.3 Calculations, by clause

Table 10A.2 — Calculations the calculator shall perform

Step	Calculation	Clause
C1	**Applicability.** Chapters 4 and 5 apply where land disturbance ≥ 0.1 ha or new plus replaced impervious area ≥ 500 m², over the common plan of development. Report exemptions. Flag that the universal provisions apply at every size, and that RWH applies under Appendix 6 of the TCP Rules 2014 to every building, existing or proposed, in an area where the Himachal Pradesh Town and Country Planning Act 1977 operates, as roof-top storage of at least 20 litres per m² of roof area (about 20 mm over the roof), in place before a water supply connection is given; recharge is credited only where Clause 8.8.1 allows it, which is on the Siwalik valley fills of Una, Paonta–Kala Amb and the Nalagarh upper terraces with pre-treatment, never on a natural slope steeper than 10°, in a mapped sinking or sliding zone, on debris cover, colluvium, slide debris or moraine, within twice the height of a cut slope or retaining wall upslope of it (unless a geotechnical certificate allows it), or in the Balh valley where the seasonal water table is within 1 m of the ground.	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
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)

Step	Calculation	Clause
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 43N (EPSG:32643), or 44N (EPSG:32644) east of 78° E (eastern Kinnaur, Spiti east of about Kaza and Dodra Kwar; a project that crosses 78° E uses one zone for all its layers), whichever contains the site (Clause 10.4.4(c)). One system shall be used for all layers.

- (c) **Vertical reference.** All levels shall be in metres relative to a named vertical datum, stated in the metadata. The metadata shall also state the relationship between that datum and the river datums of the CWC gauges on the receiving rivers, of the reservoir levels of BBMB for Bhakra (Gobind Sagar), Pong and Pandoh (published in feet and converted at 0.3048 m per foot), of the reservoir and pond levels of NTPC, SJVN, NHPC, HPSEBL and the other dam operators, and of the flood marks surveyed on ungauged khads and nallahs 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 `SMC–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
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

Field	Type	Unit	Req.	Content	Source
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
GPT	T	—		Y / N: gross pollutant trap fitted	Clause 8.10.1

Field	Type	Unit	Req.	Content	Source
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
TIDE_REL	Relationship of the vertical datum to the Chapter 5 river datums of the CWC gauges on the receiving rivers, of the reservoir levels of BBMB for Bhakra (Gobind Sagar), Pong and Pandoh (published in feet and converted at 0.3048 m per foot), of the reservoir and pond levels of NTPC, SJVN, NHPC, HPSEBL and the other dam operators, and of the flood marks surveyed on ungauged khads and nallahs (for example, MSL = x.xx m on the site datum)

Field	Content
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
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)

Code	Meaning
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)
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

Element	Requirement	Clause
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 Himachal Pradesh cities vary widely (Clause 10.13, Commentary). The State Stormwater Technical Committee may add standard values to Table 10C.2 when it issues the standard drawings of Annexes 6C and 9B.

Annex 10D — Model O&M plans by facility type

Supports Clauses 10.11, 10.12 and 10.13 of Chapter 10.

The model plans below are starting points. The designer adapts them to each facility and completes the items marked "_____". Inspection frequencies are the minimum frequencies of Table 10.3; a plan may set more frequent inspection, never less. Where this annex leaves a value to the designer, the Manual does not set it.

10D.1 Contents of every O&M plan

Every plan shall contain the items of Clause 10.11.1:

Table 10D.1 — Contents of an O&M plan

Item	Content	Clause
1	Inventory and plan drawing of each facility, with design levels, volumes and outlet details (from SW_FAC, Annex 10B)	10.11.1(a)
2	Routine tasks and their frequency (Tables 10D.2 to 10D.8)	10.11.1(b)
3	Trigger for sediment removal, as a depth (mm) or a percentage of design volume: _____	10.11.1(c)
4	Inspection checklist matching Form 10-7	10.11.1(d)
5	For pumps, gates and valves: operating rules, test schedule, standby power, and actions on a cyclone or heavy-rainfall warning	10.11.1(e)
6	Actions against standing water and mosquito breeding, consistent with the drawdown times of Clause 4.7	10.11.1(f)
7	Safety: confined spaces, deep water, public access	10.11.1(g)
8	Access routes and equipment (Annex 10C)	10.11.1(h)
9	Annual cost estimate (₹ _____ per year) and who pays it	10.11.1(i)
10	Records to be kept, and for how long: _____ years (pump records at least 5 years, Clause 9.9.8(c))	10.11.1(j)

10D.2 Model plans

Table 10D.2 — Retention and infiltration (soakaways, trenches, bioretention, permeable paving)

Task	Frequency	Standard or trigger	Clause
Inspect surface, inlets, pretreatment and overflow	Every 6 months; before 31 May; 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
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 May; 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 Hindi 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 May; 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 May	Station meets its design duty point	Table 10.3, 10.9.3
Standby power	Monthly with the test run; full test before 31 May	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)

Task	Frequency	Standard or trigger	Clause
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 May	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 May	Stop-log slot or penstock operable	9.10.3
Hinges, pins and fixings	Before 31 May	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 May; 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 May	Free of silt and debris	Table 10.3
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 TCP. 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 Himachal Pradesh Town and Country Planning Rules 2014 (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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Lodge with every Stage 1 and Stage 2 submittal. For each item give the page or sheet where it is addressed, or the reason it does not apply. The Authority does not start technical review without a completed Form 10-1 (Clause 10.4.3).

Table 10F.1 — Form 10-1, Section A: Submittal

No.	Field	Entry
A1	Authority and file number	_____
A2	Site name and address; survey numbers	_____
A3	Stage: 1 / 2 / combined 1 and 2 (Clause 10.3.3) / public work DPR or tender (Clause 10.3.4)	_____
A4	Applicant	_____
A5	Certifying professional (name, registration and empanelment number)	_____

Table 10F.2 — Form 10-1, Section B: Stage 1 contents (Clause 10.4.1)

No.	Item	Clause	Page / sheet	Not applicable: reason
B1	Form 1-1; Form 1-2 where a variance or waiver is sought	10.4.1(a)	_____	_____
B2	Site plan: existing and proposed levels, impervious areas, catchment boundaries to and through the site	10.4.1(b)	_____	_____
B3	Soils (HSG), seasonal high groundwater, infiltration tests or test plan	10.4.1(c)	_____	_____
B4	Design Rainfall Sheet (Form 2-1)	10.4.1(d)	_____	_____
B5	Pre-development condition and hydrologic method	10.4.1(e)	_____	_____
B6	Order of measures: areas preserved, retention method, detention concept, conveyance	10.4.1(f)	_____	_____
B7	Preliminary retention, WQ and detention volumes and release rates, with Form 10-2	10.4.1(g)	_____	_____
B8	Downstream extent and tailwater case	10.4.1(h)	_____	_____
B9	Waterbodies, setbacks and the 1% AEP level	10.4.1(i)	_____	_____
B10	Land reserved for facilities and maintenance access	10.4.1(j)	_____	_____
B11	Professional Design Certificate (Form 10-3)	10.4.5	_____	_____

Table 10F.3 — Form 10-1, Section C: Stage 2 contents (Clause 10.4.2)

No.	Item	Clause	Page / sheet	Not applicable: reason
C1	Updated Stage 1 contents (Section B)	10.4.2	_____	_____
C2	Final calculations for every storage duration and AEP, with the outfall-closed check	10.4.2(a)	_____	_____

No.	Item	Clause	Page / sheet	Not applicable: reason
C3	Stage–storage–discharge tables; emergency spillway design	10.4.2(b)	_____	_____
C4	Hydraulic design of conveyance, inlets and structures	10.4.2(c)	_____	_____
C5	Water quality design; first-flush device or GPT where required	10.4.2(d)	_____	_____
C6	Construction drawings, details and specifications of every facility	10.4.2(e)	_____	_____
C7	Construction sequence, with protection of retention and infiltration areas	10.4.2(f)	_____	_____
C8	Hold-point schedule (Form 10-4, Section A)	10.4.2(g)	_____	_____
C9	Draft O&M plan and draft Maintenance Declaration (Form 10-6)	10.4.2(h)	_____	_____
C10	Model input files and GIS data	10.4.2(i)	_____	_____
C11	Certificates (Form 10-3, signed by designer and, where required, checker)	10.4.2(j)	_____	_____

Table 10F.4 — Form 10-1, Section D: Digital submittal (Clause 10.4.4)

No.	Item	Clause	Provided (yes / no)	Detail
D1	Reports and drawings as searchable PDF	10.4.4(a)	_____	_____
D2	Models in native, runnable format; software name and version	10.4.4(b)	_____	_____
D3	GIS data to Annex 10B; horizontal reference system (EPSG code)	10.4.4(c)	_____	_____
D4	Vertical datum named; relationship to the Chapter 5 river datums of the CWC gauges on the receiving rivers, of the reservoir levels of BBMB for Bhakra (Gobind Sagar), Pong and Pandoh (published in feet and converted at 0.3048 m per foot), of the reservoir and pond levels of NTPC, SJVN, NHPC, HPSEBL and the other dam operators, and of the flood marks surveyed on ungauged khads and nallahs	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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Produced by the compliance calculator (Annex 10A) with Stage 1, 2 and 4 submittals. Until the calculator is issued, complete it by hand and enter "not issued" in A3. One column per drainage area where the site has more than one outfall.

Table 10F.6 — Form 10-2, Section A: Site and route

No.	Field	Entry	Clause
A1	Authority, file number, stage (1 / 2 / 4)	_____	10.5.2(a)
A2	Site area, ha; land disturbance, ha; new + replaced impervious area, m²	_____	1.5.2
A3	Calculator version and release date	_____	10.5.3
A4	Tier (A / B); flood-sensitive (yes / no); approved BSMP for the basin (yes / no)	_____	1.6, 4.5.3, 11.12
A5	Route: full method / S-1 / S-2 / fixed-coefficient / constrained redevelopment / regional or fee-in-lieu	_____	1.7, 4.5.6, 4.13, 4.14
A6	Flags raised by the calculator (list)	_____	Annex 10A.4

Table 10F.7 — Form 10-2, Section B: Rainfall and soils

No.	Field	Entry	Clause
B1	Rainfall zone; Form 2-1 reference	_____	2.13
B2	Retention depth P_R, mm; 3-month ARI depth P_3m, mm	_____	2.10, 8.4.1
B3	Climate factor applied (≤ 6 h; > 6–72 h)	_____	2.8
B4	HSG by sub-area; seasonal high groundwater, m below base	_____	3.7, 4.4.3
B5	Measured and design infiltration rates, mm/h	_____	4.4.3

Table 10F.8 — Form 10-2, Section C: Volumes

No.	Quantity	Required (m³)	Provided (m³)	Clause
C1	Retention volume (RRV)	_____	_____	4.4.2
C2	Water quality volume (WQv)	_____	_____	8.4.2
C3	Retention credit against detention	_____	—	4.4.6
C4	Detention volume	_____	_____	4.6, 4.14
C5	Fee-in-lieu or regional volume, and fee (₹)	_____	_____	4.5.6.3, 4.13.3

Table 10F.9 — Form 10-2, Section D: Release rates (each outfall)

AEP	Q_pre or cap (L/s)	Q_post (L/s)	Governing duration (h)	Meets criterion (yes / no)	Clause
50% (2-yr)	_____	_____	_____	_____	4.5
10% (10-yr)	_____	_____	_____	_____	4.5

AEP	Q_pre or cap (L/s)	Q_post (L/s)	Governing duration (h)	Meets criterion (yes / no)	Clause
1% (100-yr)	_____	_____	_____	_____	4.5

Table 10F.10 — Form 10-2, Section E: Outlets, drawdown and stage comparison

No.	Field	Entry	Clause
E1	Low-flow orifice, mm (minimum 50 mm)	_____	4.8.2
E2	Detention: time to release 90% of the 10-yr stored volume, h (≤ 48 h)	_____	4.7.1
E3	WQv release time, h (24–48 h)	_____	4.7.2
E4	Retention emptying time, h (≤ 72 h)	_____	4.7.3
E5	Model result differs from the calculator screen by more than the guide tolerance? If yes, report section that explains it	_____	10.5.2(c)
E6	Stage 4 only: changes from the Stage 2 values (list), and whether every criterion is still met	_____	10.9.2
E7	Prepared by (name, registration number), signature, date	_____	10.6.3(b)

Form 10-3 — Professional Design Certificate

Supports Clauses 10.6.1 to 10.6.5 of Chapter 10.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Signed by the designer with every Stage 1 and Stage 2 submittal, and by an independent checker for facilities under Clause 10.6.1(c) and (d).

Table 10F.11 — Form 10-3, Section A: Project and signatory

No.	Field	Entry	Clause
A1	Authority, file number, stage	_____	—
A2	Site and facilities covered by this certificate	_____	—
A3	Designer: name, qualification, TCP Rules 2014 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 Himachal Pradesh Stormwater Design Manual, except for the variances listed at A5, which have been approved	_____
B2	the rainfall, soils and tailwater inputs are as recorded on Form 2-1 and Form 10-2	_____
B3	the models submitted reproduce the results reported	_____
B4	I understand that a false or negligent certificate is a contravention under Clause 10.15	_____

Table 10F.13 — Form 10-3, Section C: Certificate of the independent checker (Clause 10.6.4)

No.	Field or statement	Entry
C1	Checker: name, registration and empanelment number	_____
C2	I am independent of the designer and the Applicant and have not worked on this design	_____
C3	I have checked the facilities listed: _____, and agree with the certificate in Section B	_____
C4	Matters on which I do not agree, if any	_____

Table 10F.14 — Form 10-3, Section D: Signatures

Role	Name	Signature	Date
Designer	_____	_____	_____
Independent checker (where required)	_____	_____	_____

Form 10-4 — Hold-Point Inspection Record

Supports Clauses 10.4.2(g), 10.8 and 10.9.3 of Chapter 10.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Section A is the hold-point schedule, approved at Stage 2. Section B is completed at each hold point, with dated, geotagged photographs (Clause 10.8.2). Work shall not proceed past a hold point until Section B is signed. See Figure 10.2.

Table 10F.15 — Form 10-4, Section A: Hold-point schedule

Hold point	Facility (FAC_ID)	Stage of work	Planned date	Notice to Authority sent (date)*	Authority attended (yes / no)
(a) Excavated base, before media, liner or structure	_____	_____	_____	_____	_____
(b) Outlet structure, orifice and trash screen, before backfill or first filling	_____	_____	_____	_____	_____
(c) Infiltration and verification tests (Clause 10.9.3)	_____	_____	_____	–	_____
(d) Outfall, flap or tide gate and non-return valve, before downstream connection	_____	_____	_____	–	_____
(e) Pumps and controls, at commissioning	_____	_____	_____	–	_____
Other hold points added by the Authority	_____	_____	_____	_____	_____

* For sites under Clause 10.6.1, at least 3 working days' notice of hold points (a) and (b) (Clause 10.8.2).

Table 10F.16 — Form 10-4, Section B: Inspection record (one per hold point)

No.	Field	Entry
B1	Hold point and facility	_____
B2	Date and time of inspection; weather	_____
B3	Inspected by (certifying professional); others present	_____
B4	Approved drawing and revision checked against	_____
B5	Levels, dimensions and materials found, against approved values	_____
B6	For (a): retention and infiltration areas protected from traffic and stockpiles (Clause 10.8.3(a))	_____
B7	For (b): orifice size and invert; screen in place	_____
B8	For (c): infiltration test result and emptying time (≤ 72 h); pump duty point; gate opening and sealing	_____
B9	For (d) and (e): gate type, seating and test; pump commissioning record	_____
B10	Photograph references (dated, geotagged)	_____
B11	Result: released / not released; corrective work required	_____
B12	Corrective work checked (date, by)	_____
B13	Signature of the certifying professional, date	_____

Form 10-5 — As-built Certificate

Supports Clauses 10.9 and 10.3.5 of Chapter 10.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Lodged before the completion certificate. The Authority shall not issue the completion certificate until this form is accepted (Clause 10.9.4).

Table 10F.17 — Form 10-5, Section A: Project and survey

No.	Field	Entry	Clause
A1	Authority, file number; Stage 2 approval reference and date	_____	—
A2	Licensed surveyor: name, licence number, date of survey	_____	10.9.1(a)
A3	Vertical datum	_____	10.4.4(d)
A4	GIS data to Annex 10B, as built (file name)	_____	10.4.4(c)

Table 10F.18 — Form 10-5, Section B: Approved against as built (one block per facility)

Item	Approved	As built	Accepted (yes / no)	Clause
Storage volume at each design level, m³	_____	_____	_____	10.9.2(a)
Outlet dimensions (orifice, weir), mm	_____	_____	_____	10.9.2(b)
Outlet and outfall inverts, m	_____	_____	_____	10.9.2(b)
Spillway or overflow level, m	_____	_____	_____	4.9
Retention volume, m³	_____	_____	_____	4.4

Table 10F.19 — Form 10-5, Section C: Re-run and tests

No.	Field	Entry	Clause
C1	Compliance calculator re-run with as-built values: version, and Form 10-2 (Stage 4) attached	_____	10.9.1(b)
C2	Model re-run with as-built values (where a model was used): file name	_____	10.9.1(b)
C3	Every criterion of Chapters 4 and 5 met on re-run (yes / no; list any not met)	_____	10.9.2(c)
C4	Infiltration retention: measured emptying time, h (≤ 72 h)	_____	10.9.3
C5	Pumps: duty point achieved (flow at head)	_____	10.9.3
C6	Tide gates and non-return valves: shown to open and seal	_____	10.9.3
C7	Deviations, and how corrected or re-certified under Clause 10.3.5	_____	10.9.2

Table 10F.20 — Form 10-5, Section D: Attachments and certificate

No.	Field	Entry
D1	Completed hold-point records (Form 10-4)	_____
D2	Final O&M plan	_____
D3	Executed Maintenance Declaration (Form 10-6) or handover documents (Form 10-8)	_____

No.	Field	Entry
D4	I certify that the facilities listed were built as approved, except as stated at C7, and perform as designed. Certifying professional: name, registration number, signature, date	_____
D5	For the Authority: accepted / returned; officer, date	_____

Form 10-6 — Maintenance Declaration

Supports Clauses 10.10.1, 10.10.2, 10.10.4 and 10.13.1 of Chapter 10.

Draft form — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Model text for consideration by a competent authority. Not in force. Executed by the owner of every private stormwater facility before the completion certificate is issued, and registered so that it runs with the land.

> **Drafting note D10A.1.** The instrument under which this declaration is registered, and the Act that gives the Authority its right of entry and its power to carry out works in default, are to be confirmed by the competent authority. This form does not cite statute sections.

Table 10F.21 — Form 10-6, Section A: Parties and land

No.	Field	Entry
A1	Owner (the declarant): name and address; for a company or association, its registration number	_____
A2	Authority	_____
A3	Land: survey numbers, village, tehsil, 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 May 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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Due by **31 May** 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 June to 31 May)	_____
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 May) 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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Signed by the developer and the ULB when drains, open space facilities, regional facilities or other stormwater assets built by a developer are handed over.

Table 10F.30 — Form 10-8, Section A: Asset and parties

No.	Field	Entry
A1	Developer: name and address	_____
A2	ULB	_____
A3	Layout or project, approval reference	_____
A4	Assets handed over (FAC_ID, type, length or volume), with a plan	_____

Table 10F.31 — Form 10-8, Section B: Conditions of handover (Clause 10.14.1)

No.	Condition	Met (yes / no)	Reference or date
B1	As-built certificate (Form 10-5) accepted	_____	_____
B2	Facility cleaned; pipes and culverts inspected internally (CCTV or manual entry), record handed over	_____	_____
B3	Land, or an easement over it, transferred to the ULB	_____	_____
B4	O&M plan, drawings, GIS data (Annex 10B) and warranties handed over	_____	_____

Table 10F.32 — Form 10-8, Section C: Defects liability and register

No.	Field	Entry	Clause
C1	Defects liability period: from _____ to _____ (includes at least one full monsoon season, from 15 June 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 Himachal Pradesh Stormwater Design Manual.
2. The BSMP shall (Clause 11.1.2):
    - (a) map flood hazard for the basin under existing and future conditions;
    - (b) set the level of service for each part of the drainage system;
    - (c) identify, cost and rank the works, storage and land needed to reach that level of service;
    - (d) identify land to be reserved in the statutory land-use plan for regional storage, tal 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:** Jal Shakti Vibhag, wherever the basin includes a river, canal or tank under its control, and [other local bodies, a SADA or TCP, HPSDMA] (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, khad, reservoir, tal or kuhl 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, tal, 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, khads, reservoirs and tals: outfall invert levels, on a named datum, against the warning, danger and high flood levels of the receiving river at the nearest CWC site (the Yamuna at Paonta, the only site with warning and danger levels, or a level-monitoring site such as the Swan at Ghaluwal or the Sutlej at Rampur) and its recorded peaks, with any local gauge kept as a separate series and any conflict between published values stated; for ungauged rivers, khads and nallahs, surveyed flood marks and the 1% AEP level with its sediment and debris; for outfalls to reservoirs and tals, the maximum water level, full reservoir level and spillway and gate data from BBMB or the dam operator, converted from feet where so published; the release records of the dams and barrages that set the receiving levels; the debris-flow fans, landslide zones, muck dumps and glacial lakes above the basin; and sluices, flap gates, debris racks, sediment traps, debris basins and pumping stations on the outfalls, with their capacities and operating rules;
- (f) rainfall and water levels: all available records (IMD, including its observatories and stations at Shimla, Dharamshala, Kangra (Gaggal), Mandi, Sundernagar, Una, Solan, Bhuntar, Manali, Kalpa and Keylong and the automatic weather stations reported by the Meteorological Centre Shimla, among them Una Rampur and Kangra Aero; the district and tehsil rain gauges of the State; the self-recording gauges at Shimla, Dharamshala, Dharampur, Nahan, Dalhousie, Sundernagar and Bhuntar used for the CWC Flood Estimation Report for zone 7; the river gauges of CWC; the rain and reservoir records of BBMB at Bhakra, Pong and Pandoh, and of NTPC, SJVN, NHPC and HPSEBL at their dams; and any gauges kept by the Municipal Corporations, the Smart City companies, HPSDMA and the Jal Shakti Vibhag), including the 9–11 July 2023 (228.5 mm at Una Rampur AWS on 9 July and 250.0 mm at Nahan on 11 July, IMD, with new high flood levels on the khads of Sirmaur and Kinnaur, as reported), 14–15 August 2023 (273.4 mm at Kangra Aero and 250.2 mm at Dharmsala, IMD, with the slides at Summer Hill and Krishna Nagar in Shimla), 31 July–1 August 2024 (the cloudbursts at Samej, Bagipul and Rajban, where no gauge recorded the rain, as reported), 30 June–1 July 2025 (140.7 mm over Mandi district in 24 hours, with the floods of Seraj and Thunag, as reported) and 5 September 1995 (the Yamuna at Paonta at its high flood level of 384.6 m, CWC as transcribed by SANDRP) 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 9–11 July 2023 (228.5 mm at Una Rampur AWS on 9 July and 250.0 mm at Nahan on 11 July, IMD, with new high flood levels on the khads of Sirmaur and Kinnaur, as reported), 14–15 August 2023 (273.4 mm at Kangra Aero and 250.2 mm at Dharmsala, IMD, with the slides at Summer Hill and Krishna Nagar in Shimla), 31 July–1 August 2024 (the cloudbursts at Samej, Bagipul and Rajban, where no gauge recorded the rain, as reported), 30 June–1 July 2025 (140.7 mm over Mandi district in 24 hours, with the floods of Seraj and Thunag, as reported) and 5 September 1995 (the Yamuna at Paonta at its high flood level of 384.6 m, CWC as transcribed by SANDRP) 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 groundwater recharge on the Siwalik valley fills of Una, Paonta–Kala Amb and Nalagarh, where the stage of extraction is highest (Una 63.72%, Solan 57.89%; CGWB, 2024), the stability of hill slopes, where water put into debris cover, colluvium or moraine raises the pore pressure, as at Summer Hill and Krishna Nagar in Shimla in 2023, the springs, nauns and baolis that supply the hill towns and their recharge areas, such as that of the Bohal spring above Palampur, the kuhls that carry hill runoff, the high water table of the Balh valley, and the quality of the groundwater, which the Ground Water Act 2005 protects against effluent (s.5A), and of the rivers, khads, reservoirs and tals that the runoff reaches; effect on downstream basins and the receiving river, khad, reservoir, tal or kuhl; 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 fans, terraces and valley floors after any large flood or debris flow, the drain network of every drain-owning body (the Municipal Corporations and other ULBs, the Smart City companies, HIMUDA, HPSIDC, BBNDA, PWD and NHAI, with the drains of the British period in Shimla), the rivers, khads and nallahs with the flood-protection and channelisation works of the Jal Shakti Vibhag, the kuhls scheduled under the Minor Canals Act 1976, the reservoirs of BBMB and the other dam operators with their levels, spillways, gates and operating rules on a stated datum, the release records of Larji, Pandoh, Malana, Kol, Bhakra and Pong, the springs, nauns and baolis and their recharge areas, the sinking and sliding zones of the development plans, and the landslide, debris-flow, muck-dump and glacial-lake hazards mapped by HPSDMA and the State Centre on Climate Change (other likely sources: Survey of India, CWC, CGWB, NIH and the district land records). No basin map of any Himachal Pradesh town was found. Until the annex is published, the basins of Shimla, Mandi, Kullu–Bhuntar–Manali, Dharamshala–Kangra, Baddi–Barotiwala–Nalagarh, Parwanoo, Una, Paonta Sahib, Bilaspur and the Pong shore, Rampur Bushahr, Chamba and the valley towns 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 sub-area HP-C 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
Shimla (SMC, TCP)	Nallahs of the Shimla Planning Area draining north to the Sutlej and south to the Ashwani Khad and the Giri	British-era and AMRUT drains in the 1D network; sinking and sliding zones shown; intakes and treatment plants on the Ashwani Khad marked; 1% AEP nallah level with debris as boundary
Mandi (Municipal Corporation)	Catchments draining to the Beas and the Suketi	Larji and Pandoh releases and surveyed flood marks as boundary
Kullu, Bhuntar and Manali	Catchments of the valley towns and their side khads, including the Sarvari and the Parbati	Old Beas channels mapped; Malana and Parbati releases upstream; flood marks as river boundary
Dharamshala–Kangra (Municipal Corporation, Smart City company)	Khads crossing the towns, including the Manjhi, the Gaj, the Banner and the Bhagsunag nallah	Debris racks and basins at the foot of the range; 1% AEP level with debris as boundary
Baddi–Barotiwala–Nalagarh (BBNDA, ULBs)	Catchments draining to the Sirsa and the Balad	Industrial drains and effluent outfall in the 1D network; industrial and storm drains separated
Parwanoo	Catchments draining to the Sukhna	Sewage loads shown
Una	Catchments draining to the Swan through its embankments	Ghaluwal level and surveyed 1% AEP level as boundary; outfall-closed case a design case
Paonta Sahib	Catchments draining to the Yamuna and the Bata	CWC Paonta and Ganguwala levels as boundary; outfall-closed case a design case
Bilaspur and the Pong shore	Catchments draining to Gobind Sagar and Pong	Reservoir levels of Chapter 5, converted from feet, as boundary; feeding khads kept free of muck
Rampur Bushahr	Catchments of the town and its khads on the Sutlej	CWC Rampur level (conflict stated) and outburst scenario as boundary
Chamba and other valley towns	Catchments of the town and of each khad crossing it	Surveyed flood marks as boundary; debris fans, slides and sinking zones mapped; in HP-C, hazard screening first

Tier A body or area	Basin	Note from Chapter 11
Other Tier A bodies, including Solan, Palampur, Hamirpur and Nahan	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_HI	Text	Basin name in English and Hindi
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 Jal Shakti Vibhag 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 Himachal Pradesh building types

Supports Clause 11.8.2 of Chapter 11.

To be prepared. This annex will contain depth–damage curves for the main building types of Himachal Pradesh cities, for structure and contents, for use in computing expected annual damage under Clause 11.8.2. It needs a building-type classification and building stock data (Census housing tables, property-tax records, Lead Authority GIS), damage surveys and claims from the 9–11 July 2023 (228.5 mm at Una Rampur AWS on 9 July and 250.0 mm at Nahan on 11 July, IMD, with new high flood levels on the khads of Sirmaur and Kinnaur, as reported), 14–15 August 2023 (273.4 mm at Kangra Aero and 250.2 mm at Dharmsala, IMD, with the slides at Summer Hill and Krishna Nagar in Shimla), 31 July–1 August 2024 (the cloudbursts at Samej, Bagipul and Rajban, where no gauge recorded the rain, as reported), 30 June–1 July 2025 (140.7 mm over Mandi district in 24 hours, with the floods of Seraj and Thunag, as reported) and 5 September 1995 (the Yamuna at Paonta at its high flood level of 384.6 m, CWC as transcribed by SANDRP) floods (Revenue Department and HPSDMA 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)	_____	_____	_____	_____	_____	_____	_____

Depth of water above floor level (m)	0	0.25	0.5	1.0	1.5	2.0	3.0
Contents damage (% of contents value)	_____	_____	_____	_____	_____	_____	_____
Building type, source and year of costs	_____						

11C.1 Use in option assessment

Expected annual damage (EAD) is computed for each scenario from the damages at the modelled AEPs. With damages D_1, D_2, … at annual exceedance probabilities P_1 > P_2 > …, using at least the 50%, 10%, 1% and 0.2% AEP results of Clause 11.7.2:

> $$EAD \approx \Sigma \tfrac{1}{2} \times (D_i + D_{(i+1)}) \times (P_i - P_{(i+1)})$$

The reduction in EAD between scenario (c) and scenario (d), or between options, is the risk-reduction benefit used to rank works per rupee (Clause 11.8.4(e)). The BSMP shall state how damages beyond the 0.2% AEP and below the 50% AEP were treated.

Annex 11D — BSMP data and model publication standard

Supports Clauses 11.5.1 and 11.10 of Chapter 11, and Clause 10.17 of Chapter 10.

11D.1 What is published, and when

Table 11D.1 — Items to be published

Item	Format	At draft (Clause 11.10.1)	At approval (Clause 11.10.2)
BSMP report, with the level-of-service assessment and options	Searchable PDF	Yes	Yes, final
Flood hazard maps: extent, depth, velocity, hazard class, for each AEP and scenario of Clause 11.8.4(a)	GeoTIFF rasters; extents also as GeoPackage polygons	Yes	Yes
Capital Improvement Programme	CSV and PDF	Draft	Yes
Basin release rates, recommended flood-sensitive catchments, regional facility sites, fee-in-lieu unit rate	GeoPackage and CSV	Yes	Yes
Data of Table 11.1 (terrain, drains, waterbodies, cross-sections, river, reservoir and tal levels, debris hazards and outfall structures, rainfall and levels, flood evidence, land use, soils and groundwater, sewer interaction)	GeoTIFF (terrain); GeoPackage (features); CSV (tables and time series)	Summary	Yes, except security-sensitive asset details
Model files: native, runnable, with all boundary-condition, rainfall and control files, the software name and version, and a run log	Native format, zipped	No	Yes
Calibration and validation report	Searchable PDF	Yes	Yes
Consultation log of comments and responses	PDF or CSV	—	Yes

11D.2 Formats and references

- (a) Raster data shall be GeoTIFF, preferably cloud-optimised, with the cell size stated. Vector data shall be GeoPackage. Tables and time series shall be CSV in UTF-8, with a header row and units in the column names.
- (b) Horizontal and vertical references shall be as in Annex 10B.1(b) and (c). The vertical datum and its relationship to the Chapter 5 river datums of the CWC gauges on the receiving rivers, of the reservoir levels of BBMB for Bhakra (Gobind Sagar), Pong and Pandoh (published in feet and converted at 0.3048 m per foot), of the reservoir and pond levels of NTPC, SJVN, NHPC, HPSEBL and the other dam operators, and of the flood marks surveyed on ungauged khads and nallahs 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 `ashwani_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 — Himachal Pradesh Stormwater Design Manual, Draft v1.0. Published by the Lead Authority for each basin with an approved BSMP before each south-west monsoon, by **31 May** (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 June to 31 May)	_____
A4	Date of publication (by 31 May) 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 tal 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	_____