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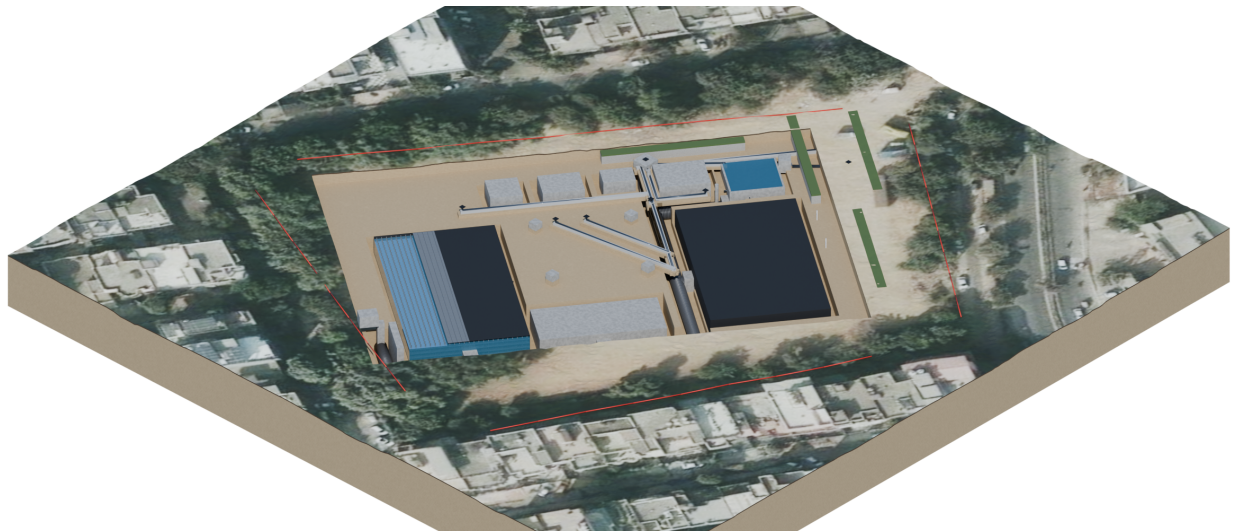


FloodAstra | Gurugram

Ram Lila Ground

Underground flood capture and groundwater recharge scheme

Engineering summary report



Whole-scheme view of the buried works under Ram Lila Ground (orthographic, from simulated design geometry)

Site	Ram Lila Ground, Sheetla Mata Mandir Road, Gurugram, Haryana
Client	Municipal Corporation of Gurugram
Prepared by	IIT Gandhinagar with AIReSQ
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Document control

Rev	Date	Description	Prepared	Checked	Approved
P1	18 Oct 2026	First issue for review			
P2	18 Oct 2026	Forebay-to-storage links upsized to 2 × DN450			
P3	18 Oct 2026	Street capture: 7 pumped street pits, DN700 main; pumping and instrumentation plan			

This report summarises a preliminary design and planning-level simulation results. It is not a construction document. Levels are on the terrain-model datum; the tie to a surveyed benchmark is outstanding. The Ram Lila Ground boundary shown is a provisional visual boundary and not a cadastral survey.

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1 Executive summary

Ram Lila Ground is an open public ground on Sheetla Mata Mandir Road, Gurugram, that lies in a closed hollow. In the 107 mm, 3-hour design storm the simulated flood depth on the ground reaches about 0.91 m by 3.25 h from rain start, and the water has no gravity outlet. This report describes a proposed underground scheme that captures the ponded water, stores and treats it below the ground, and recharges it to the deep aquifer, while keeping the surface available for Ramlila and daily use. Design-storm results are provisional in this issue (at 3.25 h from rain start) and will be replaced automatically when the simulation completes.

The scheme comprises:

- seven flush pond inlets and seven pumped street pits at nearby flooded street pockets, all draining to a collector sump with a booster pump and a DN700 main;
- a forebay and a hydrodynamic separator in precast reinforced concrete, the only concrete units that need desilting;
- two buried storage fields SF-1 and SF-2 of polypropylene column-and-deck modules (each about 42 m × 25 m, 4 m deep, 4,000 m³), wrapped in geomembrane under at least 0.8 m of cover and rated for crowd loading;
- a buried precast plant room with treatment pumps and filter, a clean-water tank of polypropylene modules and an injection booster;
- four deep injection well positions, provided and simulated, screened in the receiving aquifer; phase 1 constructs two (the 50 L/s treatment train feeds about two wells), with wells 3 and 4 added if the injection test confirms acceptance; observation wells and four gravel recharge trenches;
- a walk-in inspection gallery (2.4 m corrugated HDPE pipe) in the full scheme, with access risers and manholes in phase 1; the only above-ground unit is a small kiosk at the edge of the ground.

Key performance indicators: scheme compared with no works at 3.25 h from rain start

73.7 lakh L	–76%	–44%	4,207 m³
Water removed from the ground	Water above 0.15 m on the ground at 3.2 h	Ground area still above 0.15 m at 3.2 h	Captured from nearby streets
7,366 m ³ in 0–3.2 h	2,878 to 703 m ³	9,185 to 5,143 m ²	7 pumped street pits, 0–3.2 h
0.91 to 0.72 m	76%	330 m³	1.06 m³/s
Maximum depth on the ground	Buried storage in use at 3.2 h	Recharged to the deep aquifer	Peak intake to the plant
–21%; peak occurs during the rain	7,022 of 9,205 m ³	in 0–3.2 h; stored water follows in approx. 39 h at 50 L/s	5-min mean, 14 grates

The main limitations are: the terrain model contains obstacles inside the ground that do not exist on site, so the simulated pond extent is conservative; the boundary is not cadastral; aquifer properties are regional estimates that need a test bore and injection test; levels are not yet tied to survey; treatment and recharge need regulatory approval; and the intake rate is limited by the DN700 main and booster (about 1.04 m³/s); street pits are simulated as openings into the sump, with their pumps and rising mains sized by calculation from the simulated flows. Section 11 lists these with the next steps.

Table 1. Key numbers (design storm with works provisional)

Measure	Before works	With scheme
Maximum flood depth on the ground (m)	0.91	0.72
Ground area with peak depth > 0.15 m (m ²)	9,186	5,209
Ground area still > 0.15 m at 3.2 h (m ²)	9,185	5,143
Model area (600 m × 600 m) with peak depth > 0.15 m (m ²)	93,373	80,775
Buried storage provided (m ³)	–	9,205
Water taken off the ground in the event (m ³)	–	7,366
Water recharged to the deep aquifer in the event (m ³)	–	330
<i>30-minute burst, earlier deep-cell layout with the same 8,000 m³ storage; at 0.58 h</i>		
Ground area with peak depth > 0.15 m (m ²)	8,118	7,127
Maximum depth on the ground (m)	0.79	0.73

Design-storm figures are provisional: both columns are compared at 3.25 h from rain start, the time the simulation had reached at issue. They will be replaced automatically when the simulation completes.

Source: FloodAstra 2D/1D model, 107 mm 3 h design storm with 3 h recession, run 18 Oct 2026 (results at 3.25 h from rain start; provisional)

2 Site and problem

2.1 Site

Ram Lila Ground is an open, unpaved public ground of about 1.3 ha on the south side of Sheetla Mata Mandir Road, enclosed by dense residential blocks (Figure 1). It is used for the annual Ramlila performances and for daily recreation. Ground level near the proposed inlets is about 217.24 m on the terrain-model datum.



Figure 1. Location of Ram Lila Ground with the provisional boundary

Source: Imagery: Esri, Vantor, Earthstar Geographics and GIS User Community. Boundary: provisional visual boundary, not cadastral. Coordinates WGS 84 / UTM zone 43N.

2.2 Flooding problem

The ground sits in a closed hollow: the surrounding roads and plots are higher on all sides, so rain falling on the ground and on the streets draining to it collects as a pond with no gravity outlet. In the design storm without works the simulation gives (by 3.25 h from rain start) a maximum depth of 0.91 m, 9,186 m² of the ground deeper than 0.15 m, and 93,373 m² deeper than 0.15 m across the 600 m model area (Figure 6). Because the closed hollow has no outflow, water persists after the rain stops and the ground is unusable until it soaks away or evaporates.

The design brief is therefore to remove water from the hollow without a surface outlet and without taking the ground out of public use.

3 Design storms and method

3.1 Design storms

Two rainfall events are used:

- **Design storm:** 107 mm in 3 h, followed by a 3 h recession period with no rain;
- **Short burst:** 100 mm in 30 min, to test intake capacity under intense rain.

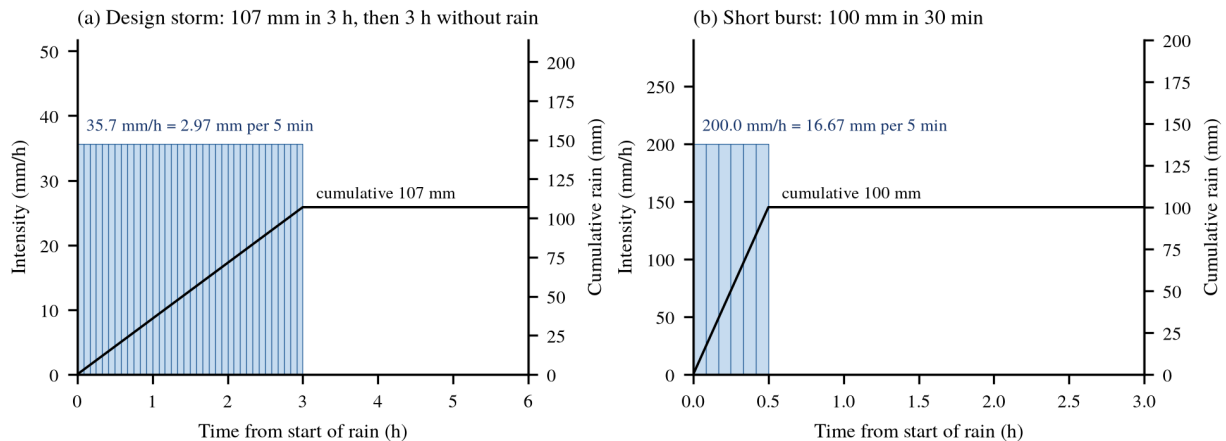


Figure 2. Hyetographs of the two rainfall events: 5-minute intensity (bars) and cumulative rain (line)

Source: Design-storm definition used in the simulations. Rain is applied uniformly over the 600 m model area.

3.2 Model

The simulation uses a 1 m terrain model of a 600 m × 600 m area centred on the ground. Two-dimensional surface flow is coupled to the inlet and pipe network, the treatment and recharge plant (forebay, storage fields, filter, clean tank and pumps) and a layered deep aquifer receiving water through the injection-well screens. Existing buildings act as barriers. The model area has no outflow and no infiltration, so all rain stays on the surface unless captured; real street drains would reduce flooding in both cases. Results are of planning-level accuracy and are intended to compare the cases with and without the works and to size the scheme, not to predict exact depths at a point.

3.3 Engineering quality checks

Table 2 lists the checks applied to the simulations reported here.

Table 2. Engineering quality checks on the simulations

Check	Criterion	Status
Water balance	Closes every 5 s step across surface, sump, pipe, tanks, wells and aquifer to below $1 \times 10^{-6} \text{ m}^3$	Met
Non-negative depths	No negative water depth in any cell or storage at any step	Met
Like-for-like comparison	Same rain, terrain and empty start for the runs with and without works	Pending full run
Benefit threshold	Differences under 0.02 m or 5% treated as numerical noise; not claimed as benefit	Applied
Peak sampling	Peak depth tracked per 1 m cell over the whole run, not taken from the final state	Met
Boundary condition	Closed 600 m model area: no outflow or infiltration (conservative for both cases)	Noted
Recharge trenches	Estimated by hand calculation; not part of the simulation	Noted

Source: FloodAstra 2D/1D model, run 18 Oct 2026

A DEVELOPED HYDRAULIC LONG SECTION | H 1:500 V 1:100 AT A1 | VERTICAL EXAGGERATION 5x

Developed along the flow path inlet - sump - main - forebay - storage field - plant room - clean tank - booster - well; units at true internal length.

Pond peak before works 217.94 m (0.70 m over IN-1 grate 217.24); main GM-1 invert 215.74 at sump to 215.64 at forebay port; forebay outlet to cells 214.04.

SIMULATED (results at 3.2 h from rain start): PEAK INFLOW 1.06 m³/s; TAKEN OFF GROUND 7,366 m³; FILTERED 364 m³; TO WELLS 339 m³; INTO AQUIFER 330 m³

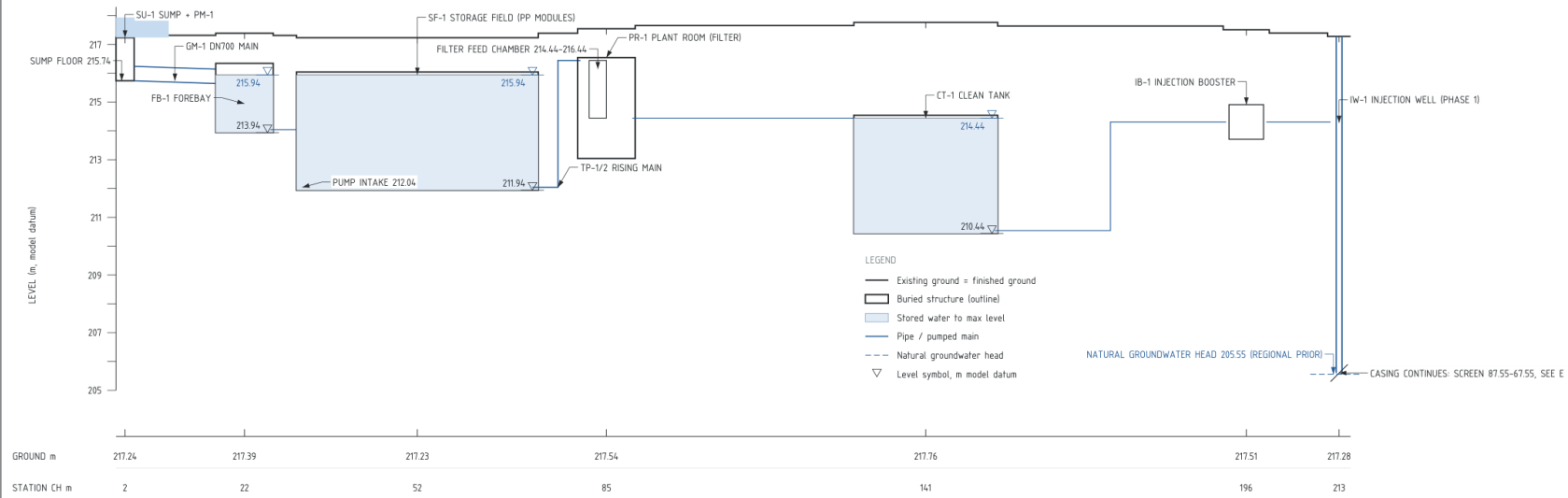


Figure 3. Developed hydraulic long section from pond inlet to injection well (vertical exaggeration 5)

Source: Drawing FA-RL-02, Hydraulic long section and typical sections, Rev P1. Levels in m on the terrain-model datum.

4 Scheme description

4.1 Arrangement

All works are buried except the edge kiosk (Figure 4). Water follows a single path: the pond is drained by seven flush inlets and seven pumped street pits to a collector sump, lifted by a booster pump through a DN700 main to a buried forebay with a hydrodynamic separator, passed to two buried storage fields of polypropylene modules, treated and filtered in the buried plant room, held in a clean tank, and pumped by an injection booster to the deep wells (Figure 3). Four deep injection well positions are provided and simulated; phase 1 constructs two, since the 50 L/s treatment train feeds about two wells, and wells 3 and 4 are added if the injection test confirms acceptance. Silt is caught in the separator and the forebay, so that only pre-settled water enters the storage fields. Four recharge trenches along the edges of the ground take additional surface water by infiltration. In the full scheme a walk-in inspection gallery (2.4 m corrugated HDPE pipe) links the kiosk to the plant room, the storage and the wells for operation and desilting; phase 1 uses access risers and manholes instead. Table 3 gives the schedule of works as simulated.

Table 3. Schedule of works (sizes and levels as simulated)

Tag	Item	Size	Levels (m)	Capacity
IN-1–7	Pond inlet grates (7 no.)	0.5 m ² each, Cd 0.62	GL 217.22–217.29	see FA-RL-01
SP-1–7	Street pits with pumps (7 no.)	0.5 m ² grate, 0.08–0.14 m ³ /s	GL 217.25–217.75	see FA-RL-06
SU-1	Collector sump	10 m ² × 1.5 m	floor 215.74	15 m ³
PM-1	Pond booster on main	1.2 m ³ /s free, 3 m lift		52 kW limit
GM-1	Gravity/booster main	DN700, L 15.7 m	IL 215.74 to 215.64	1.04 m ³ /s
FB-1	Forebay (buried)	10 × 10 × 2 m	213.94 / 215.94	200 m ³
SF-1,2	Storage fields, PP column-and-deck modules	42 × 25 m each, approx. 4 m deep	211.94 / 215.94	2 × 4,000 m ³
TP-1,2	Treatment pumps	25 L/s each, 12 m	intake 212.04	2 × 3 kW
FS-1	Filter skid	20 m ² media	feed 214.44–216.44	50 L/s
CT-1	Clean tank (buried)	25 × 10 × 4 m	210.44 / 214.44	1,000 m ³
IB-1	Injection booster	0.1 m ³ /s, 10 m		15 kW
IW-1–4	Injection wells, deep	DIA 0.5 m, 20 m apart	screen 87.55–67.55	see FA-RL-02
OW-1,2	Observation piezometers	passive		
RT-1–4	Recharge trench + 2 shafts	30 × 2 × 3 m, shafts 1.2 × 9 m	GL approx. 217.2–217.3	approx. 13 L/s each*

Source: Drawing FA-RL-01, schedule of works. Levels on the terrain-model datum. RT-1 to RT-4 are estimated by hand calculation and were not simulated.

4.2 Key levels

Ground level at the inlets is 217.24 m. The sump floor is at 215.74 m and the main discharges to the forebay at 215.64 m. The storage fields span 211.94 m (floor) to 215.94 m (maximum water level) and the clean tank 210.44 m to 214.44 m. The natural groundwater head is taken as 205.55 m (regional estimate). The injection-well screens are at 87.6 m to 67.6 m, about 130 m to 150 m below ground, in the receiving aquifer below a clay aquitard (drawing FA-RL-02, detail E).

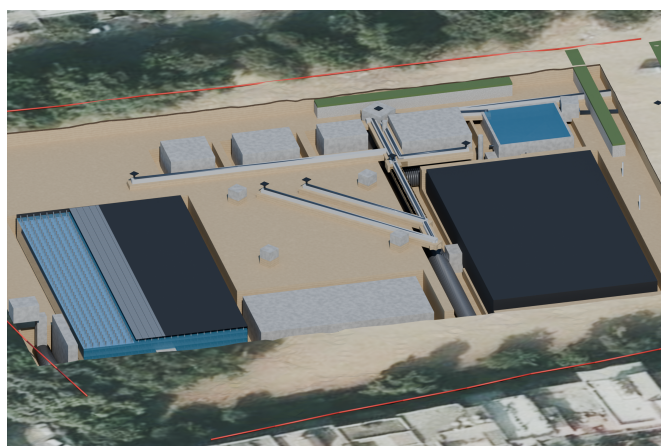


Figure 4. General arrangement plan of the buried works on Ram Lila Ground

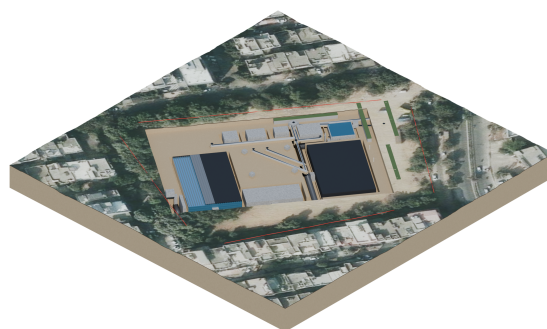
Source: Drawing FA-RL-01, General arrangement plan (plan viewport), Rev P1. Schedule of works and surface-use zoning: Table 3, Table 11 and the full drawing. Imagery: Esri, Vantor, Earthstar Geographics and GIS User Community.

4.3 Design loads

Each buried unit is designed so that the ground above remains usable. Roofs and module decks carry the soil and turf cover (at least 0.8 m over the storage fields, about 1 m elsewhere; $18\text{--}20\text{ kN/m}^2$) plus a crowd load of 5 kN/m^2 (IS 875 Part 2, assembly areas), giving a typical design load of about $25\text{--}30\text{ kN/m}^2$, with a local check for stage and light-vehicle loads. Heavy cranes and piling over the buried units are excluded. Construction materials are given in Section 9.



(a) Cutaway with the soil cover removed



(b) Whole-scheme view of the site

Figure 5. Three-dimensional views of the buried scheme: (a) cutaway of the storage fields, forebay and plant; (b) whole-scheme view of the site

Source: Orthographic views from the same terrain model, plan positions and levels as the simulated design geometry; vertical exaggeration 1.0. Imagery: Esri, Vantor, Earthstar Geographics and GIS User Community.

5 Results – design storm

Provisional. At the time of issue the simulation had reached 3.25 h from rain start. All values in this section are at that time, for both cases, and will be replaced automatically when the simulation completes.

5.1 Flooding before and after works

Table 4 compares flooding without and with the scheme, and Figure 6 maps the peak depth.

Table 4. Flooding before and after works, design storm

Measure	Before	After	Change
Ram Lila Ground: area with peak depth > 0.15 m (m ²)	9,186	5,209	–3,977 (–43%)
Ram Lila Ground: maximum depth (m)	0.91	0.72	–0.19 (–21%)
Ram Lila Ground: water above 0.15 m at 3.2 h (m ³)	2,878	703	–2,175 (–76%)
Ram Lila Ground: area still > 0.15 m at 3.2 h (m ²)	9,185	5,143	–4,042 (–44%)
Plant site (forebay): peak depth (m)	0.76	0.46	–0.30 (–39%)
600 m model area: area with peak depth > 0.15 m (m ²)	93,373	80,775	–12,598 (–13%)
600 m model area: water above 0.15 m at 3.2 h (m ³)	20,830	15,257	–5,573 (–27%)

Peak depth is the maximum over the run in each 1 m cell. 0.15 m is the reportable ponding threshold. Differences under 0.02 m or 5% are within numerical noise.

Source: FloodAstra 2D/1D model, 107 mm 3 h design storm with 3 h recession, run 18 Oct 2026 (results at 3.25 h from rain start; provisional)

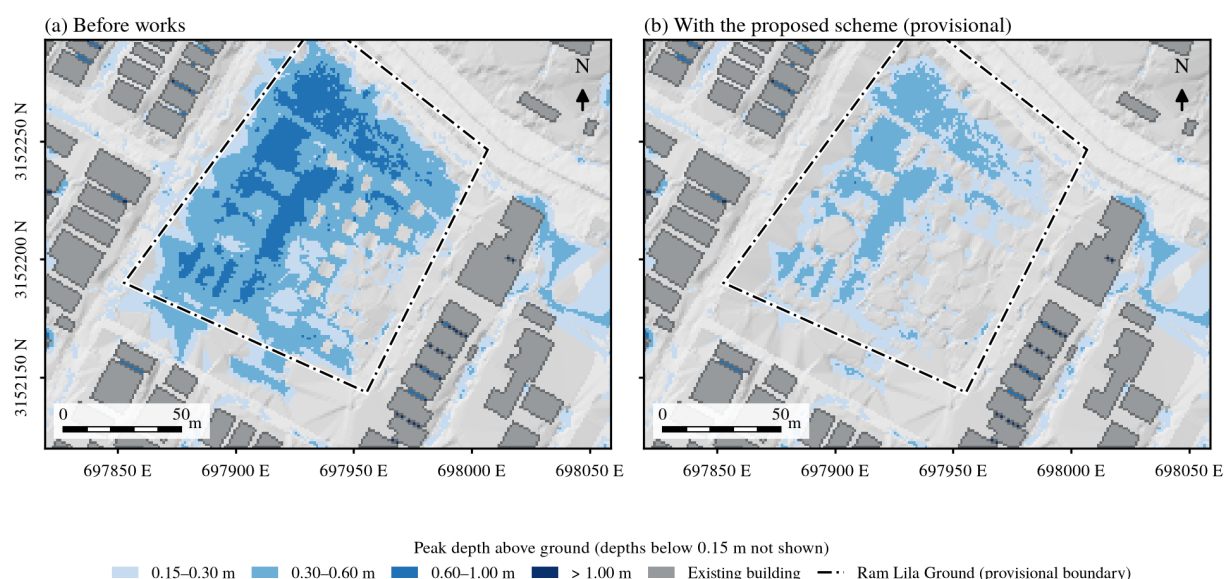


Figure 6. Simulated peak flood depth in the design storm: (a) before works, (b) with the proposed scheme
Source: FloodAstra 2D/1D model, 107 mm 3 h design storm with 3 h recession, run 18 Oct 2026 (results at 3.25 h from rain start; provisional). Drawing FA-RL-03.

5.2 Flow path and capacity

Table 5 follows the water from the pond to the aquifer with the design capacity of each step and the simulated quantity, and Table 6 lists the rate limits. Figure 7 shows the inflow to the sump and the cumulative volume taken off the ground. In this event the peak grate inflow (about $1.06 \text{ m}^3/\text{s}$) stays below the forebay-to-storage link capacity (about $1.10 \text{ m}^3/\text{s}$); in more intense rain, short peaks above this capacity are buffered by the 200 m^3 forebay and the sump, and once these are full the inlets throttle and the surplus remains on the ground until capacity frees up.

Table 5. Flow path from pond to aquifer

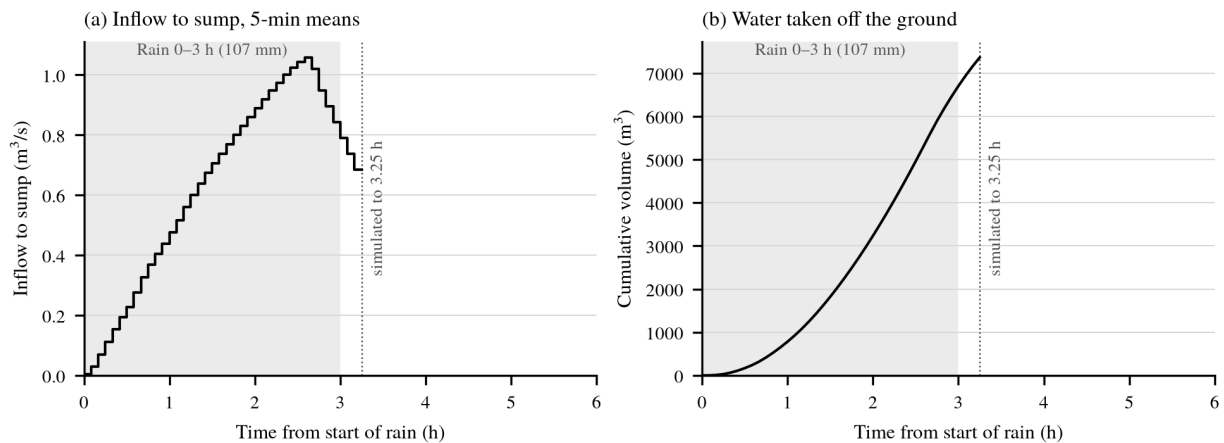
Step	Design capacity	Simulated
Pond (RAM LILA)	peak 0.70 m deep	simulated: $7,366 \text{ m}^3$ out
14 inlet grates	7 pond + 7 street pits	simulated peak $1.06 \text{ m}^3/\text{s}$
Sump + 3 m booster	$15 \text{ m}^3 / 1.2 \text{ m}^3/\text{s}$	simulated: sump buffer
DN700 main 15.7 m	up to $1.04 \text{ m}^3/\text{s}$	simulated: $7,366 \text{ m}^3$
Forebay	200 m^3	simulated peak 199 m^3
2 × DN500 links	approx. $1.10\text{--}1.10 \text{ m}^3/\text{s}$	as modelled
Storage fields	$2 \times 4,000 \text{ m}^3$	simulated peak $6,793 \text{ m}^3$
Treatment pumps	$2 \times 25 \text{ L/s}$ at 12 m	simulated 5 kWh
Filter 20 m^2	50 L/s	simulated 364 m^3
Clean tank	$1,000 \text{ m}^3$	simulated peak 25 m^3
Injection booster	100 L/s at 10 m	simulated to wells 339 m^3
4 deep wells	screens $87.6\text{--}67.6 \text{ m}$	simulated aquifer 330 m^3

Source: FloodAstra 2D/1D model, 107 mm 3 h design storm with 3 h recession, run 18 Oct 2026 (results at 3.25 h from rain start; provisional)

Table 6. Rate limits along the flow path

Step	Limit	Basis
Pond inlets: 7 grates 0.5 m ²	1.06 m ³ /s peak	simulated
DN700 main with 3 m booster	1.04 m ³ /s max	pump curve limit
Forebay to storage fields, 2 × DN500	approx. 1.1 m ³ /s	plant hydraulics
Treatment pumps 2 × 25 L/s at 12 m	0.05 m ³ /s	control setting
Filter (20 m ²)	0.05 m ³ /s	control setting; limits well supply
Injection booster 10 m to 4 wells	0.10 m ³ /s	control setting
Deep wells, 4 × DIA 0.5 m, 20 m screens	0.03 m ³ /s mean	simulated (aquifer priors)
Recharge trenches RT-1–4*	approx. 0.05 m ³ /s	analytic, verify by test

Source: FloodAstra 2D/1D model, 107 mm 3 h design storm with 3 h recession, run 18 Oct 2026 (results at 3.25 h from rain start; provisional). RT-1 to RT-4: hand calculation, to be verified by test.

**Figure 7.** Inflow to the sump and cumulative volume taken off the ground, design storm

Source: FloodAstra 2D/1D model, 107 mm 3 h design storm with 3 h recession, run 18 Oct 2026 (results at 3.25 h from rain start; provisional).

5.3 Storage and water balance

Table 7 gives the capacity and simulated fill of each storage unit and Table 8 the event water balance. To pass 48–96 L/s into the wells, filter and treatment capacity must be raised from 50 L/s; well acceptance itself (approx. 15–20 L/s per well) is an aquifer-prior estimate to confirm by injection test. Stored water is treated and injected over the following days; storage fields must be drawn down before the next storm to give the same benefit.

Table 7. Storage capacity and simulated fill

Unit	Size	Capacity (m ³)	Peak (m ³)	End (m ³)	Peak fill
Forebay + separator	10 × 10 × 2 m buried	200	199	199	100%
Storage field SF-1 (PP)	PP module field 42 × 25 x approx. 4 m	4,000	3,408	3,408	85%
Storage field SF-2 (PP)	PP module field 42 × 25 x approx. 4 m	4,000	3,385	3,385	85%
Filter feed chamber	1 × 2.5 × 2 m in filter skid	5	5	5	96%
Clean tank	25 × 10 × 4 m buried	1,000	25	25	3%
Total plant storage		9,205		7,022	

Source: FloodAstra 2D/1D model, 107 mm 3 h design storm with 3 h recession, run 18 Oct 2026 (results at 3.25 h from rain start; provisional)

Table 8. Event water balance, design storm

Account	Volume (m ³)	Volume (litres)
Rain on 600 m × 600 m model area (107 mm)	38,520	38,520,000
Water taken off the ground by the 7 pond inlets and 7 street pits	7,366	7,366,394
Accepted into the plant (forebay)	7,360	7,360,335
of which held in forebay + storage fields + clean tank at end	7,022	7,021,682
of which filtered (treated)	364	363,654
of which pumped to injection wells	339	338,654
of which entered the deep aquifer through screens	330	330,242
Recharge trenches RT-1–4 (estimate, not simulated)	1,190	1,190,000
Electricity: inlet booster	17.8 kWh	
Electricity: treatment pumps / injection booster	5.0 / 10.8 kWh	

Rain is the full design storm; all other rows are at 3.25 h from rain start. One crore litres = 10,000 m³. The recharge-trench row is a hand-calculation estimate and is not part of the simulated balance.

Source: FloodAstra 2D/1D model, 107 mm 3 h design storm with 3 h recession, run 18 Oct 2026 (results at 3.25 h from rain start; provisional)

6 Results – 30-minute burst

The 30-minute burst was simulated with an earlier layout that used deep concrete cells of the same storage volume (8,000 m³) as the proposed storage fields. Its results are reported as a sensitivity test of storage volume and intake capacity, not as the performance of the proposed layout.

Provisional. The burst simulation had reached 0.60 h of 3 h at the time of issue; values are interim.

In the burst the ground area deeper than 0.15 m changes from 8,118 m² without works to 7,127 m² with the scheme, and the maximum depth from 0.79 m to 0.73 m. The peak inflow to the plant is 0.57 m³/s. In this event the peak grate inflow (about 0.57 m³/s) stays below the forebay-to-storage link capacity (about 1.10 m³/s); in more intense rain, short peaks above this capacity are buffered by the 200 m³ forebay and the sump, and once these are full the inlets throttle and the surplus remains on the ground until capacity frees up.

Table 9. Flooding before and after works, 30-minute burst

Measure	Before	After	Change
Ground area with peak depth > 0.15 m (m ²)	8,118	7,127	–991 (–12%)
Maximum depth on the ground (m)	0.79	0.73	–0.07 (–8%)
Water above 0.15 m on the ground at 0.58 h from rain start (m ³)	1,869	1,377	–492 (–26%)
Model area with peak depth > 0.15 m (m ²)	96,336	95,032	–1,304 (–1%)
Water above 0.15 m in the model area at 0.58 h from rain start (m ³)	17,861	17,315	–546 (–3%)
Peak depth at the plant site (m)	0.64	0.58	–0.07 (–11%)

Source: FloodAstra 2D/1D model, 100 mm in 30 min burst, 3 h simulated (simulated to 0.60 h; provisional)

Table 10. Plant response, 30-minute burst

Plant account	Value	Plant account	Value
Water taken into the plant (m ³)	717	Pumped to injection wells (m ³)	0
Held in plant storage at end (m ³)	714	Entered the deep aquifer (m ³)	0
Filtered (m ³)	24	Peak inflow to the plant (m ³ /s)	0.57

Source: FloodAstra 2D/1D model, 100 mm in 30 min burst, 3 h simulated (simulated to 0.60 h; provisional)

7 Ground use during Ramlila

The scheme is designed so that Ramlila and daily use continue. About 70% of the ground lies over no structure and is fully usable; most of the remainder lies over the buried storage fields, tanks and plant room, which carry crowds, a stage and light vehicles. Only the flush grates, hatches and wellhead vaults must be kept clear for access, and only the edge kiosk is permanently unusable (Table 11; zoning plan on drawing FA-RL-01).

Table 11. Surface use of Ram Lila Ground with the scheme in place

Surface zone	Area (m ²)	Share	Permitted use
A Permanently unusable	30	0.2%	Edge kiosk, gallery entry stair and hatch, vent stacks
B Keep clear - no fixed structures	1,058	8.3%	Access and desilting hatches and risers with 3 m apron, wellhead vaults, maintenance route from the road
C Load-limited use	2,508	19.6%	Over storage fields, tanks, plant room and gallery: crowds, stage, light vehicles; no heavy cranes, piling or deep tent pegs
D Recharge trench strips	236	1.9%	Walkable turf; no vehicles
E Fully usable	8,938	70.0%	Open ground, no restriction
Total	12,769	100%	

Source: Drawing FA-RL-01, surface-use zoning (areas from drawn geometry). Areas within the provisional boundary; to be confirmed against a cadastral survey.

For the Ramlila season the following practical rules apply: locate the stage and any effigy-burning area on fully usable open ground away from hatches and vents; do not drive tent pegs deeper than 0.3 m over the recharge trenches or buried units; keep the access route from the road to the kiosk and hatches clear; and do not bring cranes or heavy vehicles over the buried units.

8 Street capture, pumping and instrumentation

Seven street pits capture water from the flooded street pockets around the ground and pump it to the forebay. In the simulation the street pits supplied 4,207 m³ and the pond inlets 3,160 m³ to 3.25 h from rain start. Table 12 gives the flow through each grate; the pumps and rising mains in Tables 13 and 14 are sized from these flows. Design flow = 1.25 x simulated 5-min peak per grate (intake allocated by the model opening law). Mains at up to 1.8 m/s, Hazen-Williams C = 140, routes along road corridors (least-cost path on the 1 m grid avoiding buildings), static lift 2.5 m. Costs are concept estimates (INR lakh, +/-30 %, excl. GST).

Table 12. Simulated flow through each grate (5-min peak and volume)

Grate	Peak (m ³ /s)	Volume (m ³)	Share
P1 pond (main)	0.070	436	6%
P2 pond	0.072	495	7%
P3 pond	0.069	526	7%
P4 pond	0.066	449	6%
P5 pond	0.064	477	6%
P6 pond	0.063	409	6%
P7 pond	0.059	368	5%
S1 NW street pocket	0.109	773	10%
S2 NW street pocket	0.086	593	8%
S3 NW street pocket	0.058	295	4%
S4 NE pocket	0.105	778	11%
S5 E pocket	0.073	610	8%
S6 NE near pocket	0.057	472	6%
S7 S pocket	0.105	686	9%

Source: FloodAstra 2D/1D model, 107 mm 3 h design storm with 3 h recession, run 18 Oct 2026 (results at 3.25 h from rain start; provisional); intake allocated to grates by the model opening law

Table 13. Pump schedule

Tag	Duty	Units	Rating	Power
SP-1	Street pit, NW street pocket	1 duty + 1 standby submersible	0.14 m ³ /s at 6 m	12 kW
SP-2	Street pit, NW street pocket	1 duty + 1 standby submersible	0.11 m ³ /s at 6 m	10 kW
SP-3	Street pit, NW street pocket	1 duty + 1 standby submersible	0.08 m ³ /s at 8 m	9 kW
SP-4	Street pit, NE pocket	1 duty + 1 standby submersible	0.14 m ³ /s at 5 m	10 kW
SP-5	Street pit, E pocket	1 duty + 1 standby submersible	0.10 m ³ /s at 5 m	8 kW
SP-6	Street pit, NE near pocket	1 duty + 1 standby submersible	0.08 m ³ /s at 4 m	5 kW
SP-7	Street pit, S pocket	1 duty + 1 standby submersible	0.14 m ³ /s at 5 m	11 kW
PM-1	Intake booster at collector sump	2 duty + 1 standby	1.04 m ³ /s at 3 m (1.2 m ³ /s free)	52 kW limit
TP-1,2	Treatment pumps, storage fields to filter	2 duty	2 × 25 L/s at 12 m	2 × 3 kW
IB-1	Injection booster, clean tank to wells	1 duty + 1 standby	100 L/s at 10 m	15 kW

Source: Sized from the simulated flows

Table 14. Rising mains along road corridors (drawing FA-RL-06)

Tag	From	To	Pipe	Length	Flow	Friction
RM-2	SP-2	SP-1	DN355 HDPE PE100	96 m	0.11 m ³ /s	0.5 m
RM-3	SP-3	SP-1	DN315 HDPE PE100	342 m	0.08 m ³ /s	1.9 m
RM-NW	SP-1 (NW hub)	Forebay FB-1	DN560 HDPE PE100	481 m	0.33 m ³ /s	2.2 m
RM-4	SP-4	Forebay FB-1	DN400 HDPE PE100	311 m	0.14 m ³ /s	1.5 m
RM-5	SP-5	Forebay FB-1	DN315 HDPE PE100	179 m	0.10 m ³ /s	1.5 m
RM-6	SP-6	Forebay FB-1	DN315 HDPE PE100	132 m	0.08 m ³ /s	0.7 m
RM-7	SP-7	Forebay FB-1	DN400 HDPE PE100	362 m	0.14 m ³ /s	1.7 m
OF-1	Overflow chamber OC-1 (weir 215.94, flap gate FG-1)	MCG trunk storm drain (to confirm)	DN800 RCC NP3, gravity	45 m	1.04 m ³ /s	gravity

Source: Hazen-Williams, C = 140

8.1 Instrumentation and control

A PLC in the edge kiosk runs the scheme and sends data to an MCG dashboard. Table 15 lists the instruments. The control interlocks are:

- Design assumption: downstream drains are full during the storm, so flap gate FG-1 on overflow OF-1 stays closed and no water leaves the plant (as simulated). When SF-1 and SF-2 reach top level (215.94) the street-pit and intake pumps stop. FG-1 stops trunk-drain water backing into the plant; OF-1 relieves the plant only after the trunk drain recedes.
- No injection unless filter outlet turbidity < 5 NTU and well head below the set limit.
- All pumps stop at low level (dry-run protection); check valves on every rising main prevent backflow to the street.
- Duty/standby rotation each storm; standby starts on duty-pump fault.

Table 15. Instrumentation schedule

Tag	Instrument	Location	Qty	Function
LT	Radar level transmitter	Each street pit, sump, forebay, SF-1, SF-2, filter feed, clean tank	13	Pump start/stop, high-level alarm, storage-full inlet shut
FT	Electromagnetic flow meter	DN700 main, each rising main, filter outlet, each well feed	13	Water balance; volume captured and injected per storm
AT-T	Turbidity analyser	Filter inlet and outlet	2	Injection stop if outlet > 5 NTU
AT-C	Conductivity / EC analyser	Filter outlet	1	Water-quality record before injection
PT	Pressure transducer (vented)	Each injection well and each observation well	6	Injection head and aquifer response; injection cut-back on high head
RG	Tipping-bucket rain gauge	Edge kiosk roof	1	Storm start; pumps on standby ahead of ponding
PLC	PLC with 4G/fibre telemetry	Edge kiosk	1	Interlocks, alarms, MCG dashboard
CCTV	Camera at grates and kiosk	Pond and each street pit	8	Blockage and safety checks

Table 16. Street-capture add-on cost (concept, $\pm 30\%$, excluding GST)

Item	Quantity	INR lakh
Street pits SP-1–7 (precast, grate, silt trap, valve chamber)	7 no.	42
Submersible pump sets, 1 duty + 1 standby per pit, with panels	14 no.	56
HDPE rising mains DN200-DN560, laid in road incl. reinstatement	1,903 m	285
Intake upgrade: DN700 main, 52 kW booster set (in place of DN500 / 26 kW)	lump sum	45
Overflow chamber OC-1 with DN800 flap gate FG-1 and outfall to trunk drain	45 m	26
Instrumentation, PLC, telemetry and CCTV	lump sum	55
Total street-capture add-on		510

Source: Concept estimate; to be replaced by a priced BOQ

9 Construction materials and cost drivers

Bulk storage is in polypropylene (PP) column-and-deck modules rather than buried reinforced concrete. The modules are about 95% void, so almost the whole excavated volume stores water; they are chemically inert, are delivered as light units that are assembled by hand and installed quickly, and their cost per cubic metre of storage is typically lower than that of buried reinforced concrete. Their limits are a practical depth of about 4–6 m and the need to keep silt out, because modules cannot be desilted in the way an open concrete chamber can. The scheme therefore catches silt upstream in the forebay and the hydrodynamic separator at the forebay, which are the only concrete units that need desilting, and stores only pre-settled water in the two storage fields. The storage fields are wrapped in geomembrane, covered by at least 0.8 m of soil and turf, and rated for crowd loading.

Table 17 lists the construction type of each unit and the quantity that drives its cost; the scheme will be priced in a bill of quantities (BOQ) against the Haryana PWD Schedule of Rates.

Table 17. Construction materials and cost drivers

Unit	Construction type	Cost-driving quantity
Forebay	Precast RCC, desiltable; 10 × 10 × 2 m	RCC volume, excavation: to BOQ
Hydrodynamic separator	Precast RCC chamber at the forebay, desiltable	Unit rated for the main (1.04 m ³ /s): to BOQ
Storage fields SF-1, SF-2	PP column-and-deck modules, 42 × 25 × 4 m each, geomembrane-wrapped, 0.8 m minimum cover	Modules approx. 8,420 m ³ gross; geomembrane approx. 5,270 m ² ; excavation approx. 10,710 m ³
Clean tank	PP column-and-deck modules, 25 × 10 × 4 m, geomembrane-wrapped	Modules approx. 1,050 m ³ gross; geomembrane approx. 780 m ²
Plant room	Precast RCC box, buried	RCC volume, excavation: to BOQ
Inspection gallery	2.4 m corrugated HDPE pipe, walk-through	Pipe length: to BOQ
Pond inlets, sump, main	Flush heel-proof gratings; precast sump; DN500 PE100 or DI main	Numbers and length: to BOQ
Injection and observation wells	Cased deep wells, screens at depth; flush lockable vaults	Drilling depth (about 150 m per well): to BOQ
Recharge trenches (4)	Geotextile-wrapped gravel with gravel-filled shafts	Gravel 720 m ³ ; geotextile, shafts: to BOQ

Quantities are approximate, from the design geometry with a 95% module void ratio, 0.8 m cover and a 0.3 m bedding layer; all other quantities to BOQ (Haryana PWD Schedule of Rates).

Source: Design geometry; drawings FA-RL-01 and FA-RL-02.

Because the storage fields are shallower than a deep concrete cell, the head available to fill them from the forebay is smaller and filling late in the event is slightly slower. The design-storm simulation of this layout checks the filling rate.

10 Cost plan (concept stage)

The client's budget target is up to INR 5 crore, excluding GST and overheads, for 1 crore litres (10,000 m³) of storage. Table 18 allocates this target to the elements of the scheme. The cost plan assumes a first phase with two deep injection wells and access risers in place of the walk-in gallery; the storage allowance is the balance of the budget after the other elements. The storage basis is 8,000 m³ in the storage fields plus 1,000 m³ in the clean tank, 9,000 m³ of net module storage (about 9,500 m³ of gross module volume at about 95% void). With the forebay, sump and pipes the plant holds 9,205 m³ (about 0.92 crore litres), and the recharge trenches add about 250 m³. **All figures are concept-stage allowances with an accuracy of about ±30%.** They will be replaced by a bill of quantities priced on the Haryana PWD Schedule of Rates and by vendor quotes.

Table 18. Concept cost plan for 1 crore litres of storage (INR crore)

Item	INR crore	Basis
Two deep injection wells with wellheads; share of injection booster	1.00–1.20	Earlier MCG recharge pilot costing, 2025 Delhi-NCR price basis
Treatment train: 50 L/s filter, pumps, controls, electrical	0.60–0.80	Earlier MCG recharge pilot costing, 2025 Delhi-NCR price basis
Seven pond inlets, laterals, sump, booster, main (DN500 basis)	0.25	Concept allowance
Forebay and hydrodynamic separator, precast	0.30	Concept allowance
Recharge trenches and shafts	0.20	Concept allowance
Access risers and manholes in place of a walk-in gallery	0.10	Concept allowance
Subtotal excluding storage	2.45–2.85	
Polypropylene module storage, 9,000 m ³ net (excavation, geomembrane, modules, backfill)	2.15–2.55	Balance of budget; implied tender target INR 2,389–2,833 per m ³ of net storage installed, to be confirmed by 2–3 vendor quotes
Total works (excluding GST and overheads)	5.00	Client budget target
GST at 18% on works	0.90	
Overheads and contingency (10%, placeholder)	0.50	To client's norm; 10% shown as a placeholder only
Grand total	6.40	

Ranges are concept-stage allowances (±30%). GST is applied to the works total; overheads and contingency are to the client's norm, with 10% shown only as a placeholder.

If module quotes exceed the target. The budget can be held by reducing storage to about 5,000–6,000 m³ and adding shallow recharge shafts, so that the water stored plus the water recharged in each event still approaches 1 crore litres.

INR 4 crore variant. About 5,000 m³ of module storage, two deep wells, access risers in place of the gallery and additional recharge shafts. The capture benefit of this variant would be confirmed by simulation before it is adopted.

11 Limitations and next steps

11.1 Limitations

- **Terrain model.** The 1 m terrain model contains obstacles inside the ground that do not exist on site. The simulated pond extent and the before-works flooding are therefore conservative. A rebuilt terrain model without these obstacles is in preparation; the results will be re-run on it.
- **Boundary.** The Ram Lila Ground boundary is a provisional visual boundary from imagery, not a cadastral survey. Utilities, trees, access and setbacks have not been surveyed. The storage-field footprint must be checked against small existing structures on the ground before design.
- **Aquifer.** Aquifer layers and properties are regional estimates, not bore logs. Well acceptance (about 15–20 L/s per well) must be confirmed by a test bore and an injection test before the well design is fixed. The four recharge trenches are sized by hand calculation and were not part of the simulation.
- **Levels.** Levels are on the terrain-model datum. A tie to a surveyed benchmark is outstanding.
- **Water quality.** Injection of treated stormwater into the aquifer requires water-quality testing, a treatment standard and approval by the Central Ground Water Authority and the State authorities.
- **Intake capacity.** With 2 × DN500 forebay-to-storage links the forebay no longer backs up. With seven street pits, intake is limited by the DN700 main and 3 m booster (about 1.04 m³/s). Street pits are simulated as openings into the sump; their pumps and rising mains are sized by calculation (Section ??) and should be simulated explicitly in the next stage. Inlet laterals to the sump are shown schematically; their head losses were not modelled.
- **Treatment rate.** The 50 L/s filter limits the supply to the wells; raising treatment capacity is needed to use the full well capacity. The storage fields must be emptied between storms to give the same benefit in the next event.

11.2 Next steps

1. Complete the design-storm and burst simulations on the rebuilt terrain model and reissue this report.
2. Topographic and utility survey of the ground, tied to a surveyed benchmark; cadastral boundary.
3. Test bore to the receiving aquifer with an injection test; water-quality baseline.
4. Test pumped feeder pits at nearby street pockets with a larger intake main, and higher treatment capacity.
5. Geotechnical investigation for the buried units; structural design of the precast units and module load rating.
6. Consultation with the Ramlila organising committee on stage, access and event layout.

A Drawing register

Table 19. Drawing register

Drawing	Title	Scale (A1)	Rev
FA-RL-01	General arrangement plan, schedule of works and surface-use zoning	1:400	P3
FA-RL-02	Hydraulic long section and typical sections	As shown	P3
FA-RL-03	Peak flood depth before and after works	1:600	P3
FA-RL-04	Water balance, storage capacities and filling timeline	NTS	P3
FA-RL-05	Three-dimensional views of the underground scheme	NTS	P3
FA-RL-06	Street capture pits, rising mains, pumping schedule and instrumentation	1:1500	P3
FA-RL-07	Instrumentation, monitoring and injection control	1:500	P3

All drawings are A1 sheets, Rev P1, dated 18 Oct 2026; status: proposed design, preliminary, not for construction.