

Figure S1. The distribution of irregular river conduits

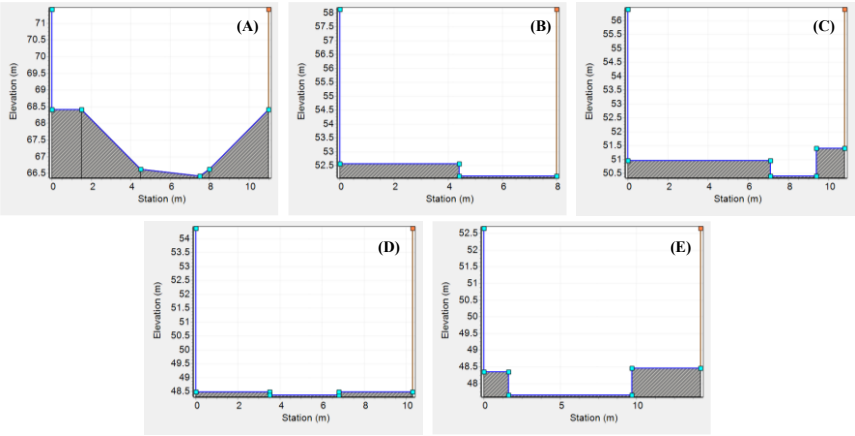


Figure S2. The cross-sectional geometries of irregular river conduits: (A) MGH01, (B) MGH07, (C) MGH08, (D) MGH09, and (E) MGH10

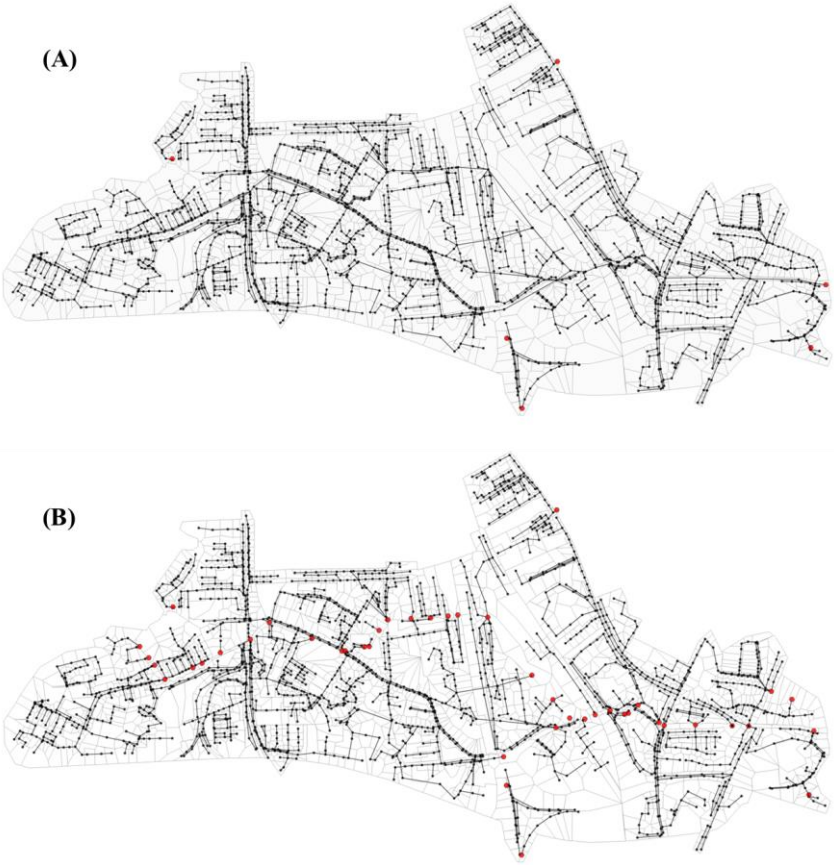


Figure S3. SWMM of the Mugu River Basin coupling storm pipe network and river channels or considering the storm pipe network alone

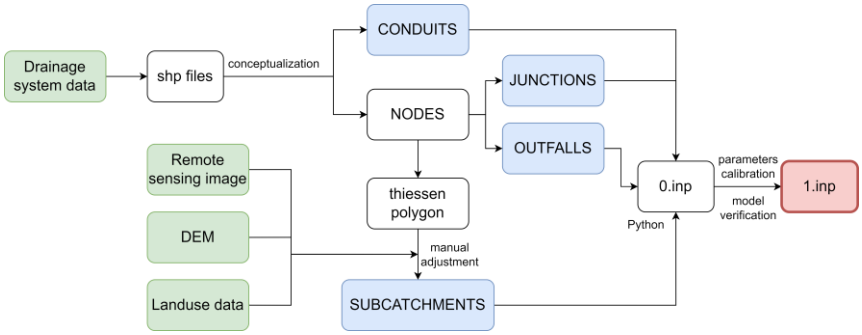


Figure S4. The pipeline of the SWMM construction

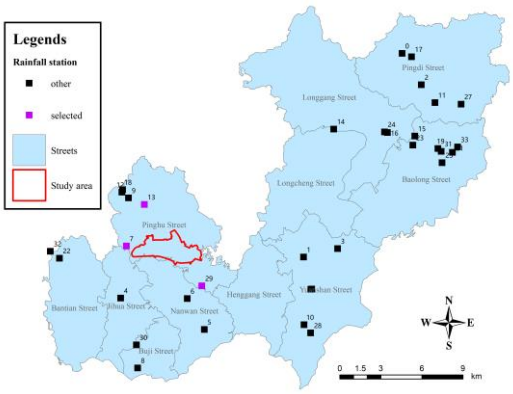


Figure S5. Distribution of rain gauge stations in Longgang District

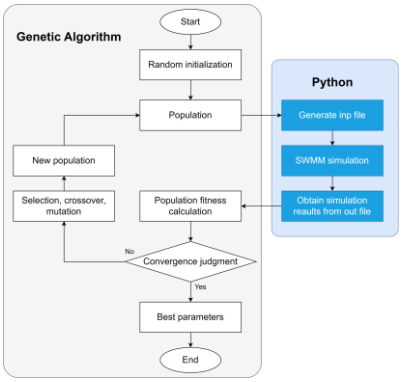


Figure S6. Process of parameter calibration via the genetic algorithm

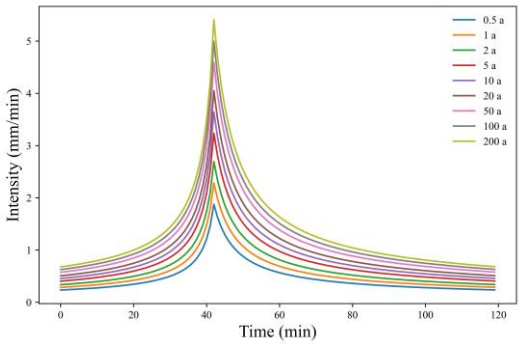


Figure S7. Designed rainfall events at different recurrence periods (duration = 2 h)

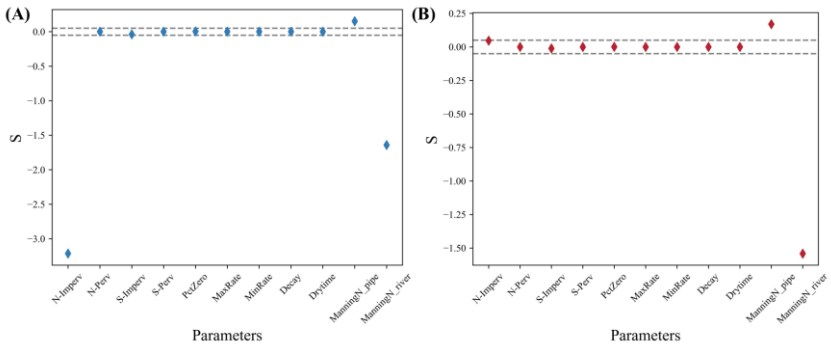


Figure S8. The sensitivity of the variation in the SWMM parameters for the (A) maximum and (B) average flow rates

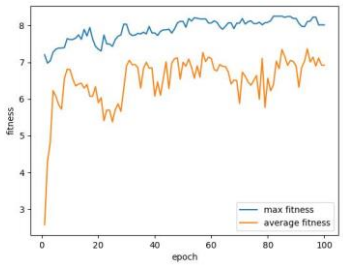


Figure S9. The variations in the maximum and average fitness during the genetic algorithm calculations

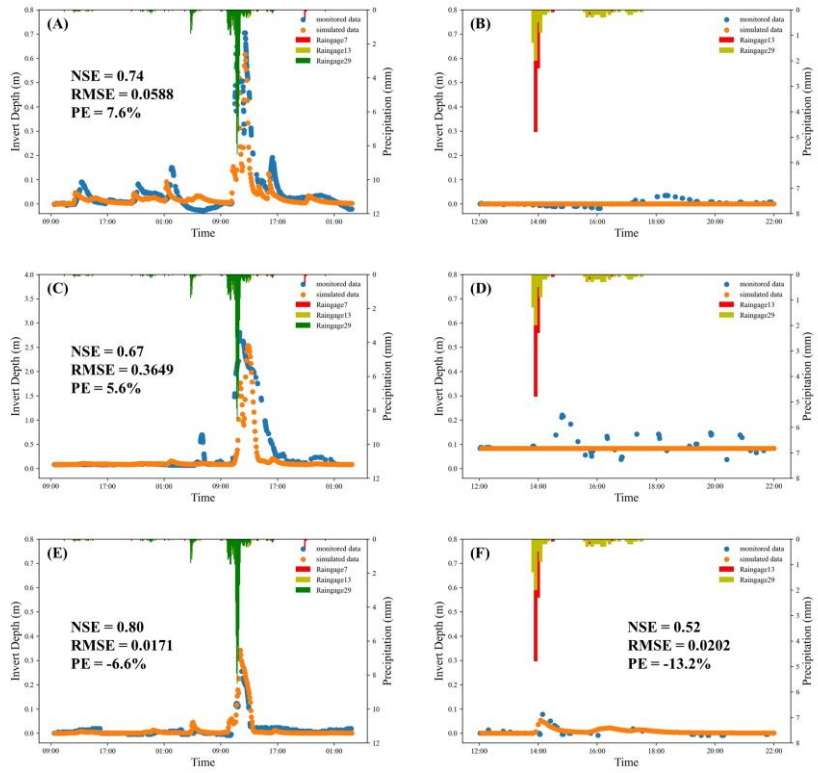


Figure S10. The monitored rainfall and simulated/monitored liquid level at the (A, B) MP1, (C, D) MP2, and (E, F) MP3 points during the (A, C, E) R20240512 and (B, D, F) R20240520 events.

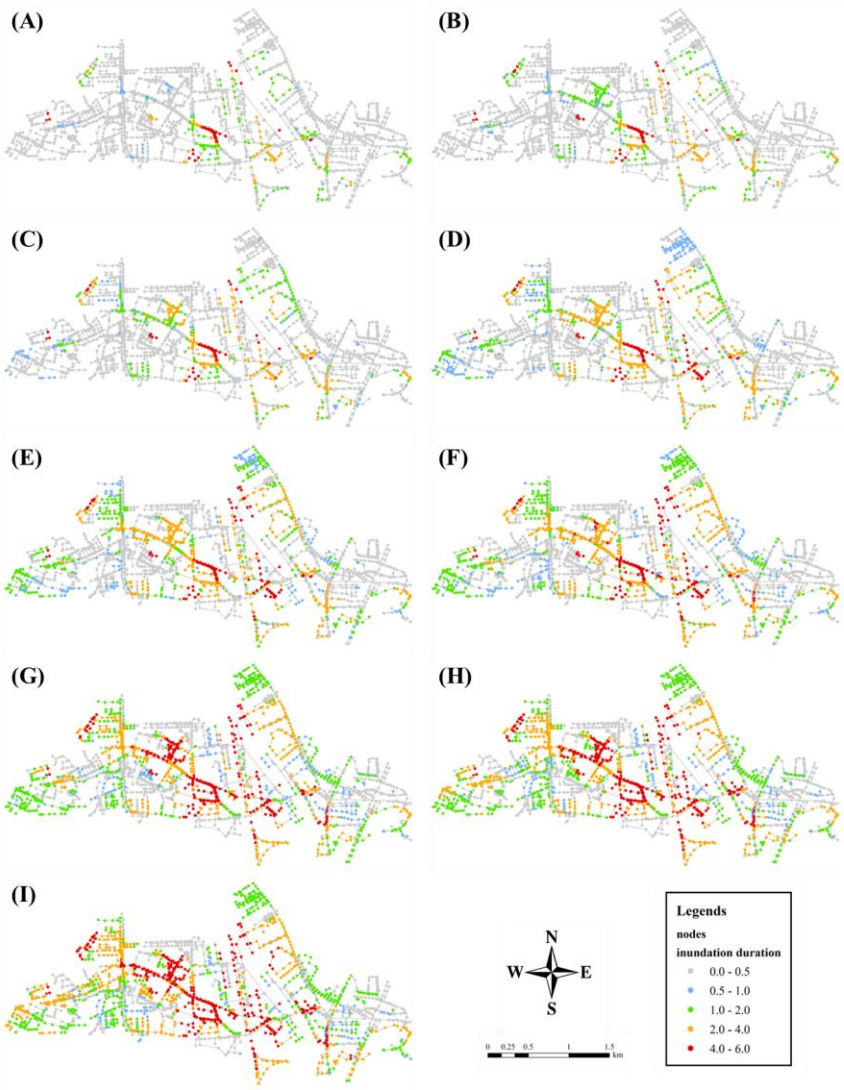


Figure S11. The inundation durations of nodes under the distinct recurrence periods: (A) 0.5-year, (B) 1-year, (C) 2-year, (D) 5-year, (E) 10-year, (F) 20-year, (G) 50-year, (H) 100-year and (I) 200-year (unit: hour)

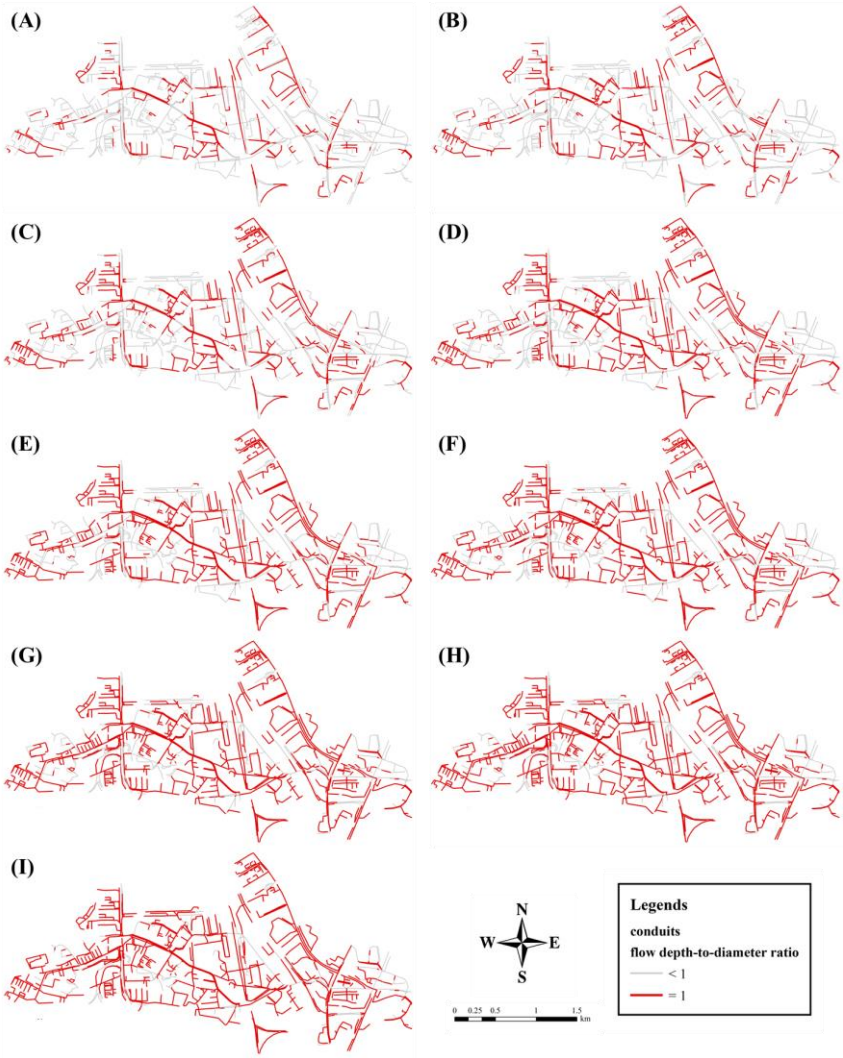


Figure S12. The ~~flow-~~flow-depth-to-diameter ratios of conduits under the distinct recurrence periods: (A) 0.5-year, (B) 1-year, (C) 2-year, (D) 5-year, (E) 10-year, (F) 20-year, (G) 50-year, (H) 100-year and (I) 200-year

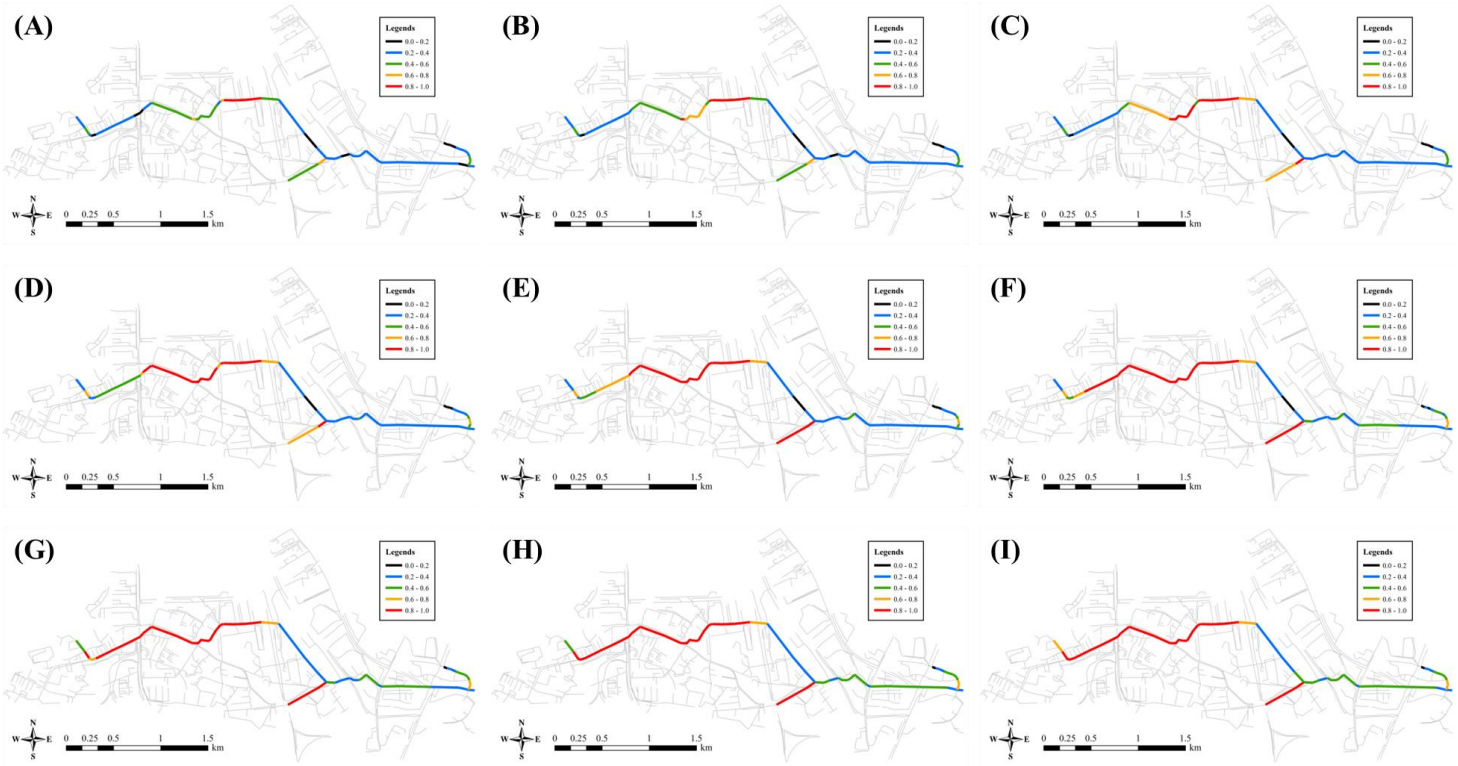


Figure S13. The ~~flow-~~flow-depth-to-diameter ratios of river conduits under distinct recurrence periods: (A) 0.5-year, (B) 1-year, (C) 2-year, (D) 5-year, (E) 10-year, (F) 20-year, (G) 50-year, (H) 100-year and (I) 200 year

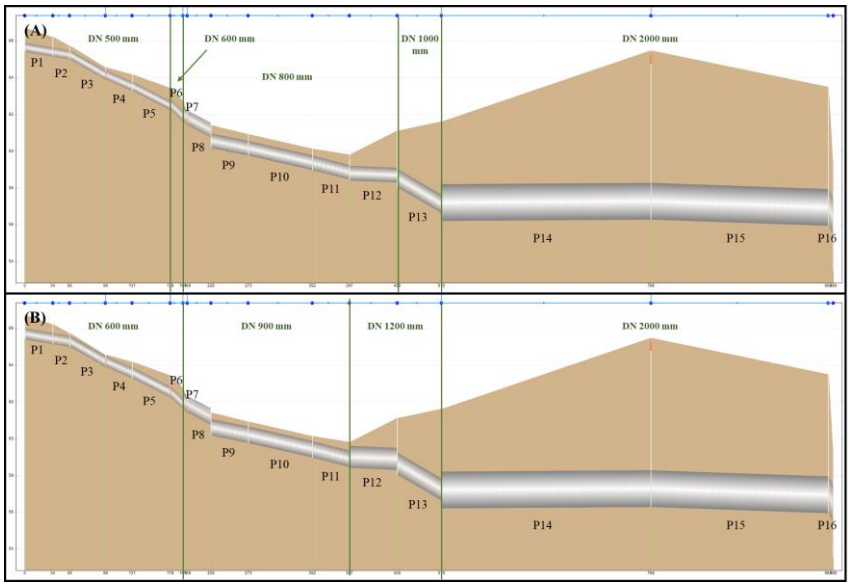


Figure S14. Improved hydraulic profiles of target conduits in zone P1 for Strategy (A) A and (B) B

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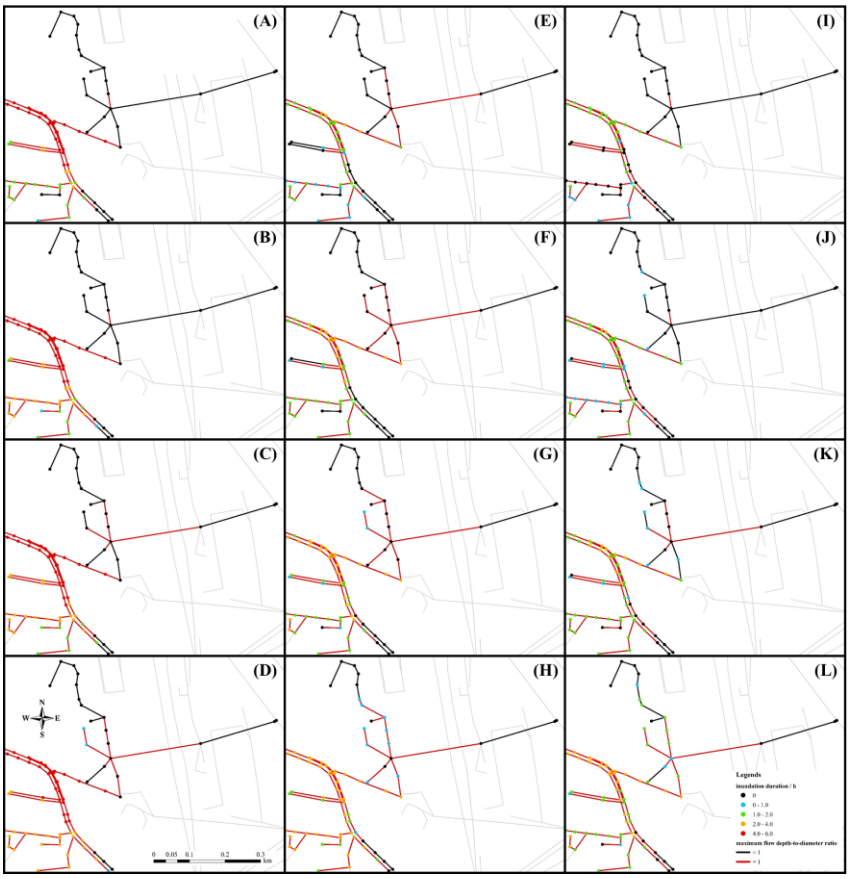


Figure S15. The inundation durations of selected nodes and the maximum ~~flow-~~flow-depth-to-diameter ratio of selected conduits (A–D) without improvement or after improvement by Strategies A (E–H) and B (I–L) under the distinct recurrence periods: 0.5-year (A, E, I), 1-year (B, F, J), 2-year (C, G, K), and 5-year (D, H, L)

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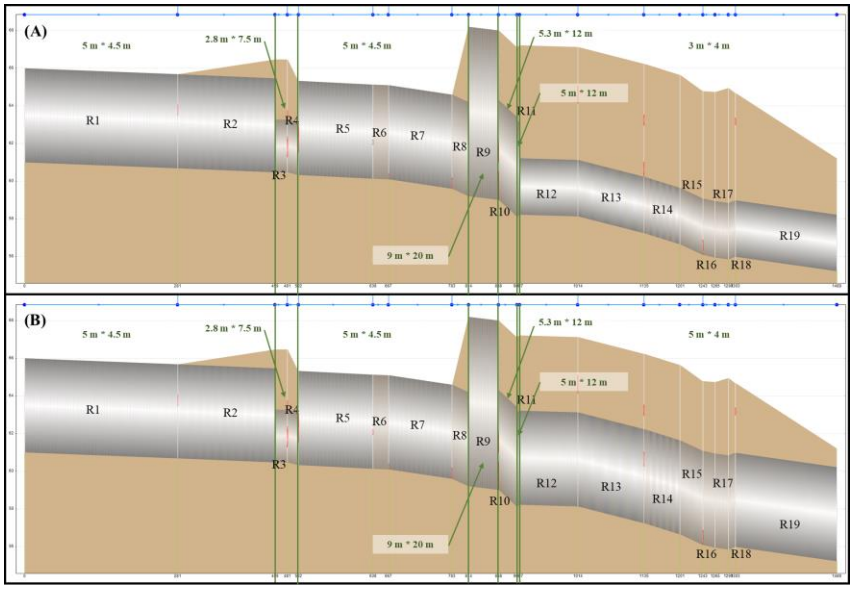


Figure S16. Improved hydraulic profiles of target river conduits in zone R for Strategy (A) C and (B) D

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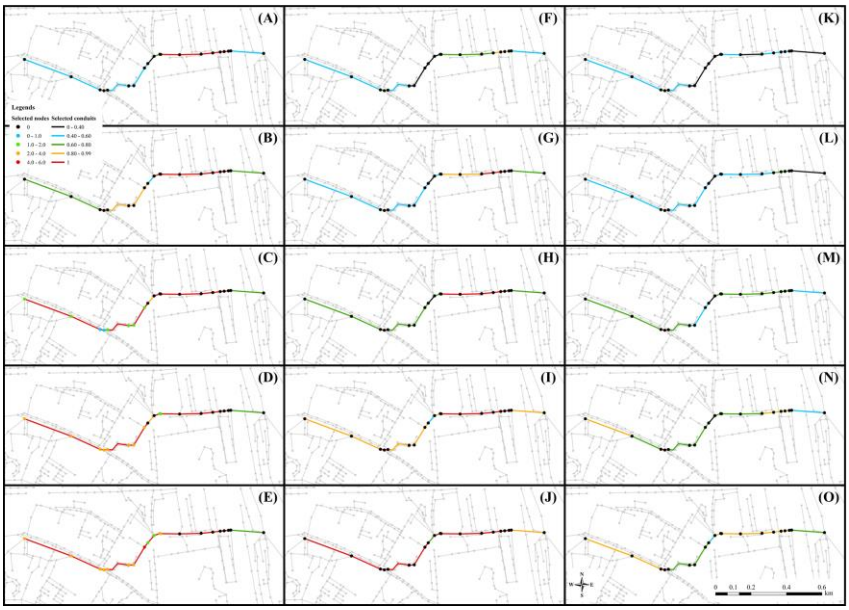


Figure S17. The inundation durations of selected nodes (river) and the maximum ~~flow-~~ flow-depth-to-diameter ratio of selected conduits (river) without improvement (A–E) or after improvement by Strategies C (F–J) and D (K–O) under the distinct recurrence periods: 0.5-year (A, F, K), 2-year (B, G, L), 10-year (C, H, M), 50-year (D, I, N), and 200-year (E, J, O)

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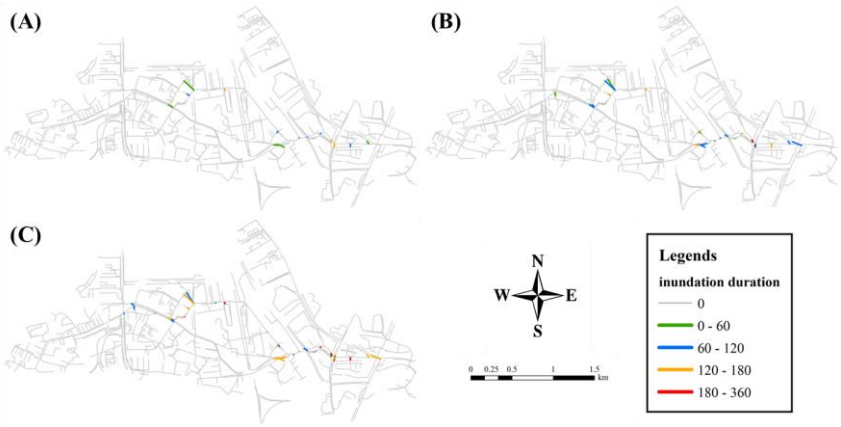


Figure S18. The inundation durations of storm pipes that discharged into the Mugu River under the distinct recurrence periods after improvement via Strategy C: (A) 0.5-year, (B) 10-year, and (C) 50-year (unit: min)

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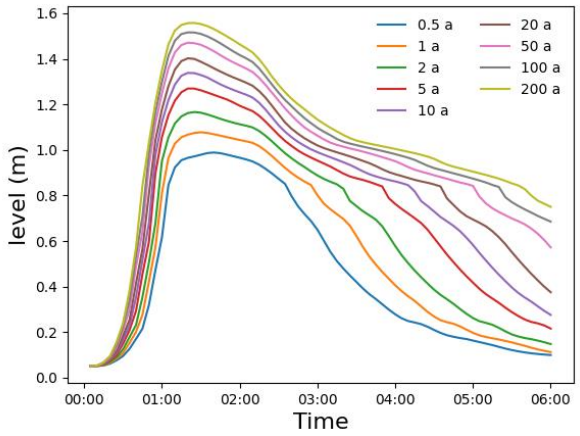


Figure S19. The variation in the flow depth at the Mugu River outlet under distinct recurrence periods

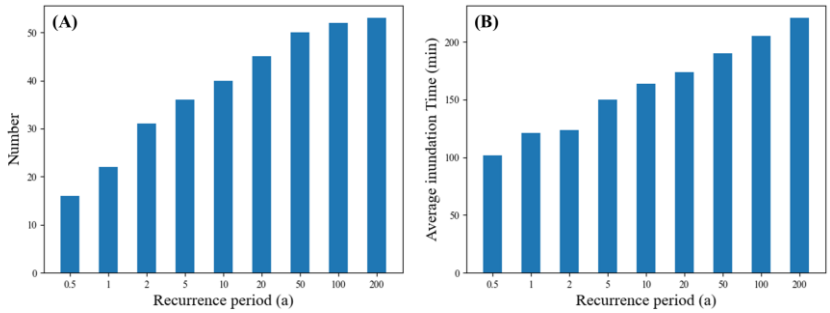


Figure S20. The variation in the inundation number and average inundation duration of conduits along the river under distinct recurrence periods

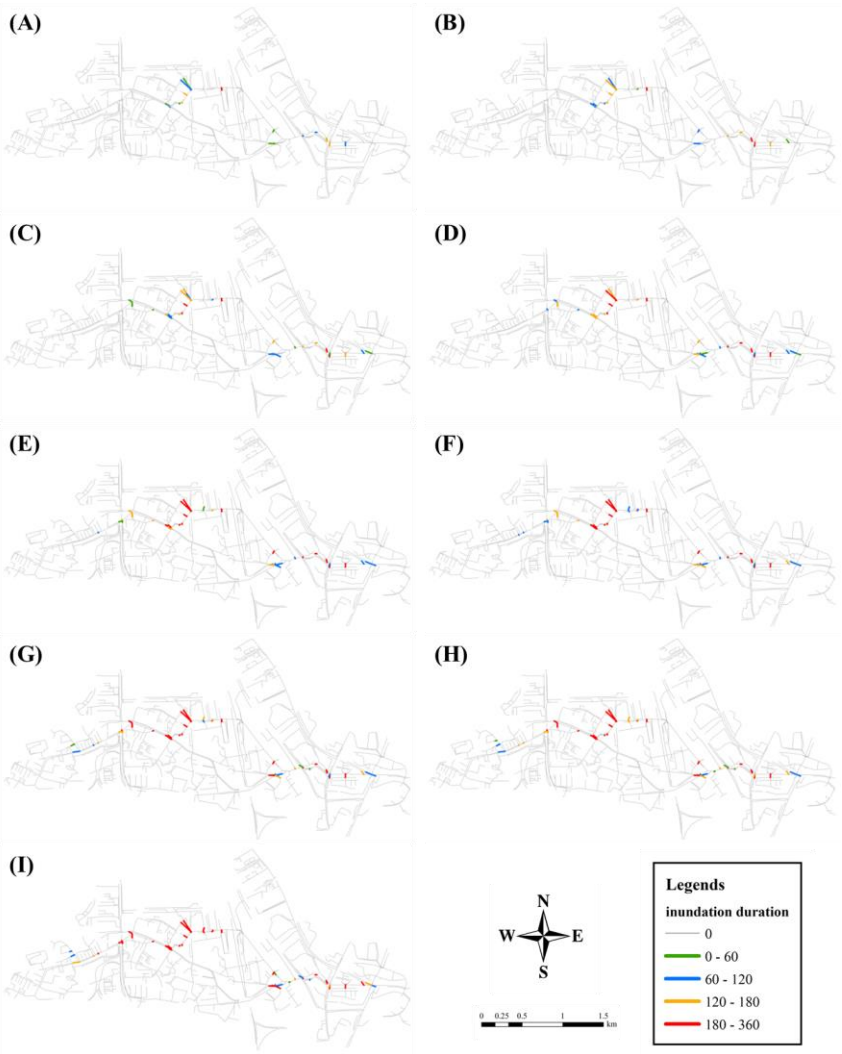


Figure S21. The inundation durations of storm pipes that discharged into the Mugu River under distinct recurrence periods: (A) 0.5-year, (B) 1-year, (C) 2-year, (D) 5-year, (E) 10-year, (F) 20-year, (G) 50-year, (H) 100-year and (I) 200 year (unit: min)

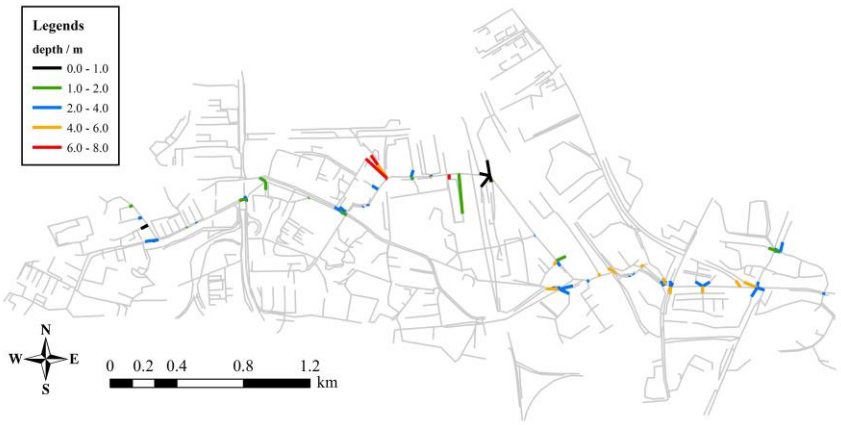


Figure S22. The buried depth of storm pipe outlets that discharged into the Mugu River

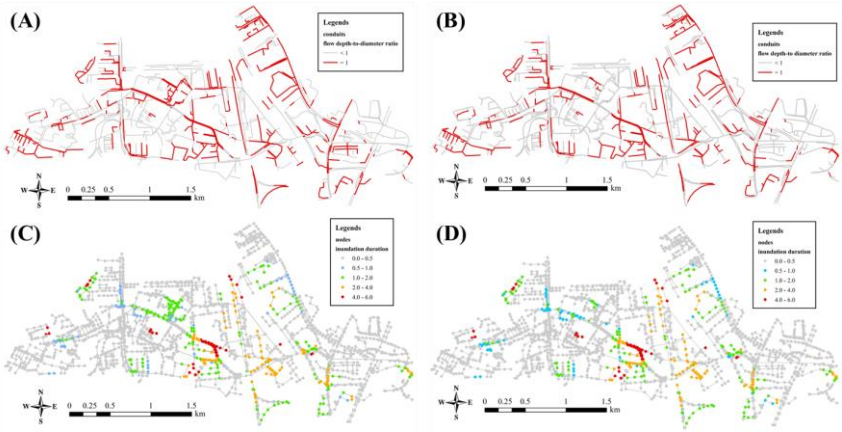


Figure S23. The (A, B) ~~flow-~~flow-depth-to-diameter ratio of conduits and (C, D) inundation durations of nodes (unit: hour) under a 1-year rainfall event. A and C considered both storm pipe network and river channels while B and D considered storm pipe network alone.

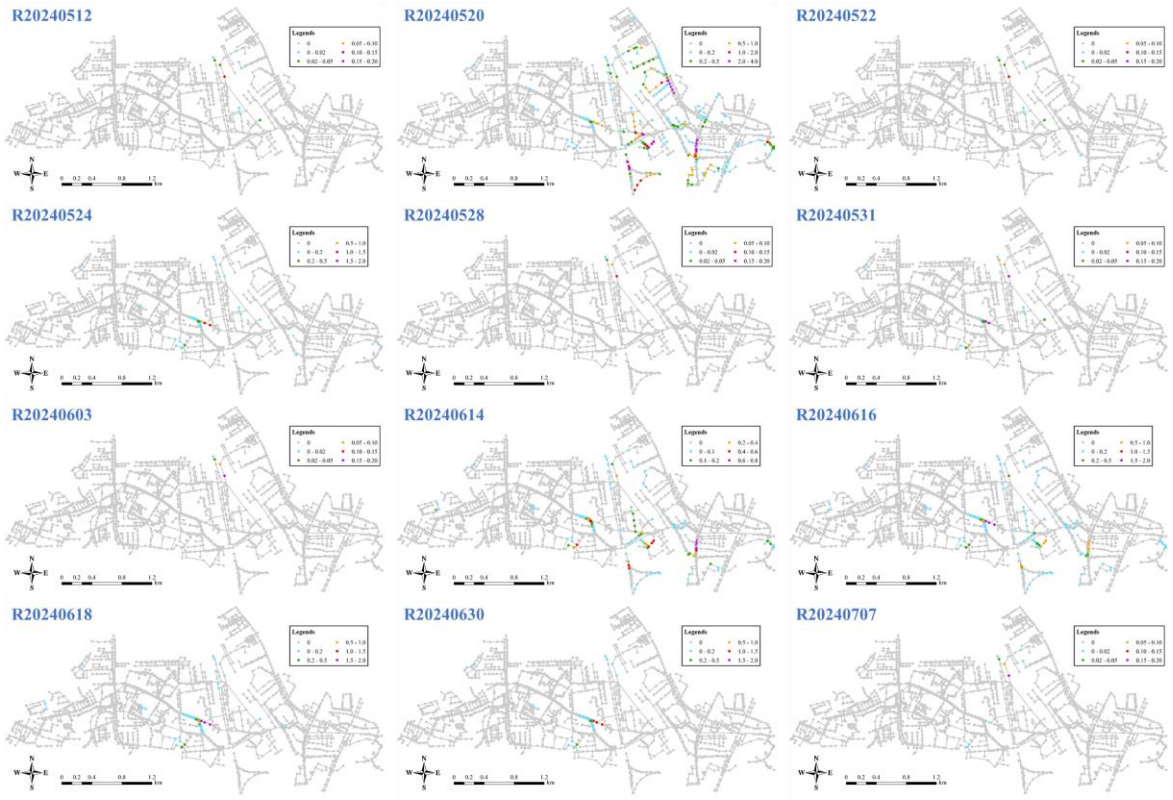


Figure S24. Spatial distributions of the *NCIV* ($\times 10^3$ m^3) under the distinct actual rainfall events

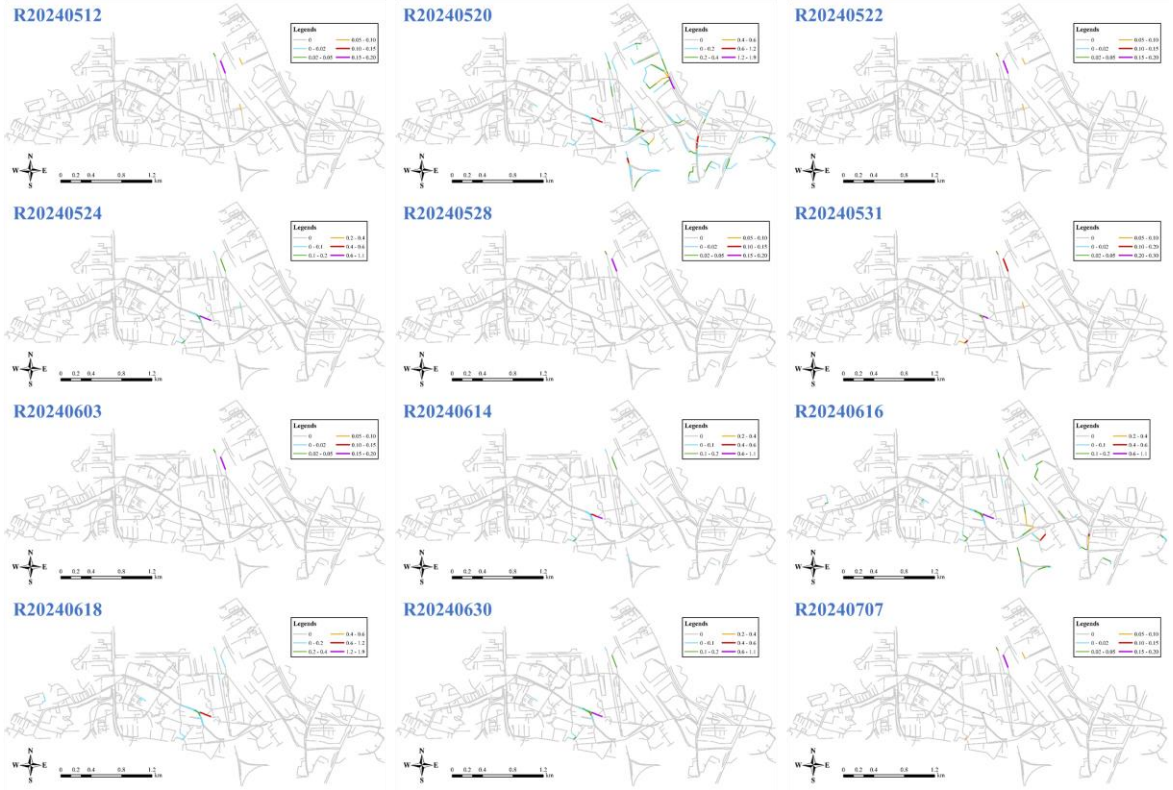


Figure S25. Spatial distributions of the *CCIL* (km) under the distinct actual rainfall events

Table S1. Detailed information ~~of~~ about the required data

No.	Data type	Subitem	Spatial/temporal resolutions	Source
1	Stormwater drainage pipe networks data	Diameters, lengths, elevations, and coordinates of pipes, the elevations, depth and coordinates of manholes	-	Prospecting
2	Mugu river data	channel cross-sections, elevation, and length	-	Prospecting
3	DEM	-	7.5 m	Prospecting
4	Remote sensing image	-	1.0 m	Open-source databases
5	Precipitation series data	-	5.0 min	Recorded by rain-gauge stations
6	Liquid-level series data	-	1.0 min	Recorded by ultrasonic devices or radar detectors
7	Land-use data	-	1.0 m	Treated from remote sensing image via supervised learning

Table S2. Information about twelve rainfall events

No.	Rain	Max rainfall intensity (mm/min)			Total precipitation (mm)			Duration (h)	Dry Time (d)	Calibration /Verification
		Rain-gauge 7	Rain-gauge 13	Rain-gauge 29	Rain-gauge 7	Rain-gauge 13	Rain-gauge 29			
1	R20240512	0	0.96	0.40	0	10.8	8.5	10	3	Verification
2	R20240520	0.68	1.54	1.70	16.2	53.3	75.6	42	1	Verification
3	R20240522	0.06	0.84	0.52	0.4	9.4	6.4	4	1	Calibration
4	R20240524	0.44	0.30	0.46	17.9	21.9	22.8	9	1	Calibration
5	R20240528	0.06	0.20	0	1.4	12.1	0	5	2	Calibration
6	R20240531	0.24	0.36	0	11.8	32.1	0	36	2	Calibration
7	R20240603	0.04	0.12	0	1.8	14.3	0	10	2	Calibration
8	R20240614	0.36	0.68	0.62	11	14.8	22.8	16	4	Calibration
9	R20240616	0.56	0.82	1.00	29.2	40.2	53.3	18	1	Calibration
10	R20240618	0.54	0.06	0.48	23.2	1	4.8	9	1	Calibration
11	R20240630	0.38	0.48	0	15	12.4	0	7	2	Calibration
12	R20240707	0.24	0.58	0	2.3	19	0	10	4	Calibration

Table S3. Summary of the average node inundation durations and node inundation volumes under distinct recurrence periods

Recurrence period	Average node inundation duration (h)					Average node inundation volume (m^3)				
	Without improvement	After Strategy A	After Strategy B	After Strategy C	After Strategy D	Without improvement	After Strategy A	After Strategy B	After Strategy C	After Strategy D
0.5-year	0.32	0.25	0.24	0.25	0.25	10.02	8.88	8.55	8.98	8.98
1-year	0.46	0.39	0.37	0.37	0.37	16.99	15.67	15.25	15.37	15.36
2-year	0.63	0.56	0.54	0.52	0.52	27.07	25.65	25.12	24.48	24.48
5-year	0.9	0.82	0.8	0.77	0.77	44.57	42.8	42.22	40.03	39.97
10-year	1.12	1.04	1.02	0.97	0.97	61.26	59.2	58.55	54.34	54.15
20-year	1.33	1.25	1.23	1.17	1.16	79.78	77.49	76.79	70.36	70.05
50-year	1.62	1.53	1.51	1.41	1.4	107.81	105.09	104.27	93.72	93.11
100-year	1.84	1.76	1.73	1.59	1.57	131.35	128.31	127.41	112.64	111.78
200-year	2.07	1.99	1.96	1.75	1.73	156.71	153.3	152.34	132.92	131.41

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Table S4. Cost table of the unit length pipe network under different pipe diameters and buried depths (unit: CNY/100 m)

D (mm) \ H (m)	2.5	3.5	4.5	5.5	6.5
600	111680	224875	287927	—	—
800	136649	253441	317631	—	—
1000	169467	288285	357385	—	—
1200	204089	325282	394450	—	—
2000	—	586786	674014	814452	—
2700	—	—	969717	994242	1239690

Note:

(1) D and H represent pipe diameters and average buried depth, respectively.

(2) Data was derived from "Research Institute of Standards and Norms Ministry of Housing and Urban-Rural Development. Volume 4: Drainage engineering. In *Investment Estimation Index for Municipal Engineering*; Beijing: China Planning Press, 2007; ISBN 978-7-80242-076-2. ~~*Investment Estimation Index for Municipal Engineering, Volume 4, Drainage Engineering [M]. Beijing: China Planning Press, 2007 (HGZ 47-104-2007)*~~".

Table S5. Estimated costs for Strategies A and B

Pipe	Average buried depth (m)	Origin diameters (mm)	Length (m)	Strategy A			Strategy B		
				Improved diameters (mm)	Unit cost (CNY/100 m)	Cost (CNY)	Improved diameters (mm)	Unit cost (CNY/100 m)	Cost (CNY)
P1	1.2	500	34.15	—	—	—	600	111680	38144.19
P2	0.915	500	20.78	—	—	—	600	111680	23211.57
P3	0.71	500	43.75	—	—	—	600	111680	48862.12
P4	0.785	500	32.64	—	—	—	600	111680	36447.1
P5	1.055	500	46.55	—	—	—	600	111680	51991.51
P6	1.18	600	15.34	—	—	—	—	—	—
P7	0.925	400	29.09	800	136649	39756.93	900	169467	49305.07
P8	0.98	400	29.09	800	136649	39756.93	900	169467	49305.07
P9	1.22	400	45.66	800	136649	62393.11	900	169467	77377.62
P10	1.18	400	78.45	800	136649	107197.45	900	169467	132942.3
P11	1.295	400	45.34	800	136649	61960.07	900	169467	76840.57
P12	2.25	800	58.4	—	—	—	1200	204089	119182.7
P13	4.25	1000	54.05	—	—	—	1200	394450	213212.9
P14	7.305	2000	256.26	—	—	—	—	—	—
P15	8.38	1000	217	2000	814452	1767380.4	2000	814452	1767380.4
P16	6.78	1000	6.04	2000	814452	49227.92	2000	814452	49227.92
Sum						2127672.81			2733430.93

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