PN-ACD-125

Environmental Policy and Technology Project

For the New Independent States
of the former Soviet Union

Prepared for
Bureau for Europe and the New Independent States
U.S. Agency for International Development

By
A USAID Project Consortium Led by CH2M HILL

Environmental Policy and Technology Project

Contract No CCN-0003-Q-09-3165-00

UKRAINE

Summary of Interim Data on the Current System of Lviv Vodokanal

Delivery Order #09, Task U2
August 1997

Prepared for
U S Agency for International Development
Regional USAID Mission to Ukraine, Belarus & Moldova

Bureau for Europe & the New Independent States
Office of Environment, Energy & Urban Development
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PREFACE

Under the 1992 Freedom Support Act the United States Congress initiated a program to provide various forms of assistance to new independent states (NIS) of the former Soviet Union Cooperative Agreements were signed between representatives of the U S government and each country in which assistance was to be undertaken The U S Agency for International Development (USAID) was given the responsibility to coordinate all U S government assistance to the NIS under the Act

Through competitive bidding USAID awarded a multi-year contract to a team managed by CH2M HILL International Services Inc (CH2M HILL) to support implementation of an environmental assistance program to republics of the former Soviet Union Under this contract termed the Environmental Policy & Technology (EPT) Project CH2M HILL is to as sist USAID s missions in Moscow Kyiv and Almaty undertake a program to promote environmental improvements in the NIS The USAID mission in Kyiv supports environmental and other assistance programs to Ukraine Belarus and Moldova CH2M HILL established an office in Kyiv from which to perform services in these countries under the EPT Project

This report was prepared as a contractually required deliverable under a contract between USAID and CH2M HILL Although work on this report was conducted in cooperation with the assisted governments and USAID the findings and recommendations are those of the CH2M HILL team They do not necessarily represent official positions of the governments of the assisted countries nor of the United States of America

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- Consortium for International Development
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NOTE ON TRANSLITERATION

Ukrainian personal, institutional, and place names used in EPT documents are transliterated into English from Ukrainian (not Russian), according to the modified U S Library of Congress standard for Ukrainian-to-English transliteration that has been adopted by many Western organizations and publications, including the *Encyclopedia of Ukraine* (University of Toronto Press, 5 vols, 1984-1993) and O Subtelny's authoritative *Ukraine A History* (University of Toronto Press, 1988, 2nd edition 1994), as well as by the Ukrainian Commission on Legal Terminology (Resolution No 9 dated 19 April, 1996)

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ABBREVIATIONS, ACRONYMS & GLOSSARY

atm	atmosphere
BAH	Booz, Allen and Hamilton
CH2M HILL	CH2M HILL International Services, Inc A U S -based international environmental engineering consulting firm under contract to USAID to implement a large component of the EPT Project
COWI	COWI Consultants (Denmark)
DHF	District Heating Facility
DO	Delivery Order
e g	for example
EPT	Environmental Policy & Technology (Project) A USAID-funded program to provide environmental assistance to New Independent States of the former Soviet Union
h/d	hours a day
hrs	hours
in	inch
kbv	karbovanets (Ukrainian currency, until Sep 96)
konto	Vodokanal customer account based on a water supply connection
kWh	kilowatt hour
lcd	liters per capita per day
lch	liters per capita per hour
l/d	liters per day
l/h	liters per hour
l/s	liters per second
LVK	Lviv Vodokanal (municipal public water utility)
m/s	meters per second
m^2/s	square meters per second
m^3/d	cubic meters per day
m^3/h	cubic meters per hour
m^3/s	cubic meters per second
m^3/y	cubic meters per year
min	minute
N/D	no data
NIS	New Independent States (of the former Soviet Union)
No	number
Nos	numbers
oblast	A government territorial-administrative unit in the former Soviet Union that is still in use following Ukraine's independence A U S analogue would be something between a state and a county
PADCO	Planning & Development Collaborative, Inc A U S -based consulting firm under contract to USAID to implement part of the U S government's assistance program to Ukraine's housing and communal services sector
p/d	per day
PS	Pump Station
psi	pounds per square inch

rpm	revolutions per minute
TDH	Total Dynamic Head
US $ or USD	United States dollar
USD/h	dollars per hour
USD/d	dollars per day
USAID	U S Agency for International Development
vodokanal	A quasi-government agency responsible for municipal water supply and wastewater collection and treatment A U S analogue would be a water utility
WB	World Bank (International Bank for Reconstruction & Development)
ZhEK	A municipal entity responsible for operation and maintenance of houses and multi-apartment buildings owned by city administrations, as well as water, sewerage, gas, electricity, and heating systems within them

Section 1

INTRODUCTION

As part of a United States government bilateral assistance program, the U S Agency for International Development (USAID) is supporting environmental management in Ukraine Under direction from USAID, a consortium led by CH2M HILL International Services, Inc (CH2M HILL) is implementing part of USAID's Environmental Policy & Technology (EPT) Project by undertaking various tasks that have been agreed to by representatives of the governments of both countries

USAID authorized CH2M HILL to perform a series of tasks in Ukraine as part of Delivery Order (DO) No 9 Under Task U-2 (Urban Water Management Demonstration Lviv) of DO #9, CH2M HILL is to assist the local water utility, Lviv Vodokanal (LVK), strengthen its operations and improve service to its customers Task U-2 includes a requirement (Subtask 2 1 - Collect Data on Current System) and (Subtask 2 2 - Evaluate Data on Operations, Repairs and Maintenance) for CH2M HILL to collect data on the existing status, operation, and management of the water system operated by LVK

The Contractor will produce an outline of the basic data that should be collected on a utility system in order to begin to analyze operations and prepare a strategic plan for system improvement This will include the source of water, treatment system, storage, distribution, pressure zones, metering, billing as well as facilities for repair, maintenance, engineering and construction, water quality and financing

Using this guideline and existing, readily available data from the Lviv Vodokanal, the Contractor will characterize (quantity, size, location) the general components of the Lviv water system

Devise a methodology to collect and present data on the critical aspects of the physical facilities, operation, water quality, repair and maintenance of a Vodokanal

Use this methodology to collect and present data for the Lviv system

The methodology shall include an evaluation of the existing operation strategy, capabilities to implement repairs, identify existing constraints to making repairs and present recommendations for improving current repair and maintenance capacity to the level required by the condition of the Vodokanal's facilities

Present the data as contract deliverables in a series of reports

- *Summary of initial data on the current system*
- *Summary of interim data on the current system*
- *Summary of final data on the current system*

This is the second (interim) report in response to USAID's requirement It was prepared using readily available information from Lviv Vodokanal and the Lviv Institute for the Design of Communal Services, as well as field observations Information presented herein focuses on historical development of Lviv's water system, the water supply resource, and water transmission, whereas the first (initial) report presented an overview of water system issues, and well field data The final data report will compile information from the initial and interim reports, as well as further details

An overview of the entire Lviv water system is presented in the report *Ukraine General Schematic of Lviv Water System*, prepared for USAID by CH2M HILL International Services as part of the EPT Project, dated August 1997

Section 2

MAIN COMPONENTS OF LVIV WATER SUPPLY

The city's drinking water source is groundwater pumped from a series of grouped wells (called "wellfields") outside the city perimeter Water from the wellfields is conveyed to the city in transmission pipelines These pipelines generally terminate at large pump stations at the city boundary, where additional pressure is added in order to distribute water within the city Booster pumps and storage tanks within the city further assist the delivery of water to residents and other users The entire water system can be characterized by the following major components

- Water source, consisting of
  - a series of wells, grouped into wellfields
  - well pumps
- Water transmission, consisting of
  - transmission pipelines, conveying water from the wellfields to the city perimeter
  - transmission pumps, in pump stations along the transmission lines
- Water distribution, consisting of
  - distribution pumps, in pump stations at the end of the transmission pipelines
  - reservoirs, at distribution pump stations
  - chlorination, which is conducted at the distribution pump stations
  - distribution pipelines (water mains), to deliver water to end-users
  - water tanks, to store water within the city for use during periods of peak water demand
  - booster pumps, to increase water pressure within the distribution system in order to deliver water to customers at higher elevations or remote from the distribution pumps

A schematic of the Lviv water system is presented in Figure 2-1

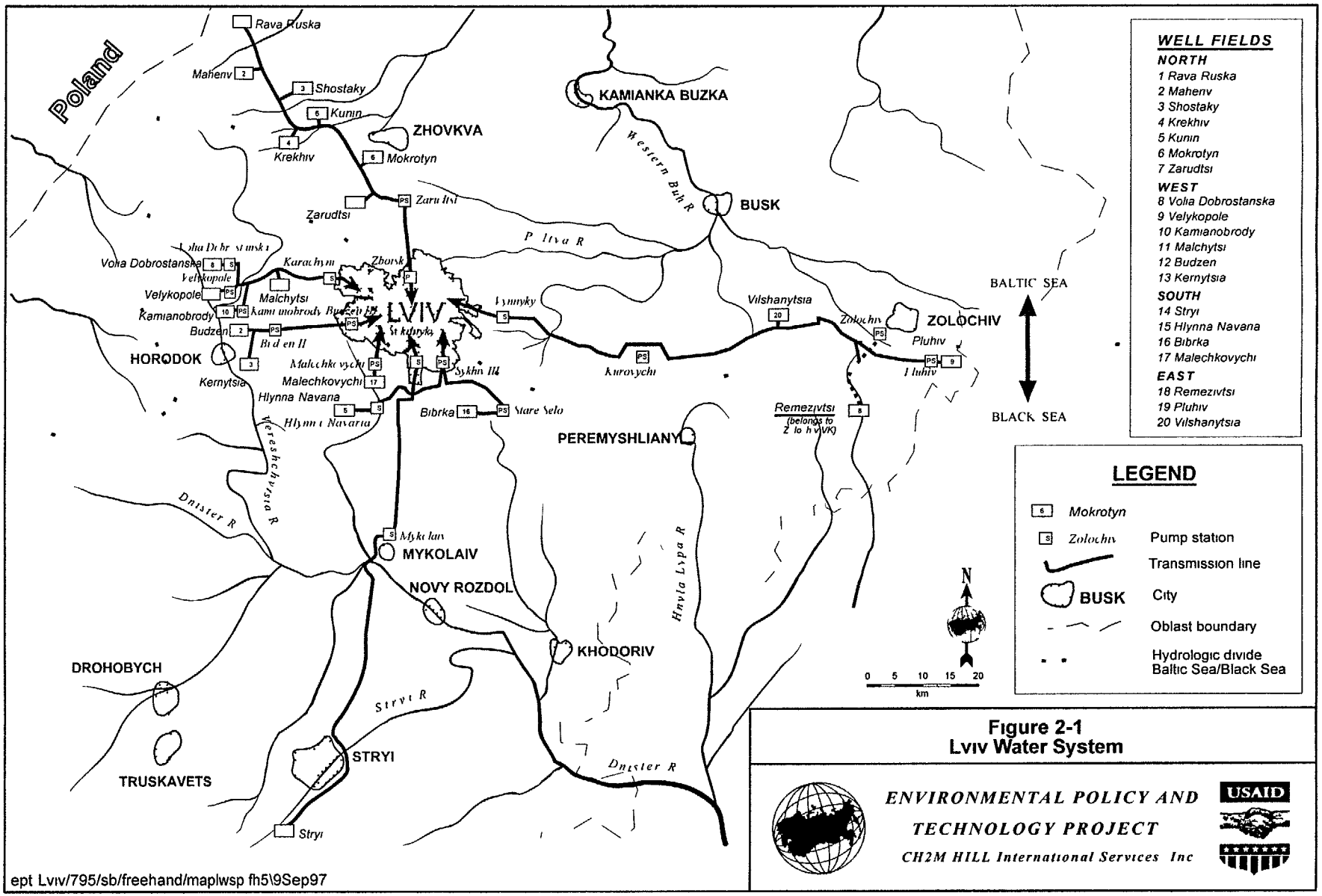

Figure 2-1
Lviv Water System

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept Lviv/795/sb/freehand/maplwsp fh5\9Sep97

Section 3

HISTORICAL REVIEW OF LVIV WATER SUPPLY

The following presents a review of the development of Lviv's water supply system during this century, based upon readily available data

3.1 1900 TO 1945

The first centralized water supply system in Lviv was put into operation in 1901 About 29 km from Lviv, not far from the village of Volia Dobrostanska, some 16 wells were drilled on a strip of land 2 2 km long The wells obtained groundwater from tertiary deposits of lithospheric limestone Pipelines with diameters ranging from 300 mm to 1000 mm transferred the water to a storage tank, from where steam-powered pumps lifted it from an elevation of 280 m via 600-mm diameter iron water mains 34 7 km long, to a reservoir in the lower zone of Lviv This 7,000 m^3 reservoir is situated on Zelena Street at an elevation of 329 m

Due to differences in elevation within the city (272 m to 375 m), the water distribution system was divided into zones A 3,000 m^3 reservoir was built for the highest zone (average elevation 357 m) where water was pumped directly from the 600-mm water mains by the Miska Smuha pump station (PS) The steam-powered pumps operated until 1926, when they were replaced by electrical centrifugal pumps

Until 1935 the Volia Dobrostanska PS used three steam pumps They pumped 18,000 m^3/d In 1925, in the village of Shklo, a second well field was built collecting waters under the Shklo River bed by means of a tunnel The Shklo PS pumped water via two 300-mm and 350-mm water mains 7 3 km from an elevation of 264 m to the Volia Dobrostanska PS tank

A 30 m gravity difference in elevation, at the halfway point of the two supply lines, was used to advantage to drive a water turbine at the local electric station

The Shklo well field, including an artesian well drilled in 1929, produced about 10,000 m^3/d

In 1928 the third Lviv well field was built near the village of Velykopole, which is situated 2 6 km from Volia Dobrostanska Using screw pumps powered by locomotive engines, 6,500 m^3/d of water was pumped from its wells (elevation 278 m) to the transmission lines that started in Volia Dobrostanska

To pump 34,500 m^3/d in the 600-mm supply lines it was necessary to create a pressure of more than 10 atmospheres (atm), which resulted in breakdown of pipe joints To alleviate this problem, the Karachyniv PS was built about 20 km from Volia Dobrostanska On the site of the pump station an intermediate 500-m^3 tank was established which received water from the well fields and then transmitted it to Lviv

During 1931-1935 all pump stations in the Lviv well fields were electrified and the steam engines phased-out At that time, rapid development of the city required that the districts of Novy Lviv, Verkhni Lychakiv and Pasika, as well as the upper part of Yanivska St and Bohdanivka St , were supplied with water too Thus in 1932 several construction projects were begun, including the following

- A water tower in Novy Lviv district (120-m^3 tank, the bottom elevation 373 m), the Miska Smuha PS (installation of the second group of pumps with higher pressure with a servomotor for regulating pressure in the water mains system) and a new 2 6 km long 200-mm main All these were put into operation in 1933

- A water tower in Pasika district (120-m^3 tank, the bottom elevation 397 m), an automatic pump station in Lychakivska St , and a 3 75 km long 150-mm main from the pump station to the water tower The water was pumped by the pump station straight from the elevated zone into the water tower

- A new booster station in Yanivska St , and a 1 45 km long 350-mm water main along Piratska St (Zaliznychna St , Stepana Bandery St) The pump station took water from the 600-mm principal main and pumped it into the elevated zone, both to provide high pressure there and also to reduce pressure on the principal water mains

This rapid development of the Lviv water supply system was finished in 1936 with the construction in the lower zone of another 12,000-m^3 reservoir which is situated on Zelena St near the Miska Smuha PS In 1939 the total length of the water mains within the Lviv city limits was 202 5 km The average water consumption was 23,780 m^3/d and the maximum water consumption reached 33,100 m^3/d

The population of Lviv at that time was 318,090, thus the average water consumption was 74 8 liters per capita per day (lcd)

3 2 1945 TO THE PRESENT

During the Second World War the Karachyniv, Yaniv and Lychakiv pump stations were completely destroyed and the water supply was based on small sources within the city limits (Spartak, Pohulianka, Zalizna Voda, Marunk), the productivity of which was 5,500 m^3/d The city found itself in a very difficult situation because of the poor water system In 1945 the pump station were reconstructed and the water supply was resumed at the rate of 33,100 m^3 /d for a population of 165,000 people The average daily water use was 201 lcd

In 1952 a new well field was built in Kamianobrody There, 15,000 m^3 /d of water was pumped from four wells and transmitted to the Kamianobrody PS From there it was pumped directly to the Volia Dobrostanska PS via a 4 5-km long 600-mm diameter cast iron main At the same time, another 600-mm cast iron water main was built which delivered water 22 km to the Yaniv booster station in Lviv In 1956 Budzen well field was built and a new 500-mm diameter main delivered 10,000 m^3/d to the Kamianobrody PS In

1960 a third 600-mm cast iron water main was constructed from the Kamianobrody PS to the Karachyniv PS

At that time it became evident that the water supply sources were lagging behind the growth of housing and industrial construction Between 1950 to 1960 the shortage of water worsened despite the fact that the water supply was increasing In 1958 the water shortage was so serious that the existing 24-hour water supply was reduced to a scheduled water supply in different city districts All operating well fields in 1960 supplied water only into the Karachyniv PS reservoir Since these well fields were situated west of Lviv, this group of fields became known as the western well field group The total quantity of water delivered into the city water supply distribution network was 67,000 m^3/d for a population 421,000 people, thus the average water consumption was 160 lcd

During the next five years, reconstruction of the western well field group (Kamianobrody and Budzen) was carried out As a result, 40,000 m^3/d of water was diverted from the Kamianobrody well field to the new Budzen II PS A steel 700-800-900-mm transmission main 18 km long delivered water from the pump station to the western part of the city In 1965 the total city water supply was 105,000 m^3/d for a population of 496,000 people, thus the average water supply was 211 lcd

In 1965 a master plan was developed for Lviv that forecast a significant growth of population and industry The plan anticipated building a chemical plant and a sulphur quarry near the town of Yavoriv, situated in the area of the functioning western well field group Exploitation of the quarry was likely to reduce productivity of the western well fields Therefore it was proposed to start developing the northern well field group as an alternative Also, intensive housing construction was commenced in the southern city area (Stryiska, Volodymyra Velykoho, Kniahyni Olhy, Gasheka Sts) As a result, the population in this district increased to such an extent that in 1968-1971 water had to be transported in by truck Sources of water supply for this area had not been taken into account

At the same time, construction of large enterprises such as the Lviv Bus Plant, an automatic fork lift truck plant, the enterprises Electron, Kineskop, Progres, Svitanok, and others was being carried out at a rapid rate Capital investments into industry were three times higher than in housing construction All the industrial sector took its water from the city water supply distribution system Therefore, beginning in 1965, well fields aimed at developing the northern and southern sources of water were built Due to the need to develop sources outside the city limits, the general water supply system consists of a well field, transmission mains, tank at a pump station, and distribution network within the city

Development details of the northern well field group are presented in Table 3-1 All of this water is delivered to the Zboisk PS in the northern part of the city

Table 3-1 Development of the Northern Well Field Group		
Name of Well Field	**Design Capacity in m^3/d**	**Year of Construction**
Zarudtsi	19 700	1965
Mokrotyn	16,100	1966
Krekhiv	21,300	1970
Maheriv	27,000	1971
Rava Ruska	17 000	1972
Total water supply	**101,000**	

Information regarding development of the southern well field group is presented in Table 3-2 Water from these well fields is distributed in the following way Hlynna-Navaria and Bibrka well fields convey water to the Sykhiv III PS in the south-eastern part of the city, the Stryi well field conveys water to the Sokilnyky PS in the southern part of the city

Table 3-2 Development of the Southern Well Field Group		
Name of Well Field	**Design Capacity in m^3/d**	**Year of Construction**
Hlynna Navaria	19,000	1971
Bibrka	20,000	1973
Stryi	140,000 (100,000 in 1978)	1982
Total water supply	**179,000**	

Development of the western well field group is presented in Table 3-3 Water from these well fields is delivered to the Karachyniv PS and Budzen II PS in the western part of the city They provide water to those parts of the city that were recently developed In 1973, the Shklo well field (10,000 m^3/d) began supplying water to the town of Novoiavorivsk (center of the chemical industry)

Table 3-3 Development of the Western Well Field Group		
Name of Well Field	**Design Capacity in m^3/d**	**Year of Construction**
Malchytsi	21 300	1967
Kernytsia	15 400	1969

In 1975, the total city water supply was 254,000 m^3/d For the population of 629,000 people the average daily water use increased to 404 lcd

Development of the eastern well field group from 1976 to 1989 is listed in Table 3-4 Water from these wells is delivered to Vynnyky PS and then pumped to the Kryvchytsi PS and Dovha PS in the eastern part of the city

Table 3-4 Development of the Eastern Well Field Group		
Name of Well field	**Design Capacity in m^3/d**	**Year of Construction**
Pluhiv	34,000	1982
Remezivtsi	16,000	1989
Vilshanytsia	13,400	1989
Total water supply	63,400	

From 1976 to 1989 there were 200 km of water mains built, 33 9 km within the city network, and outside the city limits the construction of the Budzen III, Vynnyky and Kryvchytsi pump stations and one of the reservoirs at the Dovha site was finished

Meanwhile housing construction was carried out at a fast pace, and development of water works fell behind schedule Consequently the city water supply worsened even though large well fields such as Stryi and Pluhiv were put into operation

In the period between 1989 and 1994 construction of ten new water supply facilities began Verkhniobusky well field (90,000 m^3/d), Pluhiv well field (50,000 - 90,000 m^3/d), reconstruction of the Vynnyky, Budzen II, Zboisk, Dovha, and Kryvchytsi pump stations, and construction of the Dovha-Miska Smuha and Zboisk-Hrinchenka suburb pump stations water mains Due to a shortage of funds, construction of some of the works was stopped

Currently the Lviv water supply system consists of a complex of water facilities consisting of 20 ground well fields situated 10-80 km from Lviv city limits, 20 pump stations, tanks with a total capacity of 145,000 m^3, about 900 km of water distribution network pipelines and about 600 km of water mains

The water system in the city center was developed between 1901-1936 and consists mainly of 300 to 600-mm diameter pipelines made of cast iron, and 700 to 1400-mm pipelines made of steel There is an acute shortage of water in the city and it is supplied according to a schedule (three hours in the morning and three hours in the evening) In 1995, according to Lviv Vodokanal current financial indices, the average daily water supply from Lviv well fields was 405,070 m^3/d The average water consumption was 294,669 m^3/d In 1995 the city population was 805,900 people (366 lcd)

Historical development of the Lviv water system is presented in Figure 3-1

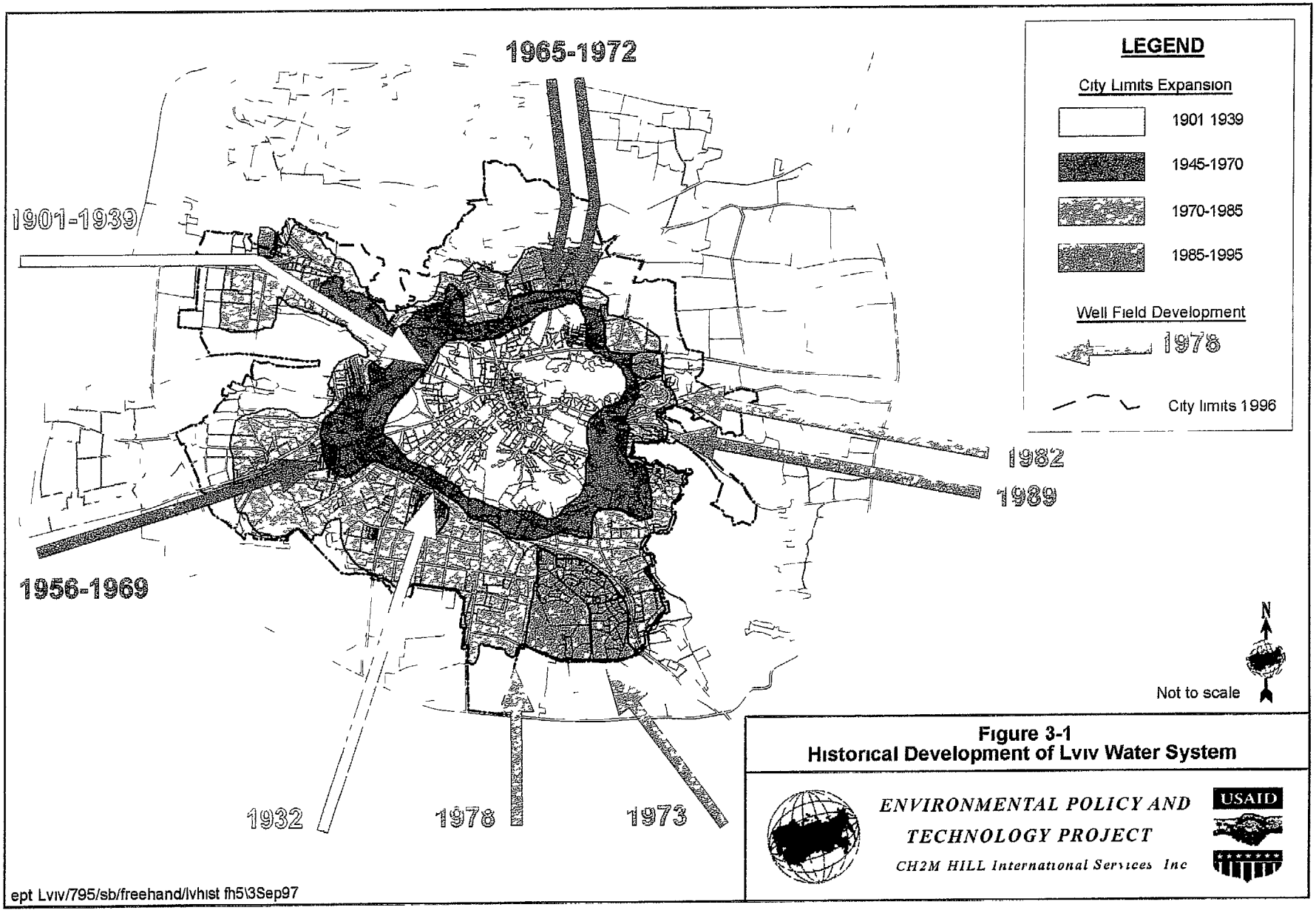

Figure 3-1
Historical Development of Lviv Water System

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CH2M HILL International Services Inc
USAID

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Section 4

LVIV URBAN WATER SUPPLY SOURCE

Information regarding the source of Lviv's water is presented in this section

4 1 GENERAL DESCRIPTION

The Lviv water supply system is a sophisticated engineering complex Its development started about 100 years ago Water production from the well fields has grown from 18,000 m^3/d to 412,000 m^3/d

The Lviv water supply is based on groundwater, which is abstracted from well fields located all around Lviv The oldest well field for the centralized water supply was constructed in 1901, about 29 km to the west of the city The latest well fields were constructed to the east of Lviv in 1989 The locations of the well fields are indicated on the map in Figure 2-1

The city of Lviv draws water from some 173 wells in 20 different well fields The well fields are located at distances of 10 to 80 kilometers from Lviv Based on these locations and the connection they have to the water distribution system, they have been divided into four groups (North, West, South, East) Each group includes the following number of well fields and wells

Group	Well Fields	Wells
North	7	45
West	6	53
South	4	59
East	3	16
Total	20	173

In addition to the city of Lviv, the system supplies water to 90 villages and four towns, located in the zone of influence of the Lviv well fields

Water from 17 of the well fields is within quality norms set by the State Drinking Water Standards (1984) Aggressive carbonic acid and hydrogen sulfide is present in small quantities at the Pluhiv well field Iron is present in the well fields at Remezivtsi and Budzen Total hardness of water in all well fields varies from 8 to 9 mg/l expressed as $CaCO_3$ Some water quality data is presented in Appendix A

The total potential yield of Lviv underground water resources is estimated at 730,000 m^3/d Present design capacity is based on the assumption that water is abstracted from 173 wells and is estimated to be 538,000 m^3/d According to LVK data, the water production in 1995 was 412,000 m^3/d Information on each well field is given in Appendix A of the report *Summary of Initial Data on the Current System of Lviv Vodokanal*

4 2 WELLS

Well design and aquifer characteristics can be divided into the following types, according to the general geological and hydrogeological location of the well fields, the depth of water-bearing strata and water-bearing rock lithology More detailed data covering this information for each well field is presented in Appendix A of the report *Summary of Initial Data on the Current System of Lviv Vodokanal* In general

- all seven northern and two of the eastern well fields draw from upper Cretaceous siltstone and chalk deposits
- all six western and two of the southern well fields draw from Miocene sandstone
- the southernmost field (Stryi) draws from shallow quaternary alluvial complex
- one eastern field (Pluhiv) draws from the middle Devonian limestone interspersed with sand

The summary of depth and the casing used is as follows

Group	Depth (m)	Screen Diameter (mm)
North	60-75	377-426
West	45-85	377-426
South	30-75	426
East	70-200	426

Most wells were constructed using a rotary-wash technique, which tends to negatively affect their operating lifespan Wells of the Stryi southern well field were constructed using a percussion drilling technique

More-detailed data on the design of selected wells and the diameter, total depth and depth to the static and dynamic water surface, are given in Appendix B

4.3 PUMPING EQUIPMENT

All wells have Moldovan-made (Moldavhidromash and Kishiniov) and Ukrainian-made (Electroremontny plant, Sevastopil and Hydromash, Berdiansk) submersible well pumps installed Information on pumps in the Lviv well fields is given in Appendix B

The reliability of the well pumps depends on the manufacturer According to LVK data, Moldavhidromash and Berdiansk pumps are of satisfactory quality Sevastopil pumps, as a rule, are less reliable

The time between repairs of pumps varies from one week to two years, with an average of seven to eight months Pumps are repaired by LVK in their workshops, which are supervised by the chief mechanic When purchasing pumps, LVK tries to obtain the

recommended mechanical and electrical spare parts from the manufacturers The time needed for a typical submersible pump repair is about five weeks This includes a week for dismantling and shipping to the workshop, and up to four weeks for actual repair

4.4 WELL FIELD OPERATION

All well pumps are operated 24 hours a day (when servicable), and deliver water to the transmission pump stations Most of transmission pump stations have water storage tanks, except for Volia Dobrostanska, Velykopole, and Kamianobrody

Well field operation is controlled according to the level of water in transmission pump station storage tanks Well pumps are controlled manually, by partial closing or opening of the valves or switching the pumps on and off, based on the LVK dispatcher's orders Pump throttling causes increased power consumption

Well pumps are controlled by pump station staff, based on ammeter readings Usually there are no functioning water meters or pressure gauges at the well fields Calculation of the amount of water produced is based on power consumption

Pump power supplies are 'second' and 'third' category A second category supply means power is supplied from two independent power sources (Stryi and Pluhiv) A third category supply means power is supplied from one power source

LVK has a team of 176 workers for the operation and maintenance of well fields The number of workers serving each well field group is as follows

Group	Well Fields	Workers
North	7	43
West	6	61
South	4	48
East	3	24
Total	20	176

Hydrogeological investigations for improvement of well operation are not routinely undertaken because LVK has neither a hydrogeological service team nor monitoring wells Lack of maintenance causes frequent stoppages due to various breakdowns at well fields, such as power cuts, pump failures, and the clogging of well screens

Wells are rehabilitated by the LVK when their yield drops The most recently rehabilitated well fields are at Stryi and Hlynna-Navaria, which were rehabilitated in 1996 Hydrodynamic rehabilitation using the principle of electric discharge is reported to improve the yield by 25 to 30 percent for a period of up to one year, depending on the type of aquifer This job requires five workers and takes about three days for a well 30 meters deep

A list of reasons for pump failures over the period from 1993 to 1995 is given in Appendix A of the report *Summary of Initial Data on the Current System of Lviv Vodokanal* Appendix B herein presents data on wells and pumping equipment at well fields Appendix C presents information based upon interviews with well field managers concerning the main problems of well field operation

4 5 MAJOR PROBLEMS

Based on discussions with well field managers, and an analysis of well field conditions, their operation and measurements, the following major well field problems have been identified

1 **Low well field production** The present production of the northern and western well fields (Karachyniv subsystem) is 50% lower than their design capacity, the safe yield

2 **Flow meters do not exist at well fields** Measurements of water produced are based on power consumption This method may not be correct since well production reduces with time, while power consumption remains at the same level Throttling pumps with valves distorts the relationship between power and production

3 **Not enough money is spent on well field maintenance** Insufficient means are available for well field maintenance, rehabilitation and repair, which leads to frequent down time and low water production

4 **Well fields are not efficient as a result of poor design and/or reconstruction** Pump characteristics at some well fields do not achieve the most efficient mode of work Well screens are of low quality The range of pumps available is not wide enough to provide efficient operation of well fields

5 **Water quality factors** The quality of water is generally acceptable Iron is a problem in the well fields at Budzen, Bibrka and Remezivtsi, and there is some treatment at the latter two locations only Aggressive water is a problem in Pluhiv To avoid corrosion the water is air stripped just after reaching the surface, but nevertheless causes a number of maintenance problems due to corrosion of the pipes and well casings Ammonium is higher in some wells than the European standards, this is particularly observed in Budzen, and it could be an indicator of contamination Traces of Strontium (Sr) can be found in some well fields, but it does not exceed the norms

Section 5

LVIV WATER TRANSMISSION AND DISTRIBUTION SYSTEM

Information regarding the transmission of water from the well fields to Lviv, and the distribution of water within Lviv, is provided in this section

5.1 GENERAL LAYOUT

In keeping with the location of the well fields, the transmission system is divided into four major subsystems (north, east, south, west), which comprise pipelines, tanks, and transmission pump stations Water is transmitted to the Lviv city distribution system using conventional means well - transmission line - tank - transmission pump station - transmission line - tank - city pump station The location of the major water transmission lines is presented in Figure 5-1

When designing transmission mains it was assumed by LVK that the capacity of all well fields is equal to the safe yield plus 50 percent of the added yield, and that all this water is pumped further by transmission pump stations The standard velocity for transmission mains is 0 8 to 1 8 m/s, and optimum velocity for the majority of pipes is 1 2 to 1 3 m/s In actuality, most of the well fields actually produce less water than their design capacity yield Under such conditions velocity in the transmission mains is generally less than 1 m/s

Transmission pipes are made of steel, cast iron and reinforced concrete with diameters of between 500 and 1400 mm The diameter and the material often vary even on the same transmission main, since supply shortages during construction resulted in using whatever diameter and material could be obtained at the time

Approximately 90 villages and towns with a total population of about 67,000 inhabitants are supplied directly from the Lviv transmission lines Locations of the largest villages supplied in this way are shown at Figure 5-2

The city of Lviv receives water from the transmission system through seven major city pump stations located around the city perimeter These pump stations add pressure to ensure water distribution around the city network The total volume of water tanks located at the city and booster pump station sites, plus the volume of gravity tanks, is 141,000 m^3 This volume constitutes over 40 percent of average daily consumption

5.2 TRANSMISSION MAINS

Table 5-1 presents a classification of transmission mains according to pipe material, pipe diameter and construction period

5.2.1 Transmission Systems

The four major water transmission systems are outlined below

5 2 1 1 The Northern System

This system includes transmission mains that were constructed during the period 1965-1973, totaling approximately 102 km Pipe diameters vary in the range of 200 to 400 mm for the feeder pipelines and 500 to 1000 mm for the transmission mains Transmission pipes are made of steel, cast iron and reinforced concrete Tees for the village supply utilize cast iron pipes of 100 to 200 mm in diameter that are connected directly to the transmission mains without flow meters or reducing valves

5 2 1 2 The Western System

This system includes two major transmission mains Karachyniv and Budzen

5 2 1 2 1 The Karachyniv System

These transmission mains were constructed during the period 1901-1935 with additional work in 1965, totaling approximately 83 km, pipe diameters are 350 and 600 mm The transmission mains constructed during this period utilize British- and Polish-made cast iron pipes that have lead caulked socket ends The transmission mains constructed in 1965 utilize Soviet made steel pipes of 600 mm diameter Tees for the village supply utilize cast iron pipes of 100 to 150 mm in diameter that are connected directly to the transmission mains without flow meters or throttling valves

5 2 1 2 2 The Budzen System

These transmission mains were constructed in 1964, totaling approximately 18 km, pipe diameters vary in the range of 700 to 900 mm Transmission pipes are made of steel and cast iron Tees for the village supply utilize cast iron and steel pipes of 100 to 150 mm diameter that are connected directly to the transmission mains, without flow meters or throttling valves Tees to the towns of Horodok, Rudky, and Liuben Velyky utilize steel pipes of 200 to 400 mm in diameter

5 2 1 3 The Southern System

This system includes four major transmission mains Malechkovychi, Hlynna-Navaria, Sokilnyky, and Stare Selo

5 2 1 3 1 The Malechkovychi System

These transmission mains were constructed in 1932, totaling approximately 14 km, pipe diameter is 225 mm The transmission mains utilize Polish-made steel pipes Tees for the village supply utilize steel pipes of 100 mm in diameter that are connected to the transmission mains, without flow meters or throttling valves

5 2 1 3 2 The Hlynna-Navaria System

This transmission main was constructed in 1971, totaling approximately 14 5 km, pipe diameters vary in the range of 600 to 700 mm Transmission pipes are made of steel Tees for the village supply utilize steel pipes of 100 mm in diameter that are connected directly to the Hlynna-Navaria pump station without flow meters

5 2 1 3 3 The Sokilnyky System

This transmission main was constructed in 1989, totaling approximately 75 km, pipe diameter is 1200 mm Transmission pipes are made of steel Villages are supplied directly from the two wells at the Stryi well field and cast iron pipelines of 100 to 150 mm in diameter transfer water to the rural water distribution network

5 2 1 3 4 The Stare Selo System

This transmission main was constructed in 1973, totaling approximately 15 9 km, pipe diameter is 600 mm Transmission pipes are made of steel Tees for the village supply utilize steel pipes of 100 mm in diameter that are connected directly to the Stare Selo pump station without flow meters

5 2 1 4 The Eastern System

These transmission mains were constructed during the period 1982-1990, totaling approximately 109 km, pipe diameters vary in the range of 700 to 1200 mm Transmission pipes are made of steel and reinforced concrete Tees for the village supply are connected directly to the pump station and utilize steel pipes of 100 to 200 mm in diameter without flow meters or throttling valves

5 2.2 Breakdown Frequency

Based on assessments made by LVK, the condition of the 458 km of transmission mains can be classified as follows

- bad condition, needing frequent repair 117 km or 26%, constructed mainly during the period 1945-1975
- acceptable condition 128 7 km or 28%
- good condition 212 3 km or 46%

The reinforced concrete transmission mains are in the most urgent need of rehabilitation or replacement, with the following lines needing highest priority

- Northern system the transmission mains from the Rava-Ruska well field to the Zarudtsi pump station, totaling approximately 34 km of existing pipelines

- Western system the section from the Budzen II pump station to the Budzen III pump station, approximately 18 km long

- Southern system the transmission main from the Stare Selo pump station to the Sykhiv III pump station, approximately 16 km long

None of the pipes of the Lviv water supply system have any lining at all, and most have no outside coating Protective coating on the few pipes that have it is a thin, uneven and perforated layer of bitumen mastic

Figure 5-3 indicates the location of breakages along the transmission mains during the past three years The consequence of a breakage is that the transmission line is put out of operation for repair, for a period of one to three days In the past three years the number of breakdowns and the calculated breakdowns frequency, distributed among the four major transmission systems, have been as follows

- Northern system - 11 breakdowns, corresponding to 0 042/km/py
- Western system - 13 breakdowns, corresponding to 0 061/km/py
- Southern system - 12 breakdowns, corresponding to 0 039/km/py
- Eastern system - 13 breakdowns, corresponding to 0 040/km/py

For transmission systems, the above annual, breakage frequencies are high

The bell and spigot connections at the socket ends are the weak point of the reinforced concrete pipes, caused by construction techniques and by the fragility of the reinforced concrete pressure pipes However, frequent breakdowns are also observed at connections between reinforced concrete pipes and steel pipes Breakdowns are usually repaired by replacing several pipe segments

5.2.3 Village Supply

Approximately 90 villages, with a total population of about 67,000 inhabitants, are supplied directly from the Lviv water supply system The figures include villages with less than 50 inhabitants and towns with populations of over 5,000

Some of these villages are connected directly to feeder pipes from single wells These villages often have very high water pressure, which can exceed what is necessary for a satisfactory supply Other villages are supplied directly from the transmission mains, where the pressure is normally in the range of 1 to 5 atm, which is a satisfactory range According to LVK reported data, the number of villages supplied from the four major water transmission systems, and the amount of water supply, are as follows

- Northern system - 53 villages (about 3,285 m^3/d)
- Western system - 19 villages and towns (about 7,604 m^3/d)
- Southern system - 10 villages, (about 2,450 m^3/d)
- Eastern system - 11 villages and towns (about 5,931 m^3/d)

The total supplied is about 19,270 m^3/d

Rural water distribution pipes are made of cast iron, diameters vary in the range of 100 to 200 mm

5 3 PUMP STATIONS

The various pump stations that move water through the Lviv water supply system can be categorized into transmission, city, and city-booster, stations The general condition of pump station sites can be classified as acceptable, and is presented in Table 5-2 Most pump stations have associated water tanks, with volumes ranging from 100 to 10 000 m^3 (see Table 5-3)

The pump stations are power supplied according to standard Category I, II, or III Category I power supply ensures supply from two independent sources, with mandatory automatic emergency reserve switching equipment on the sectionalizing circuit breaker Category II power supply ensures supply from two independent sources Category III power supply ensures supply from one source

5 3.1 Transmission Pump Stations

All transmission pump stations, when serviceable, are operated 24 hours a day and transmit water from the well fields to the city pump stations Data on the transmission pump stations is presented in Table 5-4 and in Appendix D

5 3 2 City Pump Stations

The water distribution network for Lviv is pressurized by seven pump stations located around the city perimeter These stations feed water directly to the city distribution network, or they transmit water to booster pump stations or tanks located directly within the distribution system, that subsequently deliver water into the distribution system, or they operate both ways

The average total daily supply from these seven pump stations for 1995 was 363,000 m^3/d Detailed data on the city pump stations is given in Table 5-5 and in Appendix D

5.3.3 City Booster Pump Stations

There are four booster pump stations located within the city boundaries Yanivska, Kryvchytsi, Dovha, and Miska Smuha Data on these four stations is presented in Table 5-6 and in Appendix D

5.4 PUMP STATION OPERATION

All serviceable well pumps are operated 24 hours a day They deliver water to the transmission pump stations Some of the stations have water tanks, others do not

The steady, 24-hour pumping from the transmission pump stations is manually adjusted to the supply from the well fields, thus the stations have to be continuously staffed Pumping from the transmission pump stations is adjusted by throttling or opening of valves, not by switch-on/shut-off instructions from the dispatcher's office Transmission pump stations with no tanks are operated on a 'noise level' basis This means that if there is insufficient feed water that the pump starts to cavitate creating a noise in the pump casing The operator than throttles the pump until cavitation stops Transmission pump stations with water tanks are operated by observation of the water level in the tank This operation of pumps by throttling of valves results in increased unit power consumption

Transmission pump stations transmit water to tanks of the city pump stations The latter pump stations supply the city distribution network, including tanks and booster pump stations, primarily according to a six-hour schedule of two periods lasting three hours each

- 6 00 to 9 00 am
- 6 00 to 9 00 pm

During these pumping periods, tanks of the city pump stations are emptied down to the minimal water level, and the interim period is used to refill the water tanks Operation of the Vynnyky city pump station is an exception to the rule, it is operated continuously for 24 hours a day and it pumps water to the tanks of the Kryvchytsi and Dovha booster pump stations

Operation of pump stations according to the six-hour schedule negatively affects the functioning of the huge pump units which have high-voltage motors Frequent turning off and then restarting the high-voltage (6 and 10 kV) motor pump sets installed at pump stations (for example, at the Sokilnyky pump station) results in equipment failures The high-voltage breakers used are not designed for frequent on/off operation Consequently, a common practice is to control pump discharge by throttling This results in unnecessarily high energy consumption, especially between the two daily periods of intensive pumping

Sokilnyky pump station provides approximately one third of the total daily water supply to the city -- 115,000 m^3/d Not all pump stations are operated like Sokilnyky At Budzen III, Sykhiv III, Zboisk, and Karachyniv pump stations, pumps are switched off during the periods of low supply However, even at these stations some occasional throttling of pumps is also practiced

On the whole, the size of pumps in operation does not correspond to the amount of water supplied from the well field An extreme example is the Volia Dobrostanska pump station, where the design capacity of each of the two working pumps exceeds the supply from the well field by four times This means that the pumps have to be constantly throttled during operation, which results in high energy consumption

The small water tank of 500 m^3 at the Budzen II pump station empties after less than half an hour's operation if the pump discharge is not throttled In this case using smaller pumps could result in energy savings

Availability of reliable data on the amount of water pumped into the system is important analysis of general water supply, transmission, and consumption as well as for making correct technical decisions for improving the system performance Presently LVK measures the amount of water transmitted to the city pump stations using stationary ultrasonic flow meters manufactured at the Samara (Russia) instrument-manufacturing plant These meters were installed during the period 1989-1993 All stationary ultrasonic flow meters are placed in man-holes

Meters at the four pump stations (Karachyniv, Budzen III, Sokilnyky, and Vynnyky) are installed at the discharge pipelines that connect the pump station to the city distribution network Meters at the Zboisk pump station are installed on the intake at transmission mains where they enter the pump station's tanks Two pump stations (Sykhiv III and Malechkovychi) have no meters installed All water tanks are equipped with water level measuring devices

Staff at the pump stations record data on pump station performance daily The following data are recorded hourly in the log book and transmitted via telephone to the LVK dispatcher

- water flow meter readings
- pressure gauge readings
- water level in the tank
- amperage for each functioning motor
- inlet voltage

Monitoring of the water supply is based on these records

The LVK chemical and bacteriological laboratory periodically analyzes water quality at the pump stations The analysis results for some of the pump stations are presented in the Appendix A

5.5 SYSTEM OF REMOTE MONITORING

5.5.1 System Concept

In 1989 the Lviv Institute for the Design of Communal Services "Lvivdiprocommunbud" designed a project of establishment of Automatic Control System for Water Supply (ACS Water) for Lviv According to this design, the data collection and processing system should provide information on performance and the status of the water supply system (flow, pressure, pump motor current, water level in tanks, position of valves) on a real time basis Such a system will enable LVK staff to make technically sound decisions when controlling the water supply system that could considerably improve its operation and decrease energy consumption

The data collection system was to consist of autonomous microprocessor controller sets and a basic personal computer united into a network by communication lines or system The sets were to consist of measuring devices (initial converters), peripheral controller,

communication and data accumulation controller, and a device for matching communication controllers with the computer Radiotelemetry channels are to be used for the installations with difficult telecommunication conditions

According to the project, the remote monitoring system should begin with the following water pump stations Zarudtsi, Zboisk, Vynnyky, Sokilnyky, Sykhiv III, Budzen III, Karachyniv, Kryvchytsi, and Miska Smuha (see Figure 5-4) The system should provide the possibility of expansion and increase in the process of operation in order to ensure flexible cooperation between the dispatch center and the pump stations and other operational centers Using appropriate software in the computers, the data is to be shown as a graphic display in the form of mimic control panels and charts More thorough information processing can be done using spreadsheets like Excel or similar applications, with the input data being prepared by the appropriate compilers

In 1996 this system was undergoing engineering development phase and the phase of implementation The remote monitoring system is being developed by Information Technology Monitoring Ltd The Lviv City Administration ordered the system and provided funding Initial devices are installed at the major pump stations and their readings are currently transmitted verbally or automatically to the dispatcher over telephone or radio Table 5-7 contains types of data transmitted to the LVK dispatcher Flows at the pump stations are measured with Russian made (Samara plant) stationary ultrasonic flow meters

5.5 2 Schedule for System Completion

The Automatic Control System for the Lviv water supply system was to be completed in four phases

1 Installation of the information collecting system at the city pump stations and transmission of the information by telephone communication line

2 Transmission of the information by radio link

3 Installation of pressure pickups at 72 principal points in the city water distribution network

4 installation of distributing zonal valves with the electric drive in the city distribution system

Due to lack of funds only the first two phases were partially implemented, the other two need to be revised and improved The date of the project completion is not defined

In order to complete the remote monitoring system at the above mentioned pump stations, it will be necessary to

- install the system peripheral devices at the Vynnyky pump station

- install and connect pickups (according to the above table)
- carry out integrated testing and maintenance check-up of the installed pickups
- ensure reliable communication
- carry out the staff training and organizational procedures to provide cooperation of the dispatcher service with the repair crews

The cost of completing the remote monitoring, data collection and processing system for the Lviv water supply system is estimated to be about US$ 200,000

5 6 MAJOR PROBLEMS

Analysis of the Lviv water transmission system performance for 1995 revealed the following major problems of the transmission system

- age of the equipment
- energy effectiveness
- transmission line pipe material
- system hydraulics
- village supply (pressure and wastage)
- rural water distribution systems
- tank volume
- instrumentation
- water leakage

The age of pumps in operation at many pump stations exceeds 20 to 25 years, some pumps have been operated for over 50 years

The actual capacity of many pumps in operation at the pump stations does not correspond to the supply from connected well fields

Some booster pump stations are not provided with water tanks At other stations, the tanks are too small to ensure smooth operation of the booster pumps Several pump stations are operated without water tanks, thus operation of pumps at these pump stations depends on alterations in operation of the related well fields It means that the pumps need to be constantly throttled The result is higher unit energy consumption

The frequency of failure by breakage for the transmission lines is high, and is highest for the western transmission system The weak point of the transmission system is reinforced concrete pipes - bell and spigot connections at the socket ends However, frequent breakages are also observed at connections between reinforced concrete and steel pipes

The direct pumping from wells and well fields to the transmission mains presents a potential problem Many of the well pumps have not been adjusted for changes that have

taken place in the system's hydraulic conditions since its installation e g , new wells connected to the system or changes in the transmission mains

In addition, the well pumps that are worn-out or broken down are replaced by available pumps rather than by pumps designed to suit the hydraulic condition of the actual transmission system This results in operation of a significant number of pumps outside their optimal ranges resulting in high unit energy use for water abstraction An example is the northern system where seven well fields with 44 wells, pump water directly to the transmission mains over a distance of 39 km

Table 5-1 Pipe Diameters, Lengths, and Construction Periods				
Diameter (mm)	**Length (km)**			
	1900-1945	**1945-1975**	**1975-1995**	**Total**
200	15 0	20 0		35 0
250		1 3	14 0	15 3
300		3 5		3 5
350	0 6			0 6
400		4 9	4 5	9 4
500		7 0	12 5	19 5
600	35 3	46 0	12 0	93 3
700		47 0		47 0
800		2 2	15 0	17 2
900		19 0	7 0	26 0
1,000		41 2	11 0	52 2
1,100				0
≥1200			139 0	139 0
Total	**50 9**	**192 1**	**215 0**	**458 0**

Table 5-2
Condition of Lviv Pump Stations

Pump Station Name	Year		General Condition			Overall Site Condition	Remarks
	Built	Rehabilitated	Site	Mechanical	Elect & IC		
North							
Zarudtsi	1965	-	Good	Poor	Good	Fair	Very old pumps
Zboisk	1965	-	Fair	Poor	Good	Fair	Very old pumps
West							
Volia Dobrostanska	1901	1936	Good	Poor	Fair	Fair	Very old
Velykopole	1928	1936	Good	Poor	Fair	Fair	Very old
Kamianobrody	1952	-	Good	Poor	Fair	Fair	Very old pumps
Karachyniv	1928	1976	Good	Poor	Fair	Fair	Very old
Yanivska	1932	1965	Poor	Poor	Poor	Poor	Very old
Budzen II	1964	-	Poor	Poor	Poor	Very Poor	Very old
Budzen III	1989	-	Good	Good	Good	Good	No problem observed
South							
Malechkovychi	1932	1963	Fair	Fair	Fair	Fair	Very old
Mykolaiv	1978	-	Good	Good	Good	Good	No problem observed
Sokilnyky	1978	-	Good	Very Poor	Fair	Fair	No regulating drives
Hlynna-Navaria	1971	-	Fair	Poor	Fair	Fair	Very old pumps
Stare Selo	1973	-	Fair	Poor	Fair	Fair	Very old pumps
Sykhiv III	1971	1989	Good	Fair	Good	Good	Control problems
East							
Pluhiv	1982	-	Poor	Poor	Poor	Poor	Incomplete construction
Vynnyky	1980	1990	Good	Good	Good	Good	Incomplete construction
Kryvchytsi	1965	1966	Good	Good	Good	Good	Incomplete construction
Dovha	1995	-	Good	-	-	Good	Incomplete construction
Center							
Miska Smuha	1933	1978	Poor	Poor	Poor	Poor	Very old

Table 5-3
Lviv Pump Station Tanks

Tank and Pump Station Name	Year Built	Characteristics			Shape and Size, m	Remarks
		Number of Tanks	Volume, m^3/ea	Total, m^3		
North						
Zarudtsi	1982	2	1 000	2,000	square 18 (w) x 18 (l) x 3 6 (h)	
	1965	2	1 000	2 000	circular 18 diameter ×3 6(h)	
Zboisk	1965	2	10,000	20 000	square 48(w)×48(l)×4 8(h)	1 partially constructed
Subtotal				**24,000**		
West						
Volia Dobrostanska	1901	1	100	100	circular 6 diameter ×4(h)	
Karachyniv	1928	1	500	500	rectangular 14(w)x16(l)x3(h)	Not used
	1980	1	6 000	6 000	square 36(w)×36(l)×4 8(h)	
Budzen II	1964	1	500	500	circular 12 diameter ×4 8(h)	
Budzen III	1989	2	6 000	12,000	square 36(w)×36(l)×4 8(h)	
Subtotal				**19,100**		
South						
Mykolaiv	1978	2	3 000	6 000	square 24(w)×24(l)×4 8(h)	
Sokilnyky	1978	5	10 000	50 000	square 48(w)×48(l)×4 8(h)	
Hlynna Navaria	1971	2	500	1 000	square 12(w)×12(l)×3 6(h)	
Stare Selo	1973	2	3 000	6 000	square 24(w)×24(l)×4 8(h)	
Sykhiv III	1971	2	6 000	12 000	square 36(w)×36(l)×4 8(h)	
Subtotal				**75,000**		
East						
Vynnyky	1980	1	2 000	2 000	rectangular 36(w)x60(l)x4 8(h)	
	1989	2	10 000	20 000	rectangular 18(w)x24(l)x3 6(h)	
Kryvchytsi	1980	1	3 000	3 000	square 24(w)×24(l)×4 8(h)	1 partially constructed
	1965	1	6 000	6 000	square 36(w)×36(l)×4 8(h)	
Dovha	1995	1	10 000	10 000	rectangular 36(w)×60(l)×4 8(h)	2 partially constructed
Subtotal				**41,000**		
Center						
Miska Smuha	1933	1	7 000	7 000	rectangular 32(w)x75(l)x3 5(h)	
	1933	1	12 000	12 000	rectangular 60(w)x75(l)x3 5(h)	
	1933	1	3,000	3 000	square 32(w)×32(l)×3 5(h)	
Subtotal				**22,000**		
Total				**181,100**		

Table 5-4
Lviv Water Transmission Pump Stations

Transmission Pump Station	Number of Pumps		Pump Characteristics			Pump Shaft Elev	Year		Design Daily Capacity	Average Daily Flow 1995	Annual Flow 1995	Power Supply Category	Power Usage in 1995		Disinfection
	Working	Stand-by	m^3/h	atm	kW	m	Built	Rebuilt	m^3/d	m^3/d	1000 m^3		kWh	kWh/m^3	
North															
Zarudtsi	2	2	2 300	6 5	800	274 7	1965	-	110,400	87,953	32 103	II	13 689,900	0 426	yes
West															
Volia Dobrostanska	2	2	1 200	6 8	500	282 9	1901	1936	22,000	7,026	2 564	II	3,769 900	1 470	no
Velykopole	2	1	360	9	190	282 1	1928	1936	13,000	7,015	2,560	II	2 337 400	0 913	no
Kamianobrody	2	-	540	7	250	274 4	1952	-	23 000	15,289	5 580	II	3,241 400	0 581	no
	-	1	720	7	190										
Budzen II	2	2	1 250	12 5	630	277	1964	-	45,000	43 047	15 712	II	17 988,900	1 145	yes
South															
Mykolaiv	2	2	3,000	19 7	1600	265 0	1978	-	140,000	117 655	42 944	I	24 087,800	0 561	no
Hlynna-Navaria	1	1	720	8 9	250	327 0	1971	-	19,000	14,238	5,197	III	5,405,100	1 040	yes
Stare Selo	2	1	560	7	160	302 1	1973	-		24 192	8 830	III	5 846 500	0 662	yes
East															
Pluhiv	2	-	1,250	6 5	250	285 1	1982	-	37,000	50,572	18,459	II	6,581,800	0 357	no
Total									**409,400**	**366,987**	**133,950**		**82,948,700**	**0 619**	

Table 5-5
Lviv City Pump Stations

City Pump Station Name	Number of Pumps		Pump Characteristics			Pump Shaft Elev	Year		Design Daily Capacity	Average Daily Flow 1995	Annual Flow 1995	Power Supply Category	Power Usage in 1995		Dis-in-fec-tion
	Working	Stand by	m^3/h	atm	kW	m	Built	Rebuilt	m^3/d	m^3/d	1000 m^3		kWh	kWh/m^3	
North															
Zboisk	1	1	1,260	3 2	250	321 9	1965	-	105,600	31,670	11,560	I	1 100 691	0 095	yes
	1	1	1 080	3 2	160										
	by gravity					324 0				47,300	17,265				
West															
Karachyniv		1	640	5 5	250	307 7	1928	1976	79 800	38 592	14,086	II	6,411 579	0 455	yes
	1	-	2 200	5 5	600										
	1		2 200	5 5	630										
		1	2,300	8 9	800										
Budzen III	2	2	1 250	6 5	320	314 3	1989	-	66,800	30,786	11 237	II	2,383,763	0 212	yes
South															
Malechkovychi	1	1	200	7	100	298	1932	1963	5,000	4,924	1 797	III	1,226,750	0 683	yes
Sokilnyky	2	1	3,200	7 5	800	338 5	1978	-	140,000	115,216	42 054	I	12 928,300	0 307	yes
	1	1	4 000	9 5	800										
Sykhiv III	3	-	540	9 4	250	345 2	1971	1989	39,000	31,723	11,579	II	3,477 500	0 300	no
	2	1	540	7 4	160										
	1	1	300	3 8	75										
	1	1	90	3	15										
East															
Vynnyky	1	1	1,250	13	630	284 3	1980	1990	65,000	62 460	22,798	I	9 088,000	0 399	yes
	3	-	1,250	6 5	250										
Total									**501,200**	**362,671**	**132,375**		**36,616,583**	**0 277**	

Table 5-6
Lviv City Booster Pump Stations

City Booster Pump Station Name	Number of Pumps		Pump Characteristics			Pump Shaft Elev	Year		Design Capacity	Average Daily Flow 1995	Annual Flow 1995	Power Supply Category	Power Usage in 1995	
	Working	Stand by	m^3/h	atm	kW	m	Built	Rebuilt	m^3/d	m^3/d	1000 m^3		kWh	kWh/m^3
East														
Kryvchytsi	5	2	400	12 5	250	299 5	1965	1988	65,000	46 834	17,094	II	9,979,847	1
	1	-	200	10	100									
Dovha	-	-	-	-	-	379 5	1995	-	10 000	10,000	3,650	-	-	-
Center														
Miska Smuha	-	1	1600	7	135	329	1933	1978	38,400	5 610	2,048	III	392,400	0 192
	1	-	900	3	100									
	1	1	120	7	55									
West														
Yanivska	1	-	120	4	160	328 4	1932	1965	15,000	14,048	5,128	III	487 514	0 095
	-	1	300	6	320									

Table 5-7 Types of Data Transmitted to the LVK Dispatcher					
Pump Station Name	Indices				
	Flows	Pressures	Currents	Valves	Levels
Zarudtsi		•	•		•
Zboisk	•	•	•		•
Vynnyky	•	•	•		•
Sokilnyky	•	•	•	•	•
Sykhiv III		•	•	•	•
Budzen III	•	•	•		•
Karachyniv	•	•	•		•
Kryvchytsi		•	•	•	•
Miska Smuha	•	•	•		•

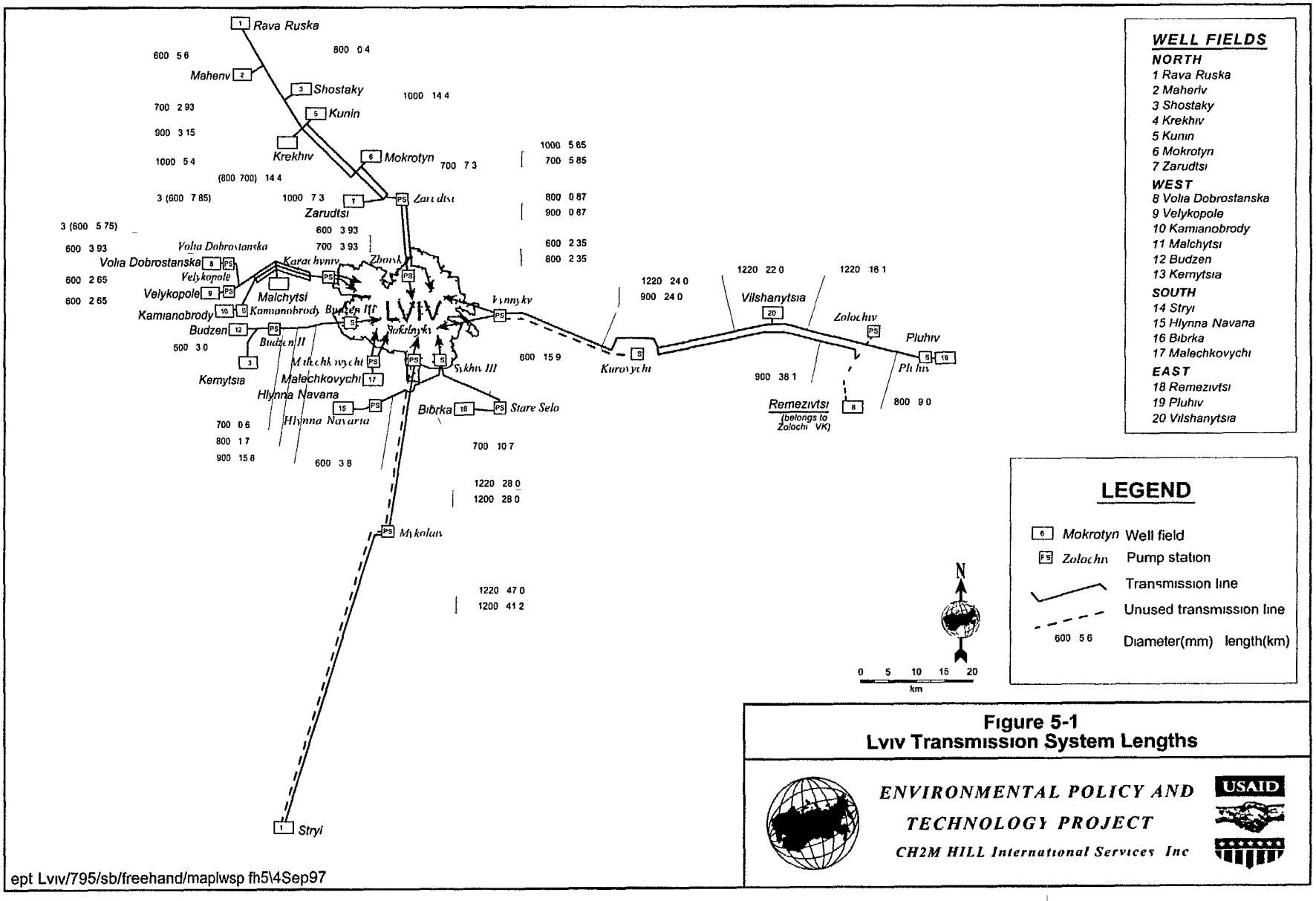

Figure 5-1
Lviv Transmission System Lengths

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USAID

ept Lviv/795/sb/freehand/maplwsp fh5\4Sep97

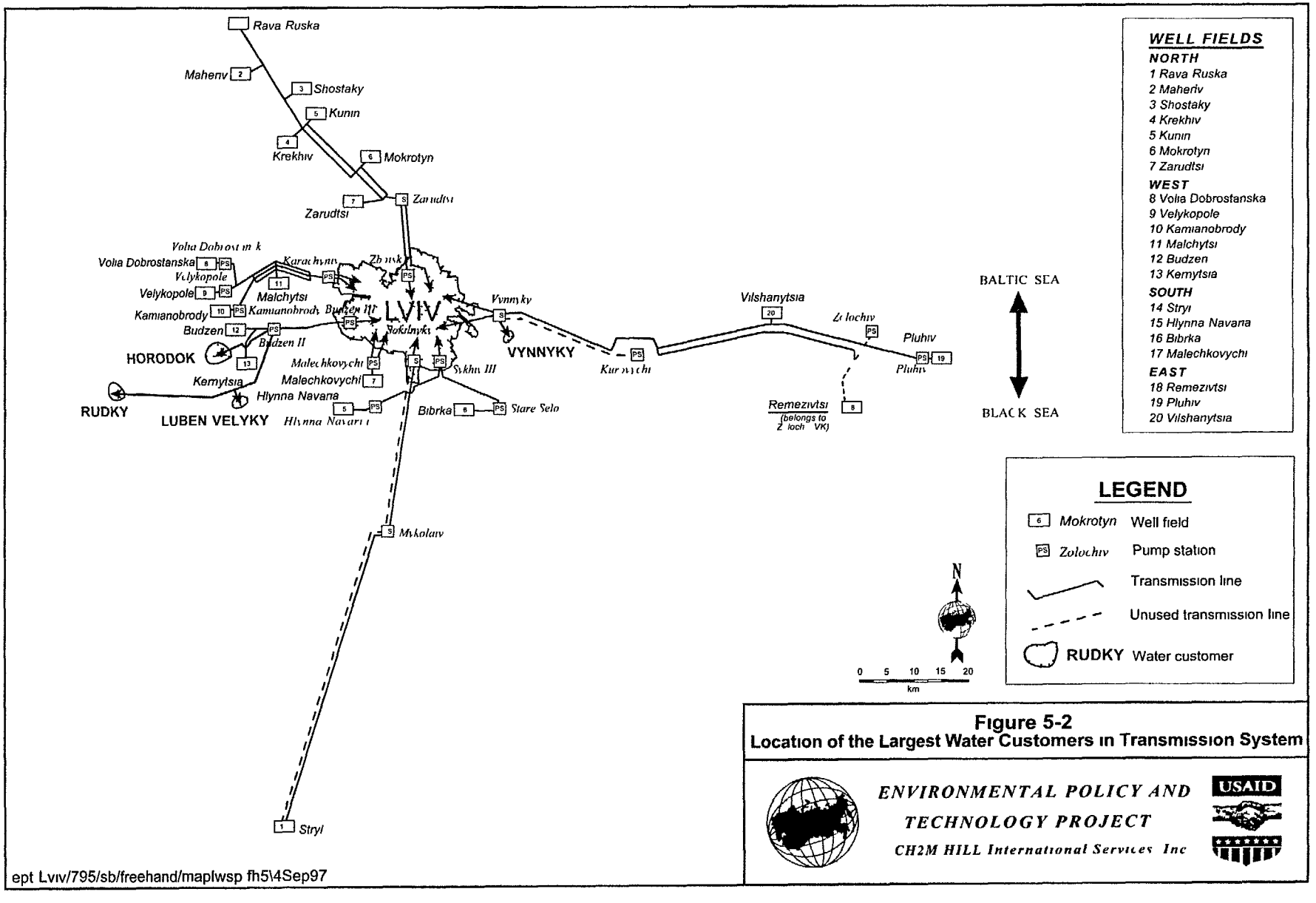

Figure 5-2
Location of the Largest Water Customers in Transmission System

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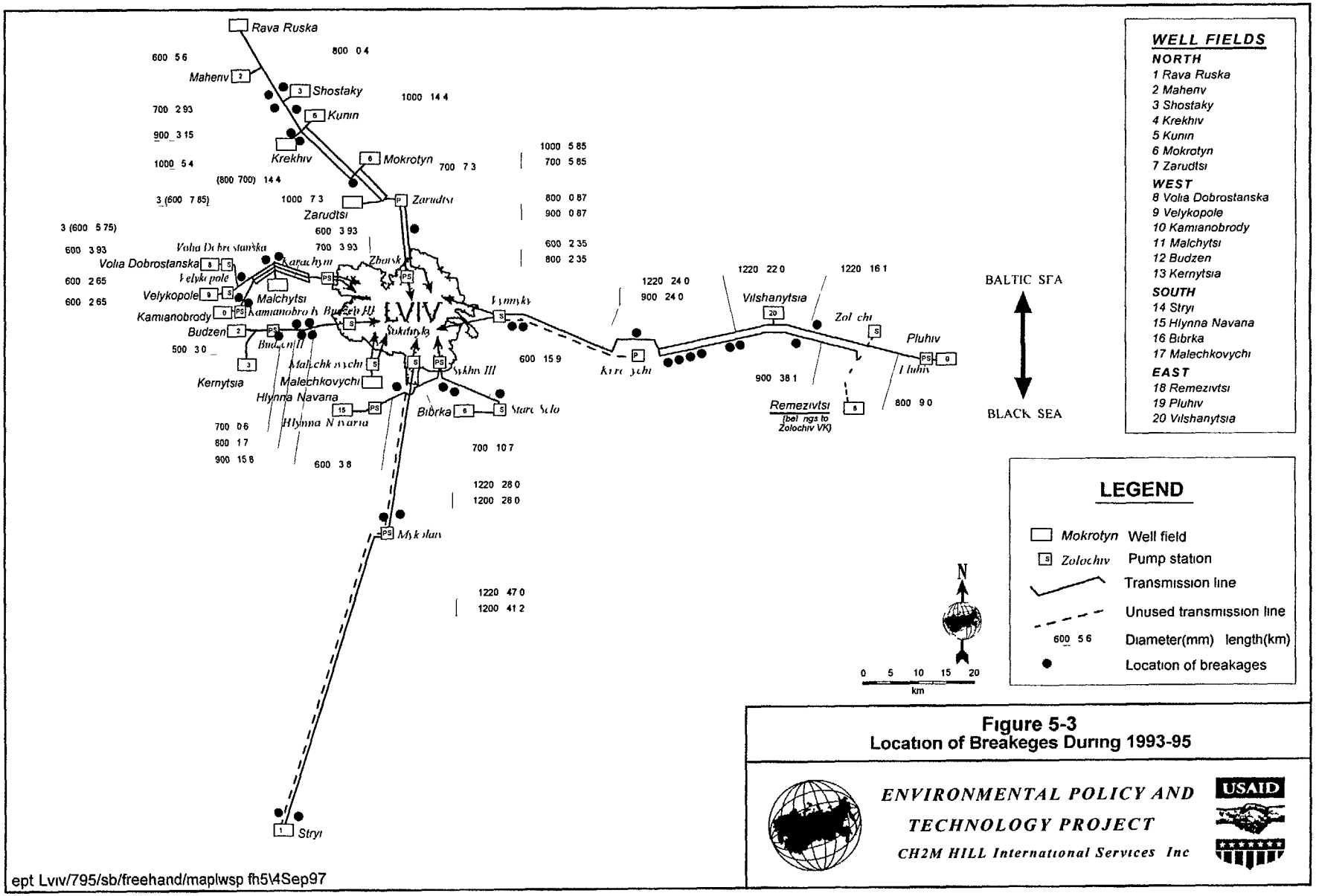

Figure 5-3
Location of Breakeges During 1993-95

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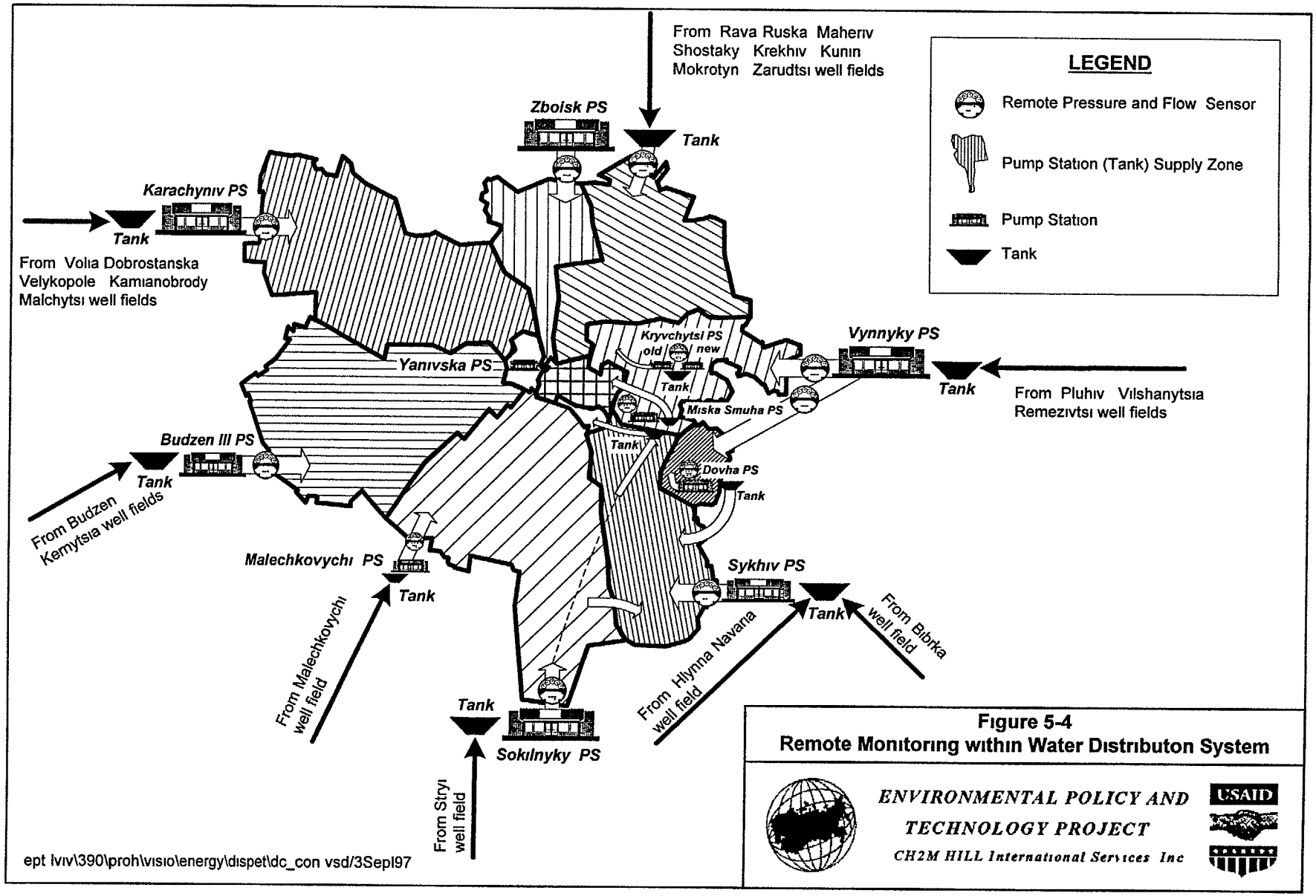

Figure 5-4
Remote Monitoring within Water Distributon System

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Appendix A

INFORMATION ON WATER QUALITY

This appendix contains the results of water quality tests carried out by the LVK chemistry and biological laboratory

Table A-1
Chemical Bacteriological Laboratory LVK Water Analysis Results, 9 March 1994

No	Water Characteristics	Karachyniv	Sokilnyky	Budzen III	Kryvchytsi	Zboisk	Malechkovychi	Sykhiv III
1	Temperature							
2	Smell	0	0	0	0	0		
3	Taste	0	0	0	0	0		
4	Color (degrees)	0	0	10*	0	0		
5	Transparency (mg/dm^3)	0	0	0 9	0	0		
6	Water characteristic (pH)	7 26	7 7	76 92	7 17	7 2	7 15	
7	Iron (mg/dm^3)	0 05	0 11	0 77	0 21	0 24	0 05	
8	General solidity (mg/ekv)	5 15	3 7	7 8	8 55	7 1	10 4	
9	Alkali (mol/dm^3)	4 3	3 3	5 6	7	6 6	6 2	
10	Ammonia (mg/dm^3)	0	0	0 19	0	0	0	
11	Nitrite (mg/dm^3)	0	0	0 009	0	0	0	
12	Nitrates (mg/dm^3)	6 75	7 29	9 18	2 95	2 38	4 65	
13	Calcium (mg/dm^3 mg/ekv)	4 25/85 7	2 4/48 09	6/120 24	0 7/134 27	5 6/112 22		
14	Magnesium (mg/dm^3 mg/ekv)	0 9/10 93	1 3/15 79	1 8/21 87	1 85/22 48	1 5/18 22		
15	Manganese (mg/dm^3)	0 02	0 012	0 008	0 03	0 025		
16	Fluorine (mg/dm^3)	0 38	0 25	0 18	0 28	0 28		
17	Copper (mg/dm^3)	0 003	0	0 025	0	0 008	0	
18	Molybdenum (mg/dm^3)	0	0	0	0	0	0	
19	Lead (mg/dm^3)	0	0	0	0	0	0	
20	ZinC (mg/dm^3)	0	0	0	0	0	0	
21	Chlorides (mg/dm^3)	15	17	300	13 5	30 5	28 5	
22	Sulphate (mg/dm^3-mg/ekv)	1 63/78 37	1 37/65 82	3 75/180 4	3 06/146 87	2 05/98 32		
23	CO_2 (mg/dm^3-mg/ekv)	4 3/262 3	3 3/201 3	5 6/311 6	7/427	6 6/402		
24	Total solid (mg/dm^3)	374 71	302 81	584 25	617 44	556 92		
25	Mineralization (mg/l)	481 77	384 25	723 86	791 37	722 11		
26	K+ + N+ (mg/l-mg/ekv)	1 2/30	1 45/36 25	2 39/59 75	1 89/47 25	2 41/60 25		

Table A-2
Chemical Bacteriological Laboratory LVK Water Analysis Results, 8 April 1995

No	Water Characteristics	Karachyniv	Sokilnyky	Budzen III	Kryvchytsi	Zboisk	Malechkovychi	Sykhiv III
2	Smell	0	0	0	0	0		0
3	Taste	0	0	0	0	0		0
4	Color (degrees)	0	0	10*	0	0		0
5	Transparency (mg/dm^3)	0	0	0 6	0	0		0
6	Water characteristic (pH)	7 35	7 6	7 05	7 35	7 15		7 2
7	Iron (mg/dm^3)	0 05	0 05	0 84	0 16	0 27		0 29
8	General solidity (mg/ekv)	5 5	3 55	8 25	8 6	7 4		8 1
9	Alkali (mol/dm^3)							
10	Ammonia (mg/dm^3)	0	0	0 17	0	0		0 12
11	Nitrite (mg/dm^3)	0 005	0	0 009	0	0		0 01
12	Nitrates (mg/dm^3)	7 47	6 48	10 8	1 48	2 38		1 3
13	Manganese (mg/dm^3)	0	0	0 04	0	0 012		0
14	Fluorine (mg/m^3)	0 38	0 24	0 48	0 24	0 24		0 24
15	Copper (mg/dm^3)	0 008	0	0 03	0	0		0 008
16	Molybdenum (mg/dm^3)	0	0	traces	0	traces		0
17	Arsenic (mg/dm^3)	0	0	0	0	0		0
18	Lead (mg/dm^3)	0	0	0	0	0		0
19	Selenium (mg/dm^3)	0	0	0	0	0		0
20	Strontium (mg/dm^3)	0 8	0 6	5 3	1 7	3 4		2 4
21	Zink (mg/dm3)	0	0	0	0	0		0
22	Beryllium (mg/dm^3)	0	0	0	0	0		0
23	Chlorides (mg/dm^3)	13 5	14	26	8 5	26 5		26 5
24	Sulphate (mg/dm^3)	48 68	34 76	142 96	94 62	91 57		130 2
25	Acidity (mg/dm^3)	1 6	1 6	2	1 04	1 84		1 52
26	Total solid (mg/dm^3)	41 16	240 59	554 2	531 16	505 82		584 3
27	Chlorine residual (mg/dm^3)	0 7	0 6	0 25	0 7	0 7		0 35

Appendix B

WATER SUPPLY WELL DESIGN, CONSTRUCTION AND EQUIPMENT DATA

Tables B-1 and B-2 present data on well construction and equipment

Table B-1
Construction Parameters of the Wells at Lviv Well Fields

No	Well Field Name	Year Built	No of Wells	Diameter of Wells	Depth of Wells	Static Water Level	Dynamic Water Level	Remarks
				mm	m	m	m	
	North							
1	Rava-Ruska	1972	8	426	60-70	3 3	12-17	Size is based on measurements in September, 1996
2	Maheriv	1971	4	426	60-71	3 8	7-15	
3	Shostaky	1972	3	426	61 2	32	35	
4	Krekhiv	1970	5	426	60	4 8	13-15	Measurements made in August 1996
5	Kunin	1970	2	426	60	4 8	18	
6	Mokrotyn	1966	7	426	75	4	18-24	
7	Zarudtsi	1965	10	377	55 70	3 8	17-18	
	(Zavadiv)	1972	6	426	55-70	3 8	17-18	
	Group total		**45**					
	West							
8	Volia Dobrostanska	1901	5	426	70	15		
9	Velykopole	1926	5	426	70	5 6		
10	Kamianobrody	1952	4	426	45	3 6		
11	Malchytsi	1967	9	426	70	7		
12	Budzen	1956	22	426	55-70	6 5	23-25	Measurements made in August 1996
13	Kernytsia	1969	8	377	85	6 5		
	Group total		**53**					
	South							
14	Stryi	1979 1982	34	426	20-22	2 5-3 0	4 5-6 2	Measurements made in September-November, 1996
15	Hlynna-Navaria	1971	12	426	70	15-20	20-23	Measurements made in November 1996
16	Bibrka	1973	12	426	75	4 5		
17	Malechkovychi	1932	1	426	70-80	1 2		
	Group total		**59**					
	East							
18	Remezivtsi	1982 1986	4	426	65	2 6		
19	Pluhiv	1982 1989	8	426	200	2		
20	Vilshanytsia	1989	4	426	70	3		
	Group total		**16**					
	Total		**173**					

Table B-2
Pumping Equipment of the Wells at Lviv Well Fields

No	Well Field Name	No Of Pumps	Well Numbers	Type of Pumps	Pump Characteristic			Notes
					Q, m³/h	H, m	N, kW	
	North							
1	Rava Ruska	3	8 8a 9a	ЕЦВ10-63 110	63	110	32	
		2	11 12	ЕЦВ12 160-140	160	140	90	
		3	7 9 10	ЕЦВ12 160 100	160	100	65	
2	Maheriv	1	4a	ЕЦВ10-63 110	63	110	32	
		1	6	ЕЦВ8 25 70	25	70	17	
		2	4 5	ЕЦВ12 160-100	160	100	65	
3	Shostaky	3	1 2 3	ЕЦВ12 160-100	160	100	65	
4	Krekhiv	3	1 3 5	ЕЦВ12 160-100	160	100	65	
		1	2	ЕЦВ10-63 110	63	110	32	
		1	4	ЕЦВ8 16 100	16	100	17	
5	Kunin	2	6 7	ЕЦВ12 160-100	160	100	65	
6	Mokrotyn	6	1-4 5a 6	ЕЦВ12 160-100	160	100	65	
		1	5	ЕЦВ8 25 70	25	70	17	
7	Zarudtsi	5	1 3 5a 7 8	ЕЦВ10-120-60	120	65	32	
		5	2 2a 4 6	ЕЦВ8 25 70	25	70	17	
	(Zavadiv)	5	1 1a 2 2a 3	ЕЦВ10-120-60	120	65	32	
		1	1b	ЕЦВ8 25 70	25	70	17	
	Group total	**45**			1665			
	West							
8	Volia Dobrostanska	4	1 5 7	ЕЦВ12 160-65	160	65	45	
		1	11	ЕЦВ10-63 65	63	65	22	
9	Velykopole	2	1 5	ЕЦВ10-120-60	120	65	32	
		2	2 4	ЕЦВ12 160-65	160	65	45	
		1	3	ЕЦВ8 25 70	25	70	17	
10	Kamianobrody	4	1-4	ЕЦВ12 255 30	255	30	32	
11	Malchytsi	2	1 2a	ЕЦВ8 25 70	25	70	17	
		4	2 3 3a 4a	ЕЦВ10-63 110	63	110	32	
		3	4-6	ЕЦВ12 160-65	160	65	45	
12	Budzen	16	1 2 6a 7 7a 8					
			9 9a 10 10a 11 11a					
			12 13 13a 15a	ЕЦВ10-120-60	120	65	32	
		3	5 5a 14a	ЕЦВ10-63 110	63	110	32	
		2	6 12a	ЕЦВ12 160-65	160	65	45	
		1	17	ЕЦВ8 25 70	25	70	17	
13	Kernytsia	7	1 1a 3 3a 4-6	ЕЦВ10-120-60	120	65	32	
		1	2	ЕЦВ12 160-65	160	65	45	
	Group total	**53**						
	South							
14	Stryi	10	1-6 8 11	ЕЦВ12 160-65	160	65	45	
		22	12 26 28 34	ЕЦВ12 255 30	255	30	32	
		1	7	ЕЦВ10-63 65	63	65	22	Rural water
		1	27	ЕЦВ12 255 30	255	30	32	supply
15	Hlynna Navaria	7	1 1a 2a 4 5 7 7a	ЕЦВ10-63 110	63	110	32	
		2	2 3	ЕЦВ8 16 140	16	100	17	
		3	6 6a 8	ЕЦВ12 160-100	160	100	65	
16	Bibrka	5	1 3 4 4a 6	ЕЦВ12 160-65	160	65	45	
		6	1a 2a 6a 7 8 8a	ЕЦВ10-120-60	120	65	32	
		1	2	ЕЦВ8 25 70	25	70	17	
17	Malechkovychi	1	1	ЕЦВ12 160-65	160	65	45	
	Group total	**59**						
	East							
18	Remezivtsi	2	1 2	ЕЦВ10-120-60	120	65	32	Purchased
		2	3 291	ЕЦВ12 210-60	210	60	22	water
19	Pluhiv	8	1 8	ЕЦВ12 255 30	255	30	32	
20	Vilshanytsia	2	1 2	ЕЦВ12 160-140	160	140	90	
		1	3	ЕЦВ12 160-100	160	100	65	
		1	4	ЕЦВ10-63 110	63	110	32	
	Group total	**16**						
	Total	**173**						

Appendix C

WATER SUPPLY WELL FIELD OPERATIONAL ISSUES

A discussion was held with LVK well field supervisors, which centered around the following issues

C.1 WELL MALFUNCTIONS

The major cause of well mulfunctions were

- frequent interruption of electrical energy supply causing engine problems in the pumping apparatus - even though the electricity supply is supposed to be on a Priority 1 basis
- large fluctuations in power (5,600 W instead of 6,000 W) also cause damage to engines
- acts of nature, such as the migration of birds or freezing temperatures
- aggressiveness of raw water, leading to rapid corrosion of bolted joints and pipes (e g , Pluhiv Well Field)
- massive theft and destruction of property
- forced shutdown of a well when the pump falls to the bottom and cannot be pulled out through the small-diameter well opening

C.2 WELL CLEANING

When the level of water in the well periodically drops, cleaning is carried out in order to improve its productivity The hydrodynamic method is one of the most effective cleaning methods, it is based on electric discharge effect, at a rate of 5 discharges per 20 cm Lviv Vodokanal does not have its own well cleaning capability The last work of this kind was done in 1987 at the Stryi and Budzen well fields, managed by Lvivkomunekolohia (then a municipal government agency) The Burvod specialists only rinse the wells with the airlift technique, or redrill them

C 2 1 Effectiveness of Well-Cleaning

The hydrodynamic method of cleaning wells has an average effectiveness rate of 25-30% for a period of six months to one year, depending on the aquifer

C 2.2 Number Well-Cleaning Personnel

There are five people dedicated to carrying out well cleaning work For a well approximately 30 meters deep this work usually takes three days

C.2.3 Using Crane Mechanisms

Well-cleaning work is facilitated by the use of automatic cranes weighing 10 tons, and 12 8 m^3/min-capacity compressors

C.3 IMPROVED WELL FIELD OPERATION

For normal operation of the 20 well fields (167 wells) it would be helpful to have

- portable meter for 150-200-mm lines (6-8 in)
- depth observation device for wells
- boring tool for 600-800-mm wells
- 30% spare pumps for wells (i e , 50 pumps, to decrease pressure in rural water supply networks the pumps must have pressure-reducing valves)

Appendix D

PUMP STATION DETAILS

Information regarding pumping statations of the LVK water system is provided in this appendix

D.1 WATER TRANSMISSION PUMP STATIONS

Nine transmission pump stations deliver water to the city water distribution system (Figure D-1)

D 1.1 Northern Pump Stations

The Zarudtsi transmission PS pumps water to the northern part of the city Water continuously fills four underground water tanks (1,000 m^3 each) located at Zarudtsi pump station which continuously supply water to Zboisk pump station Power supply of the pump station is Category II from two independent sources Water quality complies with the state water standard

D.1.2 Western Pump Stations

Volia Dobrostanska, Velykopole, Kamianobrody, and Budzen pump stations deliver water to the western part of the city

Water from Volia Dobrostanska well field is pumped by Volia Dobrostanska PS Water from wells continuously fills a 100 m^3 tank The pumps work continuously throughout the day to supply water to the Karachyniv pump station Power supply of the pump station is 2nd category, from two independent sources Water quality complies with the state water standards

Water is pumped from the Velykopole well field by Velykopole PS Velykopole PS continuously pumps water from Velykopole well field directly to the pump's suction pipeline Pumping equipment works continuously throughout the day and delivers water to Karachyniv PS site Power supply of the pump station is 2nd category from two independent sources Water quality complies with the state water standards

The Kamianobrody PS pumps water from Kamianobrody well field Water from the wells flows to the pump's suction pipeline Pumping equipment works steadily 24 h/d and pumps water to Karachyniv PS site Power supply of the pump station is 2nd category from two independent sources Water quality complies with the state water standards

The Budzen II PS pumps water from the Budzen and Kernytsia well fields Water from the wells fills one underground, 500 m^3 tank The pumping equipment works 24 h/d delivering water to Budzen III PS Power supply of the pump station is 2nd category from two independent sources Water quality does not comply with the state water standards (iron

content in the water is about 0 84 mg/l), but with the agreement from the Region Sanitary Inspection, water is not treated to reduce the iron content

D 1.3 Southern Pump Stations

The Mykolaiv, Hlynna Navaria, Stare Selo pump stations pump water to the southern part of the city

The Mykolaiv PS pumps water from Stryi well field Water from the wells fills two underground 3,000 m^3 tanks located next to the pump station The pumping equipment works 24 h/d The pump station power supply is 1st category from two independent power sources The quality of water complies with the state water standard

The Hlynna Navaria PS pumps water from Hlynna Navaria well field Water from wells fills two 500 m^3, underground tanks located next to the pump station The pumping equipment works 24 hours a day The power supply of the pump station is 3rd category The quality of water complies with the state standard

The Stare Selo PS pumps water from Bibrka well field Water from the wells fills two 3,000 m^3, underground tanks located next to the pump station The pumping equipment works 24 hours a day The power supply of the pump station is 3rd category Water quality does not comply with the state water standards (iron content in water is about 1 mg/l), but with the agreement from the Region Sanitary Inspection, water is not treated to reduce the iron content

D 1 4 Eastern Pump Stations

Pluhiv PS pumps water to the eastern part of the city

The Pluhiv PS pumps water from Pluhiv well field Water from the wells flows directly to the pump's suction pipeline Pumping equipment works 24 hours a day Power supply of the pump station is 2nd category, from two independent power sources Water quality does not comply with the state water standards (hydrogen sulfite, H_2S content is about 0 6 mg/l, and aggressive free carbon acid, HCO_3, is about 250 mg/l) Degassing installations are used for water treatment

Water from Vilshanytsia well field is delivered directly to the transmission pipeline (1,200 mm in diameter) between the Pluhiv and Vynnyky pump stations About 7,400 m^3/d of water purchased from Remezivtsi well field is also delivered to the same transmission pipeline

The Kurovychi PS has been temporarily removed from operation since the capacity of Pluhiv PS is sufficient for transmitting water to Vynnyky PS located in the vicinity of Lviv

D 2 CITY WATER DISTRIBUTION PUMP STATIONS

Some information on a number of the city pump stations is presented in this subsection, based on data from records and observations by CH2M HILL's EPT-Lviv staff during the period April to September, 1996

D.2.1 Sokilnyky Pump Station

Site name Sokilnyky PS site
Year of construction 1978
Well fields providing water to the pump station Stryi well field and Mykolaiv PS
Suction pipelines
a) number of pipelines - 2 pipelines
b) pipeline type & diameter - 1020×12 mm, steel
Storage tanks 5 pcs, 10000 m^3 each (48×48 m)
a) functioning - all
b) not functioning - none
Delivery pipelines
a) number of pipelines - single-piped water main Mykolaiv-Sokilnyky
b) pipeline type & diameter - 1220×12 mm, steel
c) meter availability - none
d) flow - 1330 l/sec
Pumping equipment
a) number of pumps - 5 pump units (3 working, 2 stand-by)
b) pump unit indices Q - 3200 m^3/h, H- 75 m, N- 800 kW (2 working, 1 stand-by),
Q - 4000 m^3/h, H - 95 m, N - 800 kW (1 working, 1 stand-by)
c) working hours - 1 pump with Q - 3200 m^3/h and 1 pump with Q - 4000 m^3/h work with throttling for 24 hrs, 1 pump with Q -3200 m^3/h work according to the schedule from 5 pm till 9 pm
Pressure pipelines
a) number of pipelines - 2 pipelines
b) pipeline type & diameter - towards the city distribution system - two 800 mm pressure pipelines connect by the surge tank the pump station to the single steel 1420×17 mm pipeline, towards Miska Smuha pump station - single steel 600 mm pipeline
c) meter availability - meters are installed in the surge tank at a distance of 50-100 m from the pump station on each water pipeline going out of the pump station
f) flow - 1160 l/sec to city and 134 l/sec to Miska Smuha PS
Connection points
to the city distribution system - switch chamber at the Naukova-Stryiska crossing to Miska Smuha PS - 12000 m^3 tank
Water distribution by directions
a) towards the city distribution system (zone 2)
b) towards Miska Smuha PS
Rural water consumption none

Water treatment

a) chlorination - 0 6 - 0 8 Cl mg/l

b) fluorination - none

Pump and storage tank performance monitoring, flow meter registration

Every hour the following data is put into the register book and reported to the LVK dispatcher by the pump station servicing staff readings of three flow meters and three pressure gauges installed on each pressure line, readings (indicated at the pump station) of water level sensors in storage tanks, amperage of each functioning engine, voltage at two inlets

Actual flow measurement

Test measurements on the water main Stryi-Mykolaiv-Lviv were carried out during the period 2 07 96 to 12 07 96 using US made ultrasonic flow meter PT 868 with clamp-on transducers Actual production of Stryi well field and water inflow to Sokilnyky PS, as well as water flow in two intermediate points of water main were measured The measurement results are given in the table

#	Point on the Water Main	Measurement			Meter Reading	Q m^3/h	Q m^3/h
		Start Date & Time	End Date & Time	Duration hrs			
1	Stryi well field, 7 km downstream	2 07 96 3 00 PM	3 07 96 3 00 PM	24	123,672	5,153	123,672
2	Mykolaiv PS 3 km downstream	5 07 96 11 35 AM	5 07 96 12 35 PM	1	4,932	4,932	118,372
3	village Derevachi, 20 km off Lviv	5 07 96 2 55 PM	5 07 96 3 55 PM	1	5,094	5,094	122,258
4	Sokilnyky PS, Lviv	11 07 96 9 45 PM	12 07 96 9 45 PM	24	115,460	4 810	115 460

According to the measurement results, the inflow to Sokilnyky PS is about 115,000 m^3/d Schematic diagram of the Sokilnyky PS is shown at Figure D-1 Daily flow and pressure curves of this pump station are presented at Figure D-2

D.2 2 Karachyniv Pump Station

Site name Karachyniv PS site

Year of construction 1928, rebuilt in 1976

Well fields providing water to the pump station

Western group well fields Volia Dobrostanska, Velykopole, Kamianobrody, Malchytsi with transmission PS Volia Dobrostanska, Velykopole, Kamianobrody

Suction pipelines

a) number of pipelines - 1

b) pipeline type & diameter - steel, 1220×10 and 630×7 mm

Storage tanks 2 pcs, 6000 and 500 m^3

a) in operation - 1 tank 6000 m^3 (36×36 m)

b) out of operation - 1 tank 500 m^3, in operation since 1928

Delivery pipelines

a) number of pipelines - 3

b) pipeline type & diameter - all cast iron, 600 mm, in operation since 1901, 1928, 1956 respectively

c) meter availability none

Pumping equipment

a) number of pumps - 4 pump units - (2 working, 2 stand-by)

b) pump unit indices Q - 2300 m^3/h, H - 89 m, N - 800 kW (1 working)
Q - 2200 m^3/h, H - 55 m, N - 630 kW
Q - 2200 m^3/h, H - 59 m, N - 600 kW
Q - 640 m^3/h, H - 55 m, N - 250 kW

c) working hours - 1 pump (N-800) 24 h/d, 1 pump (can be any) in two periods 5 30-8 45 am and 17 30 - 20 00 pm

Pressure pipelines

a) number of pipelines - 2

b) pipeline type & diameter - cast iron, 600 mm

c) flow - 190 l/sec

d) meter availability - 2 interchangeable meters, 1 stationary meter at the discharge pipeline to the city about 10 m from the site wall, 1 clamp-on meter inside the pump station at the discharge

e) meter type - ultrasonic, index in place

f) meter condition - good

Connection point water distribution system at Shevchenka St

Water distribution by directions 1 direction, Shevchenka St

Rural water consumption Riasna Ruska, Pidriasne, Domazhir

a) connection point pipeline 600 mm

b) diameter at connection 50 - 100 mm

c) flow Riasna Ruska - 210 m^3/d, Pidriasne - 52 m^3/d, Domazhir - 13 m^3/d (LVK data)

d) meter availability none

Water treatment

chlorination - 0 5 - 0 6 Cl mg/l

Pump and storage tank performance monitoring, flow meter registration

Every hour the following data is put into the register book and reported to the LVK dispatcher by the pump station servicing staff readings of two flow meters and one pressure gauge at the pipeline, readings (indicated at the pump station) of water level storage tanks, amperage of each functioning motor, voltage at two inlets

Actual flow measurement 33,263 m^3/d (measured 09 10 96)

Measurements of water volume which flows into the tank with the shut off tank discharge pipe

The pumps were stopped on May, 11 at 1 15 pm for 15 minutes During this time the level in tank increased by 38 cm In one hour 1,900 m^3 of water would flow into the tank, in one day - 45600 m^3

D 2 3 Budzen III Pump Station

Site name Budzen III PS site

Year of construction 1989

Well fields providing water to the pump station

Budzen and Kernytsia well fields and Budzen II pump station

Suction pipelines

a) number of pipelines - 2

b) pipeline type & diameter - steel, 1020×12 mm

Tanks 2 pcs, 6000 m^3 (36×36 m) each

a) in operation all

b) out of operation none

Delivery pipelines

a) number of pipelines - 1

b) pipeline type & diameter - steel, 820×9 mm

c) flow 375 l/sec (measured at Budzen II site)

d) meter availability none

Pumping equipment

a) number of pumps 4 (2 in operation, 2 stand-by)

b) characteristics of 1 pump Q - 1250 m^3/h, H - 65 m, N - 320 kW

c) hours of operation 1 pump - 24 h/d, 1 pump - on/off

Discharge pipeline

a) number of pipelines 1

b) diameter and type 820×9 mm, steel

c) flow 290 l/sec

d) meter availability 1 meter

Connection point to distribution system 700 mm diameter pipeline at Horodotska St

Water distribution by direction

Delivers water only to Zone 1 of the water distribution system

Rural water supply

Horodok, Rudky, Liuben Velyky receive water from Budzen II PS

a) connection point transmission main Budzen II - Budzen III

Water treatment

a) chlorination - 0 6 - 0 8 Cl mg/l

Pump and storage tank performance monitoring, flow meter registration

Every hour the following data is put into the log book and reported to LVK the dispatcher by the pump station servicing staff readings of 1 flow meter at the transmission main, water level in storage tanks, current at each running motor, voltage at two inlets All meters are Russian made (Kuibyshev)

Actual flow measurement 25,135 m^3/d (measured 09 09 96 at Budzen III site)

D.2 4 Sykhiv III Pump Station

Site name Sykhiv III PS

Year of construction 1971, rebuilt in 1989

Well fields providing water to the pump station

a) Hlynna-Navaria, Hlynna Navaria transmission PS

b) Bibrka, Stare Selo PS

c) Water from tanks at Dovha flows by 700-mm pipeline and connects to the city distribution system at Zubrivska St

Suction pipelines

a) number of pipelines - 2, connected in series from both tanks

b) pipeline diameter - 600 mm

Storage tanks 2 pcs, 6000 m^3 (36×36 m) both

a) in operation both

b) out of operation none

Delivery pipelines from Hlynna-Navaria PS and Stare Selo PS

a) number of pipelines - 2

b) pipeline diameter - 600 mm

c) flow 170 l/sec at Hlynna-Navaria and 220 l/sec at Stare Selo

d) meter availability not available

Pumping equipment

a) number of pumps - 6 for city water supply (2 working, 2 stand by)
2 for factory (1+1)
2 for hospital (1+1)

b) pump unit indices

city Q - 540 m^3/h, H - 94 m, N - 250 kW (3 working)
city Q - 540 m^3/h, H - 74 m, N - 160 kW (2 working, 1 stand-by)
factory Q - 300 m^3/h, H - 38 m, N - 75 kW (1 working, 1 stand-by)
hospital Q - 90 m^3/h, H - 30 m, N - 15 kW (1 working, 1 stand-by)

c) working hours - by schedule

Pressure pipelines

a) number of pipelines - 4

b) pipeline diameter - city 1 pipeline, 500-mm
factory 2 pipelines (1 used), 400-mm
hospital 1 pipeline, 150-mm

c) meter availability - none

Connection point Sykhivska-Zelena St

Water distribution by directions

a) Zone 3 of city distribution system

b) Izoliatorniy factory and Kineskop factory

c) TB Regional hospital

Rural water consumption from Transmission pump stations

Water treatment

a) chlorination - none, chlorinator out of operation

Pump and storage tank performance monitoring, flow meter registration

The following type of data is registered in a log voltage, amperage and head by hour for each pump, water level in tank by hour and passed to the dispatcher Valve on the pipeline from Dovha is operated from pumping station by schedule on dispatcher's instructions, normally the valve opens 5 30 - 9 10 am and 5 30 - 9 00 pm

Actual flow measurements

city 13,691 m^3/d, plant 567 m^3/d, hospital 175 m^3/d
Total 14,433 m^3/d (measured at Sykhiv III PS on 09 06 96)

Measurements of water volume which flows into the tank with the shut off tank discharge pipe

The pumps were stopped on May, 11 at 3 30 pm for 22 minutes During this time the level in tank has increased by 22 cm In one hour 1,022 m^3 of water would flow into the tank, in one day - 24,540 m^3

D.2.5 Zboisk Pump Station

Site name Zboisk PS site
Year of construction 1965
Well fields providing water to the pump station

Northern group Rava-Ruska, Maheriv, Shostaky, Kunin, Krekhiv, Mokrotyn, Zarudtsi and Zarudtsi transmission PS

Suction pipelines

a) number of pipelines - 2
b) pipeline type & diameter - steel, 630×8 mm

Storage tanks 2 pcs , cubic capacity 10000 m^3 (48×48 m) each

a) in operation - both
b) out of operation - none The site also has an uncompleted reinforced concrete tank 10000 m^3 (36×36 m) Construction stopped due to the lack of funds

Delivery pipelines

a) number of pipelines - 2, transmission mains Zarudtsi - Zboisk
b) pipeline type & diameter - reinforced concrete and steel, 600-1000 mm Directly by the site 2 pipelines of 600 and 700-mm
c) flow 370 l/sec and 220 l/sec
d) meter availability meters installed at each transmission main, about 10 m from the chlorinator in wells by the site walls

Pumping equipment

a) number of pumps - 4 pump units (2 working)
b) pump unit indices Q - 1,260 m^3/h, H- 32 m, N- 250 kW
Q - 1,080 m^3/h, H - 32 m, N - 160 kW, (all working)
c) working hours - all pumps operate 6 hours a day 6 00 - 9 00 am and 6 00 - 9 00 pm
Gravity pipelines controlled by valve by dispatcher The valve is usually 1/3 open to Kryvchytsi PS from 6 till 11 am, it is 1/10 open for Kryvchytsi PS the rest of the time The valve is open towards the city distribution system for two periods a day 5 30 - 9 00 am and 5 30 - 9 00 pm

Pressure pipelines

a) number of pipelines - 2 pressure, 2 gravity
b) pipeline diameter and type towards Kryvchytsi one 600-mm steel pipeline to the tank at Kryvchytsi PS, this pipeline branches off transmission mains Zarudtsi-Zboisk downstream from meters Towards the city distribution system pressure pipelines from pump station and gravity pipeline directly from the clean water tank Two pressure pipelines leave the pump station 600 mm, cast iron, 529×7 mm, steel The former supplies water to the city center, the latter (Zboisk-Yanivska) supplies water to the newly built residential area and an

educational complex (sports and trade institutes) Zboisk-Yanivska pipeline was designed for water transmission from the eastern group well fields

c) flow 560, 150, 540 and 430 l/sec respectively

d) meter availability - 2 meters at pressure pipes 600 and 527×7 mm, no meters at gravity pipelines

Connection point

600-mm pressure pipeline is connected to the distribution system at the crossing of Mazepa and Lniana streets 529×7-mm pressure pipeline is connected to the distribution system at the crossing of Zamarstynivska and Topolna streets 600-mm gravity pipeline from the tanks is connected to the distribution system at the crossing of Hrynchenka and Pluhova streets Connection point to Kryvchytsi PS tanks at Kryvchytsi site

Water distribution by directions

a) Kryvchytsi PS

b) Yanivska PS

c) Water distribution systems, Zones 5 and 6

Rural water consumption

none, except for a number of summer gardening allotments which use water directly from the gravity pipeline

Water treatment

chlorination - 0 6 - 0 8 Cl mg/l

Pump and storage tank performance monitoring, flow meter registration:

Every hour the following data is put into the register book and reported to the LVK dispatcher by the servicing staff of the PS readings of 2 flow meters and 2 pressure gauges at the pipeline, readings of water level sensors in storage tanks with indexing in place, amperage of each functioning motor, voltage at two inlets, for data recording from ultrasonic clamp-on meters the servicing staff turns on computers simultaneously with the pumps

Actual flow measurement

50,800 m^3/d Flow was measured for 24 hours on 07 10 96 and 07 14 96 at delivery pipelines 2 km upstream from Zboisk PS Measurements at Zboisk PS showed the following flows

to Kryvchytsi PS 13,100 m^3/d

to the city by gravity 12,100 m^3/d

to the city by pressure pipeline 11,500 m^3/d

to the city by pressure pipeline 9,400 m^3/d

D.2.6 Vynnyky Pump Station

Site name Vynnyky PS site

Year of construction 1980, rebuilt in 1990

Well fields providing water to the pump station

Eastern group Pluhiv well field and Pluhiv transmission PS, Vilshanytsia well field Remezivtsi well field (purchased water)

Suction pipelines

a) number of pipelines - 2

b) pipeline type & diameter - steel, 1020×12 mm

Storage tanks 3 pcs, cubic capacity 2000 m^3 (18×24 m)
10000 m^3 (36×36 m), 10000 m^3 (36×36 m)
a) in operation - all
b) out of operation - none

Delivery pipelines transmission main Pluhiv-Vynnyky
a) number of pipelines - 1
b) pipeline type & diameter - steel, 1220×12 mm
c) Meter availability none
d) flow 696 l/sec

Pumping equipment
a) number of pumps
to Kryvchytsi PS - 3 pumps all working
to Dovha PS - 2 pumps 1 working, 1 stand-by
b) pump unit indices
to Kryvchytsi PS - Q - 1250 m^3/h, H - 65 m, N - 250 kW
to Dovha PS - Q - 1250 m^3/h, H - 125 m, N - 630 kW
c) working hours - 24 h/d

Pressure pipelines
a) number of pipelines - 2
b) pipeline type & diameter
to Kryvchytsi PS - 1 line, 900-mm, reinforced concrete,
2 connections upstream from meter for Tobacco factory
and slaughter house - 100-mm pipe, and for Silbud boiler house
to Dovha PS - 1 line, 1000-mm, steel and reinforced concrete pipes
c) meter availability - meters located directly on transmission mains
d) flow 210 l/sec to Dovha PS and 290 l/sec to Kryvchytsi PS

Connection point tanks at sites

Water distribution by directions
a) to Kryvchytsi PS
b) to Dovha PS
c) to Vynnyky region

Rural water consumption Vynnyky
a) connection point 2 connections at the site and
1 connection 700 m from the site
b) diameter at connection 2 pipelines of 100 and 150-mm for
industrial enterprises, 1 pipeline of 80-mm for Vynnyky
c) working hours 24 hours a day
d) meter availability none

Water treatment
chlorination - 0 6 - 0 8 Cl mg/l

Pump and storage tank performance monitoring, flow meter registration
Every hour the following data is put into the register book and reported to the LVK dispatcher by the pump station servicing staff readings of 2 flow meters at 2 transmission mains, readings of 2 pressure gauges at 2 transmission mains, readings of water level in tank, voltage and amperage in each working motor

Actual flow measurement

60,114 m^3/d Flow was measured for 24 hours on 08 06 96, 8 km upstream from Vynnyky PS at delivery pipeline Discharge to Dovha tank was 11,540 m^3/d (measured at Vynnyky PS on 06 29 96)

D 3 CITY BOOSTER PUMP STATIONS

There are four city pump stations within the city boundaries They are Yanivska, Kryvchytsi, Dovha, Miska Smuha

D.3 1 Western

The Yanivska PS is located in the western part of the city and pumps water to the higher elevation areas of the city supplied from Karachyniv pump station The water reaches Yanivska PS by the suction pipeline directly from the 600-mm cast iron pipeline running along Shevchenka street The pump station operates in two daily periods - from 6 to 9 am and 6-9 pm The pumps are turned off the rest of the time The pump station has a 3rd category power supply

D 3.2 Eastern

There are two pump stations in the eastern part of the city - Kryvchytsi and Dovha

The Kryvchytsi PS pumps water directly into the city distribution system and gets water from Vynnyky PS through a separate 900-mm reinforced concrete pipeline Throughout the day water flows continuously into the Kryvchytsi PS tanks The site includes two pump stations - the old pump station operating in Mayorivka built-up area, and the new pump station situated in the built-up area around Lysenka, Piskova and Muchna streets In addition, in order to create sufficient head around Lysenka street, one pump was installed on top of the 6,000 m^3 water tank The pumps operate continuously throughout the day, apart from the above mentioned pump which operates in two daily periods - from 6 to 9 am and 6 to 9 pm The pump station has a 2nd category power supply from two independent power sources The site contains two water tanks - 6,000 m^3 and 3,000 m^3 in volume The construction of the third tank for 10,000 m^3 was begun but then stopped due to the lack of funds Kryvchytsi PS can be supplied with water from Zboisk tank by gravity through the 600 mm pipeline It can also pump water to Zboisk PS if necessary, provided there is enough water to pump

Sykhiv area, located in the south-eastern part of Lviv, is supplied with water from the 10,000 m^3 tank at Dovha PS site Dovha tank receives water from Vynnyky PS by a single 1,000 mm pipeline made of steel and reinforced concrete pipes It was originally planned to build a pump station and 3 tanks of 10,000 m^3 each at Dovha site for the water supply of an area with ground elevation points from 370 to 380 m Not enough funds were available for the planned construction, and only one 10,000 m^3 tank was completed

D.3.2 Central

The central part of the city (the old part) is supplied with water from Miska Smuha PS and tanks which are located along Zelena street Water is provided from Sokilnyky PS (a single steel 500-mm pipeline) and from Kryvchytsi PS (through the water distribution system) The pump station operates in the following way one pump operates in two, daily periods from 9 am to 1 pm and from 9 pm to 12 am supplying water to the 3,000 m^3 pressure tank located at ground elevation of 360 m, at the same time one small pump pumps water towards the area around Tarnavskoho and Tolstoho streets Part of the water is supplied into the city distribution system directly from the two tanks (total volume 19,000 m^3) located at ground elevation of 328 m The discharge valves on the tanks are open from 6 to 9 am and 6 to 9 pm The pump station has a 3rd category power supply The site includes two underground water tanks of 7,000 m^3 and 12,000 m^3 The 3,000 m^3 pressure tank located 500 m from the pump station also operates in the same network

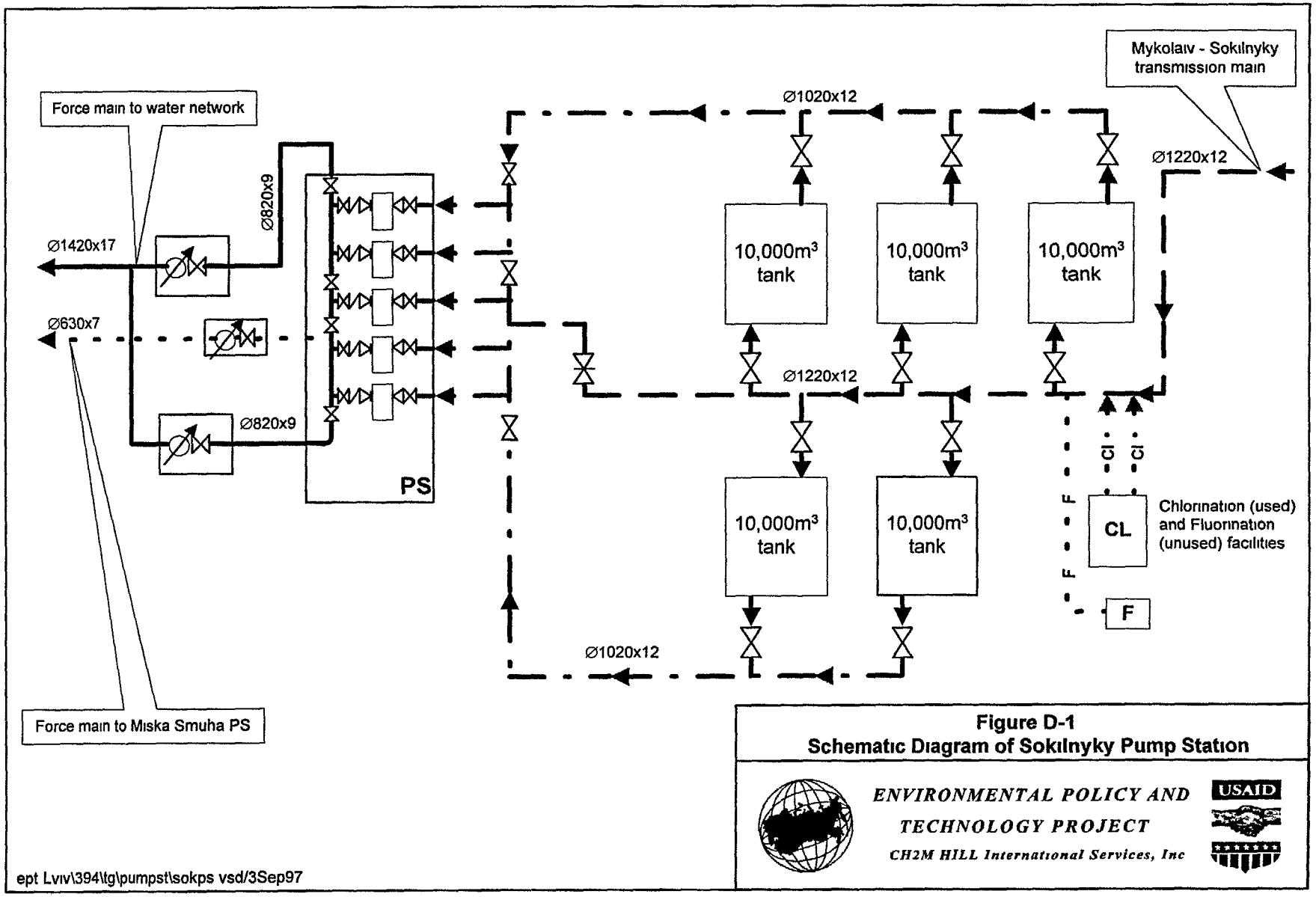
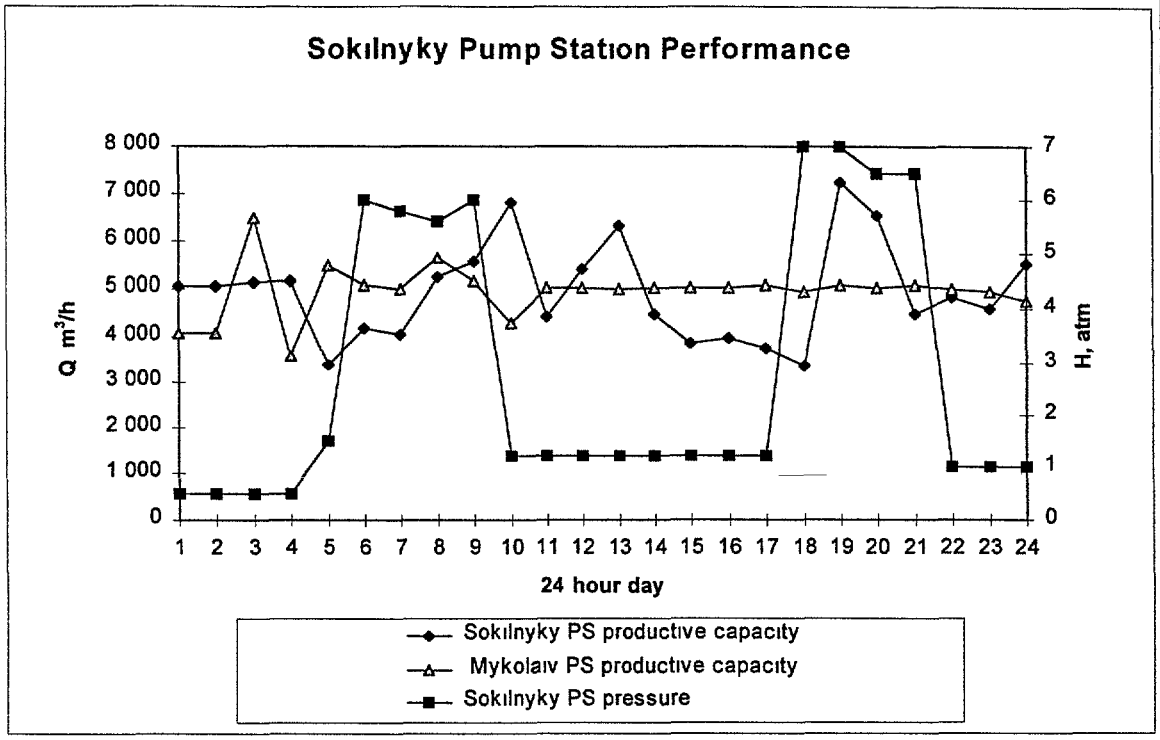


Figure D-1
Schematic Diagram of Sokilnyky Pump Station



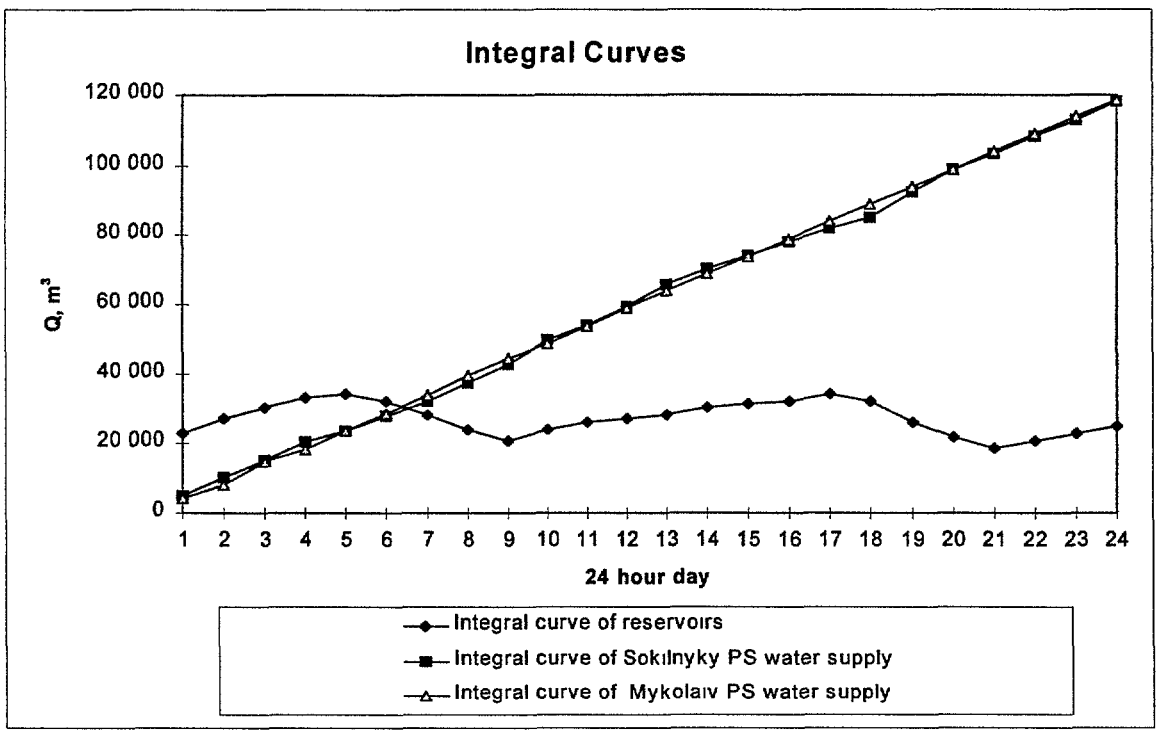


Figure D-2
Daily Flow and Pressure Curves for Sokilnyky PS

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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 partnerships 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 Kazakhstan

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