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A USAID Project Consortium Led by CH2M HILL

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NEW INDEPENDENT STATES

PROJECT REPORT

Completion of Rehabilitation Program for the Kosaman and Berdykol Wellfields

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Executive Summary

In accordance with the Memorandum of Understanding (MOU) between the United States Government and the Government of Kazakstan (GOK) dated March 18, 1994, the United States Agency for International Development (USAID) allocated funds for improvements to the potable water systems in Aralsk and Novokazalinsk Rayons of the Kzyl Orda Oblast in Kazakstan. The improvements were implemented through the USAID Environmental Policy and Technology (EPT) Project which is managed by CH2M HILL International Services, Inc. Under the Delivery Orders 7 and 12 of the EPT Project, Kosaman and Berdykol wellfields in the Aralsk Rayon were rehabilitated to improve reliability of the drinking water supply in Aralsk and Novokazalinsk Rayons.

The Kosaman and Berdykol wellfields were constructed in the 1980s and are the only known source of groundwater of acceptable quality in the area. The purpose of the rehabilitation program was to ensure that the wellfields produced the required amount of clean groundwater for years to come.

As a result of the wellfield rehabilitation project, twenty-nine wells were rehabilitated and the capacity of the pumping equipment at the wellfields increased from 285 Lps (4,507 gpm) to 587 Lps (9,300 gpm). The objectives of the program were met with the completion of the installation of reliable pumping equipment at twenty-nine wellfields, the installation of submersible sand separators at selected well, mechanical and chemical redevelopment, installation of new well screens, and operator training.

The project has been a joint accomplishment of the Government of Kazakstan (GOK) and the USAID. The GOK supplied construction labor and equipment to provide well repair, general civil, mechanical, and electrical services at the construction site. Some construction materials, including pump column, wellhead fittings, and electrical materials were also provided by the GOK. Without support from numerous GOK officials at the federal, oblast, and rayon level and participation of laborers who worked under extremely harsh conditions, the project would not have been successfully completed.

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Abbreviations/Acronyms

Abbreviations

ft	foot
ft bgs	feet below ground surface
gpm	gallons per minute
HP	horsepower
in.	inch
km	kilometer
kW	kilowatt
Lps	liters per second
m	meter
mm	millimeter
mg/L	milligrams per liter
No.	number
pH	reciprocal logarithm of the hydrogen ion concentration
ppm	parts per million
rpm	revolutions per minute

Acronyms

EPT	Environmental Policy and Technology
GOK	Government of Kazakstan
MCL	Maximum Contaminant Limit
MOU	Memorandum of Understanding
O&M	Operations and Maintenance
TDS	Total Dissolved Solids
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
WHO	World Health Organization (of the United Nations)

Section 1
Introduction

The Kosaman and Berdykol wellfields are the only known sources of groundwater of acceptable quality in the Aralsk and Novokazalinsk Rayons. Thirty wells at Kosaman and eight wells at Berdykol were constructed in the 1980s to supply water to the population of the two rayons via six pump stations and a 240-kilometer long transmission pipeline. Based on data collected during an initial wellfield investigation in June-July 1995, and the results of a pilot rehabilitation program implemented in September 1995, a comprehensive full-scale wellfield rehabilitation program was developed. The main purpose of the full-scale rehabilitation program was to ensure that the wellfields can produce the required amount of clean groundwater for years to come. Figure 1 shows the location of the wellfields. The lifetime of the groundwater resource, as described in the "Groundwater Survey and Hydrogeologic Characterization Report" (EPT, 1995), has been estimated to be greater than 50 years at a production rate of 630 liters per second.

With only 15 wells in operation and the remaining 23 wells out of order, combined production capacity available at both wellfields totaled at about 285 Lps (4,517 gpm) in June 1996. As a result of the wellfield rehabilitation project, twenty-nine wells were rehabilitated and the capacity of the pumping equipment installed at the wellfields increased to 587 Lps (9,300 gpm). This wellfield flow capacity is now entirely provided by the US-made equipment procured and installed under the EPT Project. All of the objectives of the program were met with the following tasks completed:

- installation of twenty-nine (29) US-made pumps, motors, and control panels provided reliable pumping equipment for the wellfields
- installation of fifteen (15) US-made submersible sand separators at selected wells protected the new pumping equipment
- mechanical and chemical redevelopment of twenty-five (25) selected wells improved well efficiency and increased well yields by 25-31 percent
- installation of new well screens at two (2) selected wells protected the new pumping equipment
- operator training, provision of a Russian operations and maintenance manual, and provision of spare parts and tools enhanced wellfield reliability

The original Soviet-made pumping systems that were replaced, lasted six months to two years before requiring replacement. Life of the new equipment will be extended by proper pump design for existing and future hydraulic conditions, manufacture of pumps from abrasion resistant materials, mitigation of the deleterious effects of high sand concentration in

groundwater by installation of sand separators, new wellscreens, and low-flow pumps, installation of electrical and mechanical safety devices that protect pumps and motors, and extensive operator training and provision of O&M manuals in Russian. Additionally, installation of new pumping equipment resulted in an approximately 40% reduction in power consumed by the wellfield equipment.

Section 2
Well Rehabilitation

2.1 Overall Strategy

Results of the initial wellfield investigation and pilot rehabilitation in 1995 indicated that the majority of the wells at Kosaman and Berdykol would benefit from well rehabilitation and replacement of pumping equipment. Although the wellfields were constructed during the early 1980s, they were found to be in a critical state of disrepair. The Soviet-made submersible pumping equipment was found to have a useful life between six months to two years; life extremely short in comparison to equivalent US application. Aral-Sarybulak, the water utility operating the two wellfields, suffered cash flow problems and could not afford pump replacement during the last two years. As a result, pumping capacity gradually diminished to critically low levels in the summer of 1996.

Several reasons for the short life of the pumping equipment were identified. The submersible pumps manufactured under the Soviet standards were of low quality. Also, pumps of improper head and capacity were often purchased for the wellfields. Improper design and construction of wells also added to the short life of the equipment. By improperly designing well screens with slots too large and by constructing wells without artificial gravel pack in formation composed mainly of fine sands, severe evacuation of sand from the formation resulted. High sand content in discharge water produced rapid equipment abrasion and wear. Additionally, electric power supplied to the wellfields is of poor quality and frequent power outages and power fluctuations seemed to have a damaging effect on electrical components. Last, because of the lack of an equipment maintenance program and careless work practices, many avoidable problems with equipment operation were caused.

The wellfield program was designed to address the above problems. The program addressed each of the thirty-eight wells at Kosaman and Berdykol using a rehabilitation scenario modified for specific conditions at each well. First, each well was inspected for the presence of Soviet-made pumping equipment and the equipment was performance tested. Because the wells were protected with pump houses made of precast concrete, the pump houses had to be taken apart and then assembled again to allow for access of construction equipment to the wellhead. In wells with inoperable equipment, the pumping equipment was pulled out from the well interior using cranes or drilling rigs. Although the pulled pumps and pump column were always inspected for future use, most of the old equipment was found unsuitable and disposed of. Then, each well and wellscreen were logged for actual depth. If as-built well logs were available, the well logging results were compared to as-built drilling logs to assess accumulation of foreign material in wells. If foreign objects were found in the well, an attempt was made to remove them. Next, each well was hydraulic tested using the airlift method or, if operable, by the existing pumping equipment. During the airlift, flowrate, drawdown, and sand content were measured at short intervals. By indicating potential well yield and well efficiency, airlift testing helped determine the most appropriate redevelopment method and find pump size suitable for each specific well. If a well showed low well

3

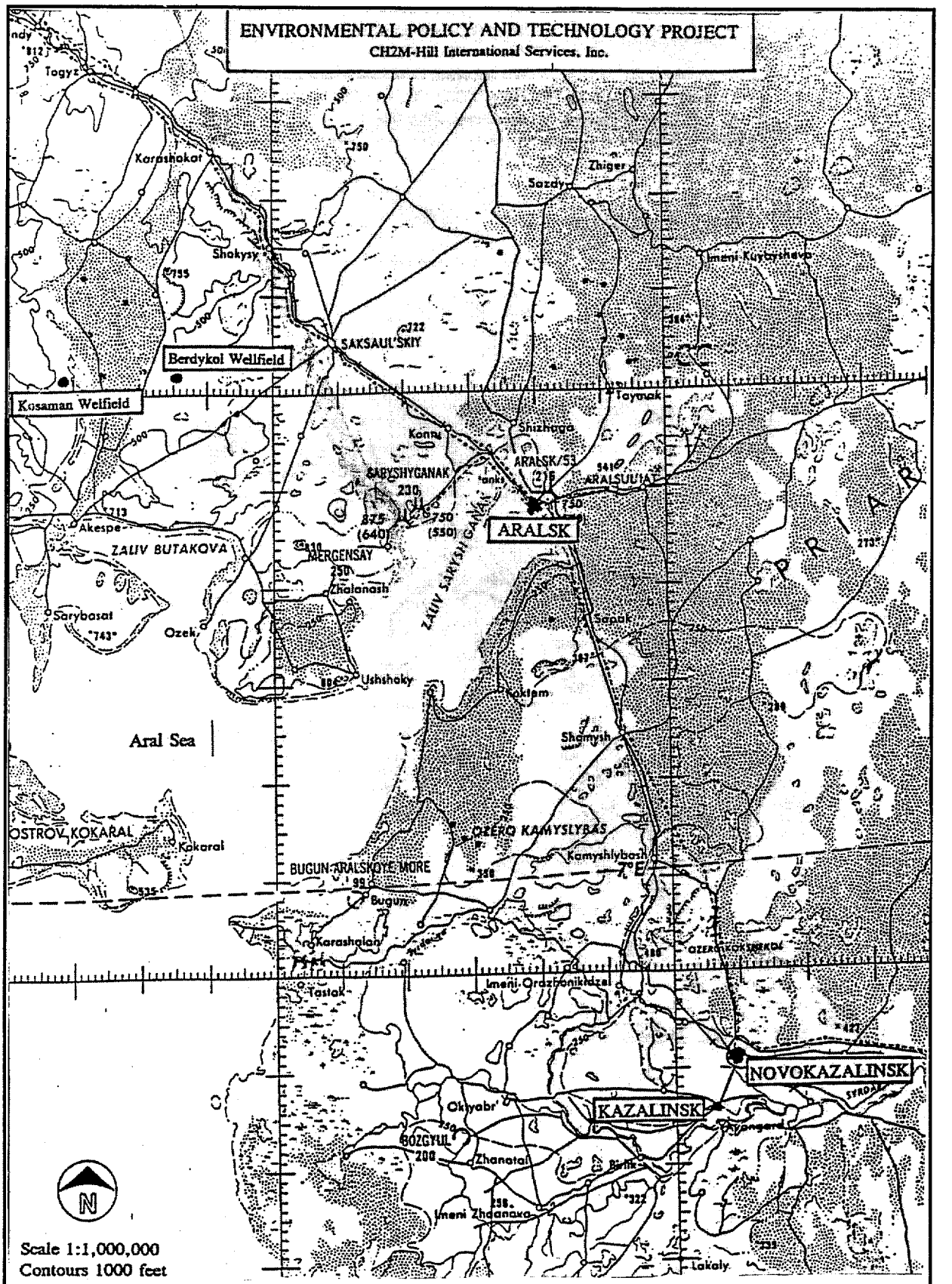

Figure 1
Location of Wellfields

efficiency during the airlift testing, mechanical and chemical redevelopment methods were applied. The redevelopment methods included mechanical surging, extensive airlift pumping, and chemical treatment with acid-based chemicals lasting on average three days. Following well rehabilitation, a new pumping equipment was installed in each suitable well. Several wells were abandoned due to low yield, poor water quality, high sand content, or foreign object which could not be removed. In suitable wells, a new submersible pump with motor was lowered into well on a new pump column. Each pump was provided with a surface-mounted control panel which included multiple electric protection devices. In wells suffering from high sand content, submersible sand separators or new well screens were installed. At all rehabilitated wells, new wellhead fittings were installed, electrical service to wellhead restored, and pump houses reconstructed.

2.2 Well Testing

Well testing was performed at each well to determine if redevelopment would be effective in improving well efficiency and also to determine optimum capacity of a new pump. The testing consisted of determining well yield and well efficiency by measuring well drawdown and flowrate and by measuring sand content in the discharge water.

Well efficiencies were measured by comparing the theoretical specific capacity, based on the results of aquifer tests, to actual specific capacities. Aquifer test results conducted in 1995 determined the theoretical specific capacity at the Kosaman aquifer to be 17 Liters per second per meter of drawdown (15 gpm/ft). Specific capacities were found by measuring flowrates and drawdowns during pumping. Water level measurements were taken after a minimum of 30 minutes of pumping. Flowrates were measured with ultrasonic flowmeters, in-line propeller flowmeters, or by measuring time required to fill a container of known volume. Given the different conditions and methods used to measure efficiencies, efficiency results should be considered approximate.

Many of the wells at both wellfields produced high concentrations of sand during pumping. High concentrations of sand caused excessive wear on pump impellers and significantly shortened the useful life of a pump and motor. High concentrations of sand were produced because the wells do not contain an artificial filter pack that would keep sand from entering the well, and because the openings in the wellscreen installed were too large. Rather than use an artificial filter pack which would prevent entry of fine materials into wells, the wells were originally constructed with a natural filter pack.

In wells designed with the natural filter pack, the wellscreen openings are usually sized so that up to 60 percent of the aquifer formation will pass through the screen. As the well is developed, the fine-grained sediments enter the well and are pumped out, leaving the large-grained sediments trapped behind the wellscreen. The large-grained sediments that build up behind the wellscreen and form a natural filter pack with grain size gradually increasing toward the well screen. The aquifer formation at the Kosaman Wellfield is comprised mostly of fine sands with small percentage of large-grained sediments available to build a natural filter pack around the well. Creating an additional difficulty in the formation of a natural filter

pack is the size of wellscreen openings originally installed. As mentioned previously, typically wellscreen openings are sized to allow no more than 60 percent of the aquifer formation into wells with natural filter packs. Slot openings in screens originally installed allow approximately 90 percent of the formation to enter the well.

The severity of the sand production problem at the wellfields is not only apparent from the short average lifespan of submersible pumps, but also from the large amount of sand that accumulates in the reservoirs at the Kosaman and Berdykol pump stations. According to Aral-Sarybulak managers, the reservoirs have to be emptied of sand on an annual basis.

Sand testing was done using Rossum sand tester or a bucket method. Wells equipped with pumps were tested using the Rossum sand tester, which provides a quantitative measurement in parts per million (ppm). Rossum sand tester requires steady, laminar flow in a long section of a pipe flowing full. If sand content measurements were required during airlift pumping, qualitative measurements were taken by diverting discharge water into a container and visually assessing the amount of sand collected in the container.

2.3 Removal of Dropped Objects from the Wells

During the well assessment, eight wells were found to be blocked by large foreign objects dropped into the well interior. In most cases, the objects were identified as pumps with motors, sometimes with sections of the pump column. It appears that the pumps and motors have fallen into wells due to use of only four bolts at flange connections instead of the standard eight bolts, poor tightening of the joints, and use of poor quality material. According to the local operators, the equipment would sometimes fall into the well during pump pull or installation due to operator's fault or accident. In all cases, an attempt to remove the objects was made.

Fallen objects usually became wedged at the well reduction near the bottom of the casing column and top of the screened section of the well. Prior to removing the equipment, an imprint or testing tool was carefully lowered into the well to determine the depth of the foreign object and to estimate its size. An optimum fishing tool was then selected from available tools or a new dedicated tool was manufactured at the site. Several types of fishing tools were used, including bells with internal and external threads and hooks. The tool was then lowered on 2 in. drilling rods to the top of the fallen object and a threading tool or hook were used to make a connection with the object. After the connection was made, the object was slowly and cautiously pulled out. Often, the object became loose during the pull, fell back to the well, and the fishing operation had to be repeated again. Foreign objects at Kosaman Wells Nos. 4, 6, 16, 28, and 30 were successfully removed. Objects from Kosaman Well No. 19 and No. 22 and Berdykol Well No. 1 could not be removed despite repeated attempts.

2.4 Well Redevelopment

Wells with low yield and specific capacity were redeveloped using mechanical and chemical methods. Mechanical pumping and surging and redevelopment with acid-based chemicals were used most often.

Mechanical pumping and surging was accomplished using a standard airlift method. Airlifting was accomplished by installing a 50 mm (2 in.) air line inside a 150 mm (6 in.) eductor pipe into a well. The eductor pipe and air line bottoms were set below the water level in the well, with the eductor pipe set two to six feet below the airline. Usually, about 60% percent of the eductor's length was submerged under the water under the dynamic conditions to obtain high efficiency airlift. The tops of the air line and eductor piping were rested against the drilling rig's rotary table. Using diesel-powered piston compressors, compressed air was injected into the well through the air line. As the air exiting the air line mixed with water inside the eductor pipe, it created a mixture lighter than water that rose to the surface following hydraulic balance. Flow rates produced by air lift pumping ranged from 8 to 21 Lps. Photo 4 in Attachment 1 shows a well undergoing airlift redevelopment. The air supply was cut off every five to ten minutes during the airlift to provide a surge effect caused by a free fall of water through the eductor pipe back into the well. The surge effect helped in stabilizing the filter pack and removing the fines from the formation. An average 25% improvement in well efficiency was accomplished by the pumping and surging method.

The purpose of chemical redevelopment was to restore well yield and improve well efficiency impaired by clogging of the wellscreen with chemical precipitates and/or biological growth. Results of chemical redevelopment of a well during the pilot rehabilitation project showed that this method was effective in increasing well efficiency by over 40 percent. To remove possible mineral encrustation, the wells were treated with acid-based chemicals. The chemical, Swyco S/C, is comprised of sulfamic acid (H_3NO_3S), dispersants, and inhibitors. Sulfamic acid dissolves a wide variety of mineral precipitates. Dispersants are designed to keep dissolved chemicals in suspension until removal by pumping, while inhibitors are designed to minimize corrosion of the casing and wellscreen during treatment. Along with dissolving mineral encrustation, sulfamic acid dissolves the protective coating of biological organisms, particularly that of iron bacteria. To remove biological growth, Swyco B/E consisting of glycolic acid, was used.

Granular Swyco S/C was poured into the well. A surge block was then lowered into the well and raised and lowered repeatedly to help dissolve the acid in the water and to agitate the acid/water mixture within the wellscreen. Agitating the acid accelerated the dissolving action of the acid on encrustation in the screen and surrounding formation. After a minimum of 24 hours, the liquid Swyco B/E was poured directly into the screened section through the pipe connecting the surge block to the surface. After another 24 hours of surging with the surge block, the chemicals were pumped out of the well to the ground surface. Once on the surface, the acidified water was quickly neutralized and diluted by fresh groundwater from the well.

Kosaman Wells Nos. 16, 17, 18, and 21 were treated with chemicals. An average 31% increase in the well efficiency was accomplished using the method.

2.5 Well Disinfection

Upon the completion of well redevelopment and pump installation, each well was disinfected. A sufficient dose of granulated calcium hypochlorite was dumped into the well to produce a chlorine concentration of 100 mg/L in the well water. After 24 hours of contact time, each well was purged for a minimum of two hours before placing on-line.

2.6 Other Construction Work

Wellhead fittings, pump houses, and power distribution systems underwent extensive repairs. The majority of the existing gate valves, air relief valves, check valves, elbows, and miscellaneous fittings installed within the pump houses were replaced to build a reliable water distribution system. The pump houses were reconstructed by repairing the doors and roof hatches and by pouring new concrete floors and painting the pump houses. Also, repairs to the power distribution system were made, including new installation and repairs of low-voltage power conductors and power transformers.

2.7 Water Quality

In addition to the overall groundwater quality assessment conducted by previous EPT teams in 1995 and 1996, water quality monitoring was conducted at each well to detect any negative impact of the rehabilitation program on the water quality. Special attention was paid to water quality in wells undergoing chemical redevelopment. Groundwater quality was monitored by both the EPT team and by Aral-Sarybulak personnel through the analytical laboratory in Aralsk.

Staff from the Aral-Sarybulak collected water samples at each well equipped with a new pumping system. Analytical results obtained at the local laboratory in Aralsk indicated that the groundwater met local drinking water standards. Water analyses conducted by the EPT staff were done using the portable, hand-held Hach analytical instruments. The water analyses performed indicated that no negative impact on the water quality resulted from the rehabilitation activities. Table 1 summarizes the groundwater quality parameters measured at Kosaman and Berdykol by the EPT teams during 1995 and 1996.

Table 1
Wellfield Water Quality

Well No.	Date	Temp (C)	EC (uS/cm)	TDS (mg/L)	pH	Cl (mg/L)	SO4 (mg/L)	Fe (mg/L)	Hardness (mg/L as CaCO3)	Alkalinity (Total mg/L)
Kosaman Wellfield										
USEPA Standards*				**500**		**250**	**250**	**0.3**		
WHO Guidelines				**1,000**	**6.5-8.5**		**400**	**0.3**		
Well- 1	Sep-96	19.9	963	482		180	200	1	20	204
Well- 2	Jun-95	21.3	910	580	7.9	160	150	0.7	20	204
Well- 2	Sep-96	20.6	949	477		125	>200	1.5	20	187
Well- 3										
Well- 4	Jun-95		970	620	7.7					
Well- 5										
Well- 6										
Well- 7	Sep-96	19.4	902	452		100	>200	1	20	204
Well- 8	Sep-96	19.5	755	378		120	150	1	20	187
Well- 9										
Well- 10	Jun-95	19.7	710	450	7.6					
Well- 11	Jun-95	21.6	670	430	7					
Well- 12	Sep-96	19.3	604	302		60	125	1	20	136
Well- 13	Sep-96	18.8	645	324		60	125	1.8	20	153
Well- 14	Sep-96	19.1	768	384		90	125	1.2	40	170
Well- 15										
Well- 16	Jun-95	13.5	470	300	9.8					
Well- 17										
Well- 18	Sep-96	18.5	1,198	600	6.5	240	>200	1.2	80	204
Well- 19	Sep-96	17.4	543	272		55	100	1.3	40	160
Well- 20										
Well- 21	Sep-96	17.2	1,732	862	7	320	>200	0.8	140	204
Well- 22	Sep-96	16.8	1,732	868		380	>200	1.2	100	204
Well- 23	Sep-96	16.7	651	326	7	90	150	0.8	60	170
Well- 24	Jun-95		720	460	7.1	100	115	1.2	60	170
Well- 24	Sep-96	17.1	685	343	6.5	85	150	1.3	40	153
Well- 25	Jun-95	17.5	730	470						
Well- 25	Sep-96	16.2	732	367	6.5	105	150	1.1	60	153
Well- 26	Jun-95	14.4	550	350						
Well- 26	Sep-96	15.8	489	245	6.5	60	90	1	60	136
Well- 27	Sep-96	15.6	475	238	6.5	50	90	1.4	80	143
Well- 28	Jun-95	18.3	540	350			85	>5	80	153
Well- 28	Sep-96	14.6	528	264	6.5	75	100	0.7	80	153
Well- 29										
Well- 30	Jun-95	13.1	490	310						
Well- 30	Sep-96	14.8	527	264		65	90	0.5	100	142
Berdykol Wellfield										
Well- 1	Jun-95	25.0	1,000							
Well- 2	Jun-95	20.3	1,880	880	8.3		125	1	20	187
Well- 3	Jun-95	20.4	960	480	7.3					
Well- 4	Jun-95	21.2	950	470	7.8					
Well- 5	Jun-95	21.1	1,010	450						
Well- 6	Jun-95	21.2	1,530	760			170	>5	60	187
Well- 7										
Well- 8										

*Secondary Drinking Water Maximum Contaminant Limits (MCLs), USEPA, 1995.

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Section 3

Replacement of Pumping Equipment

New USAID equipment installed at Kosaman and Berdykol included twenty-nine (29) submersible pumps and motors, twenty-nine (29) control panels with submersible power cable, fifteen (15) sand separators, two (2) well screens, twenty-nine (29) check valves, twenty-nine (29) flowmeters, and a safety cable. Additionally, GOK provided wellhead fittings, pump column, and construction materials which were installed at the project site. The equipment was installed in rehabilitated wells using standard hydraulic construction cranes or drilling rigs of rotary type. The equipment installation was performed by the GOK contractors under the supervision of the EPT staff.

3.1 Submersible Pumps

Twenty-nine multistage submersible turbine pumps were procured for the wellfield rehabilitation program and installed at the wellfields in 1996. Four units were procured and delivered as spare pumps for future needs. Pumps of three different sizes with the following capacity/head parameters were provided: 9.5 L/s/40 m (150 gpm/130 feet), 22 L/s/55m (350 gpm/180 feet), and 32 L/s/66 m (500 gpm/215 feet). Table 2 summarizes the nominal capacity, nominal head, available head and capacity ranges, and number and type of pumps provided. All the pumps were of an identical make: cast iron bowls and bronze closed-type impellers, bronze bowl bearings, and stainless steel bowl shafts. The 500 and 300 gpm pumps were of a three-stage type with an 8 in. diameter, while the 150 gpm pumps were of a four-stage type with a 6 in. diameter. Maximum pump efficiencies ranged between 65 and 78%.

The pumps were sized from results of hydraulic modeling conducted by using anticipated aquifer withdrawal rates and taking into account effects of well interference. All pumps were manufactured by J-Line Pump Company of Memphis, Tennessee, USA. See Photo 5 in Attachment 1 for a depiction of a 350 gpm pump ready for installation.

Table 2

Submersible Pumps

Nominal Capacity gpm (Lps)	Nominal Head feet (meters)	Available Head Range feet (meters)	Available Capacity Range gpm (Lps)	Number Purchased
150 (9.5)	130 (40)	112-160 (34-49)	96-163 (6-10.3)	5
350 (22)	180 (55)	138-225 (42-69)	230-415 (14-26)	23
500 (32)	215 (66)	168-219 (51-67)	480-690 (30-44)	1

3.2 Electric Motors

Twenty-nine electric submersible motors of 10, 25, and 50 horsepower were provided to power 150, 350, and 500 gpm pumps, respectively. The motors were of a three-phase, 380-volt, 50-hertz type with nominal 2,900 revolutions per minute. The motors were built corrosion-resistant with stainless steel shafts, hermetically sealed windings, and water lubrication. Table 3 summarizes the number and type of electric motors purchased for the wellfield rehabilitation project. All motors were manufactured by Franklin Electric of Bluffton, Indiana, USA. Photo 5 in Attachment 1 shows a 25 HP motor attached to a 350 gpm pump.

Table 3

Electric Motors

Horsepower (HP)	Kilowatts (kW)	Number Purchased
10	8	5
25	19	23
50	37	1

3.3 Electrical Equipment

Each submersible motor was connected with a power source by a submersible power cable through a surface-mounted control panel. Four-wire, flat-jacket cable of the 4/3, 8/3, and 10/3 sizes were used for the 500, 350, and 150 gpm pumping systems, respectively. The electrical cable was spliced to the motor leads in the field using a heat-shrink splicing method. The control panels were designed to protect the pumping equipment against the damaging effects of overvoltage, undervoltage, phase loss, phase reversal, phase unbalance, overfrequency, underfrequency, equipment cycling, lightning damage, and dry pumping in addition to the standard motor protection customarily provided in the United States. The control panels included the following types of protective devices: power monitors, frequency monitors, lightning arrestors, circuit breakers, contactors, overload relays, time delay relays, and water level shutoff and restart probes and relays to provide the above protection. The panel components were mounted in a NEMA 4X fiberglass enclosure to protect the equipment against dust and water and equipped with a lock to avoid tampering. On/off buttons, mode selector switches, and equipment status indicator lights were installed on the panel door to allow convenient operator interface. The panels were mounted on the interior walls of the pump houses and labeled with operating instructions in Russian language.

The control panels were manufactured by Controlled Systems of Memphis, Tennessee, USA. Photo 6 in Attachment 1 shows a control panel with final connections being made by an electrician.

3.4 Pump Column

Each submersible pumping system was lowered into a rehabilitated well and suspended on a pump column. The depth of pump setting and length of pump column varied between 49 m to 72 m (161 to 237 ft.), depending on pump capacity and well efficiency. The pump columns used to support the 9.5 L/s (150 gpm) pump were assembled from several sections of 114 mm diameter (4 in.) steel piping with a wall thickness of 7 mm. The 4.3 m to 9.8 m long sections of pump column were interconnected by flange connections made by threaded bolts and sealed with rubber gaskets. The 350 gpm and 500 gpm pumps were supported by a 159 mm (6 in.) diameter steel pipe with a 9 mm wall thickness. The steel piping used for the pump column was manufactured in the former Soviet Union according to GOST standards and procured by the GOK.

3.5 Sand Separators

Fifteen sand separators were designed, procured, and installed at wells which produced high sand concentration in discharge water despite the rehabilitation efforts. The separators used for the project were of a submersible type which used centrifugal effect to separate sand from the water before it reaches the intake of submersible pump. The actual separators with separation chambers were attached to the low end of the pump and motor assemblies, while the pump and motor were encased in a shell to direct the water flow to separator. The separated sand was discharged via flapper valve to the well bottom. The separators were installed to extend the life of the pump by reducing damaging effects of sand abrasion.

Two types of sand separators were installed. Type F was designed for flowrates between 150 gpm and 325 gpm, while type G was designed for flowrates between 325 gpm and 650 gpm. Separator installation was usually accomplished simultaneously with the installation of pump and motor assembly following well rehabilitation. Results of sand testing indicate that the submersible sand separators are effective in reducing the sand content of the discharge water, thereby providing the submersible pumps significant protection from the harmful effects of high sand content.

Table 4 lists the acceptable flow range and the number of each type of sand separator installed. The sand separators were manufactured by Lakos Separators of Fresno, California, USA. Photo 5 in Attachment 1 shows a pump enclosure shell being attached to the sand separator, which is inside the well. A pump, motor and check valve assembly ready for installation inside the pump enclosure shell is in the foreground.

Table 4

Submersible Sand Separators

Type	Flow Range gpm	Number Installed
F	150-325	5
G	325-650	10

3.6 Wellscreens

In addition to the installation of sand separators and use of low-flow pumps, new wellscreens were used to reduce the amount of sand reaching the pumps and to extend the equipment life. New wellscreens were installed at two wells at Berdykol which produced high sand concentrations despite extended rehabilitation efforts. Because their removal would be extremely difficult, if not impossible, the existing 200 mm (8 in.) diameter screens were left in place. New screens of 100 mm (4 in.) diameter were slipped into the interior of the old screen to provide additional barrier against sanding.

The screens were constructed of 4 inch (101 mm) diameter steel casing by drilling evenly-spaced 1 in. (25 mm) diameter circular perforations over the length of the screen. A wire mesh composed of a copper-nickel alloy was wrapped around the casing to cover the perforations and fastened to the pipe with longitudinal tie rods. A cone reducer was used to rest the screen on top of the existing screened section and a conic bottom was attached to the screen column to guide the screen through the well during the installation. The well screens were manufactured by a drilling contractor in Kzylorda from the local materials according to the GOST standards.

The two wells were carefully logged prior to screen installation to determine depths and internal diameters of all well sections. Screen sections were measured and cut at the surface to allow them to rest in suspension on the top of the existing screen packer without resting against the well bottom. This installation method was selected to avoid flexural stress and excessive buckling in the relatively unstable screen. After screen preparation at the surface, screen sections were gradually lowered to the well interior using 2 in. (50 mm) drilling rods. The top of the screen section was connected to the drilling rods by a counter-clockwise thread. After the screens were lowered to their desired position, the threaded connection was made loose by turning the drilling column clockwise. Then, the drilling rods were pulled out from the well and the well was airlifted to create a stable filter pack in the annular space between the old and new screens. Although the internal well conditions were largely unknown, each installation effort was accomplished without wedging and actual installation depths were only inches away from resting depths predicted by well logging.

The wellscreens were placed in Wells Nos. 3 and 8 in the Berdykol Wellfield. Figure 3 shows the configuration of the new screens in these wells. Photo 7 in Attachment 1 shows the wellscreens and casing as delivered to the wellfield.

3.7 Other Equipment

Other equipment installed with each pumping system include check valves, safety cables, and flowmeters.

Check valves were placed directly above each pump to prevent water in the riser pipe or distribution system from flowing back into the well. Backflow from the distribution system was observed in several wells because of leaking or broken check valves and gate valves at the wellhead. Preventing backflow is important to keep water from the distribution system

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returning to the well and possibly contaminating it with bacteria and other organisms.

To prevent the pump and motor assemblies from falling into the well, permanent safety cables were used to attach the pumps and motors to the wellhead at the surface.

Flowmeters were installed at most of the wells fitted with new pumping systems. The flowmeters were welded onto the discharge pipe. The flowmeters utilize an in-line propeller to provide instantaneous flow measurements in liters per second as well as total cumulative flow in cubic meters. The flowmeters were manufactured by Ketema, Inc., McCrometer Division, Hemet, California, USA.

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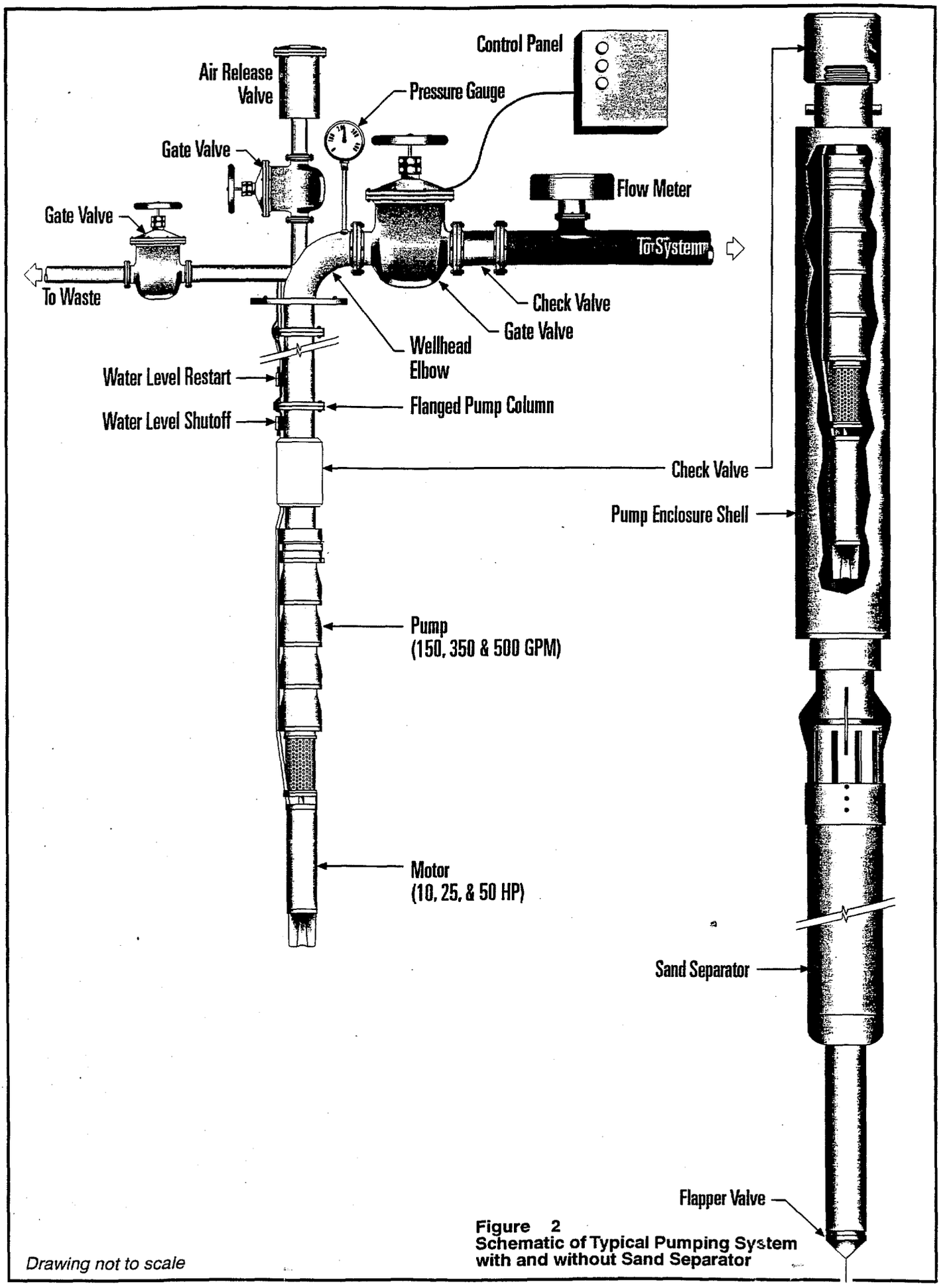
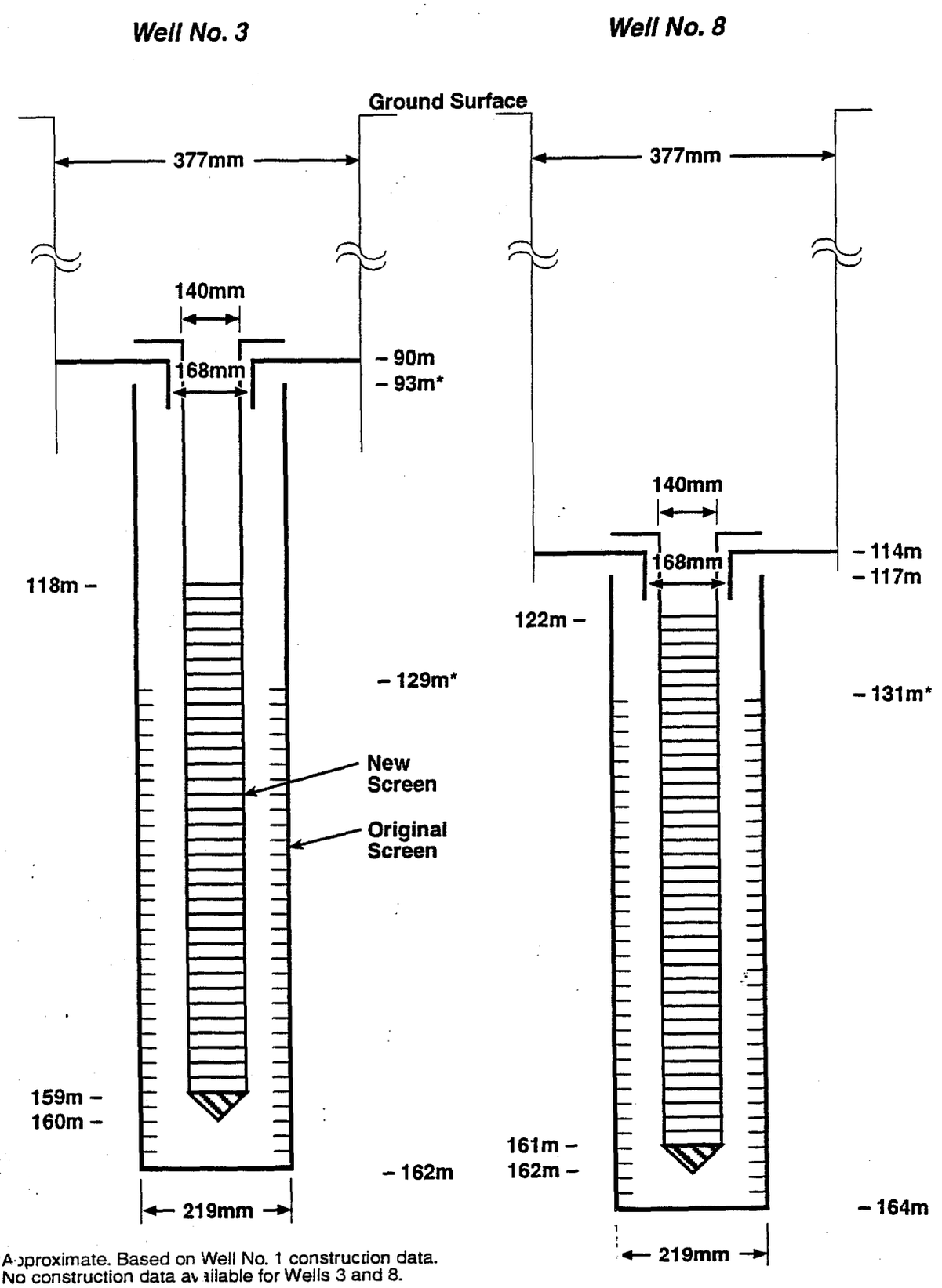


Figure 2
Schematic of Typical Pumping System with and without Sand Separator

Drawing not to scale



**Approximate. Based on Well No. 1 construction data. No construction data available for Wells 3 and 8.

NOT TO SCALE

Figure 3
Configuration of New Screens Installed in Berdykol Wells No. 3 and 8

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Table 5
New Equipment Installed

Well No	Date Installed	Pump Size Installed (gpm)	Actual Pumping Rate* (gpm)	Motor Size Installed (HP)	Power Cable Size (gauge/strands)	Diameter of Pump Column (in.)	Sections of Pump Column	Type of Sand Separator**	Depth of Pump Intake (ft bgs)	Depth of Shutoff Water Level Controller (ft. bgs)	Depth of Restart Water Level Controller (ft. bgs)	Remarks
Kosaman Wellfield												
Well- 1	6/22/96	150	150	10	10/3	4	9	-	177	145	141	
Well- 2	8/22/96	350	427	25	8/3	6	11	-	215	155	151	Old pump replaced, no redevelopment.
Well- 3			440									Original pump left in place.
Well- 4	8/22/96	350	**350**	25	8/3	6	11	G	217	157	153	
Well- 5			375									Original pump left in place.
Well- 6	8/15/96	350	**350**	25	8/3	6	11	G	209	149	145	
Well- 7	8/7/96	350	350	25	8/3	6	15	G	212	152	148	
Well- 8	8/3/96	350	396	25	8/3	6	12	G	216	156	152	
Well- 9	8/13/96	150	**150**	10	10/3	4	5	-	161	141	137	
Well- 10			344									Original pump left in place.
Well- 11	9/19/95	300	205	50	2/3	4	NA	-	200	-	-	Pump installed last year during pilot test program.
Well- 12	8/14/96	350	285	25	8/3	6	11	G	220	160	156	
Well- 13	8/17/96	350	349	25	8/3	6	13	-	237	177	173	
Well- 14	8/23/96	350	349	25	8/3	6	12	-	219	159	155	
Well- 15			100									Original pump left in place.
Well- 16	8/21/96	350	**350**	25	8/3	6	11	F	221	161	157	Well treated with acid.
Well- 17	8/28/96	350	**350**	25	8/3	6	11	F	220	175	171	Well treated with acid.
Well- 18	7/18/96	150	206	10	10/3	4	12	-	191	161	157	Well treated with acid, casing crooked, won't accept 6"pipe.
Well- 19	7/23/96	350	348	25	8/3	6	12	-	210	150	146	
Well- 20												Pump removed due to excessive sand and clay, well abandoned.
Well- 21	7/26/96	350	412	25	8/3	6	15	-	218	154	150	Well treated with acid.
Well- 22	7/6/96	150	190	10	10/3	4	12	-	193	159	155	
Well- 23	8/19/96	350	443	25	8/3	6	12	-	219	159	155	Old pump replaced, no redevelopment.
Well- 24	8/20/96	350	348	25	8/3	6	12	-	219	159	155	Old pump replaced, no redevelopment.
Well- 25	8/2/96	150	150	10	10/3	4	9	-	222	188	184	
Well- 26	8/8/96	350	301	25	8/3	6	9	G	217	157	153	
Well- 27	8/5/96	350	364	25	8/3	6	13	G	217	157	153	
Well- 28	7/4/96	350	443	25	8/3	6	11	G	204	144	140	
Well- 29												Pump removed due to excessive sand and clay, well abandoned.
Well- 30	7/19/96	350	427	25	8/3	6	12	G	201	141	137	
Berdykol Wellfield												
Well- 1												Unremoveable obstruction, well abandoned.
Well- 2	9/13/96	350	**350**	25	8/3	6	11	F	214	154	150	
Well- 3	9/9/96	350	**350**	25	8/3	6	11	F	221	161	157	New screen installed.
Well- 4	9/6/96	350	**350**	25	8/3	6	11	-	222	162	158	
Well- 5												Excessive sand, obstruction prevents screen installation, abandoned.
Well- 6	8/30/96	350	**350**	25		6	11	F	220	160	156	
Well- 7	9/18/96	500	482	50	4/3	6	11	-	220	164	160	
Well- 8	9/20/96	350	152	25	8/3	6	14	G	213	193	189	New screen installed.

*Where actual flow rates are not available, rated value of pump is used (shown in bold).
**G type separator for high flow rates (>325 gpm), F type for low flow rates (<325 gpm)
NA = Not Available

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Section 4

Operations and Maintenance

During the final stages of the wellfield rehabilitation program, wellfield operations and maintenance guidelines were developed. The purpose of the guidelines was to provide local wellfield personnel with operational guidance for various foreseeable conditions and to provide maintenance guidelines that will maximize the service life of the newly installed equipment. These guidelines, as well as technical information on all new equipment, were provided in an Operation and Maintenance (O&M) Manual. The O&M Manual was written in English and translated to Russian before given to local operators of both wellfields.

4.1 Operational Guidelines

Guidelines for wellfield operations were based on a site-specific model developed by project staff that incorporated well efficiencies and the impact of pumping neighboring wells on water levels. The purpose of the guidelines is to optimize well flow distributions to avoid the development of excessive drawdowns. Excessive drawdown can strain the pump motors, increase power demand, and cause wells to shut off because water levels exceed that of the automatic water level shutoff safety device.

Guidelines provided in the O&M Manual include recommendations on which pumps should not be operated simultaneously and suggested pumping scenarios that will minimize drawdowns and maximize wellfield efficiency for a variety of existing and foreseeable operating conditions.

Local officials in charge of monitoring power consumption at the wellfields noted that as the new equipment came on-line, power demand dropped significantly. The reduced power demand is a result of the high efficiency of the newly installed equipment.

4.2 Maintenance Guidelines

Guidelines for wellfield maintenance were provided by project staff in order to enhance pump and motor longevity. The guidelines consisted of general comments on the importance of maintenance, a pump rotation schedule, and maintenance instructions provided by equipment manufacturers. A pump rotation schedule was provided to prevent the deterioration of pumps and wells due to idleness. Some wells will be idle because the total production capacity of the wellfields exceeds the capacity of the Federal transmission pipeline by over 200 percent. Maintenance guidelines were also provided for the electrical equipment, flowmeters, and wells. Guidelines on well maintenance included instructions on how to disinfect wells and to restore lost well efficiency by periodic chlorination and acid treatment.

An extensive troubleshooting section was included in the O&M Manual to assist wellfield operators in identifying and fixing typical problems that may arise.

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Detailed instructions on how to remove and install pumps, motors, sand separators, and electrical equipment were also provided.

4.3 O&M Manual

In addition to containing the operations and maintenance guidelines described in the previous two sections, the O&M Manual contained engineering specifications and diagrams for all the equipment provided. The manual was written in English and translated to Russian before being provided to local wellfield staff and other involved individuals and agencies.

4.4 Spare Parts

Three 350 gpm and one 150 gpm complete pumping systems were provided to the wellfields for future use. The system included pump, motor, electrical cable, splice kits, check valves, and components for the control panels. Additional spare parts and tools were provided to the wellfields after the completion of the field phase of the wellfield rehabilitation project. A supply of chemicals were provided to Aral-Sarybulak to allow for future chemical rehabilitation. The amount of Swyco S/C and B/E remaining are sufficient to chemically redevelop seven wells. A large amount of calcium hypochlorite was left at the wellfields to provide for regular disinfection. Sufficient calcium hypochlorite was left for up to 56 disinfection applications.

4.5 Potential Problems

There are two major problems that may adversely affect the long-term performance of the new wellfield equipment: poor maintenance and the circumventing of electrical safety devices.

Every effort was made to stress the importance of maintenance to local wellfield operators by personal communication and training. In addition, a comprehensive O&M Manual was provided. In spite of this effort, there appears to be an insufficient understanding of the importance of preventive maintenance, as demonstrated by the relative lack of preventive maintenance in current practices. It appears that typical practice is to operate equipment until it fails, then replace it, and operate it until it fails again. Even though the submersible pumping systems require little maintenance, if wellfield operators fail to conduct regular and preventive maintenance, the long-term reliability of the wellfield equipment may be adversely affected.

Many safety features contained in the electrical control panel are designed to protect the motor from inconsistencies in the quality of power provided to the wellfields. In late August 1996, the frequency of the power supply dropped below acceptable limits, causing all the new on-line pumping systems to cease operating. Unable to rectify the power supply problem, local wellfield operators adjusted the level of frequency protection to outside manufacturers specifications in order to make the pumps operational. Specifically, the lower frequency

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setting on the Frequency Monitor was lowered from 48 hertz (Hz) to 47 Hz. If the safety devices are circumvented or continue to be circumvented, the service life of the new equipment may be shortened.

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Section 5
GOK Support

Under the terms of the MOU, USAID was responsible for providing technical assistance and a limited amount of new equipment, which consisted primarily of new submersible pumping systems. The GOK was responsible for providing labor, construction equipment, and some materials.

The GOK allocated funds to ODSP Aral, a government entity in Kzylorda responsible for construction of the water supply systems, to support the rehabilitation effort. The support was provided by five different contractors from Kzylorda and Aralsk. Kzylordagidrogeologyia and PMK-66, two drilling contractors from Kzylorda, were involved in well rehabilitation and installation of new pumping systems. PMK-13, a general civil contractor from Aralsk, served as a general contractor under the project and provided civil engineering services, such as pump house disassembly, assembly, and repair, and transportation services. PMK-52, an electrical contractor firm from Kzylorda, rehabilitated electrical service at the wellfields by repairing existing transformers and repairing low-voltage power distribution system. PMK-112, a mechanical contractor from Kzylorda, installed new wellhead fittings. The contractors were reimbursed for their services directly by the ODSP Aral.

The equipment used by the contractors included rotary-type drilling rigs, diesel-powered air compressors, hydraulic construction cranes, and heavy trucks. Up to forty laborers were involved in the rehabilitation effort between May and September 1996.

Materials provided by the GOK for the wellfield rehabilitation project included pump column, wellhead elbows, valves, bolts, gaskets, pressure gauges, electrical equipment, prefabricated concrete pump houses, concrete, and other miscellaneous supplies. Without support from the GOK, the rehabilitation of the two wellfields would have been extremely difficult and perhaps impossible.

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Section 6
Conclusions

In 1994, when the MOU between the United States Government and the GOK was executed, there was a recognition that the potable water systems in and around the cities of Aralsk and Novokazalinsk needed improvements. Subsequent field investigations showed that the source of water for these communities, the Kosaman and Berdykol Wellfields, also needed significant improvements.

To address these problems, a wellfield rehabilitation program was developed and implemented. The comprehensive full-scale wellfield rehabilitation program was developed based on the results of an initial wellfield investigation in June-July 1995 and the pilot rehabilitation program implemented in September 1995. The overall objectives of the full-scale rehabilitation program were to ensure that the wellfields can produce the required flow rate and provide a reliable source of water for the population of Aralsk and Novokazalinsk Rayons for years to come. The overall objectives of the wellfield rehabilitation program were accomplished through the completion of the following activities:

- installation of twenty-nine (29) US-made pumps, motors, and control panels provided reliable pumping equipment for the wellfields
- installation of fifteen (15) US-made submersible sand separators at selected wells protected the new pumping equipment
- mechanical and chemical redevelopment twenty-five (25) selected wells improved well efficiency and increase well yields by 25-31 percent
- installation of new well screens at two (2) selected wells protected the new pumping equipment
- operator training, provision of a Russian operations and maintenance manual, and provision of spare parts and tools enhanced wellfield reliability

As a result of the wellfield rehabilitation program, the reliability of the Kosaman and Berdykol Wellfields has been significantly improved and the production capacity has been increased from 285 Lps to 587 LPs.

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Appendix A
Photographs

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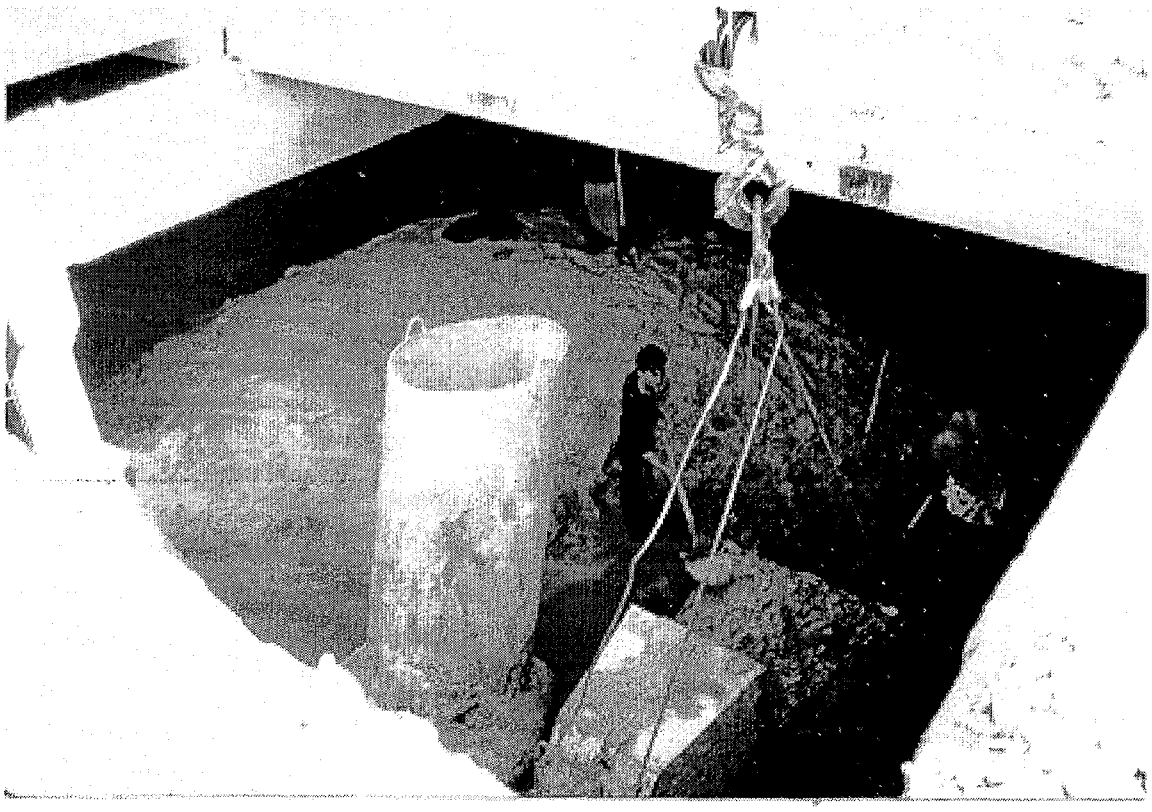

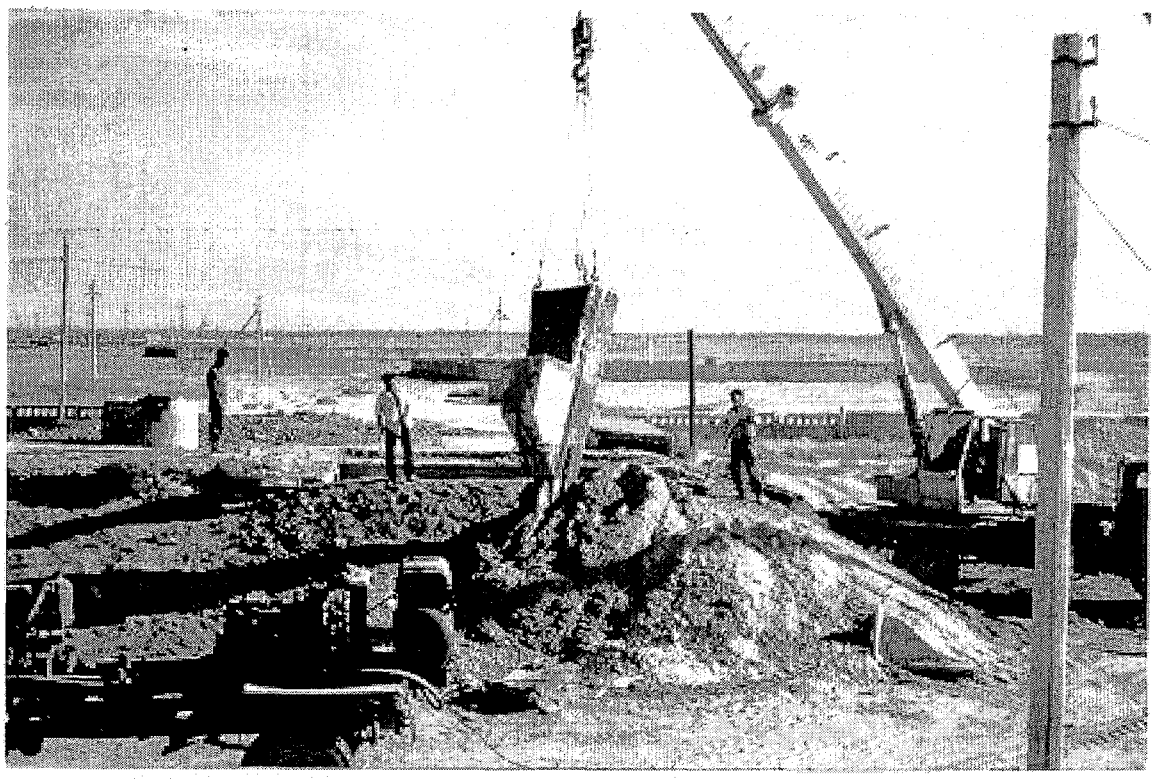

Photos 1 & 2: Sand being removed from reservoir at Pump Station 1.

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Photo 3: Sand content being measured during airlift pumping.

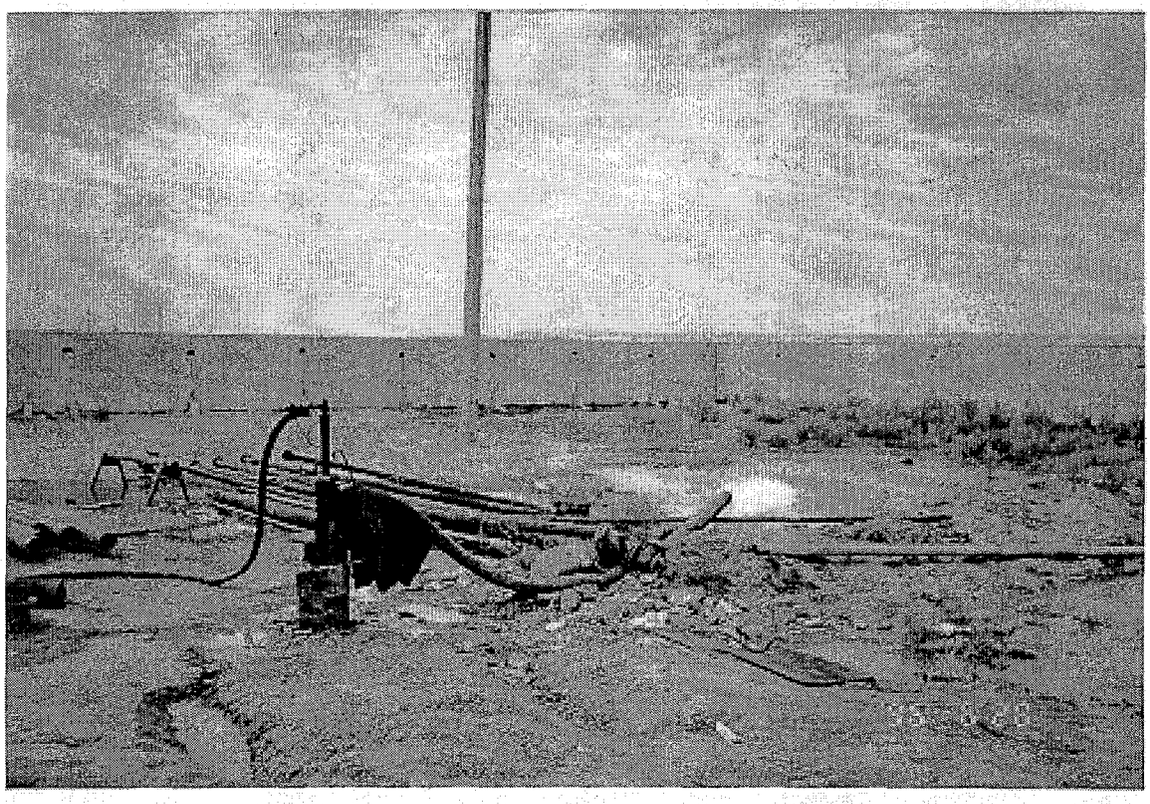

Photo 4: Airlift pumping.

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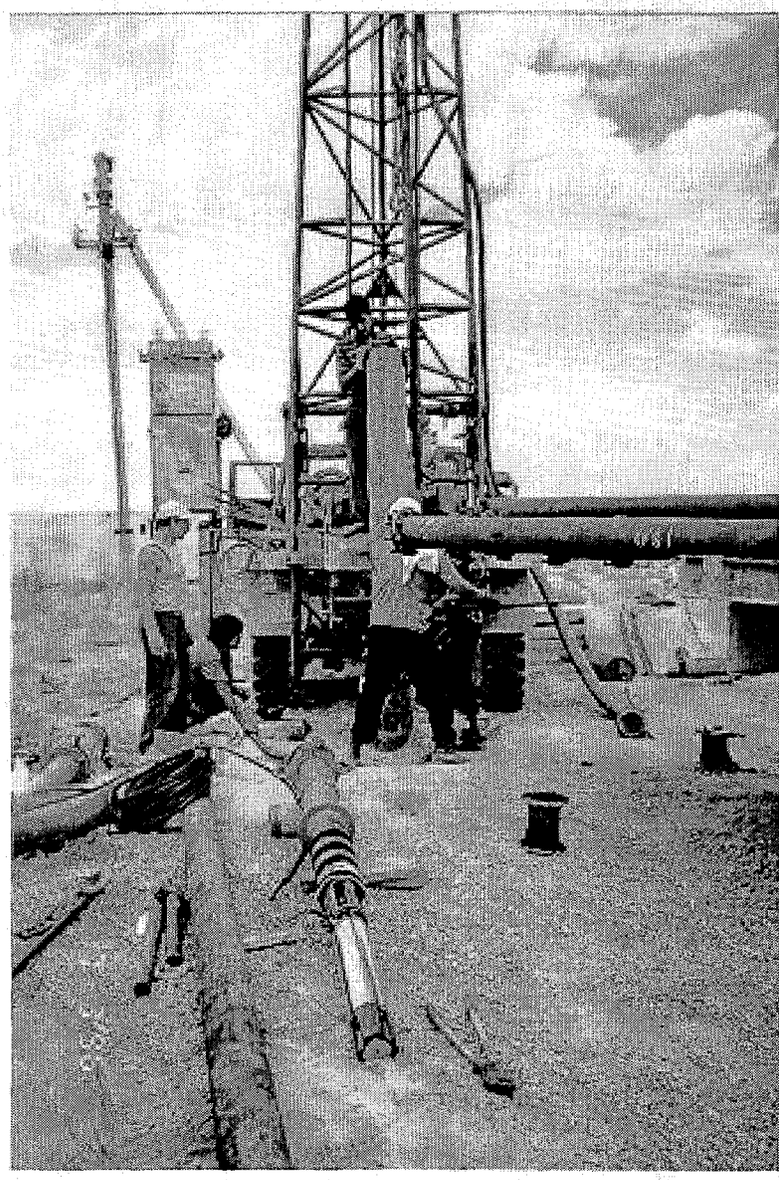

Photo 5: Pump enclosure shell being attached to sand separator (in well). Motor, pump, and check valve are assembled (in foreground) and ready for installation inside pump enclosure shell.

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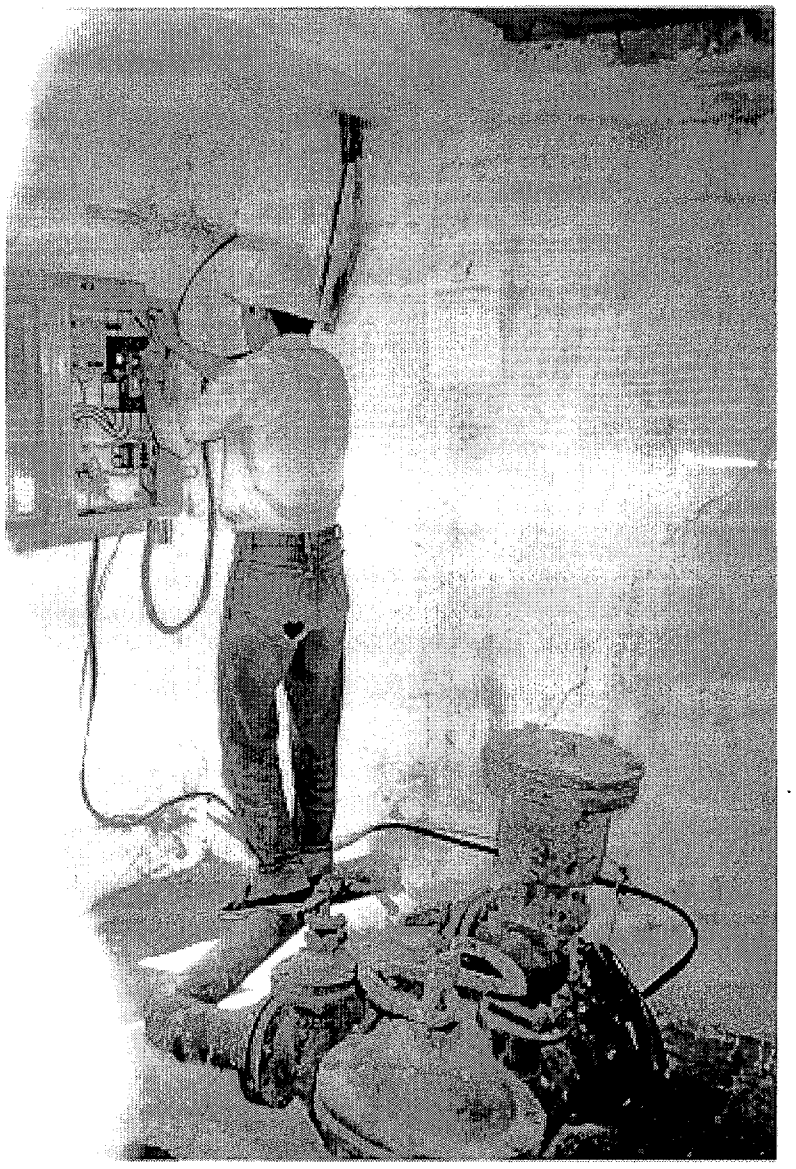

Photo 6: Final electrical connections being made to control panel.

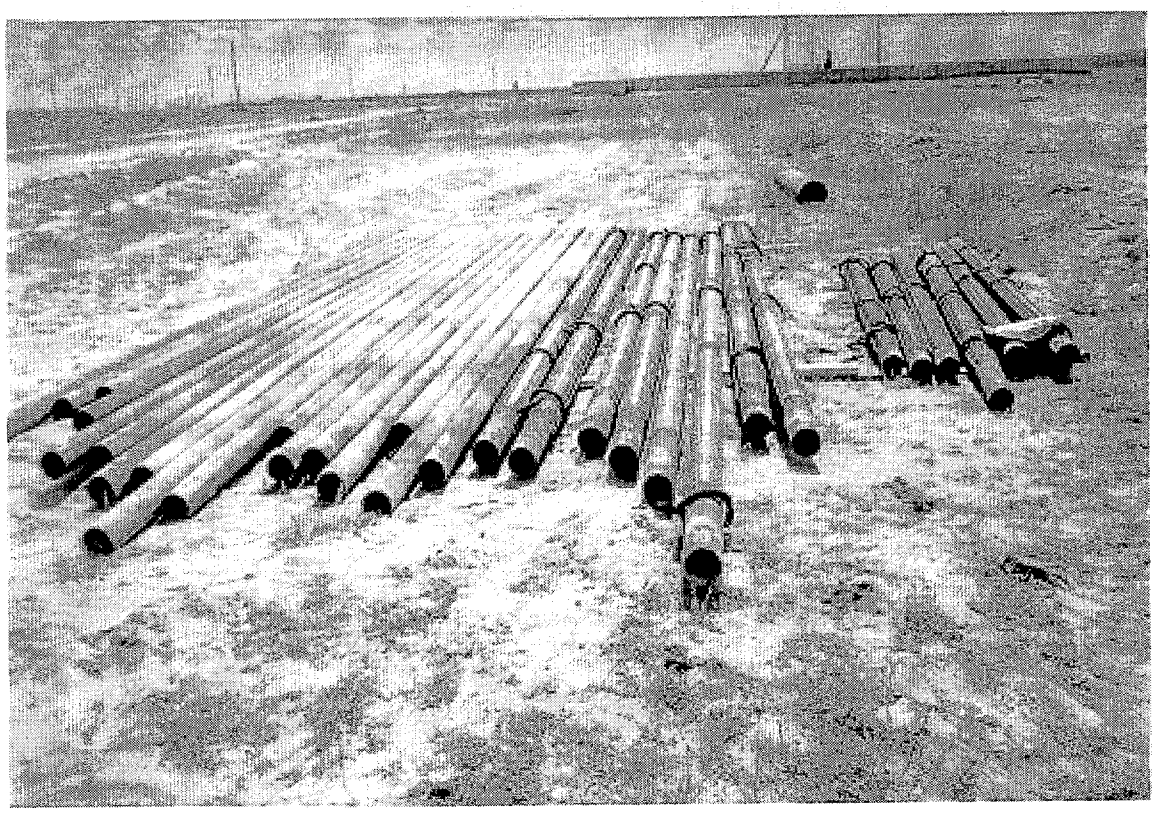

Photo 7: Locally manufactured wellscreens. Perforated screen on the right. Blank casing on left.

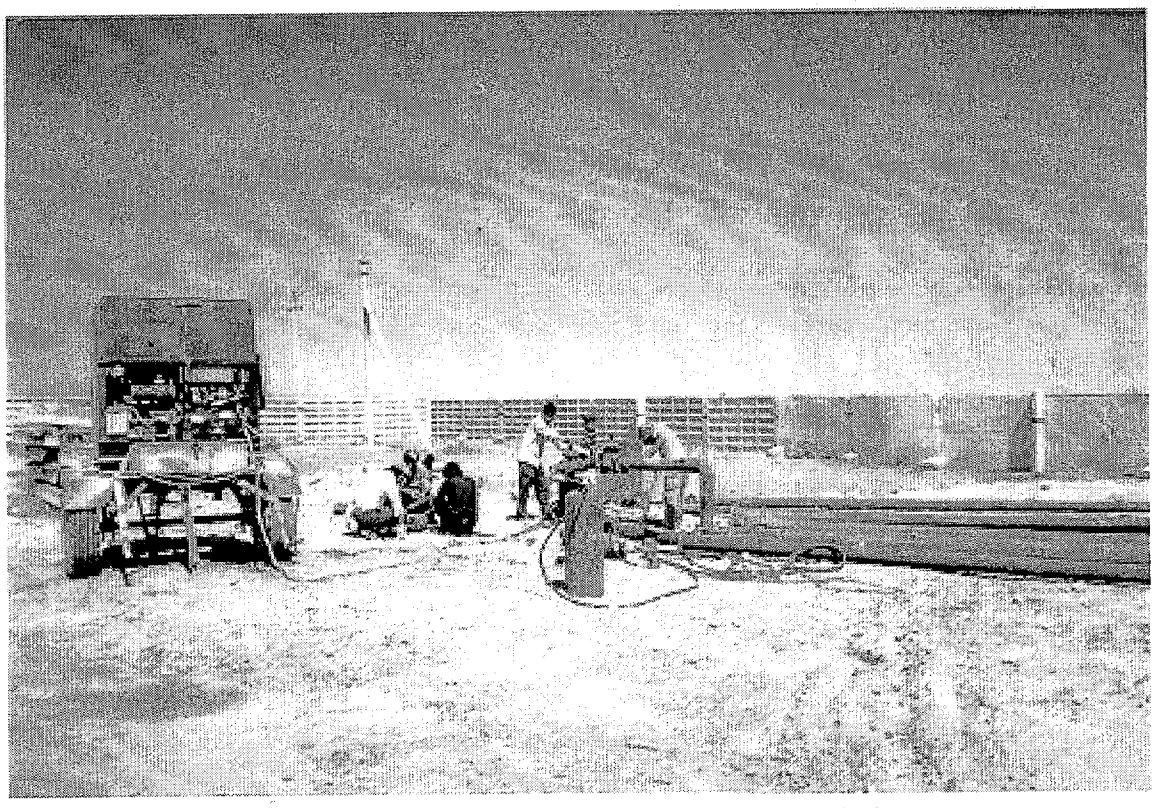

Photo 8: Wellhead assembly near completion.

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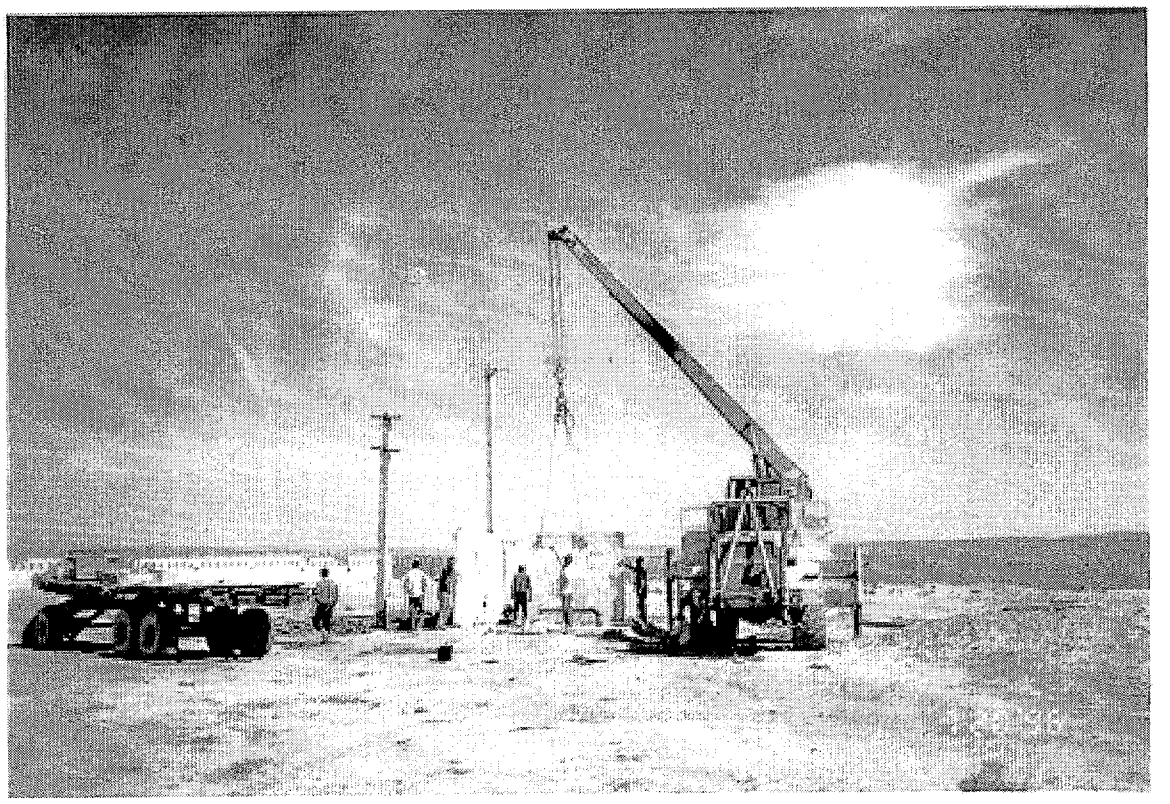

Photo 9: Pump house being reassembled after new pump installation.

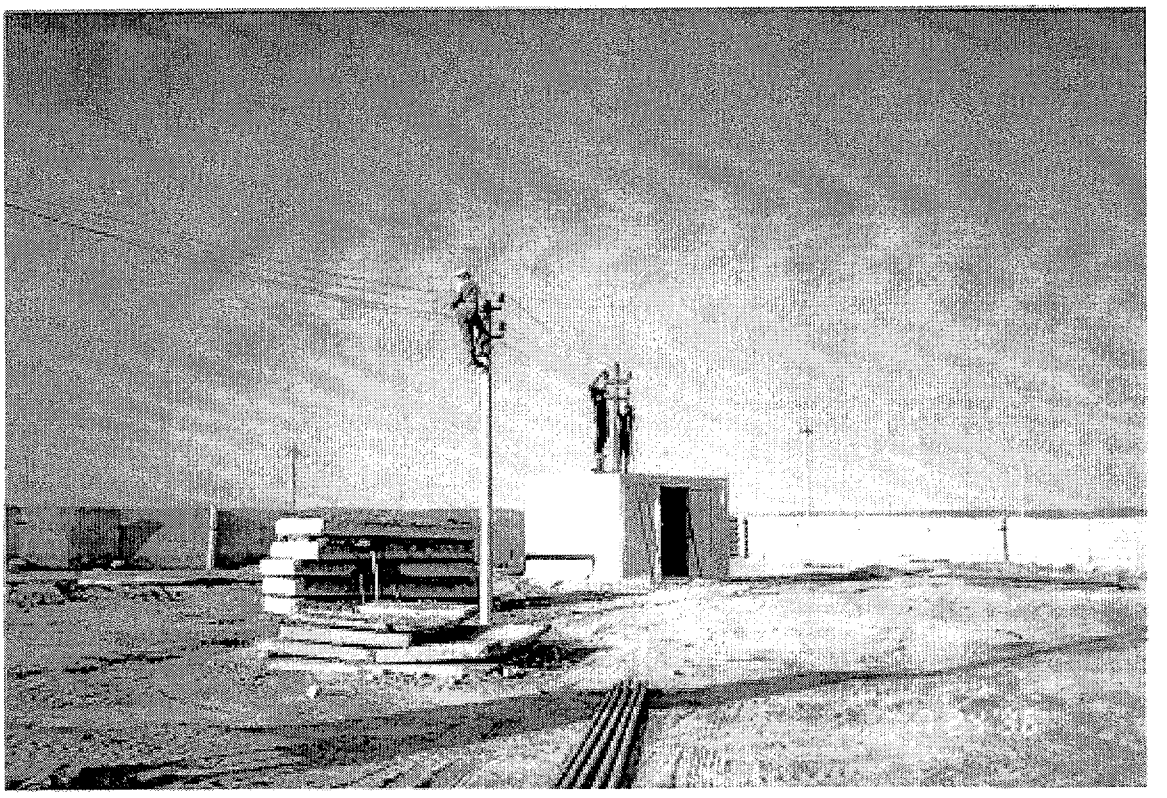

Photo 10: Electrical system being installed.

Appendix B
Kosaman and Berdykol Wellfield Data

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Appendix B
Kosaman Wellfield Data

Well No.	Date	Pump Installed	Pump Operational	Flow Rate (gpm)	Static WL (ft bgs)	Pumping Water Level (ft bgs)	Drawdown (feet)	Specific Capacity (gpm/ft)	Efficiency (assumed 100 % Efficiency is SC=15 gpm/ft)	Sand (ppm)	Current (amps)	Pressure at wellhead (psi)	Well Depth Measured** (ft)	Well Depth as Constructed (ft bgs)	Telescope Depth as Constructed (ft bgs)	Remarks
Well- 1	Jun-95	N	N									s				Pump never installed.
	Sep-95	Y	Y	295	66	130	64	4.6	31%	265	63	10	725			300 gpm installed (9/22/95), sanding.
	Jun-96	Y	Y	125	66*	94	28	4.4	29%	5			703			Pump pulled, reduced Q from leaks in riser pipe?
	6/22/96	Y	Y	174	66	111	45	3.9	26%							150 gpm installed, pumping to waste.
	7/22/96	Y	Y	150						0						Pumping to system, no sand, a few flakes of rust.
Well- 2	Jun-95	Y	Y	420	66*	100	34	12.3	82%							
	Sep-95	Y	Y	290							52					Smooth pump, replaced in 1994.
	Jun-96	Y	Y		61	80				<5		10				Possibly pumping air and water.
	9/4/96	Y	Y	427.4	57	85.4	28.3	15.1	101%	20	32					Pump replaced, 350 gpm installed, pumping to system.
Well- 3	Jun-95	Y	Y		69											Sand problems?
	Sep-95	Y	N													Pump shuts off in <2 min, possible sanding problems.
	Jun-96	Y	Y	440	62	97	35	12.7	85%	200						Excessive sand.
Well- 4	Jun-95	Y	Y	275	65*	87	22	12.6	84%							
	Sep-95	Y	Y	210							50					Smooth pump.
	Jun-96	N	N		65								562.7			Open hole, pump and motor dropped in well.
	8/20/96	N	N	316.6	54	73	19	16.7	111%	High						Pump removed, airlift measurements.
	8/22/96	Y	Y							0.5						350 gpm w. separator installed, pumping to system.
Well- 5	Jun-95	Y	Y													Sounder getting stuck.
	Sep-95	Y	N	?							58					Problems with pump shutting off.
	Jun-96	Y	Y	375	65*	90	25	15.1	100%	200						Repairs made w. US cable.
	8/10/96	Y	N													Black water w. H2S odor, pump shutting off.
Well- 6	Jun-95	Y														Caved floor.
	Sep-95	Y	Y	288							62					
	Jun-96	N	N		66								520			Pump and motor dropped in well.
	8/13/96	N	N	118.7	66	69.5	3.5	33.9	226%	High			708			Pump removed, airlift measurements, WL's suspect.
	8/15/96	Y	Y							40						350 gpm w. separator installed, pumping to system.

Appendix B
Kosaman Wellfield Data

Well No.	Date	Pump Installed	Pump Operational	Flow Rate (gpm)	Static WL (ft bgs)	Pumping Water Level (ft bgs)	Drawdown (feet)	Specific Capacity (gpm/ft)	Efficiency (assumed 100 % Efficiency is SC=15 gpm/ft)	Sand (ppm)	Current (amps)	Pressure at wellhead (psi)	Well Depth Measured** (ft)	Well Depth as Constructed (ft bgs)	Telescope Depth as Constructed (ft bgs)	Remarks
Well- 7	Jun-95	Y	Y													Sounder getting stuck, sanding.
	Sep-95	Y	Y	370							67					Sanding problems, pump replaced in Nov. 1994.
	Jun-96	N	N		66								556.1			Open hole.
	8/3/96	N	N	267.2	71	88.3	17.3	15.4	103%	High						Airlift measurements.
	9/4/96	Y	Y	350	59	97.5	38.2	9.2	61%	10	31					350 gpm w. separator installed, pumping to system.
Well- 8	Jun-95	N	N													Never had pump.
	Sep-95	N	N		66											Never had pump.
	Jun-96	N	N		65								769			Never had pump.
	7/30/96	N	N	316.6	65	95	30	10.6	70%	High						Airlift measurements.
	7/31/96	N	N	238	75	93	18	13.2	88%	High						Airlift measurements.
	9/4/96	Y	Y	395.8	59	94.6	35.3	11.2	75%	High	33					350 gpm with separator installed, pumping to system.
Well- 9	Jun-95	N	N		68											Never had pump, suspect telescope at 550 ft bgs.
	Sep-95	N	N		68								775			
	Jun-96	N	N		66								556.1			Never had pump.
	8/9/96	N	N	292.9	66	87	21	13.9	93%	V. High						Airlift measurements.
	8/13/96	Y	Y							75						150 gpm installed, pumping to system.
Well- 10	Jun-95	Y	Y	387	65*	93	28	13.9	92%							
	Sep-95	Y	Y	356						90	55	18				Smooth pump.
	Jun-96	Y	Y	344	65	88	23	15.1	101%	5						
Well- 11	Jun-95	Y	Y	260	65*	102	37	7.0	47%							
	Sep-95	Y	Y	290	66	94	28	10.4	69%	10	66	15	762.5			300 gpm installed (9/19/95).
	Jun-96	Y	Y	205	66*	90	24	8.5	57%	4						Pump working fine.

Appendix B
Kosaman Wellfield Data

Well No.	Date	Pump Installed	Pump Operational	Flow Rate (gpm)	Static WL (ft bgs)	Pumping Water Level (ft bgs)	Drawdown (feet)	Specific Capacity (gpm/ft)	Efficiency (assumed 100 % Efficiency is SC=15 gpm/ft)	Sand (ppm)	Current (amps)	Pressure at wellhead (psi)	Well Depth Measured** (ft)	Well Depth as Constructed (ft bgs)	Telescope Depth as Constructed (ft bgs)	Remarks
Well- 12	Jun-96	N	N		64								768			Never had pump.
	8/10/96	N	N	223	64	91	27	8.3	55%	High						Airlift measurements.
	8/12/96	N	N	242.2	64	86	22	11.0	73%	High			763			Airlift measurements.
	9/4/96	Y	Y	284.9	60	93	33	8.7	58%	25	32					350 gpm w. separator installed, pumping to system.
Well- 13	Jun-95	Y	Y											787	525	
	Sep-95	Y	?													Leakage back into well through backflow valve.
	Jun-96	N	N		62								513.4			Open hole, well filled with sand per Chingis.
	8/14/96	N	N	234.3	61	113	52	4.5	30%	Low						Airlift measurements.
	8/15/96	N	N	223.2	61	108	47	4.7	32%	Low						Airlift measurements.
	9/3/96	Y	Y	348.7	67					0	32					350 gpm installed, pumping to system, cannot get WL's.
Well- 14	Jun-95													771	492	
	Sep-95	Y	?													
	Jun-96	Y	Y	265	62*	76	14	18.9		<5		9				WL's suspect, leaking riser pipe?
	9/3/96	Y	Y	348.7	67	116	49.7	7.0	0.468	<5	32					350 gpm installed, pumping to system.
Well- 15	Jun-95	Y	Y											784	443	Sounders getting stuck.
	Sep-95	Y														Control panel missing.
	Jun-96	Y	Y	100		61				<5						Leak in riser pipe at 30 ft, WL's suspect.
Well- 16	Jun-95	N	N		57									787	558	Open hole.
	Sep-95	N	N		56								500**			Pump Broken off in well, not able to get past 500 ft bgs .
	Jun-96	N	N		59								495**			Open hole.
	8/17/96	N	N	209	59	102	43	4.9	32%	Nil						Dropped pump removed, airlift measurements.
	8/20/96	N	N	284.9	59	104	45	6.3	42%	Low						Well treated with acid, airlift measurements.
	8/21/96	Y	Y													350 gpm w. separator installed.
Well- 17	Jun-95	N	N											787	518	Open hole, well pumps dry.
	Sep-95	N	N		54								460			Open hole, possibly filled with sand.
	Jun-96	N	N		55								452.8			
	8/21/96	N	N	253.3	66	107	40.5	6.3	42%	High			741.5			Airlift measurements.
	8/26/96	N	N	223.2	66	101	35	6.4	43%	Low						Well treated with acid, airlift measurements.
	8/28/96	Y	Y							0						350 gpm w. separator installed.

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Appendix B
Kosaman Wellfield Data

Well No.	Date	Pump Installed	Pump Operational	Flow Rate (gpm)	Static WL (ft bgs)	Pumping Water Level (ft bgs)	Drawdown (feet)	Specific Capacity (gpm/ft)	Efficiency (assumed 100 % Efficiency is SC=15 gpm/ft)	Sand (ppm)	Current (amps)	Pressure at wellhead (psi)	Well Depth Measured** (ft)	Well Depth as Constructed (ft bgs)	Telescope Depth as Constructed (ft bgs)	Remarks
Well- 18	Jun-95													787	558	
	Sep-95	N	N		45								755			Open hole.
	Jul-96	N	N	253.1	61	116	55	4.6	31%	Low			754.6			Airlift measurements.
	7/18/96	N	N	167	67*	97	30	5.6	37%	High			748			Well treated with acid, WL's suspect, airlift measurements.
	7/30/96	Y	Y	205.8	68	98	30	6.8	45%	10	14					150 gpm installed, pumping to system.
Well- 19	Jun-95	N	N		57									774	335	
	Sep-95	N	N		54								290**			Open hole.
	Jun-96	N	N		55								280.5			Open hole.
	7/20/96	N	N	169.6	64	107	43	4.0	27%	Low						Cannot remove obstruction, airlift measurements.
	7/31/96	Y	Y	348.3						0	32					350 gpm installed, pumping to system, cannot get WL's.
Well- 20	Jun-95	Y	?		54									761	495	
	Sep-95	Y	?													
	Jun-96	Y	Y		55					V. High		Low	740			Extremely low pressure at wellhead, No WL's.
	8/29/96	N	N													Remove pump. Well pumps sand, should be abandoned.
Well- 21	Jun-95	N	N		54									804	502	Open hole.
	Sep-95	N	N		50								490**			Open hole.
	6/30/96	N	N	219.5	53	99	46	4.7	32%	Nil			482**			Airlift measurements.
	7/26/96	N	N	220	53	85	32	6.9	46%	Nil						Well treated with acid, airlift measurements.
	9/15/96	Y	Y	411.6	61	108	47	8.8	58%	0	33					350 gpm installed, pumping to system.
Well- 22	Jun-95													787	525	
	Sep-95	N	N													Open hole.
	7/5/96	N	N	152	54	127	73	2.1	14%	Nil			512**			Airlift measurements.
	7/6/96	N	N	182.3	54	132	78	2.3	16%	Nil						Final airlift measurements, obstruction at 512 ft.
	7/30/96	Y	Y	190	64						14					150 gpm installed, pumping to system.
Well- 23	Jun-95	Y	?													
	Sep-95	Y	Y	295							54					
	6/11/96	Y	Y	302	51	108	57	5.3	35%	Nil						
	8/27/96	Y	Y	443.2						1	33					350 gpm installed, pumping to system, cannot get WL's.

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Appendix B
Kosaman Wellfield Data

Well No.	Date	Pump Installed	Pump Operational	Flow Rate (gpm)	Static WL (ft bgs)	Pumping Water Level (ft bgs)	Drawdown (feet)	Specific Capacity (gpm/ft)	Efficiency (assumed 100 % Efficiency is SC=15 gpm/ft)	Sand (ppm)	Current (amps)	Pressure at wellhead (psi)	Well Depth Measured** (ft)	Well Depth as Constructed (ft bgs)	Telescope Depth as Constructed (ft bgs)	Remarks
Well- 24	Jun-95	Y	Y	410	50*	110	60	6.8	45%							
	Sep-95	Y	Y	412						4	57					New pump installed in Sept. 1994. Prev. pump lasted 2 yrs.
	6/11/96	Y	Y	428	49	112	63	6.8	45%							Appears to be producing no sand.
	8/27/96	Y	Y	348.3	68	114	46	7.6	50%	2	32					Pump replaced, 350 gpm installed, pumping to system.
Well- 25	Jun-95	Y	Y	332	50*	147	97	3.4	23%		54					
	Sep-95	Y	N													Check valve leaking, 11 meter pump column.
	Jun-96	Y	Y	414	48	119	71	5.8	39%	>500						Valve at wellhead broken, water going into well (swl=15ft).
	7/30/96	N	N	190	54	112	58	3.3	22%	High			574.2			Airlift measurements.
	7/31/96	N	N	221.6	54	116	62	3.6	24%	High						Airlift measurements.
	8/1/96	N	N	224	54	106	52	4.3	29%	High						Airlift measurements.
	8/30/96	Y	Y	150.4	80	94	14.5	10.4	69%	35						150 gpm installed, pumping to system.
Well- 26	Jun-95	N	N		52											Open hole.
	Sep-95	Y	Y	382	46	85	39	9.9	66%	>500	58	9	550			300 gpm installed (9/12/95).
	Jun-96	Y	N		47								531			Pump removed 6/96, electrical problems.
	8/5/96	N	N	250.1	62	88	26	9.7	65%	V. High						Airlift measurements.
	8/7/96	N	N	270.2	62	81	19	14.2	95%	High						Final airlift measurements.
	8/30/96	Y	Y	300.8	75	109	34	8.8	59%	75						350 gpm w. separator installed, pumping to system.
Well- 27	Jun-95	N	N													Open hole.
	Sep-95	N	N		47											Open hole, no electric control panel.
	6/30/96	Y	Y	240	47	88	41	5.8	39%	>500						Initial water black with H2S odor, clears after 30 min.
	7/10/96	Y	Y	231	49	81	32	7.2	48%	5			675		494	Motor/pump failed 7/11/95. Pump pulled on 7/12/95.
	7/25/96	N	N	284.9	57	82	25	11.2	75%	High						Airlift measurements.
	8/30/96	Y	Y	364.1						13						350 gpm w. sep., pumping to system, cannot measure WL's
Well- 28	Jun-95	Y	Y	176	45*	65	20	8.7	58%							
	Sep-95	Y	N	38							56					Faulty valve may be restricting pump flow, broke 9/95.
	6/30/96	N	N	307	46	77	31	9.9	66%	High			478			Dropped pump removed, airlift measurements.
	7/8/96	Y	Y	426	56	91	35	12.2	81%	Low	33					350 gpm w. separator installed, pumping to waste.
	8/30/96	Y	Y	443.2	69	103	33	13.3	89%	0						Pumping to system.

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Appendix B
Kosaman Wellfield Data

Well No.	Date	Pump Installed	Pump Operational	Flow Rate (gpm)	Static WL (ft bgs)	Pumping Water Level (ft bgs)	Drawdown (feet)	Specific Capacity (gpm/ft)	Efficiency (assumed 100 % Efficiency is SC=15 gpm/ft)	Sand (ppm)	Current (amps)	Pressure at wellhead (psi)	Well Depth Measured** (ft)	Well Depth as Constructed (ft bgs)	Telescope Depth as Constructed (ft bgs)	* Remarks
Well- 29	Sep-95	N	N		51											Open hole.
	Jun-96	N	N		46								629**			Open hole.
	7/20/96	N	N	185	52	109	57	3.2	22%	High						Airlift measurements.
	7/22/96	N	N	260	52	110	58	4.5	30%	High						Airlift measurements.
	7/31/96	Y	Y	300	54					V. High						350 gpm w. separator installed, pumping to waste.
	8/28/96	N	N													Pump removed, defective well, high sand and clay
Well- 30	Jun-95	N	N		43											
	Sep-95	N	N										350**			Open hole, pump broken off in well.
	7/4/96	N	N	333	44	72	28	11.7	78%	High			282**			Dropped pump removed, airlift measurements.
	7/24/96	Y	Y	425	47	88	41	10.3	69%							350 gpm w. separator installed, pumping to waste.
	8/27/96	Y	Y	427.4	54	86	32	13.2	88%	5	32					Pumping to system.

*Assumed static water level.

**Maximum depth obtainable with bottom sounder

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Appendix B
Berdykol Wellfield Data

Well No.	Date	Pump Installed	Pump Operational	Flow Rate (gpm)	Static WL (ft bgs)	Pumping Water Level (ft bgs)	Drawdown (feet)	Specific Capacity (gpm/ft)	Efficiency (assumed 100 % Efficiency is SC=15 gpm/ft)	Sand (ppm)	Current (amps)	Pressure at wellhead (psi)	Well Depth Measured** (ft)	Well Depth as Constructed*** (ft bgs)	Telescope Depth as Constructed (ft bgs)	Remarks
Well- 1	Jun-95	N	N		58											Pump column collapsed inside the casing.
	Sep-96	N	N		69								77			Pump and motor dropped in well, no transformer.
	9/11/96	N	N	61.6	68	153	84	0.7	5%							Unremoveable obstruction, well abandoned.
Well- 2	Jun-95	Y	Y	180												Well pumped to system, cannot measure WL's.
	Sep-95	Y	N		59											
	9/10/96	N	N	211	59*	101	42	5.0	33%							Airlift measurements.
	9/11/96	N	N	218	59*	104	45	4.9	32%	Medium						Airlift measurements.
	9/12/96	N	N	204	59*	101	42	4.9	32%	Medium			318			Airlift measurements.
	9/13/96	Y														350 gpm w. separator installed.
Well- 3	Jun-95	Y	Y	148	56*	84	28	5.3	36%							Well pumped to system.
	Aug-96	Y	Y		57	71				High			295			
	9/3/96	N	N	206	57*	80	23	8.9	60%	V. High			532			Airlift measurements, new screen installed.
	9/5/96	N	N	195	57*	82	25	7.8	52%	Medium						Airlift measurements w. new screen.
	9/9/96	Y														350 gpm w. separator installed.
Well- 4	Jun-95	Y	Y	409	59									554	315	Well pumped to system.
	9/5/96	N	N	214	52	92	40	5.3	36%	Low						Airlift measurements.
	9/6/96	N	N	217	52*	91	39	5.6	38%	Low						Airlift measurements.
	9/6/96	Y														350 gpm installed.
Well- 5	Jun-95	Y	Y	53	67									564	282	Well pumped to system.
	8/1/96	Y	?		56								518			
	9/3/96	N	N	174	56*	105	49	3.6	24%	V. High						Obstruction won't allow new screen, well abandoned.
Well- 6	Jun-95	Y	?		79									564	321	Well has significant sanding, settleable matter 20ml/L.
	Aug-96	N	N		66								546			
	8/26/96	N	N	135	66*	81	15	8.9	59%	High						Airlift measurements, cannot install screen, obstruction.
	8/30/96	Y														350 gpm w. separator installed.
Well- 7	Jun-95	Y	?		74									564	295	Well not connected to system.
	Aug-96	Y	Y	420	65					Medium						Flow rate measured via field method.
	9/16/96	N	N	206	64	97	34	6.1	41%	Low						Airlift measurements.
	9/17/96	N	N	230	64	100	36	6.4	43%	Low						Airlift measurements.
	9/18/96	Y	Y	482	64	146	82	5.9	39%	Low						500 gpm installed.
Well- 8	Jun-95	Y	?		78											Well not connected to system.
	Aug-96	Y	N		67											Pump not electrically connected, no control panel.
	9/14/96	N	N	209	67	95	28	7.5	50%	High						Airlift measurements.
	9/16/96	N	N	209	67	95	28	7.5	50%	High						Airlift measurements.
	9/18/96	N	N	182	67	105	38	4.8	32%	Medium						New screen installed, airlift measurements.
	9/20/96	Y	N	152	65	118	53	2.9	19%	Low						Airlift measurements, 350 gpm w. sep. installed.

*Assumed static water level.

**Maximum depth obtainable with bottom sounder

***Wells 1, 2, 3, 4, 6, 8 were replaced by new wells at similar locations inside surface sumps. Well construction details based on original wells.

Appendix C
References

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References

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New Independent States (NIS)

★ **EPT Regional Offices**

The Environmental Policy and Technology (EPT) Project: Environmental degradation and natural resource mismanagement threaten public health, biodiversity and economic vitality in the New Independent States (NIS). To assist the NIS in alleviating these problems, the U.S. Agency for International Development (USAID) began the EPT Project in 1993. EPT provides technical assistance and policy advice in the environmental sector and promotes environmentally sound economic development through public and private, U.S. and NIS partnership. The EPT Project is managed by USAID with support from the U.S. Environmental Protection Agency (USEPA). For assistance in project design, management and implementation, USAID has agreements with CH2M HILL International, Harvard Institute for international Development and ISAR. As the primary EPT contractor, CH2M HILL International has the lead role in delivering technical assistance, logistical support and policy support for selected projects. EPT Regional Offices are located in Washington, D.C.; Moscow, Russia; Kiev, Ukraine; and Almaty, Kazakstan.

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