The Role of Soil and Water Conservation in the Sustainable Development of Water Resources in the Yellow River

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1 Background

In the region of the Loess Plateau of the Upper and Middle Reaches of the Yellow River, including closed area from LongYang Gorge of the Yellow River to TaoHua Valley, the total area is 0.64 million km^2 including the area of soil erosion 0.434 million km^2; annual soil erosion is 1.6 billion ton.

Since 1949, great achievements have been obtained for Soil and Water Conservation(SWC) in the Yellow River, controlled area occupied 41.4% of soil erosion, which got obvious benefits of social and ecology for reducing sediment. Comprehensive treatments of SWC transformed the small topography situations and improved vegetation (crop) cover and enhanced precipitation infiltration rate and reduced amount of surface runoff and lessened erosion amount and corroded force, thus put a positive effort to the quality and quantity of water resources of the downstream.

2 Abating flood peak and buffering flood

2.1 The function of small runoff region for abating and buffering flood

It was proved from the data observed in the different points for many years, that single treatment of SWC had significant function for abating and buffering flood at microcosmic measurement units in small runoff region.

TianShui Water Conservation Station of the Yellow River Conservancy Commission deduced from analyzing and discussion in runoff ground (district) of water conservation experiment station in the Middle Reaches of the Yellow River, that abated index after treatment of flood abating measurement from varied flood frequency. Of 5% flood frequency, influent impounded body of terraced field was 60,000 m^3/km^2—12,600 m^3/km^2, abated flood rate was 59%—88%. influent impounded body of man-made forest was 29,000 m^3/km^2—51,000 m^3/km^2, abated flood rate was 16%—52%. influent impounded body of artificial grasslands was 10,500 m^3/km^2—34,000m^3/km^2, abated flood rate was 12%—27%.

Table 1 Abated index in varied flood frequency in representing small region in the yellow river middle stream

Flood Frequency %	Small Area of DaZhou Ditch,Yan'An			Small Area of WangJia Ditch,LiShi		
	Terraced fields	Forestation	Artificial grassland	Terraced Fields	Forestation	Artificial grassland
5	12.6	5.10	3.40	6.0	2.90	1.05
10	9.10	5.40	2.59	4.10	2.40	1.01
20	6.20	4.43	1.90	2.40	1.65	1.00
30	4.70	3.55	1.60	1.65	1.37	0.90
40	3.65	2.80	1.25	1.25	1.15	0.70
50	2.75	2.10	1.05	0.95	0.95	0.50
60	1.90	1.50	0.82	0.75	0.81	0.30
70	1.20	0.90	0.61	0.50	0.60	0.20
80	0.60	0.40	0.38	0.20	0.38	0.10

90	0.10	0.05	0.03	0.05	0.05	0.02

2.2 The function of small and middle watershed for abating and buffering flood

From analyzing and testifying to observed date, in the scale of small and middle watershed, comprehensive treatment of SWC also had significant effection for abating and buffering flood.

Area of DaShu Ditch in DanTaZi Town in QingShuiHe county in Inner Mongolia autonomous region is 18km^2 and had planted 1,133hm^2 trees(with pasture between lines), in summer, 1984, this ditch inside did not flood and gained harvest of wheat in ditch after 3 hours consecutive precipitation 56mm. XiHeiDai Ditch of ZhunGeR Qi, Inner Mongolia, valley area is 32km^2, launched comprehensive treating Since 1982. by 1992, there already completed 62.7% valley area, had constructed 15 major works and water conservancy silt arrester with the total capacity 8.548million m^3 in main and branch valley, thus formed basically small watershed dam system, through '7.21' storm, all flood was impounded into dam so as to protect 53.3hm^2 farmland in main valley and averted disaster.

For contrasting the benefits for abating flood and reducing sediment, five flood data of ChabBa Ditch watershed of WuDing river were selected. so two types of flood data were contrasted and analyzed respectively which both had the similar rainfall, rain duration, rain fall distribution, antecedent influence precipitation before treating and after treating. it could be deduced that the benefits of comprehensive treating for abating flood and reducing sediment in ChaBa Ditch were great, the average five year flood peak reduction was 64.1%; flood mitigation was 42%, sediment reduction was 51.4%.

Table 2 Contrasting and analyzing list of similar flood in chaBa ditch (Each area of rainfall was 187km^2)

Contrasting Year	Rainfall Amount/time (mm/h)	Antecedent Influence Precipitation (mm)	Peak Flow (mm)	Flood Flow Amount (10,000m^3)	Flood Sediment Discharge	Mitigation Of flood Flow		Reduced Water	
						Amount	Ratio	Amount	Ratio
1970	66.6/6.3	6.1	640	323	255	331	51.7	148	45.8
1980	66.6/4.6	6.4	309	175	109				
1966	54.2/2.1	21.4	1520	529	392	1309	26.1	297	56.1
1978	62.4/2.3	24.1	211	232	167				
1963	48.0/2.6	2.3	585	189	183	434	74.2	76.0	40.2
1983	39.0/3.5	3.8	151	113	80.0				
1969	54.2/1.7	3.4	818	246	237	245	30.0	27.0	11.0
1991	29.5/0.8	4.1	573	219	244				
1970	39.0/3.5	10.3	270	119	75.9	138	51.1	42.3	35.5
1992	39.6/3.8	12.1	132	76.7	60.7				
Total Or Average	Forwards	242/16.2	43.5	766.6	1406	1143			
	Afterwards	237.1/15	50.5	275.2	815.7	560.7	491.4	64.1	590.3

Table 3 Comparing to variation of two similar peak rainfall and flow amount in LuEr Ditch

Time	Rainfall (mm)	Rainfall Intensity (mm/h)	Peak Flow (m^3/s)	Peak Amount (ten thousand m^3)
1995.7.13	46	2.4	14.0	11.0
1979.7.14	45	5.5	9.1	6.3
7.14 less than 7.13			34%	59%

Luer Ditch is a branch ditch of Wei River Middle on the near suburbs of TianShui City, GanSu province. Its watershed extends 12km^2, with upper stream and downstream which are respectively soil

and rock mountains and undulating topography. From the data from 1954—1961, its average annual runoff modulus was 70,100m^3/km^2 and its average annual erosion modulus was 7,940t/km^2. In 1953, controlling work began, by 1979,the total area completed horizontal terraced fields, forestation, man-made meadow, orchards, and so on was 546.7 hm^2, up to 45% of all the region. From the two approximate precipitation forwards and afterwards, the comprehensive treatment of SWC for abating flood peak flow and flood capacity was obvious. (As Table 3).

2.3 The function of large river basin for abating and buffering flood

Observed hydrological data suggested that the large river basin (block) that had an area up to several thousands km^2 and even ten thousand km^2, also had obvious effect for abating and buffering flood when SWC was up to a certain degree.

DaLi River, a tributary affluent of WuDing River, with an area of 3,906km^2, by 1980, had 667.8km^2 treated, up to 17.1% of the total area. WuDing River treating investigation team of Water Conservancy Commission of the Yellow River, in 1983, according to the condition that it had a similar rainfall and rainfall duration and approximate antecedent influence rainfall, calculated and analyzed the precipitation, rainfall, mudflow of 147 floods of DaLi River from 1955—1980, divided by 1970, selected 42 pairs of comparison flood data near 1970 and counted out that the abating of average flood peak amount from 1971—1980 was 51.5%. As the research of the Water Conservancy Science Institution of theYellow River, 40% annual impounded flood flow of DaLi River from February to September released in un-flood season and improved river valley base flow. In 1985, Hydrology Bureau of the Yellow River Commission in《benefit of SWC for abating flood and reducing sediment from the flood and sediment of "84.7" storm in the north of Shannxi province》 said: a large scale precipitation occurred, from eight of the ninth day of July, 1984, to eight of the eleventh day, in the region east from QinLing north to HuangPu Valley, west from LiuPan Mountain east to TaiHang Mountain. the main rainfall concentrated on the valley of QingJian River and Fan river, annual precipitation in river basin was 83mm, the maximum intensity of precipitation was 20mm/1hour. it was a strong rainfall only less than that of 1977 since 1949. The yields of runoff and sediment of this storm were very low. Flood Peak Flow at GanGuYi Station of Yan River and YanChuan Station of QingJian River respectively was 105, 115 m^3/s, the 7-day runoff amount was respectively 92.41015billion m^3, flood flow modulus was 0.25, one-tenth of the ordinary flood flow modulus of this region. For tracing the reason, the four storms that took place in a larger river basin "59.8", "66.7", "69.8", "77.7" selected were contrasted to the result: the "84.7"storm, because of a larger controlled area of SWC, which treated degree was up to 31.8%, and the impounded function of reservoir, it was reasonable that had a low yields of flow and sediment. (Table 4, Table 5, Table 6)

Table 4 Comparison with characters of each storm

Storm	Rain Type	Rainfall Amount					Six-hour Precipitation (mm)	Maximum Rainfall Intensity(mm/h)	Rainfall Duration (day)
		Facing Rainfall	Maximum Point Precipitation		Single-Station One-day Rainfall				
			Amount	Station	Amount	Station	22.6	9.0	3
"59.8"	East To West	65.3	147.6	ZiChang	60.1	ZiChang	39.7	25.6	2
"66.7"	East To West	57.6	100	MaJiaJian	100	MaJiaJian	39.7	25.6	2
"69.8"	Southwest To Northeast	32.2	70	Yan'An	69.4	Yan'An	30.8	17.3	2
"77.7"	Southwest To Northeast	99.5	224	Zhao'An	165.9	Zhao'An	39.2	42.1	3
"84.7"	Southwest To Northeast	83	110	ZiChang	78	ZiChang	30	20	2

Table 5 Controlled degree of watershed and antecedent influence rainfall of each storm

Storm	Antecedent Influence of Rainfall (mm)	Controlled Degree of Watershed (%)
59.8	40.1	12
66.7	15.2	13
69.8	33.0	13.5
77.7	31.4	15
84.7	9.2	31.8

Table 6 The Statistics of the yields of the flow and sediment of each storm

Storm	Runoff	Runoff Modulus	Yield of Sediment(ten thousand ton)	Flood Peak Flow (m^3/s)	
				GanGuYi Station	YanChuan Station
59.8	16,008	0.26	8,235	1,230	6,090
66.7	10,409	0.19	6,023	2,480	4,110
69.8	8,161	0.27	5,426	2,410	3,530
77.7	25,928	0.28	16,277	9,050	4,320
84.7	1,939	0.025	21.8	105	115

The river basin of ChuanZhang Gorge of HuangPu Valley, a tributary affluent of the Yellow River extends 147km^2, the main ditch is 25 km^2 long, ditch density is 3.91km/km^2. since 1983, soil and water comprehensive treatment was carried out, by 1998, accumulated preserved area from treatment had 71.8km^2, the controlled degree was close to 48.8%, there had constructed 100 check dams, 33 seats of small reservoir and reservoir and soil and water conservancy silt arrester and key projects for harnessing HuaiHe River and projects by shrinking river to get usable land. Controlled area total was 132km^2, 89.8% of the total area of the river basin. The total reservoir capacity was up to 32.25million m^3. July 21, 1989, 15hours average rainfall in the valley was 118.9mm, the maximum rainfall was 141.2mm. It was deduced that was a storm accident for 150 years, Runoff Observe Station of HeJiaGeNeng of this basin middle-upper (56km^2 controlled) showed that the maximum flood flow was 188m^3/s. By calculation to storm, if have not taken SWC comprehensive treatment, the maximum flood peak flow would be to 847.1m^3/s, 3.65 times of the observed value. The projects of comprehensive treatments of SWC in ChuanZhangGou River Basin played a main role for buffering and abating flood peak, the amount of abatement of flood peak flow was up to 78.5%.

From analyzed result above demonstrated that the benefits of water impoundment and sediment of SWC both were rather significant not only in a small basin, but also in large area when treatments are improved to a certain degree.

2.4 The measurements of water conservancy and protection also had a notable function for buffering and reducing flood in the main stream of the Yellow River

It was reported by LiXueMei and others of the Yellow River Commission (《Yellow River》,issue5,1998), in the recent years, incidence of heavy flood in downstream of the Yellow River decreased greatly. It was calculated by HuaYuanKou Station, from 1950—1985, the flood with peak flow beyond 4,000m^3/s annually occurred 3.7times/1year, the flood over 8,000m^3/s occurred one time. But since 1986, only 1.3 times over 4,000m^3/s the flood took place, flood over 8,000m^3/s did not occurred. Decrease of flood incidence in the downstream had rather something with human activity than that of precipitation factor. Since the foundation of new China, especially from the 70s', the large scale water

conservancy and protection work had been done and many reservoirs had been constructed between the Yellow River Middle Reaches and SanHua district, so it transformed the runoff producing and confluence rules of the underlying surface of the river basin.

3 Reducing sediment in the river

Comprehensive treatments SWC decreased quantities of sediment, it had an important meaning to reduce hydraulic project silt and improved the ability of hydraulic project for abating and preventing flood and transforming runoff, which was one of the goals to carry out large scale treatment in sediment-laden district in Yellow River Middle Stream.

3.1 Comprehensive treatment of SWC had significant action for reducing sediment in small scale river basin

Loess multi-science investigation group of Chinese Academy of Science analyzed since the 50s' the most typical data of soil and water testimony place in the small scale valley of the Loess Plateau, the result indicated that the deferent measurements after SWC, the influence on hydrology mudflow of the small scale watershed were notable. From tables, it could be known that SWC of the small watershed decreased 50%—100% mudflow.

Table 7 Sediment loss benefit list of comprehensive treatment of small valley of loess plateau

Name	Area(km^2)	Controlled Degree(%)	Reduction of Sediment(%)
LongDong YangJia Valley	0.87	55	81
ShanBei XinDian Test Farm	1.40	61	73
ShanBei DaZhan Valley	3.70	39	75
JinXi WangJia Valley	9.10	40	52
LongZhong Luer Valley YuXi			
LuZi Valley ShanBei	12.0	45	59
Ani River Valley Nong Dong	20.7	88	79
Small South River Valley YanBei	22.0	78	53
LiHong River Valley ShanBei	30.6	50	97
JiuYuan Valley	36.0	70	62
Inner Mongolia	70.7	33	55
BaiShi Valley	96.0	56	47

Selected from 《water resource problem and policy of loess plateau》 China Science And Technology Press

Small watershed of JiuYuan Valley in SuiDe County, Shannxi Province, extends 70.1km^2, treatment began in1953, by 1998, the controlled degree was 56.3%. It is analyzed from the observed data from

1954—1988 by SuiDe SWC Station that before treatment, annual average sediment discharge intensity was 19,738m^3/(km^2 • a), after treatment it was 7,944m^3/(km • a). the reduction between the forwards and afterwards was 59.0%.

WuDing river second affluent, Cha Ba Gou watershed is a vice district of loess rolling and gully, watershed area is 205km^2, CaoPing Hydrology Station, controlled area 187km^2, variation of sediment in ChaBa valley was a miniature of that of WuDing River's, it had a typical meaning to analyze this region.

It was known from statistics of watershed's precipitation, runoff, mudflow in ChaBa Valley, 70s',data of runoff and mudflow began to be decreased as 60s'datum mark. 80s', the decreasement was very obvious. The reduction of runoff was only 32.1%, but reduction of sediment was up to 80.5%.

Table 8 Condition of variation of water and sediment in ChaBa ditch valley

Period	Station	Annual Average Rainfall (mm)				Annual Average Runoff(ten thousand m^3)	Annual Average Discharge (Ten Thousand ton)	Average Sediment Concentration
		Maximum One-day Precipitation	Maximum 30-day Precipitation	June to September Precipitation	Year Precipitation			
1960—1969	13	53.3	136.8	333.4	447.6	1,023.8	382.1	373.2
1970—1979	13	49.0	162.6	395.0	395.0	856.8	159.9	186.6
1980—1989	13	48.4	158.5	313.6	412.8	694.7	74.7	107.5
1990—1993	13	39.7	144.6	263.9	420.2	693.6	114.7	165.3
1994	13	79.9	262	386.9	426.2	1,227.0	445.0	362.7

Selected from 《The Reason and Tendency of Variation of Water and Sediment in Sediment-Laden and Coarse Sand District in Yellow River Middle Stream》 Yellow River Water Conservancy Press

3.2 Significant function of soil and water conservation comprehensive treatment to sediment loss in large affluent

WuDing River is a tributary affluent of the Yellow River, with an area of 30 261km^2, at the base of the live-observed data from 1956—1969(soil erosion had not been controlled) in BaiJia Valley Hydraulic Station, annual runoff was 15.37billion m^3, annual average sediment discharge was 2.177billion, average sediment concentration was 1.415kg/m^3. Contrasting with the same period (1960—1969) in SanMen Valley in Yellow River upper stream, its area was only 4.31%, annual runoff was only 3.46%, but sediment discharge was 19.34% and coarse sand (d>0.05mm) was over 25%.

In 1983, WuDing River was promoted to be nation's stress treatment region. By the end of 1993, when the first period project was completed and tested, the accumulated preliminary controlled area was 12,880km^2, 56.7% of the area of soil erosion, with new-built terraced fields were 0.1378km^2, forestation were 88. 95hm^2, improvement of grassland were 19.61hm^2, the development of muddy grounds muck land were 22,000hm^2, new-built water conservancy silt arrester were 11,631 seats, accumulated silted storage capacity were 21.45billion m^3, new-built reservoir over 1 million m^3 were 74 seats, with a total storage capacity 14.85billion m^3. Through the consecutive pieces-joint, large-scale treatment, WuDing River approximately formed the control pattern, with the joint between facing large scale treatment and ditch reservoir and dam project control. it transformed the process of water and sediment of WuDing River.

From tables 10 below, it could be know, 70s', that the decrease of annual average sediment discharge amount, contrasting with the datum mark 1956 to1959, was 101.51milliont, 40.4% of that of level period and 13.6% of the real decrease. 80s', the annual average decrease of sediment discharge was 164.76million t, 75.8% of that of datum mark period, including the decrease86.24million t in due to the influence of human activity. The precipitation of 90s' was slightly higher than that of 80s', but be less lack than that of year distribution data of precipitation, so we preliminarily estimated from analyzed result of 80s' that sediment decrease of human activity, for example, water conservancy, hydraulic measurement and so on was about 55% of the real decrease 157.29million t. The influence of precipitation was 45%.

Table 9 The list of real-observed water and sediment of baiJia valley station of WuDing river

Period (Year)	Annual Average				Variation of Annual Average Comparison to That of 1956—1969					
	Rainfall Amount (mm)	Runoff Flow (Ten Thousand m^3)	Sediment Discharg (ten thousandt)	Sediment Concentration (kg/m^3)	Rainfall		Runoff		Mudflow	
					Decrease Amount (mm)	Decrease Ratio (%)	Decrease Amount (mm)	Decrease Ratio (%)	Decrease Amount (mm)	
1956—1959	455	157,549	2,992	186.9						
1960—1969	433	152,128	18,665	122.7						
1956—1969	443	153,676	21,744	141.5						
1970—1979	389	121,074	11,593	95.8	53.6	12.1	32,602	21.2	10,151	46.7
1980—1989	384	103,615	5,268	50.8	58.9	13.3	50,061	32.6	16,476	75.8
1990—1993	385	91,691	6,015	65.6	58.2	13.1	61,985	40.3	15,729	72.3

Table 10 Analyze list of reason of variation of each-period sediment amount of WuDing river basin

Period (Year)	Sediment Amount of Annual Average Real Observing	Annual Average Calculated Sediment Amount	Real-Observed Decrease of Sediment		Decrease of Variation of Precipitation Influence		Decrease of Influence of Human Activity	
1956—1969	21,744	21,744						
1970—1979	11,593	20,367	10,151	46.7	1,377	13.6	8,774	86.4
1980—1989	5,268	13,892	16,476	75.8	7,582	47.7	8,624	52.3
1990—1993	6,015	14,666	15,729	72.3	7,078*	45.0*	8,651*	55.0*

Note: the dasta from 1990—1993 of month runoff was lack, year precipitation was slightly higher than that of 80s', annual average sediment discharge amount was estimated inferring to that of 80s'.

The basin of SanChuan River includes four counties: FangShan, LiShi, ZhongYang, LiuLin of ShanXi province, with a basin area of 4,161km^2, including soil erosion area 2,762.2 km^2, 66.5%of the total area. Through the long time controlling, by the end of 1991, the controlled area of water and soil conservation was up to 137.670 hm^2 (equal to 1,376.7km^2), the degree of controlled area was close to 49.8%. In 1957, the hydrology station was set up in this basin and began to test the water-sediment. We looked 1957—1969 as the datum mark, its annual average runoff amount was 3.234billion m^3, silt was 36.81milion t. The annual average runoff amount were respectively 1.909billion m^3, 9.63million t and silt

were respectively 51.8%, 73.8% both less than that of the level year. Runoff amount of 90s'(1990—1994) were respectively 1.913billion m^3, 11.65million t and silt were respectively 24.5%, 68.3% both less than that of the level year.

4 The comprehensive treatment of soil and water conservation also had important function to the main stream of Yellow River

From 1998 to now, the positive result to research the variation of water and sediment inYellow River were six items, which all were proved that the comprehensive treatment of water and soil conservation had great action to decrease the sediment in Yellow River.

It was deduced by the research result of three investigations that average sediment decreasement of four stations (Long, Hua, He, Zhuang)in yellow river middle and upper stream. In 70s', was 355.6—459.8 million ton and that of 80s' was 239.7—706.1 million ton.

Table 11 Comparative list of calculating result of decreased sediment of yellow river middle stream(Hekou town to Tongguan) (unit:10^8t/a)

		Water and Sediment Funds of Ministry of Water Conservancy				National Natural Science Funds		85-926-03-01 Improve Further	
Location	Decade	Hydrology Method	Water Conservancy Method (1)	Water Conservancy Method (2)	Total Report	Hydrology Method	Water Conservancy Method	Hydrology Method	Water Conservancy Method
Up Hekou	50				1.534				
Town	60				0.998				
	70				0.246	0.46	0.613	0.46	0.46
	80				0.695	0.46	0.59	0.46	0.46
Between	50				0.14				0.028
Helong	60				0.776				0.477
Region	70	2.363	1.338	1.916	0.916	2.594	1.579	0.339	2.354
	80	3.842	3.662	3.239	3.239	3.198	1.342	2.601	1.662
Jin	50				0.327				0.062
Luo	60				0.052				0.62
Wei	70	1.436	1.754	1.723	1.436	0.727	1.085	0.699	1.472
Fen	80	2.127	1.483	2.386	2.217	1.14	0.405	0.329	0.461
Region	50				0.467				0.648
Between	60				0.828				1.097
HeTong	70	3.799	4.092	3.639	3.352	3.321	0.664	0.366	3.426
	80	6.019	5.145	5.625	3.366	4.337	1.747	2.808	2.123
Long	50				4.0				0.684
Hua	60				2.828				1.557
He	70				4.598	0.781	3.556	3.826	3.886
Zhuan	80				7.061	4.797	2.397	3.268	2.583

According to the data of 《the reason of variation and tendency of development of sediment-laden and coarse sediment region in Yellow River Middle Stream》 (Yellow River Water Conservancy Press), by treatment to sediment-laden and coarse sand region in Yellow River Middle Stream, the character of water and sediment in Yellow River had a rather variation (shown as list below).

It was deduced from the data of the list above, the rate of water reduction of the two methods were respectively 16.7%, 17.7% and the rate of sediment reduction were respectively 31%, 26%.

Table 12 The calculated result to reduce water and sediment of sediment-Laden and coarse sand region in yellow river middle stream

	Reduction of water				Reduction of sediment			
	Real-observe Before 1969	70s'	80s'	70—80 Year	Real-observe Before 1969	70s'	80s'	70—80 year
Hydrology Method	76.03	11.48	13.98	12.73	121,195	35,617	39,640	37,540
Water Conservancy Method	76.03	12.08	14.82	13.44	121,195	32,771	31,035	31,904

(units: hundred million m^3/year, ten thousand ton/year)

5 Impounding few river runoff was not enough to be considered as a factor of Yellow River interception

From analyze above, comprehensive treatment of soil and water conservation impounded relatively river runoff, and reduced amounts of sediment. In 1993, many research funds were settled for research problem about variation of water and sediment in Yellow River. GuWenShu, representing water conservancy ministry to research variation of water and sediment of Yellow River, at the base of reports and experts' reports, summed up the calculated results of each pieces and took the four station (Long, Hua, He, Zhuang) on the entrance of reservoir of SanMen Gorge as objects and show the situations of each decade in the list below.

Table 13 Water capacity variation list of four stations to entrance of the reservoir of San,Men Gorge

Decade	50	60	70	80
Real Measured Annual Average Runoff Amount (hundred million m^3)	429	457	359	368
Water Reduction of Hydrology and Water Conservancy	97	136	156	190
Returned Natural Annual Runoff Amount	526	593	515	558

The water reduction in the list included that of water conservancy irrigation projects. So, this Portion must be cut off so to get the water storage amount of water and soil concentration in Yellow River Middle Stream. The book 《Yellow River Hydrology》, edited in chief by ChenXianDe enumerated irrigation water amount in SanMen Gorge Upper as list below.

Table 14 The list of average irrigation requirement of each decade (unit: hundred million m^3)

Region	50s'	60s'	70s'	80s'
Up LanZhou	9.0	14.0	15.5	17.6
LanZhou to HeKou Town	68.8	84.4	82.3	97.2
HeKou Town to LongMen	1.7	1.7	3.1	4.9
LongMen to SanMen Gorge	17.8	26.9	39.2	34.9
Total	97.3	127	140.1	154.6

Synthesizing column 13 and column14, we get Yellow River channel runoff amount of water and soil conservation storage volume as list below.

Table 15 Yellow river channel runoff amount of water and soil storage volume (unit: hundred million)

Decade	50	60	70	80
Water Reduction of Water Conservancy	97	136	156	190
Irrigation requirement	97.3	127	140.1	154.6
Water Storage of Conservation	0.3	9.0	16.1	35.6

The data of column15 reflected the three situations: firstly, water conservation need to store up a portion of river channel runoff of Yellow River; secondly, with the expanding of the controlled area, the portion of storage of river runoff had the tendency to enlarge; thirdly, although water conservancy need river runoff, it increased continuously, the amount is rather low, even in 80s',only 6% of average annual flow of yellow river.

Next, water and sediment derive from the deferent sources, water inflow mostly was from up medium region mostly concentrate on region between Hekou to Longmen. According to the result of tables15, the controlled degree in Yellow River Middle Stream was up to 70%, the decreasement of water amount in Yellow River Main Stream was not more than 80billion m^3, which occupied 14% of the mean stream, it had a great meaning to control sediment of Yellow River, meanwhile, because of its small amount, it was not enough to be considered as a factor of Yellow River interception. Considering it further, if Yellow River medium reaches, especially between HeLong region, the water and soil conservation, plus to hydraulic projects' demand of water production in this region, it meant that intercept the overwhelming majority of sediment in Yellow River, so as to eradicate the sediment problem of Yellow River.

Thirdly, Yellow River interception mainly happened from February to July in non-flood reason, but the impounding function of comprehensive measurement of water and soil conservation mainly happened in July to September, it was not synchronous in time (Table 16); (1) Water and soil conservation impounded mostly storm flood runoff, which was unusable or difficult to use; (2) A rather portion of storm flood impounded in flood reason by water and soil conservation comprehensive measurement released in non-flood reason, it had positive effect to reduce interception for improving the river channel base water.

Table 16 Statistics of situations of yellow river interception in LiJin

Year	The date of Interception(Month. Day)		Days for Interception
	Initial	Final	
1972	4.23	6.29	19
1974	5.14	7.11	20
1975	5.31	6.27	13
1976	5.18	5.25	8
1978	6.3	6.27	5
1979	5.27	7.9	21
1980	5.14	8.24	8
1981	5.17	6.29	36
1982	6.8	6.17	10
1983	6.26	6.30	5
1987	10.1	10.17	17
1988	6.27	7.1	5
1989	4.4	7.14	24
1991	5.15	6.1	16
1992	3.16	8.1	83
1993	2.13	10.12	60
1994	4.3	10.16	74
1995	3.4	7.23	122

1996	2.14	12.18	136
1997	2.7	12.23	226

Selected from: “Look Back the History of Yellow River Interception and Simple Analyze” (《Yellow River》 Issue10,1998).

6 Reducing the water for flushing sand

In order not to aggravate further deposition of river channel in Yellow River downstream, Yellow River training plan presented 200bilion-240billion m^3 water (mostly was flood in flood season). It was calculated by the real-observed data in Yellow River downstream that requirement of water for flushing sediment per-ton was $13m^3$—$16m^3$.

At present, soil and water conservation comprehensive treatment area in Yellow River Middle Stream was up to 180,000km^2, these measurement annually reduced average mudflow into Yellow River 3billion ton, which was 18% of the annual average sediment discharge of Yellow River of 16billion ton. 3billion ton mudflow impounded by soil and water conservation comprehensive treatment could reduce requirement of water for flushing sediment 39billion—48billion m^3, relatively, improve the amount of usable water resource of Yellow River main stream.