Table S1 Scheme I model update specification

Implement	Engineering Parameters
Underground storage reservoir	With a length of 620 m, a width of 500 m, a depth of 10 m, and a bottom elevation of 13 m, it is connected to the Shawan River in front of the Shawan Gate.
Underground reservoir inlet tunnel	An overflow weir is installed at the tunnel inlet to control the activation conditions of the underground reservoir, with the weir crest elevation set at 23 meters.
Newly built tunnel	The tunnel starts upstream of the Shawan Gate and discharges into the Shenzhen River at the northeast corner of the River Estuary. The tunnel operation is controlled by an inlet gate, with a discharge regulation mode set at 120 m^3/s.
Shenzhen reservoir	Opration：29.416m＞$z_{reservoir}$≥28.186m,$q_{dischrge}$=150m^3/s；27.786m＞$z_{reservoir}$≥28.186m,$q_{discharge}$=50 m^3/s

Table S2 Scheme II model update specification

Implement	Engineering Parameters
Newly built Tunnel	The newly built tunnel is located on the left bank of the Shawan River, upstream of the Shawan Gate. It intercepts waters from the Shawan River to the east side of the Yantianshi Street, discharging directly into the sea. A gate is installed at the tunnel inlet, and the operation mode is controlled discharge.

Table S3 Scheme III model update specification

Implement	Engineering Parameters
The Former Shenzhen Reservoir	The area covers approximately 0.44 km^2,with a base elevation of 19.416 m. At a water level of 29.416 m,the corresponding storage capacity is 3.1 million m^3.
Newly Built Tunnel	The inlet is located downstream of the Wutongshan River Estuary, and the outlet is situated downstream of the original discharge tunnel. The tunnel operation is controlled by an inlet gate, with a discharge regulation mode set at 120 m^3/s.
Shawan Gate	Free discharge
The Connecting Gate Between the Former Reservoir and the Main Reservoir	The former reservoir and the main reservoir are connected by a five-opening gate. The operation mode is as follows: when the water level in the former reservoir reaches 29.416 m, the connecting gate opens.
Shenzhen Reservoir	Opration：29.416m＞$Z_{reservoir}$≥28.186m,$Q_{dischrge}$=150m^3/s；27.786m＞$Z_{reservoir}$≥28.186m,$Q_{dischrge}$ =50m^3/s.

Table S4 Scheme IV model update specification

Implement	Engineering Parameters
1#Regulating Lake	By deepening the riverbed and widening the channel upstream of the Shawan Gate, an additional 100,000 m^3 of flood regulation capacity has been added to the river channel.
2#Regulating	The area covers 182,800 m^2 with a designed storage capacity of 400,000 m^3.

Lake	The base elevation is 38 m, and the design water level is 42 m. A gate is installed downstream of the left branch of the Jiankeng River to retain water without discharge.
3#Regulating Lake	At the confluence of Shawan River and Dongshen Water Supply Channel (219,800 m^2), series or parallel connection is feasible. A gate on Shawan River downstream of 3# Regulating Lake controls water levels.
4#Regulating Lake	Located along Dongshen Channel near Shuiguan Expressway (173,400 m^2), series or parallel connection is feasible. A gate at Dongshen Channel head (default closed) and another downstream of 4# Regulating Lake control water levels.
Newly built Tunnel	The new built tunnel starts upstream of Shawan Gate and discharges into Shenzhen Reservoir flood discharge channel. Two gates at inlet and outlet control discharge at 120 m^3/s.
The original tunnel	It is only used for regulating initial rainwater and sewage, and the gate is closed during flood events.
Shenzhen Reservoir	Operation：$29.416m > Z_{reservoir} \geq 28.186m, Q_{dischrge}=150m^3/s$；$27.786m > Z_{reservoir} \geq 28.186 m, Q_{dischrge}=50m^3/s$.

Table S5 Scheme I statistical table of the results of each calculation scenario

	Underground Storage Reservoir		Original tunnel		Newly built tunnel		Shawan Gate		Shenzhen Reservoir	
Serial number	Maximum Water Level (m)	Maximum Storage Capacity ($104m^3$)	Maximum Discharge Duration(h)	Discharge Volume ($104\ m^3$)	Maximum Discharge Duration(h)	Discharge Volume($104\ m^3$)	Maximum Water Level in front of the Gate(m)	Gate Operation Status (Open/Close)	Maximum Water Level (m)	Maximum Discharge ($m^3 \cdot s^{-1}$)
1	20.345	227.695	3.18	41.69	3.83	792.53	28.57	close	28.906	
2	19.939	215.109	4.08	48.11	4.68	798.79	28.86	close	28.906	
3	19.846	212.226	4.83	51.93	5.30	801.86	29.25	close	28.906	150
4	18.618	174.158	5.22	53.11	5.55	802.12	29.31	open	29.023	
5	17.181	129.611	5.52	55.07	5.82	804.11	29.31	open	29.107	

Table S6 Scheme II statistical table of the results of each calculation scenario

	Original tunnel		Newly built tunnel		Shawan Gate		Shenzhen Reservoir	
Serial number	Maximum Discharge Duration(h)	Discharge Volume($10^4\ m^3$)	Maximum Discharge Duration(h)	Discharge Volume($10^4\ m^3$)	Maximum Water Level in front of the Gate(m)	Gate Operation Status (Open/Close)	Maximum Water Level (m)	Maximum Discharge ($m^3 \cdot s^{-1}$)
1	2.47	24.10	2.77	1017.83	29.31	Open	28.55	
2	2.30	22.63	2.57	1025.24	29.31	Open	28.55	270
3	2.10	21.27	2.37	1032.08	29.31	Open	28.55	

4	2.23	22.33	2.47	1044.75	29.19	Close	28.48	
5	2.08	21.17	2.30	1046.08	28.99	Close	28.48	
6	1.93	20.07	2.15	1047.35	28.78	Close	28.48	
7	1.78	19.02	2.00	1048.57	28.58	Close	28.48	
8	1.63	18.03	1.87	1049.74	28.38	Close	28.48	

Table S7 Scheme IV statistical table of the details of each calculation scenario

Serial number	4#Regulating lake		3#Regulating lake	
	Connection Method with Dongshen Channel	Maximum Discharge($m^3 \cdot s^{-1}$)	Connection Method with Dongshen Channel and Shawan River	Maximum Discharge($m^3 \cdot s^{-1}$)
1	In Series	10	In Series	30
2				35
3				40
4				45
5				50
6		15		30
7				35
8				40
9				45
10				50
11	In Parallel	10	In Parallel	30
12				35
13				40
14				45
15				50

Table S8 Scheme IV statistical table of the results of each calculation scenario

Serial number	Maximum Flood Regulation Capacity(10^4 m^3)					Newly built tunnel		Shawan Gate
	1#Regulating Lake	2#Regulating Lake	3#Regulating Lake	4#Regulating Lake	Total	Maximum Discharge Duration(H)	Discharge Volume(10^4 m^3)	Maximum Water Level in front of the Gate(m)
1	10.00	37.08	181.05	88.53	316.66	3.37	965.93	27.09
2			172.33	88.53	307.94	3.98	969.50	27.50
3			164.32	88.53	299.93	4.6	969.17	27.9
4			157.08	88.53	292.69	5.28	968.82	28.3
5			150.53	88.53	286.	6.02	968.46	28.71

Serial number	Maximum Flood Regulation Capacity(10^4 m^3)					Newly built tunnel		Shawan Gate
	1#Regulating Lake	2#Regulating Lake	3#Regulating Lake	4#Regulating Lake	Total	Maximum Discharge Duration(H)	Discharge Volume(10^4 m^3)	Maximum Water Level in front of the Gate(m)
6			189.17	80.72	14 316.97	3.37	967.89	27.09
7			180.02	80.72	307.82	3.98	973.35	27.50
8			171.65	80.72	299.46	4.60	973.12	27.90
9			163.92	80.72	291.72	5.28	972.79	28.30
10			156.95	80.72	284.76	6.02	972.44	28.71
11			206.22	87.60	340.90	3.37	698.94	27.09
12			187.42	87.60	322.10	3.98	717.43	27.50
13			170.72	87.60	305.40	4.60	733.79	27.90
14			156.34	87.60	291.02	5.28	747.84	28.30
15			143.56	87.60	278.24	5.95	760.24	28.71