



# 2022年长江口抗咸潮保供水

Prevention of Salt Water Intrusion to Ensure Water Supply at Changjiang Estuary in 2022

水利部长江水利委员会

Changjiang water resources commission

Ministry of water resources in China

2023-09-13



水利部长江水利委员会

Changjiang Water Resources Commission

1. Background
2. Response measures
3. Results
4. Lesson Learnt
5. Next steps



01

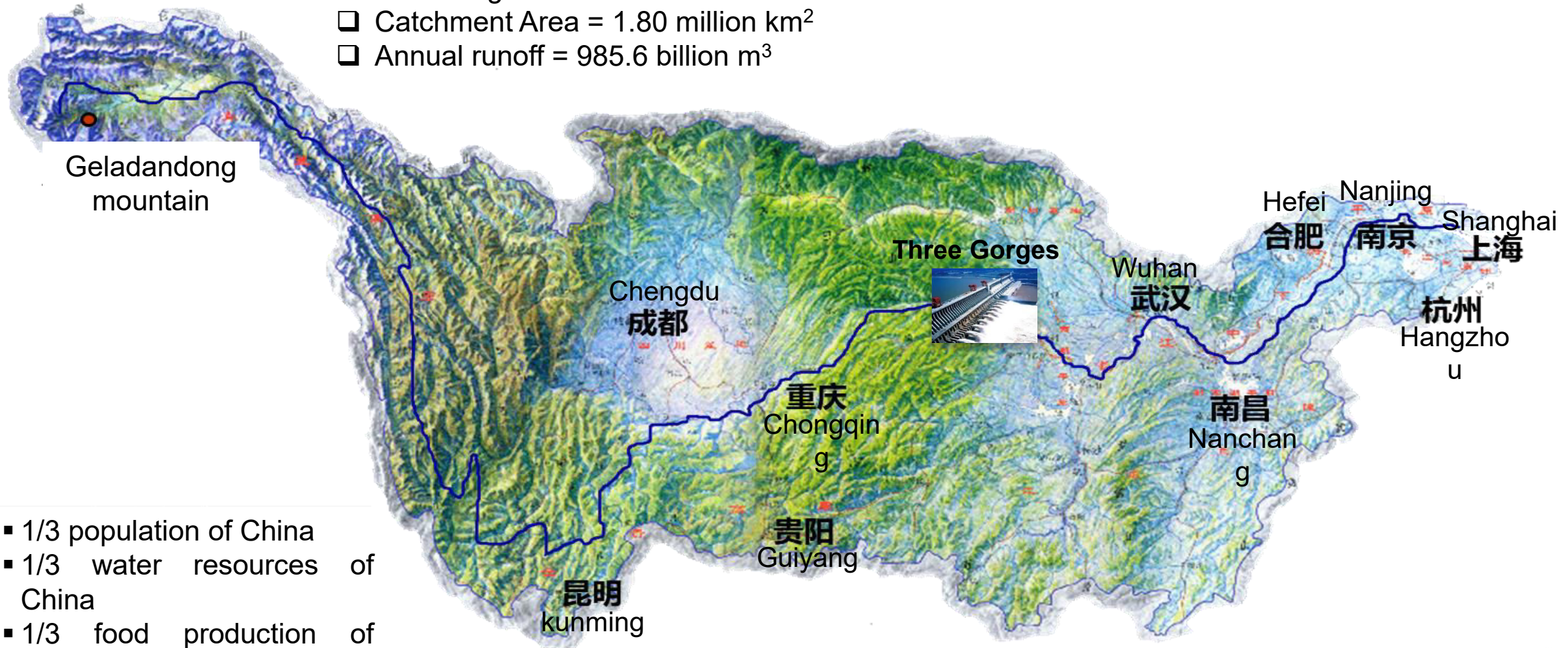
Part 1

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# Changjiang River – also known as Yangtze River

- ❑ Originates from Geladandong mountain of Qinghai-Tibet Plateau in southwest China
- ❑ River length = 6300km
- ❑ Catchment Area = 1.80 million km<sup>2</sup>
- ❑ Annual runoff = 985.6 billion m<sup>3</sup>



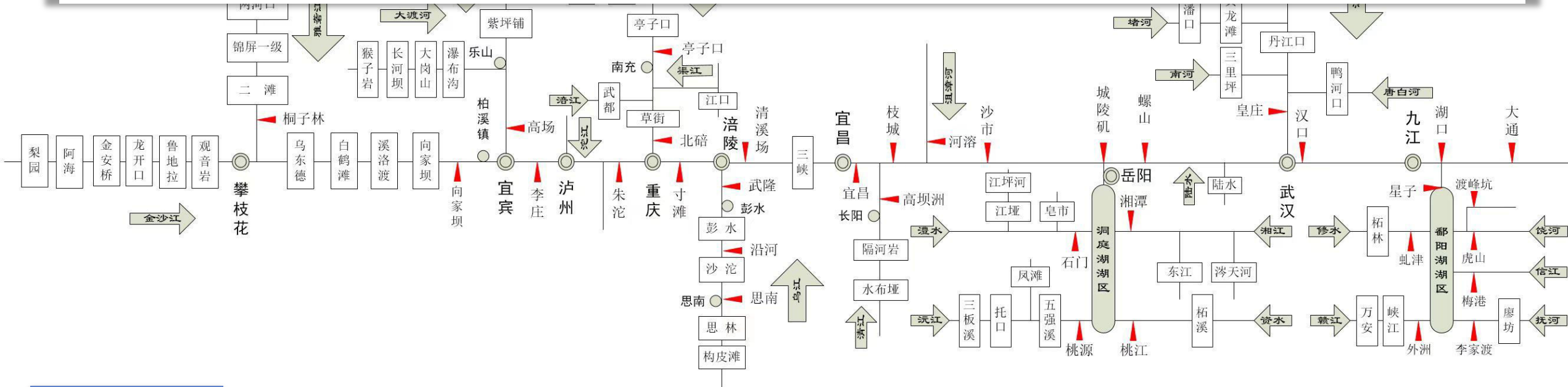
- 1/3 population of China
- 1/3 water resources of China
- 1/3 food production of China
- 1/3 GDP of China



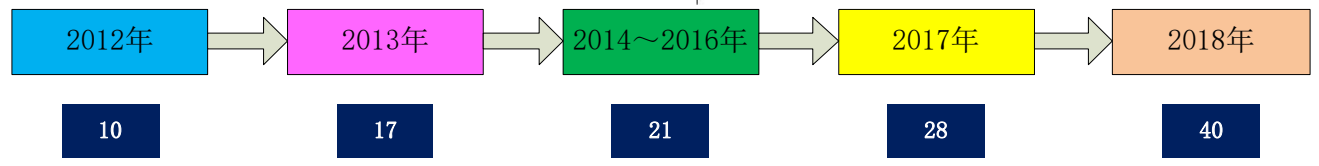
# Joint regulation of water projects is the key for river management

In 2023, 125 water works are involved in the joint regulation scheme of the River basin:

- 53 reservoir, Regulatory storage: 116 billion m<sup>3</sup>, Flood control storage: 70.5 billion m<sup>3</sup>
- 46 flood storage and detention areas
- 11 pumping stations
- 9 sluice and gates
- 6 water diversion projects

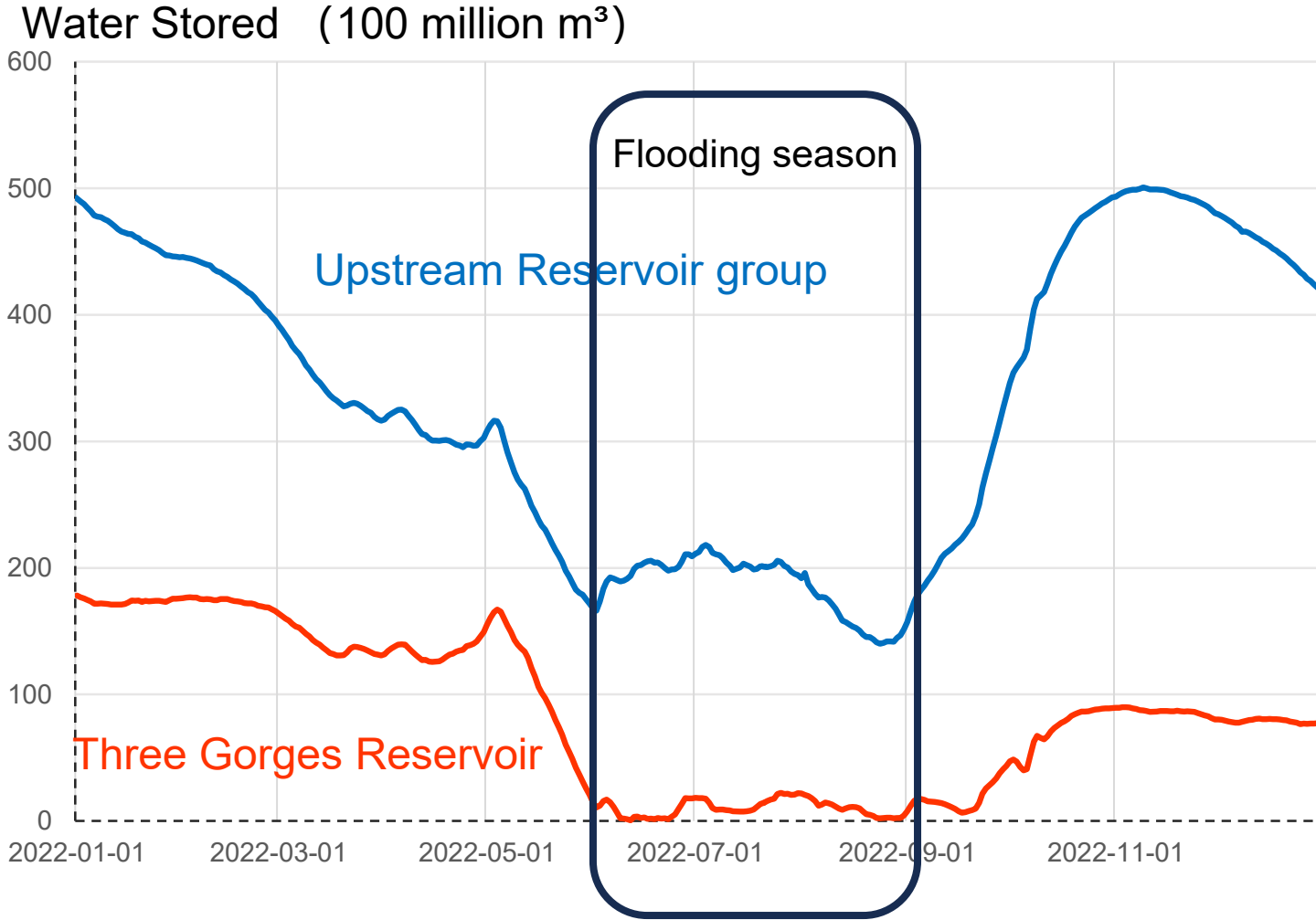


Annual Joint regulation scheme



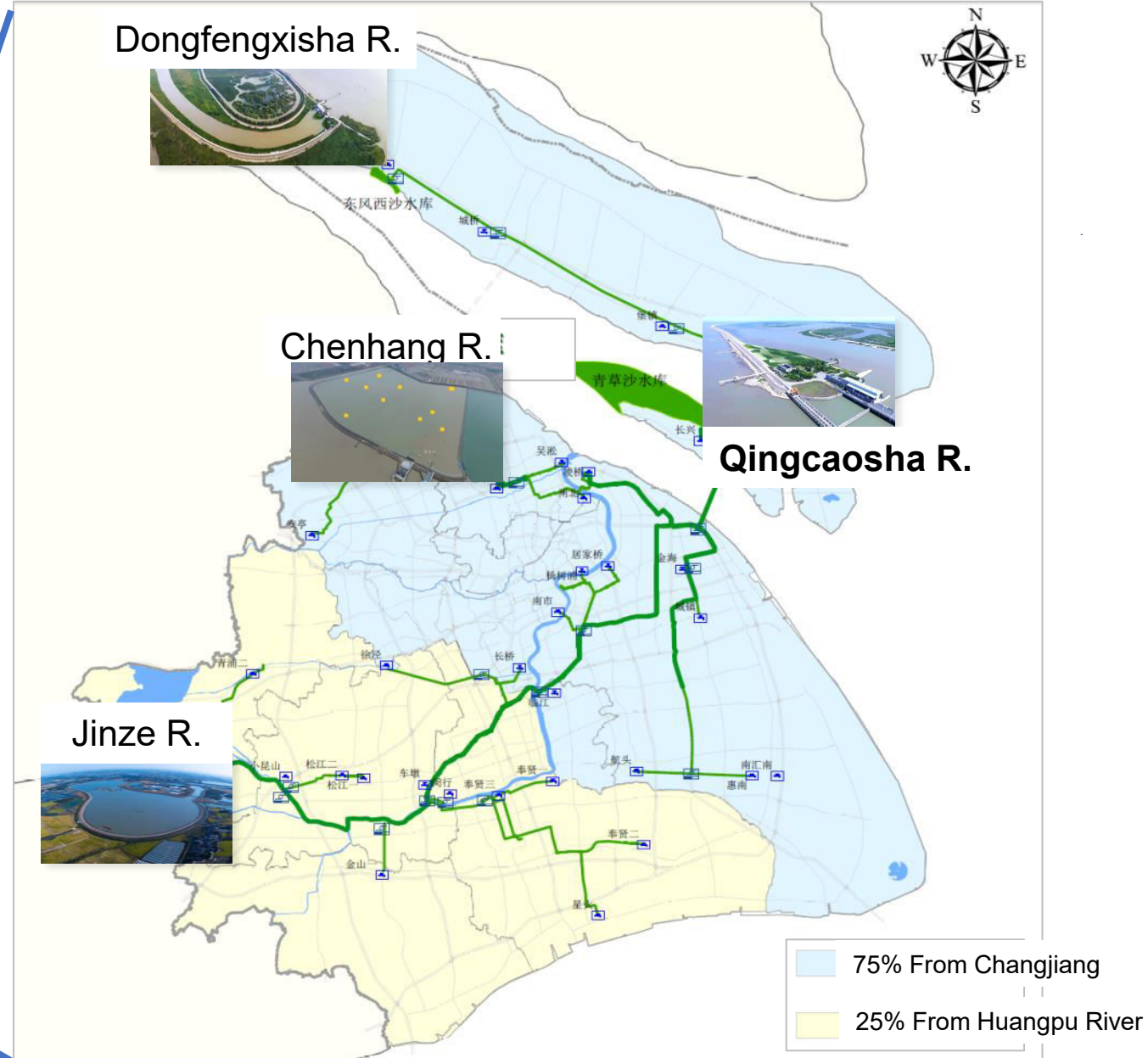
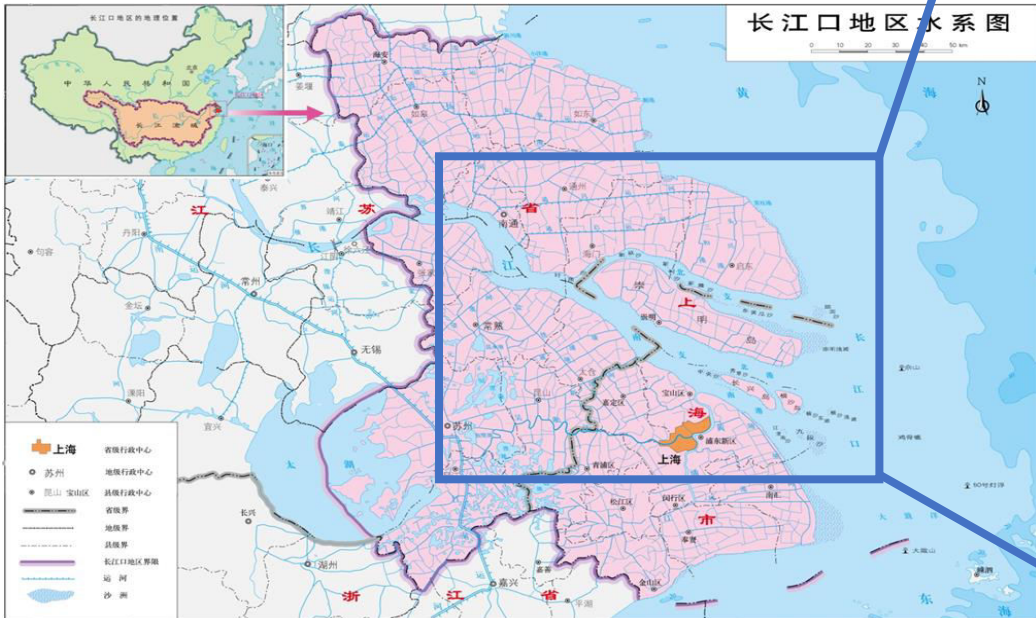
Start from 2019, not only reservoirs but also retention basins, pumping stations, water intake projects etc. were included in the scheme

# Impoundment process of controlled reservoir groups in 2022



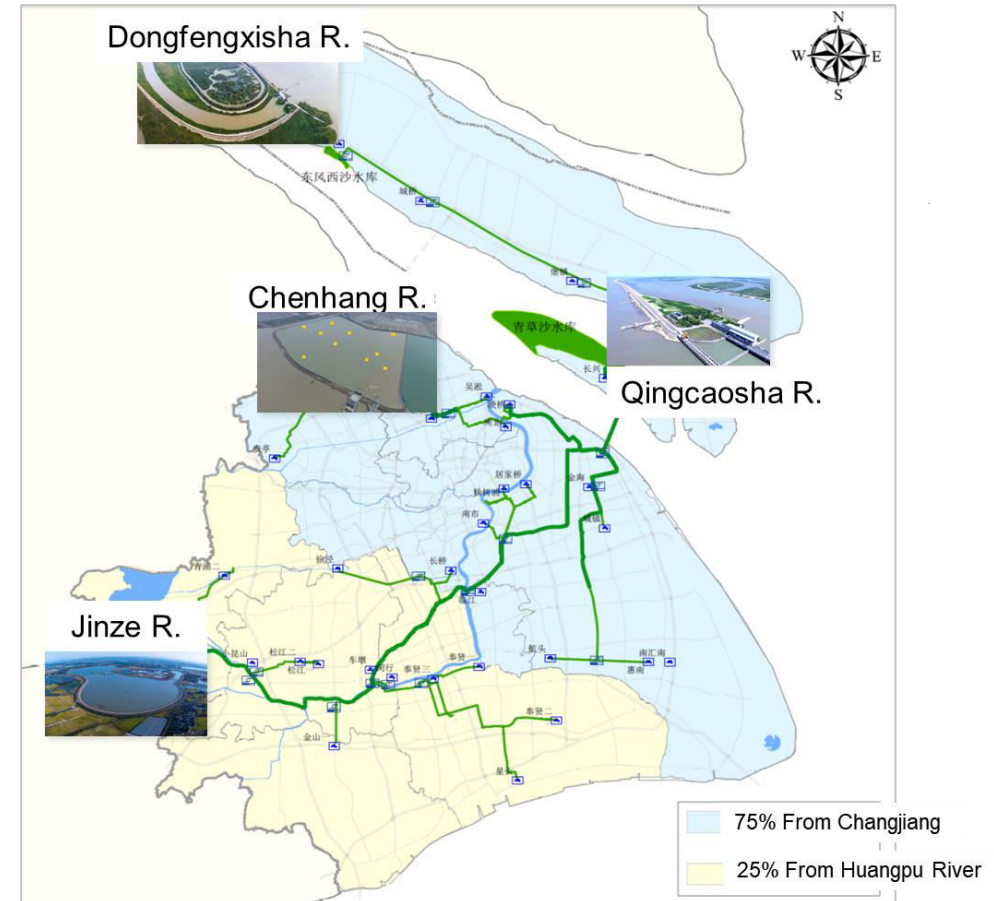
# Water Supply in Shanghai

- ❑ Located in the estuary of the Changjiang River, **Shanghai** is a mega city with ~25 million people.
- ❑ Main Water supply reservoirs taking water from **Changjiang river**:
  - Qingcaosha
  - Chenhang
  - Dongfengxisha
- ❑ Daily supply capacity of **9.22 million m<sup>3</sup>/d** (75% of total water supply) for 18 million people



# Water Supply in Shanghai

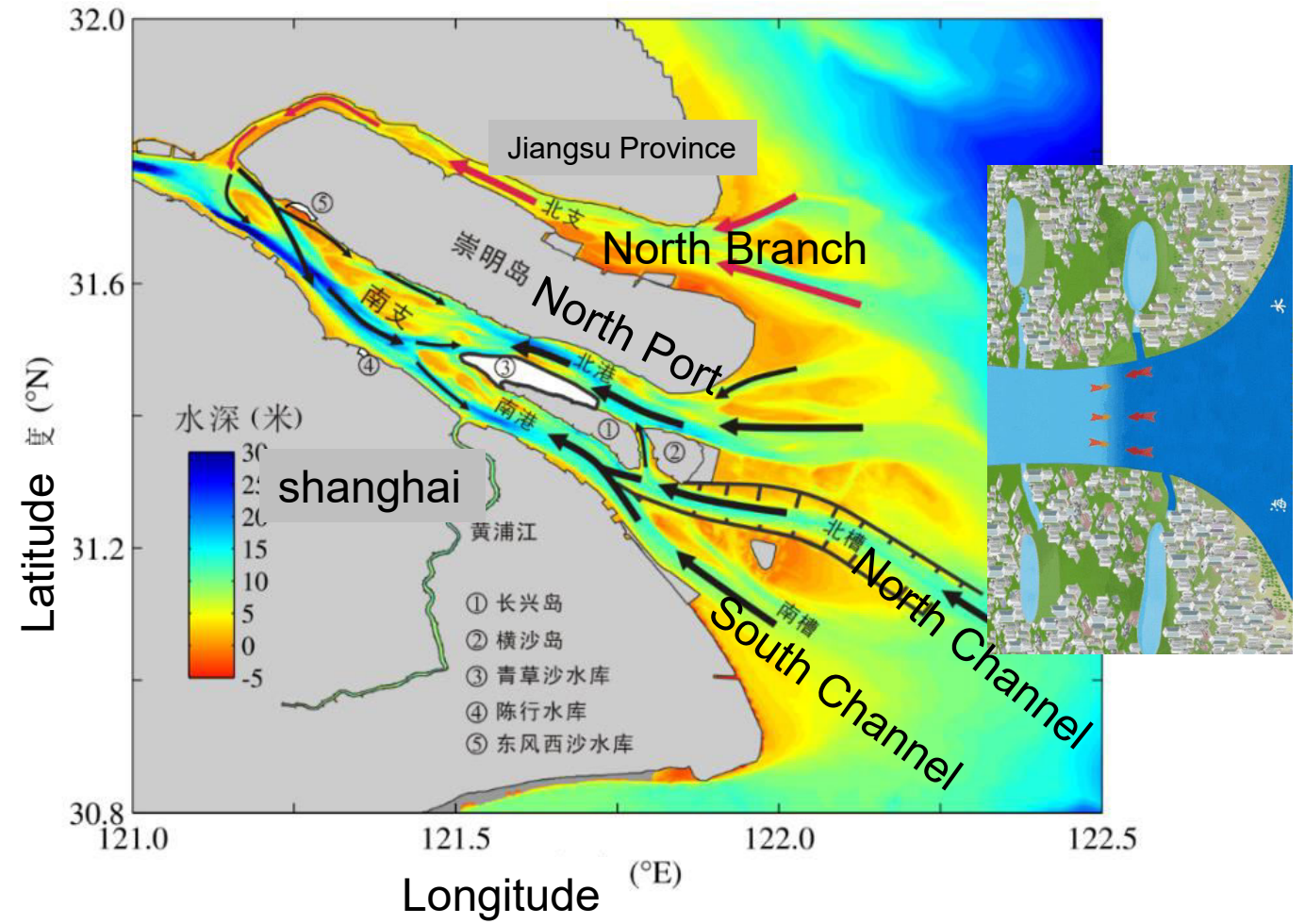
Reservoir	Storage (million m3)	Supply Water (million m3/d)	People (million)	Safe supply days (day)	Supply area
ChengHang	8.33	2.28	5.3	6	Raw water for water suppliers in Jiading, Baosha and north central city
DongFengXiSha	8.9	0.245	0.5	26	CongMing Island water supply
QingCaoSha	<b>438</b>	<b>7.31</b>	<b>13</b>	<b>68</b>	Changxinghengsha of Congming island, Pudong district and central city
Jinze	5.25	3.51	6.7	2 ~ 3	MinXing, Fengxian, Jinshan, Qingpu and 5 districts in west-south of Shanghai





# Intrusion of saltwater at Changjiang estuary

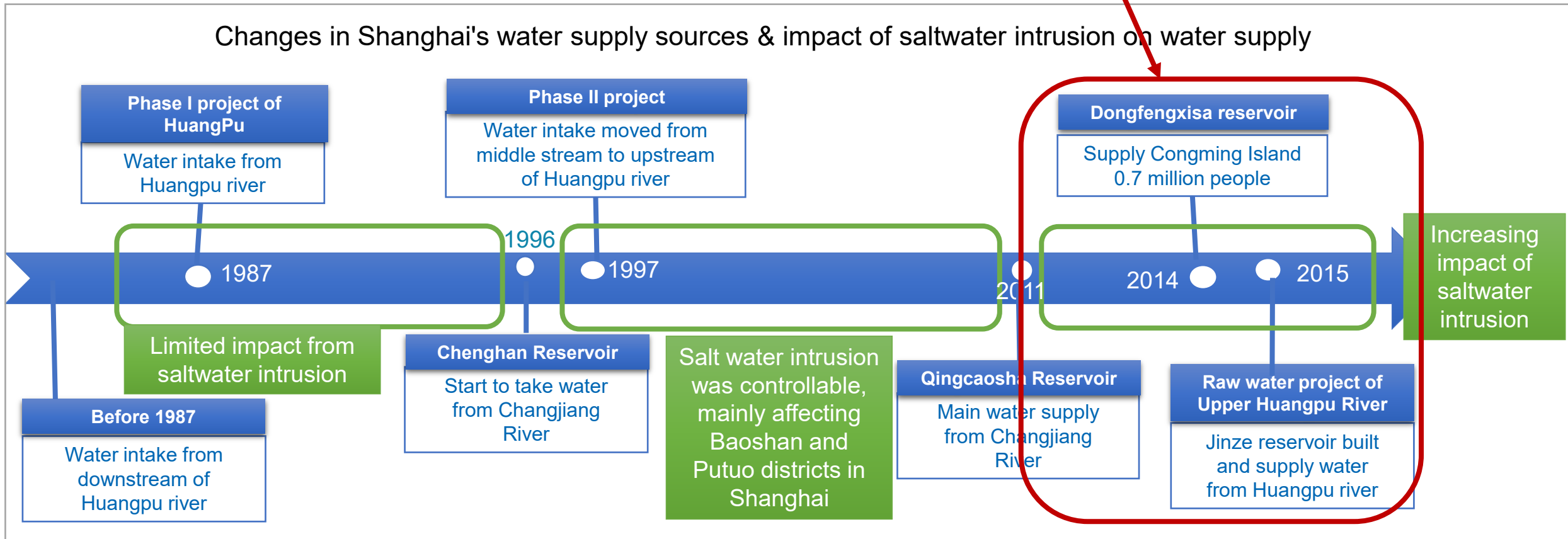
Indicator of salt water intrusion impact: the chloride concentration  $\geq 250\text{mg/L}$  and last for  $>2$  consecutive hours



# Saltwater intrusion at Changjiang estuary

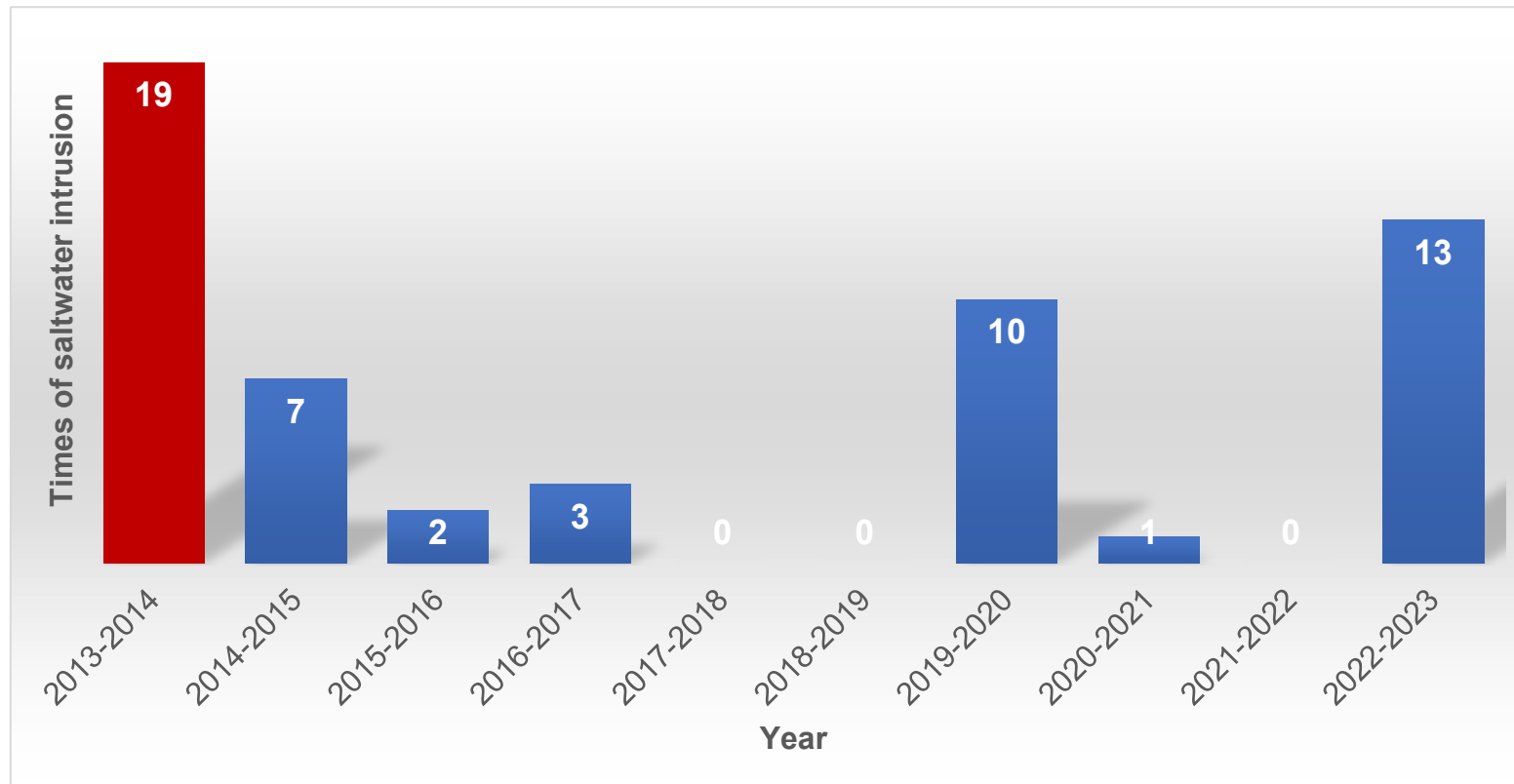
- ❑ Occurs during **Oct ~ next April**
- ❑ In **1978-1979, 1987, 2006-2007, and 2014**, the estuary area suffered from severe saltwater intrusion.
- ❑ **After 2011**, due to various factors such as the water quality deteriorating of Huangpu River, the sources of water supply gradually shifted to the **Changjiang River**, the impact of saltwater intrusion has increased.

Changes in Shanghai's water supply sources & impact of saltwater intrusion on water supply



# Intrusion of saltwater at Changjiang estuary

- ❑ The most serious saltwater intrusion happened in **Feb 2014**, lasted for **23 days**.
- ❑ To reduce the saltwater intrusion impacts on water supply, **special operation of Three Gorges Reservoir** was carried out which achieved remarkable results.



Statistics of saltwater intrusion during 2013 ~ 2022



News letter of the first reservoir operation to deal with saltwater intrusion

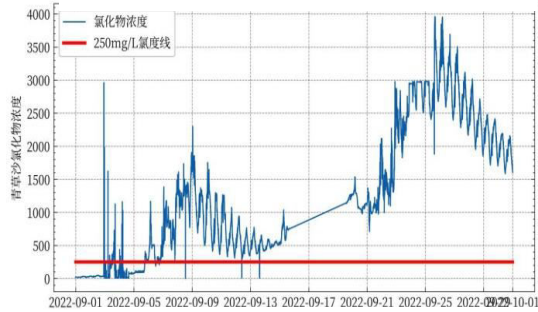
# **Saltwater intrusion in 2022 at Shanghai Estuary Area**

**Characteristics   Cause   Impacts**

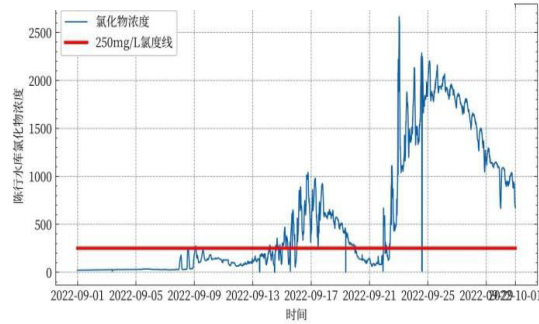
# Characteristics of saltwater intrusion in 2022

Early occurrence: Chloride concentration in Sep. is high

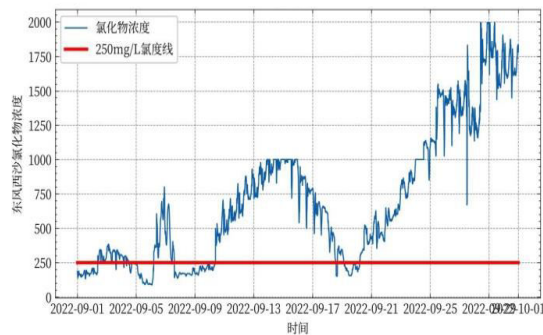
Qingcaosha R.



Chenhang R.



Dongfengxisha R.



The DongfengXisha water intake suffered the first saltwater intrusion of the year in 1-4, Sept 2022, nearly 3 months earlier than usual.

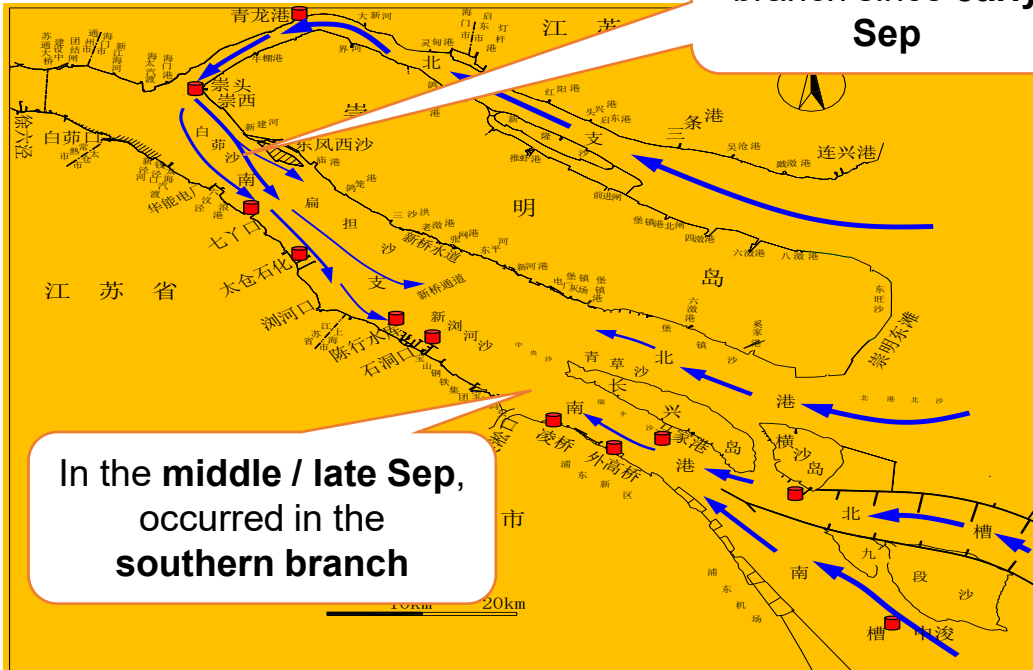
Saltwater intrusion in 2022, Long duration

Reservoir	Times	Time of first appearance	Duration of the longest session	Maximum chloride concentration at intake
Chenghang	5	Sept 14	26 days 12 hours (Sept 21 - Oct 18)	2166mg/L
Qingcaosha	1	Sept 5	97 days 7 hours (Sept 5 - Dec 12)	3959mg/L
Dongfeng xisha	7	Sept 1	27 days 15 hours (Sept 20 - Oct 18)	2176mg/L

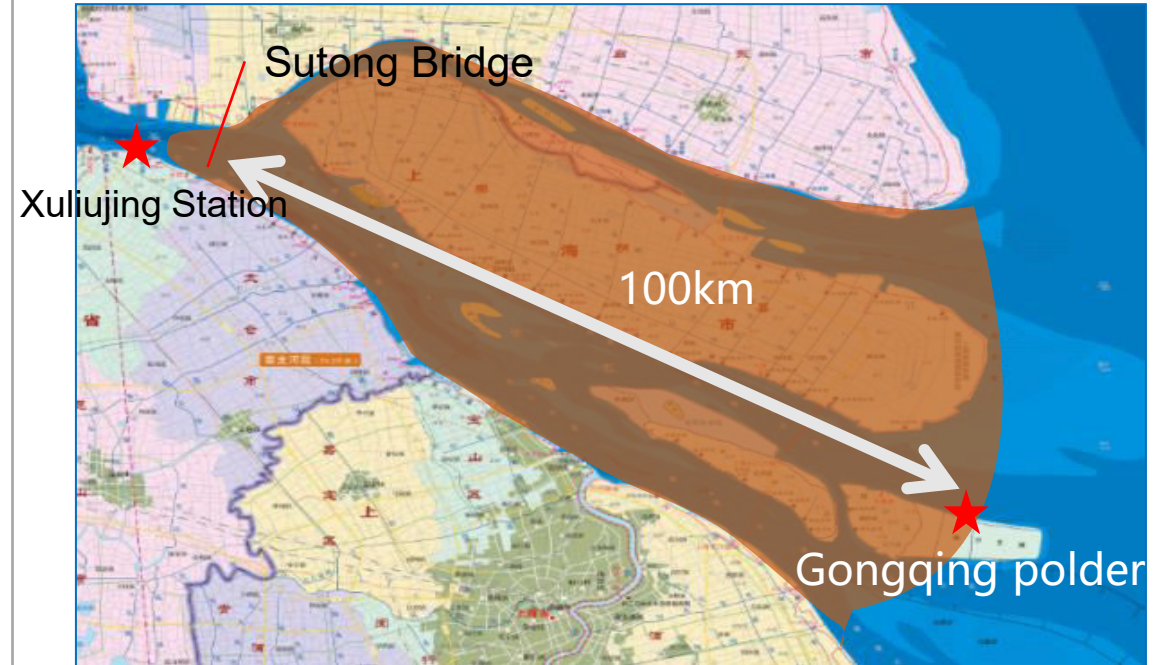
# Characteristics of saltwater intrusion in 2022

The North and South Branches are both serious

Start from **North** branch since **early Sep**



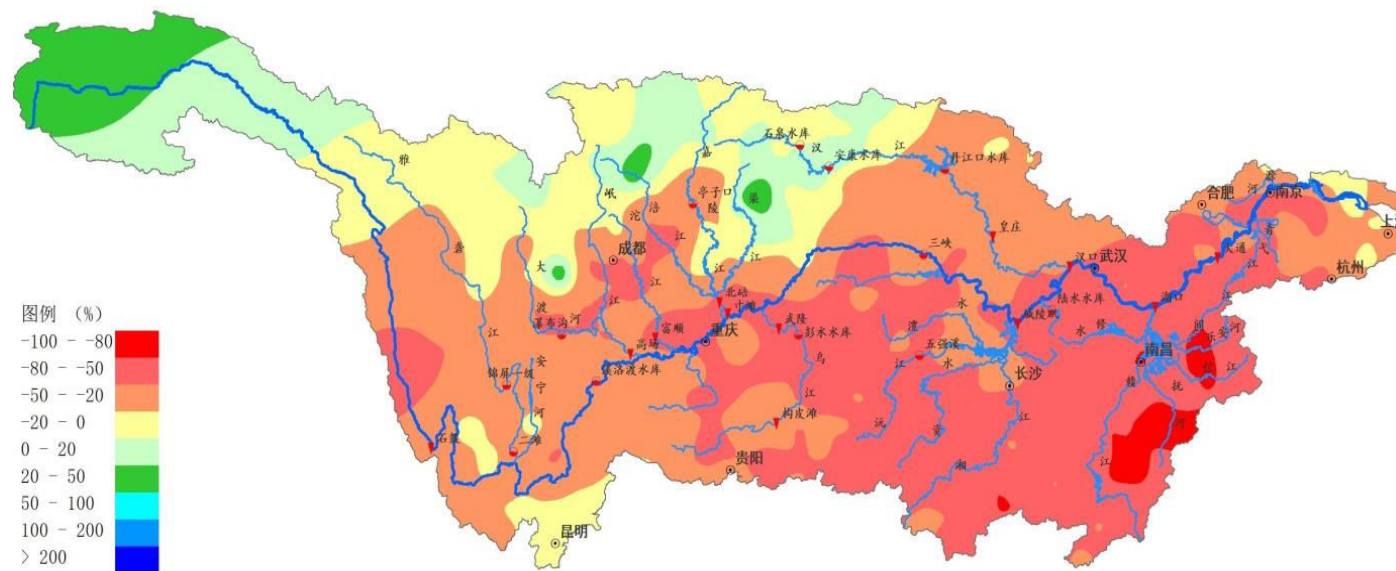
Affecting larger areas



The frontal of the saltwater reached the Sutong Bridge and approaching XuLiuJing hydrological Station

# Cause: Severe Meteorological drought happened in 2022

- July ~ Oct 2022, the cumulative rainfall in the Changjiang River Basin was **291mm**, only **61%** of the average for the **same period** in 30 years, the **lowest** for the same period since 1961.
- The average temperature and number of high temperature days were the **highest** for the same period **since 1961**.



Rainfall anomaly distribution map in Changjiang River, July ~ Oct 2022

Month	Yangtze river basin		Upper reaches		The middle and lower reaches	
	Rainfall (mm)	Reduce	Rainfall (mm)	Reduce	Rainfall (mm)	Reduce
Jul	113.6	34%	105.4	37%	123.7	32%
Aug	61.2	56%	81.8	41%	35.8	75%
Sep	67.7	33%	103.5	8%	23.3	74%
Oct	48.7	26%	50.0	19%	47.1	33%

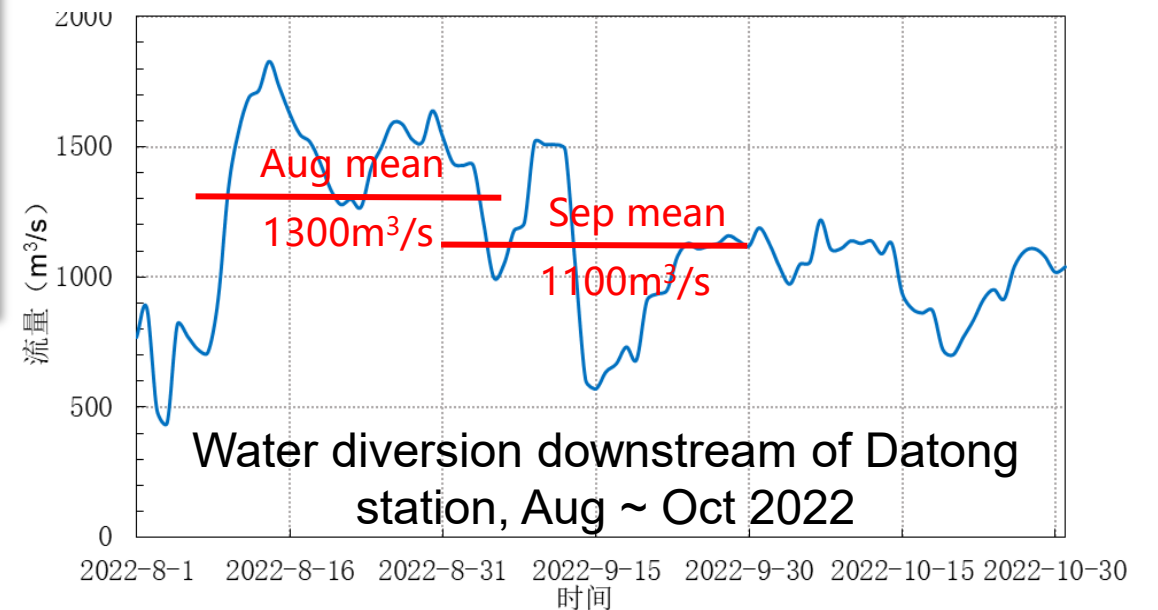
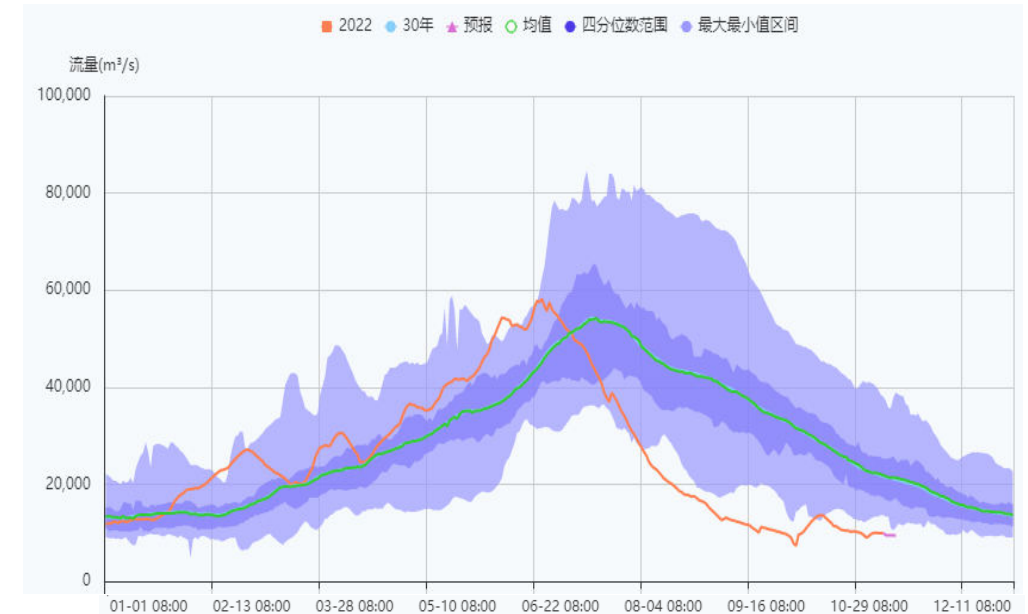
# Cause: Low water levels at Datong Station during Aug ~ Oct 2022

The **daily minimum flow** broke the historical record for the same period in the history:

- Water level: 0.85 ~ 1.5 m lower
- Discharge: 5 ~ 7% less.

**Water intake** downstream of Datong station further reduced the amount of freshwater flow to the estuary

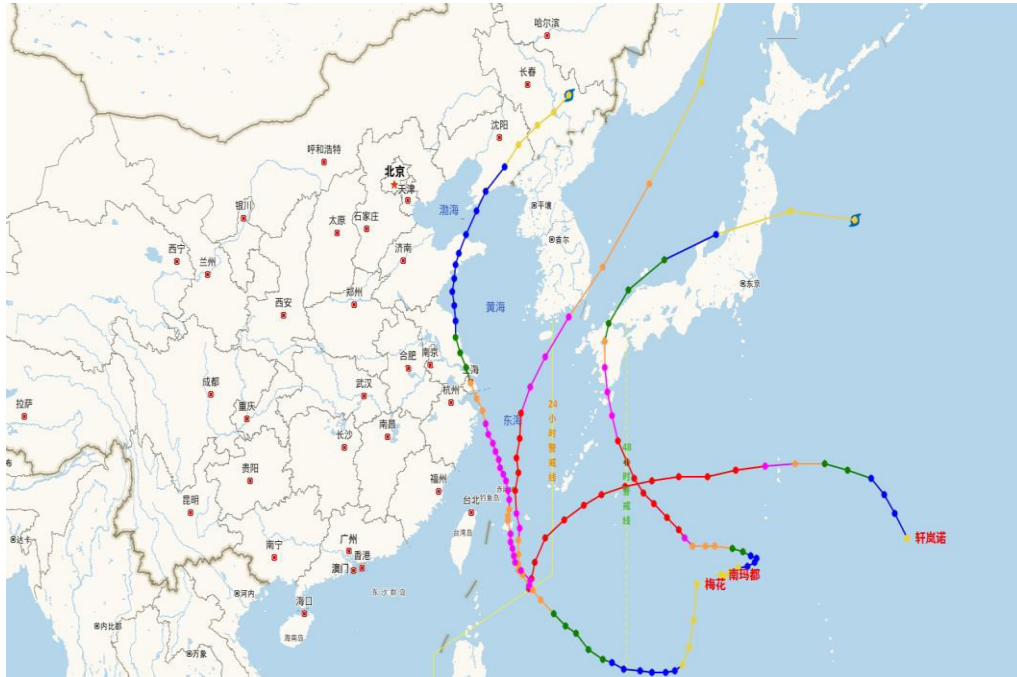
- 14 main water diversion projects
- Water withdraw are **1300 m<sup>3</sup>/s** in Aug and **1100 m<sup>3</sup>/s** in Sep, about **6 ~ 10% of the monthly average flow** at Datong Station.



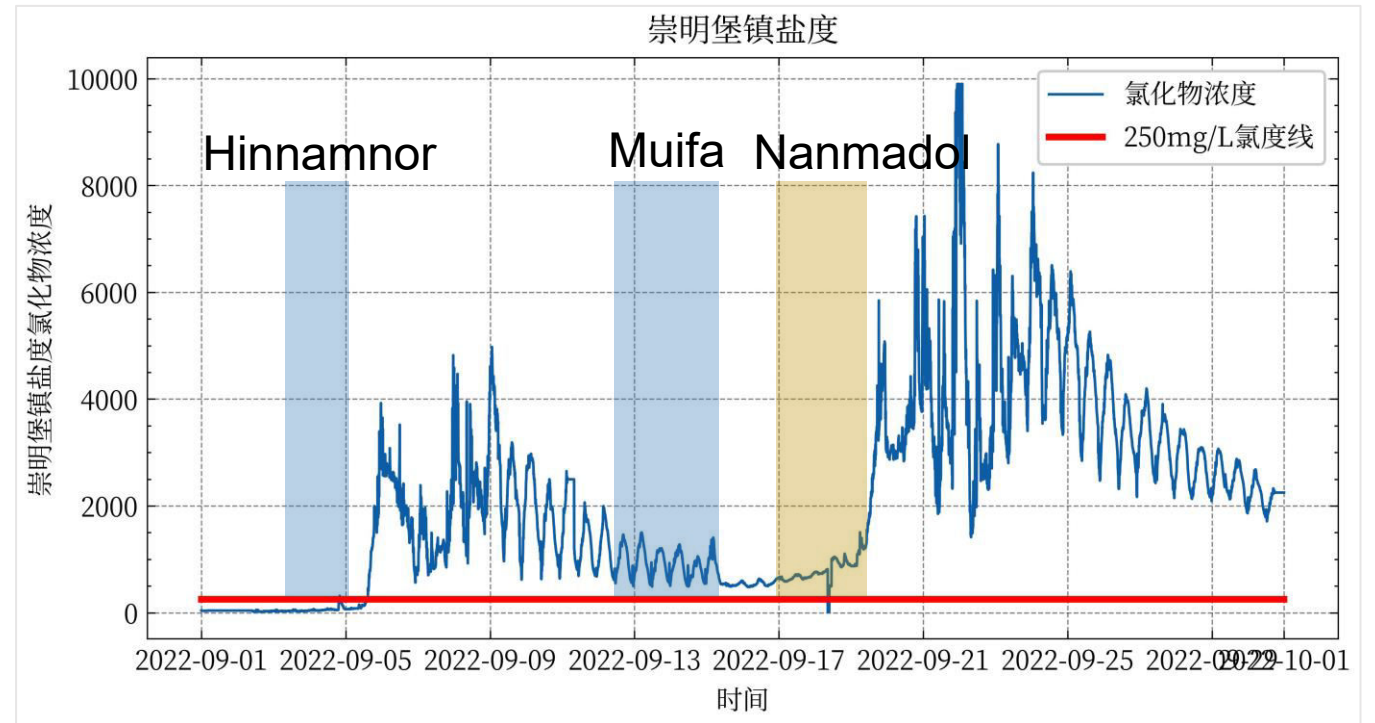


# Cause: worsen by typhoon / high tide impacts at the estuary

- ❑ In early and mid-Sep 2022, the Changjiang River estuary area was hit by **Super Typhoon Hinnamno**, Muifa, and Nanmadol, further enhanced the **saltwater intrusion**.



Typhoon Track Map



The influence of typhoon on salt tide

# Impacts to Shanghai Water supply from Saltwater Intrusion

- Starting from **early September**, saltwater intrusion began to occur in various reservoirs for water supply and was estimated would last for a long time **if no measures to be taken (till end Oct)**.

water resources	Water level (m)	usable storage (million m <sup>3</sup> )	Water supply population (million)	Cut-off time for safe water supply	<b>Expected cut-off time</b> for water supply if emergency regulation was not undertaken
ChenHang	4.08	351	530	Oct 20	<b>After Oct 26</b>
Qingcaosha	1.31	8200	1300	Oct 26	Around Oct 22
Dongfeng xisha	2.77	174	50	Oct 24	<b>No water supply until December</b>

02

第二部分

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应对措施  
Measures & Solutions

## Strengthen the consultation on reservoir regulation



### Ministry of Water Resources of China

- ❑ On Sep 27, Minister **Mr. Li Guoying** chaired consultation meeting to fight against saltwater intrusion to protect water supply
- ❑ Launched a **special program** to "resist salty tides and ensure Shanghai's water supply"

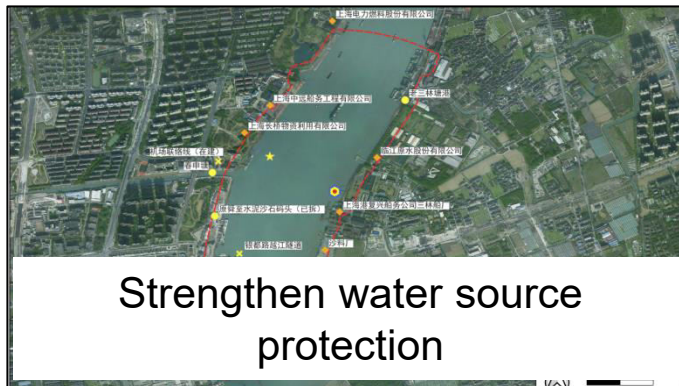
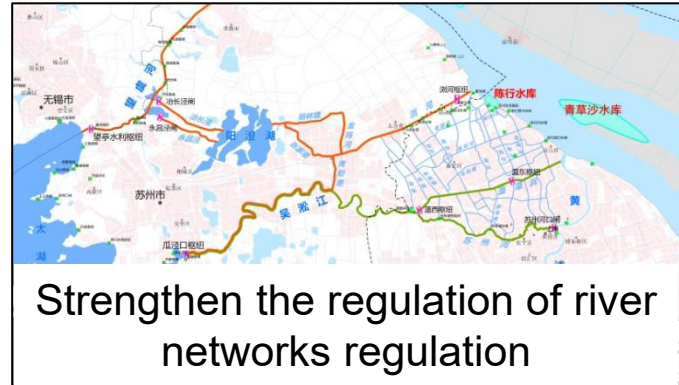
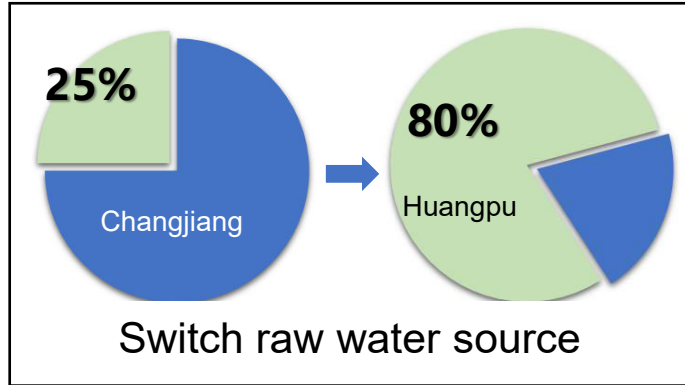


### Changjiang Water Resources Commission

- ❑ Conducted **8** consecutive rolling consultations
- ❑ Convened a plenary meeting of the Leading Group on Water and Drought Disaster Defense

# Adopt Integrated response plan

To mitigate saltwater intrusion impacts, **integrated response plan** involving multiple measures were adopted.



Implement ensuring plans to secure water supply

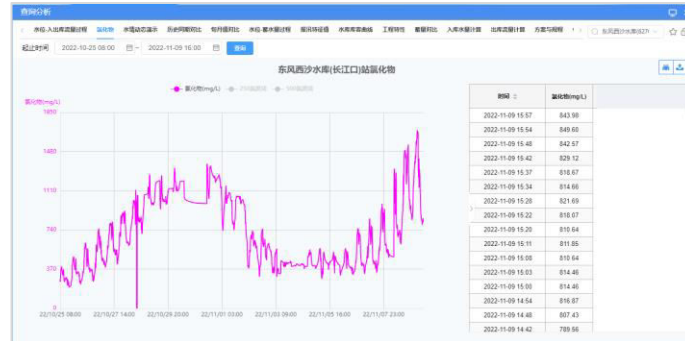
# Main measures: Emergency monitoring & Information sharing

Strong cooperation has been developed between **CWRC** and **Taihu Lake Bureau**, **Shanghai Municipality**, **Jiangsu Province** and **Anhui Province**:

- ❑ Real-time **data sharing** on 34 water diversion projects, 46 chloride monitoring stations, 3 water intake reservoirs.
- ❑ **Special** monitoring, analysis and research have been carried out jointly.



Emergency monitoring



## 长江口咸潮入侵应急专项监测简报

(第 01 期)

长江口水文水资源勘测局

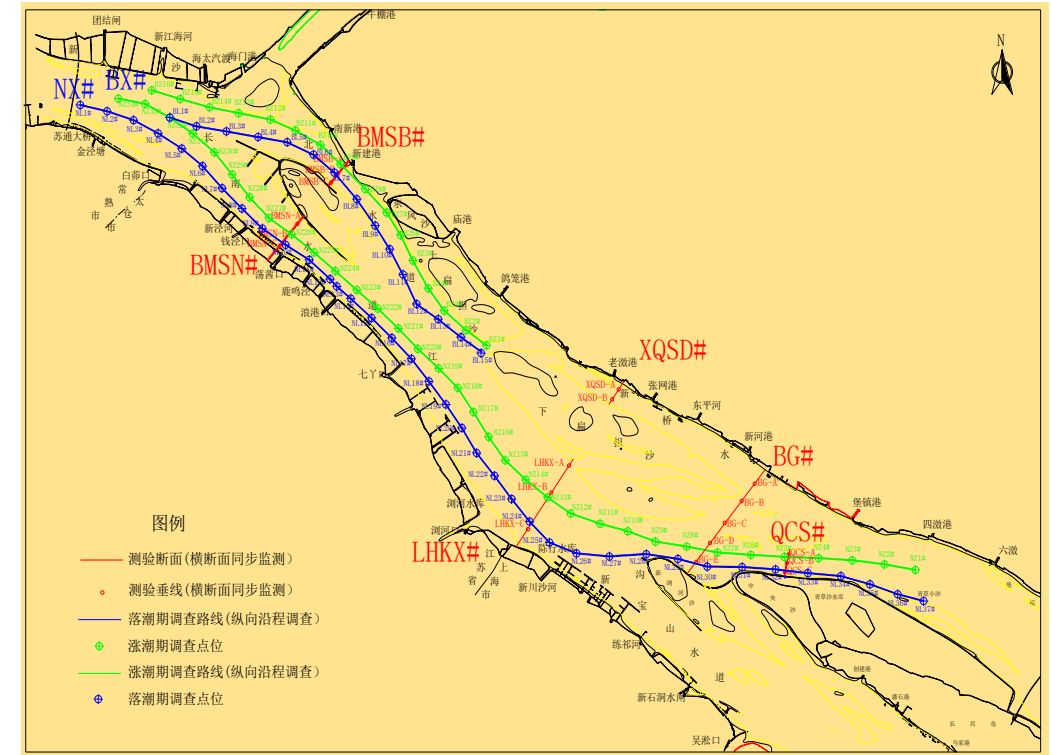
2022 年 10 月 17 日

### 一、水情信息

#### 1、上游来水

昨日，大通站日均流量 13500m<sup>3</sup>/s；今日 8 时大通站流量 13100m<sup>3</sup>/s，三峡水库库水位 158.33m，入、出库流量分别为 9000m<sup>3</sup>/s、8160m<sup>3</sup>/s；对应大通站提前 5-7 天平均流量为 12100m<sup>3</sup>/s。

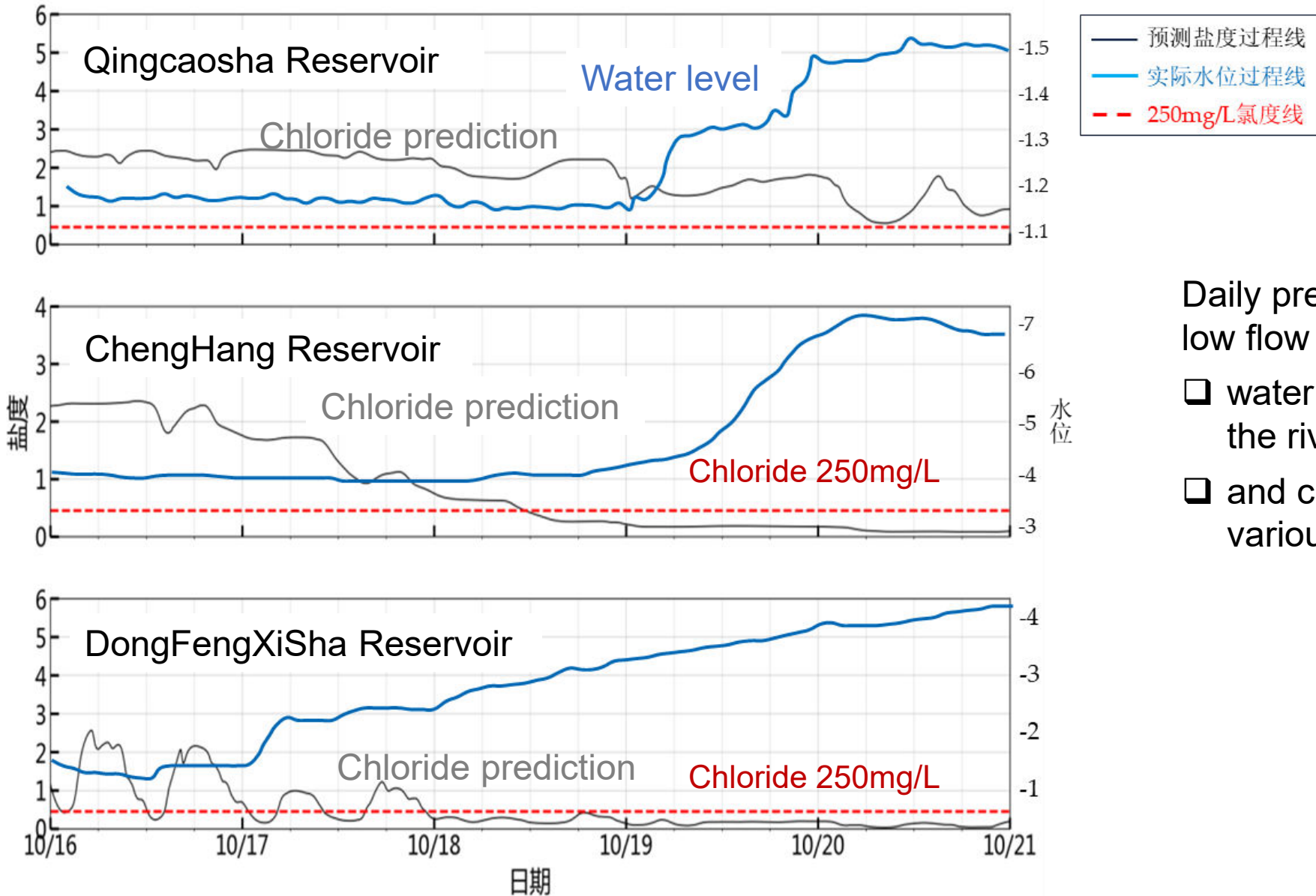
大通站流量过程见图 1。



Distribution of monitoring sections

Timely Briefing Releases

# Main measures: timely flow and chloride prediction

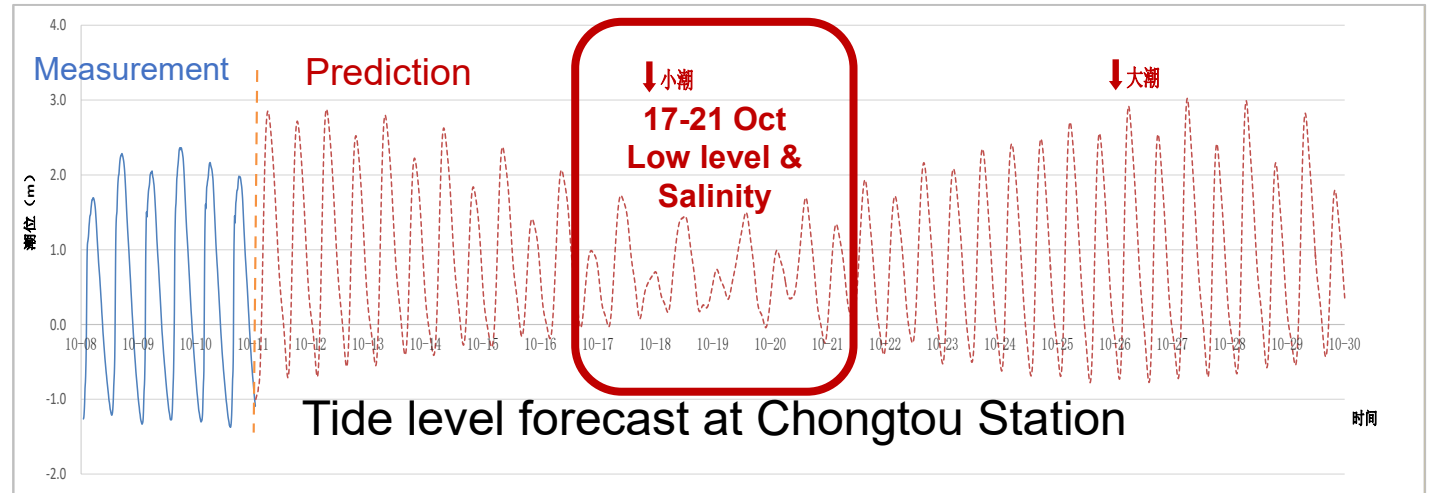


Daily prediction has been made on low flow which involves:

- ☐ water level and discharge along the river,
- ☐ and chloride concentration at various places at the estuary area.

# Main measures: Reservoir regulation – water and salinity prediction

- ❑ Prediction: **Oct 19** will be the **lowest** tide level at the estuary, **17-21 Oct** will be the **low salinity period** when reservoirs can take water from the river.
- ❑ Combined with **flow prediction**, to mitigate salinity impacts, the **window period for compensation water release** from the Three Gorges Reservoir was **2-11 Oct**.



River Reaches from Three Gorges Reservoir (km)	Effect time (day)	Arrival time of Maximum water rise (day)
Luoshan 501	1.5	2
Hankou, 711	3	3.5
Hukou, 1010	4	6.5
Datong, 1222	5.5	8
Estuary, 1925	9.5	<b>13</b>

**Effect time (day):** the propagation time from the Three Gorges reservoir of increased discharge to the beginning of each river reaches

**Arrival time Maximum water rise rate (day):** the propagation time from the Three Gorges reservoir release to the river reach when the maximum rate of water level rise is obtained.



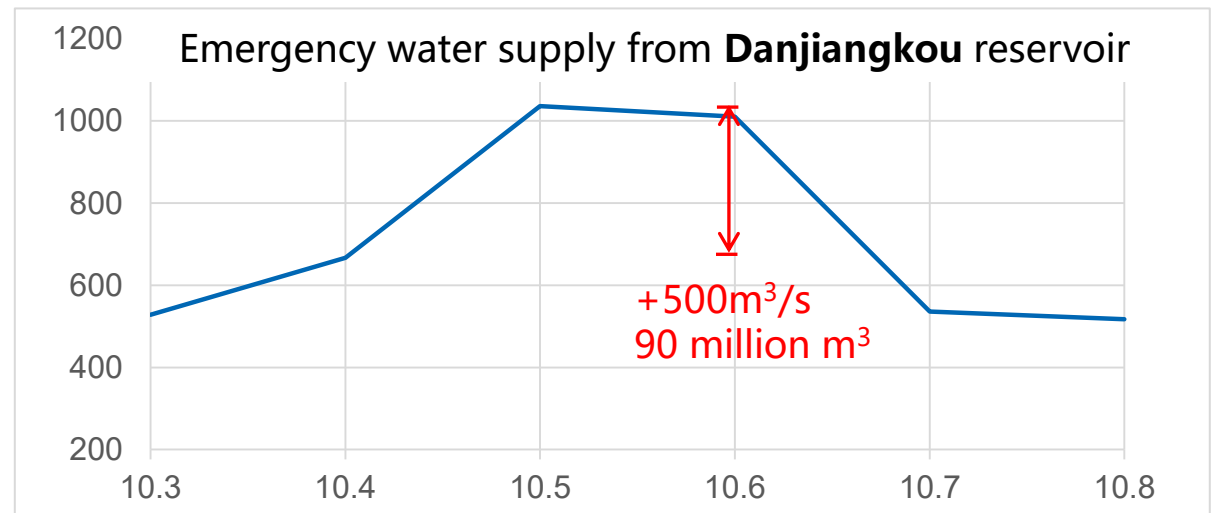
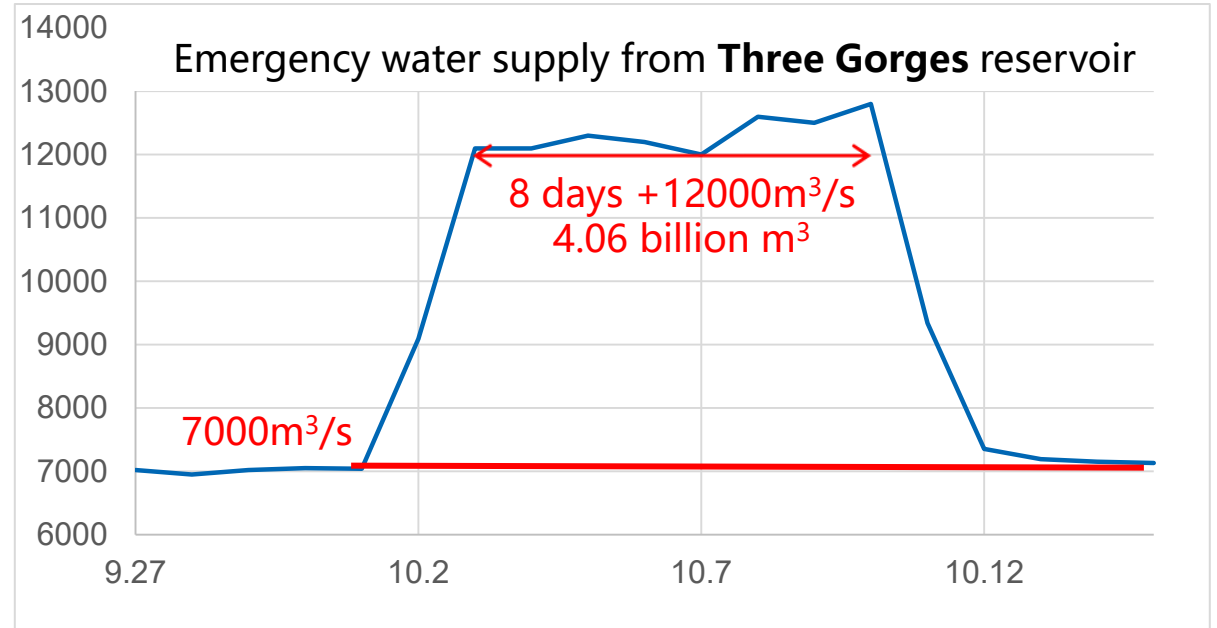
# Main measures: Reservoir regulation for water supply

## Discharge Water from Three Gorges Reservoir:

- 2 Oct: daily average discharge from 7,000 m<sup>3</sup>/s to 9,000 m<sup>3</sup>/s
- 3-7 Oct: further increased to **12,000 m<sup>3</sup>/s**.
- 8-10 Oct: further increased to **12,500 m<sup>3</sup>/s**
- 10-12 Oct: gradually decreased to 7,000 m<sup>3</sup>/s.

## Discharge water from Danjiangkou reservoir:

- 5-6 Oct: increase discharge to 1,000 m<sup>3</sup>/s,



# Main measures: Reservoir regulation for water supply

In total, from upstream reservoirs **4.153 billion m<sup>3</sup>** water were discharged to mitigate the saltwater intrusion problem for Shanghai:

- ❑ The Three Gorges Reservoir released **4.06 billion m<sup>3</sup>**:
- ❑ Danjiangkou reservoir released **90 million m<sup>3</sup>**

Compensation regulation of Three Gorges Reservoir during 1-11 Oct 2022

Time	Reservoir inflow (m <sup>3</sup> /s)	Reservoir inflow (m <sup>3</sup> /s)	Cumulative increase in water supply (100 million m <sup>3</sup> )
Oct 1	10100	7040	0
Oct 2	9280	9090	1.81
Oct 3	8050	12100	6.21
Oct 4	7400	12100	10.62
Oct 5	12000	12300	15.20
Oct 6	20400	12200	19.69
Oct 7	24400	12000	24.01
Oct 8	19900	12600	28.85
Oct 9	12300	12500	33.60
Oct 10	10300	12800	38.61
Oct 11	10900	9340	40.63

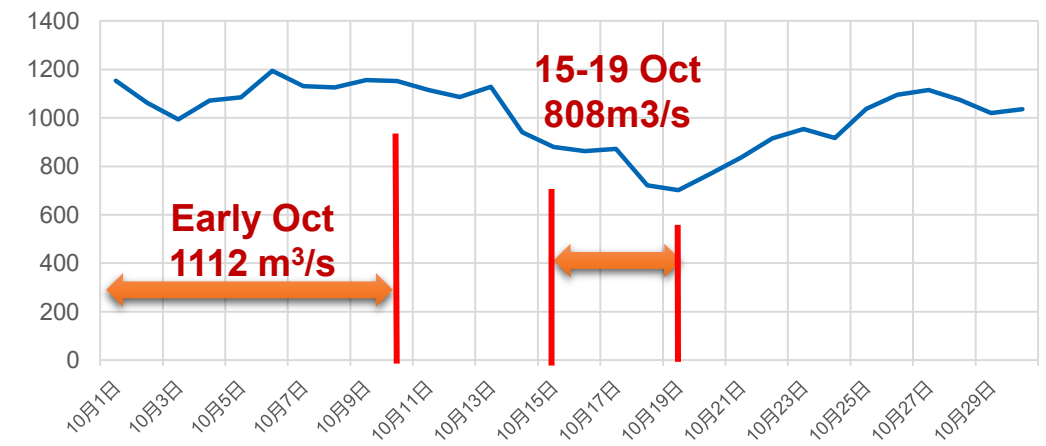
# Main measures: control water intake along the river

- ❑ Coordinated with **Anhui and Jiangsu provinces**, **reduced** daily water intake for 14 major water diversion projects.
- ❑ **15-19 Oct**, water intake decreased by 26% (Jiangsu) and 66% (Anhui), compared with the first half of October.

Time	Diversion flow of Anhui Province (m <sup>3</sup> /s)	Diversion flow of Jiangsu Province (m <sup>3</sup> /s)	Total of 14 water diversion projects (m <sup>3</sup> /s)
Early Oct	43.5	1069	1112
15-19 Oct	14.7	793	808
Reduced water amount	28.8	276	304
Reduction ratio	66%	26%	<b>27%</b>



14 water diversion projects upstream of Shanghai



Control water intake process of 14 diversion projects

03

Part 3

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成效  
Results



# Increased discharged at Datong station significantly

**13700** m<sup>3</sup>/s

Maximum Discharge

**9** day

Duration of flow above  
12000 m<sup>3</sup>/s

**17** day

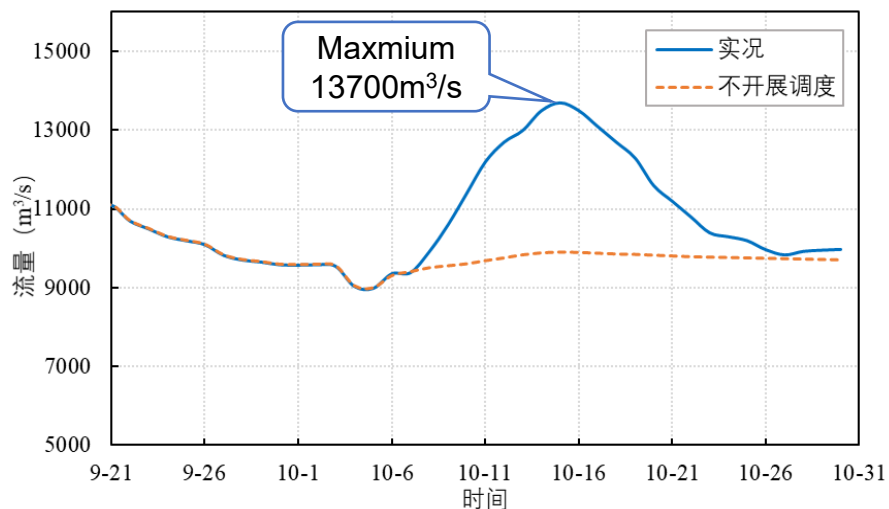
Duration of flow above  
10000 m<sup>3</sup>/s

**4000** m<sup>3</sup>/s

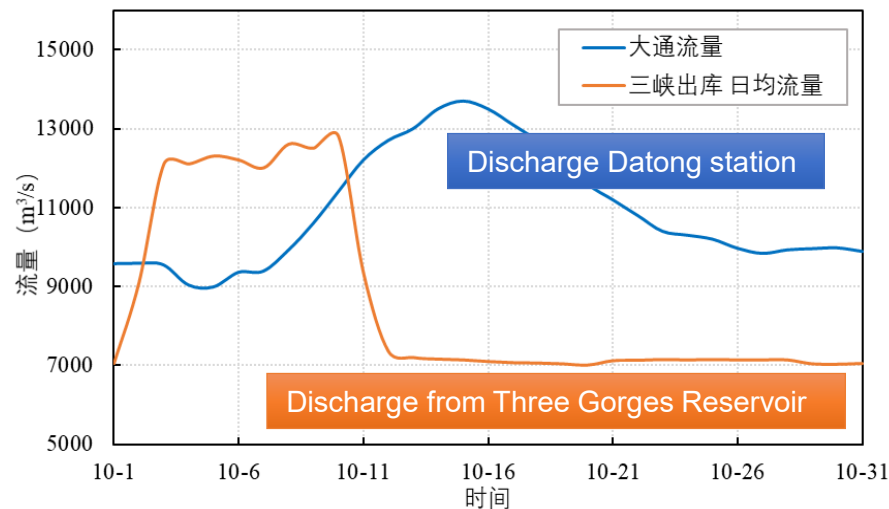
Maximum increase in  
flow discharge

**40**%

Increasing range of  
water flow



Daily discharge with & without water compensation at Datong Station



Discharge of Three Gorges reservoir and Datong Station in October

<b>三峡出库流量:</b>	<b>9000</b>	<b>→</b>	<b>12000</b>	<b>→</b>	<b>12500</b>
(立方米/秒)	10月2日		10月3日		10月10日
<b>大通日均流量:</b>	<b>9500</b>	<b>→</b>	<b>13700</b>	<b>→</b>	<b>11600</b>
(立方米/秒)	10月初		10月15日		10月20日

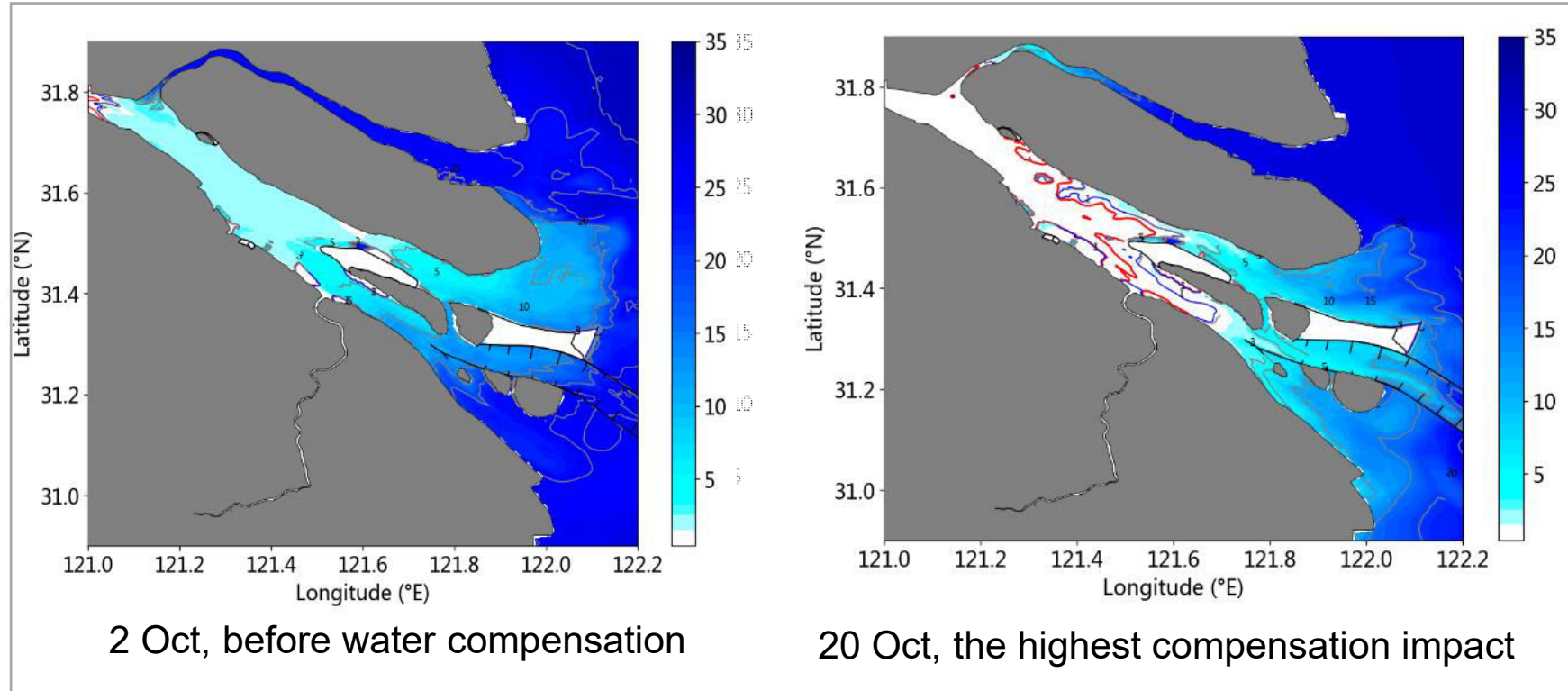
# Reduce the chloride concentration at the water intake section

Reservoir	Items	Without Compensation	With Compensation	Comparison items
Chenhang	Average chloride concentration (mg/L)	600	350	
	Minimum concentration (mg/L)	350 (20/Oct)	100 (20/Oct)	
	Number of days water can be taken (d)	0	8	
Dongfengxisha	Average concentration of chloride (mg/L)	850	660	
	Minimum concentration (mg/L)	200 (20/Oct)	55.4 (20/Oct)	
	Number of days water can be taken (d)	4	8	
Qingcaosha	Average concentration of chloride (mg/L)	1350	1050	
	Minimum concentration (mg/L)	<b>750 (20/Oct)</b>	<b>257 (20/Oct)</b>	
	Number of days water can be taken (d)	0	Created window for water intake	

Note: The statistics period is 10-26 Oct

# Push down the salt water and tidal frontal

- ❑ **16 Oct**, the 250mg/L demarcation line for the high & low tide periods in the **South Branch** was shifted downward by **10-20km**.
- ❑ **Mid-Oct**, when the **maximum impact** of compensation water is reached, the frontal he dividing line is shifted downward to the central sand head, and the 250 mg/L dividing line is **further push down by >20 km**.



The impact of **joint operation of reservoirs** on the frontal of saltwater intrusion

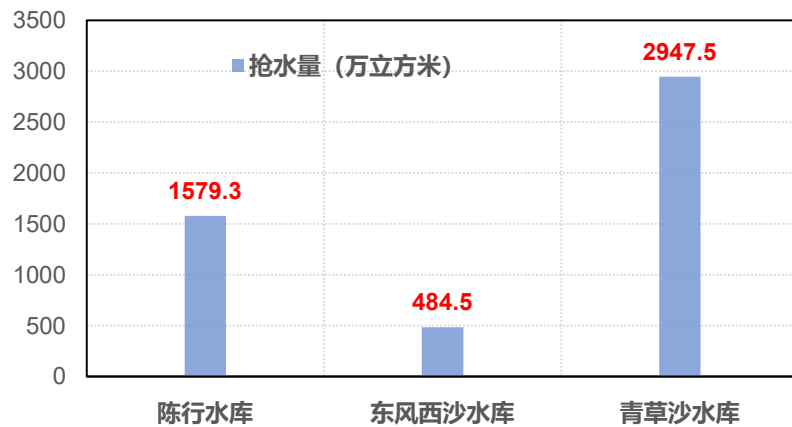
Comparison items	No joint operation	Joint operation
The upward movement of the 250mg/L chlorinity line.	To Sutong Bridge (above Bai Mao)	More than 20km downward movement

# Alleviate the stress on water supply in Shanghai

□ 19-31 Oct, a total of 50 million m<sup>3</sup> of emergency water was supplied to the 3 reservoirs:

- Chenhang & Dongfengxisha reservoirs were nearly full.
- Qingcaosha reservoir was filled with 29.47 million m<sup>3</sup> low-salinity water from the Changjiang River.

□ The average daily water supply of 1.3 million m<sup>3</sup>, the amount of water withdrawn during the water compensation period can meet the water demand for ~ **40 days**.



Water withdrawn for 3 reservoirs



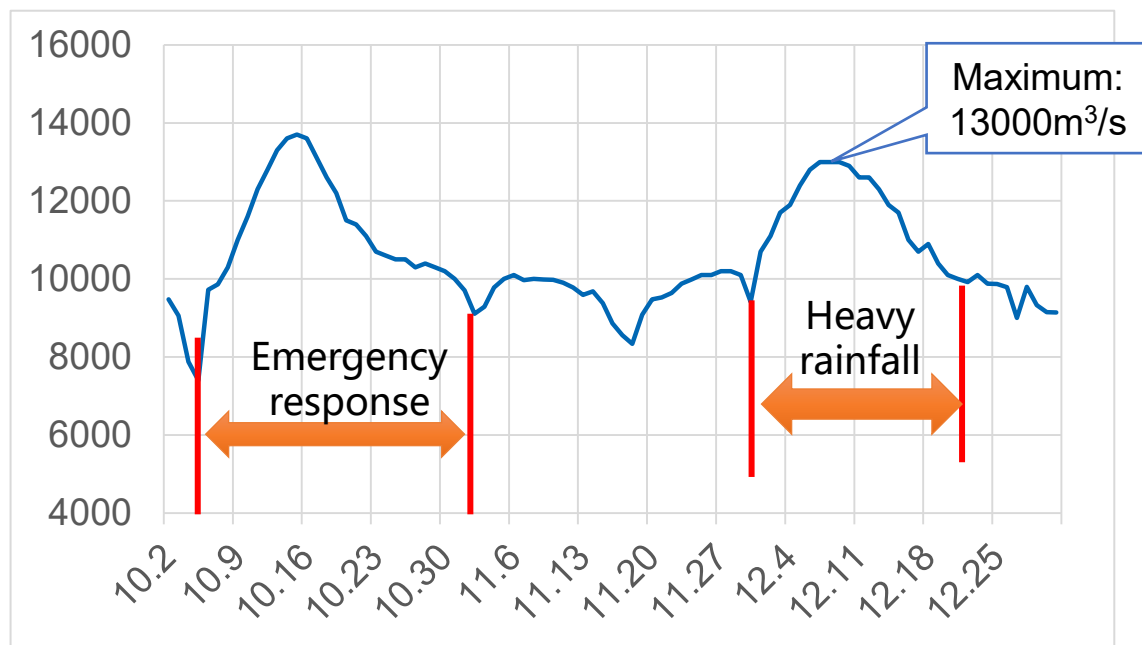
The water level of Qingcaosha Reservoir has significantly increased



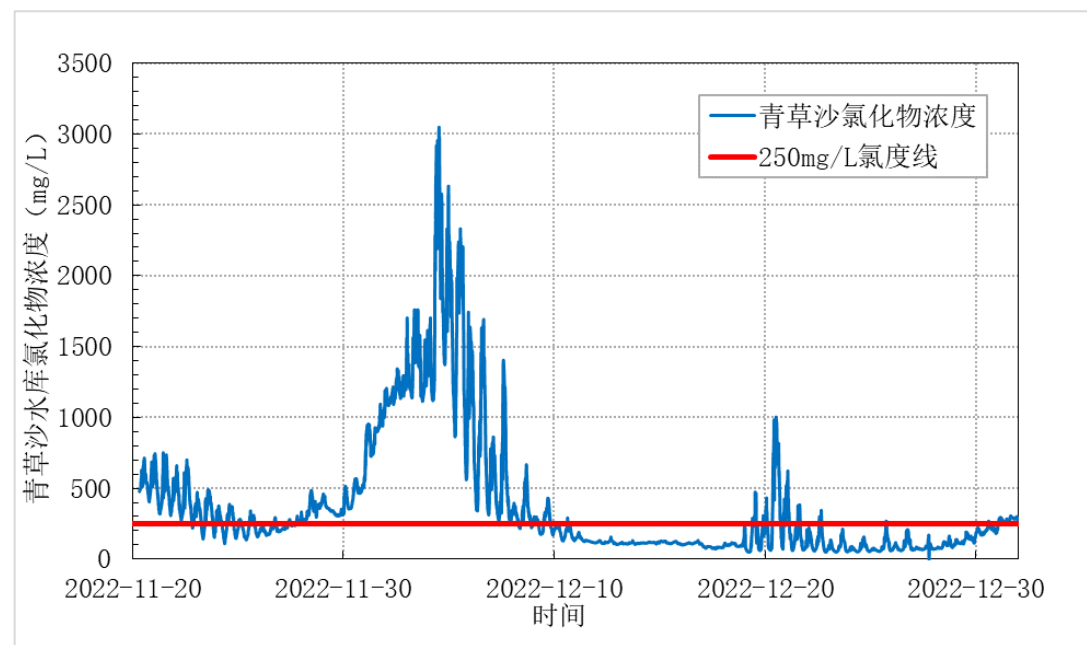


# Ensured water supply for the coming winter and spring in Shanghai

- ❑ Water supplied from reservoirs upstream + relatively big rainfall during LateNov~EarlyDec, there saltwater intrusion pressure was successfully mitigated.
- ❑ Qingcaosha Reservoir officially ended saltwater intrusion emergency response on 12 Dec, the **water supply crisis** was resolved. The winter and spring water supply security of Shanghai has been guaranteed.



Discharge hydrograph at Datong Station  
Oct~Dec, 2022



Salinity at Qingcaosha Reservoir  
Late November ~ December, 2022

04

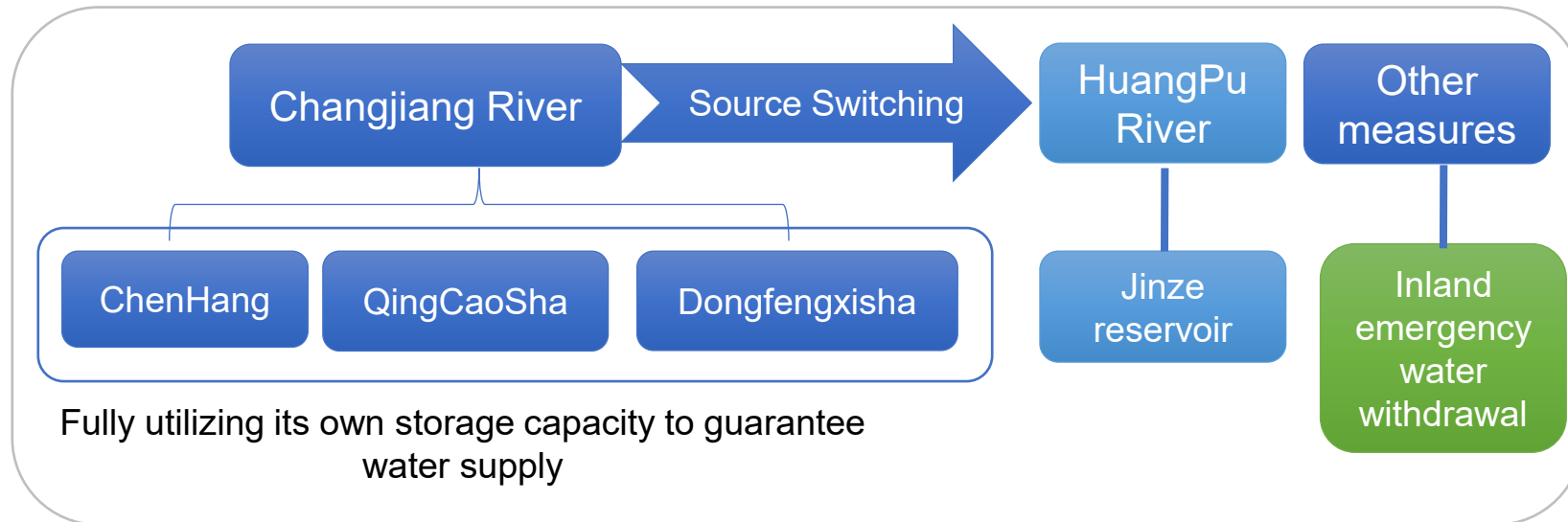
Part 4

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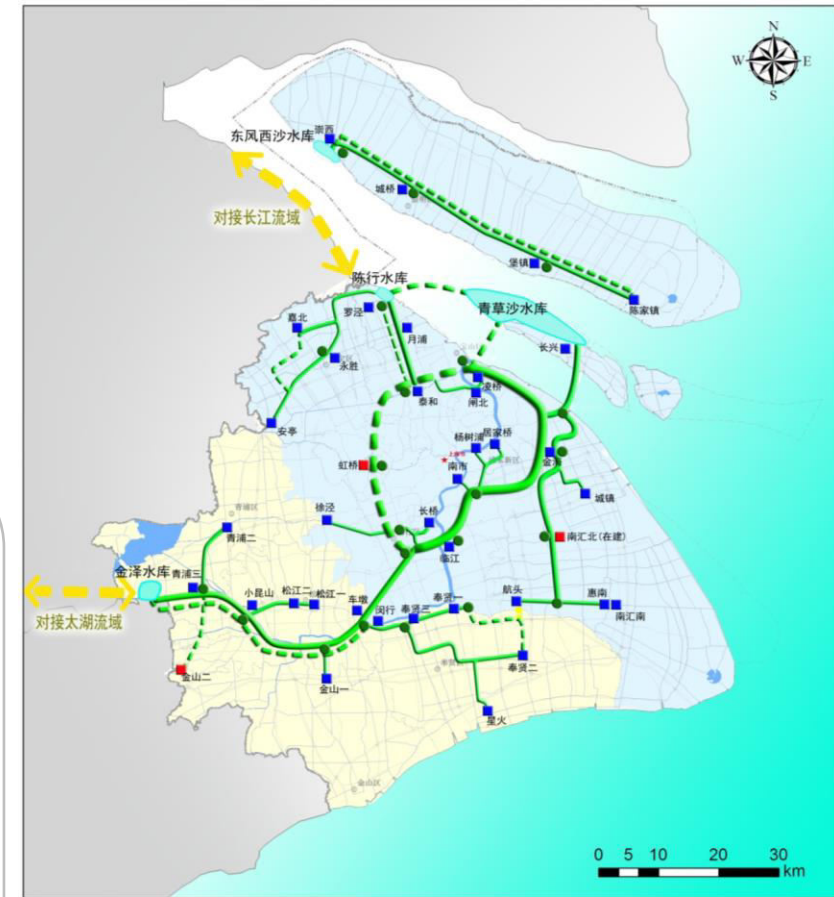


# A comprehensive and flexible water supply system was the basic insurance

- ❑ Make full use of the water source system and **timely switched the main water source to the HuangPu River**
- ❑ The 3 major **water storage** have been fully used, which has gained **time** for the subsequent water regulation of upstream reservoirs.



Integrated Regulation of Water Supply Network

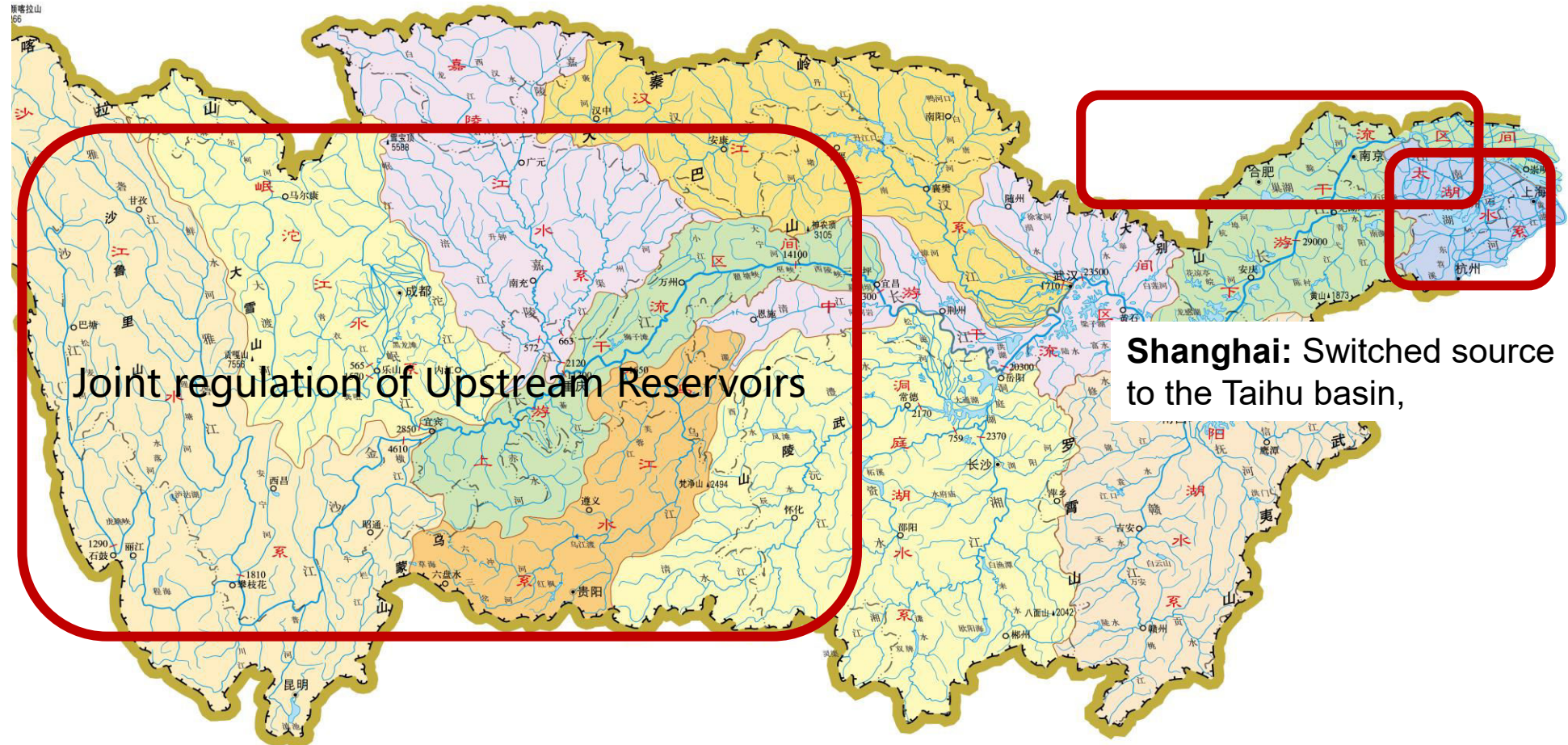


Water supply planning of Shanghai

# The basin-wide coordination & cooperation play a significant role

## CWRC

- ❑ Carried out emergency water regulation of Three Gorges Reservoir.
- ❑ Jointly regulated reservoirs upstream increased water storage by 14.2 billion m<sup>3</sup> in advance, creating conditions for water compensation for downstream.
- ❑ Coordinated needs from shipping, water supply, power generation, and water impoundment of reservoirs



## Anhui & Jiangsu provinces:

reduced water intake of water diversion projects along the river.

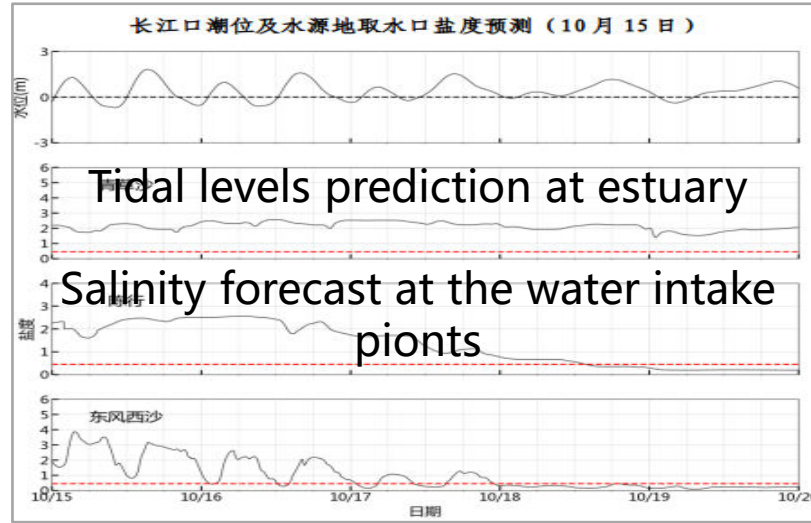
Joint regulation of Upstream Reservoirs

Shanghai: Switched source to the Taihu basin,

# Timely and accurate monitoring and forecasting provided strong support

## Supports provided:

- meteor-hydrological monitoring and forecasting,
- reservoir group joint operation
- tracking / monitoring / prediction of salinity
- low flow routing
- analysis of timing of action



## 长江水情预警

(第3期)

水利部长江水利委员会水文局 2022年9月15日15时

### 枯水黄色预警

Timely issuance of early warnings



水利部长江水利委员会水文局 2022年9月15日15时发布长江中下游干流及洞庭湖湖区、鄱阳湖湖区枯水黄色预警。

## 水利部长江水利委员会发电

等级 明电 长江电〔2022〕34号

### 长江水利委员会关于做好近期抗旱工作的通知

湖北、湖南、江西、安徽、江苏省水利厅：  
7月上中旬，长江流域降水量偏少3成多，其中，长江上游偏少近4成，中下游偏少近3成，流域各分区均偏少，尤其是长江下游干流及鄱阳湖水系偏少5成左右，7月上中旬降水量均为近10年同期最少，根据预测分析，7月下旬至8月，两湖水系降水仍将持续偏少，考虑到未来较长一段时间的持续晴热高温少雨天气，长江中下游地区可能会出现阶段性旱情，部分地区可能供水紧张。请你们提高警惕，认真贯彻落实习近平总书记关于防汛抗旱工作的重要指示精神和党中央、国务院决策部署，提高政治站位，增强底线思维，提前做好防范中下游地区可能发生夏旱的各项准备工作。

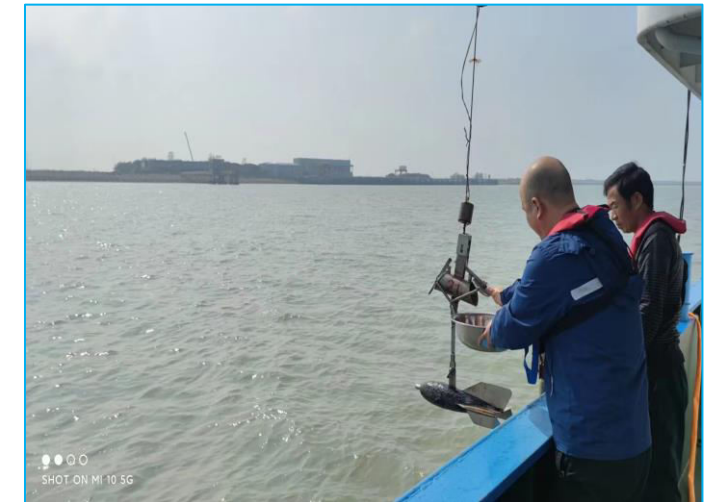
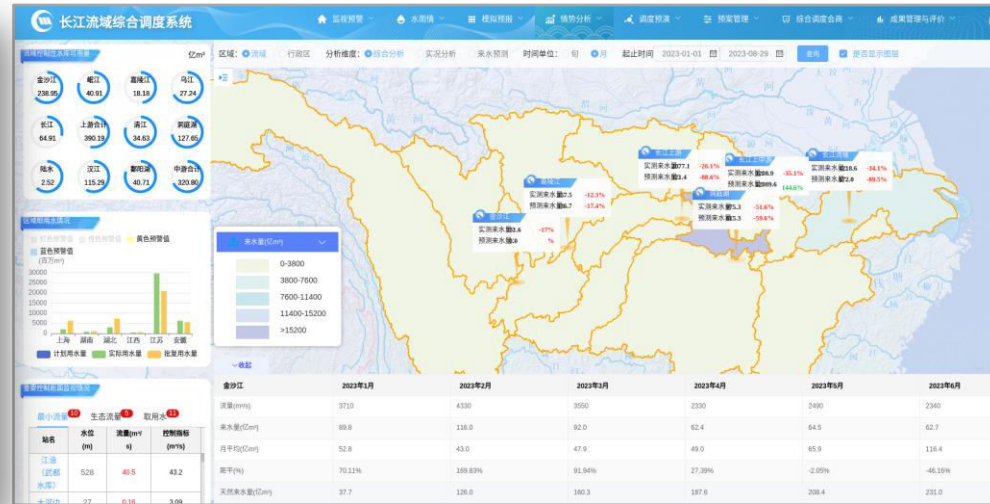
**一要强化组织领导**，充分认识做好抗旱保供工作的重要性，坚持人民至上、生命至上，克服麻痹侥幸、靠天等思想，

## 汛(旱)情通报

水利部长江水利委员会编

2022年8月23日 第20期 签发: 胡向阳

7月以来，长江流域大部地区降水偏少，流域降水量较30年均值偏少近5成，为1961年以来同期最少，受其影响，长江干支流来水量较常年偏少2-8成，上中游来水量为1949年以来同期最少。其中，8月上中旬，流域来水总体偏少5成，上游主要支流及两湖来水偏少4-7成。当前，长江中下游水位维持消退态势，较历史同期大幅偏低，8月23日8时，中下游干流及两湖出口控制站水位较常年同期偏低5.83-7.03米，汉口、大通、湖口站位列8月历史最低水位倒数第1位，七里山站位列8月历史最低水位倒数第2位；洞庭湖四水合成流量和鄱阳湖五河合成流量分别退至2000立方米每秒、967立方米每秒，据水文气象预报，未来一周长江中下游干流以南仍无明显降雨过程，过程累计雨量小于10毫米的笼罩面积仍35万平方公里。考虑前期流域面上大范围、长时间干旱，长江中下游局部地区降雨虽对土壤墒情有缓解，但大部分地区旱情仍将持续。



Preparedness to respond

Decision support system

Emergency monitoring

05

Part 5

[www.cjw.gov.cn](http://www.cjw.gov.cn)



# Carry out researches on response to saltwater intrusion issues

- ❑ Characteristics of **extreme drought** of Changjiang River and its impact to saltwater intrusion
- ❑ Salty tide intrusion at the estuary of Changjiang River
- ❑ Low flow routing and prediction
- ❑ Joint regulation of reservoirs upstream to deal with water supply crisis
- ❑ Response strategy and measures



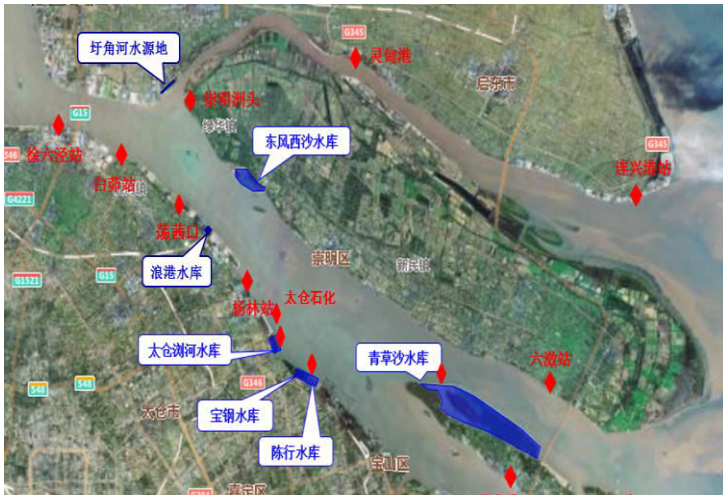
Strengthen Study on Three Gorges Reservoir's operation to deal with saltwater intrusion



Promote key scientific & technological researches on dealing with salty tides

# Strengthen salinity and tide monitoring capacity and information-sharing

- ❑ Optimize the salinity monitoring network – adopting new/advanced technologies
- ❑ Strengthen the comprehensive monitoring capability of water, sand, salt and tide in the Changjiang estuary
- ❑ Promote the establishment and regularization of a multi-party consultation mechanism
- ❑ Strengthen information sharing



Optimize the monitoring network of salinity



Improve salinity and tidal level prediction



Promote the establishment of a multi-party consultation mechanism



# Promot the planning and construction of multiple water sources in Shanghai

- ❑ The **third water source** schemes in Qiandao Lake, southern Anhui, and Dongtaihu Lake.
- ❑ Study the feasibility of improving water intake scheme: moving intake points to **upstream** for Qingcaosha and Chenhang Reservoir, and construction of a **new backup water intake point**, Construction of a **dam** in the northern branch, construction of **groundwater reservoir**.
- ❑ Explore and promote **seawater desalination**.



Third Water Source Program Study



Sea water desalination



Gate building for control



谢谢!

**THANKS**

