Strengthening Disaster Preparedness of Agricultural Sector in China

Study report

Control of Water logging and Drought and Restoration of Water Conservancy Projects in Qilin Town, Juye County

prepared by

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1. Introduction

Juye County is located in the southwest of Shandong province with latitudes between 35°05'N and 35°30'N and longitudes between 115°47'E and 116°13'E. It is in the west of Jiaxiang county and Jinxian county, and to the east of Mudan district of Heze city and Dingtao county, and in the north of Chengwu county and to the south of Yunchen county. Juye county covers 45km in the length from east to west and 42km in the width from north to south with a gross area of 1303.4km², farmland area of 76.4×10^4 hm² and a general population of 931.7 thousand. Juye county is in the alluvial plain of Yellow River and the lake basin of southern four-lake watershed in Huaihe basin with a flat terrain, which is mostly consisted of floodplain, gentle sloping field and shallow billabong which result from flooding, course-changing, dyke break and alluvion of the Yellow River. Currently, there are two water systems in Juye county, that is Wanfuhe Canal and Zhuzhaoxinhe Canal. The Wanfuhe canal crosses Liulin town, Wanfeng town and Yingli town in the south of Juye county, including several main branches such as Penghe canal, Wuhe canal, Youyihe canal and Fengshouhe canal and so on. The Zhuzhaoxinhe canal crosses Tianqiao town, Juye town, Tianzhuang town, Qilin town and Gushan town in the north of Juye county with several main branches such as Zhushuihe canal, Yunjuhe canal, Julonghe canal, Qiugongcha canal and so on. Overall, the two flood control and drainage systems of Wanfuhe canal and Zhuzhaoxinhe canal were formed in Juye County.

Qilin town is located in the east of Juye county, to the east of Jiaxiang county, with cultivated area of 90 thousand acres and population of 65 thousand. Qilin town, a part of the alluvial plain of the Yellow River, is flat and descends from 39 meters elevation in the northwest to 37.5 meters elevation in the southeast, with natural slope of 1/5000—1/10000. In the Qilin town, it is dry and windy in spring, rainy and water logging in summer, regularity water logging in the early autumn and drought in the late autumn, and dry, cold, windy and scarcity in snow and rain in winter. The distribution of precipitation is uneven within a year and among years. The mean annual precipitation is 673 millimeter, most of which falls in June, July, August and September with 52.9%-88.7% of total amount. Therefore, drought and water logging often occur in this area, and low-grade drought and water logging even occur every year.

Besides, the Qilin town is located in the lower reach of Juye county which is located in the lower reach of Heze city, so when there is heavy rain in Heze city, Zhuzhaoxinhe canal and its branches of the Yunjuhe canal and Zhushuihe canal have to admit all the drainage from the four counties on the upper reach of these rivers. On the one hand, all these drainage flowing into Qilin town will raise the water level rapidly and increase the pressure of flood control on the one hand. On the other hand, it will also magnify the drainage difficulty and aggravate the water logging in the Qilin town.

Zhuzhaoxinhe canal and its branches of Zhushuihe canal and Yunjuhe canal in Qilin town are the main canals and sources for irrigating and dealing with drought or water
logging, and the Yuejinhe canal and Xuegongaha canal are the other larger canals for drainage and irrigation, which plays an important role in the industry and agriculture development in Qilin town.

In order to secure water applications in the industry and agriculture, and people life, a lot of water conservancy facilities have been built according to the characteristics of drought and water logging and distribution of water sources since 1950, and three irrigation systems of Yangguantun in the north, Liuying and Shuangwangzhuang in the south have been established in Qilin town, Juye county. With the construction and improvement of the water conservancy facilities, there are about 8 trunk canals and 22 branch canals, 3 pumping station with the installed capacity of 800 kw and 10 water pump, 4 check gates and 200 bridges and culverts in these three irrigation systems. The three irrigation systems of Yangguantun, Liuying and Shuangwangzhuang have brought great economic benefits and have played an important role in the industrial and agricultural development of Qilin town.

However, water conservancy facilities in the irrigation systems of Qilin town mostly were built in the middle and late 20th century and have been aging of nature, and have been operated with natural management, many key facilities such as bridges, culverts and gates don’t work well or have lay waste with low water logging criterions or in a state of disrepair. Most branch canal and field canal are lack of control facilities for distributing water according to plan and demand, so some accidents frequently occur such as the burst and jam of canal system and water shortage and waste, which results in some branch and field canal damages and sediment deposition and low discharge capacity. Because of water and soil loss and damages of the field canals in the irrigation systems, the key trunk drainage canals have lower drainage capacity with much sedimentation, which results in much heavier pressure for waterlogged and flood control. In the light of the limitations on the economic conditions of Qilin town, some key damaged facilities and attached facilities in the irrigation systems haven’t got repaired in time because of the insufficient fund input for these facilities. Some natural disasters such as water logging and drought often occur in Qilin town, which hampers the development of agriculture and industry and reduces the life level of farmers. And it is difficult for the town to realize the goal that it can drainage while water logging and can irrigate while drought. Therefore, it is urgent to repair the key projects and facilities, irrigation and drainage canals and attached facilities in the field in Qilin town. In view of limitation of FAO fund, only the following key projects and facilities can be carried into execution at first, shown in figure 1.

(1) The reparations of pumping station and the trunk canal in Shuangwangzhuang irrigation system.

(2) The construction of the drainage culvert in the Liuying irrigation system and the attached projects

(3) Reparation of the drainage and irrigation canals and the land treatment in the east of southern irrigation system.
2 Reparations of Pumping Station and Trunk Canal in Shuangwangzhuang Irrigation System.

2.1 Present Situation
The Shuangwangzhuang irrigation system (namely the southern irrigation system of Xiaguantun town) in Qilin town is located to the east of Yunjuhe canal and the west of Liuxia road, and in charge of more than ten villages such as Shuangwangzhuang, Yaoqiao, Ganhuangzhuang, Zhangyoufang, Baizhuang and so on. The irrigation system was established in October, 1991 with irrigation area of 1000 hm$^2$. The pumping station was set up in Shuanghuangzhuang and pumps water from the
Yunjuhe canal to the trunk canal which is composed of stone channel with a length of 400m and earth channel of 1600m in length. There are 6 branch canals with a total length of 8000m. Firstly, because of the shortage of maintaining expenditure and poor management, the diversion capacity of the Shuanghuangzhuang pumping station decreases with great extend. Secondly, the phenomenon of water seepage and leak of the trunk canal is severely impressive because the trunk canal is aging, and damaged in some places and lack of reparation, which results in water waste in large amount. Thirdly, the irrigation and drainage canals is not so good that some problems occur such as siltation and weed in the canal, and the dike discontinuity of canal and so on, which reduces the water flow capacity of the canals. Fourthly, the alkaline ground water of the Shuangwangzhuang irrigation system is not suitable for farmland irrigation, thus it is significant for the irrigation system to divert water from the Yunjuhe canal. Therefore, all the existing problems influence on the regular irrigation function and reduce the irrigation area sharply in this irrigation system. At present, the irrigation area is less than 5000 acres, and it is absolutely necessary to launch reparation of pumping station and the trunk canal in Shuangwangzhuan irrigation system.

The diversion project of Shuangwangzhuang irrigation system consists of pumping station, diversion canal before station and trunk canal behind station. The pumping station is installed with two 28ZLB-70 axial flow pumps with two electric motors of 160 kw, pumping height of 4.06m, and the pumping discharge of 1.0m³/s. The trunk canal behind the pumping station is made of stone canal with a length of 400m, a width of 2m in the bottom and a depth of 1.5m. The problems exiting in the pumping station and attached facilities are as follows:

(1) The aging and worn equipments such as transformer, switchboard, water pump and so on need reparation and maintaining. One of the self coupling transformer is broken, which results in that one pump will not work.

(2) The pump station room is cracking and damaged partly in some doors and windows in disrepair, which threatened the security of the pump room and equipments.

(3) The diversion canal before the pumping station is suffering from severe siltation. The design depth of the canal is 7m, while less than 4m now, which results in that the pumping station does not work well while the low water level of Yunjuhe canal.

(4) The effluent concrete pipe of the pumping station is cracking and leaking. It can not work regularly now.

(5) The stone trunk canal behind the pumping station is also completely leaking and cracking with a lot of honeycombed areas, which not only wastes water in large amount but also exerts serous influence on the life of the people in Shuangwangzhuang town.
2.2 Design and Plan of Project Scheme

In view of all the problems existing in the diversion project of the Shuangwangzhuang irrigation system, the main measures are repairing, the purchase and maintain of facilities for the restoration of the irrigation function. Please refer to figure 2 about the design and solution.

![Figure 2 Layout of the longitudinal plan of the pump station in Shuangwangzhuang Irrigation system](image)

(1) Dredging of the diversion canal before the pumping station

The designed diversion canal was 15m in width and 7m in depth, while it is less than 4m in depth and full of float grass now because of much sedimentation, which affects the regular diversion of the pumping station. Dredging machine will be used for sediment dredging of the canal during low water season in order to secure the regular function of the pumping station. The cross section after desilting is shown in figure 3. During dredging period of the low water, proper dredging machines(such as digger, scraper) should be chosen according to the actual situation of the Juye county. For the specific dredging technique, it can refer to the Technical Specifications of Dredging Facilities Construction.

![Figure 3 Cross-section of the diversion canal before and after dredging](image)

(2) Purchase and maintenance of attached equipments in the pumping station

Because one of the self controlling transformers and lifting facilities of gate are broken and can not be repaired, the new ones will be purchased. A small sized attached equipment should also be bought.
Some important devices such as switchboard, electric motor and water pump need to be maintained because of their longtime operation and ageing without necessary protection.

(3) Reparations of pumping room and effluent pipe

The enclosure wall of pumping station has inclined with a large crack because earth basement of the wall is in water infiltration and sinks with uneven, which is in danger for pumping station. It is necessary to construct a new enclosure of 20m in length, 3m in height and 0.25m in thickness. The broken windows and doors of the pumping station room need to repair too.

The concrete effluent pipe behind the pumping station is broken and useless. The new one of 2.0m length and 70cm in diameter should be purchased and installed.

(4) Reparation of the stone trunk canal behind the pumping station

On the bottom of the stone trunk canal behind the pumping station, there are a lot of honeycombed areas and long cracks, which lead to severe infiltration.

The loosing part of honeycombed area should be excavated, and then chiseled, cleaned, paved and covered in concrete on the surface. Some parts of serious destruction should be considered to be reinforced with steel. The longitudinal cracks can be treated with as follows. the deeper longitudinal cracks at the bottom of the stone canal can be treated with gravity grouting or pressure grouting. The former is that the concrete serum fills the cracks by self-weight, while the latter is that the concrete serum fills the cracks with mechanical press and gravity. After treating the above honeycomb regions and large cracks, 0.2-meter-deep concrete is poured on the bottom of stone canal with a length of 400 m and width of 2.0 m. The cross-section of the trunk canal is shown in figure 4.

![Figure 4 Reparation for the main canal behind the pumping station](image-url)
2.3 Project Quantities and Budget

(1) Sediment dredging amount in the diversion canal
The diversion canal is about 10m in width and 70m in length and 3.0m in deposition depth. And total deposition amount is about 2100m³.

Canal dredging can be carried out with two ways of manpower dredging and machine dredging. The unit cost of the manpower dredging is high to 10Yuan/m³(RMB, same as following) with a slow progress. The cost of the machine dredging is only 3Yuan/m³ with fast progress. Therefore, it is preferable to use machine dredging. the total cost of diversion canal is about 6300 Yuan (100m³×3.0Yuan/m³=6300 Yuan).

(2) Costs for purchasing and maintaining the attached equipment
The pumping station needs to purchase some equipment such as one self coupling transformer with a cost of 2000yuan, 3 lifting facilities of gate with a cost of 6000 Yuan (2000 Yuan for each) and so on.

The important equipments such as switchboard, electric motor and water pump need to maintain for their running and appearance with the cost of about 5000 Yuan.

(3) Costs for repairing the pumping room and purchasing effluent pipe
According to preliminary budget, it costs 4000 Yuan to build the enclosure wall of 20m in length, 3m in height and 0.25m in thickness, 3000 Yuan for repairing windows and doors of the pumping room, and 600 Yuan (300 yuan/m×2m=600yuan) for purchasing the concrete pipe behind the pumping station.

(4) Cost for repairing the stone trunk canal
After treatment of the honeycombed areas and cracks on the bottom of the stone trunk canal, the bottom of the canal will be covered with concrete of 0.2cm in thickness and 400m in length, which will need 160 cubic meter concrete and cost 41600 Yuan in total with a unit cost of 260 Yuan /m³.

(5) Total budget
The total budget for reparation of the Shuangwangzhuang pumping station and stone trunk canal is 70700 Yuan, and shown in the table 1 for specific budget.
Table 1:  Budget statement for repairing the pumping station and stone trunk canal in Shuangwangzhuang irrigation system

<table>
<thead>
<tr>
<th>Items</th>
<th>Expenditures (RMB Yuan)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. sediment dredging in diversion canal</td>
<td>6300</td>
<td>2100m$^3 \times 3$ Yuan/m$^3$</td>
</tr>
<tr>
<td>II. purchasing and maintaining equipments</td>
<td>13200</td>
<td></td>
</tr>
<tr>
<td>(1)maintaining equipments</td>
<td>5000</td>
<td></td>
</tr>
<tr>
<td>(2)purchasing self coupling transformer</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>(3)purchasing the filling seal in pump axle</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>(4)purchasing headstock gear</td>
<td>6000</td>
<td>2000Yuan$\times 3$</td>
</tr>
<tr>
<td>III. repairing pump room and purchasing effluent pipe</td>
<td>9600</td>
<td></td>
</tr>
<tr>
<td>(1)repairing enclosure wall</td>
<td>4000</td>
<td>20m$\times 3$m$\times 0.25$m</td>
</tr>
<tr>
<td>(2)repairing pump room</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>(3)transformer room</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>(4)purchasing the effluent pipeline</td>
<td>600</td>
<td>two outlet pipes with a length of 2m and a diameter of 70cm</td>
</tr>
<tr>
<td>IV. repairing stone trunk canal</td>
<td>41600</td>
<td>260Yuan/m$^3 \times 160$ m$^3$</td>
</tr>
<tr>
<td>V. Total</td>
<td>70700</td>
<td></td>
</tr>
</tbody>
</table>

3 Construction of Drainage Culvert in Liuying Irrigation System and Attached Projects

3.1 General description
Liuying irrigation system, one of the three largest irrigation system in Qilin town, was built in 1971 and is located on the both sides of Yujuhe canal which is the main source of irrigation and drainage canal. Liuying irrigation system consists of ten villages such as Liuxi, Liunan, Liubei, Baoguantun, Dongganzhuang etc. with a population of 9000 and a cultivate area of 9300 hm$^2$. The pump station has 4 28ZLB-70 axial flow pump machines with general assembly of 320 kw, total discharge of 4m$^3$/s, and pumping height of 4.0m. At the initial stages, Liuying pump station diverted water for irrigating farmland in dry season, and pump machine pumps water logging to the canal in the west of Yunjuhe canal and water logging drains into the Xuegongcha
canal in the east of Yunjuhe canal in the rainy season, which ensures the harvest of the irrigation system.

Water and soil losses, the activities of farmland construction and construction of farmer houses etc have caused the severe deposition of key drainage canals and some damages of branch and field canals or even blocked. In addition, management and maintenance of the drainage canal system have been neglected for long time in the irrigation system, which resulted in chaos of the drainage canal system, so there are no drainage passes in some local area, which often caused water logging disaster and even a large disaster for some villages during rainy season. For an example, villages of Liuxi, Liunan, Liubei etc with a population of 5000 and a cultivate area of 467 hm², are always confronted with severe water logging due to lower-lying region. In July, 2007, because it had rained heavily for 3 days and subsequent flurry, the whole Liuying irrigation district was suffered with flood and water logging, especially in the eastern part, and some villages were surrounded by the water logging for about a week, which resulted in a series of problems such as reduction of output, collapse of houses and bad influence etc.

3.2 Design and Plan of Project Scheme
Because of its low-lying eastern part of the irrigation district and dense villages, the rainfall in flood season always caused water logging, and the excess water had no access to the Yunjuhe canal. To protect the eastern villages from water logging, establishing a drainage passage is a key engineering measure. Considered the aspects of construction cost, the construction convenience and the drainage effects etc, building a culvert through the east dike of the Yunjuhe canal near Liuxi village can satisfy the need of drainage, and some attached projects will be also constructed in the west field of Liuying village. After those projects are constructed, the water logging disaster will greatly reduce and even hardly occur.

3.2.1 Layout of the culvert through the dike
In making choice of the location of the culvert, the following factors have been given full consideration:

(1) Matching the existing drainage canal system
At present, there are some canals but inadequate or deposited near the eastern villages of Liuying irrigation system. Therefore, it is necessary to put the culvert close to the main drainage canal for full use of the existing drainage system.

(2) Considering the drainage effects
The culvert should be on the low-lying area which is far from the village and drain smoothly with a certain drainage range.

(3) Considering the boundary conditions:
Not only the orographic condition of the irrigation district but also the boundary conditions of Yunjuhe canal such as the width and elevation of the canal bank and floodplain should be considered in layout of the culvert, which have a direct effect on the construction and the implementation scheduling.

With all above factors considered, the culvert should be put on the spot in east bank of the Yunjuhe canal which is about 1.0km from Liuxi village where there are excellent orographic condition and drainage condition.

The axis of Liuying culvert through dike is perpendicular with the riverbank of Yunju River, which is shortest culvert length and reduces the construction amount and engineering invest. Meanwhile, a lock gate will be placed inside the dike. When the water level in the Yunjuhe canal is higher, shutting up the gate will avoid water flow backwards, and when the water level is lower, opening the gate can drain water logging to the canal, as shown Figure 5.

![Figure 5 Sketch map of culvert through dike](image)

3.2.2 Culvert design

The dimension of the culvert can be determined by the drainage area, rainfall, duration of the drainage and water level etc. Generally speaking, the longitudinal slope is equal to that of channel and the inlet elevation is generally as high as channel bottom. The length of the culvert is determined by the width of the dike body, and its design discharge is the channel peak discharge. The water level downstream is the level of the Yunjuhe canal, and the water level upstream is determined by the landform and the maximum water logging depth etc.

(1) Drainage modulus

The peak discharge of culvert is calculated by drainage modulus, according to GB50288-9. For those channels whose catchments are less than 10km², drainage modulus can be determined by average exclusive method.

\[
q_d = \frac{R}{86.4T}
\]  

Where, \(q_d\) is designing drainage modulus, m³/(s·km²); \(R\) is the depth of runoff, mm; \(T\) is the time of drainage, d.
Checked the relationship curve of rainfall and runoff according to rainfall with recurrent interval of 3 years, the depth of runoff can be obtained with 70mm. According to average exclusive method, the drainage modulus

\[ q_d = 0.810 \text{ m}^3/(s \cdot \text{km}^2) . \]

(2) Drainage area

The drainage area near the Yunjuhe canal is about 4.67 km² (7000Mux667= 4.67 km²).

(3) Drainage discharge

The design discharge of the culvert can referred to the peak discharge of channel versus certain frequency. Thus, the design discharge of the culvert

\[ Q = q_d \times S = 3.78 \text{m}^3/\text{s} . \]

(4) Dimension of cross-section

The calculation formula of flow capacity is determined by the flow state, the judge of flow state is to choose proper discharge calculating formula. Flow states of culvert are divided into non-pressure flow, half pressure flow, non-submerge pressure flow and submerge pressure flow. According to no water logging for the farmland with a standard of 3-year flood and no water logging for the village with a frequency of 1/5, the calculation formula of flow capacity with submerge pressure flow is chosen for determining the culvert dimension( shown in Figure6). The culvert dimension is given with trial and error method.

\[
Q = m A \sqrt{2 g \left( H_0 + i L - h \right)} \\
m = \frac{1}{\sqrt{\sum \xi + \frac{2 g L}{C^2 R}}}
\]

Where, \( m \) is discharge coefficient; \( i \) is slope of the culvert; \( A \) is flow area, \( \text{m}^2 \); \( L \) is the length of the culvert, \( \text{m} \); \( H_0 \) is inlet depth including approaching velocity, \( \text{m} \); \( h \) is outlet depth, \( \text{m} \); \( R \) is hydraulic radius, \( \text{m} \); \( C \) is Chezy coefficient; \( \sum \xi \) is the total local head loss including the inlet and lock gate etc.

According to the above formula and factual experiences in the water logging control in Juye country, the diameter of the culvert is given as \( \varnothing = 1.5 \text{m} \).
(5) The structure of the culvert body
Culvert body is assembled with the prefabricated concrete or reinforced concrete pipe.

3.2.3 Design results of the culvert
The main design indexes are shown in table 2, and the standing drawing, plane and cross-section of the culvert and gate are shown in figure 7, figure 8 and figure 9 respectively.

<table>
<thead>
<tr>
<th>location</th>
<th>hole number</th>
<th>diameter(m)</th>
<th>Area(km²)</th>
<th>Discharge (m³/s)</th>
<th>structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>left</td>
<td>1</td>
<td>1.5</td>
<td>4.67</td>
<td>3.78</td>
<td>reinforced concrete pipe</td>
</tr>
</tbody>
</table>

Figure 7: Standing view of the culvert
3.2.4 Attached projects of the culvert

Much sedimentation in the key trunk canals and some damage of the branch and field canals resulted from water and soil losses, the activities of farmland construction and farmers building houses etc. It is difficult to control water logging only to use the culvert if the branch and field canal do not work well. To exert the drainage effect of the culvert, it’s necessary to repair and build some attached projects. According to the present situation of eastern Liuying irrigation system, 6 field canals with a length of 2350m, 6 culvert bridges for field canals and 4 culverts for ways would be planned and constructed as shown in figure 10.
3.3 Project budget

3.3.1 The attachment projects

The attached projects included 6 canals with a length of 2350m, 6 culvert bridges and 4 culverts. Earth work can be self-financed by local government. FAO mainly invests in the construction of the bridge and culvert of drainage canal including 6 culvert bridges and 4 culverts for field ways. 6 culvert bridges for field canals cost 26076 Yuan, and 4 culverts for field ways cost 12592 Yuan, and total cost is 38668 Yuan.

3.3.2 Culvert through dike

The construction of the culvert mainly includes phrasing the pipes, dredging and backfilling of the riverbank and paving pipe etc. corresponding engineering estimate as shown in table 3, total of 48300 Yuan.
3.3.3 Construction of culvert gate
To control water in the Yunjuhe canal to flow backwards to the field, a lock gate is needed on the culvert. The lock gate will cost 6728 Yuan.

3.3.4 The pipes paved on the floodplain
The floodplain of Yunjuhe canal is about 50m, requiring 50m pipes with a diameter of 1.5m. The total cost with purchasing and paving the pipes is about 10540 Yuan.

Table 3 Budget table of culvert through dike

<table>
<thead>
<tr>
<th>item</th>
<th>funds(Yuan)</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The attached projects</td>
<td>38668</td>
<td></td>
</tr>
<tr>
<td>1. 6 culvert bridges</td>
<td>26076</td>
<td>Each culvert bridge needs 5m pipe, 12m$^3$ brick or stone, 61m$^3$ excavation and 40m$^3$ backfilling</td>
</tr>
<tr>
<td>(1)pipe</td>
<td>4500</td>
<td>5×6×150</td>
</tr>
<tr>
<td>(2)bricks or stones</td>
<td>12960</td>
<td>12.0×6×180</td>
</tr>
<tr>
<td>(3)trinity mixture fill</td>
<td>3600</td>
<td>6×6×100</td>
</tr>
<tr>
<td>(4)excavation</td>
<td>2928</td>
<td>61×6×8</td>
</tr>
<tr>
<td>(5)backfilling</td>
<td>2088</td>
<td>40×6×8.7</td>
</tr>
<tr>
<td>2. 4 culverts</td>
<td>12592</td>
<td></td>
</tr>
<tr>
<td>(1)bricks or stones</td>
<td>6048</td>
<td>33.6×180</td>
</tr>
<tr>
<td>(2)pipes</td>
<td>2000</td>
<td>20×100</td>
</tr>
<tr>
<td>(3)bricks or stones</td>
<td>1200</td>
<td>12×100</td>
</tr>
<tr>
<td>(4)excavation</td>
<td>1952</td>
<td>61×4×8</td>
</tr>
<tr>
<td>(5)backfilling</td>
<td>1392</td>
<td>40×8.7×4</td>
</tr>
<tr>
<td>II Construction of culvert through dike</td>
<td>48300</td>
<td></td>
</tr>
<tr>
<td>1. Excavation and backfilling</td>
<td>36900</td>
<td>Excavation with 50m long ,32m wide at mouth ,3 m wide at bottom and 8 m high</td>
</tr>
<tr>
<td>(1)Excavation fee by machine</td>
<td>16200</td>
<td>5400×3</td>
</tr>
<tr>
<td>(2)backfilling and tamping</td>
<td>8700</td>
<td>1000m$^3$×8.7</td>
</tr>
<tr>
<td>(3)backfilling</td>
<td>12000</td>
<td>4000 m$^3 \times 3$</td>
</tr>
<tr>
<td>---------------</td>
<td>-------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>2. pipe and its paving</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)pipe</td>
<td>10000</td>
<td>50×200</td>
</tr>
<tr>
<td>(2)plumber</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>(3)protecting bricks or stone</td>
<td>900</td>
<td>5 m$^3 \times 180$</td>
</tr>
<tr>
<td><strong>Ⅲ lock gate on the culvert</strong></td>
<td>6728</td>
<td></td>
</tr>
<tr>
<td>(1)squared stone</td>
<td>2400</td>
<td>10 m$^3 \times 240$</td>
</tr>
<tr>
<td>(2)bricks or stone</td>
<td>1800</td>
<td>10 m$^3 \times 180$</td>
</tr>
<tr>
<td>(3)flashboard</td>
<td>240</td>
<td>0.3×800</td>
</tr>
<tr>
<td>(4)beam</td>
<td>288</td>
<td>0.36×800</td>
</tr>
<tr>
<td>(5) headstock gear</td>
<td>1000</td>
<td>1</td>
</tr>
<tr>
<td>(6)rubber, steel plate and installation fee</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td><strong>Ⅳ pipes on the floodplain</strong></td>
<td>15040</td>
<td>50 pipes with a diameter of 1.5m, and 30 m$^3$trinity mixture fill</td>
</tr>
<tr>
<td>(1)pipe</td>
<td>7500</td>
<td>50×150</td>
</tr>
<tr>
<td>(2)plumber</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>(3)protection head</td>
<td>1800</td>
<td>10 m$^3 \times 180$</td>
</tr>
<tr>
<td>(4)excavation</td>
<td>2100</td>
<td>1050×2</td>
</tr>
<tr>
<td>(5)backfilling</td>
<td>3140</td>
<td></td>
</tr>
<tr>
<td><strong>Ⅴ the total</strong></td>
<td>108736</td>
<td></td>
</tr>
</tbody>
</table>
4. Reparation of Drainage and Irrigation Canals and Land Treatment in the East of Southern Irrigation System

4.1 Basic situation

It is located in 2500m south of Qilin town and east of Liuxia road for reparation of the drainage and irrigation canals and the land treatment in the east of southern irrigation system The project benefits six villages of Baizhuang, Gongzhuang, Lvzhuang, Mengdian, Chaozhuang and Nanwangzhuang with total population of 4000 and a farmland area of 147 hm² as shown in figure 11.

![Figure 11 Sketch map of the eastern area of southern irrigation system](image)

In August of 1980, the Qilin town government had dug four medium-sized canals and ten branches in this area. However, the siltation in the drainage canals is severe because of the collapse of ditch slope, water loss and soil erosion. The drainage facilities are beyond use now, which cause waterlog in this area. The pilot area is low-lying with height of 38m, lower than surrounding area by 0.5m. Whenever it is rainy, the water from upper reaches and local rainfall led to severe waterlog in the fields, which makes the fields to turn into barren water-damaged land which is full of weeds without any harvest in autumn.

Besides, the depth of underground water embedment is 2.3m in average and 1.32m in minimum. The underground water is of carbonate, sulphate and chloride. Thus, the salina is severe in the dry season and the crop yields reduce greatly even to nothing.
Therefore, it is necessary to carry out reparation of the drainage and irrigation canals and the low-lying land treatment. This project will be carried out in a combination way of the low-lying land treatment and canal dredging, which means that dredging sediment in drainage canals will be used for the low-lying land.

4.2 Design and Plan of Project Scheme

4.2.1 Principles

(1) According to the current situation of facilities, terrain and water resource, the layout of irrigation and drainage canals and attached facilities should be decided for magnifying the benefits of the project in the largest scale.

(2) The soil quality can be improved by persisting on comprehensive treatment of drought, alkali and waterlog, taking care of the contradiction between drainage and irrigation, and controlling the underground water finally. The moisture of soil should be regulated properly so that there will be more yields in agriculture.

(3) The adjustment and reconstruction of the irrigation system is better to be carried out on the basis of the current facilities for realizing the goal of less investment with better effect.

4.2.2 Canal dredging and land treatment

There are four middle-sized canals and 10 branch and field canals in the east of Southern irrigation system in Qilin town, shown in figure 11. Thereinto, one east-to-west main drainage canal and three main branches suffer from severe siltation with hardly drainage capacity, which results in heavy waterlog in this area. It needs to dredge up for restoring the draining water-logging capacity of one main canal and three branches. Combining the land treatment with sediment dredging in drainage and irrigation canals will control waterlog effectively in this area. The dredged sediment from canal can cover the low-flying area, which not only makes full use of dredged sediment but also solves the problem of low-flying land effectively.

Based on the size of section and sedimentation amount, machine dredging or manpower dredging will be used in the east of the southern irrigation system in Qilin town. Usually, the machine dredging is used for large-section canals and large volume of sedimentation, and manpower dredging is used for small-section canals and small volume of sedimentation. The canal sections after dredging are shown in figure 12 and figure 13.

The east-to-west main drainage canal is designed according to recurrent interval of 3 years rainfall and 1 day drainage all. The design discharge of east-to-west main drainage canal is 3.70 m$^3$/s and that of north-to-south branch canal is 0.80 m$^3$/s.
4.3 Project Budget

4.3.1 Dredging in canals

Amount of sediment dredging in the west-to-east main drainage canal: the west-to-east drainage canal is 4000m in length with the severe sedimentation. According to preliminary estimate, the cross section before dredging is only 30% of the one after dredging, and the volume of sediment dredging is 19600 m$^3$. The cross section of west-to-east canal after dredging is shown in figure 12.

Amount of sediment dredging in the south-to-north branch canal: the south-to-north branch canal is almost flat with sedimentation. According to preliminary estimate, the cross section of the branch canal is about 20% of the one after dredging. The length of three branches is 6 km and the volume of sediment dredging is about 7200m$^3$. The cross section of south-to-north branch canal after dredging is shown in figure 13.

4.3.2 Project budget

If considering combination of the low-flying land treatment with the sediment dredging in the canals, the dredging sediment from canal will be used to cover the low-flying land near to it. The unit price of sediment dredging is 3 Yuan/ m$^3$, and the
unit price of moving soil is 2.2 Yuan/ m³. The total cost is about 139360 Yuan.

5 Overall Budget for Water Subcomponent of the Project

The overall budget of three pilot projects is about 319000 Yuan, shown in table 5.

<table>
<thead>
<tr>
<th>Items</th>
<th>expenditure (Yuan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) The reparations of pumping station and the trunk canal in Shuangwangzhuang irrigation system.</td>
<td>70700</td>
</tr>
<tr>
<td>(2) The construction of the drainage culvert in the Liuying irrigation system and the attached projects</td>
<td>108736</td>
</tr>
<tr>
<td>(3) Reparation of the drainage and irrigation canals and the land treatment in the east of southern irrigation system</td>
<td>139360</td>
</tr>
<tr>
<td>The total</td>
<td>318796</td>
</tr>
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</table>