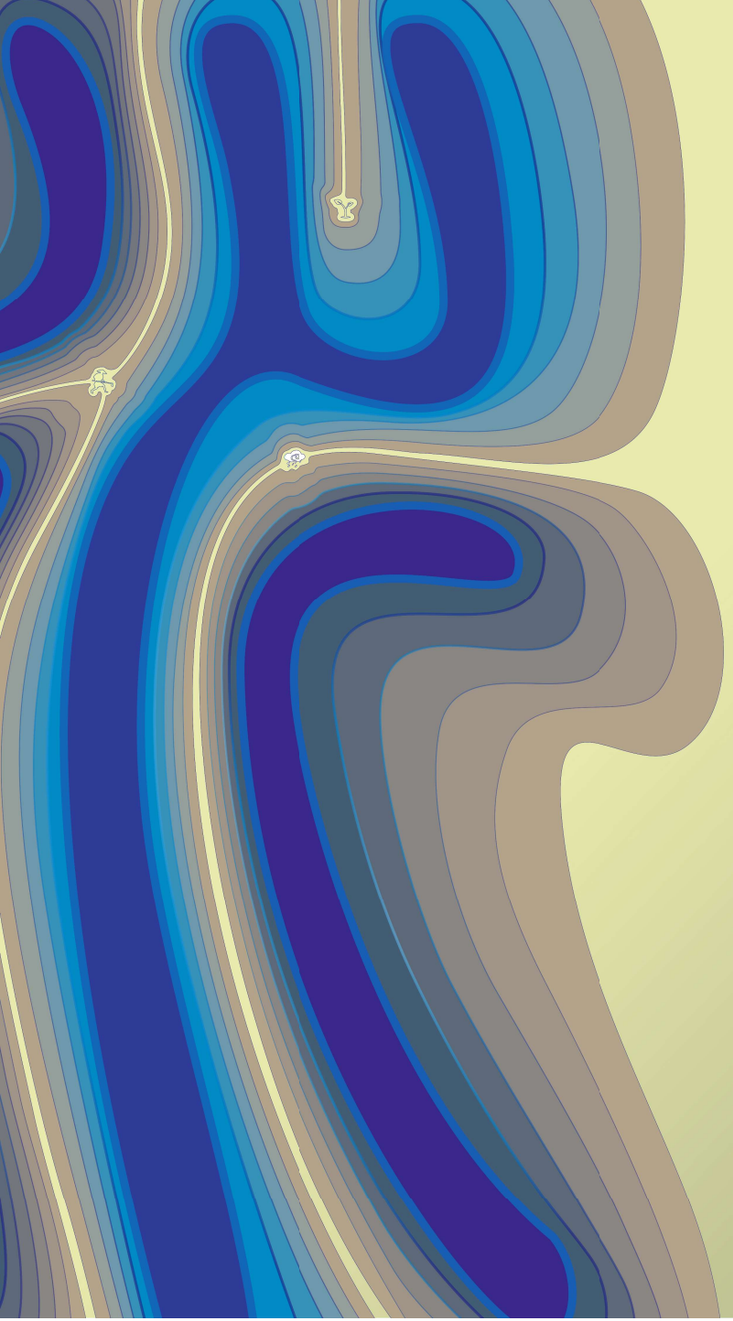

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Can water diversion polish river water quality in the polder of plain river network area? --A case study in Taihu Basin

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Nanjing Hydraulic Research Institute

XVIII WORLD WATER CONGRESS
Water for All
Harmony between Humans and Nature

第18届 世界水资源大会
水与万物：人与自然和谐共生

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Outlines

- Polders : Issues and Solutions
- Practice and Outcomes
- Conclusions

What is a Polder?

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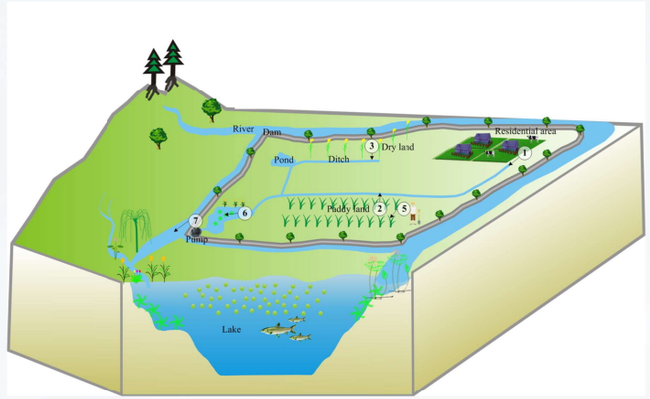
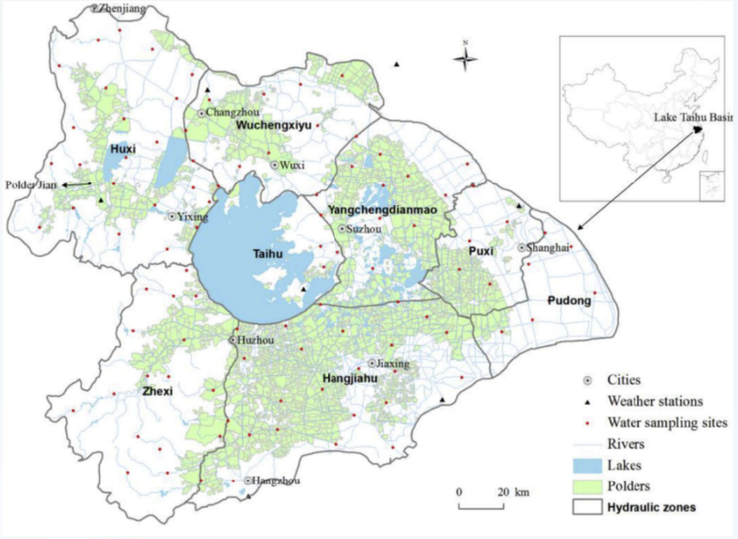
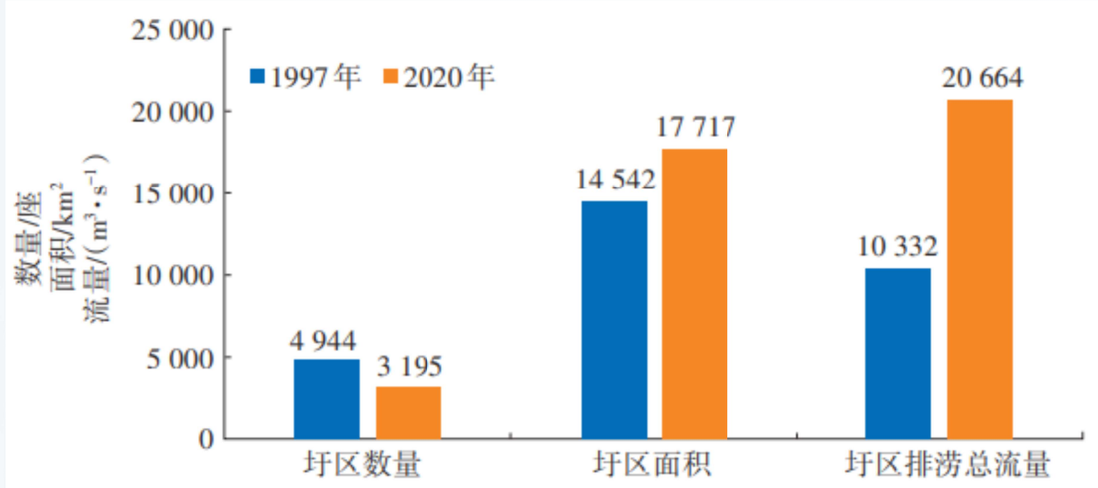
- Important hydrological unit in the plain river network area
- High production and living intensity, low water assimilation capacity, and heavy pollution discharge
- The hydrological and hydrodynamic processes are significantly affected by the construction and operation of water conservancy facilities







Main statistical characteristics of polders in Taihu Basin

Features of Polders

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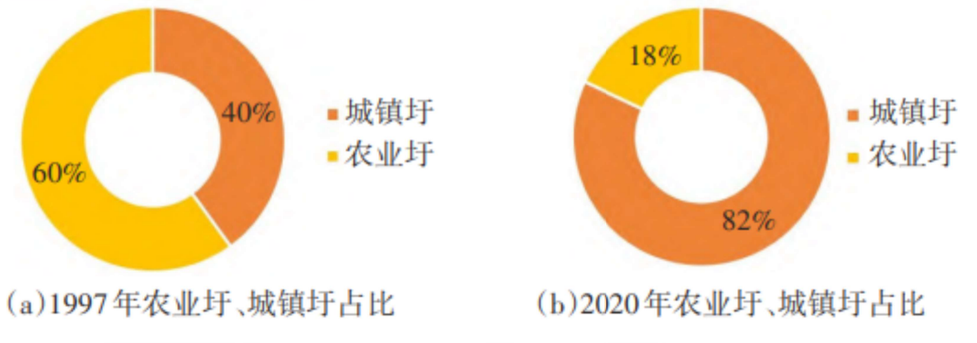
- Flat terrain
- Dense river network
- Shallow water table
- Various types of land use
- Outflow controlled by water conservancy facilities



(a)1997年农业圩、城镇圩占比　(b)2020年农业圩、城镇圩占比

Polders-- Issues & Solutions

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Issues

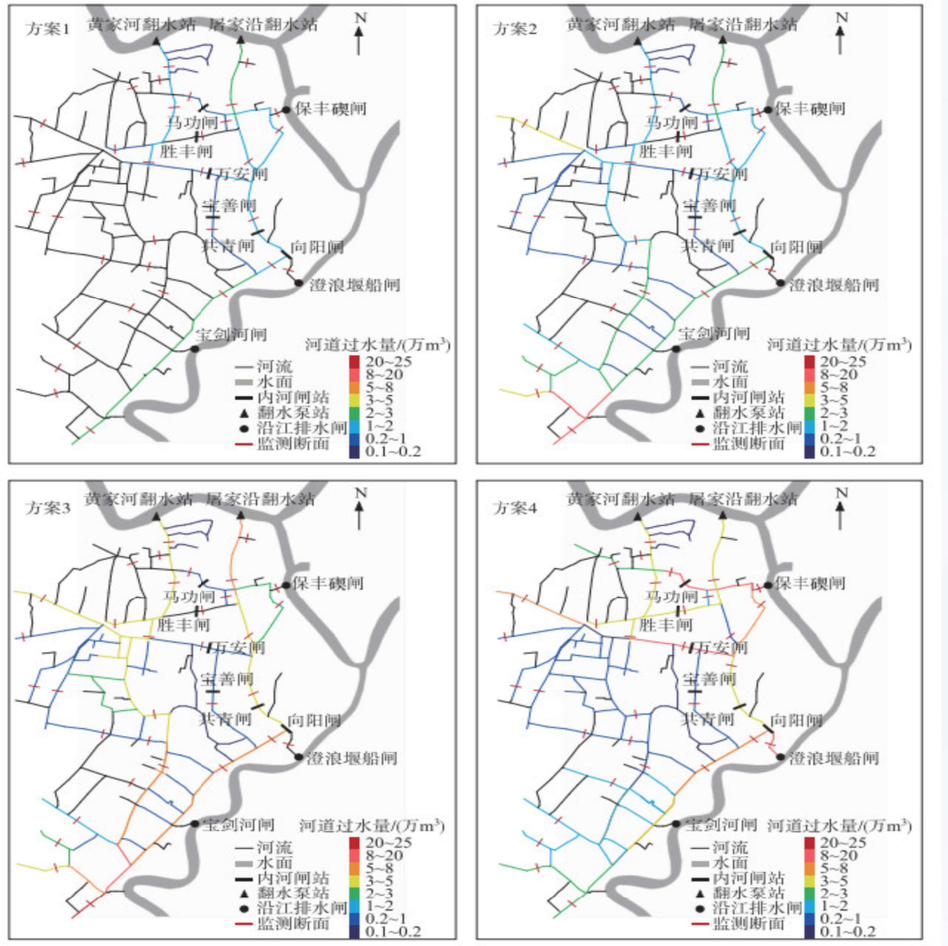
- **Poor quality of water environment**
- Urban development taking up more river space
- **Poor connectivity for segmentation of river networks**
- Low coverage of waste water treatment
- Severe siltation
- Discouraging sensorial experience of rivers

Solutions

- Source control of pollutants
- Connectivity of water bodies
- **Dynamic control and operation**
- Treatment and purification
- Regulation of rivers
- Ecological Restoration

Can water diversion polish river water quality in the polder?

- Enhancing hydrodynamic conditions has become one of the measures to solve water environment
- When/Where/How to implement water diversion
- Hydrological and water quality conditions inside and outside the polder



Practices and outcomes

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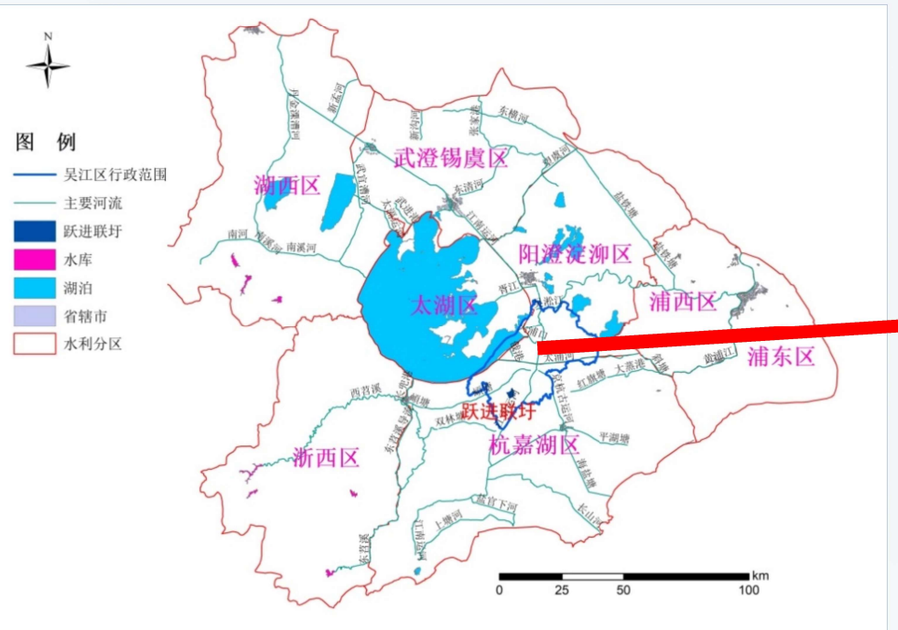
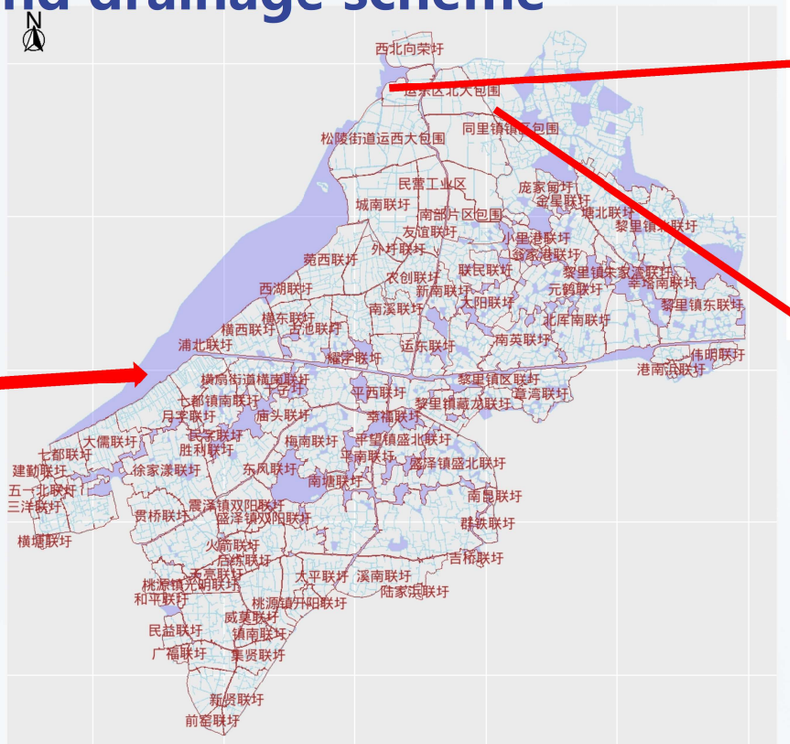
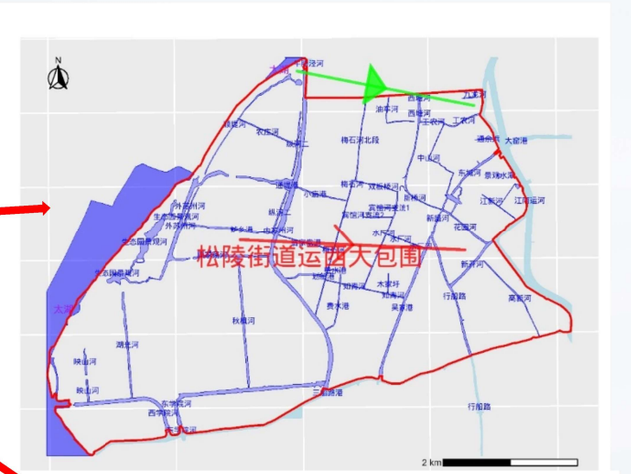
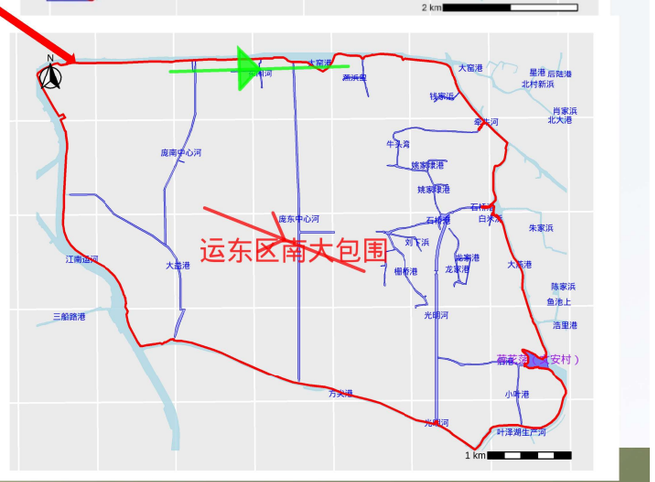
- Wujiang District, on the east of Taihu Lake， has 128 Polders
- 2663 rivers,1469.5 km embankment, 505 drainage pumping stations, 766 flood control gates
- Each polder has a diversion and drainage scheme

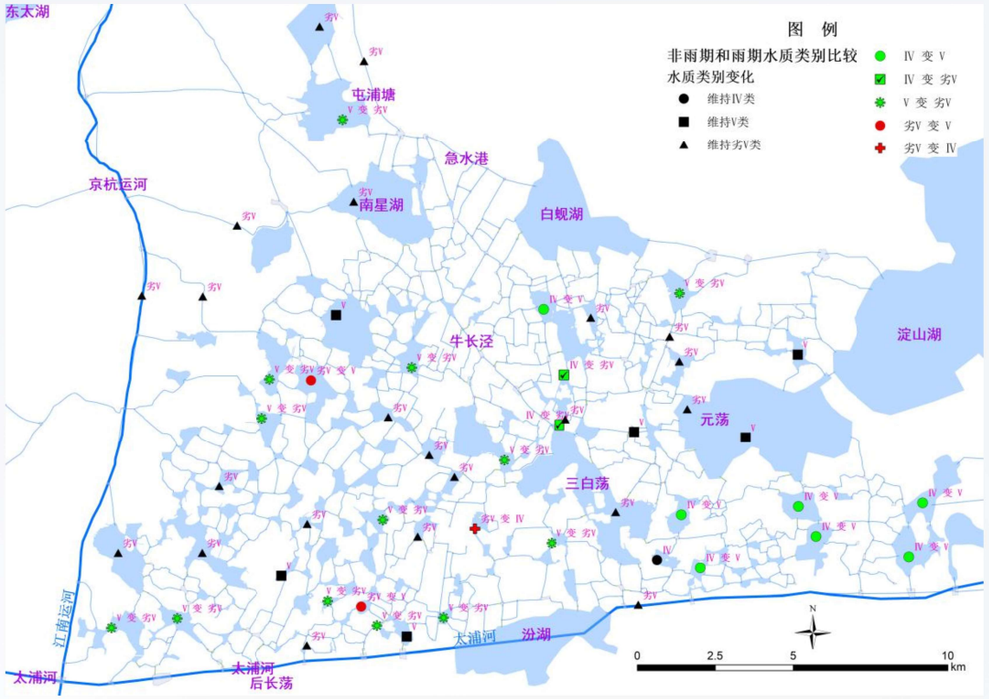








➢ The spatiotemporal differences in water quality inside and outside the polders are significant



Period		COD_{Mn}		TN		NH_4N		TP	
		Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
Non-rainy period	Ave.	7.23	5.88	1.75	2.23	0.64	0.64	0.15	0.17
	p value	0.041		0.08		0.837		0.04	
Rainy period	Ave.	4.83	4.40	2.07	2.31	0.53	0.44	0.16	0.16
	p value	0.113		0.21		0.128		0.62	

Practices and outcomes

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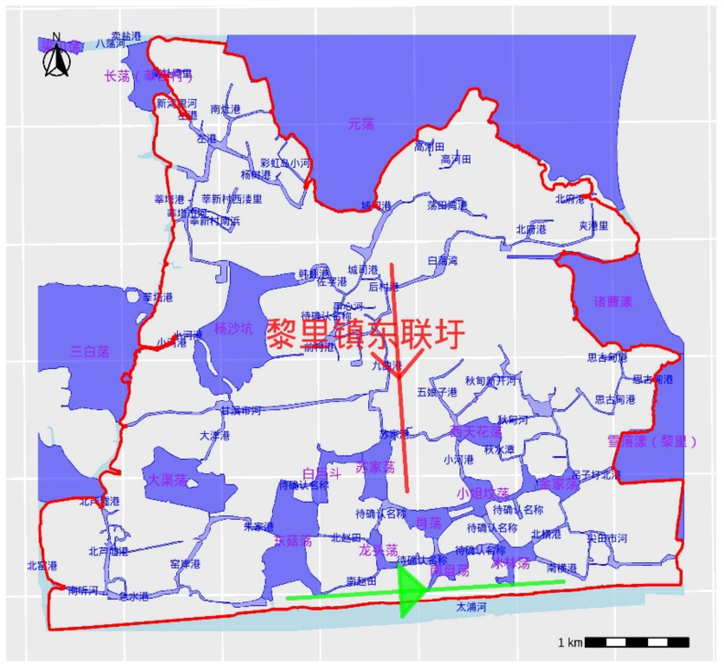
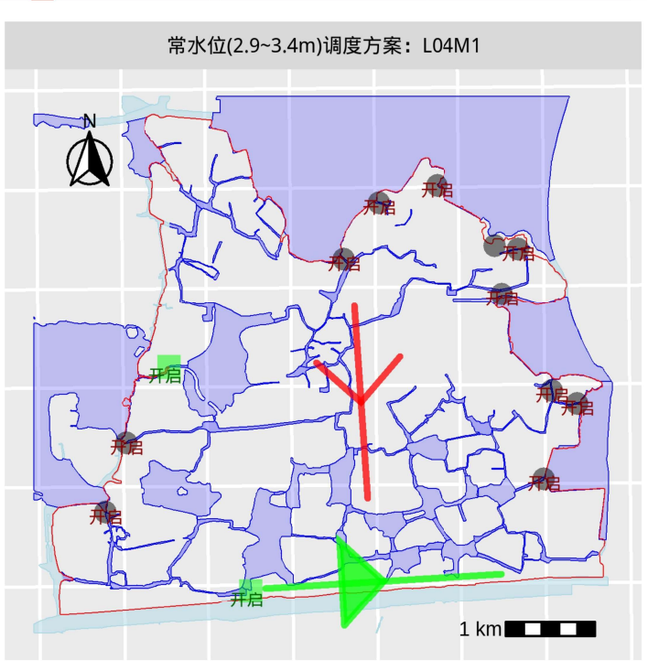
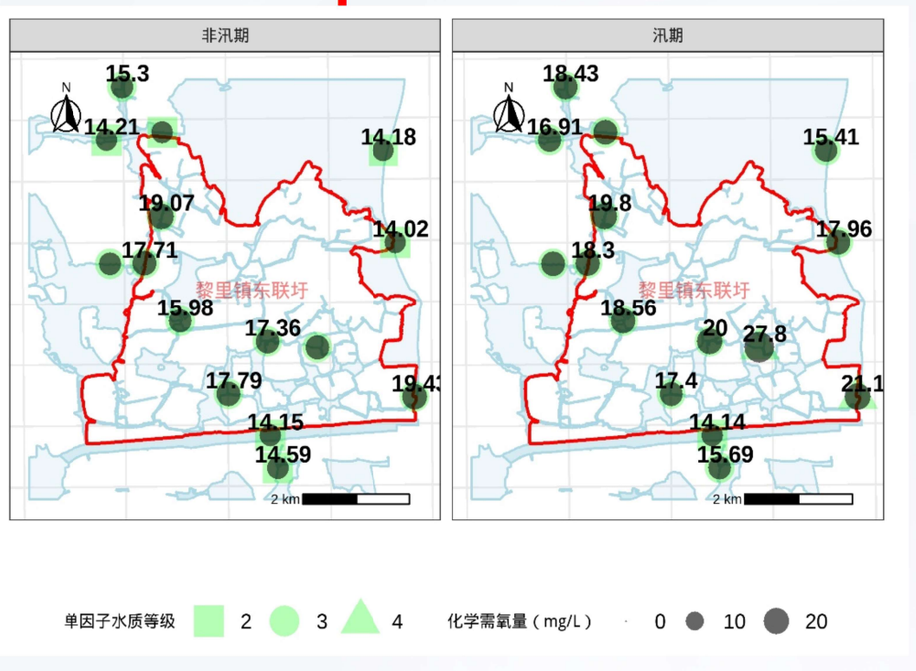
- East polder, diverts water from the east and north sides, and drains water to the south and west
- Xueluo Lake and others diversion routine are located **downstream**, and the water quality is **worse than other monitoring points**
- **The diversion and drainage routine in this area needs to be optimized**







Practices and outcomes

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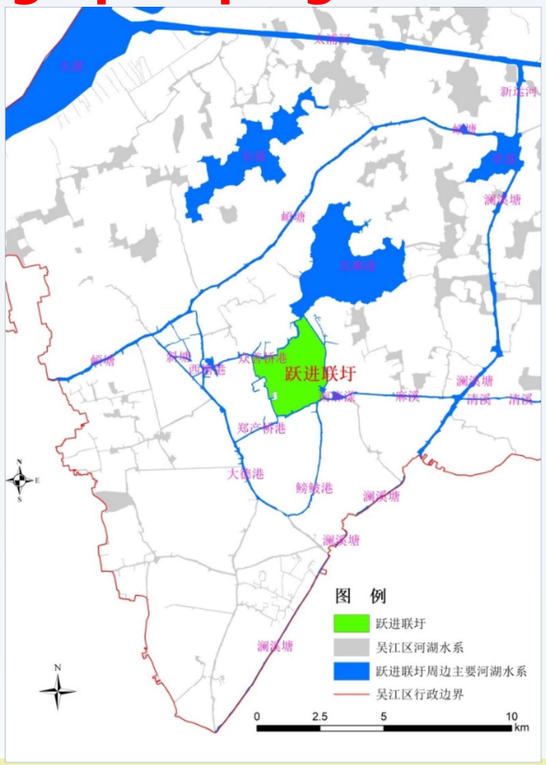
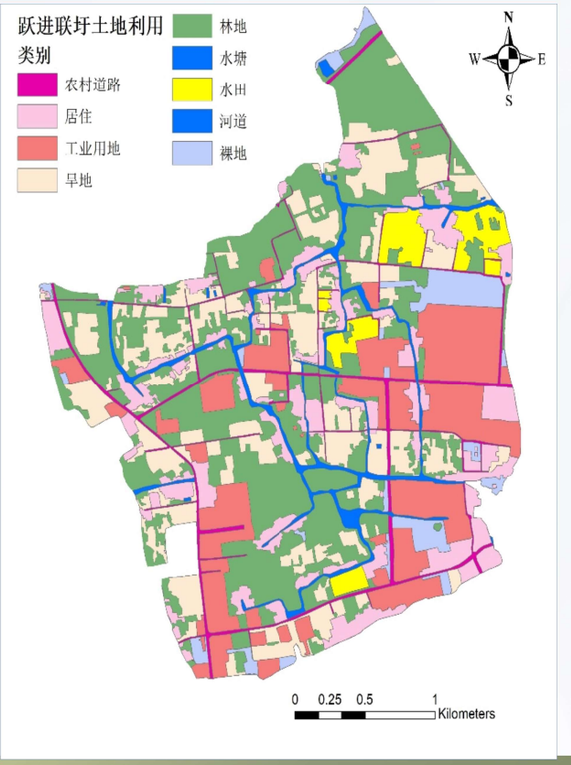
- **Yuejin Polder,located in Hangjiahu Plain in the Taihu Basin**
- **16 rivers, with a total length of 13.95km; river density is 2.12km/km²; the elevation is 3.00-4.00m**
- **3 drainage pumping stations and 5 gates**





Practices and outcomes

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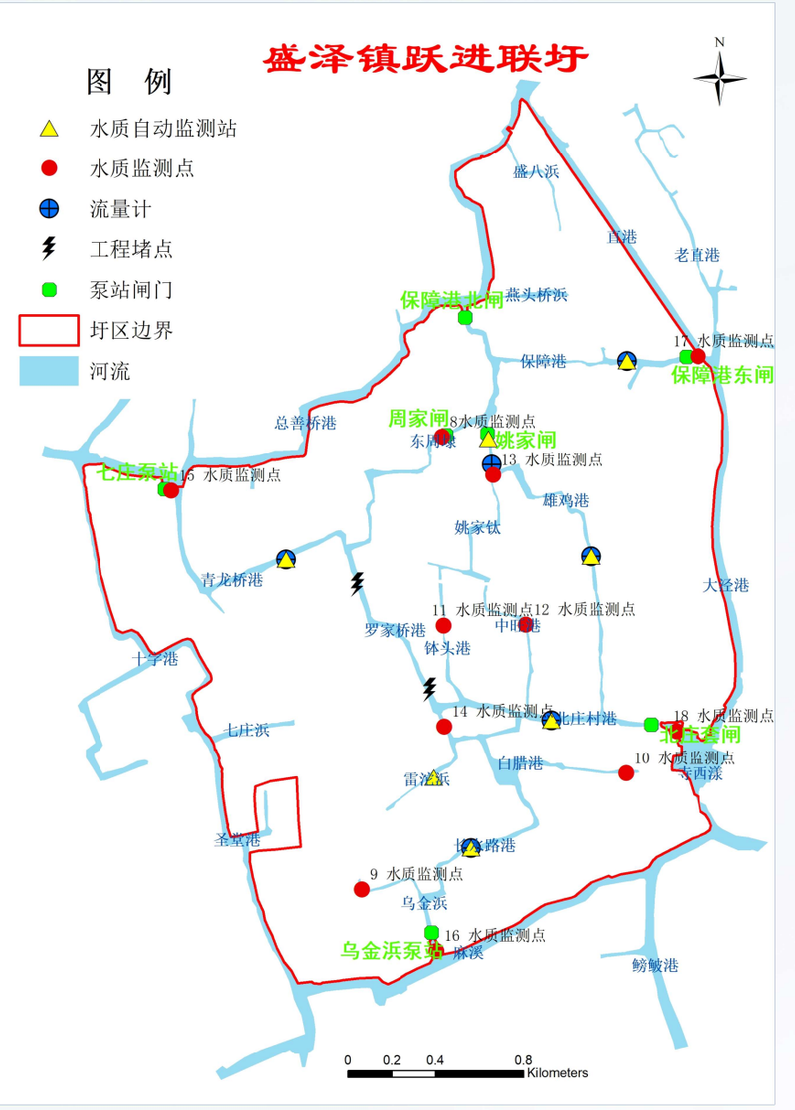
- **7** water quality/flow automatic monitoring stations
- **11** water quality inspection stations
- **1** weather station
- **2** water level stations outside the polder
- **4** water level stations inside the polder
- **2** pump station flow meters



Practices and outcomes

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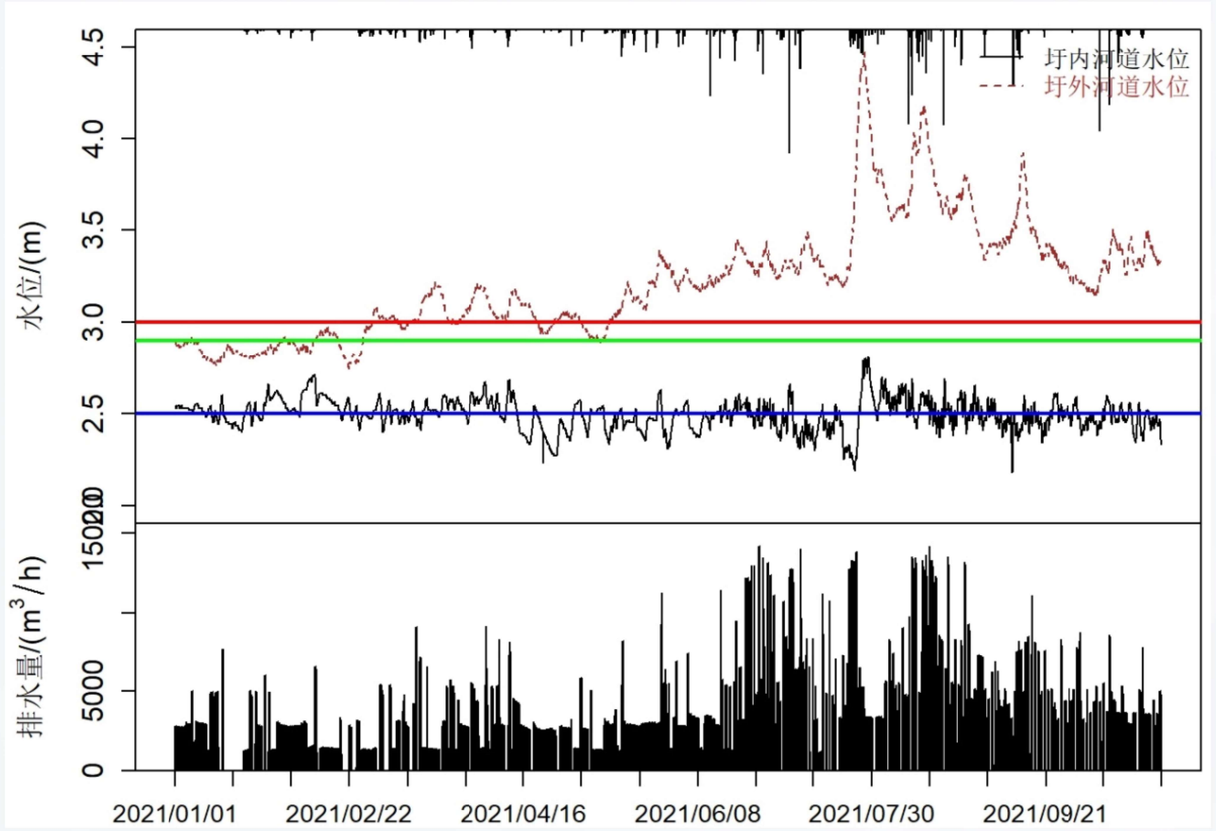
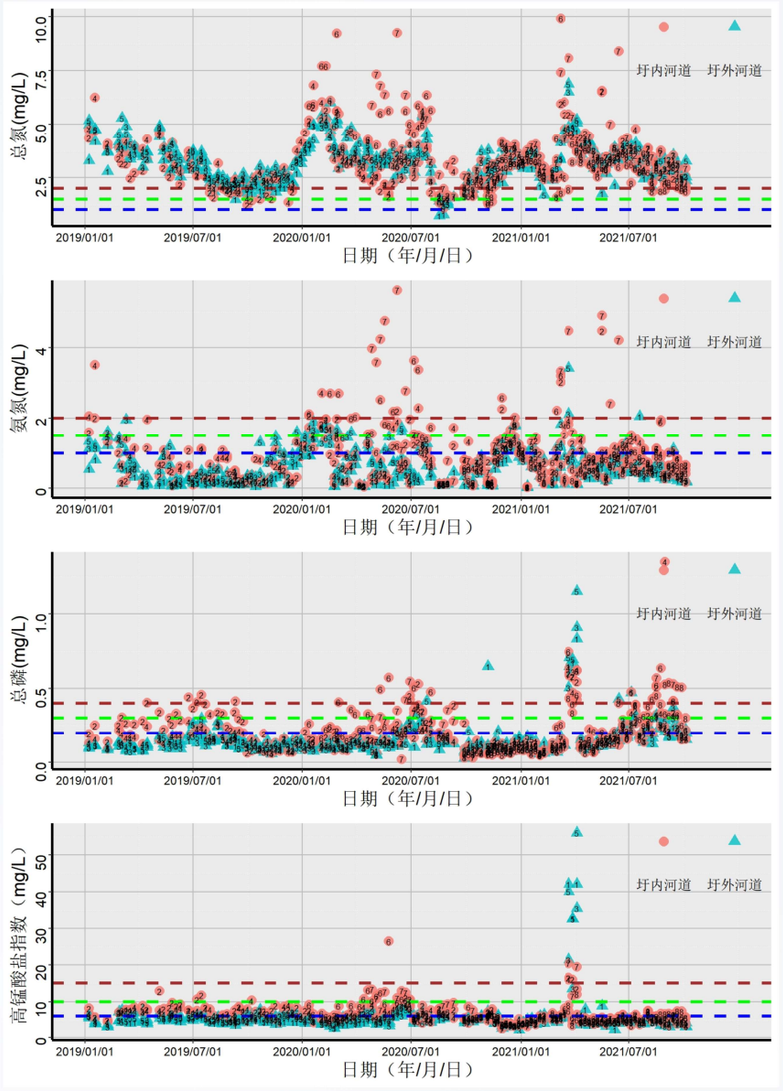
- **The water level of the river inside the polder is lower than outside all the year round**
- **The water level changes of the rivers outside the polder have an obvious response to the regional rainfall**
- **The water level inside the polder is affected by artificial pumping and drainage, and the inter-annual fluctuation is small**



Practices and outcomes

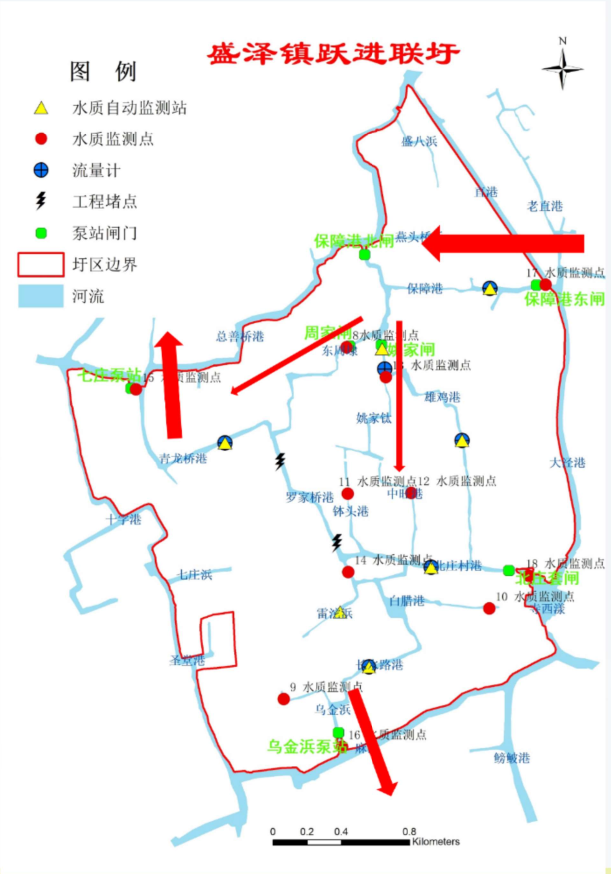


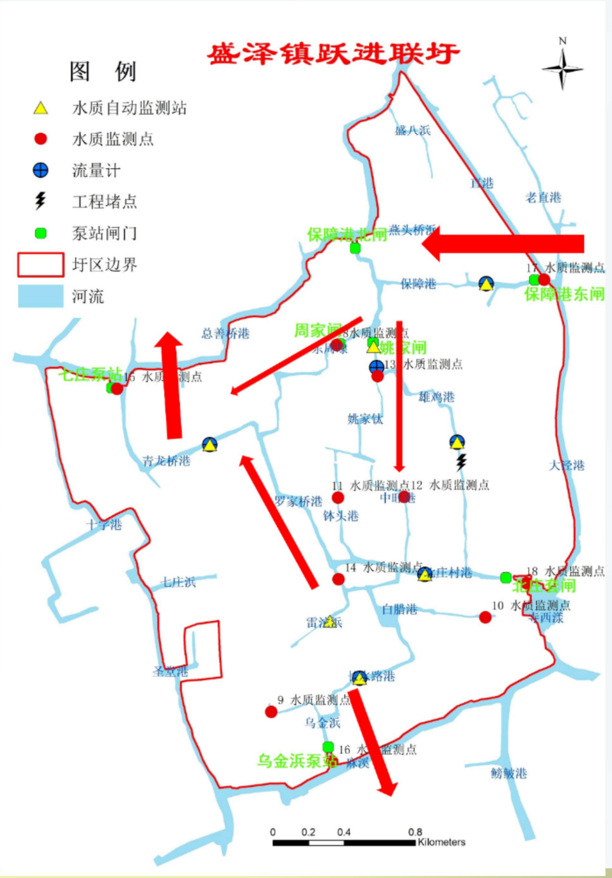
- The average TN concentration exceeds the Class V standard
- Significant difference between wet season and dry season
- Water quality inside the polder is generally higher than that outside the polder; in some periods of wet season, the water quality in the polder is better than that outside the polder

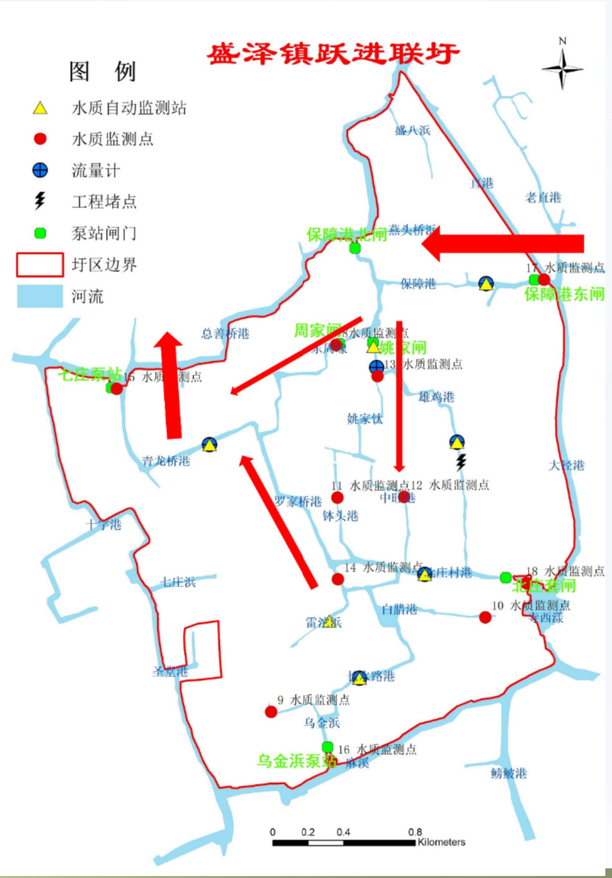
Period	TN		NH_4N		TP		CODMn	
	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside
Year	3.22	3.39	0.10	0.12	0.16	0.21	5.61	6.33
Wet season	3.01	3.26	0.13	0.15	0.18	0.27	5.08	6.57
Dry season	3.44	3.53	0.08	0.10	0.11	0.14	4.92	6.13

Practices and outcomes

- **3 groups** of water diversion and drainage tests
- Simultaneous online monitoring inside and outside the polder







Practices and outcomes

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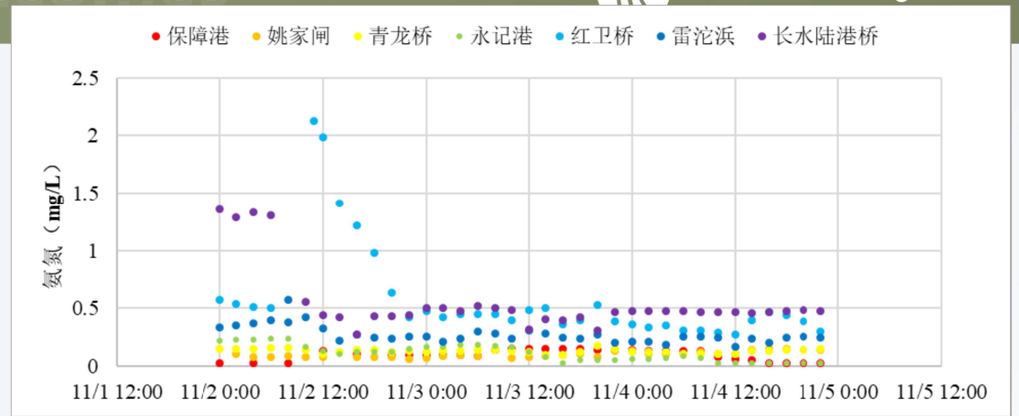
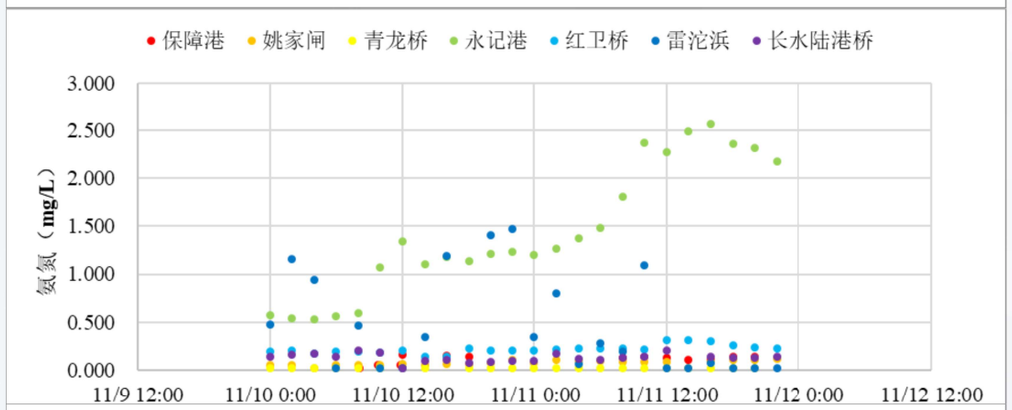
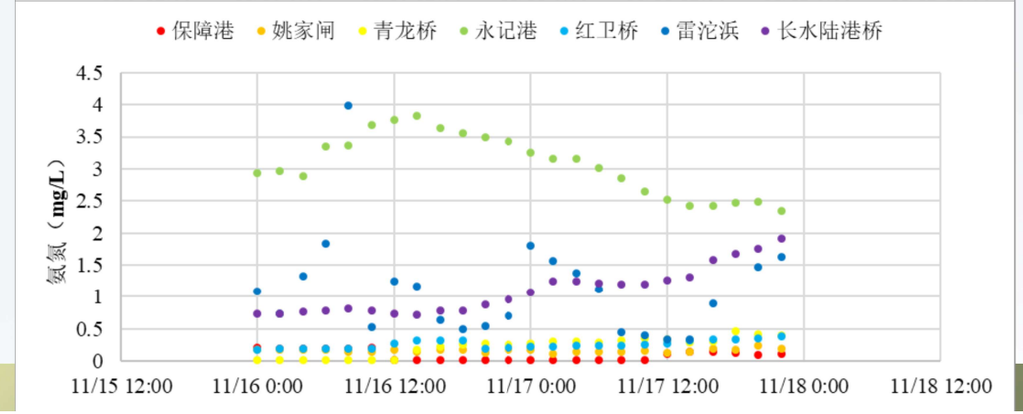
- Water quality improvement is more effective along the water diversion routine
- **Captured river** is prone to poor water quality
- **Weak water flow** leads to poor water quality
- **Blockages** in the polder can lead to poor water quality

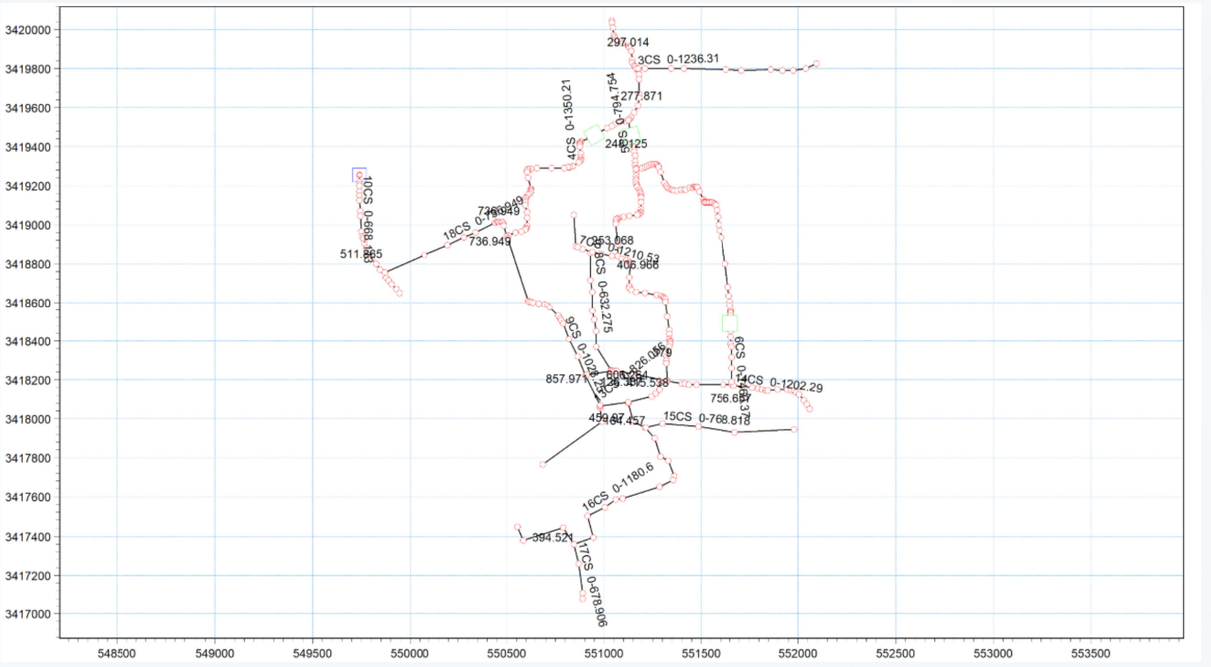






Practices and outcomes

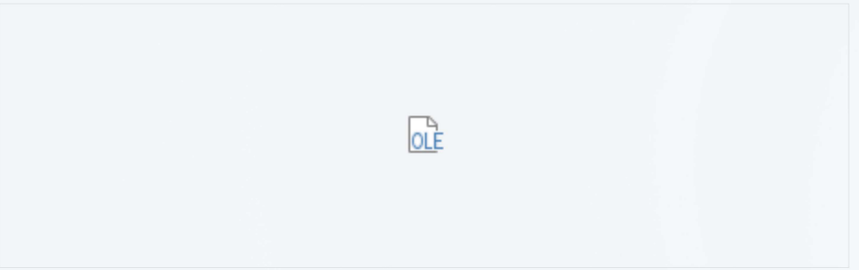
- Construct a mathematical model in Yuejin Polder
- Based on the hydrodynamic model, the water age model can be used to analyze the water system connectivity of the river network
- The water quality model is used to analyze the water quality changes of the river network



➢ hydrodynamic model

$$\frac{\partial S_{co}(A+A_o)}{\partial t}+\frac{\partial Q}{\partial X}-q=0 \qquad \frac{\partial(S_m Q)}{\partial t}+\frac{\partial}{\partial X}(\frac{\beta Q^2}{A})+gA(\frac{\partial h}{\partial x}+S_f+S_e)+L+W_f B=0$$

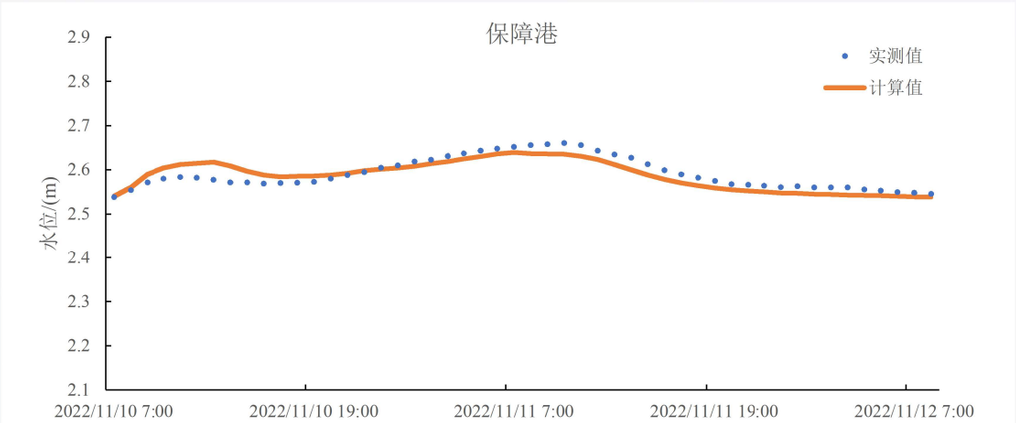
➢ water age model

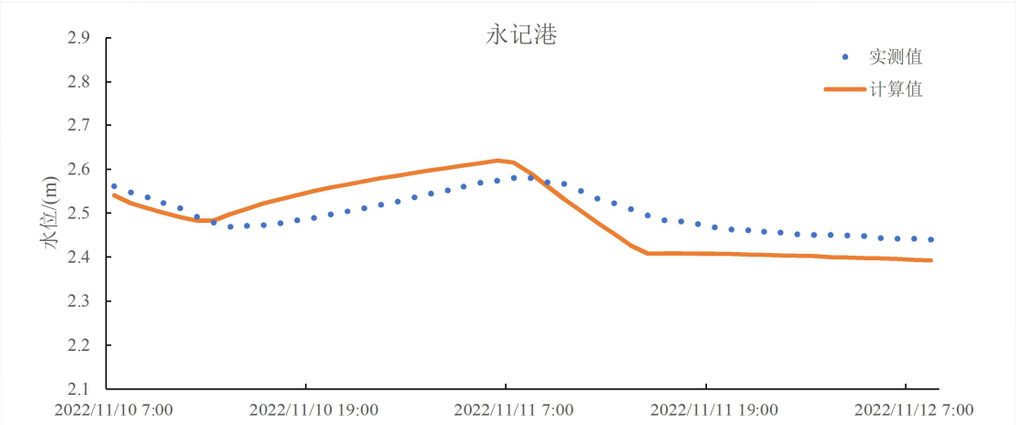


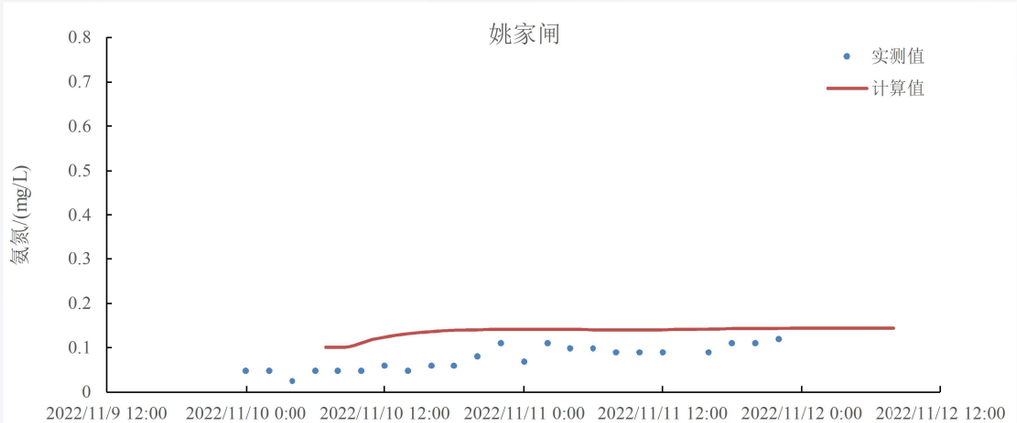
➢ water quality model

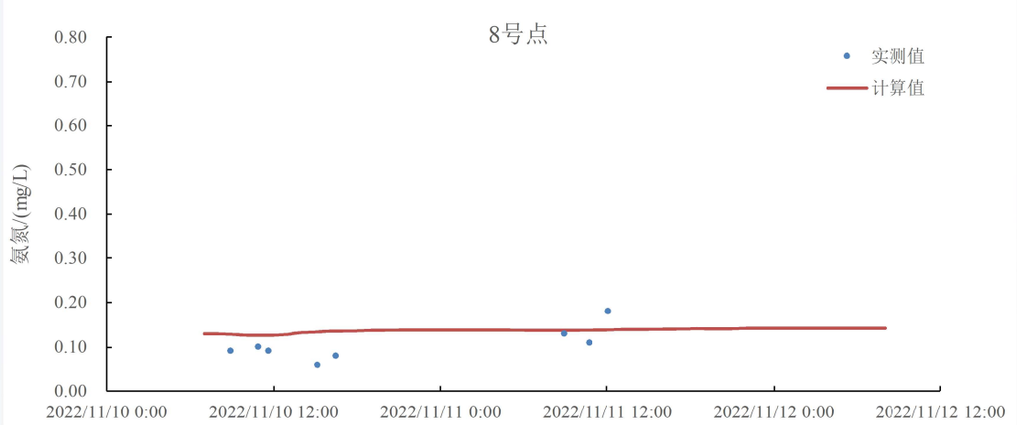
$$\frac{\partial}{\partial t}(V\phi)=-\frac{\partial}{\partial x}(Q\phi)\Delta x+\frac{\partial}{\partial x}\left(\Gamma A\frac{\delta\phi}{\delta x}\right)\Delta x\pm S$$

Model Calibration and Validation

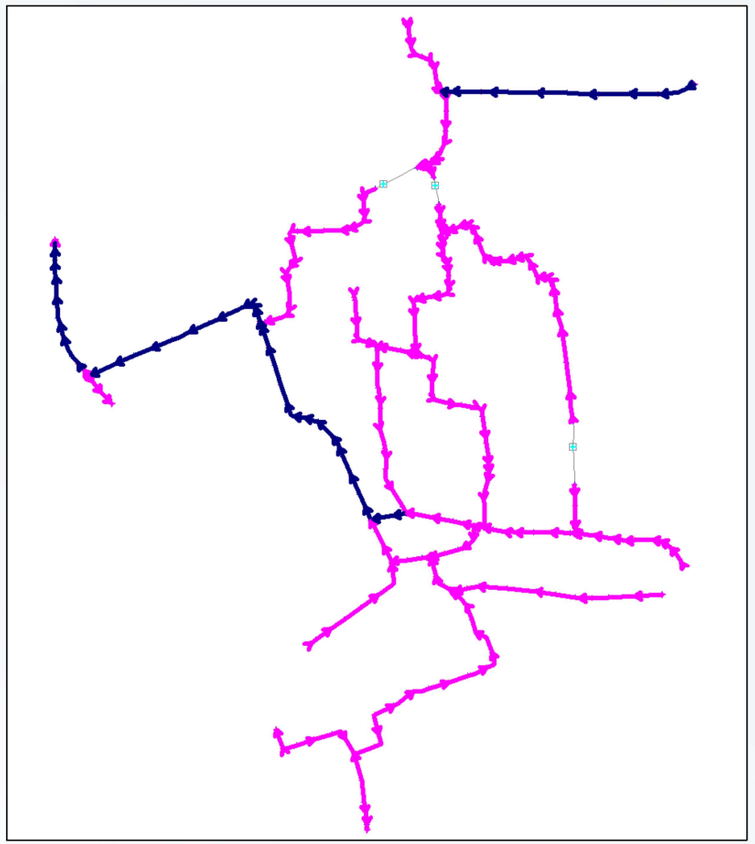




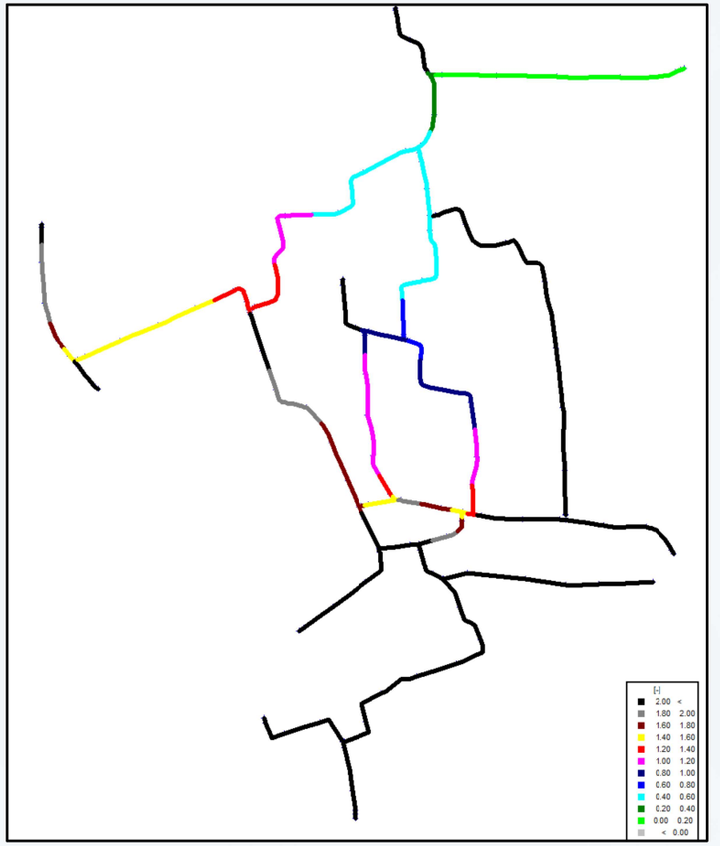




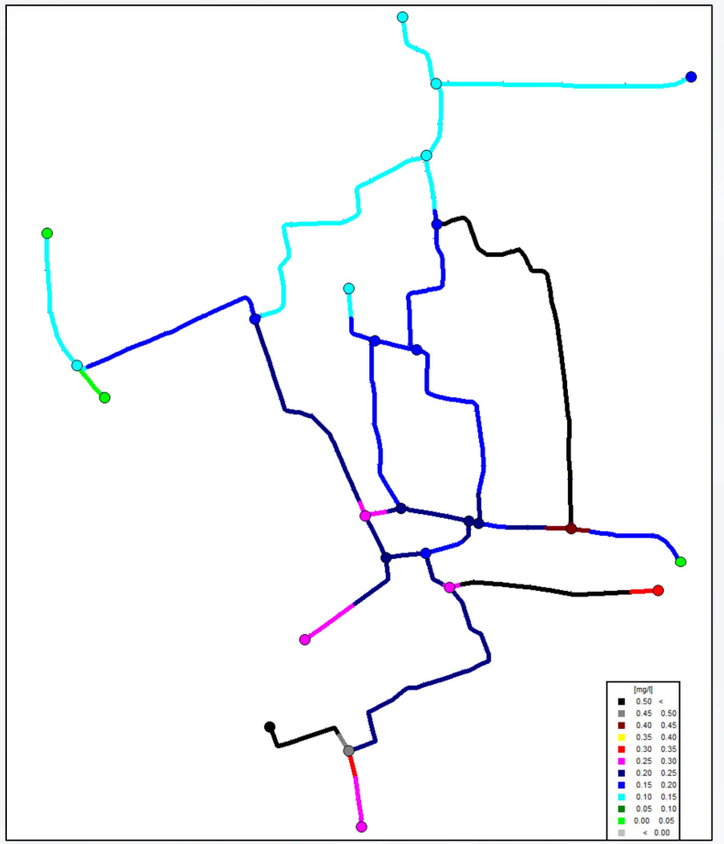
Analysis of the impact of water diversion on water environment



Water flow direction



Water exchange time （WET）



Spatial distribution of ammonia nitrogen concentration after water diversion

- **Based on the current water quality and hydrodynamic conditions, 5 simulation scenarios have been designed, and the connectivity of each scenario is increasing**

Conditions	Diversion gate		Drainage pump		Whether Yong ji Port is connected	Diversion Flow （m^3/s）
	BZG	BZ	QZ	WJB		
1	Open	-	Open	-	No	1
2	Open	-	Open	-	Yes	1
3	Open	-	Open	Open	Yes	1
4	Open	Open	Open	-	Yes	2
5	Open	Open	Open	Open	Yes	2

Practices and outcomes

- WET of the main river channels are within 5 days
- The better the water body connectivity in the river network, the shorter the WET of the river channel
- The spatial distribution trend of the concentration of water quality is basically consistent with the spatial distribution trend of WET

WET （d）	0-0.5	0.5-1	1-1.5	1.5-2	2-3	3-4	4-5	>5
Condition 1 （%）	9.08	11.81	13.56	4.34	16.53	1.41	1.12	42.14
Condition 2 （%）	9.08	8.92	15.01	5.80	17.50	12.09	2.44	29.15
Condition 3 （%）	9.08	10.31	15.63	9.22	15.44	6.02	10.43	23.87
Condition 4 （%）	12.32	16.75	24.90	12.88	7.24	0.09	0.00	25.83
Condition 5 （%）	12.32	16.75	17.68	27.25	13.34	0.36	0.78	11.53

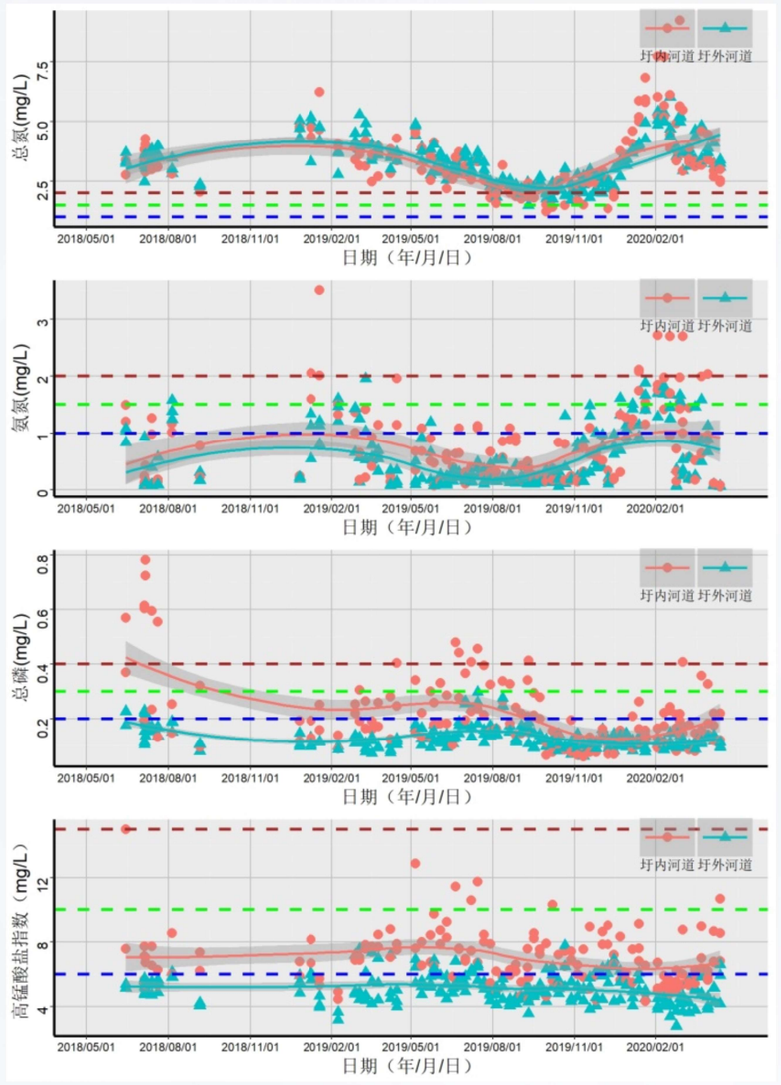
Practices and outcomes

- **Blockage points in the river network are the main areas of water stagnation and poor water quality**
- **Single regulation method is more likely to cause differences in the connectivity of the water system and the spatial distribution of water quality in the river network, forming stagnant water areas, resulting in poor water quality**

River	NH_4N (mg/L)	Reduction Rate (%)				
		Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
BZG	0.15	0.00	0.00	0.00	0.00	0.00
DZD	0.20	24.43	24.43	24.43	24.43	24.43
YJD	0.20	24.36	24.36	24.36	24.36	24.36
YJP	2.00	0.98	92.50	92.50	92.50	92.50
ZWG	0.25	33.45	33.43	33.44	33.34	33.43
BTG	0.40	62.50	62.50	62.49	62.50	62.50
LJQG	0.25	39.86	39.55	10.60	39.98	39.83
QLQG(NS)	0.15	0.00	-7.45	0.00	-0.06	0.00
LTB	2.00	43.28	43.20	55.17	43.18	57.13
BZCG	0.30	16.58	30.88	30.81	50.00	50.00
BLG	2.00	24.34	24.27	32.73	21.94	36.28
CSLG	2.00	0.00	0.00	91.09	0.00	92.32
WJB	2.00	3.32	3.55	70.59	3.23	75.15
QLQG(ES)	0.15	0.00	0.00	0.00	0.00	0.00

Pollution source-sink relationship

- With the exchange of water volume inside and outside the polder, the pollutants carried by the water body also exchanged
- During the dry season, the concentration of total nitrogen and ammonia nitrogen outside the polder is higher than that inside the polder
- **Scientific determine the water diversion time period and routine according to the water level and water quality inside and outside the polder**



Conclusions

- Source control of pollutants
- Quality water supply （source-sink）
- Water allocation according to need
- Coordinated diversion and drainage
- Refined control and operation


Thanks for Your Attention !