



Keeping Health Life of Yellow River:

Integrated Water and Sediment Management of Yellow River



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18 March 2009

Istanbul, Turkey

Outline:

- I. Yellow River Characteristic and Strategy of Integrated Water and Sediment Management of Yellow River**
- II. Implementation of Yellow River Water and Sediment Regulating**
- III. Main Technical Approaches and Innovation**
- IV. Success and Effectiveness Analysis**



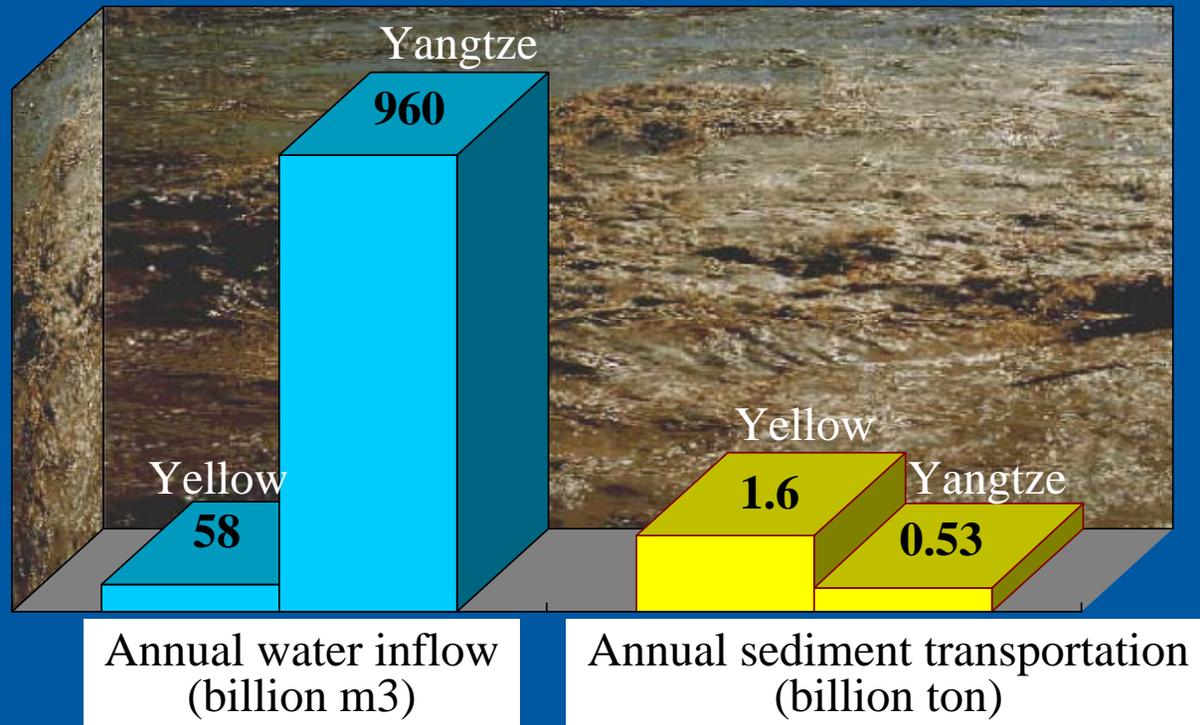
I. Yellow River Characteristic and Strategy of Integrated Water and Sediment Management of Yellow River

Yellow River Characteristics

- Less water with more sediment, disharmony of sediment and water
- Annual water inflow: 58 billion m³;
Annual sediment transportation: 1.6 billion t;
Sediment contents: 35kg/m³



Annual water inflow of YR is 6% of Yangtze, however, Annual sediment transportation of YR is 3.7 times of Yangtze, If the sediment of YR was built in a mound 1 meter high and 1 meter wide, it could circle the equator of the earth 27 times!



Yellow River in History



YR is known for its large amount of sediment, suspended river, tendency to silt, to break, to move, and frequent flood disaster;

During the past 2540 years before 1938, YR is breached averagely twice every three years and changes its course once every hundred years.

The lower YR bed was silting up 10 cm/a. The embankment of lower YR has been raised up for 4 times since 1950, with a total input of 20 billion RMB.

called as

“the Sorrow of Chinese Nation”

Yellow River in Nowadays

Carrying capacity of flood and sediment decreased;
Plain runoff reduced from 6000m³/s to 1800m³/s;
Main channel silted and shrank severely.

Large-scale overflow with only small flood;
1.8 million inhabitants suffering from the floods.

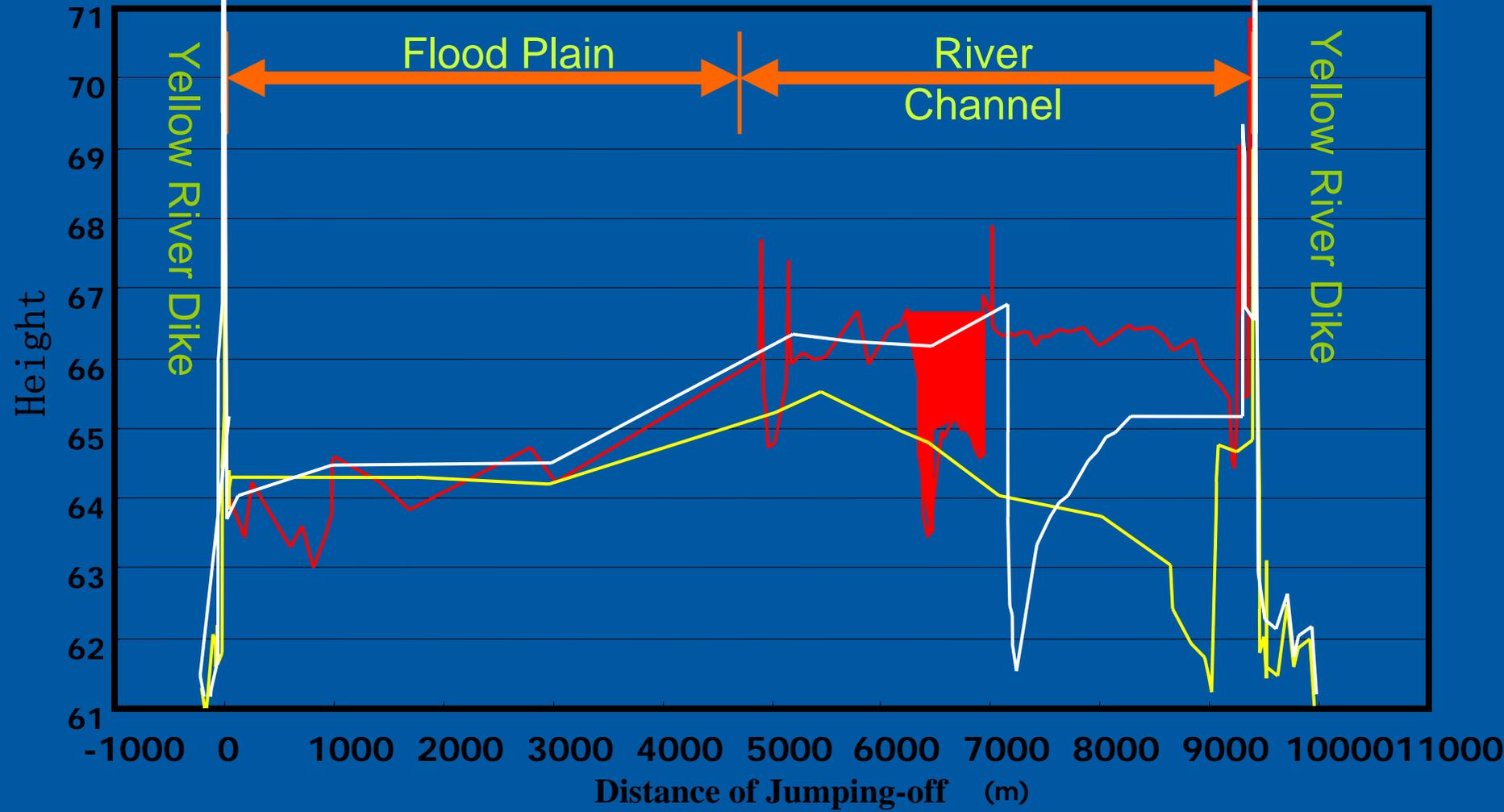
“Secondary silting” is serious;
High risk of dike breaching.

Flood level with current 7600m³/s is 29 cm higher
than 22300m³/s in 1958 (Huayuankou Station)



**Situation of
Yellow River safety
is getting severe**

The Diagram of Cross-section in Yangxiaozhai of Yellow River lower region

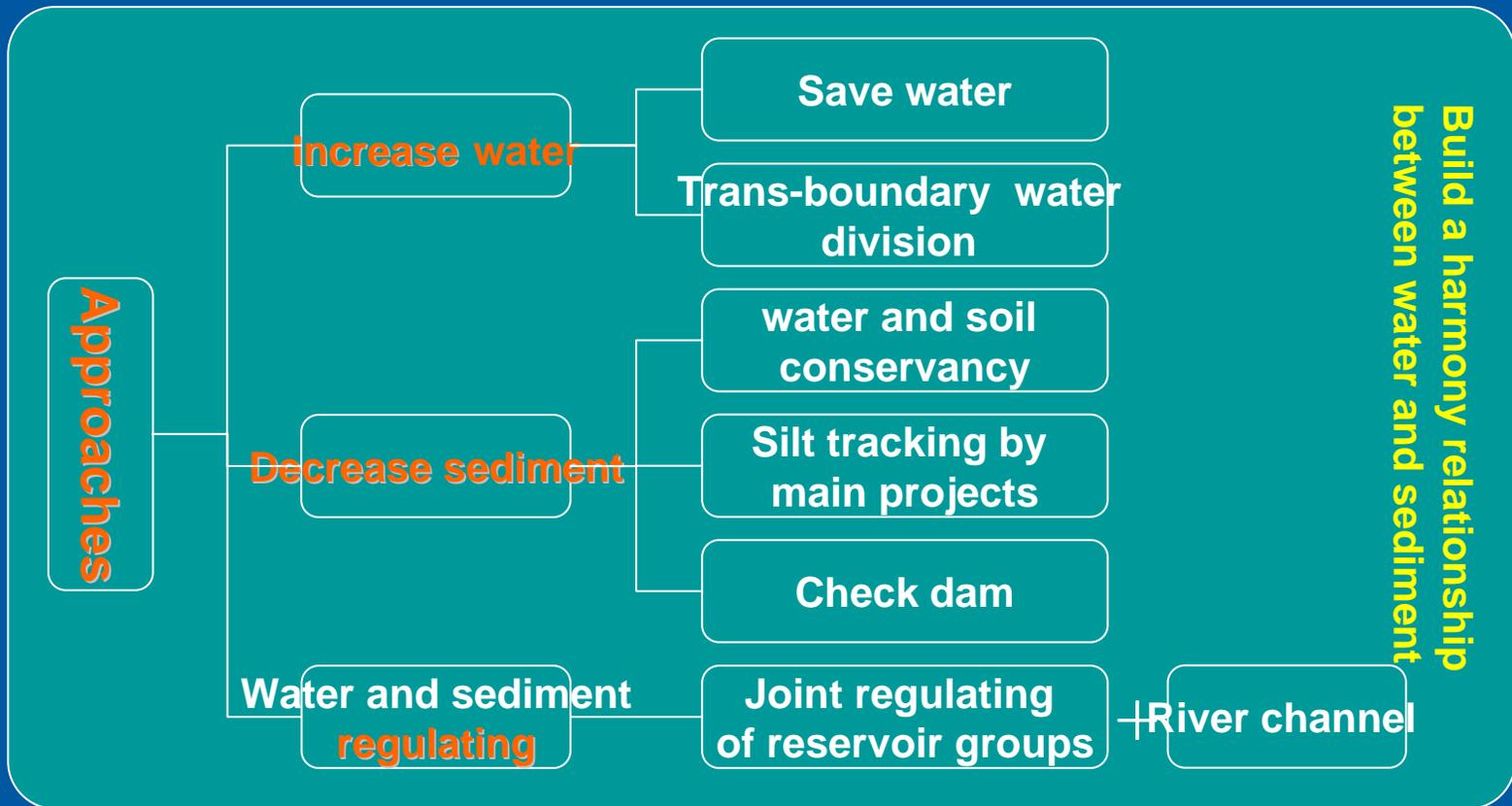


— 1958-10-25 — 1982-10-24 — 2002-7-22

Key Problems of Yellow River Management

- Restrict the tendency of downstream silting and shrinking, resume the plain runoff, avoid “**large-scale overflow with small flood**”, decrease the risk of disaster in the lower Yellow River.
- To achieve **high efficiency of sediment transportation with limited water resources**, improve the carrying capacity of sediment and flood, control the trend of “secondary silting”, make sure the safe of Yellow River.
- To accomplish sediment flushing in both reservoir and river channel, **extend the operating life of reservoir, extend the running time of lower river course, make sure Yellow River keep good training and safety in a long term.**

Water and sediment regulating is one of the main approaches to harmonize the water and sediment of the YR.



Strategy of Integrated Water and Sediment Management of Yellow River

Based on long term theory study、 model experiment、 practical experience;

Make reasonable scheme for water and sediment regulating;

Use reservoir group in main stream and tributary as regulation method;

Build a relative harmonious relationship between water and sediment;

Rehabilitate and maintain the carrying capacity of sediment and flood in main channel, *expand plain runoff, to reduce silting in both water course and reservoir, to mitigate the harsh situation of flood control in lower Yellow River;*

Explore the trend of water and sediment movement in Yellow River.

YR Water and Sediment Regulating

Short Term Objectives

To **rehabilitate the carrying capacity** of flood and sediment in lower river channel, to **increase the plain runoff**, to **mitigate the situation of “large overflow when small flood”**

To **explore the technology index system** to harmonize water and sediment in YR, and the operation methods of water and sediment regulating with reservoir groups.

Control the developing trend of “secondary silting”, make sure the YR is safe every year.

Long Term Objectives

To explore the movement rules of YR water and sediment in river course and reservoirs, to **build a technological foundation and accumulate experiences for the water and sediment regulating** in the whole River.

To explore methods to extend the operating time of lower river course, to achieve YR’s **long term safety**.

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II. Implementation of Yellow River Water and Sediment Regulating

1. Preparation

- 1、 Since 1960's to the operation of Xiaolangdi Reservoir in 1999, several generations of people work hard consistently to explore methods to harmonize the relationship between water and sediment of YR.
- 2、 Since 1990's to 2001, many researches on various index and approaches of YR water and sediment regulating, finally formed the schemes of YR water and sediment regulating.

2. Experiments

2002~2004, three experiments of Yellow River water and sediment regulating were conducted.

The range of experiment includes the reservoirs in the main stream and tributaries of Middle Yellow River like Xiaolangdi, Sanmenxia, Wanjiashai, Luhun, Guxian, and also the **2000km** river course from Wanjiashai reservoirs to the River estuary.

To ensure the success of the experiments, dozens of schemes and experimental process have been made.

On 4-15 July 2002, the first experiment of YR water and sediment regulating was conducted mainly using the storing water of Xiaolangdi Reservoir, combined with the inflow above Sanmenxia Reservoir.



First time YR water and sediment regulating



am 9:00
4 July

Experiment start



Discharge: **2740m³/s**

Totally 11 days

Water discharged: **2.61 billion m³**

Average Sediment content when release
from the reservoir: **12.2 kg/m³**



am 9:00
15 July

Return to normal discharge

3. Regular Operations

Up to the present from 2005, five times operations of Yellow River water and sediment regulating have been undertaken.



More than hundreds thousands people has involved in the experiments and operations of YR water and sediment regulating, and acquired over 10 millions sets of scientific data about hydrology and sediment.



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III. Main Technical Approaches and Innovation

1.
 - ✓ First time to successfully implement large-scale, systematic, well-planned experiments of water and sediment regulating;
 - ✓ Acquired lots of scientific data and huge outputs;
 - ✓ Makes significant benefits for flood control in the lower YR;
 - ✓ A magnificent innovation in the world history of river management.

2. ✓ Put forward the index system of water and sediment regulating, including the critical flow of initial sediment trapping in Xiaolangdi reservoir;
- ✓ Through joint regulating of water and sediment by reservoir groups, realized the artificial density flow, and developed the approaches on reservoir sediment discharge.

Index system of water and sediment regulating in lower Yellow River under current condition.

Unit: Sediment content: kg/m^3 Runoff: m^3/s

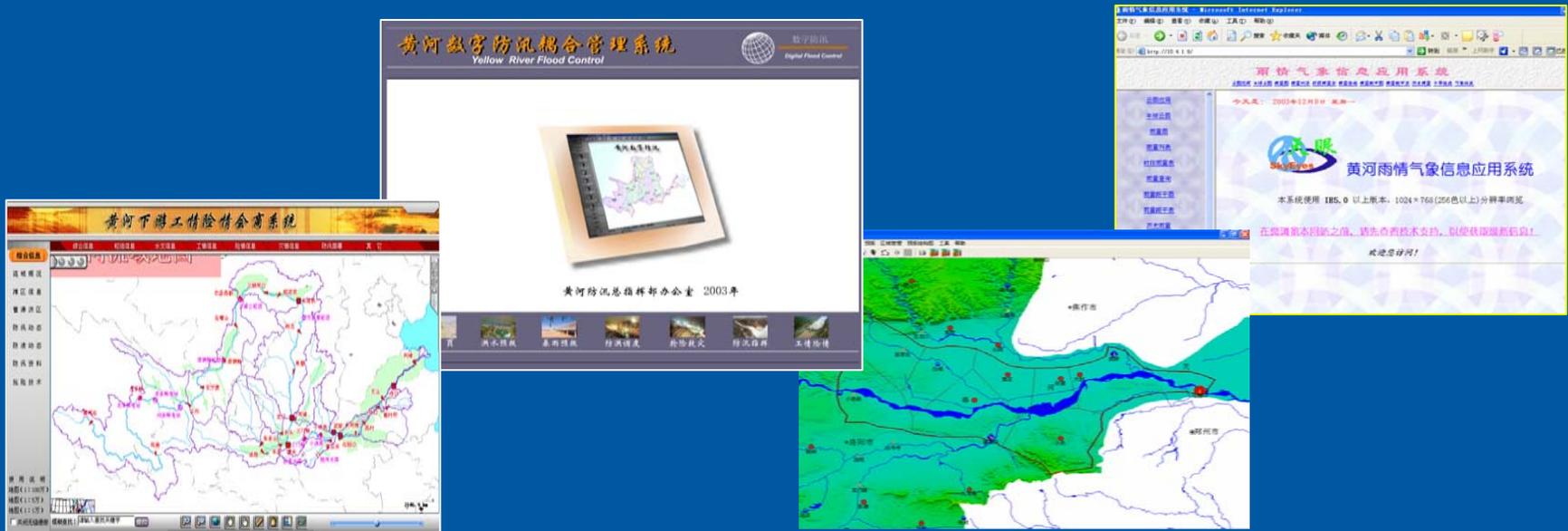
Sediment content in Huayuankou	Runoff in Huayuankou	Runoff in Aishan	Flood Duration
$S \leq 20$	$Q \geq 2600$	$Q \geq 2300$	$T \geq 9$ days
$S \leq 30$	$Q \geq 2700$	$Q \geq 2500$	$T \geq 12$ days
$S \leq 40$	$Q \geq 3000$	$Q \geq 2700$	$T \geq 8$ days

Note: Amount of fine sediment with $d < 0.025\text{mm}$ take account more than 90%

3. Three application models of Yellow River water and sediment regulating in the initial stage of Xiaolangdi Reservoir operation has been put forward as:

- ✓ Priority on single reservoir regulating of Xiaolangdi Reservoir,
- ✓ Connection of water and sediment in spatial scale,
- ✓ Joint regulating of reservoir groups in the main stream.

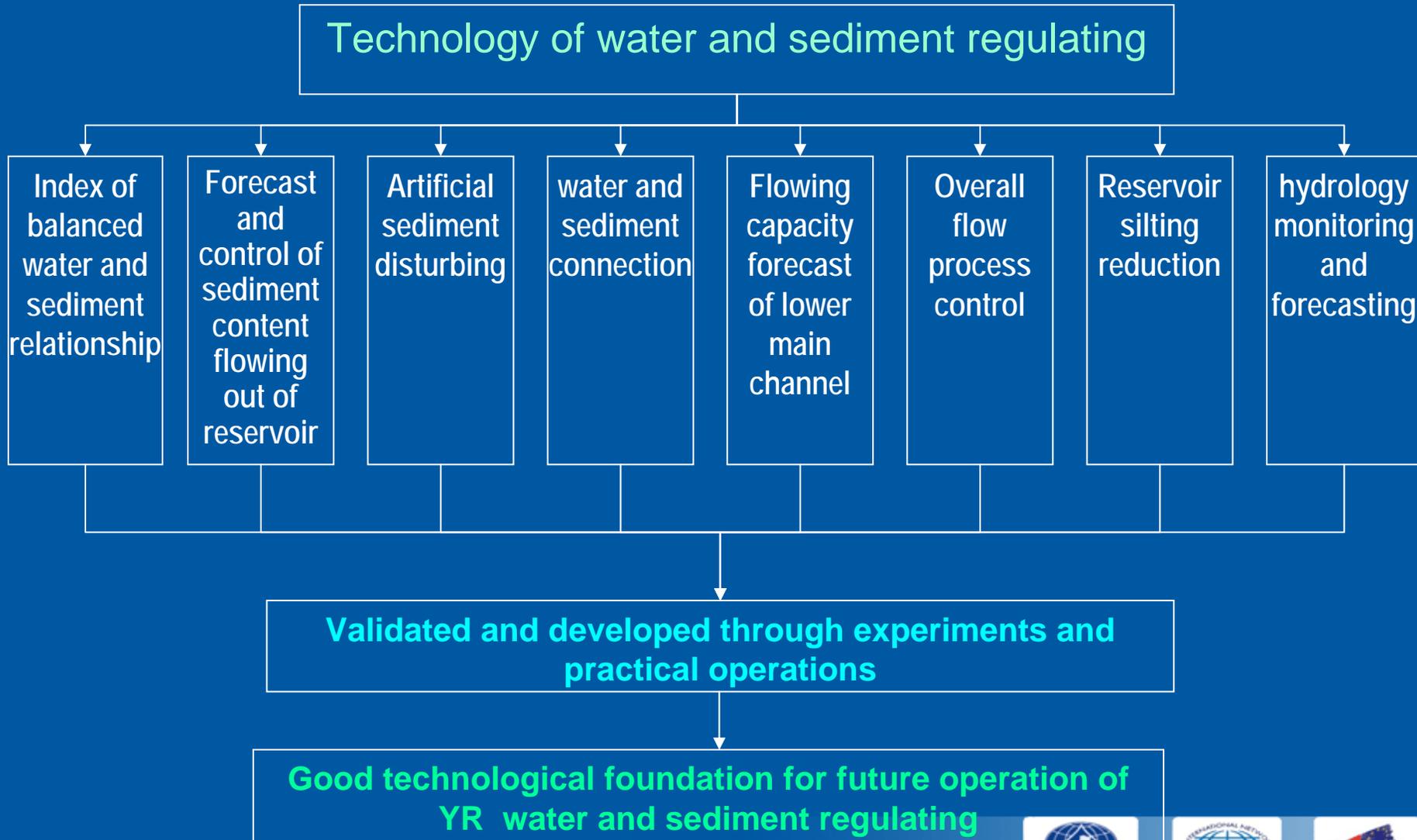
4. Made scientific scheme of water and sediment regulating based on river monitoring, modeling and digital stimulating; Achieved effective control on the process of water and sediment through the systematic innovation and integration on hydrology weather forecast, coupling of forecast and regulating, remote monitoring of water regulating, etc.



5. ✓ Developed vibratory suspending sandiness measuring system, muddy water interface detector; introduced advanced equipments suitable for muddy river measuring, such as laser particle size analyzer, etc.
- ✓ Achieved the fast online monitoring of sediment, which ensured the real time water and sediment regulating.



Main technical methods of water and sediment regulating



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IV. Success and Effectiveness Analysis

1.
 - Lower YR main channel has accomplished all line flushing;
 - Capacity of flood and sediment transportation is highly improved;
 - Plain runoff increased from 1800m³/s to 3800m³/s, and
 - Form of river channel has been modified.

雷口断面调水调沙试验前后断面对照图



2 、 Achievements of YR Water and Sediment Regulating

**Eight times YR water and sediment regulating
(2002-2008):**

Water entering the downstream: 29.4 Billion m³

Sediment flushing to the sea: 0.540 Billion T

Sediment reduced from the lower channel: 0.322Billiont

Average Scouring of the lower channel elevation: 1.70 m

Effectiveness Analysis of Eight Times Water and Sediment Regulating in the Middle and Lower Yellow River

Year	Mode	Regulated runoff (m ³ /s)	Regulated sediment content (kg/m ³)	Sediment flushing to the Sea (million ton)	Flushing from river course (million ton)	Note
2002	Priority on single reservoir regulating of Xiaolangdi	2600	20	66.4	36.2	Experiment 1
2003	Connection of water and sediment in spatial scale	2400	30	120.7	45.6	Experiment 2
2004	Joint regulating of main stream reservoir group	2700	40	69.7	66.5	Experiment 3
2005	Joint regulating of Wanjiazhai, Sanmenxia and Xiaolangdi reservoirs	3000 ~ 3300	40	61.26	64.67	Operation
2006	Joint regulating of, Sanmenxia and Xiaolangdi reservoirs	3500 ~ 3700	40	64.83	60.11	Operation
2007 Pre-flood season	Joint regulating of Wanjiazhai, Sanmenxia and Xiaolangdi reservoirs	2600 ~ 4000	40	52.40	28.80	Operation
2007 Flood season	Connection of water and sediment in spatial scale	3600	40	44.93	00.03	Operation
2008	Joint regulating of Wanjiazhai, Sanmenxia and Xiaolangdi reservoirs	2600 ~ 4000	40	59.82	20.07	Operation
Total				540	322	

3. Notable integrated social benefits

- Flow passing ability of main channel is improved, the plain runoff is increased;
- The situation of continuous shrinking of main channel is in primarily controlled;
- The situation of “secondary silting” is mitigated;
- Water for YR sediment transportation is regulated;
- Deepened the common understanding of “harmony life of human and river”;
- The ecological environment in the estuary region has improved.

Conclusion Remarks:

Through the YR water and sediment regulating:

- Pressure of flood control in the lower reach is released on certain degree;
- Social stability of the floodplain is protected;
- Promoted the development of relevant subjects;
- Significant impacts on the social, economy and ecological development.

Thanks for you attention!

