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Western Uzbekistan Water Supply System Development Project

Project Technical Analysis

Abbreviations

ADB	Asian Development Bank
ADF	Asian Development Fund
asl	above sea level
CSA	Communal Services Agency
CPS	Country's Partnership Strategy
BD	design and build
DI	ductile iron
DMA	district metering area
DMF	design and monitoring framework
EA	Executing Agency
EARF	environmental assessment and review framework
EIRR	economic internal rate of return
EMP	environmental management plan
EOCC	economic opportunity cost of capital
FIRR	financial internal rate of return
FMA	financial management assessment
FMAQ	standard financial management assessment questionnaire
FS	feasibility study
GAP	gender action plan
GOU	Government of Uzbekistan
GRM	grievance redress mechanism
HDPE	high density polyethylene
HH	household
ICB	international competitive bidding
IEE	initial environmental examination
IPPF	indigenous people planning framework
IWA	International Water Association
LAR	land acquisition and resettlement
lpcd	liters per capita and per day
MHCS	Ministry of Housing and Communal Services
MOF	Ministry of Finance
NCB	national competitive bidding
ND	nominal diameter
O&M	operation and maintenance
PCB	polychlorinated biphenyls
PCU	Project Coordination Unit

PE	polyethylene
PNPC	Provincial Nature Protection Committee
PPTA	project preparatory technical assistance
PSA	poverty and social assessment
RCM	Resolution of the Council of Ministers
WDC	water distribution center
QBS	quality based selection
QCBS	quality and cost based selection
RDD	resettlement due-diligence
REA	rapid environmental assessment
RK	Republic of Karakalpakstan
RRP	Report and Recommendation of The President to The Board
SBD	standard bidding document
SPRSS	summary poverty reduction and social strategy
SSEMP	site-specific environmental management plans
TDS	total dissolved solids
TOR	terms of reference
TN	Tuyamuyun – Nukus (water company)
UCSA	Uzbekistan Communal Services Agency
WACC	weighted average cost of capital
WDC	water distribution center
WSS	water supply and sanitation
WTP	water treatment plant
WUM	water utility management
WUWSSDP	Western Uzbekistan Water Supply System Development Project

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1 PROJECT BACKGROUND AND OBJECTIVES

1.1 Project Background

1. The Government of Uzbekistan (GOU) with the support of the Asian Development Bank (ADB) intends to implement the West Uzbekistan Water Supply Improvement Project (WUWSSDP).

2. The Project is in line with priorities set by both ADB and the GOU, namely with the ADB Country Operation Business Plan Uzbekistan 2012-2014 and the Country's Partnership Strategy (CPS) Uzbekistan 2012-2016 as well as with the Development Strategy, Road Map and Investment Program for the Water Supply and Sanitation Sector of the Republic of Uzbekistan until 2020.

1.2 Project Location and Area

3. The Republic of Karakalpakstan (RK) is located in the west part of Uzbekistan with 165,600 km^2 of land area and a population of 1.79 million people.

4. The Project area, as depicted in **Figure 1.1**, covers six major districts out of the total fourteen districts of the RK, namely Nukus, Muynak, Kungrad, Beruniy, Amudarya and Karauzak districts, which make up 125,654 km^2 of land or about 75.4 % of the total area of the RK.

1.3 Project Objectives

5. The Project aims at significant improvements to local living standards, environment, health, and for enhancing local economy in the RK, through upgrading water supply infrastructure and services in the six districts of Amudarya, Beruniy, Nukus, Karauzak, Kungrad and Muynak. The project will contribute to implementation of resource saving policy and improvement of drinking water supply infrastructure, strengthening reliability of the water supply system.

6. The main objective of this project is the provision of safe water supply on a 24 hours basis for a population of 388,000 people in 116 rural settlements and the six urban centers of Nukus, Muynak, Kungrad, Beruniy, Amudarya and Karauzyak districts by 2022.

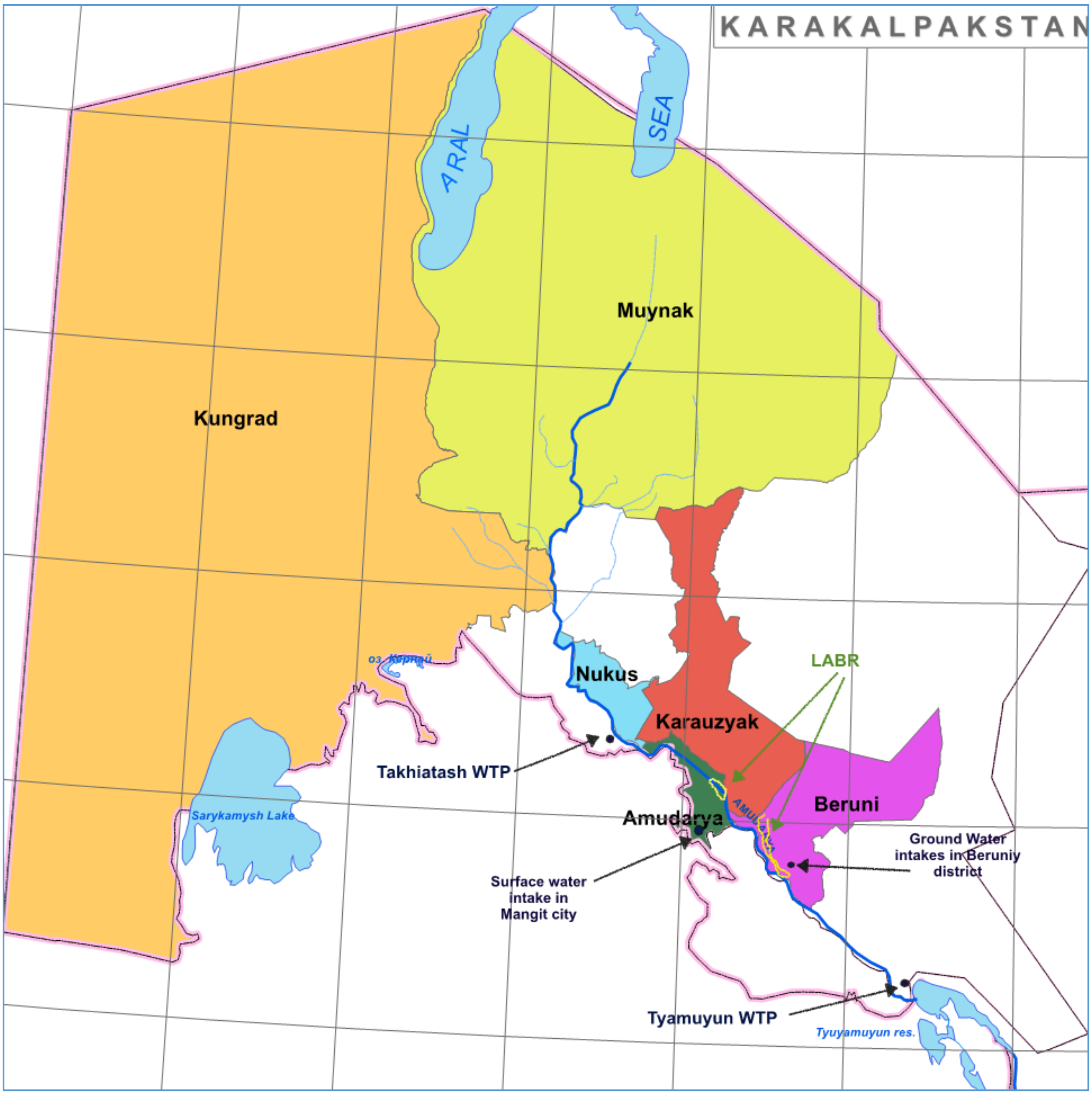


Figure 1.1 Project Location and Area

2 EXISTING SITUATION AND ISSUES

7. The Amudarya River has been and continues to be main source of water for water supply and irrigation in the RK. The flow of the Amudarya is regulated by means of a complex of reservoirs (Tuyamuyun, Kaparas, Sutansanjar and Koshbulak reservoirs) in the semi-arid desert of Central Asia. The Amudarya is also the main source of fresh water in the region and the main tributary to what remains of the Aral Sea. Other sources of water supply are constituted by groundwater contained in local aquifers in along the Amu Darya floodplains replenished by infiltration from the Amudarya River's banks or in form of pockets of fresh water trapped in permeable lenses of soil.

8. The existing water supply infrastructure in the RK has faced a number of challenging issues such as, inadequate budgets for system's operation and maintenance and expansion, insufficient capacity of technical and financial management, relatively high non-revenue water rates, and lack funding allocations for human resource development. This prolonged situation has caused a deterioration of the entire water supply infrastructure in the RK which in turn results in poor water quality and frequent system outage. Water delivery through the existing centralized distribution network is unreliable and water supply is only available on a scheduled basis, at some areas only for less than one hour each day.

9. Non-water revenue is relatively high at about 40% according to recent data.

10. The population connected to the existing centralized water supply system by means of either in-house connections or street standpipes averages 36.6%. Connectivity is significantly higher in the urban centers at 65.2% and is much lower in the settlements at 22.5%. The lowest level of piped water service is at 12.9% in the rural settlements. The population served with trucked water represents about 8.4% of people living in rural settlements. The worst case is in Muynak district rural settlements where 40.9% of the population rely on trucked water. About 10% of the rural population use unsafe water from shallow wells with handpumps due to the unavailability of water supply service.

3 TECHNICAL ANALYSIS

3.1 Water Resources Assessment

3.1.1 Surface Water Resources

11. Surface water from Amudarya River is the main source of water in the RK. Although use of water from Amudarya River for irrigation and other water supply uses was practiced already 6,000 years ago, organized abstractions with the purpose to sustain needs of agricultural development areas along the river commenced as of end of the years 1940's for the irrigation of 3 million ha. The abstractions of water estimated at 3 million m^3/yr at the end of 1940' increased up to 4.5 million m^3 in 1960. From the years 1960's up the 1990's the abstractions of water for irrigation needs had doubled. The multi-annual average total runoff of the Amudarya is estimated in a range between 47 and 108 billion m^3/yr with a multiannual average of at 78.46 billion m^3. The abstractions for irrigations gradually increased up to 120 billion m^3 in 2008, thereby rapidly reduced the water body of the Aral Sea. No water of the Amudarya reached the Aral Sea from 1993 to 1999. Nowadays the upstream flow of the Amudarya only reaches to the village of Porlitau, in the Muynak district, some 40 km southeast of Muynak city, where the river is impounded, and the flow is diverted into a Lagoon extending south of the road connecting Shagilik to Porlitau.

12. The current flow of Amudarya River is regularized by means of a complex of reservoirs (Channel, Kaparas: Kaparas, Sutansanjar and Koshbulak reservoirs) impounded with four main dams completed between 1981 and 1983 in Tuyamuyun, some 300 km upstream of the former geographical boundaries of the Aral Sea and extending over the territories of Uzbekistan and Turkmenistan. Based on planning, the reservoir complex is used to regularize the flow of the Amudarya mainly for agriculture (98%), and partly for industry and drinking water supply (up to 2%). The main impounding structure is a 141 m long and 25 m high overtopping concrete dam, with maximum and minimum operating levels at 130 and 120 m above sea level respectively. The operational volume within this operational range is 2.1 billion m^3. All reservoirs provide an accumulative operational storage volume of 5.4 billion m^3, while the total storage volume at commissioning was of 7.8 billion m^3. Siltation is the main problem in the management of the reservoirs complex. In 2001 the total storage volume decreased to 6.9 billion m^3, corresponding to a siltation volume of 0.9 billion m^3 deposited at a regime of 45 million m^3/yr.

13. Currently raw water is withdrawn from Tuyamuyun reservoir, after treatment and filtration, for water supply of urban and rural settlements in Khorezm and Karakalpakstan including the provincial centers of Urgench and Nukus. The Amudarya remains the main source of water supply of the whole settlements of Karakalpakstan and the city of Muynak in the RK desert.

14. In a whole, the use of water resources for water supply within the project area constitutes an imperceptible percentage of the total conjunctive annual runoff of the Amudarya and the replenishment of the groundwater aquifers and a very minor fraction, estimated at less than 1%, of the volumes of water diverted for irrigation. It can even be stated that the annual amounts of water utilized for water supply are smaller than the margin of error admitted for estimating annual surface and groundwater balances.

3.1.2 Groundwater Resources

15. There are four recognized groundwater aquifers in RK: i) the lower Amudarya aquifer, extending in both right and left bank of the Amudarya; ii) the Karakalpak aquifer in the left bank of the River; iii) the Khorezm aquifer; and iv) the Turtkul aquifer. Generally, groundwater in RK is salinized due to the high salinization of the groundwater bearing sediments. Ground water is also using for drinking purposes due to lack or absence other drinking water sources.

16. Many groundwater lenses of limited extension and capacity have been identified. These small aquifers are recharged essentially by seepage of fresh surface water from irrigation canals crossing the permeable areas of the shallow groundwater bearing sediments. The exploitable reserves of these aquifers are limited in quantity due to the limited recharge and due to the salinity intrusion of groundwater. These groundwater lenses are generally exploited by means

of small discharge wells for the supply of remote communities located far away from existing water distribution networks.

3.2 Water Quality Assessment

3.2.1 Surface Water Quality

17. Quality of surface water from the Amudarya is represented by monitoring results obtained from several gauging stations at Pakhta Canal intake (feeding Tuyamuyun WTP), Suenli Canal intake (feeding Takhiatash WTP), Mangit Canal intake (feeding Mangit WTP), Altinkul Canal intake (feeding Kungrad District Altinkul headworks), and Tallyk Canal intake (feeding Muynak District headworks).

18. The quality of both raw surface and ground water in the project districts and in the RK as a whole is impacted by the high salinization of the soils. The multi-annual average TDS in the water of the Amudarya progresses from 936 mg/l at Tuyamuyun to 1,177 mg/l in Samanbay. In the downstream of the Amudarya TDS was found in excess of 3 g/l between March and May. Likewise, the TDS of raw water at various canal intakes indicate to some extent an increasing trend of TDS content in water progressing towards the downstream of the Amudarya (Figure 3.1). Conversely, turbidity of raw water recorded at intakes in canals decreases towards the lower reaches of the Amudarya catchment area (Figure 3.2); however, this may due to the fact that water samples were taken after the sedimentation ponds where the raw water had already undergone some gravitational settling of solids.

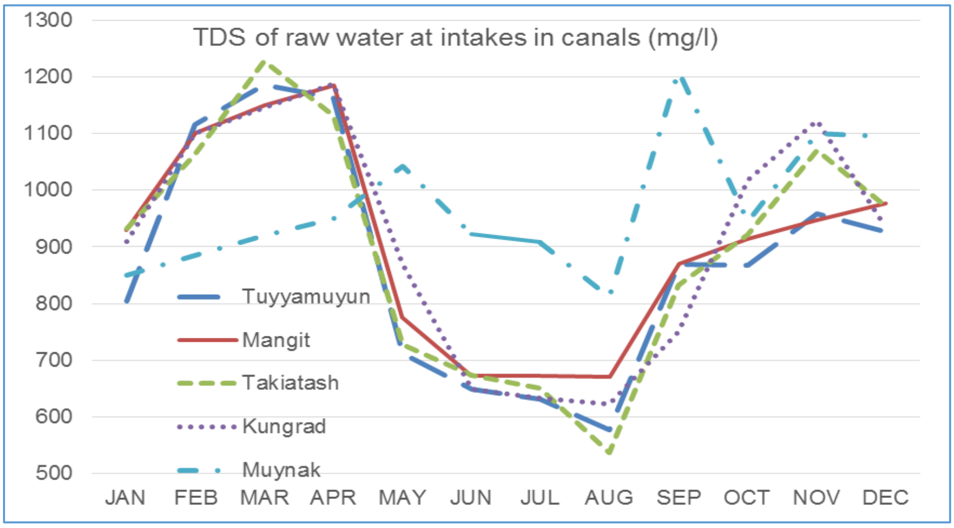


Figure 3.1 TDS of Raw Water at Various Intakes in Canals for Water Supply

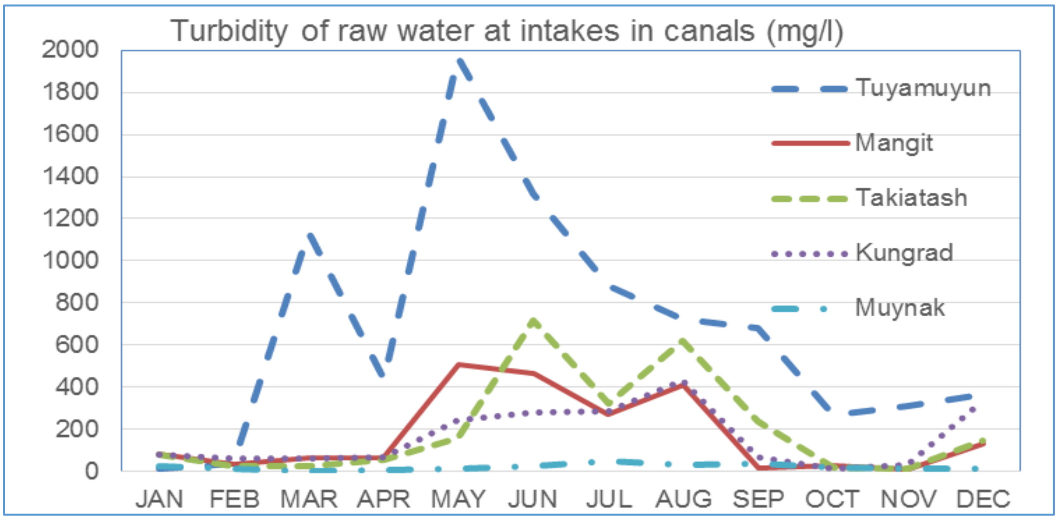


Figure 3.2 Turbidity of Raw Water at Various Intakes in Canals for Water Supply

19. **<u>Pakhta Canal intake (feeding Tuyamuyun WTP)</u>**: **Table 3.1** summaries the fluctuations in total dissolved solids (TDS) and turbidity of surface water in Pakhta Canal during 2016. Turbidity increased significantly during the Spring and early Summer months when the discharge of the Amudarya reached seasonal high level with heavy solid loading runoff from rainfall and snow melting in the upper catchment area. Precipitation during Spring and Autumn generates the spreading of highly mineralized content inflows that was contaminated by the erosion of salinized soils into the Amudarya causing a typical bi-seasonal increase of TDS content in the Amudarya.

Number	Turbidity (mg/l)	pH	Oxidability (mg/l)	NO_3 (mg/l)	Alkalinity (meq/l)	Total Hardness (meq/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	TDS (mg/l)	SO_4 (mg/l)	Fe (mg/l)	Cu (mg/l)	F (mg/l)
Min	12	6.9	1.5	3	2.2	4.7	54.1	24.3	117.3	577	205	0.02	0.04	0.02
Avg	678.2	7	2.1	3.5	2.5	7.7	97.4	34.5	190.6	871.5	287.1	0.06	0.11	0.07
Max	1970	7.2	2.7	4.25	2.9	10.8	132.3	58.3	290.7	1185	377.3	0.12	0.18	0.14
No.	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Table 3.1 Surface Water Quality Data at Pakhta Canal Intake in 2016

20. **Suenli Canal intake (feeding Takhiatash WTP)**: **Table 3.2** summaries the fluctuation in surface water quality at Suenli Canal intake in 2016. Turbidity and TDS decreased during the summer, mainly due to dilution with relatively high flow in the Amudarya. The peaks of dissolved solids content in the spring and autumn may be related to seasonal dilution from rainfall runoff.

Parameter	Turbidity (mg/l)	pH	Oxidability (mg/l)	NO_3 (mg/l)	Alkalinity (meq/l)	Total Hardness (meq/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	TDS (mg/l)	SO_4 (mg/l)	Fe (mg/l)	Cu (mg/l)	F (mg/l)
Min	13	6.9	1.8	2.2	2.1	4.5	50.1	23.1	127.5	537	210	0.02	0.02	0
Avg	202.1	7.05	2.2	3.3	2.4	7.967	96.2	38.1	206.7	895	297	0.05	0.06	0.03
Max	720	7.2	2.6	4.5	3	11.3	136.3	60.8	296.8	1227	394	0.1	0.12	0.06
No.	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Table 3.2 Surface Water Quality Data at Suenli Canal Intake in 2016

21. **Mangit Canal intake (feeding Mangit WTP)**: **Table 3.3** summaries the fluctuation in surface water quality at Mangit Canal intake. During 2016 the TDS in Mangit canal had exceeded the concentration of 1,000 mg/l in February, March and April with a maximum measured value of 1,185 mg/l in April. pH values were relatively neutral, which in turn indicates that no correction of pH is required for water treatment process. Seasonal trends of the two water quality indicators are typical of surface waters in the region, with TDS decreased during the high flows season and peaking of salinity and solids in the Spring and Autumn due to rainfall runoff.

Parameter	Turbidity (mg/l)	pH	Oxidability (mg/l)	NO_3 (mg/l)	Alkalinity (meq/l)	Total Hardness	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	Dry residue (mg/l)	SO_4 (mg/l)	Fe (mg/l)	Cu (mg/l)	F (mg/l)
Min	12	6.9	1.8	2	2	5	64.12	21.8	128	671	218	0.02	0.03	0.02
Avg	172.8	7.0	2.2	2.9	2.4	8.0	99.4	36.5	202	905	300	0.06	0.07	0.06
Max	510	7.2	2.6	3.75	2.9	10.6	130.3	54.7	306	1185	404	0.12	0.13	0.08
No.	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Table 3.3 Surface Water Quality Data at Mangit Canal Intake in 2016

22. **Altinkul Canal intake (feeding Kungrad District Altinkul headworks)**: **Table 3.4** summaries the fluctuation in surface water quality at Altinkul Canal intake in 2016.The TDS in the water of Altinkul canal intake had slightly exceeded 1,000 mg/l in February, March and April and again in October and November 2016, with a maximum recorded concentration of 1,187 mg/l in April. TDS levels were lower during the months May to September as it is typical for surface water in the RK. The peak turbidity level was recorded at 434 mg/l in 2016.

Parameter	Turbidity (mg/l)	pH	Oxidability (mg/l)	NO_3 (mg/l)	Alkalinity (meq/l)	Total Hardness (meq/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	Dry residue (mg/l)	SO_4 (mg/l)	Fe (mg/l)	Cu (mg/l)	F (mg/l)
Min	11	6.9	1.9	1.8	2	5	60.12	24.3	137.7	622	228	0.02	0.02	0.02
Avg	163.0	7.0	2.1	2.5	2.4	8.1	100.9	37.6	210.6	911.8	300.1	0.06	0.05	0.05

Parameter	Turbidity (mg/l)	pH	Oxidability (mg/l)	NO_3 (mg/l)	Alkalinity (meq/l)	Total Hardness (meq/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	Dry residue (mg/l)	SO_4 (mg/l)	Fe (mg/l)	Cu (mg/l)	F (mg/l)
Max	434	7.1	2.3	3.75	2.9	10.7	168.3	54.7	311	1187	396	0.11	0.1	0.08
No.	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Table 3.4 Surface Water Quality Data at Altinkul Canal Intake in 2016

23. **Tallyk Canal intake (feeding Muynak District headworks)**: **Table 3.5** summaries the fluctuation in surface water quality at Tallyk Canal intake in 2016. The peak of TDS did not exceed 1,000 mg/l. Sulfate and chlorides were the major components of the total dissolved minerals in water.

Parameter	Turbidity (mg/l)	pH	Oxidability (mg/l)	NO_3 (mg/l)	Alkalinity (meq/l)	Total Hardness (meq/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	TDS (mg/l)	SO_4 (mg/l)	Fe (mg/l)	Cu (mg/l)	F (mg/l)
Min	3	6.9	2.1	0.25	1.7	7.3	80.16	27.9	178.5	812	282	0.02	0.04	0.02
Avg	19.4	7.1	2.8	2.0	2.2	8.717	107.5	40.7	244.2	969.9	322.4	0.05	0.14	0.05
Max	46	7.3	4.7	3.5	2.6	11	148.3	54.72	311.1	1210	382	0.12	0.22	0.1
No.	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Table 3.5 Surface Water Quality Data at Tallyk Canal Intake in 2016

3.2.2 Groundwater Quality

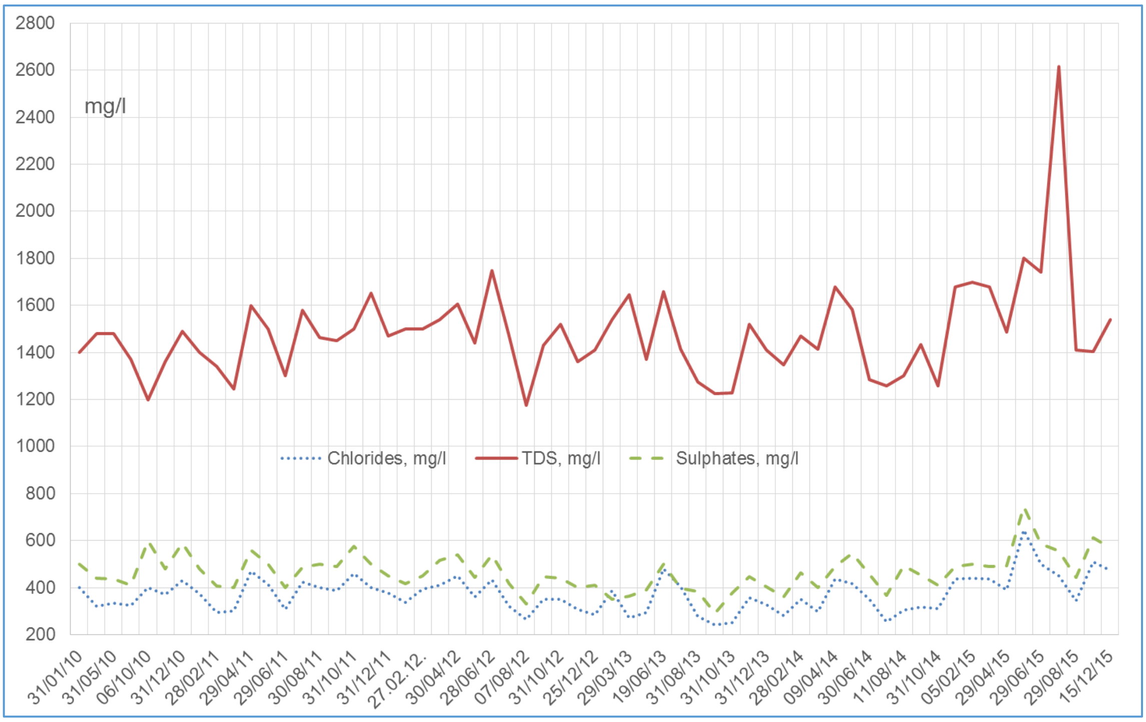
24. In general groundwater in RK is salinized due to the high salinization of the sediments constituting the substratum of the region. Groundwater aquifers of significant reserves with acceptable quality for water supply are limited in number. Most of them, found along the riverbanks of the Amudarya where groundwater bearing sediments with good permeability, are recharged by infiltration from the Amudarya. These aquifers were investigated and some of them are exploited by means of planned wellfields. However, many if not all wellfields are not exploited at planned regime mainly for the following reasons: i) high operating costs; ii) intrusion of salinized water; and iii) inadequate or no budget for operation and maintenance.

25. Within the Project area aquifers of sizeable dimensions are in the Beruniy district where there are two wellfields, the Beruniy and the Abay, located near the right bank of the Amudarya. These aquifers recharge from the Amudarya infiltration throughout the year. Quality of groundwater from small to large aquifers within the Project area exhibits generally high dissolved solids contents. The TDS and SO_4 concentration in the groundwater from the Beruniy wellfield often exceeds maximum concentrations set by national standard for drinking water.

26. Amudarya District uses groundwater from Uruzbay, Klichniyazbay, and Tash-Yab wellfields. In 2005 the salinity of groundwater was still within an acceptable range of 1 to 1.5 g/l for water supply. However, the production from these groundwater wells has been ceased due to the high fluorine content.

27. Beruniy District uses groundwater from Beruniy and Abay wellfields. Based on analysis of the groundwater taken from various wells in Beruniy wellfield between 2010 and 2015 the TDS in groundwater did not exceed 1,749 mg/l and averaged 1,134 mg/l over that 5-year period. Sulphate (SO_4) content in groundwater often found higher than 500 mg/l. It can be stated that sulphate and chlorides account for most of the TDS in the groundwater. A moderate increasing trend of TDS in groundwater water from all operated wells in the Beruniy wellfield is displayed graphically in Figure 3. 6. The concentration of other main indicators such as Cl and SO_4 were measured at concentrations of 647 mg/l and 746 mg/l.

Figure 3.6 Trend of Indicators of Mineral Content in Groundwater from Beruniy Wells



28. Nukus District uses groundwater from Madeniet, the "October-Ornana", and Ak Terek wellfields. Results of recent tests of TDS in groundwater confirm that dissolved solids content in groundwater within the Nukus District is consistently above 1 g/l at all seasons.

29. Muynak District uses groundwater from Porlitau and Kenesh Aul (Kazak Darya) wellfields. From the monthly water quality monitoring carried out in 2016 the TDS in the Tallyk canal does not exceed 1,000 mg/l. Sulfate and chlorides are also in this case the major components of the total dissolved minerals in groundwater.

3.3 Assessment of Water Production and Distribution

30. Currently the population living within the districts of Beruniy, Nukus, Karauzak and Kungrad rely on water supply produced from three major water treatment plants (WTP) namely, the Tuyamuyun, the Takhiatash, and the Nukus, that treat surface water derived from irrigation canals fed by the Amudarya. The combined production capacity of the three WTPs is 190,000 m^3/day. The population living in the districts of Amudarya and Muynak received insufficiently treated surface water derived from irrigation canals due to poor water treatment infrastructure.

31. Of the three major groundwater production units operated by TN, namely the Beruniy and the Abay in Beruniy district and the Uruzbay in Amudarya district, two are currently not operated. In Beruniy, only 5 out of 9 existing production wells are operated but only for a few hours each day.

32. The main groundwater aquifers are located near the banks of the Amudarya. Groundwater wellfields are developed within these aquifers to recharge from infiltration through the river

banks. In remote areas desalination plants were installed to treat salty groundwater, but are currently abandoned due to high operational costs.

33. The population connected to a centralized water supply system by means of either in-house connections or standpipes averages 36.6%. Connectivity significantly higher in the urban centers, where it averages 65.2% and much lower in settlements with an average of 22.5%. The lowest level of piped service is in Amudarya district, with an overall average 22.5% in urban center and is quite low at 12.9% in the rural settlements. Nevertheless, the reliability of the water supply service in general is low. Water is supplied on a scheduled basis, not only in rural settlements but also in district centers, in many places is less than one hour a day.

34. The population served with trucked water represents is about 8.4% in rural settlements. The worst case is in Muynak and Amudarya districts where 40.9% and 14.2% respectively of the population of rural settlements rely on trucked water, making of these two districts, the most critically and poorly serviced of the six districts included in the Project. People who do not have access to any water supply service have to use unsafe water from shallow wells with handpumps.

35. The balance of water supply sources versus water demand is presented in Table 3.6 and population projections for the six districts included in to the project is presented in Table 3.7.

Table 3.6. Balance of Water Supply Sources of the Region Including Project Districts

№	Description	Water demand, m3/day	Coverage, m3/day at 2043			
			WTP Tuyamuyun	WTP Nukus	WTP Takhiatash	Local sources
1	Amudarya	25 044,48				25 044,48
2	Beruniy	30 848,24	30 848,24			
3	Karauzyak	7 958,07	7 958,07			
4	Kungrad	27 457,45			14 993,45	12464
5	Muynak	6 041,52			6 041,52	
6	Nukus district (including Nukus city and Karatau)	119 524,89	22 577,00	65000	31 947,89	
	Total for 6 districts	**216 874,65**	**61 383,32**	**65 000,00**	**52 982,85**	**37 508,48**
	Beruniy	6 663,21	6 663,21			
	Karauzak	3 569,33				
	Nukus district (including Nukus city and	15 315,87			9 315,87	6 000,00
7	Takhtakupir	7 674,31	7 674,31			
8	Turtkul	34 029,87	29 029,87			5000
9	Khodjeyli (including Khodjeyli city and Takhiatash)	45 919,88			36 392,86	9 527,02
10	Chimbay	22 714,72	4 714,72		18000	
11	Shumanay	9 796,56			3 455,56	6341
12	Ellikkala	23 551,10	13 318,87			7 706,23
13	Kanlikul	8 654,30	8 654,30			
14	Kegeyli	17 161,40	8 561,40			8 600,00
	Total	**392 214,38**	**140 000,00**	**65 000,00**	**120 147,15**	**58 814,71**

Table 3.7. Population projections for the six districts included in to the project

Year >>>>>	*0*	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
ITEM	**2017**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**
1 Amudarya District																							
Mangit District Center	35 179	37 935	38 511	39 097	39 691	40 294	40 907	41 529	42 160	42 801	43 451	44 112	44 782	45 463	46 154	46 855	47 568	48 291	49 025	49 770	50 526	51 294	52 074
Settlements Outside District Center	44 603	48 097	48 828	49 571	50 324	51 089	51 865	52 654	53 454	54 267	55 092	55 929	56 779	57 642	58 518	59 408	60 311	61 227	62 158	63 103	64 062	65 036	66 024
Total Amudarya District	79 782	86 032	87 340	88 667	90 015	91 383	92 772	94 182	95 614	97 067	98 543	100 041	101 561	103 105	104 672	106 263	107 878	109 518	111 183	112 873	114 588	116 330	118 098
2 Beruniy District																							
Beruniy District Center	59 697	64 787	65 856	66 943	68 047	69 170	70 312	71 472	72 651	73 850	75 068	76 307	77 566	78 846	80 147	81 469	82 813	84 180	85 569	86 981	88 416	89 875	91 358
Settlements Outside District Center	37 823	41 048	41 725	42 414	43 114	43 825	44 548	45 283	46 030	46 790	47 562	48 347	49 144	49 955	50 779	51 617	52 469	53 335	54 215	55 109	56 019	56 943	57 883
Total Beruniy Center	97 520	105 835	107 582	109 357	111 161	112 995	114 860	116 755	118 681	120 639	122 630	124 653	126 710	128 801	130 926	133 086	135 282	137 515	139 784	142 090	144 434	146 818	149 240
3 Karauzak District																							
Karauzak District Center	15 302	16 404	16 634	16 866	17 103	17 342	17 585	17 831	18 081	18 334	18 590	18 851	19 115	19 382	19 653	19 929	20 208	20 491	20 777	21 068	21 363	21 662	21 966
Settlements Outside District Center	16 479	17 665	17 912	18 163	18 417	18 675	18 936	19 202	19 470	19 743	20 019	20 300	20 584	20 872	21 164	21 460	21 761	22 066	22 374	22 688	23 005	23 327	23 654
Total Karauzak Center	31 781	34 069	34 546	35 029	35 520	36 017	36 521	37 032	37 551	38 077	38 610	39 150	39 698	40 254	40 818	41 389	41 969	42 556	43 152	43 756	44 369	44 990	45 620
4 Kungrad District																							
Kungrad District Center	67 521	71 670	72 530	73 401	74 281	75 173	76 075	76 988	77 912	78 847	79 793	80 750	81 719	82 700	83 692	84 697	85 713	86 742	87 782	88 836	89 902	90 981	92 072
Settlements Outside District Center	28 494	30 245	30 608	30 975	31 347	31 723	32 104	32 489	32 879	33 273	33 673	34 077	34 486	34 900	35 318	35 742	36 171	36 605	37 044	37 489	37 939	38 394	38 855
Total Kungrad District	96 015	101 915	103 138	104 376	105 628	106 896	108 179	109 477	110 791	112 120	113 466	114 827	116 205	117 600	119 011	120 439	121 884	123 347	124 827	126 325	127 841	129 375	130 927
5 Nukus District																							
Akmangit District Center	9 772	10 295	10 404	10 513	10 623	10 735	10 847	10 961	11 076	11 193	11 310	11 429	11 549	11 670	11 793	11 917	12 042	12 168	12 296	12 425	12 556	12 687	12 821
Settlements Outside District Center	23 628	24 894	25 156	25 420	25 687	25 956	26 229	26 504	26 783	27 064	27 348	27 635	27 925	28 219	28 515	28 814	29 117	29 423	29 732	30 044	30 359	30 678	31 000
Total Nukus District	33 399	35 190	35 559	35 933	36 310	36 691	37 076	37 466	37 859	38 257	38 658	39 064	39 474	39 889	40 308	40 731	41 159	41 591	42 027	42 469	42 915	43 365	43 821
6 Muynak District																							
Muynak District Center	13 350	14 031	14 171	14 313	14 456	14 601	14 747	14 894	15 043	15 194	15 346	15 499	15 654	15 811	15 969	16 128	16 290	16 453	16 617	16 783	16 951	17 121	17 292
Settlements Outside District Center	10 570	11 109	11 220	11 332	11 445	11 560	11 675	11 792	11 910	12 029	12 150	12 271	12 394	12 518	12 643	12 769	12 897	13 026	13 156	13 288	13 421	13 555	13 690
Total Muynak District	23 920	25 140	25 391	25 645	25 902	26 161	26 422	26 687	26 953	27 223	27 495	27 770	28 048	28 328	28 612	28 898	29 187	29 479	29 773	30 071	30 372	30 676	30 982

Source: Design Institute under the Ministry of Housing and Communal Services, June 2017.

3.4 Assessment of Water Supply Infrastructure

36. The water supply infrastructure in the RK consists of three main water treatment plants (WTP) and a system of interregional transmission and distribution mains, as follows:

    i. the Tuyamuyun 1 WTP, located in the right bank of the Amudarya downstream of the Tuyamuyun reservoir, for the supply of districts in the right bank of the Amudarya;

    ii. the Tuyamuyun 2 WTP, located in the left bank of the River, for the supply of the Khorezm province and the Amudarya district in the RK; and

    iii. the Takhiatash WTP, located in the left bank of the Amudarya, for the supply of the Takhiatash and other districts North of Takhiatash.

37. The supply of the Amudarya district from Tuyamuyun 2 WTP has been interrupted since about 2 decades. The capital town of RK, Nukus, is supplied with drinking water from a WTP constructed 10 years ago with a treatment capacity of 65,000 m3/d of raw water withdrawn from Kizketken Canal intake

38. In a whole, the water supply system in the RK is not very old. Most of the pipeworks are less than 30 years old. On the contrary several pumping stations have not been in operation for several years and in some cases, were left unattended or abandoned.

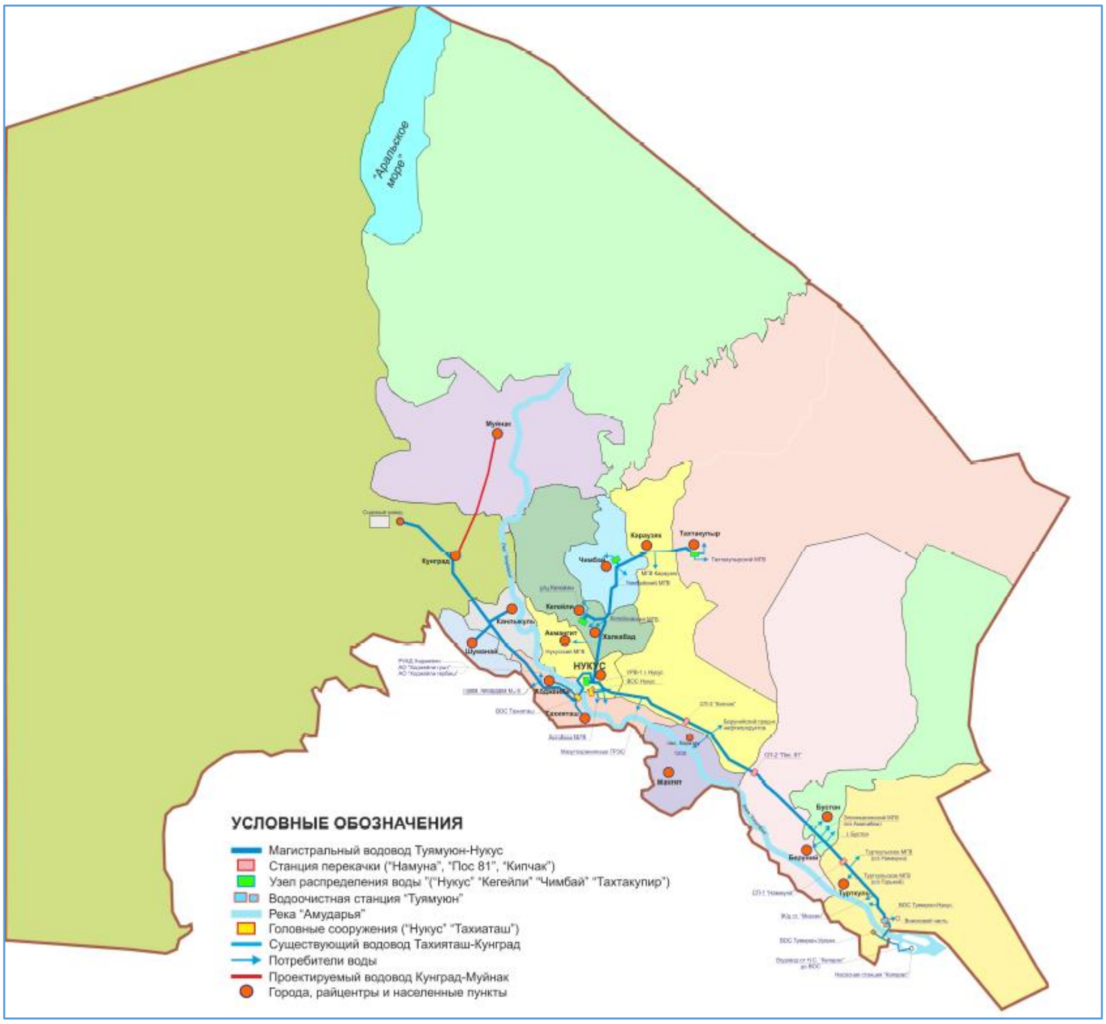


Figure 3.7 Project Area and Layout of the Tuyamuyun-Nukus Main

3.4.1 Assessment of Existing Water Treatment Works

3.4.1.1 Tuyamuyun WTP

Figure 3.8 Tuyamuyun WTP

(1-4 circular clarifiers, 5-6 longitudinal clarifiers, 7-8 filtration facilities, 9-11 Clean Water Reservoirs, 12 – 2nd lift pumping station, 13 – pumping station for own needs, 14-administration, laboratory, 15 – reagent unit, 16 – chlorination unit, 17-entrance)

39. As shown in Figure 3.8 the Tuyamuyun WTP consists of 1 raw water intake, 1 raw water PS and headworks, 4 circular settlers, 6 longitudinal clarifiers, coagulant mixing, 8 sand filtration and final chlorination, and 1 treated water PS. Due to financial reasons TN has been scaling down production at Tuyamuyun WTP to supply only to district centers of Turtkul, Beruniy, Bustan and via transmission mains to Turtkul, Beruniy and Ellikkala districts at 30,000 m^3/d during the winter months and at 60,000m^3/day during the summer months.

40. The raw water pumping station is in general good conditions. Four pumps were replaced in 2006 having a rated capacity of 4,500 m^3/h. From the intake, the raw water is conveyed to the treatment unit via 1.7 km of dia 1200 mm pipe.

41. The coagulant and chlorine dosing pumps were rehabilitated in 2005. Aluminum sulfate has been used as coagulant.

42. The circular settlers with a diameter of 52 m and a capacity of 50,000 m3/d each are aged and need full rehabilitation.

43. The equipment of the filters is rather old and backwashing does not function properly. These essential components of the treatment process should be rehabilitated as priority.

44. The 2nd lift pumping station is out of order and requires a total rehabilitation to regain the production capacity of the WTP to its initial design capacity.

3.4.1.2 Takhiatash WTP

Figure 3.9 View of the Takhiatash WTP

(1-4 circular clarifiers, 5-6 longitudinal clarifiers, 7 filtration facilities, 8-9 Clean Water Reservoirs, 10 – 2nd lift pumping station, 11-administration, laboratory, 12 – chlorination unit, 13 – reagent unit)

45. The Takhiatash WTP is located in the left Bank of the Amudarya, in Takhiatash district. The WTP is fed with raw water from the Amudarya via the Suenli Canal. The ageing WTP was commissioned in 1994 with a design capacity of 200,000 m^3/d. The facility was partly rehabilitated in 2011 to produce 60,000 m^3/d of drinking water.

46. As shown in Figure 3.9 the Takhiatash WTP consists of 1 raw water intake, 1 raw water PS and headworks, 4 circular settlers, 6 longitudinal clarifiers, coagulant mixing, 7 sand filtration and final chlorination, 9 clean water reservoirs, 2nd lift pumping station, and administration building with a laboratory.

47. The new raw intake pumping station was constructed in 2011. It is equipped with 3 submersible pumps with capacity of 1,500 m3/h, head of 18m (2 operating, 1 standby). The old raw water pump station is in state of abandon.

48. The 1st lift pump station (12x48 m) hosts 6 submersible pumps units (3200/33 m) is in good working order.

49. There are 4 circular settlers with diameter of 50 m. Two units were fully renovated under the rehabilitation program of 2011. The other 2 sets of settlers are obsolete and unfunctional.

50. There are 6 longitudinal horizontal 36x57 m settlers. Each settler unit consists of 6 corridors 6 m width. Each corridor includes an initial 18 m long flocculation compartment, followed by a 36-m sedimentation corridor and a terminal, 3 m wide collector channel perpendicular to all corridors. Two settlers were reconstructed in 2011 and are in operation. The others are obsolete and filled-up with mud.

51. The filters chamber includes 12 sand filters, each 7-m long and 4-m wide, which were rehabilitated from the existing ones in 2011.

52. There are two 2nd lift pumping station, one new and one out-of-order. The new one was constructed in 2011 which consists of 4 groups of pumps conveying water to Takhiatash, Khodieyli, and Kungrad.

53. There are 2 process pumps with unit capacity of 3,000 m^3/hour for sand filter backwashing.

54. The old 2nd lift PS is out-of-order and pump equipment was partially dismantled.

55. There is a potential for boosting the production capacity of the Takhiatash WTP to at least twice the present capacity of 60,000 m^3/d. It is envisaged to increase the treatment capacity of the WTP by rehabilitating the remaining components of the older WTP, in order to provide supplementary water supply to Kungrad and surrounding settlements as well as to the district center Muynak and other settlements within Muynak district.

3.4.2 Assessment of Existing Water Supply Distribution Works

3.4.2.1 Water Supply System in Amudarya District

56. The water supply system in the district center of Mangit was constructed in 1972. The existing network of water distribution mains in the district comprises of 240.4 km of pipes of which 32 km located within the district center of Mangit, with diameters from 100 to 300 mm largely constituted of Cast Iron (CI, 128 km) and Polyethylene (PE, 112 km). The PE pipes have been installed since 2003. Among the CI pipes, 23.3 km are older than 25 years and 104.9 km are less than 25 years old. Only 9,6 km of distribution mains are older than 30 years. Overall the distribution mains network is relatively recent and has not exceeded theoretical useful life.

57. In the past decades, it was planned to supply Mangit and other settlements in the left bank of the Amudarya by means of an inter-regional transmission main fed from a second WTP in Tuyamuyun located in the Left bank of the Amudarya (hereinafter referred to as Tuyamuyun 2). Currently the system supplies drinking water to the Khorezm province, center of Urgench as well as other rural centers including the historic city of Khiva via the transmission main in the left bank of the Amudarya. The trunk main does not supply water beyond the boundaries between Khorezm and Karakalpakstan. The reported water supply production capacity considering both surface and groundwater sources in 2016 was estimated at 12,500 m^3/d.

58. Currently Mangit City receives water supply from a system of 3 interconnected sedimentation ponds (VU-1) located within the urban perimeter, with a total capacity of 60,000 m^3, fed with raw water from the Mangit canal via 2 pumps in poor condition. The headworks, which occupy a surface area of 7.5 ha, include 2 drinking water reservoirs of 1,000 m^3/s capacity each, a 2nd lift pumping station, chlorination unit and a water laboratory. The second lift pump station, equipped with 4 pumps with a capacity of 320/50, is in working condition. The system is reportedly operated 12 to 14 hours per day. Power is suppled via 10kV lines and 2 transformers (160/10/0.4) are in working conditions.

59. Surface water intake VU-2 (Arna-Buyi) headwork consists of two sedimentation ponds with a total capacity of 50,000 m^3 each, fed with raw water from the Mangit canal, located 1 km in the upstream of VU-1. This headwork is meant for the supply of rural settlements within the district but it is currently not in operation. The 290 m^3/h raw water pump is out of order. The second lift pumping station is equipped with 3 pump units of which 2 of 200 m^3/h rated capacity are in working conditions. There is no chlorination unit. Power is suppled via 10kV lines and one transformer (160/10/0.4) is in apparently working conditions. There are plans to rehabilitate this headwork and connect the production unit to a newly constructed pumping station (RU-1) via a new 4.2 km transmission main, for the supply of rural settlements in the district.

60. This (RU-1) pumping facility was constructed in 2006 and rehabilitated in 2014 with the intention to connect the water distribution center (WDC) to the Tuyamuyun-Urgench transmission main, but has never been operated since its commissioning. The facility includes 5 centrifugal pumps (400/55), 1 chlorination unit, and 2 reservoirs of 500 m^3 capacity each. Power is supplied via a 10-kV power line and a (10/04) transformer. It is planned to connect this WDC with the VU-2 headworks via a new feeder pipe.

61. Yarinchi WDC was renovated recently. It consists of two groups of pumps. One set of 4 pumps for the supply of the village of Kitay and another group of 3 pumps for the supply of Yarinchi. The system was supposed to be fed from the Tuyamuyun-Urgench main. Currently this WDC is not in operation due to lack of water supply from the main.

62. The groundwater wellfield and WDC in Uruzbay were recently rehabilitated under a World Bank project. The headworks consist of 11 groundwater production wells and four 2nd lift pumps. Four wells were in operation for 2 months after commissioning. The reason for the suspension of the operation is unclear. It is planned to rehabilitate a 4.7 km distribution main connecting the wellfield with the WDC Kilichbay, in order to expand the water supply service to rural settlements in the south of the district.

63. The Kilichbay Groundwater wellfield and WDC here exploit a portion of the so-called Khorezm aquifer, located on the left bank of the Klichniyazbay canal, some 20 km South-southwest from Mangit City. The production capacity of the wellfield was estimated at 12,960 m^3/d. The groundwater production unit consists of 6 production wells with a reported conjunctive production capacity of 500 m^3/h (12,000 m3/d) and a dynamic groundwater depth of 45 m. Currently, 4 wells are operational and 2 are not equipped with pump so the reported conjunctive yield of the wellfield is reduced to 500 m^3/d. The Kilichbay WDC Includes 2 pumps (50/55) to supply water to Kilichbay village and 2 pumps (20/30) to supply the settlement in Khalimbek. There are 2 reservoirs of 250 m3 capacity each. This WDC has not been in operation since 2007 and would require substantial rehabilitation.

64. Groundwater wellfield and WDC at Ak Altin provides water supply to the rural communities Ak Altin and Jumur. The wellfield, consisted of 5 production wells aligned along the Tash-Yab canal at 50m apart, has a tested production of 5 m^3/h per unit. Pump setting is at 30 m of depth. There are 2 reservoirs with 300 m^3 capacity. The WDC is equipped with 5 centrifugal pumps with capacity of 20 m^3/hr. All WDC pumps are out of order and unfunctional. There is no Chlorination equipment. The whole works has been out of service since 2002 and needs full rehabilitation.

65. The situation of water supply in the districts of Mangit and Amudarya district is critical with regard to both water quality and level of service coverage. The water produced from the sedimentation ponds of unit VU-1, currently constituting the main source of water supply for Mangit, is not sufficiently treated and unsafe. The Mangit canal, which is the source of raw water for both VU-1 and VU-2 production units, crosses urban settlements upstream of the intakes VU-1 and VU-2 and is exposed to contaminants deriving from agricultural practices. There is no sanitary protection or buffer zones on both sides of the canal because there are permanent houses constructed within the theoretical protective perimeters.

66. Under the Project, a new water treatment plant with sufficient capacity to cover the demand of Mangit and nearby settlements is recommended.

3.4.2.2 Water Supply System in Beruniy District

67. The first centralized water supply network in Beruniy center was constructed in 1970. The network of water distribution mains in Beruniy district comprises of 478 km. About 81% of this length are less than 30 years old. Approximately 81 km are within the urban perimeter of Beruniy district center. 226 km of the water distribution network are of CI, 96 km of DI, and 125 km of PE. Nearly 19%, all constituted of DI pipes, of the water pipe network is older than 30 years. All PE pipes are less than 25 years old. Reportedly, water from the interregional Tuyamuyun transmission main and some groundwater wellfields delivered to Beruniy District amounts to 12,800 m^3/d.

68. The Beruniy wellfield and other appurtenances including a 2nd lift pumping station (PS) and other appurtenances were rehabilitated in 2005. Currently only 5 out of 9 production wells are operational but only operated for a few hours per day. The wells are equipped with submersible pumps with 30 m^3/h (8.3 l/s) capacity and a 30-m head. If 7 wells would be operated at a regime of 18 hours daily the production of the wellfield is expected to be up to 4500 m^3/day or more. In addition of the 4 wells currently out of service, all appurtenances and equipment need some rehabilitation. Within the wellfield premises there are 2 reservoirs with 2,000 m^3 and 5,000 m^3 capacity respectively, reportedly in good operational conditions. The 2nd lift pumping station is equipped with 5 centrifugal pumps (320m^3/h/50m), of which 3 for the supply to Beruniy and 2 to supply to the settlements of Amer and Avrora. Pumps and appurtenance are in working conditions. The building needs repairs. The chlorination plant is in good conditions but civil works are required particularly to improve ventilation.

69. The Abay wellfield was developed in 1982. There are 12 wells of which 4 are equipped with submersible pumps of 10/80, set at depth of 25/380 m and only operated for one hour twice

a day to supply the nearby settlements. The production of the wellfield has steadily decreased from 2012 to 2016. There are 2 reservoirs, each with 250 m3 capacity, are in good working conditions. The 2nd lift PS is equipped with 3 centrifugal pumps of which two (50m3/h/50m) and one (20/40), installed in 2003, supply the nearby settlements. The pumps are in apparently good conditions but the PS is not operated. The chlorination equipment is not operated but can be put back into operation. The housing buildings and fencing of the premises need rehabilitation.

70. WDC No. 18 is located near the village Mekhnatkash. It was equipped with 4 centrifugal pumps, all apparently beyond repair. Three have no electrical motor while the fourth motor are broken and beyond repair. The chlorination unit is apparently in average conditions and can be rehabilitated. Significant rehabilitation is needed also for the housing and fencing. There are 2 reservoirs each with 700 m^3 capacity in apparent working condition.

71. WDC No. 17, located near the settlement of Namuna, out of service since 2005, occupies a surface area of 1 ha. It was equipped with 4 centrifugal pumps now, all missing, delivered water supply to the settlements of Namuna, Yoshlik and Mekhnatabad. There are 2 reservoirs, each with 700 m^3 capacity. Practically all electromechanical equipment is beyond repair. Buildings need substantial rehabilitation. The whole WDC is abandoned and requires total reconstruction.

72. WDC No. 15, located near the settlement Nurmanbai, has been phased out. Constructed to host 4 centrifugal pumps for the supply of the settlements Tinchlik, Alman, Akhumbabaev, it was equipped with 2 centrifugal pumps (25m3/h/76m) which are unfunctional and apparently beyond repairs. There are 2 reservoirs, each with 700 m^3 capacity.

3.4.2.3 Water Supply System in Nukus District

73. The first water supply system in the district center of Akmangit was commissioned in 1976. The main source of water in Nukus district is from the interregional transmission main Tuyamuyun-Nukus-Taktakupir, which is partly fed from the Takhiatash WTP. Additional source is obtained from wellfields in rural areas of Shortanbay (3 wells) and Madeniet (3 wells), which produce groundwater with TDS content above 1,000 mg/l and often exceeds the norms of 1,500 mg/l. Both wellfields require rehabilitation of production wells, construction of new wells, reservoirs, 2nd lift pump stations and full reconstruction of the chlorination units. The reported daily production of water, essentially from the Tuyamuyun-Nukus-Taktakupir main in 2016, is 6,900 m^3/d.

74. Groundwater wellfield in Madeniet has 3 production wells but only 2 are in operation. Each is equipped with submersible pumps (6m^3/10m), set at 30-35 m of depth. The WDC has 2 water reservoirs with 75 m^3 capacity each, reportedly are in working conditions. The PS is equipped with 2 groups of 2 pumps with rated capacity of 45 m^3/h and 55 m^3/h/63m, respectively. The chlorination plant is based on solution of sodium hypochlorite. All buildings and fencing need significant rehabilitation. In addition, there is an old WDC near Madeniet that has been decommissioned. It is planned to construct a new WDC at this site for the supply of 3 settlements.

75. Kerder WDC was commissioned in 1992. In the pumping station, there is only one pump but it is out-of-order and beyond repairs. Chlorination was based on dosing of calcium hypochlorite solution. There are 2 reservoirs with capacity of 500 m^3 each. This WDC was decommissioned in 2002.

3.4.2.4 Water Supply System in Karauzak District

76. The main source of supply for Karauzak district comes from the regional water transmission system Tuyamuyun-Nukus-Taktakupir, with possible interconnection with other trunk mains fed from Takhiatash WTP and Nukus WTP. The reported combined production capacity in 2016 was 6,900 m^3/d. A significant population of the rural settlements in Karauzak obtains water supply from shallow groundwater developed by means of hand-pumped shallow wells.

77. The first water supply system in Karauzak center was commissioned in 1978. Currently the network of water distribution mains in Karauzak district comprises of 122 km of pipeline, mostly 100 to 150 mm in diameter of CI, DI and PE pipes. About 30 km of transmission mains are older than 30 years. The water distribution system in the district center of Akmangit was constructed in 1978. Most of the existing water supply pipes in Akmangit are older than 30

years. The majority of pipelines in rural areas were laid between 1990 and 1991 and have been in service served for 26 to 27 years.

78. The WDC Karauzak, commissioned in 1980, serves the district center. It is equipped with 5 pumps. Three replacements (290m3/h/30m) were installed in 2015, one 12/50 and two 160/30. There is one functioning 500 m3 reservoir but recently had structural failures and deteriorated top cover. The two others of 100 m3 capacity are of unknown conditions. It was reported that only one pump (160/30) is currently in operation. The WDC provides from 300 to 900 m3/d. A chlorination unit, installed in recent years, is no longer functional. Chlorination is fed directly into the 500 m3 reservoir which also needs complete rehabilitation or total reconstruction. A water laboratory equipped with old instruments is still operational. It is planned to fully rehabilitate this WDC.

79. WDC 1, for rural settlements water supply, used to provide water service to nearby rural villages for 1 hour, 2 times a day. This WDC is now in a state of abandon and extremely poorly maintained. Only one of the two 290 m3/h pumps can be operated. The two 400 m3 reservoirs need rehabilitation. A chlorination unit, installed in recent years, is in state of abandon. Some mechanical components including internal pipeworks and valves are still operational.

80. WDC VC-1 Karakol is located in Karakol, about 12 km south of Karauzak center. The pumping unit is equipped with two sets of centrifugal pumps: one set of three, 100m3/h/33m and one single pump 14/33. There are two 500 m3 reservoirs. This WDC was out of service 15 years ago

81. One desalination plant was constructed in Kirik but is not in operation. The unit was transferred to a new agro-tourism organization in Temirkhan but it has been decommissioned since, mainly due to high O&M costs and poor performance

3.4.2.5 Water Supply System in Kungrad District

82. The main source of water supply for Kungrad district comes from: (i) the Takhiatash water treatment plant (WTP) via the 96-km 1,200 mm dia Takhiatash- Kungrad transmission main for the western part of the district center at an average pumping rate of 8,000 m3/d, and (ii) surface water from sedimentation pond fed from a canal via a pumping station in Altinkul (to be fully renovated) at a rate of 3,300 m3/day on average without chlorination. The reported combined water supply production rate in 2016 was 15,000 m^3/d.

83. The first water supply system in Kungrad district center was constructed in 1972. Approximately 192 km (71.5%) of the 269-km network of distribution mains, mostly constituted by CI and PE pipes, are less than 30 years old.

84. Altinkul surface water intake and pumping facilities consist of a 10-m deep sedimentation pond fed from an irrigation canal. The pump station is equipped with 2 centrifugal pumps (630/90) installed in 2013 with a rated discharge capacity of 3,300 m^3/d. Overall conditions of the buildings are very poor. A centrifugal pump with rated capacity of 100 m^3/h, H=50 m, was installed to supply water to Ajaniyaz village. Population in the eastern part of Kungrad city is currently supplied with partially treated water from the Altinkul waterworks.

85. Other water infrastructures in Altinkul include two reservoirs, each with 300 m^3; a liquid chlorine disinfection unit; and an abandoned compact treatment unit with 6 filters.

86. WDC at Ornek site occupies about 1 ha of land. The source of water supply is Takhiatash – Kungrad trunk main. This WDC site includes one PS designed for 4 pumps but only 1 unit with a rated capacity of 17 m3/hour was installed in 2012. There are 2 water reservoirs of 300 m^3 capacity each without chlorination facility.

87. WDC at Khorezm site, built in 1989, occupies 1 ha of land. The PS has been decommissioned for years. Pumps and mechanical components have been dismantled. There are 4 reservoirs of 500 m^3 capacity each and one of 100 m^3 capacity.

88. WDC at Akumbabaev site has one PS equipped with 2 pumps, rather old and operates 2 times for 2 hours per day. Chlorination unit is not functional. There are 2 water reservoirs of 250 m^3 capacity each.

89. Substantially the City of Kungrad receives water supply from two different sources: i) the water from the Takhiatash WTP via a 100-km transmission main; and ii) the Altinkul headworks consisting of a surface water intake at a sedimentation pond fed by an irrigation canal. The population in the eastern part of Kungrad City is supplied with non-filtered water from this headworks.

3.4.2.6 Water Supply System in Muynak District

90. The Muynak district center and neighboring settlements receives water supply from one single source constituted by a series of eight 50,000-m^3 sedimentation ponds fed from a canal by means of 2 pumps but one is currently out of order. A 2nd lift pump station including three 320 m3/h pumps boosts the clarified water to the Muynak district center and nearby settlements via an 8.5-km transmission main. From Muynak district center water is distributed via a WDC to the residents of the city and nearby rural settlements. The reported production in 2016 was 8,100 m3/d.

91. The first water supply system and network in Muynak district center was constructed in 1974. The main distribution network in Muynak, mostly CI pipes, totals 73 km. Nearly 81 % of the distribution mains are older than 30 years.

92. Surface water intake Tallyk and pumping station facilities include one open air raw water pump in the Tallyk canal and a series of eight 50,000-m^3 sedimentation ponds. The 1st lift PS has 3 pumps (320/50) installed in 2015 and in working conditions. The building is in very poor conditions.

93. The WDC at Muynak is located in the center of Muynak city and occupies an area of 2.1 ha. The pumping station is equipped with 2 groups of 3 pumps each. One group includes 2 pumps (320/50) for the supply of the city and one pump (90/30) for filling water tanks. The second has 2 pumps (290/30) to supply the settlement of Uchsay. One third of the pumps are out of order. Chlorination with liquid chlorine is not functional. The building is in poor condition. There are 2 reservoirs with 1,000 m^3 capacity each and 1 reservoir with 2,500 m^3 capacity. The laboratory is poorly equipped. This WDC needs major rehabilitation.

94. More than 80% of the pipelines in Muynak district are older than 30 years and reach their service life.

95. One major problem in Muynak is the supplied water either via the centralized system or trucked is untreated.

3.5 Assessment of Existing Water Supply Service

96. Overall, about 36.6% of the population of the six districts in the Project are have access to a water supply by means of either an in-house connection or from street standpipes. There is a substantial gap between the level of piped service between the urban settlements, averaging overall 65.2%, and rural settlements, averaging 22.6%. Household connections averages 30.5%, with 63.2% in urban areas and 14.6% in the rural. People who have no access to water supply t have to use unsafe sources of water, mostly from shallow groundwater wells, canals or trucked water.

97. Considering each district separately, the highest level of coverage is in Kungrad, with 62% service coverage and is lowest in Amudarya with 22.5%. Urban piped water service level is highest in Kungrad city with an estimated 83.1% coverage. The rural areas experience the lowest coverage services with 12.9% and 17% of the rural population in Amudarya and Muynak districts respectively.

98. Water is unreliable and available only on a scheduled basis, often only a few hours every day. Overall, about 73% of population receive water supply for less than 1 hour each day.

99. According to a recent survey under the project, residents expressed dissatisfaction with water supply in the following percentages: irregular water supply at 30%; low water pressure at 42%; and salty or smelling water at 32%. Up to 77% and 79% of interviewees in the urban and rural settlements respectively report about excess of salinity and hardness in water. Overall 56% of interviewees have reported occurrence of muddy water and 30% indicated even occasional presence of algae.

100. During the focus group meetings and the stakeholder's meeting which were held during the HH survey, interviewees confirmed that consumers are very concerned about the quality of the water they are using for drinking and cooking purposes. The main complaints are the water quality parameters that affect the taste and aesthetic qualities of the water, although participants at the stakeholder's meeting frequently raised concerns about contamination from agrochemicals. The most frequently noted complaints were salinity (salty taste), suspended solids (muddy appearance) and the smell (indicating bacteriological action). There are more frequent complaints of suspended solids and smell in the summer months, while complaints regarding salty taste are more or less constant throughout the year. This is consistent with raw water quality, which is more turbid in summer. Due to the high level of suspended solids in the piped water supplies (often at a much higher level than in hand pump and hand dug well samples) chlorination of this water is often ineffective, thus allowing the transmission of pathogenic bacteria.

3.6 Assessment of Water Consumption and Demand Projections

3.6.1 Water Consumption

101. The average water use per capita is based on reported annual sales and total registered customers. Due to limited number of metered connections in rural area, water charges are fixed on assumed volumes, which are relatively high in comparison with EU effective water consumption.

102. Based on data provided by TN, as summarized in Table 3.8, the per capita consumption net of estimated losses in 2016 is estimated at 59.2 lcd. This figure includes water consumed by the industrial, commercial and institutional consumers. The per-capita water demand for household consumers only, without other categories of consumers, averages 56 lcd, and is used for the development of water supply scheme under this Project.

Table 3.8 Annual Sales of Water (m^3 x 1,000)

Item	2013	2014	2015	2016
Water production	33,991	34,038	33,760	33,836
Water treatment plant	33,991	34,038	33,760	33,836
Technologic losses	2,189	2,189	2,189	2,141
Water in network	31,803	31,849	31,571	31,695
Own use	43	42	42	43
Losses	8,702	9,245	9,109	9,178
Losses in %	27%	29%	29%	29%
Water sales	23,058	22,562	22,420	22,475
Domestic	19,793	19,117	18,925	19,653
Consumers				909,295
Per capita consumption (lcd)				59,2
Other	**3,265**	**3,445**	**3,495**	**2,822**

103. It is however from the interpretation of the socio-economic household survey carried out under this Project the per capita consumption of water including all sources is reported at between 25 and 30 lcd with a weighted average of 30.7 lcd. The per capita average consumption of piped water is calculated at 9.7 lcd.

3.6.2 Water Demand Projections

104. Water demand projections are summaries in Table 3.9. Upon completion, the Project will benefit a population of 388,000 living in the 6 district centers and in 116 rural settlements with the provision of safe water supply on a continuous base. At the project horizon 2043, the beneficiaries will be grown to some 518,000.

Table 3.9 Summary of Beneficiaries and Water Demand

Category	2,016	2,017	2,022	2,043	Water demand (m^3/d)
Amudarya district					
Mangit center	34,652	35,179	37,935	52,074	9,477
Total Amudarya district	78,587	79,782	86,032	118,098	17,674
Beruniy district					
Beruniy center	58,728	59,697	64,787	91,358	16,627
Total Beruniy district	95,937	97,520	105,835	149,240	23,616
Karauzak district					
Karauzak center	15,091	15,302	16,404	21,966	3,712
Total Karauzak district	31,342	31,781	34,069	45,620	6,568
Kungrad district					
Kungrad center	66,720	67,521	71,670	92,072	16,757
Total Kungrad district	94,876	96,015	101,915	130,927	21,449
Muynak district					
Muynak center	13,218	13,350	14,031	17,292	3,147
Total district Muynak	23,683	23,920	25,140	30,982	4,823
Nukus District	10,465	10,570	11,109	13,690	1,676
Akmangit distr. Center	9,670	9,772	10,295	12,821	1,917
Total distr. Nukus	33,052	33,399	35,190	43,821	5,507
TOTAL 6 districts	**357,477**	**362,416**	**388,181**	**518,688**	**79,638**
Total districts centers	**198,079**	**200,820**	**215,123**	**287,582**	

3.7 Initial Environmental Assessment

3.7.1 Environmental Baseline

105. The RK is located in the southwest part of Uzbekistan and occupies the northwest part of Kyzylkum desert and Amudarya delta. The total area of RK is 165,600 km^2. Climate is sharp-continental with very hot summer and cold winter without snow. Annual amount of precipitation does not exceed 150 mm.

106. The main drinking and irrigation source of water in RK is the Amudarya River. The flow of the Amudarya is regularized by means of a complex system of reservoirs (Tuyamuyun, Kaparas, Sutansanjar and Koshbulak reservoirs).

107. There are four recognized groundwater aquifers in Karakalpakstan: i) the lower Amudarya aquifer, extending in both right and left bank of the Amudarya; ii) the Karakalpak aquifer in the left bank of the River; iii) the Khorezm aquifer; and iv) the Turtkul aquifer. Generally, groundwater in RK is salinized due to the high salinization of the groundwater bearing sediments. Groundwater is also used for drinking purposes due to a lack of absence other water sources.

108. Records of diseases typically related to insufficient water supply and sanitation over the period from 2014 to 2016 from the Ministry of Health (MOH) of the Republic of Karakalpakstan showed that incidence of hepatitis A and acute intestinal diseases is higher in Muynak district. Amudarya and Beruniy districts have higher incidence on urolithiasis and calcified diseases.

109. A large part of the territory is occupied by the deserts of Ustyurt plateau and Kyzylkum. The drying Aral Sea and Amudarya river delta intervene between them and are, in their turn, divided by another (new) desert named Aralkum. The flora and fauna of the deserts reveal their adaptation to rather unfavorable ambient conditions.

110. In the RK there are recorded 498 vertebrate species spread over its territory, including 68 mammals, 307 birds (of which, 141 breeding, 20 wintering, and 14 migratory birds), 33 reptiles, 2 amphibians, and 49 fish species. Overall, the flora of the Aral Sea's desiccated floor is characterized by a small number of species. Only a small portion of the dried-up part of the Aral Sea floor is occupied by sparse desert vegetation.

111. There is the Lower Amudarya Biological Reserve (LABR) located in the territory of Beruniy and Amudarya districts. The LABR is of great importance as the guardian of the world's largest population of Bukhara/Bactrian deer (582 animals, according to records in 2010) vital for the regional and global biodiversity. The closest jobsites of the project will be located 2 km away from protected zone of LABR.

112. In view of setting water quality baselines for further reference of potential impacts related to the Project during the constructing phase or in the long range a series of analysis of indicators of water and air quality has been carried out as detailed hereafter:

a. NO2, CO2, and airborne particulate as indicators of air quality, namely 10 representative sites. Analysis showed exceeding national standards on airborne particulate almost in each site;

b. Quality of water at 24 representative places of surface, ground water and hand pumps, including Talimarjan, Takhiatash and Mangit water treatment plants; the analysis showed compliance of water samples from WTP with national standards and exceeding allowed concentration of mineralization and hardness in ground water

c. Noise: baseline measurements were carried out at 10 sites showing that currently maximum allowed day noise levels are exceeded at 1 points only in one place - center of Kungrad city.

113. There are a number of historical monuments, remains of ancient settlements, towers each district of Karakalpakstan. Within the current IEE locations of historical places in relation to the project works was discussed during the meetings with experts from Ministry of Culture of Republic of Karakalpakstan and representatives of settlements located within or near the Project areas. It was confirmed that there are no historical objects within project area and settlements which could be negatively impacted by the project. The heritage site nearest to the project site is located in 3 km from project site in Beruniy district.

3.7.2 Environmental Assessment

114. The Project is classified under environmental category B in regard to ADB Safeguard Policy Statement (SPS), 2009.

115. In general terms, the implementation of the Project will imply some negative and positive impacts. Main negative impacts occurring during the construction period are typical impacts arising during the execution of civil works, and pipe lying. These impacts are temporary and can be easily mitigated by adopting appropriate measures by contractors. Special provision will be included in the BOQs for civil works in accordance with the EMP.

116. A major impact identified to occur in the long term will be due to the anticipated supplementary amounts of wastewater produced from the various categories of consumers. This impact can be mitigated through a, staged implementation of sewerage system within each of the districts included in the Project.

117. The positive impacts are related essentially to the provision of safe water supply on a 24 hours basis which is anticipated to reduce occurrence of typically waterborne disease, better individual sanitation practices and overall improved health, to the beneficiary population.

118. Responsibility for the supervision of the EMP implementation and relative reporting as indicated in the EMP will lay with the Project Coordination Unit (PCU) through its environmental specialist supported by the Project Management Consultant's (PMC) environmental specialist. In order to secure long-term environmental due-diligence, it is recommended TPS to consider creating a position of environmental engineer within its structural chart.

3.8 Socio-Economic Assessment

119. Poverty, social, economic and gender assessment has been conducted in the six districts in the project area in April 2017. Data were collected through both qualitative and quantitative research methods from a range of contrasting sites. Qualitative data were collected through 71 in-depth interviews with beneficiaries and service delivery stakeholders and 6 public consultations with communities and public institutions. Quantitative data were collected through a formal survey of 1 200 households in the 6 district centers and in 82 rural settlements.

120. The household (HH) size in the project area consists of 6 people, the minimum number is 1 person, and the maximum number is 16 people. The size of an HH headed by a woman, without a man aged 18 years and older, ranges from the minimum of 2 to the maximum of 6 people. Survey covered 1,200 households, amounting to 6,956 people, including 50% of women, 40% women in the Turkmen ethnic group. The average age of the household member of the project area is 29 years old. Age structure of respondents (16 years and older) is as follows: the most HH members (58%) is of working age, of which 60.4% are men and 55.3% are women. In this age structure of all household members, the proportion of HH members who are older than the retirement age is 11.7%, while the group of children under the age of 16 is 30%.

121. The analysis carried out under the PSA revealed a poverty rate at 59% for the Project area as of April 2017, i.e. in 59% of the surveyed households the average per capita income did not exceed 1.5 of minimal wage or 224,662 KGS per month. Overall, the average per capita income in the poor households (126,000 UZS) of the Project area is lower than that of the non-poor (366,000 UZS). It is noticeable that the average per capita expenses do not differ significantly from the average per capita incomes: expenditure is only 32% lower than incomes. While in poor household's expenses are 7% higher than incomes, by contrast, in non-poor households' expenditure is 60% of the incomes. The data on the structure of incomes proves the high differentiation of the indicator for the population. The bottom quintile accumulates 18 % of the households; over 38 % of the surveyed report incomes below the average. As for the poor households, 39% of them fall into the low-income quintile, with 79% having incomes below the average figure.

122. Only 58% of poor households have members generating incomes from official employment; for comparison, the figure for the non-poor stands high at 85%. Moreover, the average amount of the income from official employment in poor households is half as much as that of the non-poor (641,000 UZS and 1,297,000 UZS respectively). By contrast, unofficial employment along with unregistered entrepreneurial activities generates a smaller share of incomes of smaller sizes for non-poor households. The proportion of remittances to income of 10% households is 63% and for 20% female-headed households is 54% of all income. Although the surveyed households have equal access to the pension system, the size of pensions and benefits received by the poor households is 1.5 time less than those of the non-poor (517,000 UZS and 825,000 UZS respectively). It is noticeable that pensions account for 50% of incomes of both poor and non-poor households. As for the makhalla allowances for low-income families and needy families with young children, both the coverage and the size of the social aid prove unable to affect the living standards of the poor and the population. The effectiveness of the social benefits would be higher if the allowances were paid in full, without reductions.

123. Spending on water for drinking and domestic purposes (including payments to the TN water company and water vendors, the purchase of bottled water, water carried from pumping stations by household members, treatment of water, the purchase of water storage containers, and construction/repair of water storage reservoirs) is rather small for all surveyed households, at 5% of the average household expenditure. The average monthly spending per HH for water in 2017 is estimated at 30,000 UZS.

124. A significant number of households, namely 60% of the poor and 100% of the non-poor, bore expenses on water in April 2017. On average, households spent as much as 67,000 UZS for water: 43,000 UZS by poor households, and 90,000 UZS by non-poor households. Whereas piped water makes up 4% of expenditure on water for households, the service of water vendors is at 1%, and bottled water accounts for 1% of the spending.

125. The situation with the population's access to communal services, especially in terms of piped water supply varies greatly within the Project area. By far the lowest access to piped water supply is shown for residents of private houses in Kungrad and Muynak districts (58% and 57% of the districts' households do not have access to centralized piped water supply respectively).

126. Almost 80% of kindergartens, schools, rural medical clinics in 6 districts are not connected to the piped water system. The main source of water for these institutions is constituted by shallow well pumps.

127. In a whole, the population of the surveyed areas experiences the following difficulties, which mutually exacerbate each other in a synergistic effect: i) lack of water limits the opportunities for the population to engage entrepreneurship and employment to generate income; ii) time and labor is engaged in order to gain access to drinking water; and iii) insufficient level of sanitation and high risks of diseases related to water quality. These consequences are especially acute for 59% of the population, which is classified as low-income by the criterion of low income.

128. According to the survey, the ethnic composition of the population of the Project area is as follows: 55% of the population is Uzbek. The second largest ethnic group is Karakalpak (26%) and Kazakh (16%). Such proportions persist in the sampling of all HHs. Basically, the Karakalpaks live in the northern regions (Karauzyak, Muynak and Nukus). The representatives of other ethnic groups of Central Asia (Turkmens) comprise 2% and other nationalities – 1% (Koreans, Tatars, Slavs, etc.).

129. The survey study revealed that the ethnic groups living in the Project area have equal access to all types of social protection including healthcare, education, water supply and sanitation. None of the ethnic groups is socially excluded in terms of either legislation or the actual situation. The level of household incomes and expenses along with the poverty level and access to potable water correlate fully with the place of residence, and never with one's ethnicity. Furthermore, the ethnic groups do not differ from one another regarding both cultural and social features. Therefore, none of the ethnic groups falls into the category of ethnic minorities/indigenous peoples to trigger safeguard policies in accordance with SDB SPS 2009[1].

130. Women in the project area are traditionally responsible for collecting water used for drinking, cooking, childcare, and cleaning. The traditional male occupations of crop cultivation and livestock rearing have significantly declined due to the prevailing ecological conditions. In many household's women are now the main wage earners, working in low paid service jobs such as cleaning.

131. The share of female-headed households is quite substantial, at 21% of the surveyed. The poverty level of female-headed and male-headed households shows a difference of seven percent 65% and 58% respectively). The incomes per capita for households with female heads are also lower. The female heads reported lower educational levels: while 65% of male heads have secondary vocational training, the figure for female heads is much lower, at 57%. Even though female education levels are generally comparable with those of men, it is the difference between the higher education levels for men and women (17% and 14%) that proves to be advantageous for men on the labor market.

132. The level of economic activity shown for women of working age proves very low (69%) especially in comparison with that of men (81%), due to the employment rates. The average monthly wage earned by women is about 27% less than men (471,000 UZS versus 638,000 UZS); Even though the unemployment rates for women and men are almost similar (39% and 40% respectively), as high as 39% of women neither work nor look for a job compared with a mere 40% of men of working age of the same position. Much fewer women of working age, only 30%, have a job (temporary, at least) in comparison with 41% of men in employment in the Project area. A considerable 21% of the women are employed in the public sector, especially education and health sectors, which are low pay, while the corresponding figure for men is about 13%. There 6.8 times fewer women than men employed in the non-

[1] ADB Safeguard Policy Statement (2009) Appendix 3, para. 6, p.56

agricultural sector. Also, there are 3 times fewer female entrepreneurs than male entrepreneurs.

133. The survey shows that women and children, particularly girls bear primary responsibility for the fetching of drinking in 70% of the project area households. The chore is very burdensome as women and children have to carry water several times a day, covering long distances of hundreds of meters. Only 18% of the surveyed households have a washing machine in working order, which are used mostly for producing butter from milk.

134. For woman who normally bears the responsibility of removing solid and liquid domestic waste, the work that proves very problematic for the rural population. 99% of households which have either none or non-functioning sewerage. It is women only who have to take out the feces from households and help other members with the use of toilets in the street in case there are young children and persons in need of care in the households. The sharing of public toilets with neighbors is of great discomfort for the residents as the toilets are critically unhygienic and unsafe to be used. Public toilets have become a source of flies and infectious diseases. For young children, the elderly and disabled the use of a public toilet is highly unsafe for health and life, and sometimes absolutely impossible.

3.9 Institutional Assessment

135. The Ministry of Housing and Communal Services (MHCS) has been recently instituted with decree of the President of the Republic of Uzbekistan PR-2900 dated 18 April 2017. Under the structure of the MHCS the Communal Services Agency (CSA) will endorse scope and tasks of the former Uzbekistan Communal Services Agency (UCSA).

136. The Department for Operation of Interregional Trunk Main Tuyamuyun - Nukus (DOITM-TN), hereinafter referred to as TN, is the institution in charge of the supply to the population of the RK with drinking water as well of the maintenance and expansion of the existing water supply system within the RK.

137. Due to massive degradation in quality of most locally available water resources, an elaborate scheme of water mains for transporting water to large distances was adopted as the only viable solution during the Soviet era, and is still a technical solution with no meaningful alternative. Consequently, population of the RK has an overwhelming dependence on services of TN, which is the only water supply operator in the region. Such an overreliance on TN operations by population makes sustainability and efficacy of TN operations critically important for resilience of populace to effects of climate changes.

138. TN has a vast and multifaceted set of assets; broadly geographically spread out operations; a mix of urban, semi-urban and rural water supply services; underdeveloped and largely decrepit water supply infrastructure; and otherwise complex set of operations. Such challenging operational complexities require advanced management systems and practices, which TN is evidently lacking. Without substantive modernization of management systems and practices, efficacy and sustainability of TN operations would not afford the necessary level of climate change resilience. What's more, expansion of TN networks to remote settlements would impose additional managerial responsibilities and challenges, which should be matched by corresponding capacity building measures.

139. The purpose of O&M capacity building is to overhaul the operation and maintenance practices, procedures and processes towards more responsible, rational and efficient mode of operations, based on international best practices. In absence of such overhaul of existing facilities, as well as facilities planned to be developed, upgraded and/or rehabilitated within the project may suffer from lax, disorganized and ineffectual exploitation, resulting in diminished project impact and premature degradation of assets. Considering the scale, diversity and criticality of the utility's asset base, understanding and embracing by the utility modern best practices in O&M would be of strategic and critical importance. Mismanagement of assets of such critical importance for resilience of the KR populace is a valid and significant risk, which can be reduced by substantive capacity building on O&M practices.

140. The purpose of the Corporate Development Program (CDP) is to enhance institutional efficacy and sustainability. Mismanagement of commercial and financial aspects of operations also carry risk of undermined performance capabilities. The utility has been

observed to limit its water production due to electricity affordability constraints for example, despite severe shortage of water levels supplied to end-users. The observed delivery constraints were not driven by technical capacity limitations, but by financial limitations on the number of hours the utility could afford to have its pumps running. Consequently, commercial and institutional aspects of operations need to be strengthened in order for the project's investment to yield the intended impact of enhanced levels of water supplied. The CDP's objective is to overhaul institutional settings and corporate governance practices towards greater accountability, transparency, and efficacy.

3.10 Involuntary Resettlement Assessment

141. The Project will have neither permanent nor temporary impacts in terms of land acquisition. There will be no physical displacement. Throughout the realization of the FS, a collaborative communication has been kept between the planners and the resettlement specialist. All sites for the construction of new infrastructure have been optimized in barren land areas in order to avoid impacts related to involuntary resettlement.

142. Construction of new water supply facilities will not require allocation of new lands as the new facilities will be constructed within the territories which belong to the TN. Reconstruction and upgrade of existing water supply facilities such as WDCs will be carried out within perimeters of such facilities, therefore without generating impacts related to involuntary resettlement. Construction and reconstruction of trunk mains and water distribution networks will be carried out along highways and roads within the existing roads rights-of-way.

143. The Project is classified under category C from the point of view of Involuntary Resettlement. Consequently, a Land Acquisition and Resettlement Plan (LARP) is not required.

3.11 Financial Assessment

144. A financial cost-benefit analysis was conducted and the results confirmed the financial viability of the project. The calculated financial internal rate of return (FIRR) was 1.42% which exceeds the weighted average cost of capital of 0.58%. The sensitivity analysis showed that financial viability will be at risk if increased investments and O&M costs are combined simultaneously with a decline in tariff revenues. To yield a positive FIRR, it was assumed under a worst-case scenario that tariffs would need to be increased by about 180% in real terms by 2023. Nominally, this entails increasing the tariff for residential users from the current rate of SUM675/m^3 to SUM2,786/m^3 over a span of 6 years.

145. The assumed increase in tariffs requires an annual real rate of increase of 14.5 % which is more than 12.3%, the historical average of the real rate of tariff increases in the RK over the last five years.[2] The proposed rate of increase has been discussed with the MOF and TN, and both have agreed that the rate is reasonable given the exceptionally high demand for clean, safe, and reliable water supply in the districts to be covered by the project and the relatively lower tariff increases in the past five years. The tariff would also be affordable to the targeted household beneficiaries who have expressed their willingness to pay more for cleaner, safer, and more reliable water systems. At present, most of them are only able to access clean water through trucks or vendors, at a significantly higher cost of SUM5,000/m3.

3.12 Economic Analysis

146. The economic analysis was undertaken in accordance with the relevant ADB guidelines. Benefits were derived from (i) incremental water consumption calculated using the willingness to pay and water demand projections as proxies; and (ii) resource cost savings from nonincremental water sales when households begin to switch from alternative water sources to piped water. Health benefits from improved reliability and quality of nonincremental water consumption were also estimated due to potentially lowered incidence of water borne diseases in the project areas.

[2] Water tariffs were reviewed by the MOF and reset once a year until 2009 but thereafter, tariffs have been reset twice a year, in April and October.

147. The resulting base-case economic internal rate of return (EIRR) is 11.47%, which exceeds the ADB prescribed minimum discount rate of 9%, and confirms the economic viability of the project. A sensitivity analysis, undertaken to further test economic viability, determined that the project will remain economically robust under the following scenarios: (i) a 10% increase in investment cost; (ii) a 10% increase in O&M costs; (iii) a 10% decline in benefits; (iv) a combination of scenarios (i), (ii), and (iii); and (v) a delay in subproject benefits by 1 year. The sensitivity analysis shows that the EIRR is most sensitive to a combination of an increase in capital cost with a decrease in benefits, and least sensitive to an increase in O&M costs.

4 RECOMMENDED DEVELOPMENT SCHEME

4.1 Amudarya District Development

148. The main goals in Amudarya are to: i) eliminate the risks related to the supply of partly treated water to booth the district center and to rural settlements; ii) optimize the use of existing pumping facilities, namely the WDC RU-1 and Yaranchi which are currently in stand-by.

149. In order to achieve full water supply to the 25 settlements included in the project and to district center Mangit, it is planned to construct a new compact water treatment plant at the location of the intake in the Amudarya canal VU-2 (rural water supply waterworks) in substitution of the existing surface water intake facilities VU-1 and VU-2. The existing settlement basins will be cleaned and rehabilitated and will be operated as primary settlement ponds. The source of water will remain the same, from the canal Mangit. Particular care will be undertaken to secure long term enforcement of the sanitary protection perimeters around the intakes of raw water.

150. The new WTP will have a planned treatment capacity of 28,000 m3/d. The plant will include two reservoirs of 2,000 m3 capacity each, one new raw water intake in the Mangit canal, one 1st lift pump station, and one 2nd lift PS.

151. The water treated at the new WTP will be boosted via the 2nd lift PS to: i) the existing pumping station RU-1 in Urtakala (with an installed capacity of 2,000 m3/h) for the supply of rural villages, and ii) the existing PS at the waterworks VU-1 (urban water supply waterworks) from where the treated water will be distributed to the Mangit urban center,

152. Other works will include: i) construction of a new WDC in Kuyukupir, for the supply of 10 villages, and ii) rehabilitation of the Uruzbay WDC which will include also the drilling of 3 new production wells.

4.2 Beruniy District Development

153. Most of the population of Beruniy District will continue to receive water supply from the Tuyamuyun-Nukus system. The improvement of the Tuyamuyun WTP and of the 2nd lift pumping station will satisfy the water demand of Beruniy. In order to ensure optimum water supply coverage for the 15 settlements included in the project and Beruniy town, two new WDC will be constructed in Shimom and Bodombosh, while the WDC RU-1 will be completely reconstructed.

154. The WDC 15 and 17 will be rehabilitated. The existing WDC 18 will be maintained as stand-by for the time being.

155. Due to the increasing salinization of groundwater from wells in the Beruniy wellfield, it is considered not to rehabilitate this wellfield.

4.3 Nukus District Development

156. A total of 20 villages and the district center of Akmangit are included in the Project area. All settlements will be supplied with water from the Tuyamuyun-Nukus regional water system and from the Takhiatash WTP.

157. The improvement of the water supply will require essentially upgrading of the existing WDC in Nukus, Medeniyat, Kerder and Abadan.

4.4 Karauzak District Development

158. To ensure full water supply coverage for all the 26 rural settlements included in the Project and Karauzak district center, capacity of the Tuyamuyun-Nukus system will be supplemented as needed with treated water from the Takhiatash WTP. The following 3 WDCs are planned for rehabilitation: i) the RU-1, ii) the Samat, and iii) the VS-1. The WDC in Karauzak will also be upgraded with the construction of two 1,000-m^3 reservoirs.

4.5 Kungrad District Development

159. Under another project, currently a new 400-mm transmission main connecting Kungrad to Muynak was commissioned. This pipeline transfers up to 4,900 m^3/d of treated water from the Takhiatash WTP. Under this Project, additional pump capacity will be added to the newly constructed WDC for the supply of settlements in the northeastern part of Kungrad district.

160. To achieve a 100% water supply service within the district center and in the 20 rural settlements included in the Project, six WDCs are planned for rehabilitation.

161. The Altinkul water headworks will be rehabilitated and upgraded with the construction of 2 new 1,000-m^3 reservoirs to supply the nearby villages.

4.6 Muynak District Development

162. Muynak district center and most of rural settlements within the district will be supplied with treated water from the Takhiatash WTP via the 96-km transmission main from Kungrad. Ten (10) rural settlements will be provided with piped water supply. The benefits from receiving piped water supply are anticipated to be enormous for the population of Muynak district.

163. The existing WDC in Muynak center will be rehabilitated and retrofitted with additional pump capacity. A new WDC will be constructed at the off-take from the transmission main in Shagirlik in order to boost the water along a 21-km distribution main to Porlitay and other settlements along the pipeline. A new pumping station will be constructed at the village of Shege in order to distribute water to the Village and re-boost water up to Porlitau.

4.7 Rehabilitation of Tuyamuyun WTP

164. Significant rehabilitation of the main process components should be undertaken at the Tuyamuyun WTP. The circular settlers and the rapid sand filters should be upgraded with priority. However, under the Project, only the 2nd lift pump station is to be rehabilitated

4.8 Extension of the Takhiatash WTP

165. For the supply of the estimated 39,000 m^3/d additional long term water demand to the districts of Karauzak, Muynak, Nukus and Kungrad, it is planned to undertake an expansion of the treatment capacity of the existing Takhiatash WTP to bring the capacity of the plant to 120,000 m^3/d from the current 60,000 m^3/d.

166. The capacity of the existing raw water and 2nd lift pumping stations will be expanded in the same proportion.

167. The upgrading of the Takhiatash WTP will include the rehabilitation or re-construction of the following main items:

a. Reconstruction of one raw pumping station; and
b. Rehabilitation of 2 50-m diameter circular settlers including replacement of scraper arms, piping, motors and other electromechanical equipment; Distribution chamber; Horizontal settlers (2); Filters chamber 6 filters 10 x 7 m; Electrolytic equipment; Mixing chamber; one 2nd lift PS; Internal piping; Distribution pipework; Internal electrical works; Transformer substation; Power counter; New Automation; Ancillary works, landscaping and gardening.

4.9 New WTP in Mangit

168. A new WTP is planned to produce 28,000 m^3/d of treated water for the supply of Mangit city and 24 settlements included in the Project. It will be constructed over a plot of land adjacent to the existing settlement pond of the existing water intake VU-2. The pond will be used as primary settler of the raw water derived from the Mangit canal.

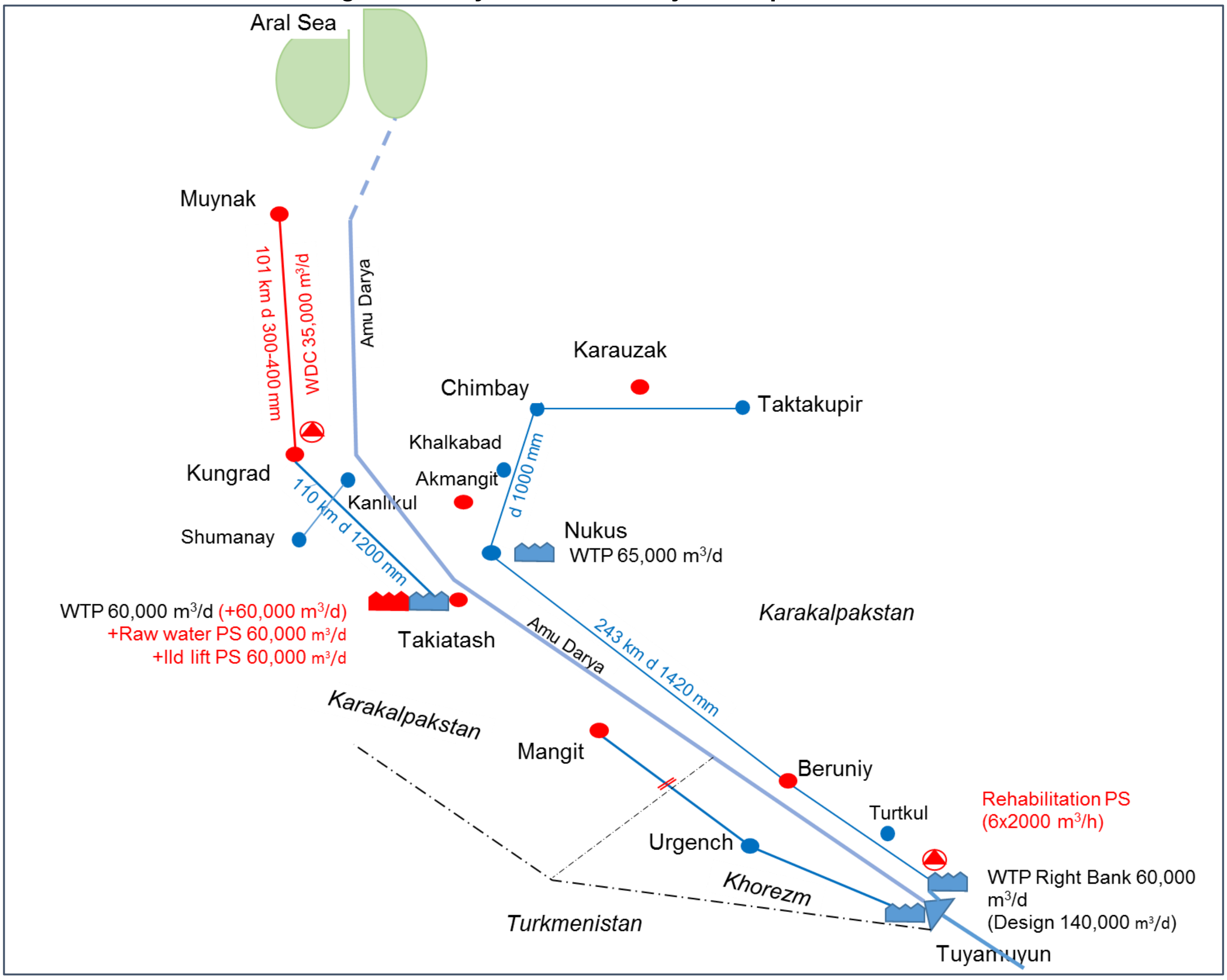
169. The WTP facilities will include a 2nd lift PS from where treated water will be boosted to: i) the existing WDC at VU-1 intake for the distribution of water to the urban center, and ii) to the existing WDC RU-1.

170. The main components and features of the new WTP will be as follows:

a. Raw water intake and pump station;
b. Transmission pipe from settlement pond to inlet chamber (2 lines, 400 mm x 100 m);
c. Mixing and flocculation tank; two horizontal settlers; filters room;
d. One 1,500 m^3 process water reservoir; and chemicals chamber;
e. Two clean water 3,000-m^3 capacity reservoirs and one 2nd lift pumping station;
f. Internal piping and distribution pipework;
g. Process water quality laboratory and lectrolysis equipment;
h. Mechanical workshop; operator housing and checkpoint (2); warehouse; garage; and
i. External electricity supply 10 kV; internal electrification & lightening; transformer substation 2x400/10/0,4; power counters (2); automation; ancillary works; gas supply; fencing and gate; restroom rooms; septic tank; landscaping; and
j. About 1.3 km of dia 300-mm transmission from WTP to the existing WDC RU-1.

171. The recommended pipeworks for water supply transmission mains and distribution network expansion under this Project is shown in Figure 4.1 below.

Figure 4.1 Layout of Main Project's Pipeworks



5 RECOMMENDED PROJECT COMPONENTS

5.1 Main Quantities of Works

172. The Project aims at significant improvements to local living standards, environment, health, and for enhancing local economy in the RK, through upgrading water supply infrastructure and services. The project covers six major districts out of the total fourteen districts of the RK, namely Nukus, Muynak, Kungrad, Beruniy, Amudarya and Karauzak districts that is about 75.4 % of the total 125,654 km^2 land area of the RK. The selection of districts for priority investment under the Project follows the priorities set by both ADB and the GOU, namely with the ADB Country Operation Business Plan Uzbekistan 2012-2014; and the Country's Partnership Strategy (CPS) Uzbekistan 2012-2016; as well as with the Development Strategy, Road Map and Investment Program for the Water Supply and Sanitation Sector of the Republic of Uzbekistan until 2020. Besides technical viability for system development continuity, raw water quality (surface and groundwater) for treatment, and constructability, the selection of the six districts namely Nukus, Muynak, Kungrad, Beruniy, Amudarya and Karauzak, was also based on weighted criteria on population, public health and safety, climate change vulnerability, service reliability, efficient financial for capital investment and operation and maintenance, future system development feasibility and long-term sustainability. Due to the unique situation of water resources in the RK that surface water from the Amudarya River constitute as the main reliable water source, technical and financial viable options are limited to (i) centralized treatment and long-haul transmissions to distribution centers; (ii) localized treatment using groundwater; and (iii) centralized treatment at 3 optimal locations and with supplemental local groundwater treatment where feasible. Option (iii) was recommended for least cost and maximum beneficial impacts. Upon completion, the Project will provide safe water supply on a 24 hours basis for a population of 388,000 people in 116 rural settlements and the six urban centers. The water supply infrastructures developed under Option (iii) will also serve as the main grid of the RK water supply system for future water supply service development in the eight remaining districts in the territory.

173. Under the Project it is planned to construct or reconstruct 315 km of dia 150 mm to 400 mm distribution mains and 921 km of dia 76 mm to 200 mm of water distribution network. 24 WDCs will be rehabilitated and 4 new constructed as summarized in Table 5.1.

174. Rehabilitation of WDC will consist of any or all of the following works: replacement of pumps switches and controls, rehabilitation of and/or construction of new water reservoirs, provision of water disinfection units (chlorination), automatic controls, upgrading of ancillary buildings, fences and other accessory works.

175. The 60,000 m^3/d extension of the treatment capacity at Takhiatash WTP and construction of a new 28,000 m^3/d WTP in Mangit are to be implemented.

176. Other sub-component include also the construction of maintenance and repair workshops in each of the district centers as well as the provision of tool machineries and mobile maintenance equipment.

177. Soft components of the Project include institutional and capacity building for project management, water utility management, O&M management, and non-revenue water (NRW).

Table 5.1 Quantities of Works for Water Network Rehabilitation and Extension

Item	Dimension	Quantity
Amudarya district		
No. WDC	No.	5
Distribution mains	km	54.3
Distribution Network	km	236.5
Off-takes for HH Connection	No.	15,238
Beruniy district		
No. WDC	No.	5
Distribution mains	km	43

Item	Dimension	Quantity
Distribution Network	km	221
Off-takes for HH Connection	No.	17,463
Karauzak district		
No. WDC	No.	3
Distribution mains	km	52
Distribution Network	km	88.6
Off-takes for HH Connection	No.	6,141
Kungrad district		
No. WDC	No.	7
Distribution mains	km	66
Distribution Network	km	180
Off-takes for HH Connection	No.	18,809
Nukus district		
No. WDC	No.	4
Distribution mains	km	39
Distribution Network	km	127.4
Off-takes for HH Connection	No.	6,610
Muynak district		
No. WDC	No.	4
Distribution mains	km	61
Distribution Network	km	67.3
Off-takes for HH Connection	No.	4,647
Total 6 districts		
No. WDC	No.	28
Distribution mains	km	315
Distribution Network	km	921
Off-takes for HH Connection	No.	68,908

178. Upon completion, the Project will benefit a population of 388,000 living in the 6 district centers and in 116 rural settlements with the provision of safe water supply on a continuous base. At the project horizon 2043, the beneficiaries will be grown to some 518,000.

5.2 Procurement Packaging

179. The overall assessment of procurement risk is Moderate. The project arrangements with appropriate mitigation measures are considered satisfactory. ADB and the government will jointly undertake reviews of the project at least once a year. The reviews will assess progress in the project activities, including implementation of the mitigation measures, procurement transactions, performance of contractors and suppliers, monitoring and reporting of project assets, identify issues and constraints, and determine necessary remedial actions and adjustments.

180. As per Table 5.2, the Project will have a total 9 ICB and 1 NCB contract packages for civil works, 9 contracts for procurements of maintenance equipment, and 7 contracts for consulting services.

Table 5.2 Procurement Packages

Type	Procurement Method	No. of Contracts	Cumulative amount ($)
Civil Works ICB	ICB	9	153,766,025
Civil Works NCB	NCB	1	1,796,203
Goods	ICB / NCB / Shopping	9	1,692,192
Consulting Services	QBCS	6	7,818,084
Consulting Services	LCS	1	144,000

ICB: International Competitive Bidding; NCB: National Competitive Bidding; QCBS: Quality and Cost-Based selection; LCS: Least Cost Selection; CQS: Consultants' Qualifications Selection

5.3 Project Outputs

181. The main project outputs are presented in Table 5.3 shown below.

Table 5.3 Summary of Project Outputs

Outputs	
1. Water supply infrastructure expanded and upgraded	1a. One WTP constructed with a capacity of 28,000 m^3/day by 2024 (2017 Baseline: not applicable) 1b. One WTP expanded to a capacity of 120,000 m^3/day by 2024 (2017 Baseline: 60,000 m^3/day) 1c. One WTP upgraded with a capacity 140,000 m^3/day by 2024 (2017 Baseline: not applicable) 1d. About 300 km of transmission pipelines constructed by 2024 (2017 Baseline: 0) 1e. About 900 km of distribution pipelines constructed or rehabilitated by 2024 (2017 Baseline: approximately 600 km in poor condition) 1f. 24 rehabilitated and 4 constructed WDCs by 2024 (2017 Baseline: 24 poorly functioning water distribution centers) 1g. 6 newly equipped water quality laboratories fully staffed by 2024, at least 30% of whom are women (2017 Baseline: 7 none or poorly functioning laboratories) 1h. 6 O&M warehouses with central maintenance workshops and gender sensitive sanitary facilities operational and staffed (at least 10% of whom are women) (2017 Baseline: 0) 1i. 69,000 household water meters (including at least 13,800 for women-headed households) installed in 100% of connected households from 2022 onwards (2017 Baseline: 27%) 1j. EMP implemented by 2024 (2017 Baseline: not applicable)
2. Institutional capacity strengthened, and project implementation capacity enhanced	2a. One new training facility (with gender sensitive sanitary facilities) constructed, equipped and commissioned by 2021 (2017 Baseline: not applicable) 2b. Geographic Information System (GIS) implemented and hydraulic model of water supply operations prepared by 2021 (2017 Baseline: not applicable) 2c. Nonrevenue water control system, including SCADA, implemented and commissioned by 2022 (2017 Baseline: not applicable) 2d. TN website with KPI-based performance reporting, grievances redress channels, and other relevant public reporting materials commissioned by 2021 (2017 Baseline: not applicable) 2e. KPI-based reporting with reliable and verifiable input data instituted by 2022 (2017 Baseline: not applicable) 2f. Billing, accounting and financial management systems improved by 2022 (2017 Baseline: not applicable) 2g. Corporate governance systems improvements attested annually by independent professional ISO auditors relating to quality controls, grievances systems, asset management, WSS services, and environmental management commencing from 2021 (2017 Baseline: not applicable) 2h. 8 TN officers (at least 3 are women) trained and professionally certified in an accredited international training center in operations and maintenance of water treatment facilities and distribution networks by 2022 (2017 Baseline: not applicable) 2i. Gender inclusive customer grievance redress mechanism commissioned by 2022 (2017 Baseline: not applicable)

6 PROJECT COSTS AND FINANCING

182. The project is estimated to cost $172.3 million (Table 6.1).

Table 6.1 Summary Cost Estimate ($ million)

Item		Amount[a]
A.	**Base Cost**[b]	
	1. Water supply infrastructure expanded and upgraded	141.5
	2. Institutional capacity strengthened and project implementation capacity enhanced	11.5
	Subtotal (A)	**153.0**
B.	**Contingencies**[c]	**12.4**
C.	**Financial Charges During Implementation**[d]	**6.9**
	Total (A+B+C)	**172.3**

[a] Includes taxes and duties of $27.3 million. Such amount does not represent an excessive share of the project cost. The government will finance taxes and duties of $27.3 million by exemption.

[b] In mid-2017 prices as of August 2017.

[c] Physical contingencies computed at 3% of base cost estimates for civil works and equipment. Price contingencies computed at an average of 1.6% on foreign exchange costs and 6.5% on local currency costs; includes provision for potential exchange rate fluctuation under the assumption of a purchasing power parity exchange rate.

[d] Includes interest for the Asian Development Bank loan at 2% per annum.

Source: Asian Development Bank estimates.

183. Detailed cost estimates by expenditure category are shown on Table 6.2.

Table 6.2 Detailed Cost Estimates by Expenditure Category

Item	(Sum Million) Foreign Exchange	(Sum Million) Local Currency	(Sum Million) Total Cost	(US$ Million) Foreign Exchange	(US$ Million) Local Currency	(US$ Million) Total Cost	% of Total Base Cost
I. Investment Costs							
A. Civil Works							
1. Water treatment plants	27,773.58	38,883.01	66,656.59	7.27	10.18	17.45	10.1%
2. Water distribution centers	25,265.37	35,371.52	60,636.89	6.61	9.26	15.87	9.2%
3. Netw ork pipelines	141,664.32	198,330.05	339,994.36	37.08	51.91	88.99	51.6%
4. Household connections	11,490.95	22,981.90	34,472.85	3.01	6.02	9.02	5.2%
5. Detailed Engineering Design	3,371.25	2,247.50	5,618.75	0.88	0.59	1.47	0.9%
6. Nonrevenue w ater control	730.22	1,022.31	1,752.54	0.19	0.27	0.46	0.3%
Subtotal	**210,295.69**	**298,836.29**	**509,131.98**	**55.04**	**78.22**	**133.26**	**77.3%**
B. Equipment and Machinery							
1. Equipment WTP	10,429.62	7,449.73	17,879.34	2.73	1.95	4.68	2.7%
2. Equipment district WSS	12,143.27	8,673.76	20,817.03	3.18	2.27	5.45	3.2%
3. Equipment nonrevenue w ater control	2,980.69	2,129.07	5,109.76	0.78	0.56	1.34	0.8%
4. Utility machineries and equipment	3,473.89	2,481.35	5,955.24	0.91	0.65	1.56	0.9%
Subtotal	**29,027.47**	**20,733.90**	**49,761.37**	**7.60**	**5.43**	**13.02**	**7.6%**
C. Project Implementation Support							
1. Project management	150.37	751.87	902.24	0.04	0.20	0.24	0.1%
2. Consulting services	6,393.39	6,393.39	12,786.77	1.67	1.67	3.35	1.9%
3. Project financial audit	229.23	320.92	550.15	0.06	0.08	0.14	0.1%
4. Environmental management	79.56	238.69	318.26	0.02	0.06	0.08	0.0%
5. Social safeguards	61.13	305.64	366.76	0.02	0.08	0.10	0.1%
Subtotal	**6,913.68**	**8,010.50**	**14,924.18**	**1.81**	**2.10**	**3.91**	**2.3%**
D. Training, studies and capacity building							
1. Corporate development program	1,130.86	2,261.71	3,392.57	0.30	0.59	0.89	0.5%
2. O&M capacity development	1,337.16	1,872.03	3,209.19	0.35	0.49	0.84	0.5%
3. GIS hydraulic model	942.06	942.06	1,884.11	0.25	0.25	0.49	0.3%
4. Rural sanitation and hygiene improvement	382.05	1,910.23	2,292.28	0.10	0.50	0.60	0.3%
Subtotal	**3,792.12**	**6,986.02**	**10,778.14**	**0.99**	**1.83**	**2.82**	**1.6%**
II. Contigencies							
Physical Contingencies	6,967.23	9,425.14	16,392.37	1.82	2.47	4.29	2.5%
Price Contingencies	69,037.73	93,238.90	162,276.63	3.47	4.68	8.15	4.7%
Subtotal	**76,004.96**	**102,664.04**	**178,669.00**	**5.29**	**7.15**	**12.44**	**7.2%**
III. Interest							
Interest During Implementation	30,917.50		30,917.50	6.88	-	6.88	4.0%
Total Project Cost (I +II+ III)	**356,951.42**	**437,230.76**	**794,182.18**	**77.62**	**94.72**	**172.33**	**100.0%**