Appendix C-2

Results of Water and Sludge Quality Analysis

REPUBLIC OF KAZAKHSTAN
CONSULT CO., LTD

REPORT
ON
WATER AND SLUDGE QUALITY ANALYSIS
FOR
THE DETAILED DESIGN STUDY
OF
THE WATER SUPPLY AND SEWERAGE SYSTEM
FOR
ASTANA CITY
IN
THE REPUBLIC OF KAZAKHSTAN

ASTANA
2003

REPUBLIC OF KAZAKHSTAN
CONSULT CO., LTD

REPORT ON WATER AND SLUDGE QUALITY ANALYSIS FOR THE DETAILED DESIGN STUDY OF THE WATER SUPPLY AND SEWERAGE SYSTEM FOR ASTANA CITY IN THE REPUBLIC OF KAZAKHSTAN

C-2-2

General Director G.A. Ibraimova

Project Manager V.M. Issakov

ASTANA
2003

TABLE OF CONTENTS

List of Tables in the Text

C-2-3

List of Figures in the text

List of photos

INTRODUCTION

The present work has been carried out by CJSC "Tsentrgeolanalit" in accordance with the Contract # 16 from October 7, 2002 and Technical Specification "Implementation of the analysis of water and sludge quality within the project on detailed designing of the systems of water supply and water disposal in the city of Astana" under the supervision of Feasibility Study Team (hereinafter referred to as the "Engineer".

The objective of the work: To study the quality of water in the water supply and water disposal system by means of sampling and analyzing the samples of water and sludge.

Water and sludge sampling was carried out in two stages:

The first period was from 8 to 12 of October 2002

During this period 14 samples of water and 6 samples of sludge were taken:

- the surface water of Vyacheslavsky reservoir (the upper and lower layers; incoming and purified water from the PFS (Pump-Filter Station) – 4 samples;
- sewage water at the inlet and outlet of STP (Sewage Treatment Plant), the purified sewage water at Taldy Kol reservoir and the water discharged on the terrain – 4 samples;
- sewage waters after primary and secondary settlers of STP in two points (3 times in a day) – 6 samples;
- sludge of STP at different stages of sewage water purification and sludge formation – 6 samples;

Description of the water and sludge sampling points is given in Table 1.1. The scheme of water sampling is given in Figure 1.

C-2-4

In the course of sampling process the following changes, agreed with the Engineer, were put into the volume of work specified by "Technical Specification":

- sewage water sampling (thrice-repeated sampling in a day) was carried out at 2 points instead of 3;
- additionally in all water samples (14 samples) the contents of petroleum products were determined;
- in addition to 5 samples of sludge one sample of sludge was taken on the first new sludge map of STP;
- for more detailed characteristics of algae of Periphyton type one addition sample in the form of scrape was taken from concrete plates at the point of purified sewage water discharge on the terrain;
- sampling of digested sludge was carried out only on the 27-th of November 2002 due to technological reasons of SPW.

The second period was from 25 to 27 of February 2003.

During this period 8 samples of water and 5 samples of sludge were taken in accordance with Technological Specification:

- the surface water of Vyacheslavsky reservoir (the upper and lower layers; incoming and purified water from the PFS (Pump-Filter Station) – 4 samples;
- sewage water at the inlet and outlet of STP (Sewage Treatment Plant) – 2 samples,
- the purified sewage water at Taldy Kol reservoir and the water discharged on the terrain – 2 samples;
- sludge of STP at different stages of sewage water purification and sludge formation – 5 samples;

Water and sludge sampling was carried out by a team of qualified specialists of CJSC "Tsentrgeolanalit", at some points the work was done in the presence of the Engineer's and "Consult LTD" representatives.

The laboratory and analytical testing of water and sludge samples has been carried out in CJSC "Tsentrgeolanalit". The Accreditation Certificate of the Testing Laboratory of "Tsentrgeolanalit" is registered in the State Register of Certificate State System of the Republic of Kazakhstan on the 16 of July, 2002 № KK.658000.06.11.00373. Its period of validity is until 16 of July 2005.

1. GENERAL PROVISIONS OF WORK METHODS

The work connected with analysis of water and sludge quality in the systems of water supply and disposal was carried out according to the following procedure:

- water and sludge sampling;
- laboratory and analytical work;
- office work and analysis of the data obtained; compilation of technical report on the investigation results.

The work was carried out in accordance with the normative documents of the Republic of Kazakhstan, the former USSR, and Russia accepted in the Republic of Kazakhstan.

1.1 Water and sludge sampling

1.1.1. Water sampling was carried out in accordance with the requirements of normative documents. Description of water and sludge sampling points is given in Table 1.1. The conservation methods and volumes of water samples (per one sample) for analytical work are given in Table 1.2.

Each sampling point was described; temperature of water and atmospheric air was measured and written down; the photos of sampling sites were made.

The water samples at PFS (inlet and outlet) and STP (outlet) were taken from special sampling taps.

During the autumn period the water samples on Vyacheslavsky reservoir (the upper layer at depth 1m and the lower layer at depth 6 m at 2 m from the bottom) and on Taldy Kol reservoir were taken from a boat, in its north-eastern part at distance of 300-400m from the dam.

While water samples were being taken on Vyacheslavsk reservoir, the lake surface was choppy due to the western wind blowing with the speed of 5-6 m/sec. Waves were observed on Taldy Kol reservoir at the south-western wind. There were many algae in the sample. The water was muddy.

C-2-5

At the turn of the winter (26-27 of February) water samples from Vyacheslavsky reservoir were taken from a hole (20 cm in diameter) drilled in the ice approximately 100 m from the shore, and on Taldy Kol reservoir a hole was drilled in 450 m from the shore.

Double rinsing of bottles with the sampled water was carried out at each sampling point (except of specially prepared bottles for determining petroleum products, grease and oil, micro-biological parameters).

Algae sampling was carried out on Vyacheslavsky reservoir (the upper and lower layer), Taldy Kol reservoir and the purified sewage water discharge on the terrain (4 samples for phytoplankton) as well as in the site of the purified water discharge by means of scraping algae from concrete plates in order to determine the presence of Periphyton (in autumn period)

The water samples were brought regularly to Karaganda into the Testing laboratory to be analyzed.

1.1.2 Sludge sampling at STP was carried out according to the technical specification with participation of the SPW technologist, who defined more accurately the sampling points.

Fresh sediment (sludge) after the primary settlers (samples S-10, S1F), a thickened sludge after the aeration tanks (sample S-3O, S3F) and digested sludge (sample S4O, S4F) were taken into special beakers. The sample weight is about 1 kg.

Samples of reciprocal sludge after aeration tanks (sample S2O, S2F) and mixed sludge in the aeration tanks (sample S5O, S5F) were taken into 6 polyethylene bottles of 1.5 l in volume to determine SV_{30}, SV_{120} and a necessary volume of firm sludge to carry out other analyses.

A sample of firm consolidated sludge (S6O) on the new sludge map was taken into special beakers. The sample weight is about 1 kg.

In the laboratory the samples were dried to their natural dry state at temperature 15-20°C for 10-15 days to be prepared for analyses.

Table 1.1

DESCRIPTION
of water and sludge sampling points of the systems of water supply and water disposal of the city of Astana.

№	Code of Sample	Date of sampling	Description of points of water and sludge sampling	Note
1	2	3	4	5
			1. The system of water supply	
			1.1. Vyacheslavsky reservoir	
1	VR1O VR1F	10.10.2002 26.02. 2003	Vyacheslavsky reservoir, the upper layer	
2	VR2O VR2F	10.10.2002 26.02. 2003	Vyacheslavsky reservoir, the lower layer	
			1.2. PFS – Pump-Filter Station	
3	PPSOO PPSOF	8.10.2002 25.02. 2003	Water coming into PFS from Vyacheslavsky reservoir	
4	PPRSO PPRSF	8.10.2002 25.02.2003	Purified water at the outlet of PFS	
			2. The system of water disposal	
			2.1. Sewage waters of STP (Sewage Treatment Plant) and Taldy Kol reservoir	
5	SPINO SPINF	8.10.2002 25.02.2003	Sewage waters influent into STP	
6	SPTRO SPTRF	8.10.2002 25.02.2003	Purified sewage waters of STPat PS-13 discharging into Taldy Kol reservoir.	
7	TKR1O TKR1F	9.10.2002 27.02.2003	Purified sewage waters in north-western part of Taldy Kol reservoir in 200 м from the dam	
8	TKR2O TKR2F	9.10.2002 25.02.2003	Purified sewage waters and possibly drainage waters discharged on the marsh-ridden terrain under the bridge of the motorway Astana-Korgalzhino.	
			2.2. Sewage waters at STP	
9 10 11	PS1 PS2 PS3	8.10.2002 10.10.2002 12.10.2002	Sewage waters after the primary settlers of SPW	

Continuation of Table1.1

1	2	3	4	5
12 13 14	FS1 FS2 FS3	8.10.2002 10.10.2002 12.10.2002	Sewage waters after the secondary settlers of SPW	
2.3 Sludge of SPW				
15	S1O S1F	9.10.2002 27.02.2003	Fresh sludge in the primary settlers.	
16	S2O S2F	9.10.2002 25.02.2003	Reciprocal sludge	
17	S3O S3F	9.10.2002 27.02.2003	Compact sludge	
18	S4O S4F	27.11.2002 27.02.2003	Digested sludge	
19	S5O S5F	9.10.2002 25.02.2003	Mixed sludge in the aeration tanks	
20	S6O	11.10.2002	Firm sludge, the first new sludge map	

C-2-6

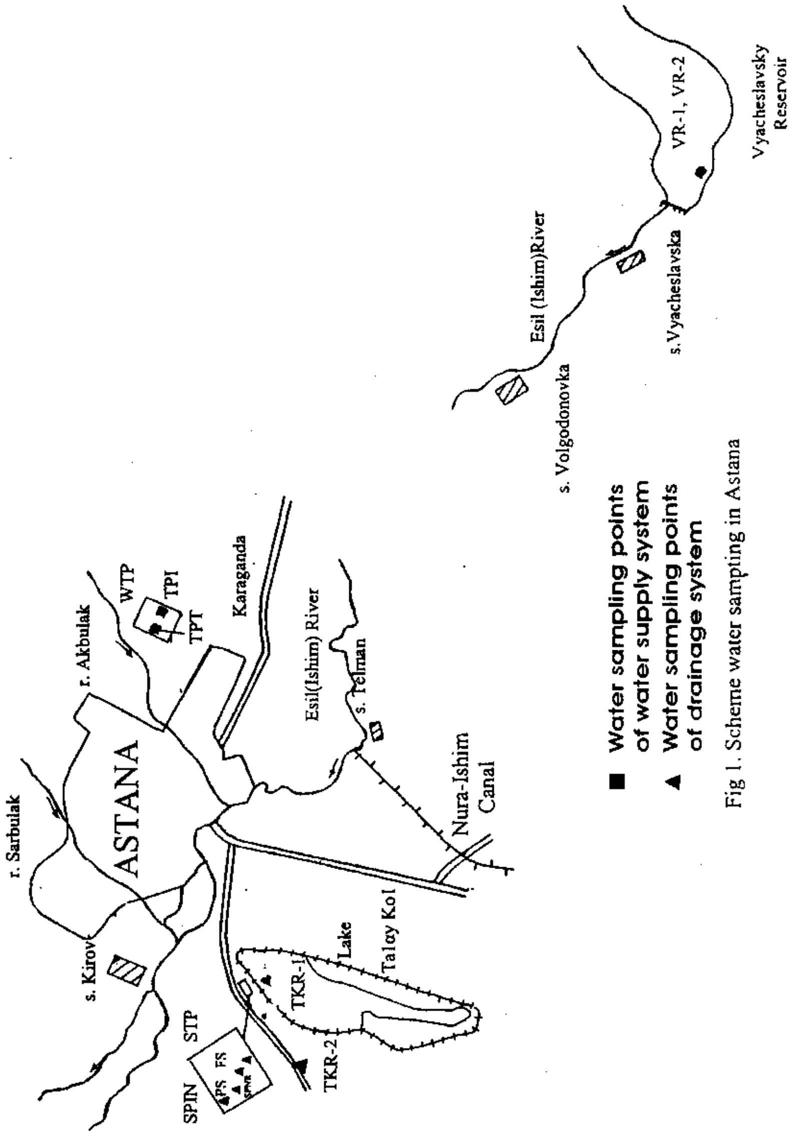


Fig 1. Scheme water sampting in Astana

Table 1.2

METHODS
of conservation and the volumes of water for analytical work (per 1 sample)

№	The component being determined	Conservation method	Water volume	Vessels
1	PH value (pH), mineralization, suspended substances, the total nitrogen content (T-N), NO_3, NO_2, NH_4, SO_4, Cl, Cr, As	Not conserved	1.5	1bottle – 1.5 L polyethylene
2	BOD, COD	Not conserved	1.0	2 bottles – 0.5 L glass, filled to the brim with H_2O
3	Cd, Pb, Zn, Hg	5 ml HNO_3 concentrated, per 1L	1.0	1 bottle – 1.0 L polyethylene
4	The total phosphorus content (T-P)	1ml of chloroform per 0.5L	1.0	1bottle – 1.0 L polyethylene
5	The total sulphur content (T-S)	1ml of 50% NaOH per 0.5 L	0.5	1 bottle – 0.5 L glass
6	Dissolved oxygen, O_2 (DO)	To fix 2ml of $MnSO_4$ + 2 ml alkaline solution of KI	0.2	Special vessel
7	Phenols	10 ml of NaOH per 1l	2	2 bottles – 1.0 L polyethylene
8	Cyanides	2 ml of NaOH per 0.25L	0.5	2bottles – 0.25L polyethylene
9	Grease and oil	2.5ml of H_2SO_4 per 0.5L	0.5	1bottle – 0.5L glass
10	Petroleum products	2ml of CCl_4 per 0.5L	1.0	2 bottles – 0.5L glass
11	Microbiological parameters	Not conserved	0.5	Sterile glassware- 0.5L
12	Algae:			
	- Phytoplankton	2ml of 4% Formalin (formaldehyde solution)	0.5	Polyethylene vessel – 0.5L
	- Periphyton	2 ml of 4% Formalin	0.1	Polyethylene vessel – 0.1L
	TOTAL:		**10.3**	**17 vessels**

C-2-7

1.2 Laboratory and analytical work

The laboratory and analytical work on estimation of the quality of water and sludge in the systems of water supply and water disposal was carried out according to the "Engineer's" Technical Specifications. The methods of analysis and measurement instrumentation (Table 1.3) provide accuracy necessary to solve the goal tasks. A brief description of the methods of analysis and tools for measuring water and sludge samples is given below.

Table 1.3

Analytical work methods and instrumentation to measure water and sludge samples

№	Work Items	Methods of analytic work	Method normative documents	Measurement instrumentation
1	2	3	4	5
I	**Water sampling**	-	The instructions on surface and sewage water sampling for chemical analysis. Ministry of Ecology and Bio-resources of the Republic of Kazakhstan (RK), 1994 "Methodical instruction on identification of the level of environment pollution with toxic substances of industrial and consumption wastes" RND 03.3.04.01.96 Drinkable water GOST 24481-80	
II	**Laboratory analysis of water samples:**			
1	pH	potentiometric	GOST 26449.1-85	Universal pH meter EV-74
2	General miniralization (dry residue)	gravimetric	GOST 18164-72, GOST 26449.1-85	Analytical balance «Sartorius»
3	Suspended substances (SS)	gravimetric	GOST 26449.1-85	Analytical balance «Sartorius»
4	Dissolved oxygen, O_2	titrimetric	RD 52.24.73-88	
5	Biological oxygen demand, BOD_5	titrimetric	RD 204.2.07-91	
6	Chemical oxygen demand, COD	titrimetric	RD 52.24.73-88 GOST 26449.1-85	
7	Sulphates (SO_4^{-2})	gravimetric	GOST 4389-72	Analytical balance «Sartorius»
8	Chlorides (Cl)	argentometric	GOST 18190-72 GOST 23268.17-78	

Continuation of Table 1.3

1	2	3	4	5
9	Total content of nitrogen (T-N)	photometric	GOST 26449.1-85	Photochemical colorimeter, concentration CPC-2MP
10	Nitrates (NO_3)	photometric	GOST 26449.1-85	CPC-2MP
11	Nitrites (NO_2)	photometric	GOST 4192-82	CPC-2MP
12	Ammonium-ion (NH_4^+)	photometric	GOST 4192-82	CPC-2MP
13	Total content of phosphorus (T-P)	photometric	GOST 26449.1-85 RD 52.24.39-87	CPC-2MP
14	Total content of sulphur (T-S)	gravimetric	Reznikov A.A. № 650/007 from 19.11.98. Registered by KarTsSMS	Analytical balance «Sartorius»
15	Cyanides (CN)	photometric	ISO 6703/1 Lurie Yu. Standardized methods of water analysis № 605/008 from 19.11.98. KarTsSMS	Spectrophotometer SP-26
16	Petroleum products	fluorimetric	MUK 4.1.068-98 GOST 26449.1-85	Fluorimeter «Quantum»
17	Grease and oil	gravimetric	Lurie Yu. Standardized methods of water analysis	Analytical balance «Sartorius»
18	Phenols	photometric	GOST 26449.1-85 RD 52.24-488-95	Spectrophotometer SP-26
19	Mercury (Hg)	flameless atomic-absorptive	GOST 26927-86 MP 2-3.05-42XC-89	Photometer «Rtut'(Mecury) 101»
20	Cadmium (Cd)	atomic-absorptive	GOST 26933-86	Spectrophotometer atomic-absorptive AAS-30
21	Arsenic (As)	photometric	GOST 4152-89 GOST 23268.14-78	Spectrophotometer SP-26
22	Lead (Pb)	atomic-absorptive	GOST 26449.1-85	Spectrophotometer atomic-absorptive AAS-30
23	Chromium (Cr)	photometric	GOST 26449.1-85	CPC-2MP
24	Zinc (Zn)	atomic-absorptive	GOST 18293-72	Spectrophotometer AAS-30
25	Micro-biological parameters	Sanitary micro-biological analysis	"Methodical instructions on sanitary micro-biological analysis of surface water of reservoirs". Approved by the chief sanitary officer of the Republic of Kazakhstan, 02.07. 1997,№ 3.05.039.97	Apparatus, laboratory utensils and reagents corresponding to GOST 18963-7

Continuation of Table1.3

1	2	3	4	5
26	Determination of algae	Hydro-biological analysis of water samples	"Manual on methods of micro-biological analysis of surface waters and bottom sludge" Gidrometizdat, Leningrad, 1983.	
III	**Laboratory analyses of sludge samples:**			
1	PH	potentiometric	GOST 26483-85	Universal pH meter EV-74
2	Water content	gravimetric	MP 02-3.05.42X-89	Analytical balance «Sartorius»
3	Density	pycnometric	GOST 5180-84	Analytical balance «Sartorius»
4	Inflammable residue (organic carbon)	gravimetric	GOST 24081.1-95	Analytical balance «Sartorius»
5	Chemical oxygen demand	titrimetric	RD 52.24.75-88	Analytical balance «Sartorius»
6	Concentration of active sludge in volume (SV_{30}, SV_{120})	sedimentary	Recommendations of Ministry of Water Resources of the USSR, Moscow, 1987	
7	Concentration of active sludge in weight, MLSS	gravimetric	Recommendations of Ministry of Water Resources of the USSR, Moscow, 1987	Analytical balance «Sartorius»
8	Loss at calcinations	gravimetric	GOST 3594.15-93	Analytical balance «Sartorius»
9	Total content of phosphorus (T-P)	photometric	GOST 262611-84	Photochemical colorimeter, concentration CPC-2MP
10	Total content of nitrogen (T-N)	titrimetric	GOST 28743-93	
11	Total content of sulphur (T-S)	titrimetric	GOST 22772.7-77	
12	Granulometric composition	gravimetric	GOST 21216.2-93	Analytical balance «Sartorius»

1.2.1 Analysis of water samples:

1) pH. GOST 26449.1-85

The value of pH is determined by the electrometric method, measuring the potential occurring at the corresponding measuring electrode.

Electrometric determination of pH with a glass electrode is based on the fact that changing of pH value for one unit in a certain area of pH causes the change of electrode potential for 58.1 Mw at 20^0C.

2) Total mineralization (dry residue). GOST 18164-72

The given GOST specifies the method to determine the content of a dry residue. An amount of a dry residue characterizes the total content of nonvolatile mineral and partially organic compounds dissolved in the water. To determine a dry residue a certain volume of the filtered water is evaporated; dried up to a permanent mass at 160^0C and weighted. Evaporation is carried out in the presence of precisely measured volume of sodium carbonate in order to minimize the effect of hydrolysis, hygroscopicity of magnesium and calcium chlorides, and difficult release of crystallization water by calcium and magnesium sulphates.

3) Suspended substances. GOST 26449.1-85

By suspended substances we mean the particles of mineral and organic origin contained in the water and having a size bigger than $1 \cdot 10^{-4}$mm.

To determine suspended substances a certain volume is taken from a thoroughly mixed water sample. It is filtered through two thick (a blue tape) filters preliminarily dried and weighed. The filter with a cake is washed with the distillated water and dried at temperature 105^0C up to the permanent mass.

4) Dissolved oxygen (O_2). RD 52.24.73-88

Determination of oxygen is based on the reaction of dissolved oxygen with manganic hydroxide (II) and on iodometric determination of the formed manganese compounds, which are higher according to the degree of oxidation. In the alkaline medium the oxygen dissolved in water is equivalently spent for oxidizing bivalent manganese (II) into tetravalent manganese (IV). After acidification manganese (IV) transforms into manganese (II) again, and in the process it oxidizes equivalent amount of iodide being in the solution. The content of dissolved oxygen is calculated according to the quantity of iodine formed.

5) Biological oxygen demand (BOD_5). RD 204.2.07-91

The essence of the method is in neutralization of the water sample under investigation. It is diluted with variable amount of water enriched with dissolved oxygen and seeds of aerobic microorganisms with or without using the measures of nitrification suppression. Then the sample is incubated in a bottle filled up to the rim and plugged with a cork in darkness at a constant temperature for 5 days. The concentrations of dissolved oxygen are determined before and after incubation. The mass of oxygen dissolved in one liter of water is calculated.

C-2-9

6) Chemical oxygen demand (COD). RD 204.2.08-91, RD 52.24.75-88

COD of water is a quantity of oxygen consumed in the process of total chemical oxidation of organic components into the final inorganic products.

COD is determined by heating the sample under investigation in concentrate sulphuric acid with a known amount of potassium bichromate in the presence of a silver catalyst in a flask provided with a reflux condenser for a certain period of time. Then the residue of potassium bichromate is titrated with Mohr's salt, and COD is calculated according to the amount of reduced bichromate.

7) Sulphates (SO_4^{2-}). GOST 4389-72

The essence of the method is in precipitating sulphate in the form of insoluble salt of barium followed by gravimetric determination. For this purpose to a certain volume of water acidified with hydrochloric acid, a solution of barium chloride is added. Then the solution is heated until barium sulphate precipitates. The precipitation is filtered. The filter with the cake is incinerated and calcinated at temperature 800^0C to the fixed weight. $BaSO_4$ is weighted.

8) Chlorides (Cl^-). GOST 4245-72

The method is based on precipitation of chlorine-ion in a neutral or slightly alkaline medium with a silver nitrate in the presence of chromate of potassium as an indicator. After silver chloride precipitation a chromate of silver is formed in the point of equivalence, a yellow color of the solution becoming an orange-yellow one. The content of chlorides is calculated according to the amount of the silver nitrate spent for titration.

9) Total content of nitrogen. GOST 26449.1-85

The method is as follows: nitrates and nitrites present in the solution under investigation are reduced with hydrogen in a slightly acidic medium. The organic compounds are decomposed with a sulphuric acid in the presence of catalyst – copper sulphate and potassium sulphate – and ammonia is removed from the alkaline solution. While interacting with Nesler's reagent the ions of ammonia form complex compounds colored with a yellow-brown color. An optical density of the solution is measured with a photocolorimeter.

10) Nitrates (NO_3^-). GOST 18826-73

Determination is based on the reaction of nitrates with sodium salicylate in the sulphuric acid medium. The reaction results in formation of the salts nitrosalicyl acid colored in yellow. Nitrate content is determined according to the color intensity.

11) Nitrites (NO_2^-). GOST 4192-82

Determination is based on diazotization of sulphanilic acid with nitrites present in the sample and the reaction of the salt obtained with alpha-naphthylamine yielding a red-violet azo dye. The intensity of color is proportional to the concentration of nitrites.

12) Ammonium-ion (NH_4^+). GOST 4192-82

The method is based on the capability of ammonia and ammonium ions to form with Nesler's reagent a compound colored in yellow-brown. The intensity of the solution color, proportional to mass concentration of ammonia and ammonium ions, is measured with a photocolorimeter.

13) Total content of phosphorus (P_{total}). GOST 26449.1-85

By means of acid digestion in the presence of sulphuric acid and ammonium persulphate all types of phosphates in the sample are turned into soluble inorganic orthophosphates, which then are determined with molybdate with ascorbic acid. Under these conditions phosphates form soluble in water compound colored in blue. Total content of phosphorus is determined according to the color intensity of the solution.

14) Total content of sulphur (S_{total}). A.A. Reznikov

Solution of alkaline is poured into a certain volume of the water under investigation, bromine is added, and the solution is boiled. Under these conditions, sulphur containing in various compounds is oxidized to sulphate. The solution after oxidation of sulphur is acidified with hydrochloric acid, and then the procedure is followed as it is specified in Clause 7.Total sulphur content is calculated from the content of sulphates.

15) Cyanides(CN). Yu.Yu. Lurie

The acid solution is added to a certain volume of water being analyzed. Then the solutions of mercury (II) and magnesium salts are added. The solution is boiled. Prussic acid being released in these conditions is absorbed by water. Then it is treated with bromine, and pyridine is added. In these conditions a compound colored in a red color, soluble in water is formed. The content of cyanides is determined from the intensity of the solution color.

16) Petroleum products. MUK 4.1.068-96

The fluorimetric method is based on isolation of petroleum products from water by carbon tetrachloride, their separation from polar hydrocarbons and admixtures of petroleum origin on the chromatographic column with aluminum oxide, and determination of the isolated petroleum products by means of the luminescent method.

17) Grease and oil. Yu. Yu. Lurie

This parameter is aimed to determine grease and oils of vegetable and animal origin. Determination is based on extraction of grease by ester from a water sample evaporated on a water bath. After distillation from the ester extract, the extracted grease and oils are weighted.

18) Phenols. GOST 26449.1-85

Volatile phenols are distilled off with water vapor and oxidized in an alkaline medium by ammonium persulphate. The products of oxidation, while interacting with 4-aminoantipyrine, give red antipyrine dyes, which are extracted with chloroform. Optical density of the solutions is measured with a photoelectrocolorimeter.

19) Mercury (Hg). MP 2-3.05-42KhS-89

Flameless atomic-absorption determination of mercury is based on absorption of mercury atoms releasing in the process of mercury reduction from the solution by stannous chloride. To eliminate the interfering effect of sulphides, sulphates, oxidizing of organic substances, the solutions are treated with potassium permanganate.

20) Cadmium (Cd). GOST 26933-86

A certain volume of water being analyzed is evaporated on a water bath until dry. Sulphuric, nitric and perchloric acids are added to the dried residue, and it is evaporated until dry again. The residue is dissolved in the distilled water. The content of cadmium in the solution is changed by means of the atomic-absorption method.

21) Arsenic (As). GOST 4152-89

The method is based on reduction of all the forms of arsenic present in the water to the volatile hydrogen arsenide (arsine) by means of hydrogen at the moment of its releasing, and arsine interaction with a solution of iodine giving arsenate-ion. Arsenate-ion is determined in the form of molybdenum arsenate blue pigment by means of photometry.

22) Lead (Pb). GOST 18293-72

The atomic-absorption determination of lead and other elements is based on exciting atoms of the elements being determined in propane-butane-air flame and measurement of atomic absorption from resonance bands of the corresponding element.

23) Chromium (Cr_{total}). GOST 26449.1-85

Sulphuric acid and solution of ammonium persulphate are poured into a certain volume of water being analyzed, and the solution is boiled. Under these conditions all chromium is oxidized to hexavalent one. To the solution obtained diphenylcarbazone is added. Chromium (VI) with diphenylcarbazone form red-violet colored compound, soluble in water. Chromium content is determined from the intensity of the color.

24) Zinc (Zn). GOST 18293-72

The procedure is similar to Clause 22.

25) Microbiological parameters. Sanitary-microbiological analysis is carried out in accordance with "Methodical instructions..." № 3.05.039-97 RK by generally accepted methods.

C-2-10

In principle these methods investigate the certain objects of water by means of sowing and growing various microorganisms (in various media) at certain temperatures, determine the quantity of colonies or colibacilli in different volumes of water. Then they calculate the quantity of certain bacteria according to special tables.

26) Determination of algae was carried out with a microscope in accordance with "The manual on methods of biological analysis of surface waters and bottom sediments",1983. Species composition of algae of phytoplankton and periphyton type was determined as well as quantity of cells in 1 ml of water, a biomass. These parameters were the initial data to determine the zones of decontamination and classification of surface waters.

1.2.2 Analyses of sludge samples.

1) Determination of pH value, pH. GOST 26483-85

The method is based on determination of potential difference of a glass ion-selective electrode and an auxiliary electrode. The values of the potential difference are dependant on activity of hydrogen ions in a sludge mixture. A sludge sample is carefully stirred to a paste-like state, adding the distilled water if it is necessary. The electrodes of a pH meter are placed into the paste obtained and readings are taken.

2) Determination of water (bound) content. MP 02-3.05.42X-89

A weighted sludge sample pre-dried in the air at temperature 15-18^{0}C is dried in the drying oven at 105^{0}C to the fixed mass. The water content is calculated from difference of masses before and after drying.

3) Density. GOST 5180-84

Soil particles density is determined from the ratio of soil particles mass to their volume. The air is pre-removed from the sample by means of boiling.

4) Determination of organic carbon. GOST 2408.1-95

A weighted sludge sample dried at 105^{0}C is calcined in an oxygen flow at 1000^{0}C. The resulting carbon dioxide is absorbed by ascarite. The content of organic carbon is calculated from the difference of ascarite masses.

5) Chemical oxygen demand. RD 52.24.75-88

Organic substances entering into sludge composition are oxidized with potassium bichromate in the presence of sulphuric acid.

A fixed volume of sludge mixture is placed into a flask with a sulphuric acid and a known quantity of potassium bichromate. After the sample decomposition a bichromate residue is titrated with Mohr's salt. COD is calculated from the quantity of the reduced bichromate.

6) Concentration of active sludge by volume SV_{30}, SV_{120}.

The recommendations of the Ministry of Water Resources

This parameter characterizes the capability of active sludge to sediment in the settlers. A certain volume of a sludge mixture is taken into a cylinder, and a velocity of sedimentation per 30 min and 120 min is noted.

7) Concentration of active sludge by weight MLSS.

The recommendations of the Ministry of Water Resources

The method is based on filtration of a fixed volume of a sludge mixture followed by drying and weighting of the sediment.

8) Loss by calcination. GOST 3594.15-93

Depending on a sludge composition the loss by calcinations (l.b.c.) can be made up with water, carbon dioxide, organic substances, sulphur and some other volatile substances. A weighted sludge sample dried at 105^{0}C is calcined in an oven at 1000^{0}C to the fixed mass. The value of the loss by calcinations is calculated from the difference of mass before and after calcinations.

9) Total phosphorus content. GOST 26261-84

All types of phosphorus in a sludge sample are turned into soluble inorganic orthophosphates by dissolving the sludge sample with a mixture of nitric, hydrofluoric and hydrochloric acids. Then the obtained orthophosphates are determined by molybdate with ascorbic acid. To eliminate the organic substances interfering with determination, the sample is pre-incinerated at 450-500^{0}C.

10) Total content of nitrogen. GOST 28743-93

A weighted sludge sample dried at 105^{0}C is treated with a boiling sulphuric acid in the presence of catalyst. The resulting ammonium hydroxide is decomposed by caustic alkali, and the content of nitrogen is calculated from the amount of ammonia obtained.

11) Total content of sulphur. GOST 22772.7-77

A weighted sludge sample dried at 105^{0}C is calcined in an oxygen flow at 1250^{0}C. The resulting sulphur dioxide is absorbed by water and titrated by a solution of potassium iodide-iodate. The sulphur content is calculated from the amount of iodine formed.

12) Granulometric composition. GOST 21216.2-93

The method is based on quantitative distribution of a matter particles according to their size depending on time of their sedimentation in a liquid medium followed by weight determination of fractions according to their size.

1.3 Office work

The office work on analysis and generalization of the materials of the field work on water and sludge sampling and laboratory and analytical research were aimed:

- to estimate the water quality in the system of water supply in the city of Astana;
- to study a chemical composition and a level of contamination of sewage waters of the system of water disposal in the city of Astana;
- to study a chemical composition and other parameters of sludge of STP (the Sewage Treatment Plant) in the city of Astana.

The primary processing of the materials obtained was to systematize analytical data on water, sewage and sludge samples and compile the tables of the results.

The following documents were used as a normative base while estimating quality and a level of contamination of various water objects (Table 1.4):

1) "Sanitary regulations and norms of surface waters protection from pollution", SanPiN 4630-88, adopted in RK as SanPiN 3.01.070.98to estimate the surface water of Vyacheslavsky reservoir and water influent to the PFS as water the of household-drinking water consumption.
2) "Drinking water. Sanitary requirements to the quality of water of the centralized systems of drinking water supply. Quality control." SanPiN 2.1.4.559-96, Russia; adopted in RK on 3.01.067.97 to control the quality of water coming out from the PFS in the city of Astana.
3) "The certification of MAD (Maximum allowable discharge) of contaminating substances coming into Taldy Kol reservoir from the sewage purification works of SSC "Astana Su Arnasy" to control the purified sewage waters at the outlet of STP.

C-2-11

In the present report the quality of sewage waters of Taldy Kol reservoir and that of their discharge on terrain was also estimated in accordance with the requirements of SanPiN 4630-88, SanPiN 3.01.070.98 RK as water of surface reservoirs.

MAC for water of the fishery reservoirs (to which the rivers Esil and Ishim are referred) are also given in Table 1.4 for information.

Table1.4

Normative data

On maximum allowable concentration (MAC) of harmful substances in the water of water objects of household-drinking and cultural and general water consumption and water of fishery reservoirs

Water quality parameters	Units Of measurement	Water of household-drinking and cultural and general consumption			MAC $_f$ for water of fishery reservoirs	Normative documents
		MAC $_{h-d}$	Hazard indicator	Class of hazard		
1	2	3	4	5	6	7
Generalized parameters						
1. Value of pH, pH	pH units	6-9	-	-	No data available	1, 2, 3
2. Total mineralization (dry residue)	mg/l	1000	-	-	No data available	1, 2, 3
3. Suspended substances, SS:	mg/l					
- household-drinking	mg/l	background+ 0,25 mg/l	-	-	No data available	2
-cultural and general water consumption	mg/l	background +0,75 mg/l	-	-	No data available	2, 3
4. Dissolved oxygen, O_2	mg/l	>6	-	-	>6	2, 4
5. Biological consumption of oxygen, BOC_5 (BOD):						
- household-drinking	mgO_2/l	3	-	-	3	2, 4
- cultural and general consumption	mgO_2/l	6	-	-	-	2
Chemical consumption of oxygen, (COD):						
- household-drinking	mgO_2/l	15	-	-	No data available	2
- cultural and general consumption	mgO_2/l	30	-	-	No data available	2
7. Sulfates, SO_4	mg/l	500	Org.	4	100	1, 2, 3
8. Chlorides, Cl	mg/l	350	Org.	4	300	1, 2, 3
Inorganic and organic substances						
9. Total content of nitrogen, T-N	mg/l	No data available	-	-	No data available	
10. Nitrates, NO_3	mg/l	45	Sanitary toxic.	3	40	1, 2, 3
11. Nitrites, NO_2	mg/l	3,3	Sanitary toxic.	2	0,08	2, 3
12. Ammonium-ion, NH_4	mg/l	2,0	Sanitary toxic.	3	0,5	2, 3
13. Total content of phosphorus, T-P	mg/l	No data available	-	-	No data available	2, 3
14.Total content of sulphur, T-S	mg/l	No data available	-	-	10,0	3
15. Cyanides, CN	mg/l	0,035	Sanitary toxic.	2	0,05	1, 3
16. Petroleum products	mg/l	0,1	org.	4	0,05	1, 2, 3
17. Grease and oil	mg/l	No data available	-	-	No data available	
18. Phenols	mg/l	0,001	Org. odor	4	0,001	2, 3
Heavy metals						
19. Mercury, (Hg)	mg/l	0,0005	Sanitary toxic.	1	0,0001	1, 2, 3
20. Cadmium, (Cd)	mg/l	0,001	Sanitary toxic.	2	0,005 (Cd^{2+})	1, 2, 3
21. Arsenic, (As)	mg/l	0,05	Sanitary toxic.	2	0,05	1, 2, 3
22. Lead, (Pl)	mg/l	0,03	Sanitary toxic.	2	0,1 (Pb^{2+})	1, 2, 3
23. Chromium, (T-Cr)	mg/l	No data available	-	-	No data available	
24. Zinc, (Zn)	mg/l	5,0	Org.	3	0,01 (Zn^{2+})	1, 2, 3

Continuation of Table 1.4

Continuation of Table 1.4

1	2	3	4	5	6	7
Microbiological parameters						
25. Total content of coli-form bacteria (TCB) in water of the centralized drinking water supply, T-Coliforms	MPN [1] в 100 ml	<0,3	-	-	-	1
26. Thermo-tolerant coliform bacteria (TTB) in water of the centralized drinking water supply, E.coli	Quantity of bacteria in 100ml	Absent	-	-	-	1
27. Total microbe number, (TMN):						
- in water of the centralized drinking water supply, at t^0	CGU[2] in 1ml $t^0 = \frac{22^0}{37^0}$	Not more than 50	-	-	-	1
- in water of surface reservoirs for drinking water supply (for the estimation of reservoirs self-purifying)	CGU in 1ml $t^0 = \frac{22^0}{37^0}$	Quality estimati-on	-	-	-	5
28. Lactose-positive Escherichia coli (LEC) in water of surface reservoirs	The number of units in 100ml	<1000	-	-	-	2,5

Note:
1) MPN – most probable number;
2) CGU – colony of generating units

Normative documents resources:

1. "Drinking water. Sanitary requirements to the quality of water of the centralized systems of drinking water supply. Quality control." SanPiN 2.1.4.559-96, Goscomsanepidnadzor of Russia, Moscow, 1988, adopted in RK on 3.01.067.97
2. "Sanitary regulations and norms of surface waters protection from pollution", SanPiN 4630-88, USSR, 1988, Moscow 1988, adopted in RK as SanPiN 3.01.070.98
3. "The summarized check list of maximum allowable concentrations (MAC) and approximate safe levels of harmful substances effect for the water of fishery reservoirs." The USSR Ministry of fisheries, authorized № 12-04-11 09 August,1990, Moscow,1990.
4. «Methodical recommendations on formal comprehensive evaluation of the quality of surface and sea waters according to hydrochemical parameters", the USSR State Committee on hydrometeorology, Moscow, 1998.

"Methodical instructions on sanitary microbiological analysis of surface reservoirs water", the Republic of Kazakhstan № 3.05.039.97, Almaty, 1997.

C-2-12

The classification given in Table 1.5 is accepted in the hydro-biological committee on observance and control of the quality of surface waters in Kazakhstan and Russia.

Table 1.5

Classification of surface water quality according to hydro-biological parameters

№	Waters	Water class	Saprobe zone	Saprobe index according to Пантле и Букку
1	Very pure	I	xenosaprobe, x	0 – 0,5
2	Pure	II	oligosaprobe, o	0,51-1,50
3	Moderately contaminated	III	beta-mesosaprobe, β	1,51-2,50
4	Contaminated	IV	alpha-mesosaprobe, α	2,51-3,5
5	Impure	V	polysaprobe, ρ	3,51-4,00
6	Very impure	VI	-	>4,00

The evaluation of water quality of the systems of water supply and disposal is given in Section 2 "Results of the work ".

Analysis data on chemical composition of sludge are systematized in Tables 2.6 and 2.7.

The normative data on maximum allowable concentrations (MAC) of contaminating substances in sludge of the sewage purification works and bottom sediments of rivers are not available in the Republic of Kazakhstan and Russia. In practice, when evaluating the level of sludge (bottom sediments) contamination, MAC of chemical substances in soils is used in accordance with "The methodical instructions on estimation the hazard degree of soil contamination with chemical substances", authorized in the RK 3.01.006.97. The data on soil MAC (total content) are given in Table 2.7.

2 RESULTS OF THE WORK

1.2 Water quality of the system of water supply

The water quality of the water supply system has been studied by means of sampling and analyzing the surface water samples from Vyacheslavsky reservoir and PFS (Tables 2.1, 2.1.1, 2.1.2, 2.2).

2.1.1 Vyacheslavsky reservoir. The surface water of the reservoir is the initial water for the centralized water supply in the city of Astana.

Before starting the analysis of the data obtained, it is necessary to pay attention the fact that the water composition of the reservoir is non-homogeneous both in its defined area of water and depth. Its water composition is non-homogeneous due to an elongated shape ao the lake and availability of isolated stretches. Unequal character of biochemical processes at different depths of the lake and different seasons creates a vertical hydrochemical zoning. Hydrochemical composition of the surface waters (of the upper layer – samples VR10, VR1F and the lower layer – samples VR20, VR2F) is given in Table 2.1.

Analyzing the data obtained one can make the following conclusions:

1. The surface water of the reservoir is alkalescent, pH varies from 7.4 to 7.9 depending on temperature and the depth of sampling. These parameters correspond to a neutral and alkalescent medium.

Some decreasing of pH with depth deepening (7.9 at the surface, 7.7 at depth of 6 m) is explained by the fact that in the upper layer a great amount of CO_2 is consumed in the process of photosynthesis, and decreasing of CO_2 creates an alkaline reaction. But in near-bottom parts a microbiological decay of organic substances with releasing CO2 is in process resulting in reduction of the solution pH.

In winter time CO_2 concentration continuously increases and at this time the solution pH is lower than it is in autumn.

C-2-13

2. A sharp decrease in dissolved oxygen down to 7.2 mg/l in winter (in summer it is 11.6 mg/l) is connected with the fact that coming in of oxygen from the atmosphere is decreased in winter. Photosynthesis almost ceases under the ice cover, and this radically changes a gas regime of the reservoir. Oxygen is consumed for breathing and other oxidizing processes taking place under the ice, and oxygen concentration reduces due to these processes.
3. Water mineralization is low - 334-456 mg/l (at MAC - 1000 mg/l), but in winter time it increases a little (from 343 to 456 mg/l in the upper layer). It is connected with the fact that a reducing atmosphere is created under the ice due to decreasing of oxygen content. Under these conditions microorganisms decompose an organic substance, finally increasing mineralization of water.
4. Biochemical oxygen demand is within the norm – 1.6-2.4 mg/l (MAC – 3). At winter sampling the chemical oxygen demand was 46.9 mg/l, and it decreased to 38.4 mg/l at depth. The excess of MAC for water of the household-drinking water supply (MAC - 30 mg/l) is 3,1-2,6 times higher and that of the cultural and general consumption (MAC -15 mg/l) is 1,6 and 1,3 times higher than normal.
5. The content of sulphates, chlorides, the nitrogen group compounds (NO_3, NO_2, NH_4), cyanides, heavy metals (Hg, Cd, As, Pb, Cr, Zn) and microbiological parameters for surface waters (total microbe number (TMN) and the presence of lactose-positive Escherichia coli (LEC) does not exceed MAC and norms for the water of surface reservoirs.
6. In the upper water layer of the reservoir at single sampling (10.10 2002) somewhat higher content of phenols – 0,004 mg/l (MAC – 0,001), petroleum products – 0,14 mg/l (MAC – 0,1), exceeding MAC in 4,0 and 1,8 times, respectively, as well as higher content of grease and oil 4,9 mg/l have been found. In the lower water layer of the

reservoir the content of phenols and petroleum products corresponds to the norms. The content of grease and oil (1mg/l) has decreased in 4,9 times.

Higher than usual contents of these parameters in the upper layer, in our opinion, can be connected with medium waves on the water surface, and also with the increase (in 2002) of the reservoir water table up to 55 km^2 against 38-42 km^2 in previous years. It was drilled during the spring (2002) flood tide up to its designed volume (about 420 ml. m^3).

7. The data of hydro-biological analysis of algae (phytoplankton) in the water of the reservoir (Table 2.1.1. – 2.1.2) confirms in principle the data of chemical analyses of water.

The algae composition in the water of the upper layer sampled during the autumn mean water (Table 2.1.1) corresponds to beta-mesosaprobe zone (β), saprobe index of water in average is equal to 1,57, what corresponds to III class of moderately contaminated water.

The decrease of algae biomass is observed in the water of lower layer. The water corresponds to oligosaprobe (O) zone. Index of saprobe decreases to 1,47, and the water is referred to II class of pure waters.

The results of analysis of algae in water sampled in the winter are given in Table 2.1.2. As it is evident from the table the water taken from depth is purer than the water taken from horizon 0.5m. The water from depth is estimated as II class of pure waters, saprobe index on the surface corresponds to III class of moderately contaminated water. A comparative analysis of the winter and autumn samples has shown that the water quality of Vyacheslavsky reservoir remains at the same level. Diatom algae compose the basis of winter phytoplankton. This can be explained be two reasons: a low temperature of water (a cold water is the most favourable condition for diatom algae existence) and higher tan normal content of active iron in the water.

In general, the analysis of hydro-chemical parameters of the water in Vyacheslavsky reservoir according to the data of sampling and analysis of the samples in principle corresponds to the requirements to the surface waters quality and their use for the household-drinking water supply with its purification at the PFS. It should be noted that water mineralization and concentrations of a number of other parameters (T-S, T-N, T-P) have decreased in comparison with the data of other water sample analyses from the reservoir (the sample from the pump station of the first lifting) carried out by CJSC "Tsentrgeolanalit" in September-October 2002 for the YaAMS Feasibility Study Team. In our opinion, this circumstance is connected with the intensity of the spring flood tide in these years as well as the volume of water in Vyacheslavsky reservoir during the period of sampling. In 2000 it was about 140-150 ml.m^3, in 2002 it was 340 ml. m^3 at the expense of water dilution with fresh snow melt waters.

Table 2.1

RESULTS
of water quality analysis in the of Vyacheslavsky reservoir

№	Water quality parameters	Units of measurement	Surface water		Water from a depth of 6 m	
			VR1O	VR1F	VR2O	VR2F
1	2	3	4	5	6	7
1	PH	unit. pH	7,9	7,6	7,7	7,4
2	Total mineralization (dry residue) (T-Mineral)	mg/l	343	456	334	426
3	Suspended substances, (SS)	mg/l	15	4,57	10	3,26
4	Dissolved oxygen, O_2 (DO)	mg/l	11,6	9,9	10,8	7,2
5	Biological oxygen demand, (BOD)	mg/l	2,4	1,8	1,6	2,2
6	Chemical oxygen demand, (COD)	mg/l	46,9	32,0	38,4	26,4
7	Sulphates, SO_4^{2-}	mg/l	62	86	65	77
8	Chlorides, Cl^-	mg/l	78	98	77	93
9	Total content of nitrogen, T-N	mg/l	0,56	0,5	0,53	0,54
10	Nitrates, NO_3	mg/l	0,66	<0,05	0,62	1,3
11	Nitrites, NO_2	mg/l	0,05	<0,01	≤0,01	<0,01
12	Ammonium-ion, NH_4	mg/l	<0,1	<0,1	<0,1	<0,1
13	Total content of phosphorus, T-P	mg/l	0,020	0,026	0,018	0,020
14	Total content of sulphur, T-S	mg/l	20,72	28,75	20,67	27,53
15	Cyanides, CN	mg/l	<0,01	<0,01	<0,01	<0,01
16	Petroleum products	mg/l	0,14	<0,02	0,08	<0,02
17	Grease and oil	mg/l	4,9	3,09	1,0	3,0
18	Phenols	mg/l	0,004	0,002	0,001	0,001
19	Mercury, (Hg)	mg/l	<0,0002	<0,0002	<0,0002	<0,0002
20	Cadmium, (Cd)	mg/l	0,001	0,0016	0,001	0,0014
21	Arsenic, (As)	mg/l	<0,01	<0,01	<0,01	<0,01
22	Lead, (Pl)	mg/l	0,01	0,015	0,01	0,01
23	Chromium (Cr_2^{6+})	mg/l	<0,02	<0,02	<0,02	<0,02
24	Zinc, (Zn)	mg/l	0,01	0,01	0,01	<0,01
25	Total microbe number (TMN): - in the water of the centralized water supply at temperature	CGU [2] in 1ml $t^0 = \frac{22^0}{37^0}$	-	-	-	-

C-2-14

Continuation of Table 2.1

1	2	3	4	5	6	7
	- in water of surface reservoirs	CGU [2] 1ml $t^0 = \frac{22^0}{37^0}$	$\frac{0}{145}$	$\frac{0}{0}$	$\frac{0}{100}$	$\frac{0}{0}$
26	Lactose-positive Escherichia coli (LEC) in water of surface reservoirs	Quantity of units in 100ml	600	200	600	200
27	Water temperature	t^0C	11,5	1	11,5	2,6
28	Air temperature	t^0C	17,5	-15,0	10,5	-15,0

Table 2.1.1

Results of hydro-biological analysis of algae in Vyacheslavsky reservoir.
Sampling 10.10.2002.

№	Parameters	Phytoplankton									
		VR1O					VR2O				
		Zone of saprobe	Index of saprobe.	Amount, thousand C/ml	biomass, mg/l	Class of water	Zone of saprobe	Index of saprobe.	Amount, th.C/ml	biomass, mg/l	Class of water
1	2	3	4	5	6	7	8	9	10	11	12
	Species composition ***Diatom***										
1	Cyclotela comta	0	1,15	0,04	0,080	II	0	1,15	0,03	0,060	II
2	Cymbella ventricosa	-	-	-	-	-	0	1,35	0,01	0,010	II
	Green										
1	Scenedesmus guadricauda	β	2,00	0,02	0,012	III	-	-	-	-	-
2	Crucigenia guadrata	-	-	0,02	0,006	-	-	-	-	-	-
3	Scenedesmus bijygatus	β	2,00	0,01	0,004	III	-	-	-	-	-
4	Healoraphidium arcuatum	-	-	-	-	-	-	-	0,01	0,002	-
	Blue-green										
1	Gomophospheria aponina	β	1,80	0,01	0,600	III	-	-	-	-	-
	Others										
1	Trachelomonas planrtonica	β-0	1,65	0,02	0,580	III	-	-	-	-	-
2	Trachelomonas storesiana						β	2,00	0,02	0,800	III
		Average				**Av.**	**Average**				**Av.**
		β	1,57	0,12	1,28	III	0	1,47	0,07	0,872	II

Table 2.1.2

Results of hydro-biological analysis of algae in Vyacheslavsky reservoir (26.02.2003)

№	Parameters	Phytoplankton									
		VR1F					VR2F				
		Zone of saprobe	Index of saprobe.	Amount, thousand C/ml	biomass, mg/l	Class of water	Zone of saprobe	Index of saprobe.	Amount, th.C/ml	biomass, mg/l	Class of water
	Species composition ***Diatom***										
1	Cyclotela comta	0	1,15	0,03	0,060	II	0	1,15	0,02	0,040	II
2	Fragilaria capucina	β -0	1,60	0,02	0,030	III	β -0	1,60	0,01	0,015	III
3	Fragilaria construens	β	2,00	0,01	0,017	II					
4	Melosira varians	β	1,85	0,01	0,800	III					
5	Cymbella ventricosa						0	1,35	0,02	0,020	II
	Blue-green										
1	Microcystis aeruginosa	β	1,75	0,03	0,011	III					
		average				average					
		β	1,67	0,10	0,918	III	0	1,37	0,05	0,075	II

C-2-15

2.1.2 The Pump-Filter Station (PFS). At the PFS two samples were taken twice (in autumn and winter) and analyzed. The samples PPSOO and PPSOF – this is the purified water at the outlet of the Pump-Filtration Station (Table 2.2).

Hydro-chemical composition of the water influent to the PFS essentially corresponds to the water parameters of the reservoir's lower layer.

The decrease of COD from 38,4 mg/l to 28,0 mg/l and some increase in grease and oil content up to 2,4 mg/l have been found. This is difficult to be explained from the data of a single analysis.

After purification the content of suspended substances, petroleum products and phenols in the water decreases and it corresponds to MAC.

According to microbiological parameters the water at the entrance and outlet from the PFS corresponds to normative requirements. The chemical composition and microbiological parameters such as total content of coliform bacteria (N-Coliforms) and a quantity of thermo-tolerant bacteria (E. coli) of the purified water coming from the PFS in the city of Astana corresponds to the requirements to the water quality in the centralized systems of drinking water supply. The parameters were investigated in accordance with SanPiN 2.1.4.559-96 from the data obtained from single sampling and analyzing of these samples.

Table 2.2

RESULTS
Of the analysis of water quality at the Pump-Filter Station

№	Water quality parameters	Units of measurement	Water incoming into PFS		Outlet of the purified water	
			PPSOO	PPSOF	PPRSO	PPRSF
1	2	3	4	5	6	7
1	PH	unit. pH	7,7	7,45	7,55	7,68
2	Total mineralization (dry residue) (T-Mineral)	mg/l	342	436	343	436
3	Suspended substances, (SS)	mg/l	10	1,6	10	0,64
4	Dissolved oxygen, O_2 (DO)	mg/l	10,8	7,6	12,2	9,6
5	Biological oxygen demand, (BOD)	mg/l	3,4	2,4	2,4	2,0
6	Chemical oxygen demand, (COD)	mg/l	28,0	27,6	20,0	18,0
7	Sulphates, SO_4^{2-}	mg/l	67	80	65	86
8	Chlorides, Cl^-	mg/l	75	95	77	95
9	Total content of nitrogen, T-N	mg/l	0,53	0,50	0,53	0,50
10	Nitrates, NO_3	mg/l	0,50	1,45	0,50	1,37
11	Nitrites, NO_2	mg/l	≤0,01	<0,01	<0,01	<0,01
12	Ammonium-ion, NH_4	mg/l	<0,1	<0,1	<0,1	<0,1
13	Total content of phosphorus, T-P	mg/l	0,017	0,017	0,011	0,012
14	Total content of sulphur, T-S	mg/l	22,65	28,19	20,56	28,97
15	Cyanides, CN	mg/l	<0,01	<0,01	<0,01	<0,01

Continuation of Table 2.2

1	2	3	4	5	6	7
16	Petroleum products	mg/l	0,08	<0,02	0,04	<0,02
17	Grease and oil	mg/l	2,4	3,06	0,8	1,2
18	Phenols	mg/l	0,001	0,002	<0,001	0,001
19	Mercury, (Hg)	mg/l	<0,0002	<0,0002	<0,0002	<0,0002
20	Cadmium, (Cd)	mg/l	0,001	0,0016	0,001	0,0016
21	Arsenic, (As)	mg/l	<0,01	<0,01	<0,01	<0,01
22	Lead, (Pl)	mg/l	0,01	0,020	0,015	0,020
23	Chromium (Cr_2^{6+})	mg/l	<0,02	<0,02	<0,02	<0,02
24	Zinc, (Zn)	mg/l	0,01	<0,01	≤0,01	<0,01
25	Total content of Coliform bacteria (TCB) in the water of the drinking water supply, N-Coliforms	MPN[1)] in 100 ml	-	-	Not detected	Not detected
26	Thermo-tolerant Coliform bacteria (TTCB) in the water of the drinking water supply, E.coli	Quantity of units in 100ml	-	-	Not detected	Not detected
27	Total microbe number (TMN): - in the water of the centralized water supply at temperature - in water of surface reservoirs	CGU[2)] in 1ml $t^0 = \frac{22^0}{37^0}$ CGU[2)] 1ml $t^0 = \frac{22^0}{37^0}$	$\frac{0}{5}$ -	$\frac{2}{2}$ -	$\frac{0}{0}$ -	$\frac{0}{0}$ -
28	Lactose-positive Escherichia coli (LEC) in water of surface reservoirs	Quantity of units in 100ml	600	200	-	-
29	Water temperature	t^0C	13	3,8	13	2,9
30	Air temperature	t^0C	16	-14,8	17,5	-15,0

C-2-16

2.2 Chemical composition of sewage water of the water disposal system

Sewage water in the city of Astana was studied at four points (Table 2.3):

- non-purified flows at the inlet of the STP (Sewage Treatment Plant)- samples SPINO and SPINF;
- the purified sewage waters at the outlet of STP – samples SPTRO and SPTRF;
- at Taldy Kol reservoir of the purified sewage waters - samples TKR1O and TKR2F;
- at the point of the purified sewage water discharge on terrain - samples TKR2O and TKR2F.

At the outlet of the STP the contents of main contaminants and parameters such as SS, BOD_5 COD, total nitrogen, phosphorus, petroleum products, grease and oil, phenols, zinc and contents of pathogenic bacteria are considerably reduced owing to technological processes of sewage water purification. At the same time the water is being enriched with oxygen. At the expense of nitrification processes the content of ammonia-ion is decreased, and the content of nitrates is increased simultaneously. In general, according to the data available at the disposal of the authors of this report, the quality of sewage water purification meets the requirements of maximum allowable discharge (MAD) specified for SPW on the following parameters: suspended substances, mineralization, sulphates, chlorides, BOD, COD, petroleum products and compounds of nitrogen group (NO_3, NO_2, NH_4).

In the purified sewage waters at the outlet from STP and in Taldy Kol reservoir during the autumn sampling, the concentrations exceeding MAC in a number of parameters for surface waters of the cultural and general water consumption have been determined. They are as follows: COD (in 2.4 – 2.9 times), mineralization in the reservoir (in 1.3), petroleum products (in 2,9), phenols (up to 9 times), cadmium (up to 3-4 times). The content of grease and oil decreases in 5 times. Further decrease of the content of nitrates and ammonia-ions is noticed in Taldy Kol reservoir. Microbiological parameters correspond to the requirements specified for waters of surface reservoirs.

In the purified sewage waters discharged from time to time from Taldy Kol reservoir on terrain (sample TKR2O), the increase of mineralization up to1660 mg/l is noted, COD is increased up to 85 mg/l. The content of sulphates and chlorides is increased up to 319 and 460 mg/l, respectively. Apparently, this is due to dilution with the mineralized surface and ground waters. The contents of a number of parameters have been found to exceed MAC of phenols (0.007 mg/l) in 7 times, petroleum products (0.2 mg/l) in 2 times, cadmium (0.006 mg/l) in 6 times, lead (0.04 mg/l) in 1.3 times. Concentrations of other contaminants: compounds of nitrogen group, cyanides, mercury, arsenic, chromium, zinc and microbiological parameters correspond to MAC requirements to surface waters. Based on the results of hydro-biological analysis (Table 2.4) of algae it has been found that the purified sewage water in Taldy Kol reservoir corresponds to alpha-mesasaprobe zone (α), and according to the index of saprobe 2,8 it is referred to the contaminated waters of IV class.

According to the analysis results of algae (phytoplankton and periphyton) in the purified sewage water discharged on terrain the water quality is improving. The water is referred to beta-saprobe zone (β) with index of saprobe for phytoplankton 2.28 and for periphyton 2.0, and it is characterized as moderately contaminated water of III class.

According to the results of the winter sampling, at the first sight, especially abnormal are the results of chemical analysis of the water discharged on terrain. Thus, in comparison with the autumn period the content of ammonium ions has drastically increased (from 0.55 to 7.0 mg/l), total nitrogen (from 1.6 to 5.6 mg/l). The content of dissoluble oxygen decreases (from 11.6 to 2.5 mg/l, water mineralization increased (from 1660 to 1854 mg/l).

These phenomena are accounted for the fact that during the winter an entry of oxygen from the atmosphere into shallow lakes under ice almost ceases, while it is consumed at all depths, but most intensively at the bottom sediments. There is an intensive decomposition of organic substances in the near to bottom layers resulting in accumulation of NH_4. Water mineralization increases at the expense of organic remains mineralization.

The content of all forms of nitrogen in the lakes is maximal, since the photosynthesis process almost ceases. Plants do not consume nitrogen, and it accumulates at the expense of decomposition of an organic substance. It is seen by the example of the sample taken at Taldy Kol reservoir: in summer the content of all forms of nitrogen is less than it is in winter NH_4^+ (3.8 – 6.0 mg/l), NO_2 (0.1 – 0.4 mg/l), NO_3 (9.2 – 11.4 mg/l), N_{total} (5.8 – 7.6 mg/l).

In the result of hydrobiological analysis of algae of the winter samples it was determined that water quality in the system of water disposal of the purified sewage waters had became better, saprobe indices in both samples appeared to be lower than in autumn phytoplankton, and in average they are 2.10 and 1.93. That corresponds to III class of moderately contaminated waters.

Preliminary analysis of hydro-chemical composition of the purified sewage waters of STP and Taldy Kol reservoir judging by single observations of the first stage of work shows that for a number of parameters given above the waters do not meet the requirements for the surface water quality. In this connection it is impossible, in our opinion, to discharge them into surface waters of the rivers Esil and Nura without preliminary additional purification according to modern technologies.

Moreover, at the STP in accordance with Technical Specification a three-stage sampling was carried out in a day in consecutive order at two points (Table 2.5): sewage waters after primary settlers (samples PS1, PS2 и PS3) and after secondary settlers (samples FS, FS_2, FS_3).

These analyses results characterize the technological processes of consecutive purification of sewage waters at STP.

C-2-17

Table 2.3

Results of the sample analysis of sewage waters of the system of water disposal of the city of Astana

№	Water quality parameters	Units of measurement	STP inlet	STP outlet	Taldy Kol reservoir	Sewage waters discharge on terrain
			SPINO SPINF	SPTRO SPTRF	TKR1O TKR1F	TKR2O TKR2F
1	2	3	4	5	6	7
1	PH	unit. pH	7,1 7,55	7,43 7,57	8,1 7,92	7,7 7,5
2	Total mineralization (dry residue) (T-Mineral)	mg/l	770 790	814 792	1258 1278	1660 1854
3	Suspended substances, (SS)	mg/l	285 225	12 7,2	9,5 1,1	14,0 5,6
4	Dissolved oxygen, O_2 (DO)	mg/l	2,0 1,8	10,0 10,6	11,8 8,0	11,6 2,5
5	Biological oxygen demand, (BOD)	mg/l	150,0 170,0	6,7 13,0	6,0 7,0	7,0 8,3
6	Chemical oxygen demand, (COD)	mg/l	298,0 162,4	86,4 34,4	72 96	85 132
7	Sulphates, SO_4^{2-}	mg/l	186 163	185 178	322 307	319 307
8	Chlorides, Cl^-	mg/l	198 198	198 200	315 319	460 498

Continuation of Table 2.3

1	2	3	4	5	6	7
9	Total content of nitrogen, T-N	mg/l	28,0 36,0	17,2 17,8	5,8 7,6	1,6 5,6
10	Nitrates, NO_3	mg/l	1,43 0,37	41,0 28,2	9,2 11,4	4,4 <0,05
11	Nitrites, NO_2	mg/l	0,1 0,01	1,1 0,5	0,1 0,4	0,08 <0,01
12	Ammonium-ion, NH_4	mg/l	32,3 44,0	9,0 14,0	3,8 6,0	0,55 7,0
13	Total content of phosphorus, T-P	mg/l	4,0 3,74	1,95 2,02	1,70 1,56	0,24 0,34
14	Total content of sulphur, T-S	mg/l	68,1 53,96	68,02 58,61	107,92 105,11	103,57 113,6
15	Cyanides, CN	mg/l	0,01 0,013	<0,01 <0,01	0,01 <0,01	<0,01 <0,01
16	Petroleum products	mg/l	3,0 3,04	0,29 0,50	0,15 <0,2	0,2 <0,2
17	Grease and oil	mg/l	15,5 5,16	3,0 2,37	3,2 2,89	3,1 2,27
18	Phenols	mg/l	0,018 0,013	0,0094 0,0025	0,010 0,0018	0,007 0,0011
19	Mercury, (Hg)	mg/l	<0,0002 <0,0002	<0,0002 <0,0002	<0,0002 <0,0002	<0,0002 <0,0002
20	Cadmium, (Cd)	mg/l	0,003 0,0026	0,003 0,0024	0,004 0,0036	0,006 0,005
21	Arsenic, (As)	mg/l	<0,01 <0,01	<0,01 <0,01	<0,01 <0,01	<0,01 <0,01
22	Lead, (Pl)	mg/l	0,03 0,03	0,02 0,02	0,03 0,03	0,04 0,05
23	Chromium (Cr_2^{6+})	mg/l	<0,02 <0,02	<0,02 <0,02	<0,02 <0,02	<0,02 <0,02
24	Zinc, (Zn)	mg/l	0,12 0,13	0,01 0,01	0,01 0,01	0,01 0,01
25	Total microbe number (TMN)	КОЕ в 1мл $t^0 = \frac{22^0}{37^0}$	$\frac{0}{200}$ $\frac{200}{300}$	$\frac{0}{150}$ $\frac{100}{200}$	$\frac{140}{170}$ $\frac{70}{90}$	$\frac{0}{50}$ $\frac{6}{15}$
26	Lactose-positive Escherichia coli (LEC) in water of surface reservoirs	Quantity of units in 100ml	9000 20000	600 900	600 900	600 500
27	Water temperature	t^0C	17,5 5,2	19,5 10,2	14 1	6 1
28	Air temperature	t^0C	11,5 -15,2	20 -15,0	8 -12,0	6 -13,8

Table 2.4

Results of hydro-biological analysis of algae in the water disposal system
(Taldy Kol reservoir and the purified sewage water discharge on terrain)
Sampling 9.10.2002.

№	Parameters	Phytoplankton										Periphyton		
		TKR1O					TKR2O					TKR2/1O		
		Zone of saprobe	Index of saprobe	Number C/ml	biomass mg/l	Class of water	Zone of saprobe	Index of saprobe	Number,th Cl/ml	Biomass mg/l	Class of water	Zone od saprobe	Index of saprobe	Class of water
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Species composition													
	Diatom													
1	Navicula gracilis	-	-	-	-	-	β-0	1,65	0,02	0,120	III	β-0	1,65	III
2	Navicula placental	-	-	-	-	-	-	-	0,01	0,022	-			
3	Nitzschia vermicuiaris	-	-	-	-	-	β	2,30	0,01	0,140	III	β	2,30	III
4	Navicula crypthocephala	-	-	-	-	-	α	2,70	0,02	0,018	IV	α	2,70	IV
5	Navicula acicularis						α	2,70	0,01	0,001	IV			
6	Navicula rynchocephala											α	2,70	IV
7	Diatoma vulgare											β	1,85	III
8	Synedra acus											β	1,85	III
9	Navicula tuscula											β	2,20	III
10	Pinnularia interrupta													
	Green algae.													
1	Cladophora glomer											0-β	1,65	III
2	Kirchneriella lunaris	β	2,00	0,01	0,005									
3	Chlorella vulgaris	P-α	3,60	0,01	0,006									
	Blue-green													
1	Lingbia Birgeri	-	-	0,24	0,432									
		Average					Average							
		α	2,80	0,26	0,443	Average. IV	β	2,28	0,07	0,301	III	β	2,00	III

Table 2.4.1

Results of hydro-biological analysis of algae in the water disposal system
(Taldy Kol reservoir and the purified sewage water discharge on terrain)
Sampling 25, 26.02.2003.

№	Parameters	Phytoplankton									
		TKR1F					TKR2F				
		Zone of saprobe	Index of saprobe.	Amount, thousand C/ml	biomass, mg/l	Class of water	Zone of saprobe	Index of saprobe.	Amount, th.C/ml	biomass, mg/l	Class of water
	Species composition ***Diatom***										
1	Diatoma vulgare	β	1,85	0,02	0,020	III	β	1,85	0,02	0,020	III
2	Navicula gracilis	β -0	1,65	0,01	0,060	III					
3	Gomphonema cjgstritum	β	2,20	0,01	0,060	III					
4	Navicula crypthocephala	α	2,70	0,01	0,009	IV					
5	Navicula tuscula						β	2,20	0,01	0,060	III
	Blue-green										
1	Microcystis aeruginosa						β	1,75	0,02	0,007	III
		average					average				av.
		β	2,10	0,05	0,149	III	β	1,93	0,05	0,087	III

Table 2.5 **Results of analysis of sewage waters of STP of the city of Astana.**

№	Parameters of sewage waters chemical composition	Units of measurement	Sewage waters after the primary settler (clarified channel)			Sewage waters after the secondary settlers		
			PS1	PS2	PS3	FS1	FS2	FS3
1	2	3	4	5	6	7	8	9
1	pH	ед. pH	7,35	6,8	7,15	6,95	7,1	7,2
2	Suspended substances, (SS)		27,0	44,0	27,0	10,0	9,0	16,0
3	Biological oxygen demand, (BOD)	mg/l	110,0	150,0	80,0	20,0	38,0	14,0
4	Chemical oxygen demand, (COD)	mg/l	166,4	182,4	154,4	86,4	102,4	86,4
5	Total content of nitrogen, T-N	mg/l	18,8	20,7	17,8	9,2	14,4	9,7
6	Nitrates, NO_3	mg/l	<1,5	<1,6	<1,5	12,0	9,0	12,2
7	Nitrites, NO_2	mg/l	0,08	0,08	0,08	1,5	2,0	2,7
8	Ammonium-ion, NH_4	mg/l	20,0	22,5	19,8	7,5	15,0	7,5
9	Total content of phosphorus, T-P	mg/l	3,0	3,25	3,40	1,92	2,50	1,70
10	Petroleum products	mg/l	0,62	0,60	0,91	0,36	0,18	0,44
11	Grease and oil	mg/l	9,4	13,6	6,6	2,9	3,3	2,8
12	Water temperature	t^0C	18	18	18	17,5	18	18
13	Air temperature	t^0C	11,5	10	12	11,5	9,5	11,5

C-2-19

2.3 Chemical composition of sludge of the Sewage Treatment Plant (STP)

Chemical composition of STP sludge was studied in accordance with Technical Specification at 5 points (Table 2.6) in autumn and winter and additionally on a new sludge map (Table 2.7) – in autumn.

Chemical composition of sludge features the following data:

1) The value of pH – 5.95 –7.35 corresponds to a subacid and neutral medium.
2) Water content in dry sludge (samples SO-1, SO-3 and SF-1 - SF-4) is 6.07 – 10,17 %, density of sludge is fixed, and it is 1,46 – 1,64 g/cm^3, inflammable residue (C org.) (samples SO-1 - SO-3 and SF-1 – SF-3) is 33,2-40,57% , and it decreases in digested sludge to 11,47 – 26.52 % (sample SO-4, SF-4).
3) Maximum values of COD have been determined in fresh sediment after the primary settlers (sample SO-1)- 24256 mg/l and digested sludge (sample SO -4) – 23760 mg/l. In reciprocal and compact sludge after aeration tanks (samples SO-2 and SO-3) the values of COD decrease to 144 and 1136 mg/l. These values are typical for the autumn sampling.
   The values of COD in samples SF-2 and SF-3 increased sharply in winter in comparison with the autumn sampling (SF-2 – 144-2000 mg/l, SF-3 1136-10 000mg/l). It is accounted for a different sludge composition. At the last sampling the sludge was soft, loose and black vegetative remains, hair and fine motley (gray, yellow, brown) sand.
4) Sludge sedimentation velocity (SV_{30} and SV_{120}) is given in Table 2.6. It correlates with granulometric composition of sludge. For fresh sediment samples (sample SO-1) and compact sludge or sludge after aeration tanks (sample SO-3) at the particles size bigger than 0.25 up to 0.01 mm comprising 49,4 % and 32,8%, respectively, the sludge sedimentation velocity is 930 –980 mg/l. In the winter sampling a fraction finer than 0.063 mm was swelling, floating and coagulating organic substance according to its granulometric composition.
   Sludge on the new sludge map (sample SO-6, table 2.7) features the following physical-mechanical properties: they belong to a fine fraction, diameter of particles is 0.063 and smaller than 0.005 mm and comprises 98,7 %. Its density is 1.99 g/cm^3. Moisture content is 3,27%, organic substances content (C_{org}) is 21.2%, losses by calcination (l.b.c.) – 42.51%.

In sludge T-N content was found to be 24.1% and low content of T-P is 0,94%, and that of T-S is 1,34%.

Contents of heavy metals and toxic chemical elements are low, and in most cases do not exceed soil MAC (Table 2.7). It has been found that some elements have concentrations slightly higher than usual and exceeding soil MAC: zinc (120 mg/kg) exceeds MAC in 1.2 times, chromium (150mg/kg) exceeds MAC in 1.5 times and manganese (2000 mg/kg) exceeds MAC in 1.3 times.

The results of chemical analysis of one sludge sample (final wastes of STP) on the new sludge map show that sludge is not of a great ecological hazard.

Based on the results obtained it is recommended to continue further work on studying ecological hazard and agrochemical properties of sludge of the sludge maps to estimate a possibility of its using in agriculture and in tree-planting as a fertilizer and a soil ameliorant.

Table 2.6

RESULTS
of analysis of sludge samples from the Sewage Treatment Plant (STP) of the city of Astana.

№	Parameters of sewage waters chemical composition	Units	Fresh sludge after primary settlers, SO-1 SF-1	Reciprocal sludge after aeration tanks SO-2 SF-2	Compact sludge after aeration tanks SO-3 SF-3	Digested sludge[1)] SO-4 SF-4	Mixed sludge in the aeration tanks SO-5 SF-5
1	2	3	4	5	6	7	8
1	pH	unit pH	5,95 5,98	7,1 7,0	6,62 6,64	6,6 7,35	6,96 6,98
2	Water content in sludge	%	6,60 6,07	10,17 9,1	9,86 8,50	- 6,11	-
3	Density	g/cm^3	1,59 1,46	1,59 1,52	1,59 1,58	1,56 1,64	-
4	Inflammable residue, $C_{org.}$	%	33,2 40,57	40,2 37,56	35,4 34,35	11,47 26,52	-
5	Chemical oxygen demand, (COD)	mg/l	24256 22800	144 2000	1136 10000	23760 16160	-
6	SV_{30}	m/l	980 998	320 780	970 800	- 995	250 840
7	SV_{120}	ml/l	930 990	180 700	950 600	- 908	-
8	MLSS	mg/l	-	-	-		2616 3060
9	Granulometric composition, %						
	More than 0.25		1,0 4,0	- 0,7	0,1 1,2	- 3,3	
	0,25-0,10		0,1 4,5	0,1 0,8	- 1,4	2,6 4,7	
	0,10-0,063		- 2,0	- 1,2	0,1 3,0	31,1 6,1	
	0,063-0,05		8,3 6,9	0,3 0,7	8,4 12,1	29,2 11,1	
	0,05-0,01		40,0 46,5	13,4 -	24,2 23,2	- 24,2	
	0,01-0,005		13,3 11,0	27,0 45,5	13,4 18,0	7,9 22,0	
	Less than 0.005		37,3 21,9	59,2 51,1	53,8 41,1	29,2 28,6	

1) A sample of digested sludge was taken during the period of the first sampling (27.11.2002) at the Pump Station at the end of pumping cycle of thick consistency sludge, so it was impossible to determine SV_{30} and SV_{120}.

Table 2.7

Results of analysis of sludge on the new sludge map of STP

Physical-technical characteristics and chemical composition of sludge

№ of sample	Content of components, %						pH	Density g/cm³	Granulometric composition, %						
									Diameter of fractions, mm						
	H_2O	$C_{org.}$	n.n.n	$R_{gen.}$	$N_{gen.}$	$S_{gen.}$			More than 0,25	0,25-0,10	0,10-0,063	0,063-0,05	0,05-0,01	0,01-0,005	Less than 0,005
S6O	3,27	21,2	42,51	0,94	24,1	1,34	8,21	1,99	0,8	0,2	0,3	11,4	35,7	15,9	35,7

Atomic-emission spectral analysis of sludge

№ sample	Content of the element, mg/kg																					
	Be	Pb	Zn	As	Cd	Co	Cu	Mo	Ni	Cr	Ba	V	Mn	Sr	Ti	Zr	Bi	Ga	Li	Ag	Sn	P
S6O	2,5	40	120			12	100	2,5	60	150	1000	100	2000	150	2000	200	2	6	20	6	6	1000
MPC of sludge, mg/kg	I class of hazard					II class of hazard					III class of hazard						IV class of hazard					
	10	30	100	20	4	50	100	5	100	100	-	150	1500	-	-	-	-	-	-	-	50	-

CONCLUSION

As the result of sampling and analysis of water and sludge samples from the systems of water supply and water disposal of the city of Astana the following results have been obtained:

1. Water supply:
   1.1 According to the parameters studied the surface waters of Vyacheslavsky reservoir correspond to the requirements to the surface waters, used as source waters for the centralized household-drinking water supply. The water quality of the lower layer becomes better, and an excess of MAC has been noted only at COD.
   1.2 Chemical and microbiological composition of the water coming into the city of Astana after its purification at PFS meets in essence the water quality requirements for the centralized systems of household-drinking water supply.
2. Water disposal:
   2.1 The chemical composition of sewage waters of STP and Taldy Kol reservoir has been studied. The purified sewage waters of Taldy Kol reservoir and the waters discharged on terrain in a number of parameters (phenols, petroleum products, cadmium, lead, COD) excess MAC for the surface waters of household-drinking and cultural and general consumption. In this connection to consider their discharge into the surface waters of the rivers Esil or Nura without additional purification is impossible, in our opinion, without a special concordance with the supervising bodies.
   2.2 The physical and chemical composition of sludge of SPW has been studied at different stages of the technological process.

It is recommended to continue studying of physical, chemical and agrochemical properties of sludge of the sludge maps to estimate a degree of its ecological hazard and possibility of its using in agriculture and in tree-planting as a fertilizer and a soil ameliorant.

Deputy General Director on Production — V.D. Fedorchenko

Chief ecology scientist — V.I. Vurman

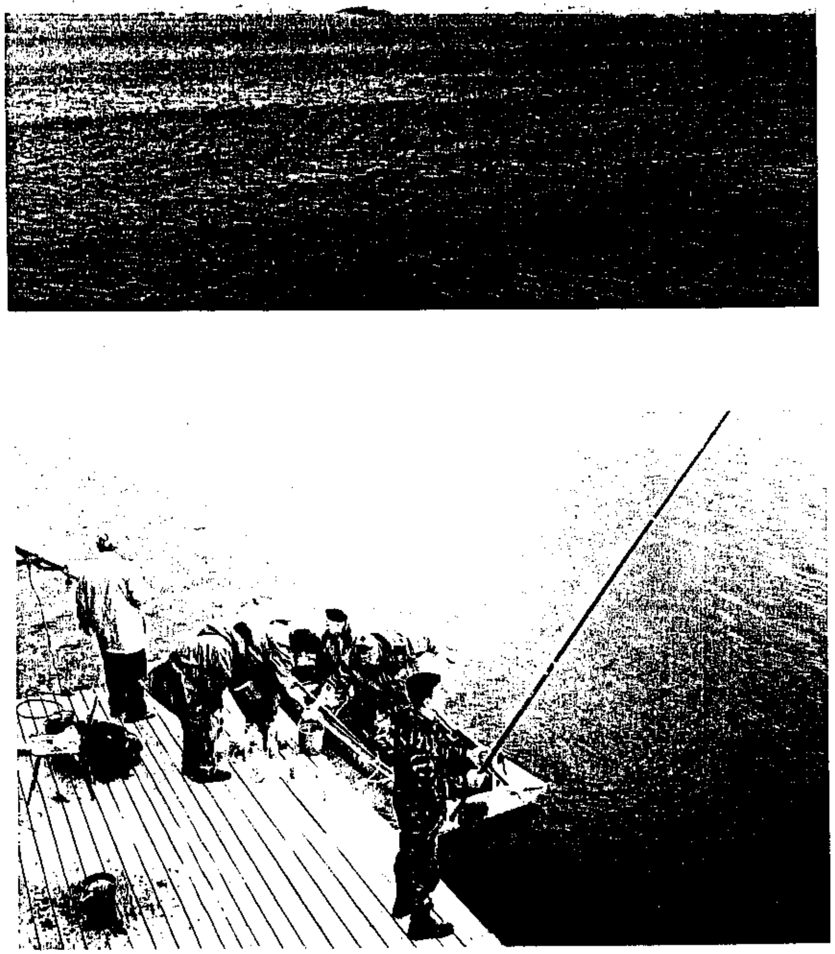


Photo 1. Vyacheslavsky Reservoir. Water sampling in October 2002.
(Upper Layer – VR1O; Lower Layer – VR2O)

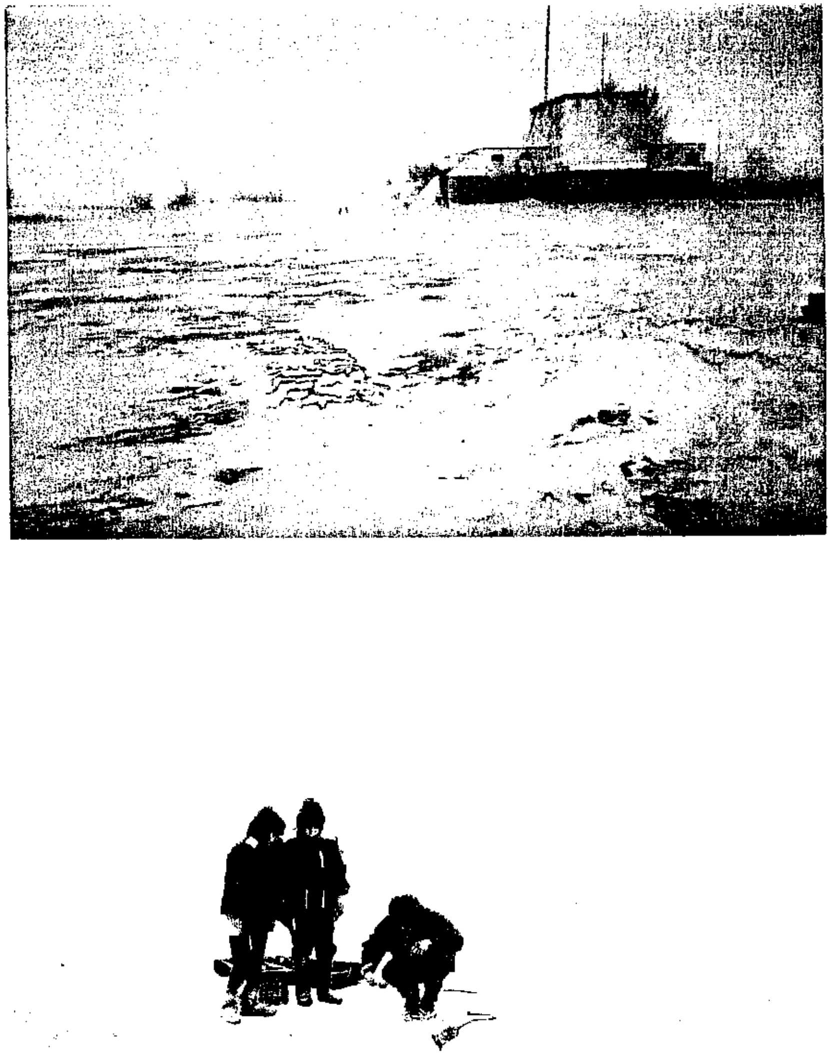
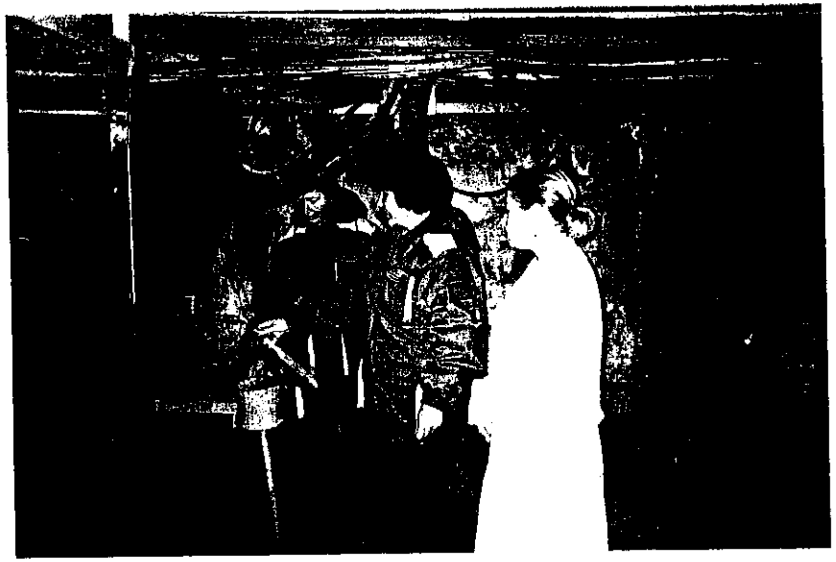


Photo 2. Vyacheslavsky Reservoir. Water sampling in February 2003.
(Upper Layer – VR1F; Lower Layer – VR2F)

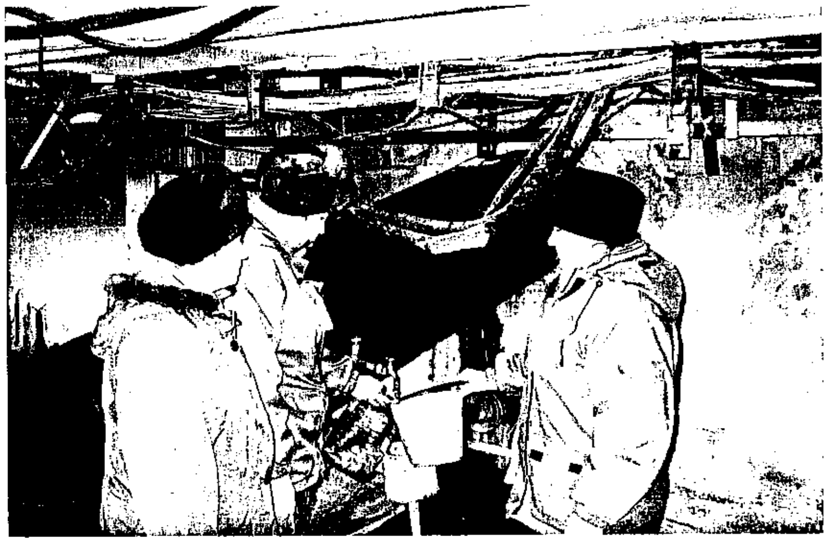
PPSOO

PPSOF

Photo 3. Influent at Water Treatment Plant



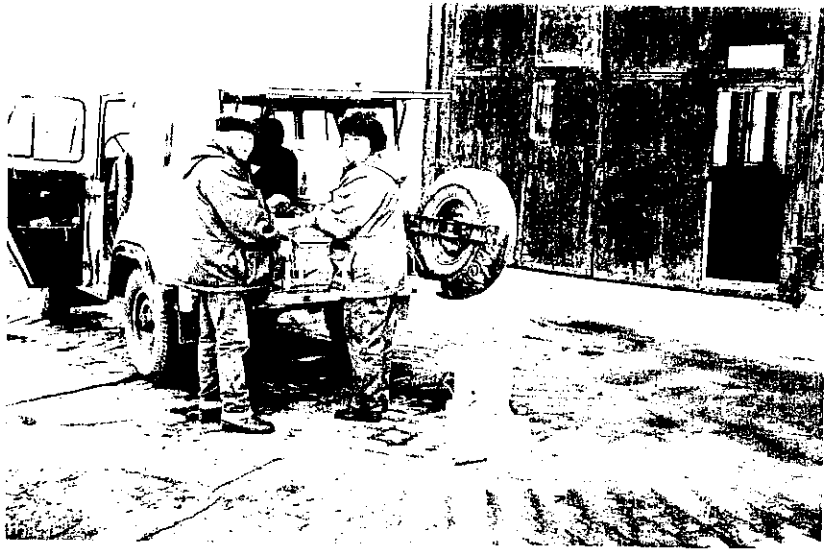
PPRSO



PPRSF

Photo 4. Treated Water at Water Treatment Plant

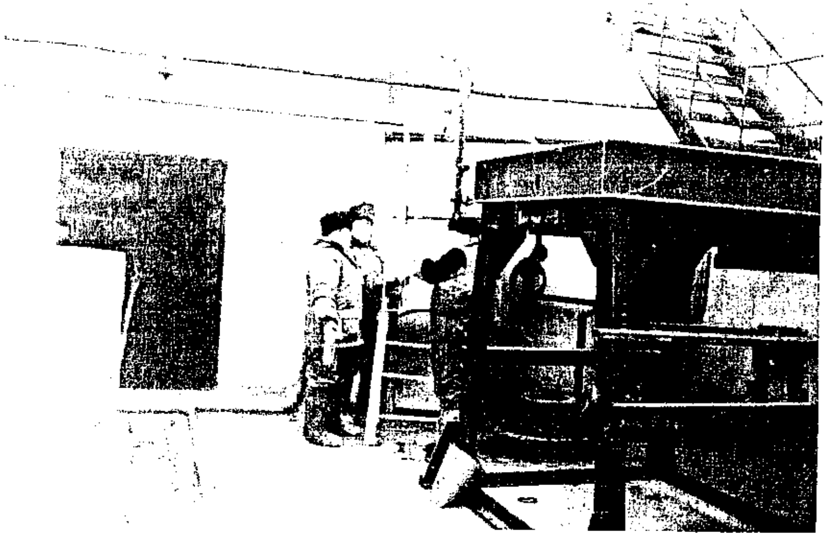
SPINO



SPTRO

SPINF

Photo 5. Influent at Sewage Treatment Plant



SPTRF

Photo 6. Treated Water at Sewage Treatment Plant

TKR1O

TKR1F

Photo 7. Lake Taldy Kol

TKR2O

TKR2F

Photo 8. Purified Sewage Waters and Possibly Drainage Waters Discharged on the March-Ridden Terrain under the Bridge of the Motorway Astana-Korgalzhino

Photo 9. Primary Sedimentation Tank Effluent
(PS1, PS2, PS3)

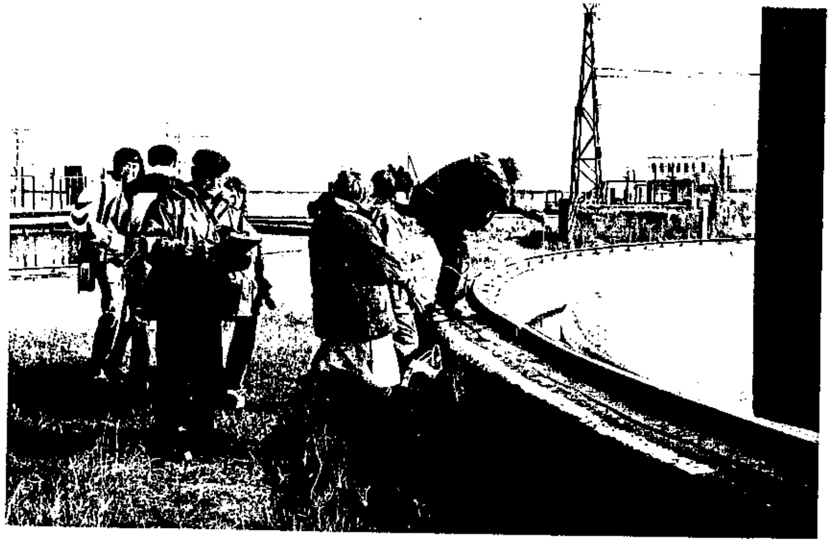


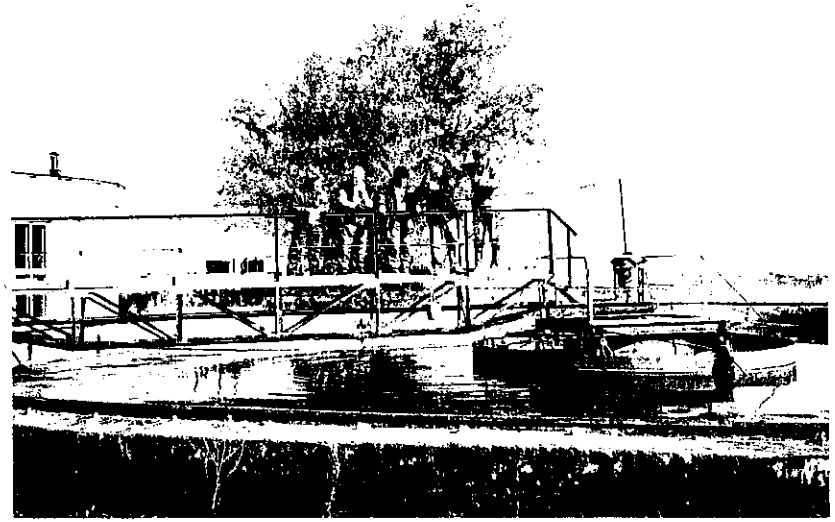
Photo 10. Final Sedimentation Tank Effluent
(PS1, PS2, PS3)

S1O

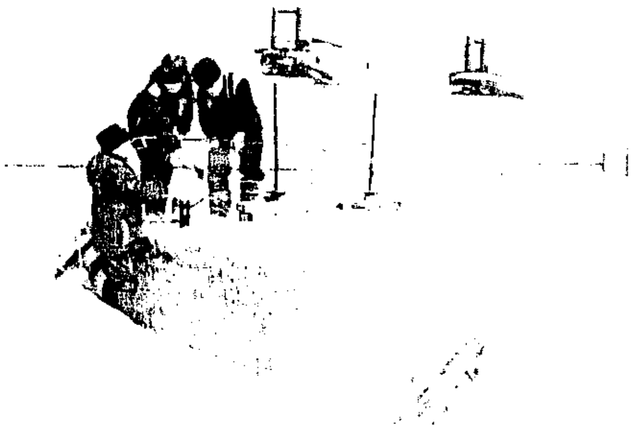
S1F

Photo 11. Primary Sedimentation Tank Sludge

S2O



S3O



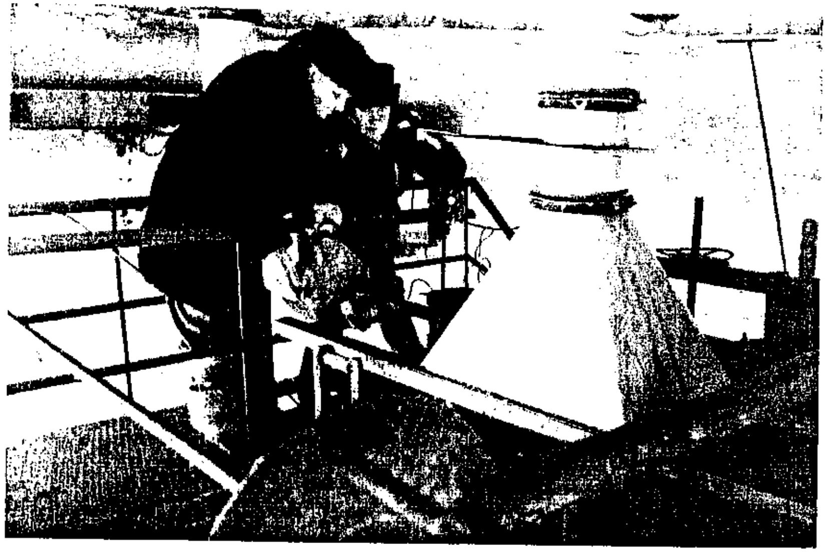
S2F

Photo 12. Return Sludge

S3F

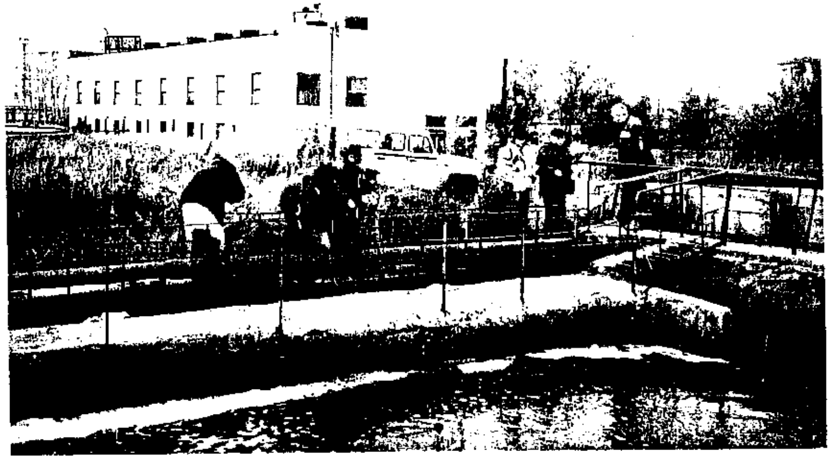
Photo 13. Thickened Sludge

S4O



S4F

Photo 14. Digested Sludge



S5O

S5F

Photo 15. Mixed Sludge (in Aeration Tank)

Photo 16. The First New Sludge Map

Appendix C-3

Agreement for Water Supply and Sewerage Services between ASA (the supplier) and the Consumer

AGREEMENT

for water supply and sewerage services

between ASA (the Supplier) and the Consumer

(relevant itesms)

« ...3.1. The Supplier has the following rights:

3.1.2. To collect the debts from the Customer indisputably based on the court decision in accordance with Article 139 of the Code for Civil Procedures of the Republic of Kazakhstan, if the payment is delayed for more that 30 days.

3.1.3. To disconnect the Customer from the water supply, if the payment is delayed for more that 3 months.

3.1.4. If the Customer is disconnected in accordance with the adopted procedures for delay of payment for the water and sewerage services, the Customer's re-connection is carried out only after the payment has been made.

3.1.5. After several disconnections of the Customer from water supply (more than once), the Customer's re-connection is carried out only after the payment has been made and the re-connection fee in the approved amount has been paid.

3.1.6. If the Customer delays his payment for the water and sewerage services, the Supplier has a right to warn the Customer, and to suspend providing of the services stipulated in this Agreement after 10 days. ...

...4.1. In accordance with Articles 350 and 351 of the Civil Code of the Republic of Kazakhstan, the Customer should pay penalties in case of delay of payment for the services rendered. The amount of penalty is 0.1% of the invoiced amount per a day of delay.

Appendix C-4

Draft TOR for Accounting & Financial Specialist during the Construction Stage (2003-2008)

Draft TOR for Accounting & Financial Specialist during the Construction Stage (2003-2008)

1. Assistance to the Project Executing Agency (the Akimat) for Financial Management & Accounting for the Project Implementation:

   - Assist to establish an adequate financial management system for the Project implementation, which would meet both JBIC's and local requirements, including internal controls, accounting procedures and reporting *(1 months upon the first loan disbursement + 1 month + 2 months)*;
   - Review the work of the Project's accounting staff and assist in reporting to JBIC *(0.75 month/year annually, before the auditing/reporting deadline).*

2. Assistance to ASA in Finance & Accounting:

   1) Follow up the medium-term financial improvement program proposed by the DD study *(0.25 month/year annually)* and provide technology transfer in the following areas

      - *Cost accounting system;*
      - *Financial modeling and budgeting;*
      - *Financial performance indicators; and*
      - *Progressive tariffs (only if allowed by the law by that time).*

   2) Assistance with the long-term financial planning *(2 months before the project closing)*

In addition to the above tasks to be fulfilled by the Financial & Accounting Specialist, there are some adjacent tasks, which shall be supplemented by other experts.

- Management & Organization
  - Customers awareness;
  - Organizational structure of ASA.
- Technical Expert
  - Non-tariff revenue;
  - Operational performance indicators; and
  - Long-term development plan update (technical aspects).

Appendix C-5

Scenarios for Financial Viability

PROPOSED SCENARIO
Table 1

100% RECOVERY, ANNUALLY BY 3.4%, TAX EXEMPTED *(Million Tenge, in real terms, 2002 prices, without discounting)*

Year	Flow change	Tariff change	Tariff rate	Sales	Direct costs	G&A costs	Non-tariff income	Extra depr.	Extra prop. tax	Net result	Less: non-monet.	Cash
1	2	3	4	5	6	7	8	9	10	11	12	13
2002	**1.000**	**1.000**	**40.54**	**810**	**800**	**180**	**180**	**0**	**0**	**10**	**-23**	**-13**
2008	1.037	1.034	41.92	869	758	180	180	667	0	-556	783	227
2009	1.042	1.069	43.34	902	759	180	180	667	0	-523	783	259
2010	1.047	1.106	44.82	938	783	180	180	667	0	-512	783	271
2011	1.085	1.143	46.34	1,004	791	180	180	667	0	-453	783	329
2012	1.124	1.182	47.92	1,076	799	180	180	667	0	-390	783	393
2013	1.164	1.222	49.55	1,152	808	180	180	667	0	-322	783	460
2014	1.206	1.264	51.23	1,235	817	180	180	667	0	-249	783	534
2015	1.250	1.307	52.97	1,322	826	180	180	667	0	-170	783	612
2016	1.295	1.351	54.77	1,417	835	180	180	667	0	-85	783	698
2017	1.341	1.397	56.64	1,518	845	180	180	667	0	6	783	789
2018	1.389	1.445	58.56	1,626	856	180	180	667	0	103	783	886
2019	1.439	1.494	60.55	1,741	866	180	180	667	0	209	783	991
2020	1.499	1.544	62.61	1,875	876	180	180	667	0	333	783	1115
2021	1.529	1.597	64.74	1,978	882	180	180	667	0	429	783	1212
2022	1.560	1.651	66.94	2,086	889	180	180	667	0	530	783	1313
Total cash accumulated												**10,076**

PROPOSED SCENARIO
Table 2

100% RECOVERY, ANNUALLY BY 4.2%, TAX PAID

(Million Tenge, in real terms, 2002 prices, without discounting)

Year	Flow change	Tariff change	Tariff rate	Sales	Direct costs	G&A costs	Non-tariff income	Extra depr.	Extra prop. tax	Net result	Less: non-monet.	Cash
1	2	3	4	5	6	7	8	9	10	11	12	13
2002	**1.000**	**1.000**	**40.54**	**810**	**800**	**180**	**180**	**0**	**0**	**10**	**-23**	**-13**
2008	1.037	1.042	42.24	875	758	180	180	667	100	-649	783	133
2009	1.042	1.086	44.02	916	759	180	180	667	100	-609	783	173
2010	1.047	1.131	45.87	959	783	180	180	667	100	-590	783	192
2011	1.085	1.179	47.79	1,036	791	180	180	667	100	-522	783	261
2012	1.124	1.228	49.80	1,118	799	180	180	667	100	-448	783	335
2013	1.164	1.280	51.89	1,207	808	180	180	667	100	-368	783	415
2014	1.206	1.334	54.07	1,303	817	180	180	667	100	-281	783	502
2015	1.250	1.390	56.34	1,407	826	180	180	667	100	-186	783	597
2016	1.295	1.448	58.71	1,518	835	180	180	667	100	-83	783	699
2017	1.341	1.509	61.17	1,639	845	180	180	667	100	28	783	810
2018	1.389	1.572	63.74	1,770	856	180	180	667	100	147	783	930
2019	1.439	1.638	66.42	1,910	866	180	180	667	100	278	783	1060
2020	1.499	1.707	69.21	2,073	876	180	180	667	100	430	783	1213
2021	1.529	1.779	72.12	2,203	882	180	180	667	100	554	783	1337
2022	1.560	1.854	75.14	2,342	889	180	180	667	100	686	783	1469
Total cash accumulated												**10,114**

APPENDIX 13.3

PROPOSED SCENARIO
Table 3

C-5-3

100% RECOVERY, AT ONCE BY 35%, TAX EXEMPTED

(Million Tenge, in real terms, 2002 prices, without discounting)

Year	Flow change	Tariff change	Tariff rate	Sales	Direct costs	G&A costs	Non-tariff income	Extra depr.	Extra prop. tax	Net result	Less: non-monet.	Cash
1	2	3	4	5	6	7	8	9	10	11	12	13
2002	**1.000**	**1.000**	**40.54**	**810**	**800**	**180**	**180**	**0**	**0**	**10**	**-23**	**-13**
2008	1.037	1.350	54.73	1,134	758	180	180	667	0	-291	783	492
2009	1.042	1.350	54.73	1,139	759	180	180	667	0	-286	783	496
2010	1.047	1.350	54.73	1,145	783	180	180	667	0	-305	783	478
2011	1.085	1.350	54.73	1,186	791	180	180	667	0	-272	783	511
2012	1.124	1.350	54.73	1,229	799	180	180	667	0	-237	783	546
2013	1.164	1.350	54.73	1,273	808	180	180	667	0	-202	783	581
2014	1.206	1.350	54.73	1,319	817	180	180	667	0	-165	783	618
2015	1.250	1.350	54.73	1,366	826	180	180	667	0	-126	783	656
2016	1.295	1.350	54.73	1,416	835	180	180	667	0	-86	783	697
2017	1.341	1.350	54.73	1,467	845	180	180	667	0	-45	783	738
2018	1.389	1.350	54.73	1,519	856	180	180	667	0	-3	783	779
2019	1.439	1.350	54.73	1,574	866	180	180	667	0	41	783	824
2020	1.499	1.350	54.73	1,639	876	180	180	667	0	96	783	879
2021	1.529	1.350	54.73	1,672	882	180	180	667	0	123	783	906
2022	1.560	1.350	54.73	1,705	889	180	180	667	0	150	783	932
Total cash accumulated												**10,120**

PROPOSED SCENARIO
Table 4

APENDIX 13.3

100% RECOVERY, AT ONCE BY 45%, TAX PAID

(Million Tenge, in real terms, 2002 prices, without discounting)

Year	Flow change	Tariff change	Tariff rate	Sales	Direct costs	G&A costs	Non-tariff income	Extra depr.	Extra prop. tax	Net result	Less: non-monet.	Cash
1	2	3	4	5	6	7	8	9	10	11	12	13
2002	**1.000**	**1.000**	**40.54**	**810**	**800**	**180**	**180**	**0**	**0**	**10**	**-23**	**-13**
2008	1.037	1.450	58.78	1,218	758	180	180	667	100	-307	783	476
2009	1.042	1.450	58.78	1,224	759	180	180	667	100	-302	783	481
2010	1.047	1.450	58.78	1,230	783	180	180	667	100	-320	783	463
2011	1.085	1.450	58.78	1,274	791	180	180	667	100	-284	783	499
2012	1.124	1.450	58.78	1,320	799	180	180	667	100	-246	783	537
2013	1.164	1.450	58.78	1,367	808	180	180	667	100	-207	783	575
2014	1.206	1.450	58.78	1,417	817	180	180	667	100	-167	783	616
2015	1.250	1.450	58.78	1,468	826	180	180	667	100	-125	783	658
2016	1.295	1.450	58.78	1,520	835	180	180	667	100	-81	783	701
2017	1.341	1.450	58.78	1,575	845	180	180	667	100	-37	783	746
2018	1.389	1.450	58.78	1,632	856	180	180	667	100	9	783	792
2019	1.439	1.450	58.78	1,691	866	180	180	667	100	58	783	841
2020	1.499	1.450	58.78	1,761	876	180	180	667	100	118	783	901
2021	1.529	1.450	58.78	1,796	882	180	180	667	100	147	783	930
2022	1.560	1.450	58.78	1,832	889	180	180	667	100	176	783	959
Total cash accumulated												**10,160**

C-5-5

APPENDIX 13.3

PROPOSED SCENARIO
Table 1 (50%)

50% RECOVERY, ANNUALLY BY 0.2%, TAX EXEMPTED *(Million Tenge, in real terms, 2002 prices, without discounting)*

Year	Flow change	Tariff change	Tariff rate	Sales	Direct costs	G&A costs	Non-tariff income	Extra depr.	Extra prop. tax	Net result	Less: non-monet.	Cash
1	2	3	4	5	6	7	8	9	10	11	12	13
2002	**1.000**	**1.000**	**40.54**	**810**	**800**	**180**	**180**	**0**	**0**	**10**	**-23**	**-13**
2008	1.037	1.002	40.62	842	758	180	180	667	0	-583	783	200
2009	1.042	1.004	40.70	847	759	180	180	667	0	-578	783	204
2010	1.047	1.006	40.78	853	783	180	180	667	0	-596	783	186
2011	1.085	1.008	40.87	886	791	180	180	667	0	-572	783	211
2012	1.124	1.010	40.95	919	799	180	180	667	0	-546	783	236
2013	1.164	1.012	41.03	954	808	180	180	667	0	-520	783	262
2014	1.206	1.014	41.11	991	817	180	180	667	0	-493	783	290
2015	1.250	1.016	41.19	1,028	826	180	180	667	0	-464	783	318
2016	1.295	1.018	41.28	1,068	835	180	180	667	0	-434	783	349
2017	1.341	1.020	41.36	1,108	845	180	180	667	0	-403	783	379
2018	1.389	1.022	41.44	1,150	856	180	180	667	0	-372	783	410
2019	1.439	1.024	41.52	1,194	866	180	180	667	0	-338	783	444
2020	1.499	1.026	41.61	1,246	876	180	180	667	0	-297	783	486
2021	1.529	1.028	41.69	1,274	882	180	180	667	0	-275	783	508
2022	1.560	1.030	41.77	1,302	889	180	180	667	0	-254	783	529
Total cash accumulated												**5,000**

C-5-6

PROPOSED SCENARIO
Table 2 (50%)

50% RECOVERY, ANNUALLY BY 1.3%, TAX PAID

(Million Tenge, in real terms, 2002 prices, without discounting)

Year	Flow change	Tariff change	Tariff rate	Sales	Direct costs	G&A costs	Non-tariff income	Extra depr.	Extra prop. tax	Net result	Less: non-monet.	Cash
1	2	3	4	5	6	7	8	9	10	11	12	13
2002	**1.000**	**1.000**	**40.54**	**810**	**800**	**180**	**180**	**0**	**0**	**10**	**-23**	**-13**
2008	1.037	1.013	41.07	851	758	180	180	667	100	-674	783	109
2009	1.042	1.026	41.60	866	759	180	180	667	100	-660	783	123
2010	1.047	1.040	42.14	882	783	180	180	667	100	-668	783	115
2011	1.085	1.053	42.69	925	791	180	180	667	100	-632	783	150
2012	1.124	1.067	43.24	971	799	180	180	667	100	-595	783	188
2013	1.164	1.081	43.81	1,019	808	180	180	667	100	-556	783	227
2014	1.206	1.095	44.38	1,069	817	180	180	667	100	-514	783	268
2015	1.250	1.109	44.95	1,122	826	180	180	667	100	-470	783	312
2016	1.295	1.123	45.54	1,178	835	180	180	667	100	-424	783	359
2017	1.341	1.138	46.13	1,236	845	180	180	667	100	-376	783	407
2018	1.389	1.153	46.73	1,297	856	180	180	667	100	-325	783	457
2019	1.439	1.168	47.34	1,361	866	180	180	667	100	-271	783	511
2020	1.499	1.183	47.95	1,436	876	180	180	667	100	-206	783	576
2021	1.529	1.198	48.58	1,484	882	180	180	667	100	-165	783	618
2022	1.560	1.214	49.21	1,533	889	180	180	667	100	-122	783	660
Total cash accumulated												**5,068**

PROPOSED SCENARIO
Table 3 (50%)

50% RECOVERY, AT ONCE BY 2%, TAX EXEMPTED *(Million Tenge, in real terms, 2002 prices, without discounting)*

Year	Flow change	Tariff change	Tariff rate	Sales	Direct costs	G&A costs	Non-tariff income	Extra depr.	Extra prop. tax	Net result	Less: non-monet.	Cash
1	2	3	4	5	6	7	8	9	10	11	12	13
2002	**1.000**	**1.000**	**40.54**	**810**	**800**	**180**	**180**	**0**	**0**	**10**	**-23**	**-13**
2008	1.037	1.020	41.35	857	758	180	180	667	0	-568	783	215
2009	1.042	1.020	41.35	861	759	180	180	667	0	-565	783	218
2010	1.047	1.020	41.35	865	783	180	180	667	0	-585	783	198
2011	1.085	1.020	41.35	896	791	180	180	667	0	-561	783	221
2012	1.124	1.020	41.35	928	799	180	180	667	0	-537	783	245
2013	1.164	1.020	41.35	962	808	180	180	667	0	-513	783	270
2014	1.206	1.020	41.35	996	817	180	180	667	0	-487	783	295
2015	1.250	1.020	41.35	1,032	826	180	180	667	0	-460	783	322
2016	1.295	1.020	41.35	1,070	835	180	180	667	0	-432	783	351
2017	1.341	1.020	41.35	1,108	845	180	180	667	0	-404	783	379
2018	1.389	1.020	41.35	1,148	856	180	180	667	0	-375	783	408
2019	1.439	1.020	41.35	1,189	866	180	180	667	0	-343	783	439
2020	1.499	1.020	41.35	1,238	876	180	180	667	0	-304	783	478
2021	1.529	1.020	41.35	1,263	882	180	180	667	0	-285	783	497
2022	1.560	1.020	41.35	1,289	889	180	180	667	0	-267	783	516
Total cash accumulated												**5,040**

C-5-8

PROPOSED SCENARIO
Table 4 (50%)

50% RECOVERY, AT ONCE BY 45%, TAX PAID

(Million Tenge, in real terms, 2002 prices, without discounting)

Year	Flow change	Tariff change	Tariff rate	Sales	Direct costs	G&A costs	Non-tariff income	Extra depr.	Extra prop. tax	Net result	Less: non-monet.	Cash
1	2	3	4	5	6	7	8	9	10	11	12	13
2002	**1.000**	**1.000**	**40.54**	**810**	**800**	**180**	**180**	**0**	**0**	**10**	**-23**	**-13**
2008	1.037	1.120	45.40	941	758	180	180	667	100	-584	783	199
2009	1.042	1.120	45.40	945	759	180	180	667	100	-580	783	202
2010	1.047	1.120	45.40	950	783	180	180	667	100	-600	783	183
2011	1.085	1.120	45.40	984	791	180	180	667	100	-574	783	209
2012	1.124	1.120	45.40	1,019	799	180	180	667	100	-546	783	236
2013	1.164	1.120	45.40	1,056	808	180	180	667	100	-519	783	264
2014	1.206	1.120	45.40	1,094	817	180	180	667	100	-489	783	293
2015	1.250	1.120	45.40	1,134	826	180	180	667	100	-459	783	324
2016	1.295	1.120	45.40	1,174	835	180	180	667	100	-427	783	355
2017	1.341	1.120	45.40	1,217	845	180	180	667	100	-395	783	388
2018	1.389	1.120	45.40	1,260	856	180	180	667	100	-362	783	420
2019	1.439	1.120	45.40	1,306	866	180	180	667	100	-327	783	456
2020	1.499	1.120	45.40	1,360	876	180	180	667	100	-283	783	500
2021	1.529	1.120	45.40	1,387	882	180	180	667	100	-262	783	521
2022	1.560	1.120	45.40	1,415	889	180	180	667	100	-241	783	542
Total cash accumulated												**5,079**

PROPOSED SCENARIO
Table 5

47% RECOVERY, NO INCREASE, TAX EXEMPTED

(Million Tenge, in real terms, 2002 prices, without discounting)

Year	Flow change	Tariff change	Tariff rate	Sales	Direct costs	G&A costs	Non-tariff income	Extra depr.	Extra prop. tax	Net result	Less: non-monet.	Cash
1	2	3	4	5	6	7	8	9	10	11	12	13
2002	**1.000**	**1.000**	**40.54**	**810**	**800**	**180**	**180**	**0**	**0**	**10**	**-23**	**-13**
2008	1.037	1.000	40.54	840	758	180	180	667	0	-585	783	198
2009	1.042	1.000	40.54	844	759	180	180	667	0	-582	783	201
2010	1.047	1.000	40.54	848	783	180	180	667	0	-602	783	181
2011	1.085	1.000	40.54	879	791	180	180	667	0	-579	783	204
2012	1.124	1.000	40.54	910	799	180	180	667	0	-555	783	227
2013	1.164	1.000	40.54	943	808	180	180	667	0	-532	783	251
2014	1.206	1.000	40.54	977	817	180	180	667	0	-507	783	276
2015	1.250	1.000	40.54	1,012	826	180	180	667	0	-481	783	302
2016	1.295	1.000	40.54	1,049	835	180	180	667	0	-453	783	330
2017	1.341	1.000	40.54	1,086	845	180	180	667	0	-425	783	357
2018	1.389	1.000	40.54	1,125	856	180	180	667	0	-397	783	385
2019	1.439	1.000	40.54	1,166	866	180	180	667	0	-367	783	416
2020	1.499	1.000	40.54	1,214	876	180	180	667	0	-328	783	454
2021	1.529	1.000	40.54	1,238	882	180	180	667	0	-310	783	472
2022	1.560	1.000	40.54	1,263	889	180	180	667	0	-292	783	490
Total cash accumulated												**4,732**

PROPOSED SCENARIO
Table 6

32% RECOVERY, NO INCREASE, TAX PAID

(Million Tenge, in real terms, 2002 prices, without discounting)

Year	Flow change	Tariff change	Tariff rate	Sales	Direct costs	G&A costs	Non-tariff income	Extra depr.	Extra prop. tax	Net result	Less: non-monet.	Cash
1	2	3	4	5	6	7	8	9	10	11	12	13
2002	**1.000**	**1.000**	**40.54**	**810**	**800**	**180**	**180**	**0**	**0**	**10**	**-23**	**-13**
2008	1.037	1.000	40.54	840	758	180	180	667	100	-685	783	98
2009	1.042	1.000	40.54	844	759	180	180	667	100	-682	783	101
2010	1.047	1.000	40.54	848	783	180	180	667	100	-702	783	81
2011	1.085	1.000	40.54	879	791	180	180	667	100	-679	783	104
2012	1.124	1.000	40.54	910	799	180	180	667	100	-655	783	127
2013	1.164	1.000	40.54	943	808	180	180	667	100	-632	783	151
2014	1.206	1.000	40.54	977	817	180	180	667	100	-607	783	176
2015	1.250	1.000	40.54	1,012	826	180	180	667	100	-581	783	202
2016	1.295	1.000	40.54	1,049	835	180	180	667	100	-553	783	230
2017	1.341	1.000	40.54	1,086	845	180	180	667	100	-525	783	257
2018	1.389	1.000	40.54	1,125	856	180	180	667	100	-497	783	285
2019	1.439	1.000	40.54	1,166	866	180	180	667	100	-467	783	316
2020	1.499	1.000	40.54	1,214	876	180	180	667	100	-428	783	354
2021	1.529	1.000	40.54	1,238	882	180	180	667	100	-410	783	372
2022	1.560	1.000	40.54	1,263	889	180	180	667	100	-392	783	390
Total cash accumulated												**3,232**

PROPOSED SCENARIO
Table 7

Main Assumptions and Direct Costs Details

(Million Tenge, 2002 prices, without discounting)

Year	Intake electr.	WTP electr.	WTP chem.	Water repair	PS electr.	STP electr.	STP coal	STP chem.	SPS electr.	Sew. repair	Labor & other	Total
2002	45.77	47.16	27.60	0.00	8.32	71.13	9.92	32.51	2.70	0.00	555.00	800.00
2008	28.47	48.90	28.62	0.00	0.00	51.22	9.92	33.72	1.96	0.00	555.00	758.00
2009	28.62	49.14	28.76	0.00	0.00	51.53	9.92	33.93	1.97	0.00	555.00	759.00
2010	28.76	49.39	28.91	11.30	0.00	51.84	9.92	34.13	1.99	12.00	555.00	783.00
2011	29.83	51.21	29.98	11.30	0.00	54.12	9.92	35.63	2.07	12.00	555.00	791.00
2012	30.93	53.11	31.09	11.30	0.00	56.50	9.92	37.20	2.17	12.00	555.00	799.00
2013	32.07	55.07	32.24	11.30	0.00	58.99	9.92	38.83	2.26	12.00	555.00	808.00
2014	33.26	57.11	33.43	11.30	0.00	61.58	9.92	40.54	2.36	12.00	555.00	817.00
2015	34.49	59.22	34.67	11.30	0.00	64.29	9.92	42.33	2.46	12.00	555.00	826.00
2016	35.77	61.42	35.95	11.30	0.00	67.12	9.92	44.19	2.57	12.00	555.00	835.00
2017	37.09	63.69	37.28	11.30	0.00	70.07	9.92	46.13	2.69	12.00	555.00	845.00
2018	38.46	66.04	38.66	11.30	0.00	73.16	9.92	48.16	2.80	12.00	555.00	856.00
2019	39.89	68.49	40.09	11.30	0.00	76.38	9.92	50.28	2.93	12.00	555.00	866.00
2020	41.18	70.71	41.39	11.30	0.00	79.19	9.92	52.13	3.04	12.00	555.00	876.00
2021	42.00	72.12	42.22	11.30	0.00	81.09	9.92	53.39	3.11	12.00	555.00	882.00
2022	42.84	73.56	43.06	11.30	0.00	83.04	9.92	54.67	3.18	12.00	555.00	889.00
2023	43.70	75.04	43.92	11.30	0.00	85.03	9.92	55.98	3.26	12.00	555.00	895.00
2024	44.57	76.54	44.80	11.30	0.00	87.07	9.92	57.32	3.34	12.00	555.00	902.00
2025	45.46	78.07	45.70	11.30	0.00	89.16	9.92	58.70	3.42	12.00	555.00	909.00
2026	46.37	79.63	46.61	11.30	0.00	91.30	9.92	60.11	3.50	12.00	555.00	916.00
2027	47.30	81.22	47.54	11.30	0.00	93.49	9.92	61.55	3.58	12.00	555.00	923.00
2028	48.25	82.85	48.49	11.30	0.00	95.73	9.92	63.03	3.67	12.00	555.00	930.00
2029	49.21	84.50	49.46	11.30	0.00	98.03	9.92	64.54	3.76	12.00	555.00	938.00
2030	50.22	86.23	50.47	11.30	0.00	100.17	9.92	65.94	3.84	12.00	555.00	945.00

Assumptions:

Cost of equipment	10,000	No investments		
Average useful life (years)	15	Current depreciation	116	
Extra depreciation	667	Current water & sewerage tariff	40.54	Tg/cu.m. (incl VAT)
Extra Property tax (1%)	100	Labor costs include Social tax		
		G&A costs = Non-tariff income	180	

PROPOSED SCENARIO
Supporting Table 8

Water Supply Major Annual Operation Maintenance Costs

				Year						
1	Item		unit	1999	2002	2009	2010	2020	2030	Remarks
2	Water Supply Flow Rate	Daily Maximum	m3/day		165,000	171,933	172,800	247,400	301,700	By M/P
3	ditto	Daily Average	m3/day		137,500	143,278	144,000	206,167	251,417	Divided by 1.2
4	**Rate of flow**	**(The value of 2002 is 100)**			**100.0**	**104.2**	**104.7**	**149.9**	**182.8**	
	Power Consumption									
	Daily Intake Power Consumption	Daily Average	kwh		33,000	20,632	20,736	29,688	36,204	*0.6 after 2009
	Daily WTP Power Consumption	Daily Average	kwh		34,000	35,429	35,607	50,979	62,168	
	Daily PS Power Consumption	No.7	kwh		6,000	-	-	-	-	No use after 2009
5	Daily Total power consumption		kwh		73,000	56,061	56,343	80,667	98,372	
	Annual Intake power consumption		1000kwh		12,045	7,531	7,569	10,836	13,214	
	Annual WTP power consumption		1000kwh		12,410	12,931	12,997	18,607	22,691	
	Annual PS power consumption	No.7	1000kwh		2,190	-	-	-	-	
	Annual Total consumption		1000kwh		26,645	20,462	20,565	29,444	35,906	
6	**Intake**		1000TG/year							
	Electricity				45,771	28,617	28,761	41,177	50,215	3.8TG/kwh
7	**WTP**									
	Electricity		1000TG/year		47,158	49,140	49,387	70,708	86,228	3.8TG/kwh
	Chemical		1000TG/year		27,603	28,763	28,908	41,388	50,472	0.55TG/m3 by F/S
8	**PS**									
	Electicity		1000TG/year		8,322	-	-	-	-	3.8TG/kwh
9	Repair of Mechanical equipment		1000TG/year		-	-	11,300	11,300	11,300	0.6% of 13milion USD
	Repair of Electrical equipment		1000TG/year		-	-	-	-	-	
10	maintenance personnel									
	salary and wages				180,000	180,000	180,000	180,000	180,000	
	Total operation maintenance cost		1000TG/year		308,854	286,519	298,356	344,574	378,215	
11										
	Unit cost per m3		TG/m3		6.2	5.5	5.7	4.6	4.1	

PROPOSED SCENARIO
Supporting Table 9

Sewerage Major Annual Operation Maintenance Costs

				Year							
1	Item		unit	1999	2002	2009	2010	2020	2030	Remarks	
2	Sewage Flow Rate	Daily Maximum	m3/day	104200	106866.6667	111533.3333	112200	171400	216800	By F/S	
3	ditto	Daily Average	m3/day	86833.3	89055.6	92944.4	93500.0	142833.3	180666.7	Divided by 1.2	
4	Rate of flow	(The value of 1999 is 100)		100	102.6	107.0	107.7	164.5	208.1		
	power consumption										
	Daily STP Power Consumption	Daily Average	kwh	50,000	51,280	37,152	37,374	57,094	72,217		
	Daily PS Power Consumption 1	Rehabilitated 17 PS	kwh	950	974	407	409	625	790		
	Daily PS Power Consumption 2	Existing	kwh	950	975	1,017	1,023	1,563	1,977		
5	Daily Total power consumption		kwh	51,900	53,229	38,575	38,806	59,282	74,984		
	Annual STP power consumption		kwh	18,250,000	18,717,051	13,560,480	13,641,535	20,839,207	26,359,044		
	Annual PS power consumption		kwh	693,500	711,389	519,432	522,830	798,565	1,010,083		
	Total consumption		kwh	18,943,500	19,428,440	14,079,912	14,164,365	21,637,773	27,369,127		
	STP										
6	Electricity		1000TG/year	69,350	71,125	51,530	51,838	79,189	100,164	3.8TG/kwh	
	Coal	6200t/year	1000TG/year	9,920	9,920	9,920	9,920	9,920	9,920	1600TG/t	
	Chemical		1000TG/year	31,694	32,505	33,925	34,128	52,134	65,943	1.0TG/m3	
7	**PS**										
	Electicity		1000TG/year	2,635	2,703	1,974	1,987	3,035	3,838		
8	Repair of Mechanical equipment	*1)	1000TG/year			-	12,000	12,000	12,000		
	Repair of Electrical equipment	*2)	1000TG/year	-	-	-	-	-	-		
9	maintenance personnel	Approx. 140	1000TG/year	125,000	125,000	125,000	125,000	125,000	125,000		
	salary and wages										
	Total operation maintenance cost		1000TG/year	238,599	241,253	222,348	234,872	281,278	316,866		
10	Unit cost per m3 of sewage		TG/m3	7.5	7.4	6.6	6.9	5.4	4.8		

*1) Annual repairing cost for the equipment shall be 0.6% of the original equipment cost in consideration of the repairing work of ASA
Assumption;
Necessary repairing rate= 3% / year of the original equipment price
90 % of the repairing work shall be conducted by ASA with the tenth cost (3%x0.9 x 1/10= 0.003)
10 % of the repairing work shall be conducted by the foreign manufacture (3%x0.1 = 0.003)
*2) Repairing cost for the electrical equipment shall be almost zero during the life of the equipment

1 The starting point is the first line (year 2002) in **Table 7** (see Direct Costs sheet in this workbook). The total direct O&M costs figure for 2002 (TG 800m) comes from the audited Financial statements of ASA - See Table 13.1 of the Main Report.

2 All O&M costs in Table 7 are split by two major categories: (1) those costs which are affected (=will change per unit) by the Project and (2) those costs which are not affected (assumed to be fixed).

3 The major O&M costs items which will change per unit after the Project completion are: electricity, chemicals & additional repair costs. These figures are taken from **Supp. Tables 8 & 9** (see Water Cost & Sew Cost sheets), prepared by engineers.

4 The major O&M costs which are assumed not to change in the future are: (1) Labor costs including social tax (TG 125m for water supply and TG 180m for sewerage, both - budget figures for 2002), (2) depreciation costs (TG 116m) and all other direct production costs like existing repair costs, purchased water, etc (TG 134m) which is equal to the difference between the total accounting costs (TG 800m) and those items which were mentioned by engineers. The total costs, which are assumed to be not changed by the Project is TG 555m. for 2002. The labor costs are assumed to not change because the assumed certain staff headcount cut in the future will be compensated by the respective increase of the average salary.

5 The Labor & other costs (TG 555m) are assumed to be fixed for 15 years. The variable costs (electricity, chemicals, etc) are assumed to change as forecasted by engineers in Supp. Tables 8 & 9 based on technical specifications of the Project. All direct O&M costs figures for 15 years are summarized in Table 7.

6 Water supply and sewerage supply flows for 15 years come from M/P (Years 2010, 2020 and 2030 as in Supp. Tables 8 & 9), evenly divided for the intermediate years.

7 **Tables 1 to 6** represent different cases under the selected Scenario, reflecting different percentage of recovery (full, 50% and maximum with no change in tariffs), tax exemption (Y/N) and the manner of the tariff increase (Annually/At once)

8 In each of the Scenario Tables 1-6 the "Flow change" (column 2) comes from M/P - see comment 6 above. Please note that the water flow change was used for the assumed overall change of the flow used for revenue calculations, because the sewerage tariffs are linked to the volumes of water.

9 "Tariff Change" (column 3) represents different patterns of the tariff increase (annual or at once by x%)

10 "Tariff Rate" (column 4) - only for information: Water & Sewerage tariff including VAT, but excluding the inflation.

11 "Sales" (column 5): The sales for 2002 of TG 810m -actual figure, see Table 13.1 of the Main Report. For the years 2008 to 2022 the sales figures are calculated as the basic 2002 sales figure (TG 810m) adjusted for change of volume (column 2) and change of tariff (column 3).

12 "Direct costs" (column 6) come from Table 7 as explained in comments 1 to 6 above.

13 "G&A costs" (column 7) and "Non-tariff income (column 8) - the basis 2002 figures are used - see Table 13.1 of the Main Report.

14 "Extra depreciation" (column 9) - depreciation costs of the Project's mech. & electr. equipment: TG 10,000 / 15 years = TG 667m.

15 "Extra property tax" (column 10) - Cost of mech.& el. equipment TG10,000 *1% = TG 100m.

16 "Net result" (column 11) = Sales (5) - Direct costs (7) - G&A costs (8) + Non tariff income (9) - Extra depreciation (10) - Extra property tax (11). Represents accounting profits or losses

17 "Less non monetary" (column 12) represents depreciation cost of the existing ASA's assets (TG 116m) plus the depreciation cost of the Project's mechan. & electr. equipment (TG 667m).

18 "Cash" (column 13) represents the difference between the net accounting result (column 11) and the non-monetary depreciation costs (column 12)

19 Assuming that ASA does not spend any cash for any investments other than the Project's mech. & electrical equipment, the Total cash accumulated represent the amount of cash available for replacement of this equipment for 15 years. Assuming the cost of this equipment TG 10,000m for its 100% recovery TG 10,000m is necessary, for 50% - TG 5,000m.