

# METHODOLOGY TO TAME THE YELLOW RIVER COMPLETELY AND FOREVER

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**Abstract:** At present the LYR bed is 3m to 10m above the bank ground level. The high water head presses the YR water constantly seeping to the ground-water-table of the vast region, causing river water dwindling and the rising of the ground water table which minimizes the upper ground porosity and decreases the capacity to accommodate surface water during flooding in the adjacent area. While the construction of riverbank levees and high dykes along LYR, and multiple reservoirs on the UYR section have contributed significantly to slow down the problem of YR flooding, these solutions address only the symptom of the problem. Unless the root causes of sedimentation are decreased to minimum, YR flooding will never be fully conquered. The author proposes solutions to the root causes through improved management and eradication of excessive sediment in a 2-prong approach as emergency steps and long range actions to follow up. The emergency steps proposed in this paper are to: (1). Stop flushing sediment to the down stream from UYR reservoirs; (2) Speed up sediment transporting at estuary and along the LYR by using advanced methods and equipment in training, dredging, sand pumping, etc., and; (3) Intensify improvements in soil and water conservation in the vast loess plateau. The long range actions are yearly maintaining and improving to keep YR healthy. Some new ideas to facilitate sand removing and training are also presented in this paper.

**Keywords:** YR (Yellow River), UYR (Upper Yellow River), LYR (Lower Yellow River), River bed-seeping, Ground-water-table, Ground porosity for flood water accommodation, Sedimentation, De-sedimentation, Siphoning, Submersible movable hollow concrete block, Training dam, Dredging and training, Sand pump, Dredging equipment, Wave de-sedimentation, Dynamite de-sedimentation, Loess plateau.

## 1. INTRODUCTION

**1.1** In a letter to the author, Mr. Yuqian Long, the former chief engineer of the YR committee, described the YR problems and the current measures to tame it, which ignited the author's interest in seeking for a permanent solution. The following is the translated excerpt from the letter.

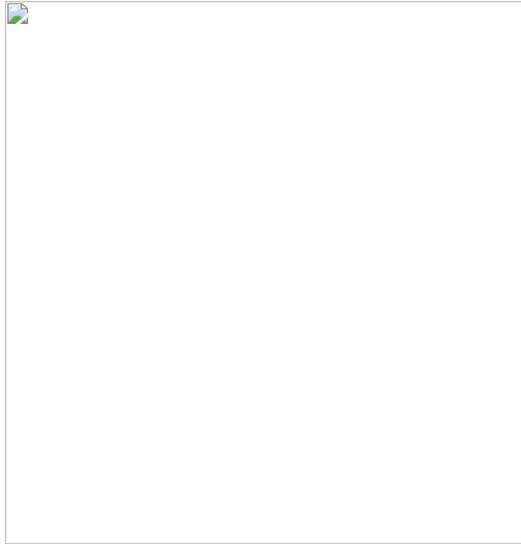
"The YR as the cradle of the Chinese culture has been known as the "menacing river flooding twice every three years" that devastates the lives of the people inhabited in that area. Since 1949 the government has conducted three major projects to build higher and stronger river bank levees, and constructed nine water reservoirs aiming to root out flooding. However, flooding is still a threatening problem. The sections of the LYR riverbed are now 3 to 5 meters above ground level, some as high as 10 meters. A levee breakage would be disastrous. Now the Xiaolangdi Reservoir under construction, located down stream of the Sanmenxia Reservoir, is aimed to YR flood control. This reservoir is expected to be completed in 2001 (now has completed). The flood control ability of the YR would certainly be improved after its completion. However, the sedimentation problem remains to be resolved."

"The water and soil preservation work has been implemented for many years with some noticeable improvement on the area known as "loess plateau" that produces about 1.6 billion metric ton sediments a year. The amount of sediment fed into the Yellow River has slightly decreased in recent years due to the decrease in the river flow rate. Water resource scarcity in our Northern provinces is an inherent problem. Increasing water consumption from the YR area in recent years has worsened the water supply problem. In recent years, LYR sections are seasonally dried up for as long as 100 days a year. Under such circumstances, the amount of sedimentation has been reduced but still noticeable. Dwindling water flow and increasing sedimentation are the two major problems confronting the administration and the authority. In addition, the water pollution problem is an added menace. These three problems (water shortage, sedimentation and water pollution) though less pressing than flooding, are perilous and must be tackled in many generations ...."

".... Because the ever changing wide and shallow riverbed at the LYR, it is impractical to use the conventional heavy dredging equipment to transport the accumulated sediment in the course (also too expensive to be considered). We have tried to use some small capacity sand pumps to draw muddy and sandy water out to the bank levee to reinforce the flank portions for more than 20 years. Regarding water shortage problem, water conservation techniques are urgently needed. ...."

**1.2.** After extensive studying and research, the author has developed the following concepts to mitigate the YR problems:

The author agrees with Yuqian Long that large water consumption and water source scarcity in the Northern provinces have a great bearing on the YR water dwindling. In addition, there is an obscure but very important cause, i.e. river water seeping to the adjacent groundwater table. The raised riverbed increases the hydraulic pressure on the adjacent groundwater table, which has even caused the ancient deposited salty water to ooze to the surface causing the farmland less fertile. The salt contamination and the drainage water unable to discharge to the river for self-cleaning have serious environmental impacts. See Fig.1,



**Fig. 1** River Section Showing River Water and Ground Water Interaction

The author considers dredging a necessity at the estuary and the LYR. The authorities did not in the past implement dredging at the estuary due to the budget constraint.

Having the problems of Yellow River in mind and knowing the devastating Yangtze River flood of in 1989, the author wrote his first article “Proposed Methodology on Defending Flooding and Taming Rivers” in 1998 and five subsequent articles under the title of “Proposal to Solve River Problem” (See References). This paper combines the recommendations in the above articles to present a comprehensive and consolidated strategy and methodology to permanently solve the YR problems.

## 2. STRATEGY AND METHODOLOGY

### 2.1 Immediate Actions:

Stop as soon as possible the dumping (flushing) sediments from all reservoirs of the Yellow River into the down stream. Use sand pumps in conjunction with siphoning systems to remove sediments from the reservoirs to collection yard on downstream river bank for disposal as described in Section 3.2 and Fig. 3-2 below.

Intensify water conservation efforts in the loess plateau area, especially surface runoff feeding into YR. The processes should include but not limited to planting trees, creating man made ponds and lakes along the valleys. Build sumps and basins to reduce runoff water during storms; and transfer surface water to groundwater as much as possible. Such processes have been implemented in the past but at an inadequate scale.

During dry seasons when riverbeds are narrow, conduct dredging on the LYR near its centerline by digging V or U shaped trenches (or canals). Utilize all available facilities and forces in combination, such as labor, electrical, mechanical equipment to remove the sediment in the river. Such work had been done in the past, however in a scale that was too small to be effective.

At the estuary, use large scale training dams, sand pumps and dredging equipment to move the massive sediment mass to the deep sea. This will also reduce the stopping effect on the stream sediment removal.

#### Other Work

In the interim, continue repairing, restoring and reinforcing the entire existing flood control dams and reservoirs.

### 2.2 Long Term Efforts:

The long term efforts would be carried out on yearly basis. Basically it is an extension to the Immediate Actions described above. Survey the results and accumulate experiences in order to improve the effectiveness and the efficiency of managing the work force.

Undertake research and development including but not limit to the suggestion covered in this paper. See Section 3.4.

Research the possibility of making the river course extending to the offshore ocean area.

Conduct repair and maintenance on the installations accomplished and under construction.

### 2.3 Quantitative Study of the Improvement Work

Work Study: The work to excavate all the sediment following the river course to the open sea (Bohai) seems impractical. However, if major efforts of de-sedimentation are placed at the estuary area and let the river itself do the work of de-sedimentation from the LYR to the estuary area, then the work seems feasible although it will certainly take a very long time to be effective. The first step is to make the amount of incoming sediment from the LYR to the estuary less than the amount going out to the sea. Then the raised riverbed would slowly decrease. According to previous studies, the maximum amount of sediment input rate is 1.6 trillion metric ton per year, which has reduced considerably because of the completion of several reservoirs. This huge amount of sediment could be further reduced by improved water and soil conservation, and sand removal at the reservoirs, and the more effective sediment transporting into the deep sea. With the above optimistic measures of reducing sediment input into the river course and the estuary, and with the achievement of contemporary science and technology in the world, changing the river from the present troublesome to a normal river course status is entirely possible. Whenever the sediment in the river course drops to a certain degree, the power of self-cleaning would increase. See Sec 2.1 for improved water and earth conservation and see Sec 3.3 for submersible training dam. The following is tentative work estimation

Assumption: One hundred million metric ton weight sand, to be transported in a year by sand pumping, sand water mixture ratio 9 to 1 by weight, working 365 days a year, 24 hours a day, specific weight of sand 1.5, water 1.

Volume of sand water mixture in 1 metric ton (1000 kg)

=  $900/1.5 + 100/1 = 600 + 100 = 700$  liter or 0.7 cubic meters.

Specific gravity =  $1/0.7 = 1.43$

One ton sand makes 1/0.9 or 1.11 ton sand water mixture.

Yearly rate of water sand mixture transporting flow rate  
(100,000,000 x 1.11) divided by (365 x 24 x 60 x 60 x 1.43)  
= 2.46 cubic meter per second (39000gpm)

Assume pressure head 10 meter, pumping efficiency 0.7, for sand water mixture 1.43, pumping power required would be:  
 $2.46 \times 60 \times 10 \times 1000 \times 1.43 \times (1/0.7) \times 0.000163$   
=492Kw (660Hp) (1kg meter per minute=0.000163kw)

Work Estimation The above gives a rough estimation on the flow rate and power requirement to pump out 100,000,000 metric ton weight sand in one year. The actual figures used for design could be verified by adjusting the values of the parameters in the calculation such as sand quantity, sand water ratio, work time, sand specific gravity, pump efficiency and the pumping head. The above quantitative study is important to figure out the project size, cost, and the number and capacity of the sand pump(s) to be used. Submersible sand pumps are assumed to be installed in the estuary area, water reservoirs, and the portion of raised riverbed. Take advantage of the siphon effect when pumping out sediment at water reservoirs and riverbed could save power. Ample safety factors should be applied for estimating the project requirement, because actually the work time could be much shorter in a year.

Cost and Time Elements The entire work is divided into two major phases, the Initial Setup Work Phase and the Subsequent Yearly Work Phase. It is impossible to project the cost of engineering work without a preliminary design. However a rule-of-thumb prediction of the cost, time and size are delineated as follows;

Initial Setup Work Phase: Including design, implementation, personnel training and miscellaneous would need of 3 to 5 years and 1 to 1.5 billion US dollars.

Yearly Input Work Phase: Including operational, maintenance, additional improvement, continuous personnel training etc, estimated to be about 200 million US dollars annually.

#### Manpower Element

The present Yellow River Committee work force is not sufficient to cope with the massive work ahead. In addition to the present limited work force to hydrology, more work force are needed in a broad range of professionals such as mechanical, civil, electrical, control, weather, dynamite, shipbuilding, marine, industrial engineering (IE), system, management, accounting, etc. Training and recruiting global expertise would be a necessity. There is a famous saying in the Personnel Management field that even for a job of technical in nature, the success is 85 percent dependent on management while only 15% on technology.

#### Effect Anticipation

If the above efforts were implemented in due time, the threat of flooding of both Yellow River and Huai River area can be greatly reduced. As the flood threat reduces, the people in these areas would be enriched with the immense resources of YR its fullest extent through controlled irrigation, improved ecology, expended water supply, even the reclamation of land from the ocean waterfront.

### **3. DREDGING METHODOLOGY AND EQUIPMENT**

#### **3.1 Adaptation of State-of-the-Art Methodology and Equipment**

Dredging techniques and dredging equipment had been developed by other countries for over one hundred years. Advancements in the recent years is astonishing. The coming of the internet website era has greatly facilitated the product and consultant information acquisition. Further actions can be taken by visiting or inviting experts for an on-site study. Mobilizing the domestic technical resources to setup a larger task force for research and development is of first concern.

#### **3.2 Siphon Out Sediment from Reservoir to Lower Shore. (See Fig 4)**

Theoretically sediment on bottom of a reservoir could be drawn out with a pump onto the shore in the same way like ore sand and crushed stone to be transported from the deposit spot to the smelt plant in water ore mixture. Siphon effect could be utilized to save pumping power when output delivery point is considerably below the intake point. Submersible pump powered with electricity or compressed air could be used to add suction force to enhance the sediment water mixture flow rate if needed. Sediment at the delivery point by the shore could be utilized for local construction purposes or land fill, which is much better than having the sediment stay in the reservoir or dumping to the down stream that could cause serious problems including but not limited to flooding. Since the coarse sediment is normally near the bottom of a reservoir, the sand pump intake should be located as near to the bottom as possible. Rubber hose are suggested to make the submerged pipeline flexible for installation. The above scheme is schematically shown in Fig. 2.

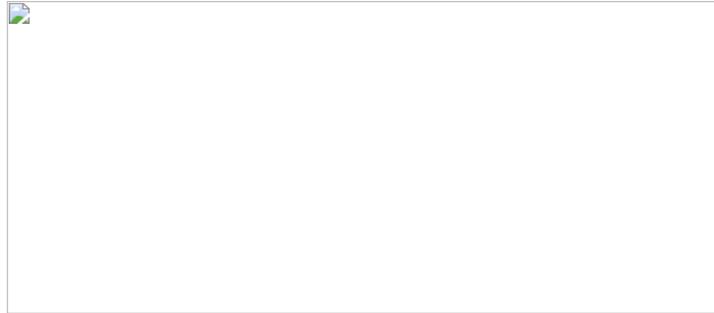
#### **3.3 Submersible Concrete Block Training Dam (See Fig. 5.)**

Design of huge prefabricated concrete block to be used in the river stream... Single piece or a train of multiple pieces can serve as a temporary stationary "training walls" to be set up in river in order to confine the water flow and forcibly push away a massive under water sedimentation in the river or at the estuary. Those concrete blocks are designed to be reusable and adjustable for relocations best meet the functional requirement. Such a block can also be manipulated to sink to the riverbed by filling with water or to made it float or to suspend in the water for relocation by introducing the proper mixture of water and air in the concrete block body remotely controlled by power pumps and compressed air systems. Controlling valves are strategically located on the concrete block. The idea of this device is derived from the famous concrete oil drilling rig extensively used in Norway. See schematic design as shown in Fig 3.

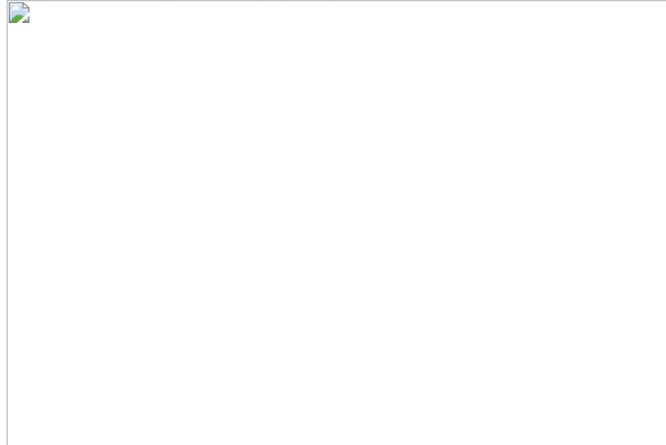
#### **3.4 Other Considerations**

##### Estuary Dredging Methods

See Fig.3 for construction and functioning of submersible training dam, Fig.4 for dynamite de-sedimentation gun and Fig.5 for wave de-sedimentation. All the above are of creative thinking intended to serve as innovative thinking reference. The gigantic power of the dynamite is easily entered into the consideration of a designer to be utilized to remove the huge under water sand. In author's mind, dynamite could be used for sand moving on the outer shallow waterfront to make deep pits in order to reduce resistance to the incoming sand flow from the estuary. A robot type submersible sand push gun is as shown in Fig 4. Another ideal is to use a specially designed grenade to agitate sand upward moving away with the flooding stream at the estuary area is considered. Such grenades to be used in great number for such purpose would be designed to have the dynamite to be concealed in a plastic bag with battery timer for delayed detonation, and heavy concrete outer shell making it heavy enough to sink into the sediment bed and the explosion would be surely occurred when it reaches a certain depth in the sediment estuary bed. All the above are for research and development purpose.



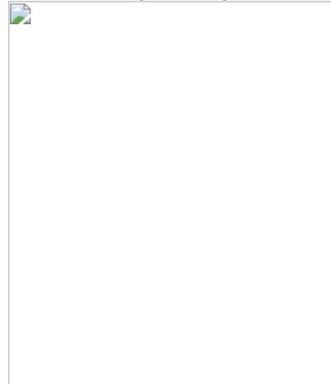
**Fig. 2** Schematic Diagram Showing Siphoning Sediments from Reservoir to Lower River bank



**Fig. 3** Schematic Diagram showing Submersible Training Dam Design.



**Fig. 4** Dynamite De-sedimentation Gun



**Fig. 5** Wave De-sedimentation Scheme

#### Groundwater Table Consideration

The effect of the groundwater has a huge impact on the YR problem though so far it seems obscure on its area of distribution, table depth, flowing direction, seasonal change and its receiving huge amount from the river seepage from the raised river course with high hydraulic head pressure. There are several consequences of river water seeping to the nearby ground including river water dwindling, streaming sand pushing force dropping, more sedimentation building and possible bank levee breakage and flooding. It might cause the groundwater table in the nearby land rising up to fill a part of soil porosity and decrease its capacity to absorb surface water in case of flooding. This is the possible explanation of the huge flooding disaster in the Huai River area in 2003. River water seeping to the ground might be good for farming when properly watered or having bad effect when salty water in the deep soil rises detrimental the farmland.

#### Plantation in Huge Loess Plateau Area

Some say that plantation depletes ground water and could partly contribute to the dwindling supply of river water. Such saying is debatable because the shadings from the direct sun ray by the plantation lessen the ground water evaporation. It retains water, reduces runoffs during storms and preserves fertile soil. Expansion of plantation should not be slowed down while investigations are in progress.

#### Prediction of the Future of the Yellow River

The future of the Yellow River lies in the hands of the government and the people of the land. The fact that recently there has been no serious flooding and severe drought makes people feeling complacent, but it is a false sense of security. If the government takes the opportunity to expedite the improving work, the problem could be solved eventually.

## **4. CONCLUSION**

**4.1** On the four problems of the YR namely flooding, sedimentation, water dwindling, and environmental water contamination, this paper presents a systematic analysis and consolidated constructive suggestions for a comprehensive solution.

Reservoirs on UYR can only ease the flooding problem temporarily unless the sediment accumulated in the reservoirs is pumped out on shores instead of dumping in their downstream. Pumping and siphoning method is proposed to solve the problem.

Training and dredging at the estuary to transport the accumulated sediment to the deep sea is the basic work to solve the YR problem. More effort and resources are needed accomplish the work. New ideas are presented to facilitate the work.

Soil and water conservation work in the loess plateau must be increased and accelerated.

**4.2** Innovated de-sedimentation processes in this article include sand siphoning, submersible concrete block training dam and use of dynamite and wave power for de-sedimentation.

**4.3** Make use of national and international resources to expedite the work. Employing experts around the world reduce the learning period of time.

**4.4** A part of the methodology aimed to solve problem of the YR is applicable to the Yangtze River.

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