PN-ACD-726

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

PN-ACD-726

Environmental Policy and Technology Project

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

UKRAINE

Summary of Final 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
Environment & Natural Resources Division

Prepared by
Ukraine, Belarus & Moldova Regional Office
Environmental Policy and Technology Project
For the New Independent States of the former Soviet Union

A USAID Project Consortium Led by CH2M HILL

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 assist 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

The CH2M HILL team includes the following organizations

- Center for International Environmental Law
- Clark Atlanta University/HBCUMI Environmental Consortium
- Consortium for International Development
- Ecojuris
- Environmental Compliance Inc
- Harvard Institute for International Development
- Hughes Technical Services Company
- International Programs Consortium
- International Resources Group Ltd
- Interfax Newsagency
- K&M Engineering
- Ogden Environmental and Energy Services Company
- Price Waterhouse
- World Wildlife Fund (US)

For additional information regarding the EPT Project contact the following

United States of America

Environmental Policy & Technology Project
Head Office
1819 H Street NW Suite 700
Washington DC 20006 USA
Telephone (202) 835-1450
Facsimile (202) 835 1463
Contact Dr James Westfield

Ukraine

Environmental Policy & Technology Project
Ukraine Belarus & Moldova Regional Office
4 Bohomoltsia Street Suite 301
252024 Kyiv Ukraine
Telephone +(380-44) 247 5633 247 5634
Facsimile +(380 44) 247 5637
Contact Mr Ties van Kempen

Environmental Policy & Technology Project
Lviv Project Office
64 Zelena Street
290017 Lviv Ukraine
Telephone +(380 322) 76-7389 76 8413
Facsimile +(380-322) 27-1152

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)

TABLE OF CONTENTS

Section		Page
List of Tables		**iv**
List of Figures		**iv**
Abbreviations, Acronyms, and Glossary		**v**
1	**Introduction**	**1**
2	**Initial Overview of Lviv Water Supply**	**3**
2 1	Main Components of Lviv Water Supply	3
2 2	Lviv Urban Water System	3
2 3	Major System Deficiencies	5
2 4	Water Consumption	9
2 5	References	12
3	**Historical Review of Lviv Water Supply System**	**17**
3 1	1900 to 1945	17
3 2	1945 to the Present	18
4	**Lviv Urban Water Supply Source**	**23**
4 1	General Description	23
4 2	Wells	24
4 3	Pumping Equipment	24
4 4	Well Field Operation	25
4 5	Major Problems	26
5	**Lviv Water Transmission System**	**27**
5 1	General Layout	27
5 2	Transmission Mains	27
5 3	Pump Stations	31
5 4	Pump Station Operation	31
5 5	System of Remote Monitoring	33
5 6	Major Problems	35
6	**Lviv Water Distribution System**	**48**
6 1	Overview	48
6 2	Pressure Zones	49
6 3	Major Water Consumers	50
6 4	Pipe Material	51
6 5	Major Problems	52

TABLE OF CONTENTS (Concluded)

7	**Lviv Vodokanal Operations, Maintenance and Repairs**		**61**
	7 1	Organization of Lviv Vodokanal	61
	7 2	Maintenance and Repairs	63
	7 3	Electricity Consumption	65

Appendix A Well Fields

Appendix B Water Supply Well Design, Construction and Equipment Data

Appendix C Water Supply Well Field Operational Issues

Appendix D Pump Station Details

Appendix E Water Quality

Appendix F Average Daily Water Consumption of District Heating Facilities

Appendix G Water Consumption of Major Industrial Enterprises

Appendix H Water Consumption by the Largest Communal Enterprises

Appendix I Water Consumption by Budget Institutions

Appendix J The 52 Largest Water Consumers from all Consumption Categories

Appendix K Norms of Water Consumption in Residential and Public Buildings

Appendix L Interview with LVK Flow Meter Repair Crew

Appendix M Pipe Breakdowns and Repairs

Appendix N Energy Consumption

LIST OF TABLES

Number		Page
2-1	Lviv Water Consumption - 1900 to 1995	13
2-2	Lviv Water Use and Revenue Collections	14
2-3	Water Consumption by Consumer Group	14
2-4	Water Supplied and Billed	15
3-1	Development of the Northern Well Field Group	20
3-2	Development of the Southern Well Field Group	20
3-3	Development of the Western Well Field Group	20
3-4	Development of the Eastern Well Field Group	21
5-1	Pipe Diameters, Lengths, and Construction Periods	37
5-2	Condition of Lviv Pump Stations	38
5-3	Lviv Pump Station Tanks	39
5-4	Lviv Water Transmission Pump Stations	40
5-5	Lviv City Pump Stations	41
5-6	Lviv City Booster Pump Stations	42
5-7	Types of Data Transmitted to the LVK Dispatcher	43
6-1	Hydraulic Characteristics of Pressure Zones	54
6-2	Estimated Water Usage by Consumer Group	54
6-3	Water Delivered and Consumed in 1995 (as reported by LVK)	54
6-4	Development of Lviv Water Distribution System	55
6-5	Distribution Piping According to Age	55
6-6	Characteristics of Water Distribution Piping of 200 mm and Larger Diameter	56
7-1	Typical Daily Schedule for a Breakdown Repair Team	66
7-2	Type of Repair Work	66
7-3	Estimate of Time for Repair Work - Two Months in 1993	67
A-1	Lviv Well Field Characteristics	A-2
A-2	Production of Well Fields in 1995	A-3
A-3	Well Field Unit Costs in 1995	A-4
B-1	Construction Parameters of the Wells at Lviv Well Fields	B-2
B-2	Pumping Equipment of the Wells at Lviv Well Fields	B-3
E-1	Chemical Bacteriological Laboratory LVK Water Analysis Results, 9 March 1994	E-2
E-2	Chemical Bacteriological Laboratory LVK Water Analysis Results, 8 April 1995	E-3
F	Water Consumption by District Heating Facilities	F-1
G	Water Consumption of Major Industrial Enterprises in 1995	G-1
H	Water Consumption of the Largest Communal Enterprises in 1995	H-1
I-1	Water Consumption of Lviv Medical Institutions in 1995	I-1
I-2	Water Consumption of Educational Institutions in 1995	I-3
J	Water Consumption of Major Customers in Lviv	J-1
K	Water Consumption Norms According to the Construction Norms and Regulations 2 04 01-85 "Plumbing and Sewerage in Buildings"	K-1

LIST OF TABLES (Concluded)

L-1	LVK Meters Reported	L-1
N-1	LVK Well Field Power Consumption in 1995	N-2
N-2	LVK Outer Pump Station Power Consumption in 1995	N-3
N-3	LVK Inner Pump Station Power Consumption in 1995	N-4
N-4	Water Distribution Supply System Pump Station Power Consumption, 1995	N-5
N-5	LVK Well Field Power Consumption in 1996	N-6
N-6	LVK Outer Pump Station Power Consumption in 1996	N-7
N-7	LVK Inner Pump Station Power Consumption in 1996	N-8
N-8	Water Distribuion Supply System Pump Station Power Consumption, 1996	N-9

LIST OF FIGURES

Number		Page
2-1	Lviv Water System	16
3-1	Historical Development of Lviv Water System	22
5-1	Lviv Transmission System Lengths	44
5-2	Location of the Largest Water Customers in Transmission System	45
5-3	Location of Breakages during 1993-95	46
5-4	Remote Monitoring Within Water Distribution System	47
6-1	Network of Pump Stations, Locations and Zones	57
6-2	The Schematic Layout of the Distribution System with the Water Mains	58
6-3	Distribution Pipelines and Design of Pressure Zones (13 zones)	59
6-4	Distribution Pipelines and Major Water Consumers	60
7-1	District Maintenance Team Jurisdictions	68
7-2	Flowchart for Repair Work in the Distribution System	69
7-3	Breakdowns in Water Distribution System in 1995	70
7-4	Breakdown Distribution of Water Supply Pipelines	71
7-5	Location of Major Breakdowns in the Water Distribution System	72
A-1	Lviv Well Fields	A-5
A-2	Geological Profile and Well Design	A-6
A-3	North Well Field Analysis - Rava-Ruska	A-7
A-4	North Well Field Analysis - Maheriv	A-8
A-5	North Well Field Analysis - Shostaky	A-9
A-6	North Well Field Analysis - Krekhiv	A-10
A-7	North Well Field Analysis - Kunin	A-11
A-8	North Well Field Analysis - Mokrotyn	A-12
A-9	North Well Field Analysis - Zarudtsi	A-13
A-10	East Well Field Analysis - Remezivtsi	A-14
A-11	East Well Field Analysis - Pluhiv	A-15
A-12	East Well Field Analysis - Vilshanytsia	A-16
A-13	South Well Field Analysis - Stryi	A-17
A-14	South Well Field Analysis - Hlynna-Navaria	A-18
A-15	South Well Field Analysis - Bibrka	A-19
A-16	South Well Field Analysis - Malechkovychi	A-20
A-17	West Well Field Analysis - Volia Dobrostanska	A-21
A-18	West Well Field Analysis - Velykopole	A-22
A-19	West Well Field Analysis - Kamianobrody	A-23
A-20	West Well Field Analysis - Malchytsi	A-24
A-21	West Well Field Analysis - Budzen	A-25
A-22	West Well Field Analysis - Kernytsia	A-26
D-1	Schematic Diagram of Sokilnyky Pump Station	D-12
D-2	Daily Flow and Pressure Curves for Sokilnyky Pump Station	D-13

LIST OF FIGURES (Concluded)

M-1	Breakdown Rate in the Water Distribution System	M-2
M-2	Water Supply Pipe Breakdowns	M-3
M-3	Fittings Breakdowns	M-4
M-4	Technical Inspection	M-5
M-5	Service Connection Breakdowns	M-6

ABBREVIATIONS, ACRONYMS & GLOSSARY

A	Ampere
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
Cl	Chlorine
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
kW	kilowatt
kWh	kilowatt hour
kWh/m^3	kilowatt hour per cubic meter
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^2/d	square meters per day
m^3/d	cubic meters per day
m^3/h	cubic meters per hour
m/s	meters per second
m^2/s	square meters per second
m^3/s	cubic meters per second
m^3/y	cubic meters per year
mg/l	milligrams per liter
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

ABBREVIATIONS, ACRONYMS & GLOSSARY (Concluded)

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
V	Volt
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)
yr	Year
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 third (final) 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 This final data report presents 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

INITIAL OVERVIEW OF LVIV WATER SUPPLY

The following presents an overview of water supply for the city of Lviv, based upon readily available data A general schematic layout of the water supply system is presented in Figure 2-1

2 1 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

2.2 LVIV URBAN WATER SYSTEM

The water supply in Lviv serves about 800,000 people Many parts of the service area receive water for only about six hours a day The water system suffers from an infrastructure which needs substantial replacement, and revenues which do not match expenses associated with system operation and maintenance

The City of Lviv is over 700 years old and its present public water supply and distribution system was started about 100 years ago The city obtains its water from about 20 well fields located outside the city perimeter In order to obtain sufficient suitable water, the more recent well fields have been established as far away as 100 km from the city center

Water is pumped in from the well fields in transmission mains Usually these terminate at large pump stations at the city boundary, where additional pressure is added to facilitate water distribution within the city The city itself is built on a series of low hills and there is an elevation difference within the city of about 150 m In 1995, an average of about 335,000 m^3/d was pumped into the city distribution system The system has been divided into six distribution areas These are generally associated with individual well field transmission lines and/or pump stations on the edge of the city Much of the water distribution system for the city and outlining areas was built in the period 1970-1985 while the city was expanding to serve industrial facilities

Due to an overall shortage of water (relative to usage demands within the system's distribution areas), the LVK is unable to maintain pressure throughout the system and the resulting service to the consumers is dependent on the location, elevation, and demand in any area A portion of this usage is leakage within the distribution system This is assumed to be at least 20 percent, and may be as high as 40 to 50 percent in some areas Portions of the installed distribution system have proved to be very susceptible to failure The reasons for this appear to be partly due to the linking of cast iron pipe with mortar-filled joints, and the use of thin-walled, uncoated, rolled-steel pipe that was supplied to the city during part of the post-war expansion This steel pipe suffers from localized surface (interior and exterior) corrosion, which creates numerous holes or weep-spots along the pipe This problem may be aggravated by the electric trams that operate in the city with resultant stray currents being grounded on the steel pipe (water mains) below the streets

During winter there is an additional problem with freezing water which can burst the piping The 1995-1996 winter was particularly harsh, and the frost line migrated down to the depth of the water mains in parts of the city This situation is further aggravated by stagnant flow in some of the pipes due to water outages

In 1994 the government of the City of Lviv directed a study to determine what would be necessary for the city to be able to have water 24 hours per day by the year 1998 The study, entitled *Water '98*[1], developed a list of projects to improve the system The estimated cost of constructing all the projects was about US$ 550 million The study named some 10 activities, referred to as Category 1 projects, that would enable the city to have water 24 hours per day The estimated total cost of these Category 1 projects was about US$ 75 million These projects were associated with building a new well field about 80 km east of Lviv

[1] *Water 98* was published in Ukrainian in October 1995 by a special task force which investigated the water supply situation in Lviv and presented certain solutions

2 3 MAJOR SYSTEM DEFICIENCIES

A number of water system deficiencies are apparent in Lviv

- measurement (metering) of water produced, transported, and consumed
- water supply
- delivery of water
- energy usage
- revenues and financing

These deficiencies are outlined below

2 3.1 Measurement (Metering) of Water

The lack of water meters in the system, and potential inaccuracies in installed equipment and previously recorded measurements of water, means that there is only a general understanding of how much water is produced and used Hence there is no precise data on which to prepare unit costs of water production and delivery, or set water-use fees based on production and delivery costs

2 3 1 1 Metering of Water Produced and Transported

On the production and delivery side, few meters exist or appear to be working in the well fields, and the reliability of meters at the large pump stations that pressurize the city's distribution system is not known In an effort to upgrade metering at pumping stations, the LVK placed an order in late 1995 for extending their remote sensors, thereby aiming to increase the number of such stations that are electronically monitored

2 3 1 2 Metering of Water Consumed

On the consumption side, less than 10 percent of the water-use connections are installed with a meter Meters that have been installed are mostly on enterprises which consume large volumes of water The remaining water consumption is estimated, from nation wide water use standards (norms) For customer billing, water consumption is determined by norms that are either based on the expected average water use for the particular category of user (e g total square meters of a residential apartment floor space), or on the diameter of the water pipe connecting the user to the distribution system

2 3 1 3 Water Balance

Due to the lack of meters, there is no reliable water balance for the system A reasonable water balance is important in order to have a basis for making decisions on future investments At present there are two ways by which Lviv water production and consumption is estimated One is to determine the total volume consumed from data presented in water billings Most of this is based on norms and thus is inaccurate - especially when water is turned off in many areas for 18 or more hours per day The second is to estimate the amount of water produced by measuring the water pumped into the

city from the well fields Only some of these pumps have measuring devices, and their accuracy is questionable

In addition, the actual productivity of each well is unknown, as no reliable metering of water production occurs The estimated production could be at considerable variance from actual production

The reason why this information is important is that there is currently only speculation as to the actual overall water usage and leakage in the system Without a reasonably sound idea of how much water is being produced, all subsequent evaluations of water leakage, water consumption, and energy usage cannot be made with any certainty

2 3.2 Supply of Water

The earliest well field serving the city was constructed around 1900 The City of Lviv is located on a hydrological divide between streams flowing to the Baltic and Black Seas Although a small stream flows through the city, groundwater was found to be the best source of water for the city It is significant that no matter which nation was governing Lviv over the past 100 years, groundwater has always been used as the most effective, long-term water supply for the city The use of groundwater has kept the supply system relatively simple, and the main treatment that it receives is disinfection by chlorination

There are 173 wells in the Lviv system Many of these are reported to have reduced capacity due to sand entering the well casings, broken pumps etc It appears that many existing wells were constructed using a small rotary rig The filtration of water into the well casing is done by a screen made from a piece of steel casing that has been drilled or punched with 40 mm diameter holes, so that the open surface area amounts to about 25 percent of the total area A stainless steel wire of about 0 5 mm in diameter is wrapped and welded around the outside the casing, leaving gaps of about 0 3 mm The spaces between the wires over the open holes allow water to pass from the formation into the well casing How effective this is in preventing fine sand from entering each casing during pumping is not known, and will depend on how the area around the well screen is packed and then how the whole assembly is developed More details on the well fields are presented in Appendix A

The *Water '98* plan emphasized development of additional groundwater supplies as a key solution to Lviv's water problems Lviv needs additional water to serve the demands of both customers and leakage Current usage in the system (both consumption and leakage) is about 335,000 m^3/d, and the Category 1 projects (total cost of US$ 75 million as estimated by the *Water '98* study) would add about 35,000 m^3/d to the water supply

The *Water '98* project plan envisioned expanding the Pluhiv well field east of the city This area is reputed to have an abundant supply of groundwater Previous plans to further develop this well field has upset people living in the vicinity Their concern is that an expanded well field will impair their ability to obtain groundwater for their own use Part of the proposed *Water '98* plan would build water facilities to serve many of the villages in the area and so improve community support for well field expansion

In addition, since the existing distribution system in Lviv is designed to service areas that were adjacent to the termination of incoming transmission lines, it appears that it will be very difficult to move surplus water (which might be produced by the Pluhiv well field) from the east side of the city to other parts without additional transmission mains being built within the interior area of Lviv

2.3.3 Delivery of Water

The water distribution infrastructure in Lviv has been developed over the past 100 years Infrastructure improvements were made to match expansion of the city Especially after 1950, however, improvements to the infrastructure were designed in order to serve new developments which were almost independent of the rest of the water infrastructure

In general, this was done by establishing and/or expanding well fields outside the city on the side of the city where the development was being supplied This avoided the necessity of transferring water through the center of the city, which became more difficult as the city expanded The overall supply system now resembles a spider, with the city being the body and the legs the supply lines bringing in the water The result is that most of the sources can supply and deliver water into the old city, which is generally at a lower elevation, but due to the capacity of pipes in the center and the relative elevations of the various distribution areas, it is very difficult to move significant quantities of water from one side of the city to the other

There exist a limited number of large diameter pipelines that have been built in an attempt to move the water around the city's perimeter, but more must be constructed in future if this objective is to be achieved This inability to readily transfer large quantities of water across the city makes it impossible to deliver any surplus water from one side of the city to make-up for shortages in other parts of the city

2 3 3 1 Construction Materials

During the expansion of the water distribution system, a variety of materials was used Some were much better than others, and the age of the materials, especially pipes, is not necessary reflected in their service life In many cases, cast iron pipes installed before 1940 are now in much better shape than those installed after 1950 Materials used for distribution and transmission mains included cast iron, steel and concrete The quality of pipes has varied considerably, largely depending on suppliers, which in most cases have not been controlled by the city since 1940 Of these materials, the thin-walled, rolled-steel pipe appears to have the poorest service life In many cases such pipes were not lined or coated, and corrosion has caused them to develop weak points resulting in slow leaks and, when a rupture occurs, fast leaks requiring urgent repair

The problems with buried pipelines are aggravated by the fact that water is only supplied during certain parts of the day Thus the pressure in the pipes can change rapidly in a short period of time, thereby placing additional stress on the pipes

2 3 3 2 Leakage

The extent of leakage is not known, and without universal metering of the system (it is reported that only 17 percent of the water is now metered), it is difficult to accurately gauge the extent of leakage Even in a system that is universally metered the amount of unaccounted-for water is usually in the range of 10-20 percent The leakage estimated by LVK is about 30 percent, which includes wastage by consumers In fact, the amount of water lost from the system due to leakage is probably more, and would vary depending on the operating conditions of the system

In most urban areas around the world, the cost of water lost from leakage is less than the short and often long-term costs of replacing the pipes in the ground Therefore, general leakage is allowed to continue, with only major breaks being repaired This has been the practice in Lviv However, the amount of water available from its sources is now insufficient to meet the demand created by both consumers and leakage Whether it is more cost-effective to increase the supply of water or decrease the amount lost though leakage is an issue yet to be resolved Therefore, no appropriate decision has been made by LVK as to where it should invest resources in order to improve water delivery to its consumers

2 3 3 3 Repairs

Due to poor quality of materials and operational constraints, the water distribution system is constantly under repair One of the LVK engineers who went on a USAID-sponsored water utility study tour to the USA in 1995 stated, that the rate of line breaks per kilometer in Lviv was 10 to 100 times more than that of the utilities he had visited in the U S (see EPT Project 1995a, b)

LVK has great difficulty in conducting repairs to its water system Repair crews lack the required tools, materials, and training Therefore they take much longer to complete work than repair crews in western countries In addition, the pipes, valves etc that they are trying to repair are often rather fragile Cut-off valves needed to isolate the system for repairs are installed less frequently than in many other water utilities This means that water supply in larger sections of the city must be turned off for longer periods of time while repairs are being made Consequently people and businesses who, under normal circumstances only have a few hours of water each day, might be without water for several days to several weeks while repairs are being made

2 3 4 Energy Usage

The cost of energy for LVK constitutes 60-70 percent of the total cost of water production The proportion keeps increasing as the cost for electricity rises in accordance with national government policies and regulations This proportion, although similar to other vodokanals in Ukraine, is very high relative to most water utilities in other countries, and reducing energy is an obvious area on which to focus efforts and investment At present, LVK has difficulty in meeting its payment obligations to the electric company, and during periods in 1995 it owed upward of US$ 3 5 million to the electric utility This represents a major

portion of revenues collected from water customers The continually rising energy costs have been a major reason for the LVK's increase in rates to its customers

Investment aimed at reducing energy consumption is critical to the long term viability of LVK If additional water is produced at the well fields and pumped into the system it could increase energy consumption without substantially increasing revenues This is because satisfying increased demand from consumers paying a flat rate for water would use more water without a commensurate boost in revenue This could make the financial position of LVK very difficult

The main usage of energy is for pumping and this is where energy reductions must be implemented This would be done by making wells and pump stations more efficient, or by modifying the overall operation of the system

2.3.5 Revenues and Financing

Ukraine's economic difficulties have severely undermined the financial viability of the country's water and wastewater utilities Lviv Vodokanal, like most in the country, suffers from inadequate finances which make appropriate maintenance and operation, and much-needed asset rehabilitation and replacement, impossible

Improved financial status of LVK is critical for its survival and future development To improve service it must invest in repairs and upgrade the system, and to do that it must become a financially sustainable unit based on user charges Although subsidies for vodokanal operations and expansion were normal in Ukraine in the past, this will be very difficult, if not impossible, in future since the central, oblast, and city governments do not have the required funds

In order to obtain investment funds from international financing institutions, it will be necessary to demonstrate that LVK is moving towards becoming a financially self-sustainable operation This means that every project loan sought from a financial institution should be examined as to its impact on vodokanal expenditures and revenue, as well as its effect on water service

The way to improve the financial health of the system is to improve revenues and reduce costs Revenues can be improved by imposing adequate tariffs and improving collections Customer resistance to the payment of tariffs may be reduced as service improves and as the economy in Lviv improves

2.4 WATER CONSUMPTION

One of the major, current problems of the Lviv water system is that the rate at which water is pumped into the distribution system is greater than the rate at which it can be extracted from the well fields Two approaches to overcome this situation would be either to produce more water or to reduce usage in the distribution system

The city's *Water '98* plan calls for producing more water This implies substantial capital investment plus incurring additional energy costs with no real promise of a commensurate increase in revenues to pay for these costs A reduction in water use in the distribution system is the alternate approach This would have the effect of reducing the need to increase water production while reducing energy costs to LVK

Water conservation needs to be practiced on the macro and micro levels On the macro level, LVK needs to conserve water by minimizing the amount of water lost by leakage The effects of this could be very significant in reducing overall unnecessary energy costs and wastage of water On the micro level, conservation of water by the residential, communal, and enterprise user groups needs to be encouraged This applies particularly to those categories of consumers from whom revenues from water sales are below water delivery costs, namely the residential and communal consumers

Using data provided by the USAID-funded contractor, PADCO, in their October 1995 report (PADCO, 1995), an analysis was made of average water use per connection, by rate category (see Table 2-2) Although residential consumers use over half the total volume of water, the average amount of water used per connection is only 7 m^3/d as compared with 38 m^3/d for communal users, and 8 m^3/d for enterprises This indicates that communal accounts have much greater potential (per connection) for both water conservation and possible future revenue than either the residential or enterprise users

Data on water consumption during 1995, by consumer group, is presented in Table 2-3 Table 2-4 lists the amount of water supplied and billed-for by LVK in 1995

2 4 1 Residential Water Users

Currently LVK supplies water to about 800,000 people Using data from Table 2-2, the number of people served by each residential connection is about 30 Using the same data, the average water usage is about 6 6 m^3/person/month, which is within the norms expected of between 3 3 to 9 1 m^3/person/month

Although the amount of water supplied to residential users is large, constituting over half the total amount of water distributed by the vodokanal, the amount used per connection is low, each connection represents a number of family or apartment units in a connected building In the short term, the effort involved in reducing residential usage by conventional means, such as moving to a volume based charge (requiring extensive metering), internal plumbing repairs by outside parties etc , would be very expensive relative to the expected overall reductions in usage or increase in revenues (probably minimal and possibly negative)

2.4 2 Communal Water Users

Based on data in Table 2-2, this is the category of users with the largest estimated usage per connection It is also the category with the lowest percentage (only 14%) of accounts which pay their bills and the highest potential revenue to be gained This is therefore the

class where the most effort should be made in reducing water usage and increasing overall revenue to the system

Since almost all communal connections are owned and funded by the city or oblast administrations, a commitment is required by these entities to budget and pay the bills rendered for water usage, including projected increases in tariffs due to inflation and increases in electric costs Once there is the commitment to pay for water used, there may exist an incentive for managers of various communal organizations to conserve water

2.4 3 Enterprise Water Users

Under present regulations for tariff-setting, enterprises subsidize the water system By national legislation, this user category is asked to pay all the remaining calculated costs of water production after projected revenues from the other two major categories are calculated This formula definitely favors urban areas, where there is a large industrial base In Lviv the majority of the calculated total costs of production are spread over eight percent of the water sold Consequently in Lviv, enterprises are charged about 30 times more than domestic users for each unit of water

Although this places a great burden on enterprises, in the short term, from a financial standpoint, this tariff system must continue as the LVK needs the revenue In the long term, tariffs for enterprises should be reduced in conjunction with raising tariffs for domestic and communal users

Currently about half of the enterprises are metered, and the collection of water charges is almost 80 percent, if payment in kind is included It is doubtful that, in the short term, the rate of collection of water charges can be increased significantly, although the list of debtors should be examined to determine if this is so

2.4.4 Conservation Through Charging on a Volumetric Basis

The vast majority of users in Lviv are charged using an estimated rate of water usage based on either the characteristics of the particular user category or the size of the connection to the system The concept of estimating the probable amount of average water use by user category is employed in other countries, such as the USA, to assess water demand in a system These norms are presently being utilized in Lviv to invoice most LVK customers for their water use This method allows users to pay a flat fee for unlimited water consumption

The method of billing using norms simplifies invoicing but does not encourage individual water conservation This practice is not much different from that of cities like London and New York In London, especially under the newly privatized water companies, there has been discussion of moving to an individually metered system, but the reason given for retaining the current practice, at least for now, is that the cost associated with metering individual connections or families exceeds the potential benefits in reduced usage

Although universal individual metering of water consumers is a national objective in Ukraine, it is critical to the prioritizing of financial investments that LVK determine whether any foreseeable reduction in usage and increase in revenues will offset the investment in metering One method of imposing the conservation of water in the short run is to continue the practice of lowering the pressure in the water system to reduce usage

A possible first step towards the goal of universal metering for non-enterprise and budget organization connections would be to have a single meter for each connection Most of these connections would be for multi-family buildings For this to function it would require that the responsibility for paying for the water passing through the meter be assigned to a ZhEK, community association, or some type of condominium operation Then the ZhEK or other management structure would need to collect the monies from the users Built into this would need to be some incentive for the use of a meter, either for the ZhEK or the management association This could be by allowing the ZhEK to charge tenants a flat fee and then keep any profits resulting from lower usage (less losses from leaky appliances), or perhaps by structuring the rates so that it is more advantageous to pay the metered cost than the flat rate

Without some incentive, there will be little reason for building groups to want a meter installed or to protect it once it is installed A large meter set up (meter, strainers, valves etc) purchased in the Ukraine for a large building can cost in the range of $US 200-400 In Lviv a meter is easily removed since the water is turned off much of the time, and it is also easily tampered with since it almost must always be located in the basement of the buildings to protect it from frost

2.5 REFERENCES

EPT Project 1995a *Ukraine Report of Study Tour Water Utility Management Training 13 August to 1 September 1995* Prepared by CH2M HILL International Services, Inc for U S Agency for International Development Washington, DC Contract No CCN-0003-Q-00-3165-00

EPT Project 1995b *Ukraine Summary Report on Water Utility Study Tour Workshops* Prepared by CH2M HILL International Services, Inc for U S Agency for International Development Washington, DC Contract No CCN-0003-Q-00-3165-00

PADCO, July 1995a *Ukraine Pricing Strategies to Increase Cost Recovery for Water Provision Vol 1 Pricing Process* Prepared for Government of Ukraine and Vodokanal, City of Lviv, Ukraine Prepared by Planning and Development Collaborative International (PADCO, Inc) Funded by United States Agency For International Development (USAID) Contract No CCS-0008-C-00-2057-00

PADCO, July 1995b *Ukraine Improving Cost Recovery For Water Provision Vol II Lviv Vodokanal Improving Cost Recovery* Prepared for Government of Ukraine and Vodokanal, City of Lviv, Ukraine Prepared by PADCO, Inc 1025 Thomas Jefferson Street, NW Suite 170 Washington, DC 20007-5209 Contract No CCS-0008-C-00-2057-00

Table 2-1 Lviv Water Consumption - 1900 to 1995			
Year	**Population, thou**	**Water Supply, m^3/d**	**Water Consumption, lcd**
1900	160 000	N/A	N/A
1910	206,000	18 000	87 4
1920	210,000	18,000	85 7
1926	240 000	24,000	100 1
1931	312,000	28,000	90 3
1939	318 000	33 000	104 1
1945	165 000	21,000	124 5
1950	332,000	39 000	117 5
1955	380,000	55,000	144 6
1960	421,000	67,000	159 8
1965	496 000	105,000	211 0
1970	564,000	177,000	313 9
1975	629,000	254,000	403 9
1980	688 000	331,000	480 4
1985	735 000	397 000	540 3
1990	780,000	387,000	495 7
1995	806,000	295,000	365 6

Table 2-2 Lviv Water Use and Revenue Collections						
Parameter	**Units**	**Residential**	**Communal**	**Enterprise**	**Total**	**Notes**
No of Connections	each	25,338	3 315	1 982	30,635	a
No of meters	each	312	590	1,053	1,955	a
Connections metered	percent	2%	20%	50%	6%	
Estimated usage	m^3/d	174,000	127 000	25,000	326,000	a, b
Percent of total usage	percent	53%	39%	8%	100%	
Average usage	$m^3/d/connection$	6 9	38 3	7 5	10 2	a b
Average rate	$US\$/m^3$	$0 04	$0 08	$1 00		c, d
Average billing	US$/mo/connection	$6	$92	$225		a, b, e
Rate of collections	Percent	57%	14%	78%		a, f
Amount collected	US$ millions/yr	**$2**	**$1**	**$7**	**$9**	g
Amount outstanding	US$ millions/yr	**$2 2**	**$8 4**	**$2**	**$14**	g

Notes

a - From PADCO report Vol 1 and Vol 2, July 1995

b The amount of usage by category is only an estimate as the number of meters is too limited These data are based on the norms (predicted use) that have been used in planning in the NIS for many years Less than 2% of the residential connections are metered

c New rates adapted by the Vodokanal in January 1996 with US$ 1 00 = 190,000 Karbovanets (kbv)

d - The average cost of production from PADCO data (PADCO 1995) is $0 08/$m^3$

e - Includes payments in kind for industries

f Based on total collections that month, not the number of accounts

g Provided by LVK Includes payment in kind

Table 2-3 Water Consumption by Consumer Group - 1995		
Consumer Group	**Water Consumption**	
	m^3/d	**%**
Residential	164,300	55 8
Industrial	21,000	7 1
Communal	87 500	29 7
Budget (City, Oblast and/or State)	21 900	7 4
Total	**294,700**	**100**

Table 2-4 Water Supplied and Billed - 1995				
Consumer Location	Reported Amount of Water Supplied (m^3)		Amount of Water Billed (m^3)	
	per year	per day	per year	per day
Lviv	141 053 000	386,000	107,554 000	295,000
Villages	3,256,000	9,000	2,397,000	7,000
Vynnyky	1,659 000	5,000	1,029,000	3,000
Other	4 571,000	12 000	3,737,000	10,000
Total	**150,539,000**	**412,000**	**114,717,000**	**314,000**

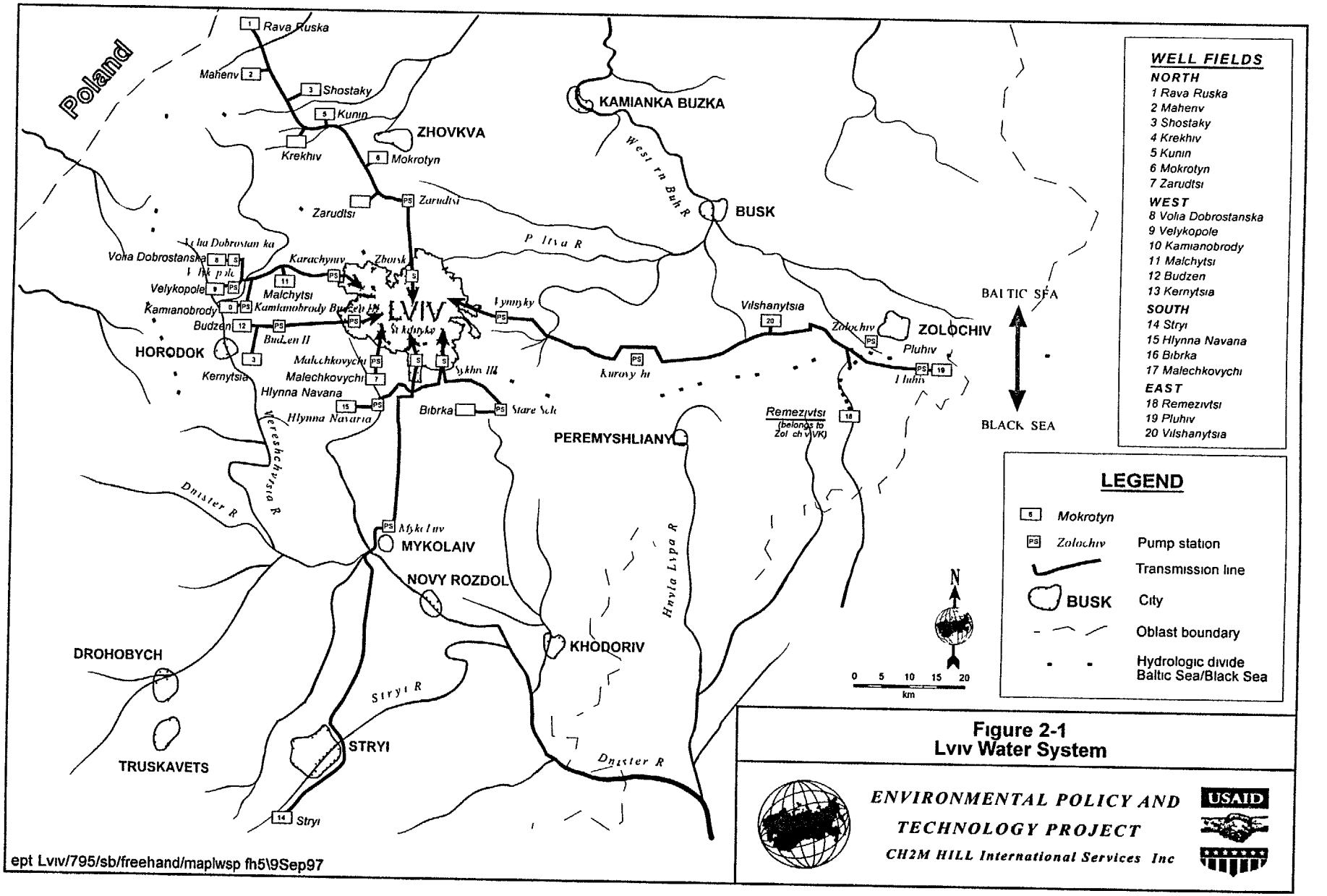


Figure 2-1
Lviv Water System

Section 3

HISTORICAL REVIEW OF LVIV WATER SUPPLY SYSTEM

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

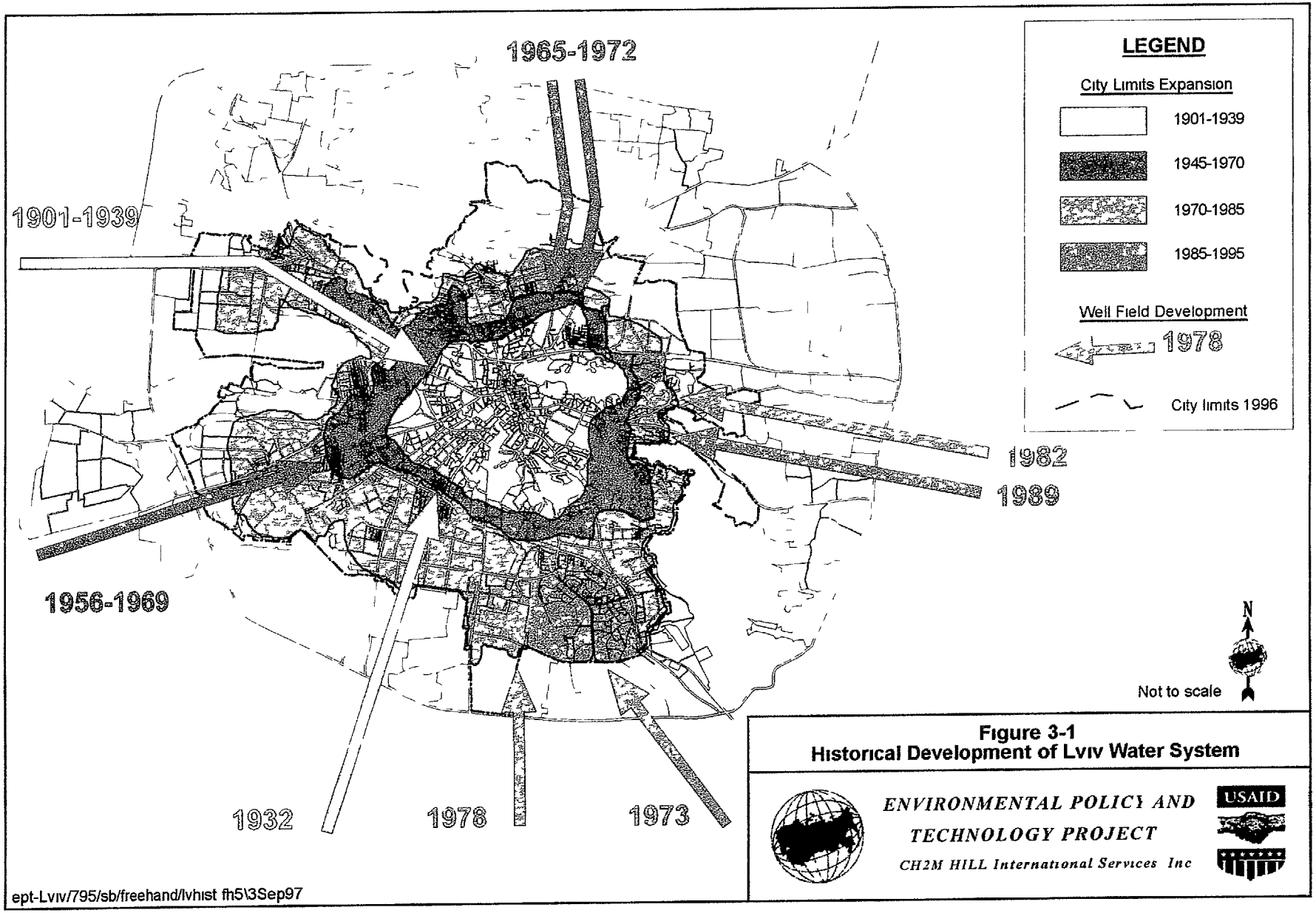


Figure 3-1
Historical Development of Lviv Water System

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept-Lviv/795/sb/freehand/lvhist fh5\3Sep97

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 E

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

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 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 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 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 E

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**	

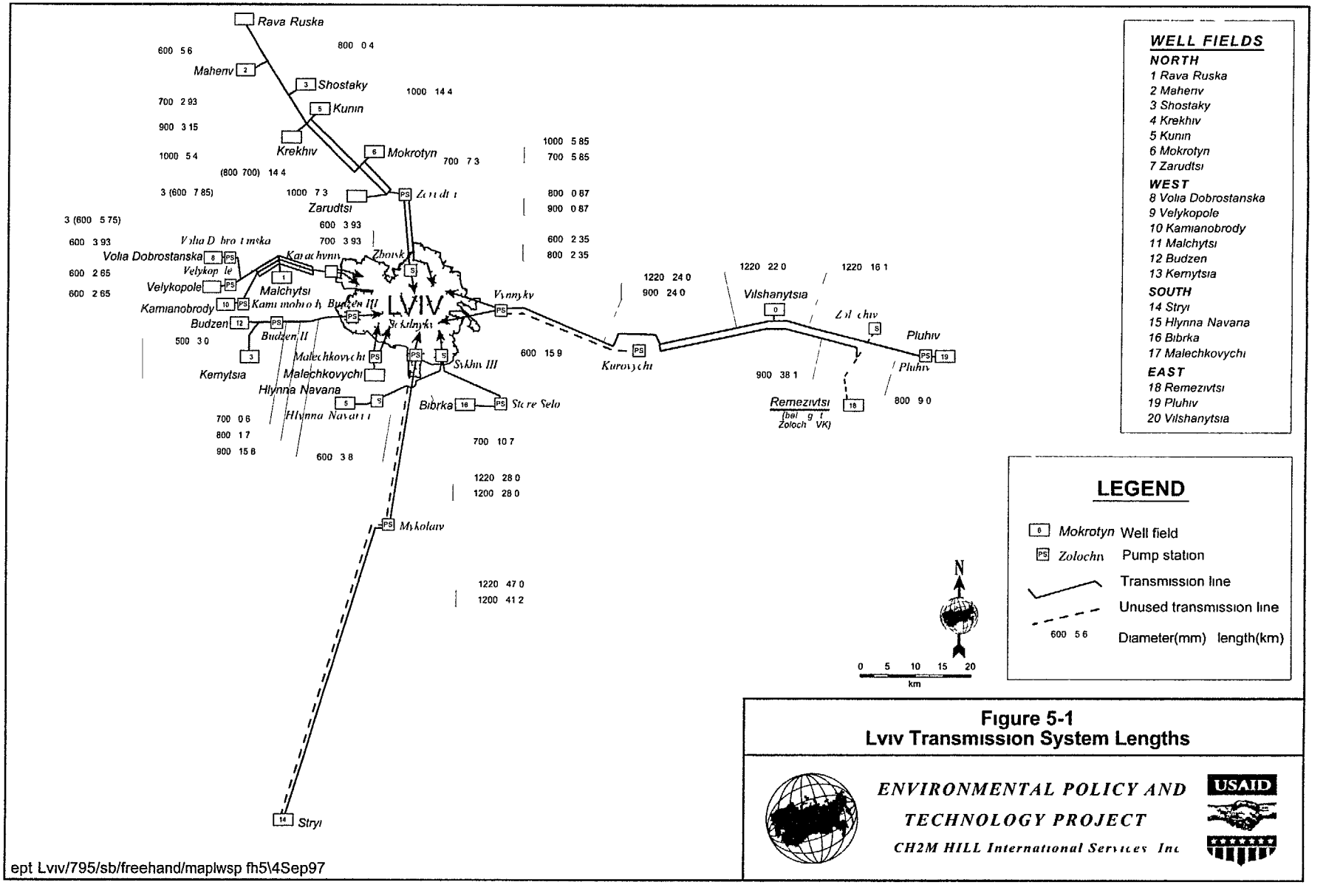
Table 5-5
Lviv City Pump Stations

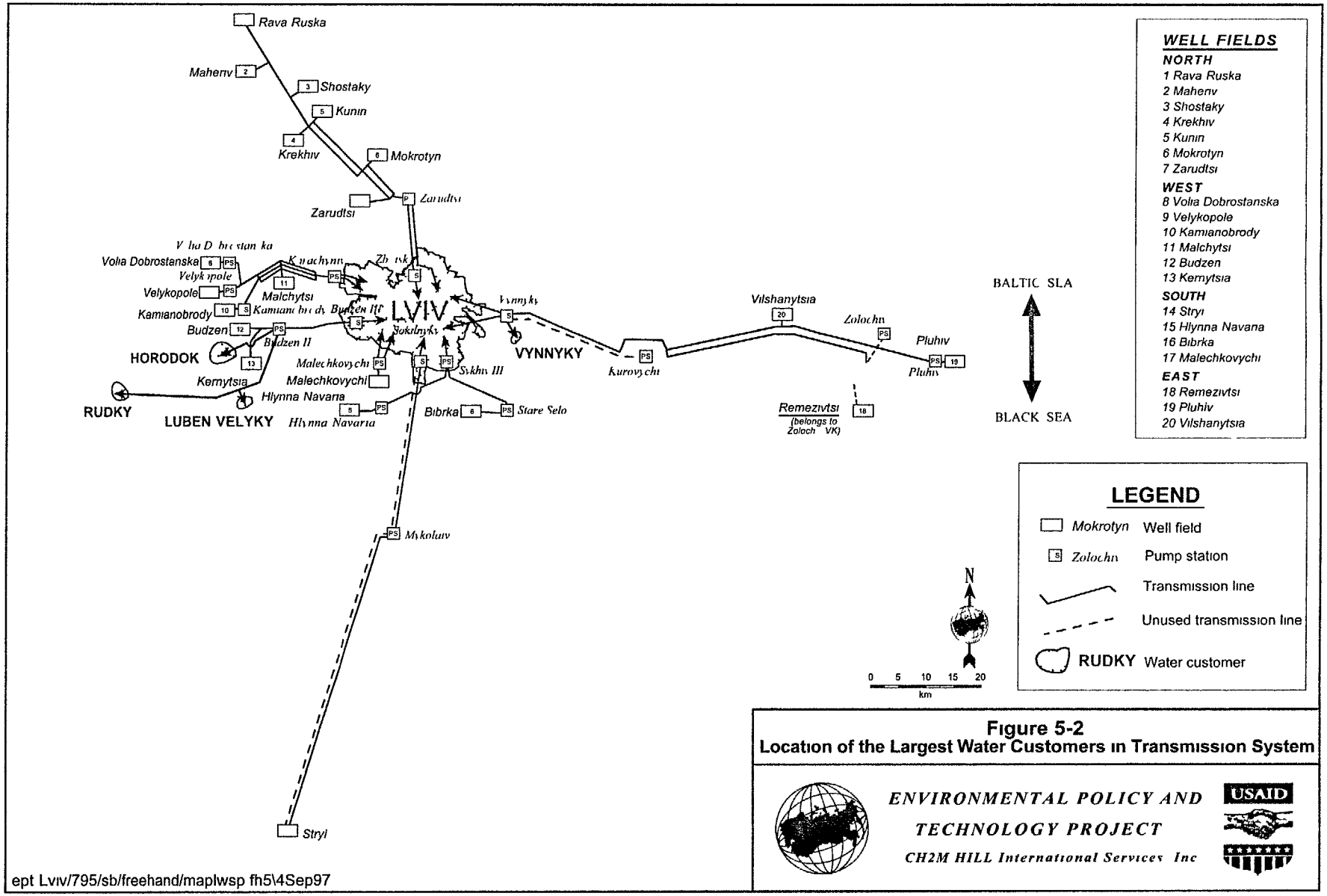
City Pump Station Name	Number of Pumps		Pump Characteristics			Pump Shaft Elev	Year		Design Daily Capacity	Average Daily Flow 1995	Annual Flow 1995	Power Supply Category	Power Usage in 1995		Dis-in-fec-tion
	Working	Stand by	m^3/h	atm	kW	m	Built	Rebuilt	m^3/d	m^3/d	1000 m^3		kWh	kWh/m^3	
North															
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	•	•	•		•


WELL FIELDS
NORTH
1 Rava Ruska
2 Mahenv
3 Shostaky
4 Krekhiv
5 Kunin
6 Mokrotyn
7 Zarudtsi
WEST
8 Volia Dobrostanska
9 Velykopole
10 Kamianobrody
11 Malchytsi
12 Budzen
13 Kernytsia
SOUTH
14 Stryi
15 Hlynna Navana
16 Bibrka
17 Malechkovychi
EAST
18 Remezivtsi
19 Pluhiv
20 Vilshanytsia
LEGEND
Mokrotyn Well field
Zolochiv Pump station
Transmission line
Unused transmission line
600 5 6 Diameter(mm) length(km)
N
0 5 10 15 20
km
Rava Ruska
Mahenv
Shostaky
Kunin
Krekhiv
Mokrotyn
Zarudtsi
Volia Dobrostanska
Velykopole
Kamianobrody
Budzen
Kernytsia
Malchytsi
Malechkovychi
Hlynna Navana
Bibrka
Stare Selo
Mykolaiv
Stryi
LVIV
Vynnyky
Kurovychi
Vilshanytsia
Zolochiv
Pluhiv
Remezivtsi
Figure 5-1
Lviv Transmission System Lengths
ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc
USAID
ept Lviv/795/sb/freehand/maplwsp fh5\4Sep97



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

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

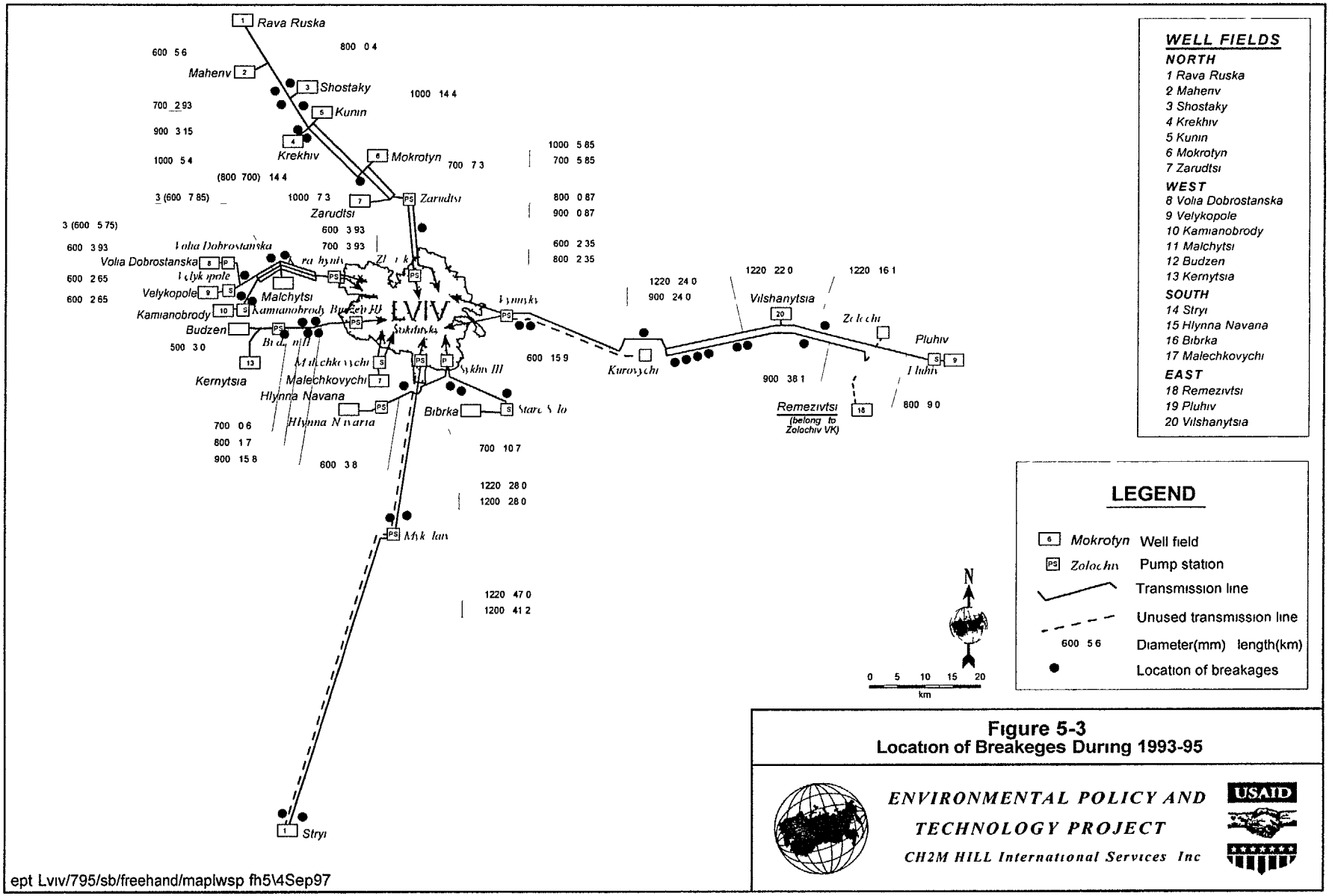


Figure 5-3
Location of Breakeges During 1993-95

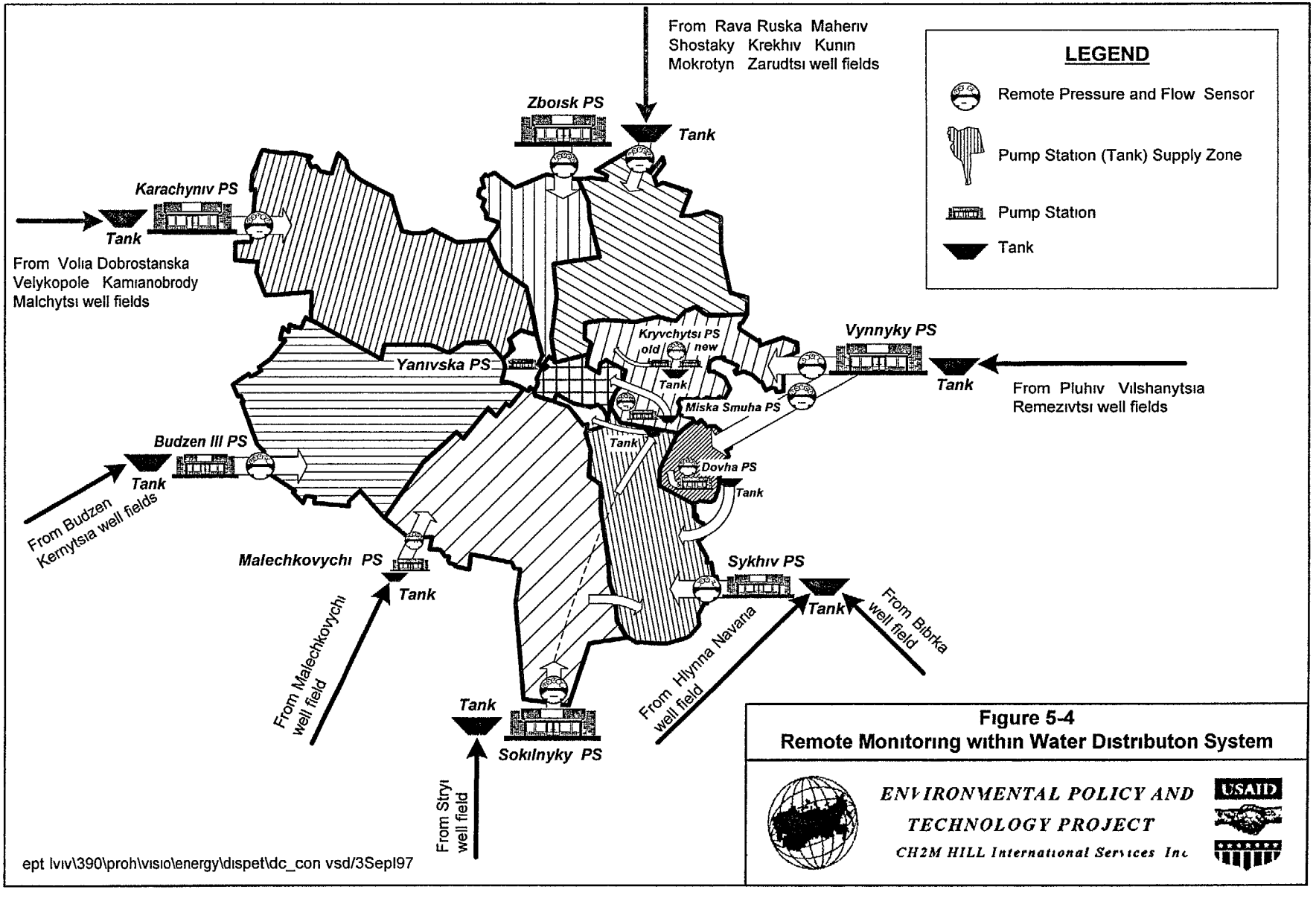


Figure 5-4
Remote Monitoring within Water Distributon System

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

Section 6

LVIV WATER DISTRIBUTION SYSTEM

An outline of how water in Lviv is distributed to end-users is presented in this section

6.1 OVERVIEW

Lviv's water distribution system was designed on the basis of future water demands of new developing residential and industrial areas Pipe sizes were determined on the basis of hydraulic and technical-economic calculations based on the maximum normative water flow rates in pipes, and the flow rate required to meet fire fighting needs

The nearest pump station would supply new areas with water, if the pump station's production and pressure were sufficient Otherwise, a new well field was designed with a pump station If the pressure of the existing pump station was not sufficient, local district heating facilities with booster pump units would create the necessary pressure

Cast iron pipes were generally used for the distribution network pipelines Beginning in 1980, steel pipes have also been used, pipes were laid at 1 6-1 8 m below ground to avoid freezing of water

The first schematic layout of the distribution system was only developed in 1973, it projected the development of the system as one entity until 1985 Taking into account the 150 m difference in elevation within the city boundaries, and the location of the existing pump stations, the schematic layout suggested dividing the water distribution network into six zones each zone was to be supplied with water from a pump station or by gravity from a water storage tank Each pump station was to have storage tanks with sufficient water for fire-fighting purposes in a given area Implementation of the schematic layout was finished in 1982

Presently the existing city distribution system consists of

- ten pump stations, located either within the city limits or at the city boundaries, which serve to establish the necessary pressure in the network
- water storage tanks located close to the pump stations, used for storing and regulating water, and for fire fighting needs, the Yanivska pump station is an exception because it takes water directly from a pipeline and does not have any tanks
- water chlorination units are located at four of the major pump stations

In 1995, according to LVK data, water delivered to consumers was 386,000 m^3/d

The total length of the distribution system is about 900 km Of this, 182 km consists of pipes which are 200 mm or larger in diameter Due to a great number of valves which do

not operate, pressure zoning is hypothetical and zones are just associated with the pump stations The scheme of pump stations and distribution zones are presented in Figure 6-1, while the layout of the water distribution system is presented in Figure 6-2

At present, only about 20-30% of the residential sector receives water 24 hours per day, some 70% have a six-hour scheduled water supply three hours in the morning and three hours in the evening

In view of growing housing and industrial construction in the 1980s, a new schematic layout had to be developed The revised *Schematic Layout of the Water Distribution System Development of Lviv* was accomplished by the Lviv Institute for the Design of Communal Services "Lvivdiprokomunbud" in 1987 This outlined the principal direction of water distribution system development through to the year 2005

6 2 PRESSURE ZONES

The city of Lviv is situated on rolling hills with a variance in local elevation of about 150 m (230 m to 380 m) In the old part of the city, residential buildings generally have 3 or 4 floors In the new residential areas, most buildings have 5-9 stories and some have 14 stories

As the distribution system pressure zones do not adequately function, there are areas of the city where water is delivered less than 6 hours a day Some residents in these areas (living higher than the 4th floor) do not receive any water for several days a week In accordance with the *Schematic Layout of the Water Distribution System Development of Lviv*, it was suggested that the distribution system should be divided into thirteen pressure zones It was planned that each zone would have a pump station or a group of pumps at the existing pump station to provide the required pressure in the given zone

Pressure zoning of the water distribution system was to be accomplished with pressure-regulating valves The schematic layout of the design pressure zones is presented in Figure 6-3, while hydraulic data regarding these design zones is presented in Table 6-1 In planning the pressure zones, the following parameters were taken into account

- difference in elevation of the pressure zone territory
- project design of the residential areas and industrial zones
- grouped location of multi-storied buildings
- distance from the pressure zones to water sources

According to the plan, the total volume of water supplied to the city was to be 500,000 m^3/d To implement the plan it would be necessary to

- rehabilitate the production of the existing well fields up to their safe yield

- increase water production from the eastern well field group from 66,400 m^3/d to 171,400 m^3/d by adding the Verkhniobusky and Khmeliovsky well fields

- install 172 km of additional water mains and distribution pipelines
- install 26 chambers with shut off valves
- install 53 chambers for pressure regulation in each zone
- build five new pump stations
- rehabilitate all existing pump stations within the city boundaries

The total estimated cost of implementing the *Schematic Layout of the Water Distribution System of Lviv by 2005* was US$ 405 million

6 3 MAJOR WATER CONSUMERS

Major water consumers within the Lviv water distribution system are

- residential sector of Lviv (which consumes about one-half of water deliveries)
- industry
- communal enterprises and budget institutions
- populated area of Vynnyky
- villages and towns situated in the protection zone or depression cone of the Lviv well fields

The population of the city (805,900 residents not including Vynnyky, Rudno, and Briukhovychi) generally live in multi-story apartment buildings

The City of Lviv has 327 industrial enterprises which in 1987 consumed 129,100 m^3/d (84,000 m^3/d of this amount was consumed through the water distribution system) Presently most enterprises are not functioning, which has caused a reduction in water consumption

The communal consumer group includes both communal services and budget institutions

- budget institutions include educational institutions (higher and secondary) and their dormitories, kindergartens and hospitals
- entities such as restaurants, cafeterias, hotels, baths, cleaners, sport halls, administrative centers, city motor vehicles and electric transport enterprises, tourist facilities, factory dormitories etc belong to the communal services group

The estimated (or metered) consumption of major customers in each consumer group, as well as a list of the major water consumers in the system, are presented in Appendices F, G, H, I and J The location of many of the major water consumers is presented in Figure 6-4

Data in Table 6-2 indicates that the residential sector is the largest water consumer However, water demand within this group varies for different consumers In areas with residential buildings that have six and more floors, pressure is established by pumping equipment installed in the buildings because the pressure in the distribution system is not sufficient to provide all the floors with water This pumping equipment usually consists of 2 or 3 pumps installed in the local heating district facility (DHF) The pumps draw water straight from the water distribution system to transmit to the residential buildings Usually one local pump in a DHF serves 1 to 40 residential buildings (100-30,000 residents) As the district heating facilities take water from the city distribution system, the LVK regards them as major water consumers of the residential sector group The other consumers of this group are grouped by residential buildings

The Lviv city distribution system has 26,166 primary users (kontos) Only 10% of these have working meters installed Appendix L contains information on the working and failed flow meters installed in various consumer groups

Due to lack of flow meters, the amount of water consumed is estimated on the basis of norms Norms of water demand by various water consumers have been developed and approved by the State Committee for Construction, Architecture and Communal Services of Ukraine (formerly the State Committee for Housing and Communal Services) Under state regulations, the Lviv Executive Committee has approved the *Water Demand Norms for Residential and Public Buildings and Institutions*, which is the basis for calculations regarding water demand A summary of these norms is presented in Appendix K

Many pump stations (that deliver water into the distribution system) do not have flow meters installed Water flow is therefore estimated on the basis of power consumption or capacity of the pumps installed and the length of their working time LVK is has recently embarked upon a program of installing meters at their principal pump stations

The difference between the amount of water transmitted into the distribution system by pump stations, and that reported by LVK as received by consumers, is reported as water losses (see Table 6-3) Water unaccounted for is about 36 million m^3/y (of 24% of water transmitted) These are theoretical losses, since delivery and consumption is not fully measured, only estimated The losses are due to pipe leakage, hardware wastage, and measurement errors

6 4 PIPE MATERIAL

The Lviv water distribution network consists of cast iron and steel pipes Distribution pipes laid before 1945 are generally British- and Polish-made cast iron pipes Pipes laid between 1945 and 1975 are mainly Soviet-made cast iron and steel pipes Distribution pipes laid after 1975 are mostly steel and partly cast iron pipes of Soviet-manufacture The length of pipes in the distribution and transmission system in the past 60 years are presented in Table 6-4

None of the distribution pipes have lining, although some steel pipes have bituminous coating The diameter and age of the distribution system pipes are presented in Table 6-5

The 900 km of water distribution pipes have been classified by LVK into three groups according, to condition

- pipes laid before 1945 the condition is reported as some poor and some acceptable
- pipes laid between 1945 and 1975 the condition is reported as almost entirely poor
- pipes laid after 1975 the condition is reported as poor to acceptable

The overall picture is as follows

• Bad condition needing frequent repair	680 km or 76% of total
• Acceptable condition	220 km or 24% of total
• Good condition	none

An analysis of the 6,486 breakdowns that occurred in 1995 in the water distribution system gave the following results

• failures in pipes	57%
• failures in fittings	28%
• failures in service connections	13%
• other	2%

The total number of breakages in 1995 amounted to 6 1 per kilometer

Table 6-6 gives an inventory of steel and cast-iron pipes of 200-mm diameter and larger in the distribution system

6.5 MAJOR PROBLEMS

Based upon evaluating the water distribution system in Lviv, several major problems are evident, as outlined below

6 5 1 Network Losses

Considering the number of breakdowns in the distribution network, it becomes clear that the major cause of water losses is the poor condition of the network Samples of damaged cast iron and steel pipes have been collected and examined The samples show cracked cast iron pipes and badly corroded steel pipes with holes of up to 40 mm in diameter There is no trace of either internal or external coating Some of the steel pipes were less than ten years old

When a breakage occurs, repairs are often conducted using methods that do not have a long service life Repairs are often made by plugging the holes with a wooden peg and welding a steel plate over it Bell and spigot joints are being repaired by caulking with hemp and filling with cement or pegs Cracked cast iron pipes are replaced

6 5.2 Water Wastage

As result of poor control over housing installations and delays in repairing by ZhEKs (housing management associations), a considerable amount of water is wasted through dripping taps and running toilet cisterns This problem was documented by continuous measurements over a 24-hour period in several residential buildings (totaling 564 inhabitants) which have a 24-hour water supply The steady night consumption during the night hours was recorded to be from 6 to 13 lch with an average of about 10 lch

Based on these sample households, those which have a 24-hour water supply could lose up to 20% of the water supplied to them

6.5 3 Measurements

Only some 10% of all connections have functioning water meters, which means that LVK cannot obtain a reliable view of water consumption and system losses An interview with a LVK meter-repair team revealed that meters were of poor quality and their operation period shorter than specified by the manufacturer More details of this interview are presented in Appendix L

Table 6-1 Hydraulic Characteristics of Pressure Zones					
Zone Number	Elevation, m	Estimated		Zone Served by Pump Station	
		Demand, m^3/d	Pressure, m	Existing	Designed
I	275-310	42,000	26	Miska Smuha	
II	310-345	115,000	42	Sokilnyky, Malechkovychi	
III	365 38	17,000	42		Dovha
IV	295 330	100 000	26/42	Karachyniv, Budzen III	
V	250 300	82 000	22/42	Zboisk (Tank)	Zboisk
VI	300-340	10,000	42	Zboisk	
VII	250-300	8,000	42		Kryvchytsi
VIII	315-350	66,000	42	Sykhiv III	
IX	300-350	24,000	26/42	Kryvchytsi	
X	230 300	27,000	42		Vynnyky
XI	300-350	3 000	22		Zboisk
XII	230 350	3,000	26	Kryvchytsi (Tank)	
XIII	315-340	3,000	26	Yanivska	

Table 6-2 Estimated Water Usage by Consumer Group		
Consumer Group	m^3/d	Percent of Total
Residential Sector	164,300	56
Industry	21,000	7
Communal Services	87 500	3
Budget Institutions	21,900	7
Total	**294,700**	**100%**

Table 6-3 Water Delivered and Consumed in 1995 (as reported by LVK)			
Consumers	Delivered	Consumed	Difference (Losses)
	m^3/y	m^3/y	m^3/y
City of Lviv	141 053,000	107 554 000	33,4999 000
Villages	3,256,000	2,397,000	859,000
Vynnyky	1 659 000	1,029,000	630,000
Others	4 571 000	3,737,000	834,000
Total	**150,539,000**	**114,717,000**	**35,822,000**

Table 6-4 Development of Lviv Water Distribution System		
Year	**Population of Lviv**	**Total Length of Pipes, km**
1939	318 100	202
1945	165 000	202
1970	563 600	700
1985	734 800	1,300
1995	831 200	1,500

Table 6-5 Distribution Piping According to Age				
Diameter, mm	**< 1945**	**1945-75**	**1975-96**	**Total**
< 100	139 0	51 0	89 0	279
150		77 0	130 0	207 0
200		89 0	94 2	183 2
250	2 5		63 5	66 4
300		19 2	22 0	41 2
350		14 3		14 3
400	1 9	25 0	13 7	40 6
500		4 2	17 0	21 2
600	7 5	22 6	7 2	37 3
700		4 0	2 0	6 0
800				
1,000				
1,100				
≥1 200			4 3	4 3
Total	**151 3**	**306 3**	**442 9**	**900 5**

Table 6-6
Characteristics of Water Distribution Piping of 200 mm and Larger Diameter

Diameter, mm	Total Length, m	Steel				Cast Iron			
		Length, m	by 1945	by 1970	by 1995	Length, m	by 1945	by 1970	by 1995
200	8 160	850	-	850	-	7,310		3 130	4 180
250	6,350	-	-	-	-	6,350	2,850	-	3,500
300	41,148	3,318	-	980	2,338	37,830		18 235	19 595
350	14,300	12 930	-	12 930	-	1 370		1 370	-
400	40,513	19 478	1 870	14,228	3 380	21,035	-	10 710	10 325
500	21 045	20 845	-	3,945	16,900	200		200	-
600	37,343	9,960	-	2 780	7,180	27,383	7,540	19 843	-
700	5 895	5,895	-	3,945	1 950	-		-	-
900	2 780	2 780	-	-	2 780	-	-	-	
1,200	750	750	-	-	750	-	-	-	-
1,400	3 500	3 500	-	-	3,500	-	-	-	-
Total	**181,784**	**80,306**	**1,870**	**39,658**	**38,778**	**101,478**	**10,390**	**53,488**	**37,600**

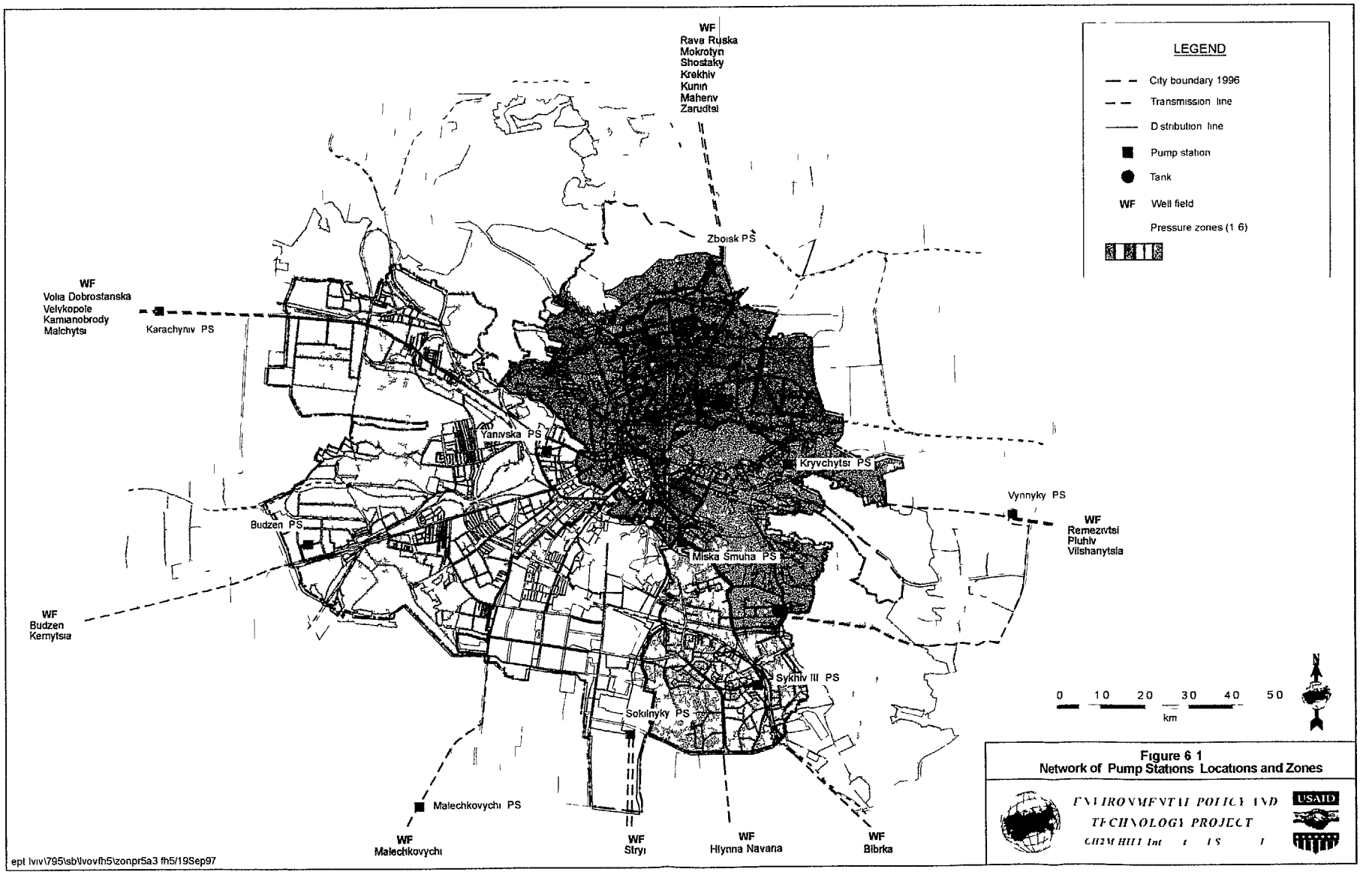


Figure 6 1
Network of Pump Stations Locations and Zones

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL Int

USAID

BEST AVAILABLE COPY

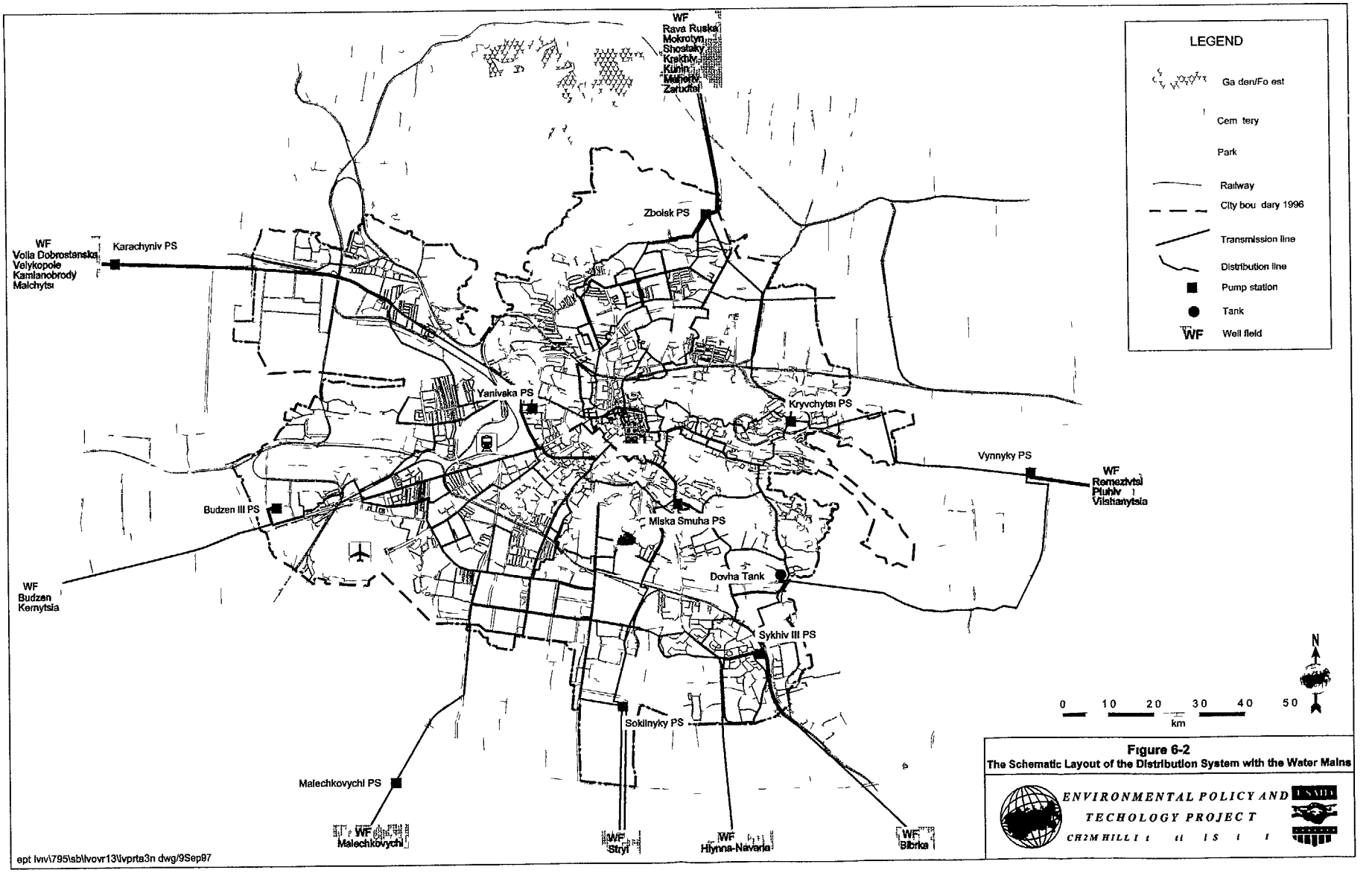


Figure 6-2
The Schematic Layout of the Distribution System with the Water Mains

BEST AVAILABLE COPY

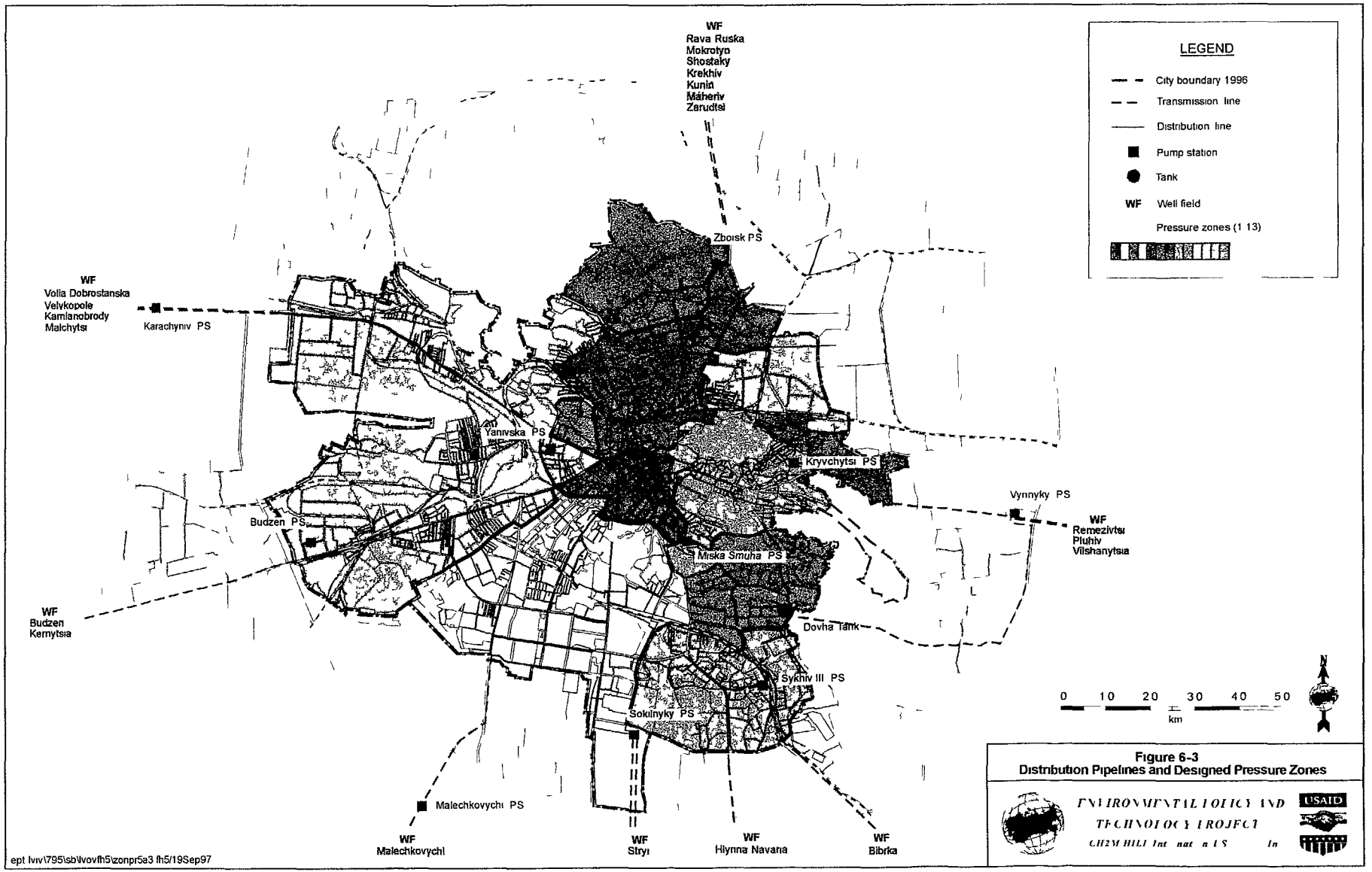


Figure 6-3
Distribution Pipelines and Designed Pressure Zones

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International LS Inc
USAID

BEST AVAILABLE COPY

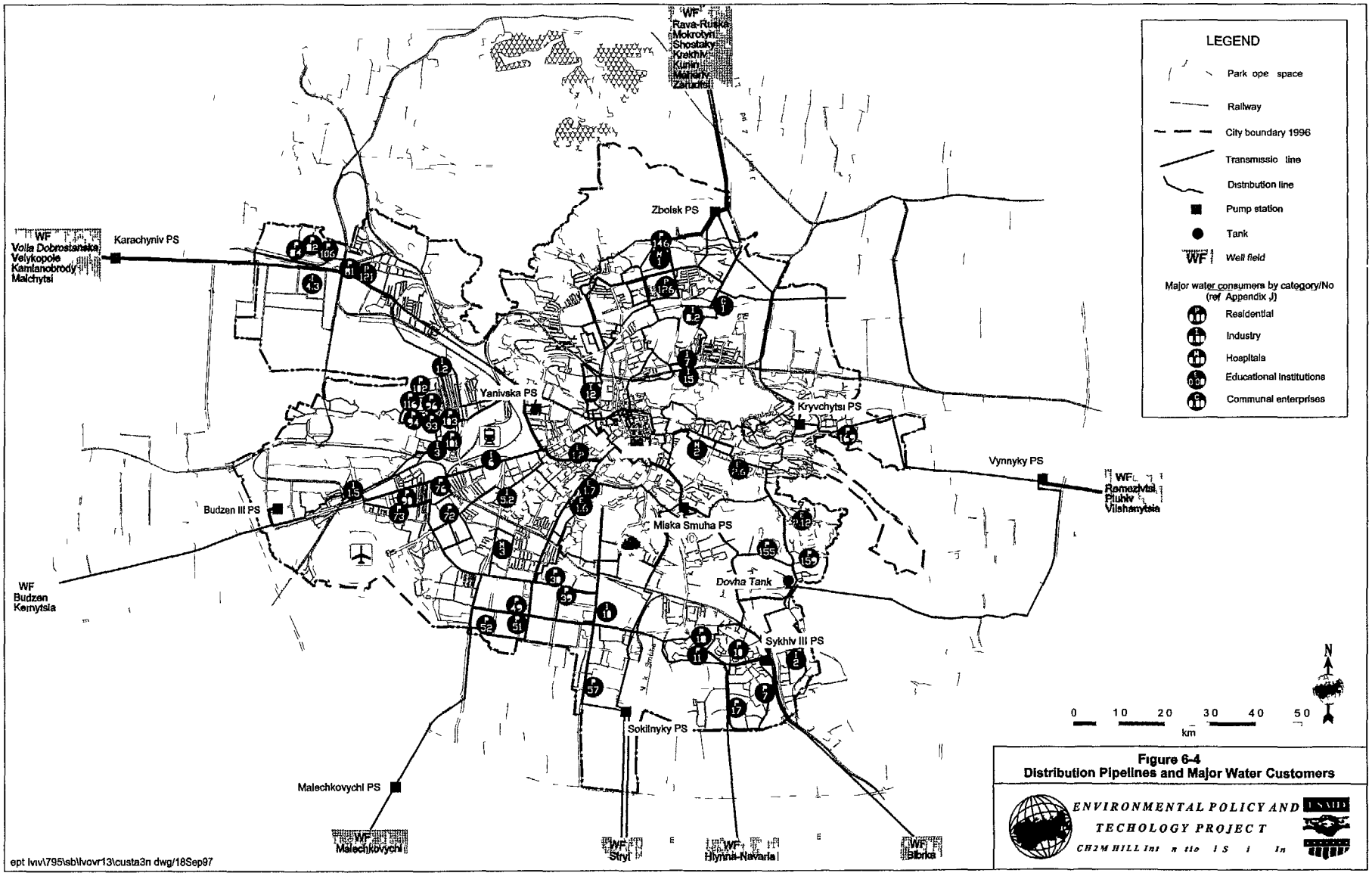


Figure 6-4
Distribution Pipelines and Major Water Customers

ENVIRONMENTAL POLICY AND TECHOLOGY PROJECT
CH2M HILL International S I In
USAID

ept lviv\795\sb\lvovr13\custa3n dwg/18Sep97

BEST AVAILABLE COPY

Section 7

LVIV VODOKANAL OPERATIONS, MAINTENANCE AND REPAIRS

An overview of the operations Lviv Vokokanal is presented herein

7.1 ORGANIZATION OF LVIV VODOKANAL

Lviv Vodokanal is organized as a state communal enterprise which provides water and wastewater services for the city The enterprise is, in theory a self supporting legal entity The vodokanal is responsible for servicing its water supply lines, wastewater sewer network, well fields, pump stations, and wastewater treatment plants

In 1995 LVK employed 1300 people, 80 percent in operations and 20 percent in management These are organized into five divisions

- water supply
- utility engineering
- mechanic
- dispatch
- maintenance

7.1.1 Water Supply Division

The Water Supply Division provides for continuous operation of well fields, transmission mains, pumping stations, and chlorinators according to set water supply rates and schedules, as well as controling compliance with the sanitary norms and rules at pumping stations and well fields Further responsibilities include water quality monitoring, and measurements of water coming from the well fields and pump operation It carries out system maintenance and repair work, and places orders for spare parts, equipment, materials, and safety kits for chlorine handling

7.1 2 Utility Engineering Division

The Utility Engineer Division is responsible for operation, maintenance and repair of power equipment, power systems and continuous power supply It is also responsible for appropriate power consumption

7 1 3 Mechanic Division

The Mechanic Division is responsible for the continuous operation of equipment, its inspection, testing and maintenance, writing cost estimates for repair works, and placing orders for spare parts and materials for the equipment

7.1.4 Dispatch Division

The Dispatch Division gathers information from the system, and coordinates operation of well fields, pumping stations, and district maintenance teams for providing scheduled water supply to the consumers It also coordinates work of repair teams, transportation and equipment

7.1 5 District Maintenance Division

The District Maintenance Division maintains the city water distribution system, including its buildings and equipment, repairs breakdowns and leakages, and maintains required pressure at service entrances and distribution of water to all water consumers within Lviv

This division has five district maintenance teams (DMT) Maintenance is carried out in accordance with the maintenance rules for water and wastewater systems in residential areas in Ukraine Based on this, each district must not contain more than 500 km of pipes and must be within 10 km of the maintenance team location The Lviv distribution system is divided into six zones The division of zones is based on the location of water supply sources, and is not strictly defined since the zones within the city are not separated by valves Zone location, as they are serviced by the DMT, is given in Figure 7-1 Responsibilities of the DMT include

- maintaining good working condition of the system, its buildings and equipment, keeping the system clean and protection against freezing
- ensuring efficient operations
- ensuring required pressure and water distribution within the system
- providing sanitary maintenance of the system, cleaning and disinfection
- providing on-going and capital maintenance for breakdowns and leakages
- keeping technical documentation and technical reports
- construction control, installation of new lines and connections

The distribution system is checked by walking along the pipeline routes and visual inspection of buildings and equipment Inspections are made once every two months Inspections include checking well appearance, availability, condition and securing of well lids, condition of well walls, ladders, presence of water, gases, leakages, ground sagging along the route and near wells, and operation of street hydrants

Maintenance works are not done on a regular basis DMTs together with consumer departments inspect the technical condition of consumer connections and meters Repairs are carried out according to the results of the inspection reports

All repairs are done by DMTs and allocated according to the extent of breakdowns and the type of work Every day each team receives (from the dispatcher service) information on location of breakdowns, transportation and equipment, tools and pumps for draining breakdown areas

The most common breakdowns include damage to pipe walls, joints, valves, check valves and fittings DMTs are responsible for carrying out repair and rehabilitation works The organization of repair works is shown in Figure 7-2

7.2 MAINTENANCE AND REPAIRS

7 2 1 Breakdowns in the Water System

According to the information received from the dispatch division, the annual number of breakdowns is about 4100 Analysis of dispatch center data showed that 6486 breakdowns occurred in the distribution system during 1995, 6268 of these happened in the distribution mains, and 218 at the service connections Information regarding these 1995 breakdowns is shown in Figure 7-3

On average, some 540 leakage breaks occurred every month during 1995 Most breakdowns happen in summer (June) and winter (December) This might be explained by seasonal variations in water consumption, ground freezing in winter and some incorrectness in registering the time of breakdowns The distribution of breakdowns in the city's distribution system from 1985 to 1995 is shown in the Figure 7-4 The areas where breakdowns occur most often are located around the following streets Naukova, V Velykoho, Medova Pechera, Pasichna, Zamarstynivska, Zelena, Lychakivska, Varshavska and several others (see Figure 7-5)

7.2 2 Typical Repair Works

A typical day of repairs to broken water distribution lines in Lviv is outlined below, for 5 April 1996

Repair No 1
Location Water leaking from pipeline at 75 Kryvchytska Doroha St
Description of breakdown service entrance, age of pipe 25 to 30 years
Repair work done by district maintenance team (DMT 5)
Description of work the head of DMT 5 learned about the breakdown from LVK Chief Engineer at a briefing at 8 50 am A repair crew of four people departed to the location at 10 20 am It was established that water was leaking from the service connections to private houses Nos 73 and 75 Within 30 minutes the supply main was shut off At 11 30 am an excavator arrived at the site The damaged pipe was uncovered in 20 minutes The service entrance was 1 2 m below the ground surface The pipe material was unprotected steel 57 mm in diameter with wall thickness of 4 mm, its surface was corroded and as a result developed a hole 20 mm in diameter in the lower part of the pipe The hole was fixed with a metal saddle sealed with rubber (the typical way of fixing similar breakages)

Repair No 2
Location water leaking from a pipeline at Zubrivska St
Description of breakdown steel pipeline, 114 mm in diameter, age of pipe 25 to 30 years
Repair work done by district maintenance team (DMT 5)
Description of work the head of DMT 5 learned about the breakdown from the LVK Chief Engineer at a briefing at 8 50 am A repair team departed to the location at 10 20 am It was established that water was leaking from the pipeline laid on the ground surface The supply main was shut off to enable repair work The pipe material was unprotected steel, 114 mm in diameter with wall thickness of 4 mm, its surface was corroded and as a result had developed three holes of 20 mm in diameter The hole was fixed with a metal saddle sealed with rubber (the typical way of fixing similar breakages)

Repair No 3
Location water leaking from a pipeline at Naukova St , 116
Description of breakdown cast iron main, 500 mm in diameter, age of pipe 15-20 years
Repair work done by district maintenance team (DMT 2)
Description of work the head of DMT 2 learned about the breakdown from the LVK Chief Engineer at a briefing at 9 00 am A repair team of five workers departed to the location at 10 20 am It was established that water was leaking from the distribution main In one hour the main was shut off to enable repair work At 12 00 an excavating machine arrived at the site The damaged pipe was revealed in 50 minutes It took two hours to pump water out of the pit The distribution pipe was 2 0 m below ground surface The pipe had developed a crack 2 5 m long A 5 0-m piece of pipe was removed and replaced with a section of steel pipe 500 mm in diameter The gaps in the bell and spigot joints were sealed with a tarred rope and filled with cement

7.2.3 Repair Work Analysis

Based on observations, a schedule of repair works in the distribution system was compiled (see Table 7-1) The average time required for fixing one breakdown is 3 5 days or 171 5 man-hours, out of which 96 3 man-hours is productive time and 75 5 man-hours is unproductive time (44%) Unproductive time is that time taken by travel, waiting for equipment, lunch, etc

The most typical repair work involves caulking bell and spigot joints on cast iron pipes, saddle installation on steel pipes, valve hydrants, repairs and well repairs and maintenance work Table 7-2 gives a classification of repair works to the distribution system

An analysis was conducted (Table 7-3) of a two month period in 1993 of the time spent on repair works, by type of breakdowns and type of work The man-hour equivalent is based on observations and the schedule of a working day for a breakdown repair Over that period, some 847 breakdowns occurred, 57 percent were pipe-related, 28 percent were caused by broken valves, and 13 percent occurred at service entrances Out of the total number of pipe-related repairs, breakdowns in the distribution system are caused by faults

at bell and spigot joint of cast iron pipes (61 percent), holes in steel pipes (33 percent), and cracks in cast iron pipes Most of the breakdowns happen because of the following reasons

- lack of pressure zone division
- limited water supply in the distribution system (2 periods of 3 hours each)
- big pressure variation in the system
- water hammer caused by air in system
- high corrosion rate of steel pipes
- low quality of repair work
- low quality of new installations
- poor quality materials for new installations and repair works

Based on the repair analysis, it is almost impossible for the current DMTs to keep up with the required repairs

7 3 ELECTRICITY CONSUMPTION

Some 60-70 percent of LVK's operating expenses are due to electricity consumption In an effort to reduce these costs, an analysis was conducted of electricity consumption by LVK during 19951996 Results of this analysis are presented in Appendix N This information will subsequently be used to identify opportunities for reductions in electricity use, and thereby a reduction in LVK operating costs

Table 7-1 Typical Daily Schedule for a Breakdown Repair Team			
Time	Type of Work	Number of Workers	
		Working	Total
8 50-9 30	Receiving information on repairs	3	6
9 30-10 30	Preparing the team for work	6	6
10 30-11 00	Getting to the breakdown location	6	6
11 00 11 30	Shutting off of a distribution main valve	3	6
11 30-12 30	Digging with an excavating machine	1	6
12 30-13 00	Digging by hand and inspection	2	6
13 00-14 00	Lunch time		
14 00 16 00	Repair work on the damaged part	3	6
16 00-17 00	Backfilling the pit	1	6
17 00-18 00	Getting back from the breakdown location	6	6
Working time, manhour		**28**	**49**

Table 7-2 Type of Repair Work		
No	Type of Damage	Type of Repair
Type of Repair Work on Pipes		
1	Damaged bell and spigot joint	Caulking of bell and spigot joints
2	Hole of 10-40 mm diameter in steel pipe	Install welded saddle
3	Hole in cast iron pipe	Install mechanical clamp
4	Several holes in steel pipe	Replacement of pipe, usually by steel one
Type of Repair Work on Fittings		
5	Gate valve damaged	Repair of damage or replacement of valve
6	Damaged hydrant	Repair of damage or replacement of hydrant
7	Damaged water meter	Replacement of water meter
8	Service connection valve damaged	Repair of damage or replacement of valves
9	Public tap damaged	Repair of damage or installing a blind flange
Type of Repair Work at Technical Inspections and Maintenance		
10	Inspection of fittings	Preventive works
11	Inspection of water meter group	Preventive works
12	Flushing of water mains	Preventive works
Type of Repair Work on Service Connections		
13	Damaged bell and spigot joint	Caulking of bell and spigot joint
14	Hole of 10-40 mm diameter in steel pipe	Install welded saddle
15	Hole in cast iron pipe	Install mechanical clamp
16	Several holes in steel pipe	Replacement of pipe, usually by steel one

Table 7-3
Estimate of Time for Repair Work - Two Months in 1993

Type of Damage	Type of Repair	Number of Breakdowns	Man Hours per Repair
Type of Repair Works on Pipes			
Damage between bell and spigot joint	Caulking of bell and spigot joints	295	171 5
Hole in 10-40 mm diameter steel pipe	Installation of welded saddle	130	122 5
Hole in cast iron pipe	Installation of mechanical clamp	34	171 5
Several holes in steel pipe	Replacement of pipe usually with steel one	28	122 5
Subtotal		**487**	
Type of Repair Works on Fittings			
Gate valve damage	Repair of damage or replacement of valve	143	49
Damaged hydrant	Repair of damage or replacement of hydrant	37	24 5
Damaged water meter	Replacement of water meter	5	24 5
Service connection valve damage	Repair of damage or replacement of valves	23	24 5
Public tap damage	Repair of damage or installing a blind flange	25	49
Subtotal		**233**	
Type of Works for Technical Inspections and Breakdown Preventions			
Inspection of fittings	Preventive work	10	24 5
Inspection of water meter group	Preventive work	2	24 5
Flushing of water mains	Preventive work	1	171 5
Subtotal		**13**	
Type of Repair Works on Service Connections			
Damaged bell and spigot joint	Caulking of bell and spigot joints	16	122 5
Hole in 10-40 mm diameter steel pipe	Install welded saddle	51	98
Hole in cast iron pipe	Install mechanical clamp	4	122 5
Several holes in steel pipe	Replacement of pipe, usually by steel one	43	98
Subtotal		**114**	
Total		**847**	

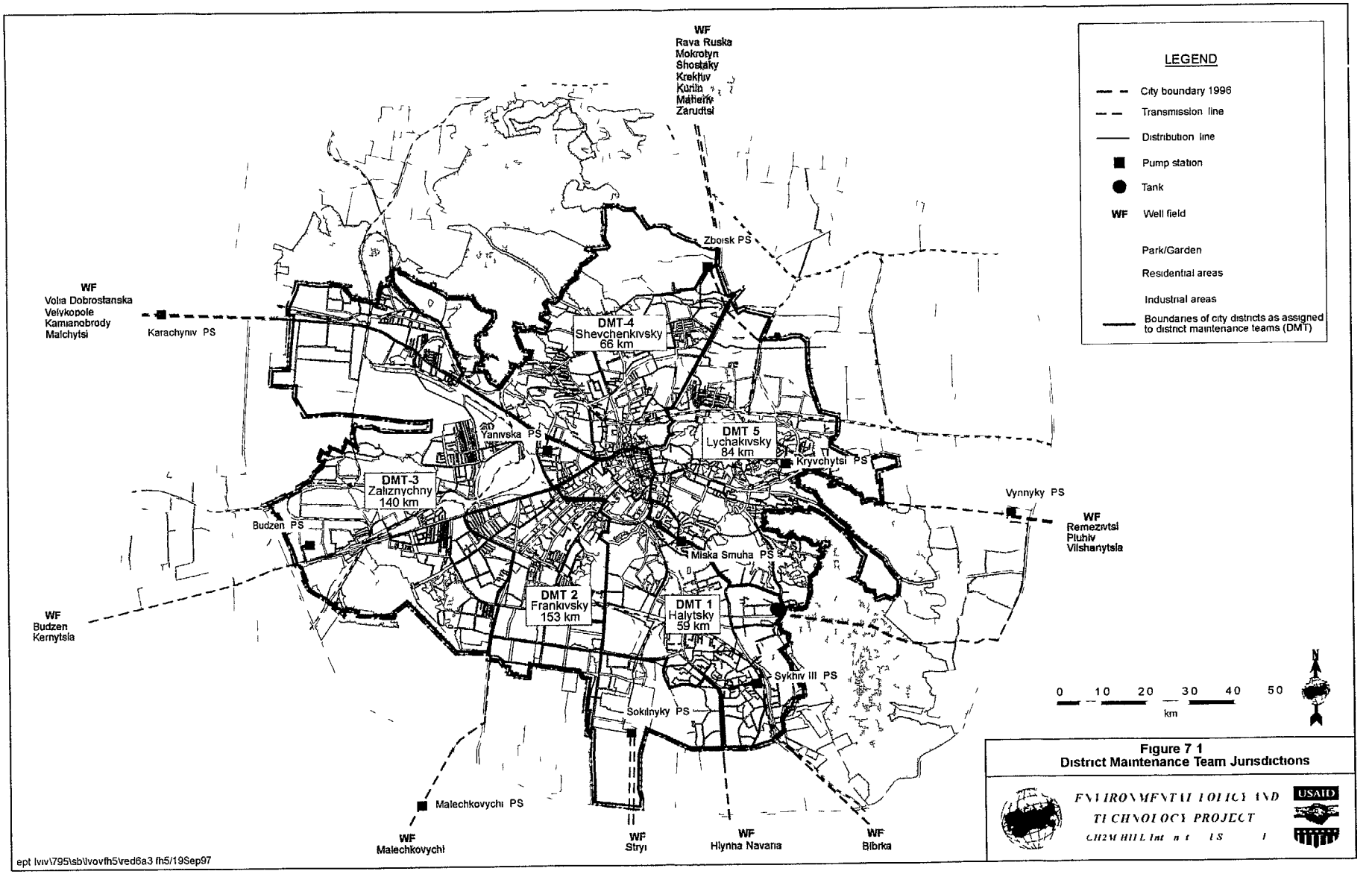
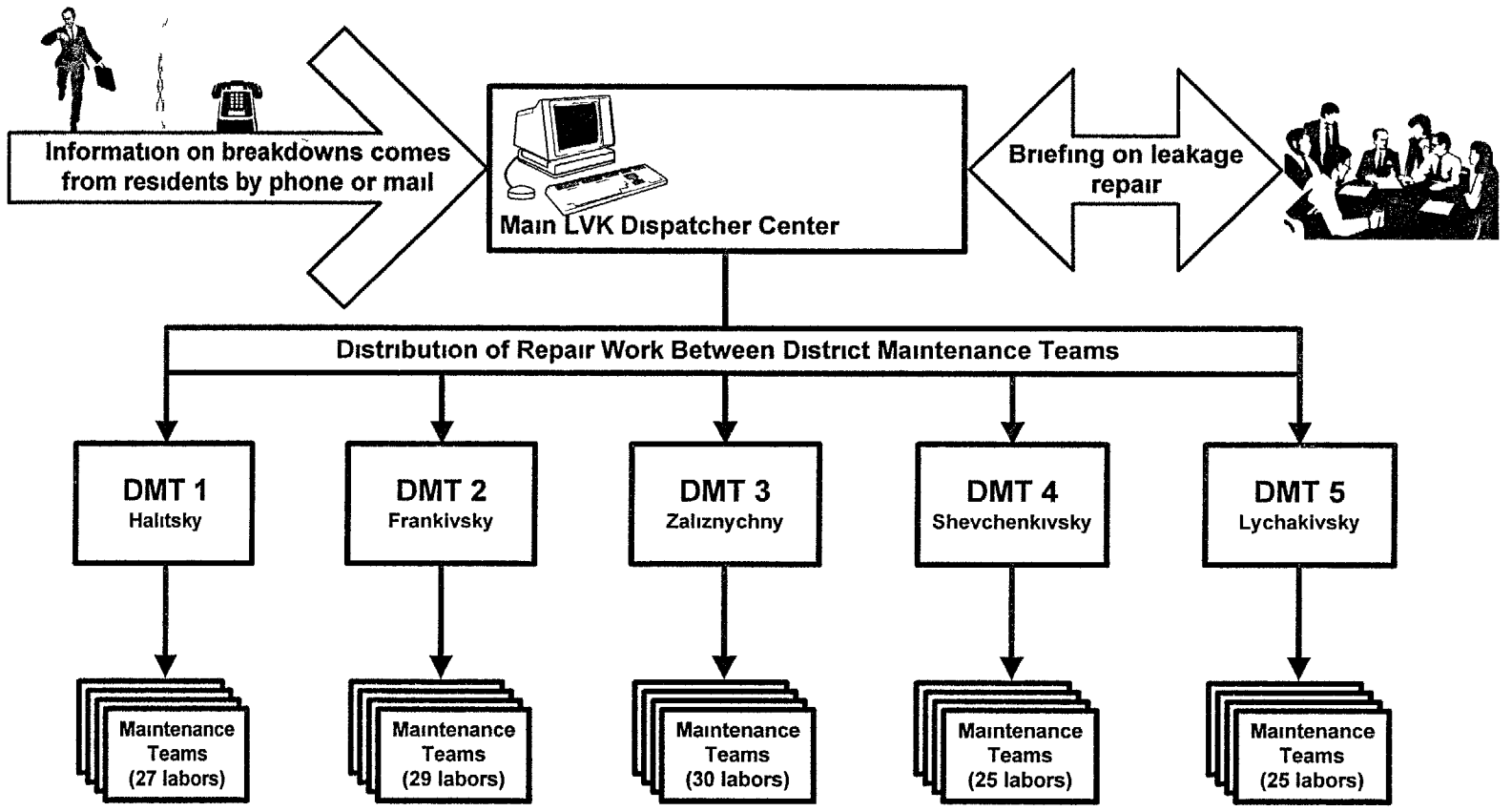


Figure 7 1
District Maintenance Team Jurisdictions

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL Int n t IS I
USAID

BEST AVAILABLE COPY

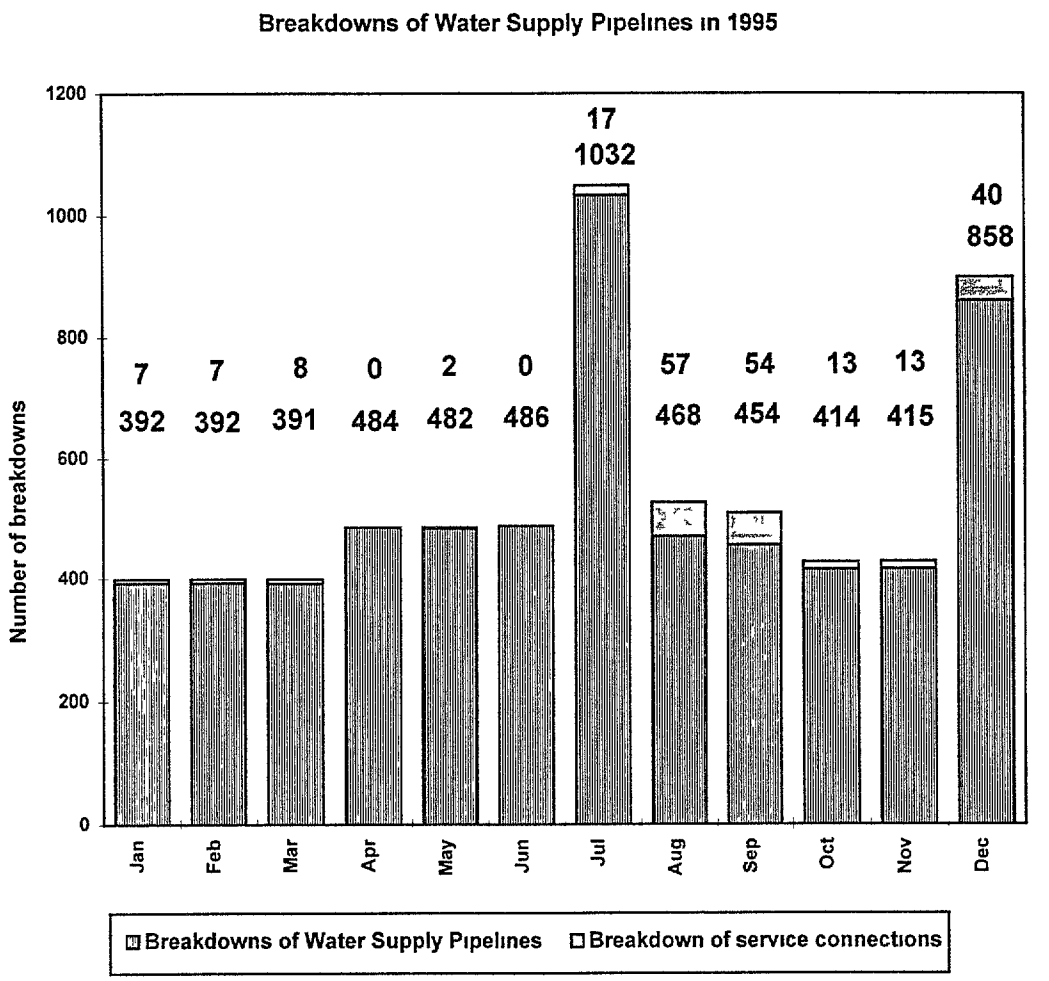


Fegure 7-2
Flowchart for Repair Work in the Distribution System

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept lviv\390\ms\proh\visio\pipeliene\utechka2 vsd/3Sep97



Total number of breakdowns in 1995 - 6486

Figure 7-3
Breakdowns in Water Distribution System in 1995

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc
USAID

ept lviv\390\ms\proh\excel\pipeline\avana xls/3Sep97

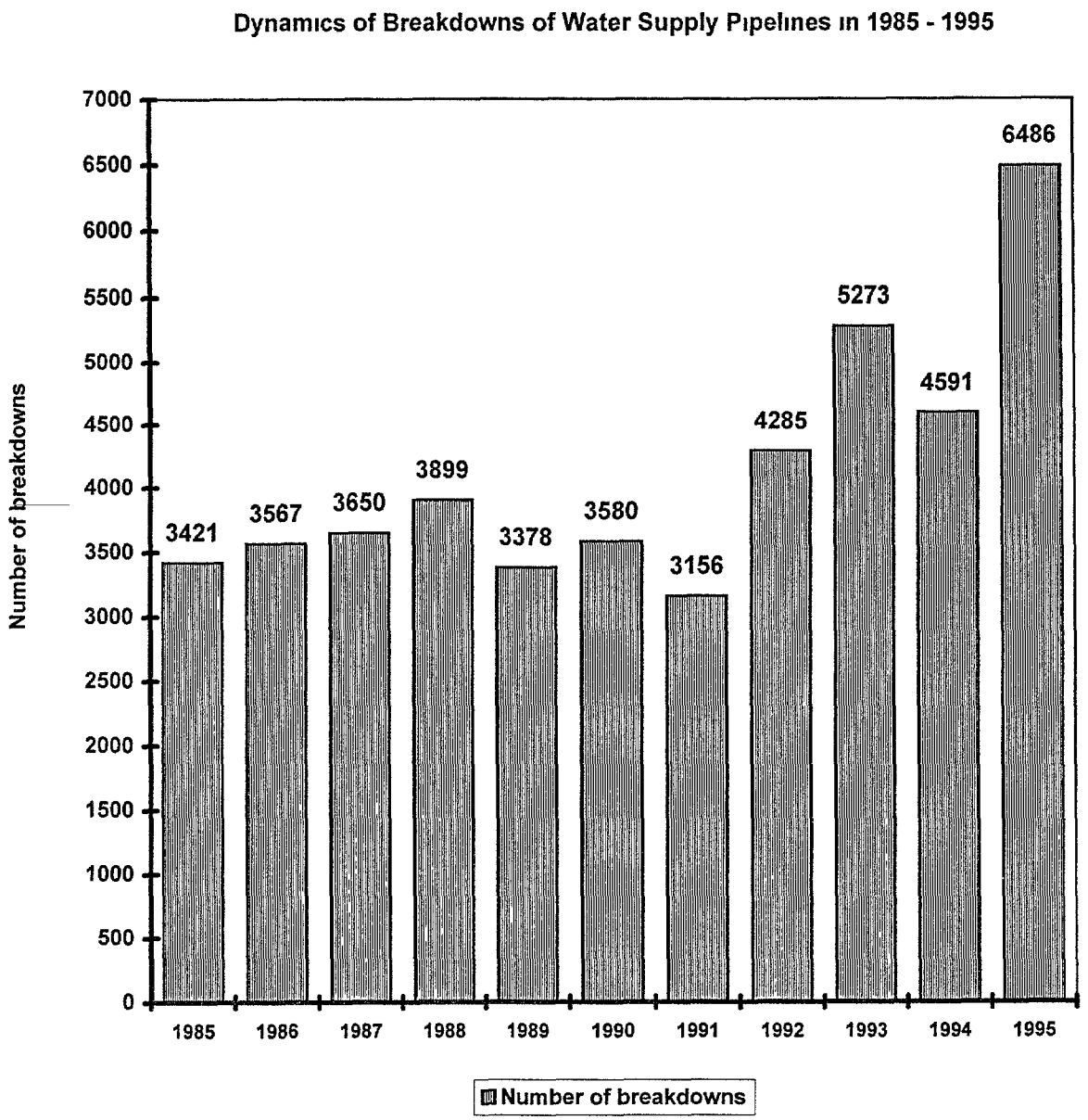


Figure 7- 4
Breakdown Distribution of Water Supply Pipelines

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\390\ms\proh\excel\pipeline\avaria xls/3Sep97

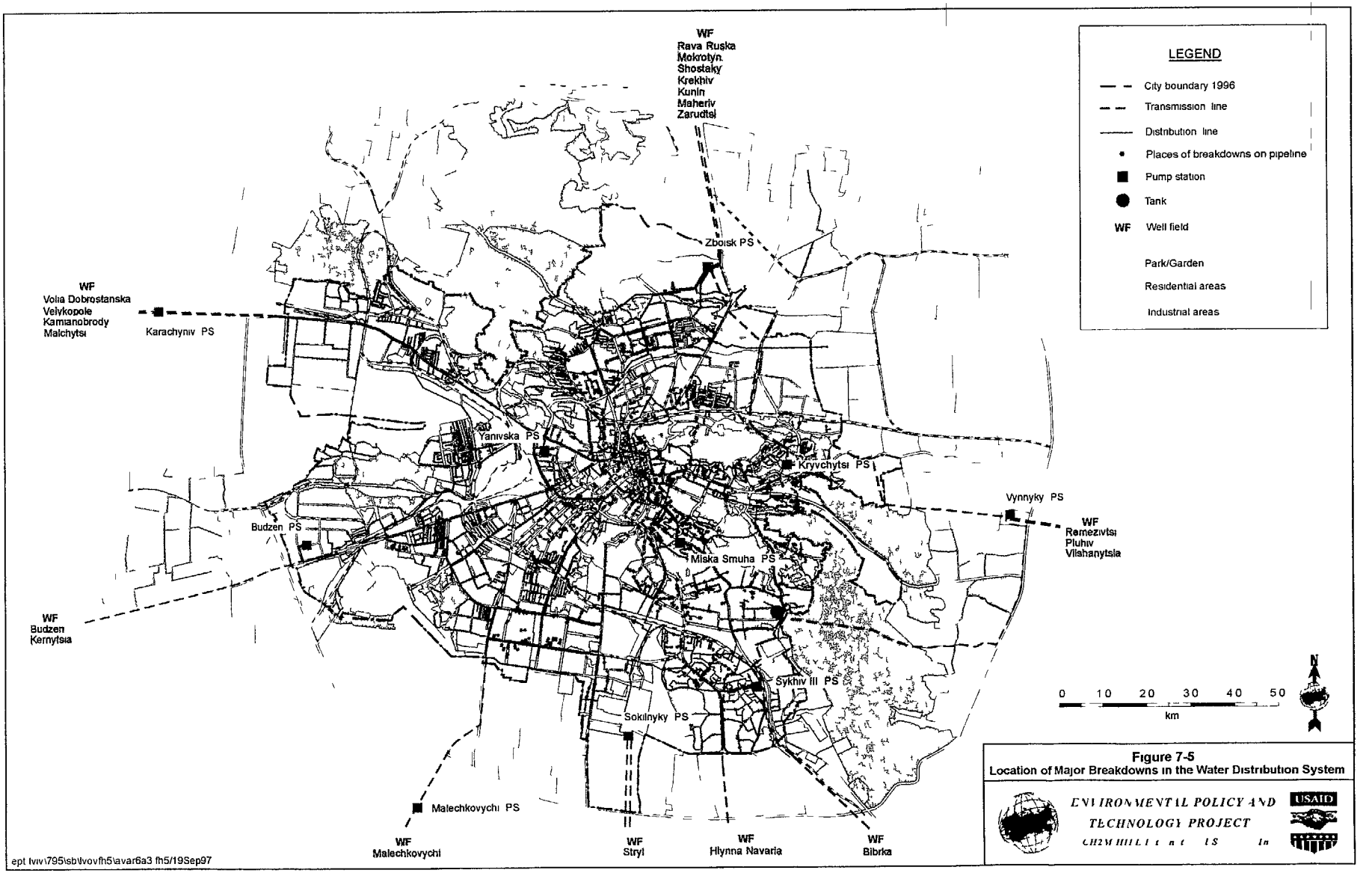


Figure 7-5
Location of Major Breakdowns in the Water Distribution System

BEST AVAILABLE COPY

Appendix A

INFORMATION ON LVIV WATER SOURCES -- WELL FIELDS

The ground water of the Volyn-Podilsk basin is the source of drinking water for the Lviv water supply system The general location of Lviv well fields is shown in Figure A-1 A typical geological profile and well design are presented in Figure A-2

Several groups of well fields from north, west, south and east currently convey water to the Lviv water supply system The location and rated capacity of each well field and associated characteristics are presented in Table A-1 The term "Safe Yield" in this table means an allowable yield based on operative and trial pumping, while "Added Yield" means an estimated possible incremental yield based on trial pumping

Currently, there is no iron removal process at the Budzen, Bibrka and Remezivtsi well fields The Pluhiv well field has special degassing units that remove carbon dioxide and hydrogen sulfide

Table A-2 presents information provided by LVK on well field water production in Lviv for 1995 In addition, the characteristics and working conditions of each well field are presented in Figures A-3 through A-22 The types of pumps used at the well fields are transliterations of Cyrillic Their capacity is given in m^3 and TDH (Total Dynamic Head) in meters The main reasons for well stoppages are as follows

1 Electricity supply problems - frequent interruption of electrical energy supply, large fluctuations of power (from 6,000 V down to 5,600 V), acts of nature, such as migration of birds

2 Poor well design - bad quality of filter, water aggressiveness, resulting in rapid corrosion of pipes, theft and destruction of property, acts of nature such as, freezing temperatures

3 Pump-operating problems, like forced shutdown of a well when the pump falls to the bottom of the well and cannot be recovered

A summary of the unit costs for the well fields is presented in Table A-3 The information in the table is in accordance with the 1995 LVK reported production costs The total energy cost is 64 % which makes up most of the total production cost A separate production cost calculation was made for each well field, which includes energy, depreciation and labor costs It has been assumed that all the other costs are about 30% of the total production cost They have been allocated in proportions to the quantity of water withdrawn

Table A-1
Lviv Well Field Characteristics

No	Well Field Name	Year Built	No Of Wells	Dist to Lviv	Static Water Level	Capacity: Safe Yield	Capacity: Added Yield	Capacity: Total	Average Daily Production 1987	Average Daily Production 1995	Problem Constituents	Number of Operating Personal	Remarks
				km	m	m^3/d	m^3/d	m^3/d	m^3/d	m^3/d			
	North												
1	Rava Ruska	1972	8	48 0	3 3	17 000		17 000	17 000	16 932	Strontium	8	
2	Maheriv	1971	4	40 5	3 8	17 200	9 800	27 000	8 800	8 466	Strontium	3	
3	Shostaky	1972	3	39 5	3 8	3 400		3 400	3 400	6 350		2	
4	Krekhiv	1970	5	29 5	4 8	15 600		15 600	13 500	13 611	Strontium	5	
5	Kunin	1970	2	30 5	4 8	5 700		5 700	5 400	5 444		2	
6	Mokrotyn	1966	7	19 8	4 0	16 100	8 000	24 100	18 000	16 222	Strontium	7	
7	Zarudtsi	1965	16	12 5	3 8	19 700	8 000	27 700	24 200	20 927	Strontium	16	
	Group total		**45**			**94,700**	**25,800**	**120,500**	**90,300**	**87,952**			
	West												
8	Volia Dobrostanska	1901	5	26 6	15 0	18 500	3 500	22 000	16 800	7 026		13	
9	Velykopole	1926	5	23 9	5 6	8 000	5 000	13 000	13 200	7 015		13	
10	Kamianobrody	1952	4	20 0	3 6	23 000	10 000	33 000	16 100	15 289		13	
11	Malchytsi	1967	9	11 6	7 0	15 700	5 600	21 300	10 300	15 868		6	
12	Budzen	1956	22	20 5	6 5	45 200	9 000	54 200	32 200	31 568	Iron Strontium	12	No removal
13	Kernytsia	1969	8	20 5	6 5	9 000	6 400	15 400	12 000	11 479		4	
	Group total		**53**			**119,400**	**39,500**	**158,900**	**100,600**	**88,245**			
	South												
14	Stryi	1982	34	75 0	4 0	140 000		140 000	122 200	126 578		16	
15	Hlynna Navaria	1971	12	14 5	1 2	14 700	4 300	19 000	10 000	14 238		13	
16	Bibrka	1973	12	15 9	4 5	13 300	6 700	20 000	17 600	24 192	Iron	14	No removal
17	Malechkovychi	1932	1	7 0	1 2	5 000		5 000	5 000	4 910		5	
	Group total		**59**			**173,000**	**11,000**	**184,000**	**154,800**	**169,918**			
	East												
18	Remezivtsi	1986	4	72 0	2 6	34 500	24 800	59 300	7 000	7 377	Iron	Purchased water	No removal
19	Pluhiv	1989	8	74 0	2 0	70 000	20 000	90 000	30 200	50 572	Carbon dioxide hydrogen sulfide	14	Air stripping to reduce hydrogen sulfide (H_2S)
20	Vilshanytsia	1989	4	40 0	3 0	16 400	10 500	26 900		8 577		10	
	Group total		**16**			**120,900**	**55,300**	**176,200**	**37,200**	**66,526**			
	Total		**173**			**508,000**	**131,600**	**639,600**	**382,900**	**412,641**			

Table A-2
Production of Well Fields in 1995

Well Field Name	No of Wells	Average Daily Water Quantity, m^3/d												Average Daily, m^3/d
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
North														
Rava Ruska	8	17 096	48 934	15 438	17 096	16 011	16 580	16 580	17 067	17 653	16 539	17 643	16 552	16 932
Maheriv	4	8 548	9 467	7 719	8 548	8 006	8 290	8 290	8 533	8 827	8 270	8 822	8 276	8 466
Shostaky	3	6 411	7 100	5 789	6 411	6 004	6 218	6 217	6 400	6 620	6 202	6 616	6 207	6 350
Krekhiv	5	13 606	15 071	12 281	14 055	13 156	14 057	13 146	13 574	14 062	13 145	14 030	13 151	13 611
Kunin	2	5 443	6 029	4 913	5 622	5 263	5 623	5 258	5 429	5 625	5 258	5 612	5 260	5 444
Mokrotyn	7	16 017	17 174	14 462	14 496	20 354	16 556	15 485	16 002	16 579	15 495	16 537	15 507	16 222
Zarudtsi	16	22 441	24 413	19 883	18 676	14 530	21 737	21 293	22 002	22 750	21 311	21 707	20 384	20 927
Group total		89 562	98 187	80 485	84 904	83 324	89 061	86 269	89 007	92 115	86 219	90 967	85 337	
													Average	**87,953**
West														
Volia Dobrostanska	5	7 035	7 775	6 348	7 233	6 848	7 257	6 781	7 001	7 241	6 809	7 240	6 778	7 026
Velykopole	5	7 022	7 762	6 337	7 233	6 781	7 246	6 775	7 000	7 236	6 776	7 236	6 777	7 015
Kamianobrody	4	16 024	17 745	13 569	15 507	14 538	15 517	15 486	15 001	15 503	14 530	15 505	14 545	15 289
Malchytsi	9	16 041	16 656	14 459	15 516	14 528	15 534	15 490	17 001	17 589	15 516	16 546	15 537	15 868
Budzen	22	34 076	34 724	31 158	34 858	31 975	34 091	28 878	32 869	29 935	28 968	29 932	27 347	31 568
Kernytsia	8	12 391	12 627	11 330	12 676	11 627	12 397	10 501	11 953	10 886	10 534	10 884	9 944	11 479
Group total		92 590	97 290	83 201	93 023	86 267	92 041	83 911	90 826	88 391	83 133	87 343	80 929	
													Average	**88,245**
South														
Stryi	34	120 845	147 392	114 642	138 186	129 719	143 073	119 920	130 597	131 528	120 990	105 139	116 905	126 578
Hlynna-Navaria	12	14 406	15 573	12 967	15 530	14 198	14 787	14 240	14 802	14 719	13 465	14 264	11 906	14 238
Bibrka	12	25 689	26 943	22 937	26 208	22 427	25 441	21 733	22 823	26 152	22 198	23 471	24 277	24 192
Malechkovychi	1	4 000	5 537	4 516	5 167	4 839	5 000	4,839	5 000	5 167	4 839	5 167	4 846	4 910
Group total		164 940	195 444	155 062	185 091	171 183	188 301	160 732	173 223	177 567	161 492	148 042	157 933	
													Average	**169,917**
East														
Remezivtsi	4	7 585	6 909	9 497	10 094	9 583	10 263	3 159	6 200	6 025	6,000	7 211	6 000	7 377
Pluhiv	8	51 774	58 993	44 973	54 776	49 242	51 797	47 554	49 148	51 185	48 362	50 744	48 321	50 572
Vilshanytsia	4	9 027	8 886	7 466	8 358	8 150	8 505	7 743	8 012	9 324	8 753	8 990	9 706	8 577
Group total		68 386	74 788	61 936	73 229	66 975	70 566	58 455	63 360	66 533	63 115	66 945	64 028	
													Average	**66,526**
Total														**412,642**

Table A-3 Well Field Unit Costs in 1995					
No	Well Field Name	Water Production	Energy Consumption	Unit Cost per m^3	
		1,000 m3	kWh/m^3	1,000 kbv	1,000 USD
	North				
1	Rava-Ruska	6173 0	0 290	4 061	0 026
2	Maheriv	3086 5	0 290	4 061	0 026
3	Shostaky	2315 2	0 290	4 061	0 026
4	Krekhiv	4968 0	0 519	6 235	0 041
5	Kunin	1978 7	0 519	6 235	0 041
6	Mokrotyn	5918 8	0 256	3 727	0 024
7	Zarudtsi	7626 8	1 597	4 585	0 030
	Group total	**32067 0**	**0 644**	**4 595**	**0 030**
	West				
8	Volia Dobrostanska	2561 5	1 472	9 702	0 060
9	Velykopole	2557 4	0 914	6 058	0 040
10	Kamianobrody	5572 3	0 582	4 099	0 027
11	Malchytsi	5787 6	0 313	2 183	0 014
12	Budzen	11510 2	1 300	7 549	0 049
13	Kernytsia	4185 5	0 724	4 361	0 029
	Group total	**32174 6**	**0 906**	**5 624**	**0 037**
	South				
14	Stryi	46127 0	0 232	1 627	0 010
15	Hlynna-Navaria	5190 6	1 041	6 682	0 044
16	Bibrka	8817 2	0 663	4 271	0 028
17	Malechkovychi	1789 3	0 686	4 646	0 026
	Group total	**61924 0**	**0 374**	**2 515**	**0 016**
	East				
18	Remezivtsi	2690 0	0 663	4 975	0 032
19	Pluhiv	18427 5	0 359	2 336	0 015
20	Vilshanytsia	3128 7	0 665	5 429	0 035
	Group total	**21556 2**	**0 432**	**3 028**	**0 019**
	Total	**147721 8**	**0 555**	**3 706**	**0 024**

Note Official Exchange Rate, National Bank of Ukraine (as of December 25, 1995) - 179,400 kbv for US $1

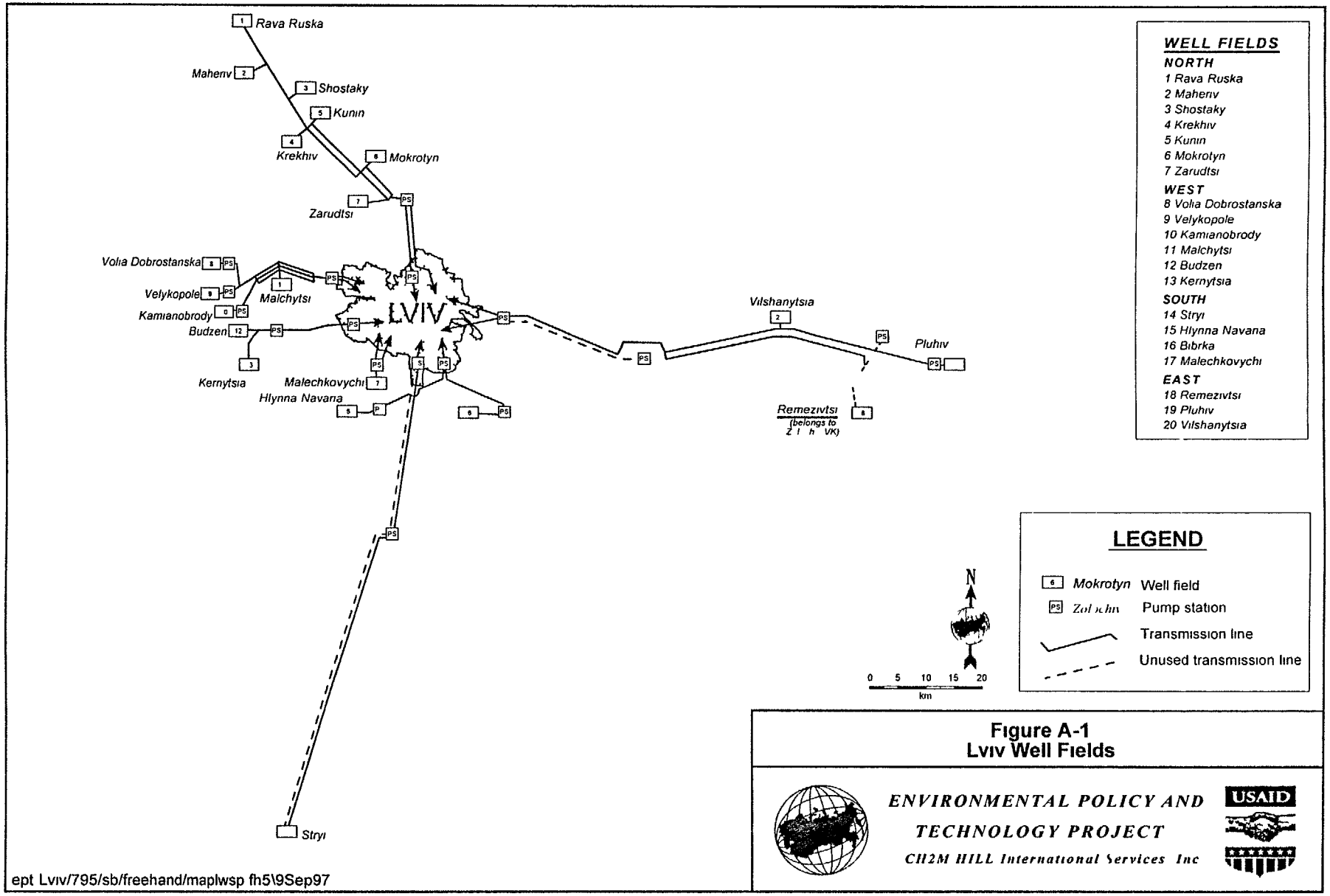


Figure A-1
Lviv Well Fields

Typical Well Design at Stryi Well Field

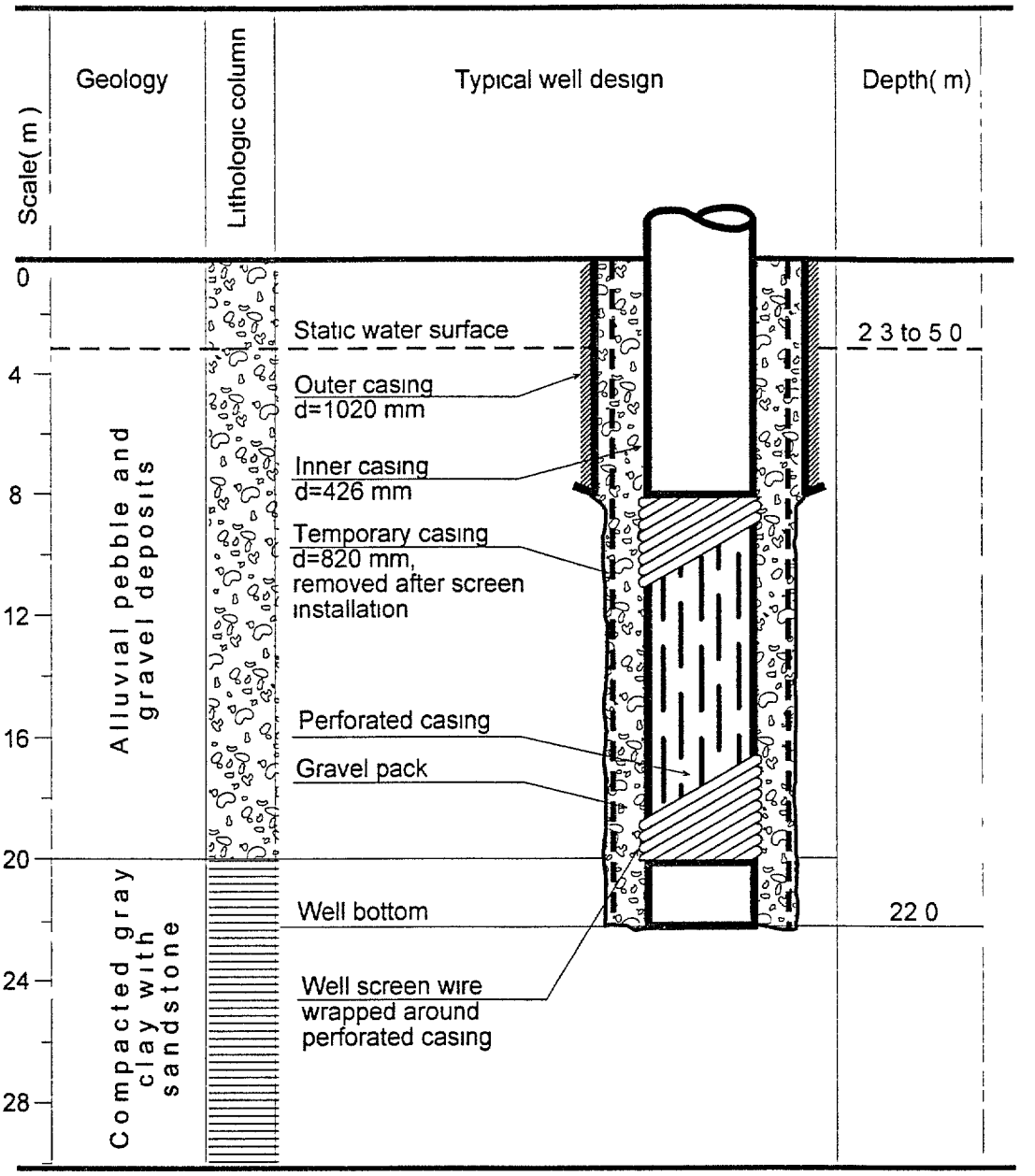


Figure A-2
Geological Profile and Well Design

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\753\sb\freehand\wellstry1 fh5/3Sep97

North Well Field Analysis Rava Ruska

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Rava Ruska	17	17	0

AQUIFER

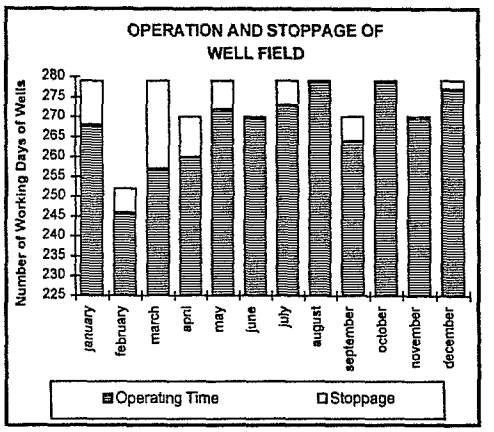
Description Upper Cretaceous Deposits Fractured Siltstones and Chalks

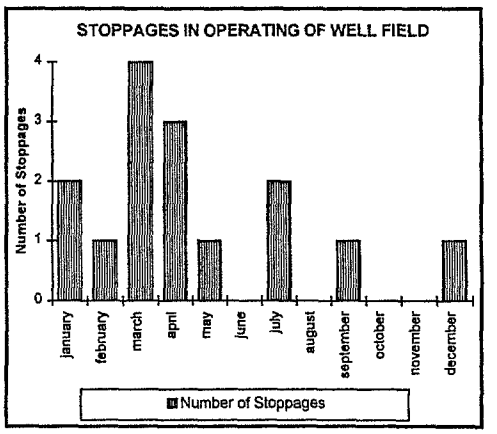
Thickness of aquifer m	30
Static water level m	(+) 2 5 4 8
Pumping rate m³/day	4294 8856
Specific capacity m²/day	1010 2573
Transmissivity m²/day	820
Thickness of covering layer m	10 80
Thickness of clay within the covering layer m	0

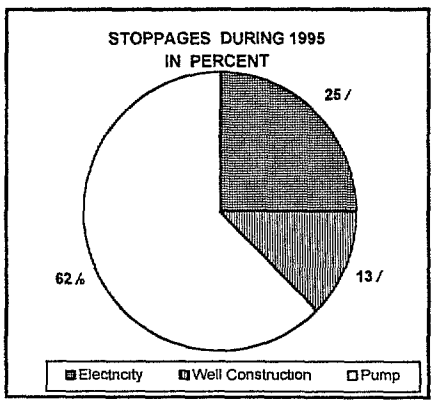
WELL FIELD (technical characteristics)

Number of wells	8
Depth of wells m	70
Diameter of wells mm	426
Type of pumps (and capacity kW)	
wells 7 9 10	ЭЦВ12 160-100 (65)
wells 8 8a 9a	ЭЦВ10-63-110 (32)
wells 11 12	ЭЦВ12 160-140 (90)

Criterion of operating effectiveness of well field	0 978
Probability of non stop work of well field	0 698
Percent of stoppages %	2 40







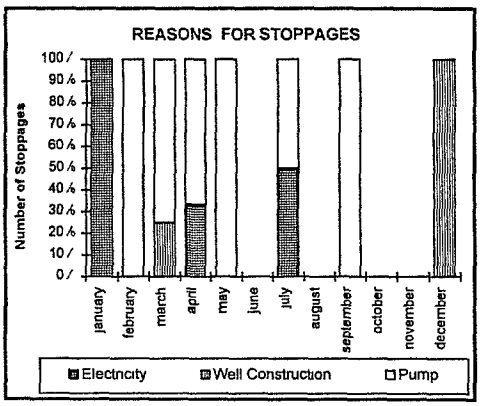


Figure A-3
North Well Field Analysis Rava Ruska

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept lviv\394\tg\ndate\wf A xls/19Aug97

North Well Field Analysis Maheriv

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Maheriv	27	17 2	9 8

AQUIFER

Description Upper Cretaceous Deposits Fractured Siltstones and Chalks

Thickness of aquifer m	30
Static water level m	(+) 2 5 4 8
Pumping rate m³/day	1395 6006
Specific capacity m²/day	276 1456
Transmissivity m²/day	300 1300
Thickness of covering layer m	10 20
Thickness of clay within the covering layer m	0 3

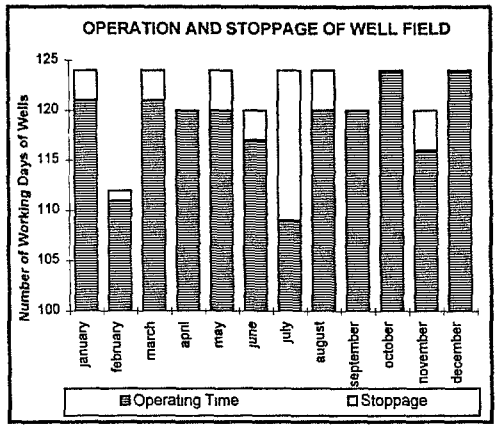
WELL FIELD (technical characteristics)

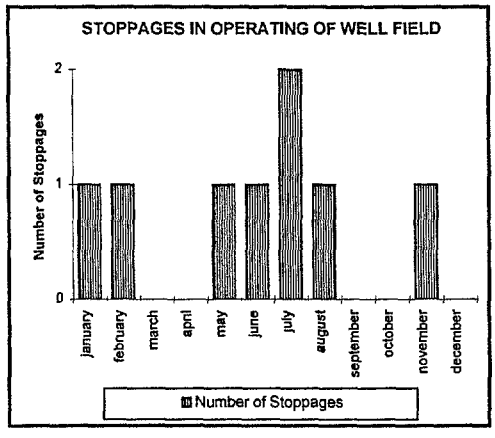
Number of wells		4
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 4 5	ЭЦВ12 160-100	(65)
wells 4a	ЭЦВ10-63-110	(32)
well 6	ЭЦВ8-25-70	(17)

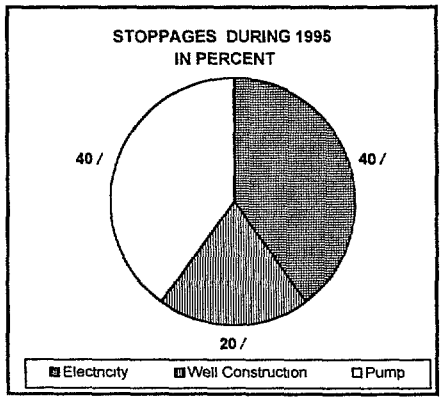
Criterion of operating effectiveness of well field 0 974

Probability of non stop work of well field 0 816

Percent of stoppages % 2 53







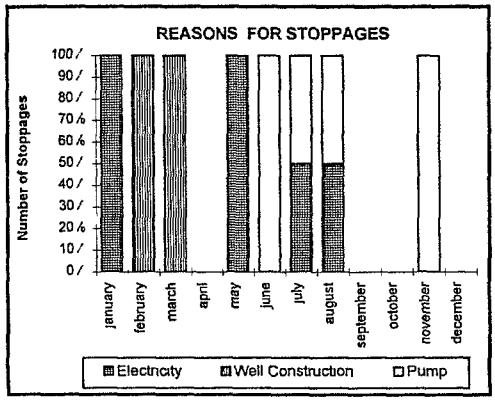


Figure A-4
North Well Field Analysis - Maheriv

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept lvv\394\tg\indate\wf A xls/19Aug97

North Well Field Analysis - Shostaky

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Shostaky	3 4	3 4	0

AQUIFER

Description Upper Cretaceous Deposits Fractured Siltstones and Chalks

Thickness of aquifer m	30
Static water level m	(+) 2 5 4 8
Pumping rate m^3/day	1395 6006
Specific capacity m^2/day	276 1456
Transmissivity m^2/day	300 1300
Thickness of covering layer m	10 20
Thickness of clay within the covering layer m	0 3

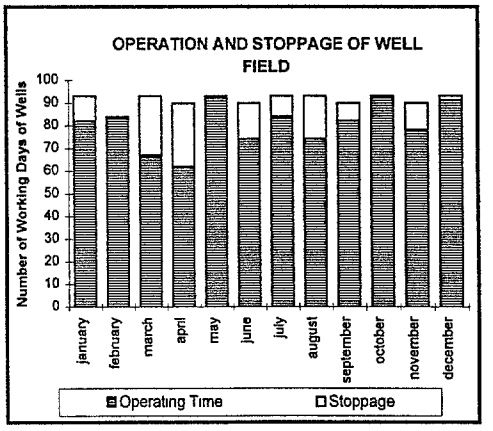
WELL FIELD (technical characteristics)

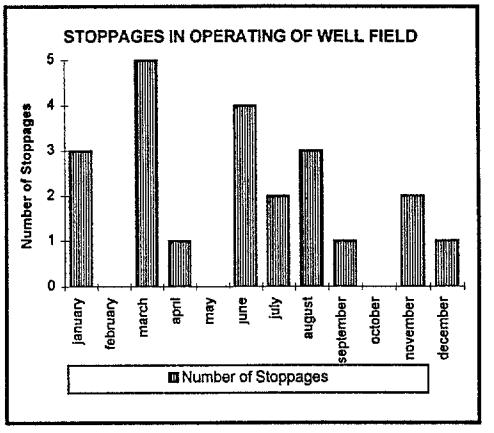
Number of wells	3
Depth of wells m	70
Diameter of wells mm	426
Type of pumps (and capacity kW)	
wells 1 2 3	ЭЦВ12 160-100 (65)

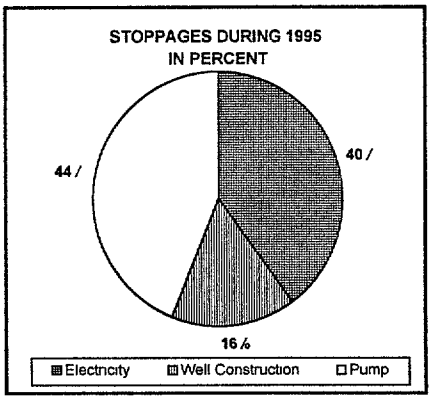
Criterion of operating effectiveness of well field 0 864

Probability of non stop work of well field 0 072

Percent of stoppages % 11 96







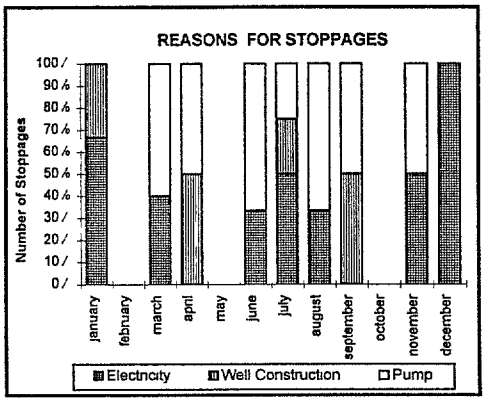


Figure A 5
North Well Field Analysis - Shostaky

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept lvivl394\tg\ndate\wf A xls/19Aug97

North Well Field Analysis Krekhiv

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Krekhiv	15 6	15 6	0

AQUIFER

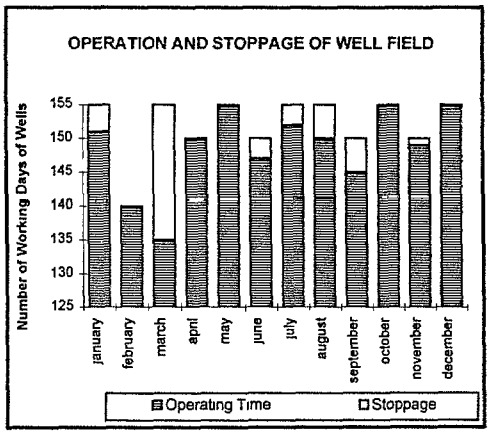
Description Upper Cretaceous Deposits Fractured Siltstones and Chalks

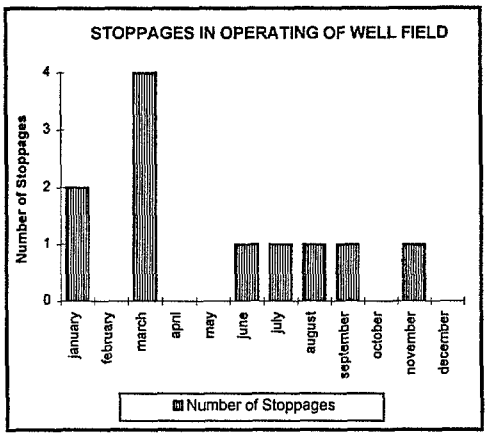
Thickness of aquifer m	30
Static water level m	(+) 2 5 4 8
Pumping rate m³/day	2500 4570
Specific capacity m²/day	282 794
Transmissivity m²/day	635 1317
Thickness of covering layer m	10 80
Thickness of clay within the covering layer m	0

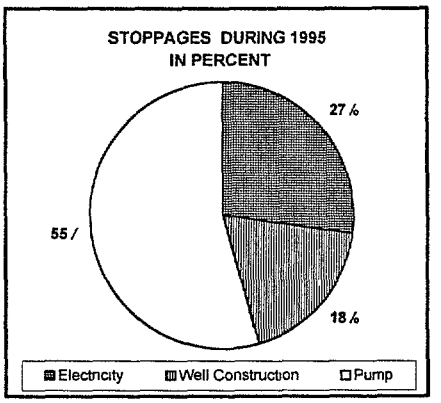
WELL FIELD (technical characteristics)

Number of wells		5
Depth of wells m		60
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 1 3 5	ЭЦВ12 160-100	(65)
wells 4	ЭЦВ8-16-100	(17)
well 2	ЭЦВ10-63-110	(32)

Criterion of operating effectiveness of well field	0 977
Probability of non stop work of well field	0 724
Percent of stoppages %	2 25







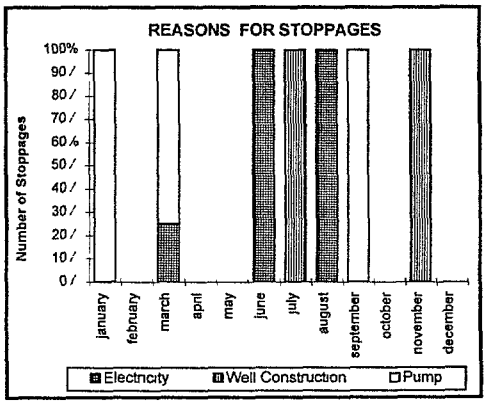


Figure A-6
North Well Field Analysis Krekhiv

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\394\tg\indate\wf A xls/19Aug97

North Well Field Analysis Kunin

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Kunin	5 7	5 7	0

AQUIFER

Description Upper Cretaceous Deposits Fractured Siltstones and Chalks

Thickness of aquifer m	30
Static water level m	(+) 2 5 4 8
Pumping rate m^3/day	2500 4570
Specific capacity m^2/day	282 794
Transmissivity m^2/day	635 1317
Thickness of covering layer m	10 80
Thickness of clay within the covering layer m	2 20

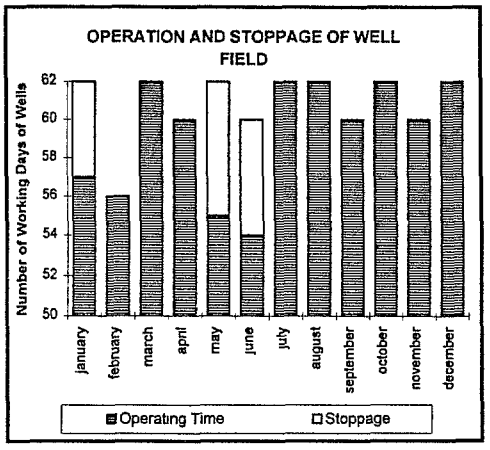
WELL FIELD (technical characteristics)

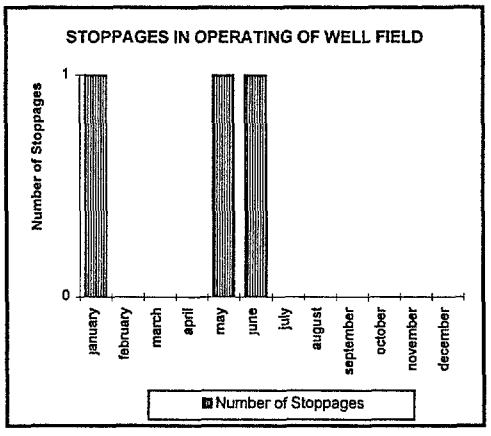
Number of wells		2
Depth of wells m		60
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 6 7	ЭЦВ12 160-100	(65)

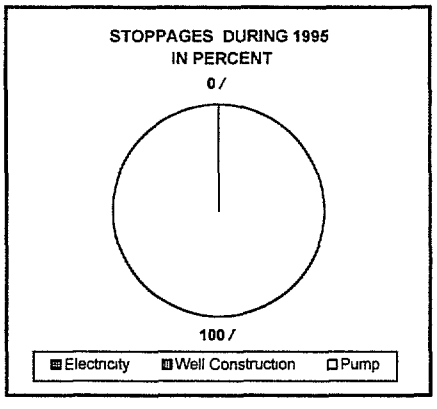
Criterion of operating effectiveness of well field 0 975

Probability of non stop work of well field 0 929

Percent of stoppages % 2 46







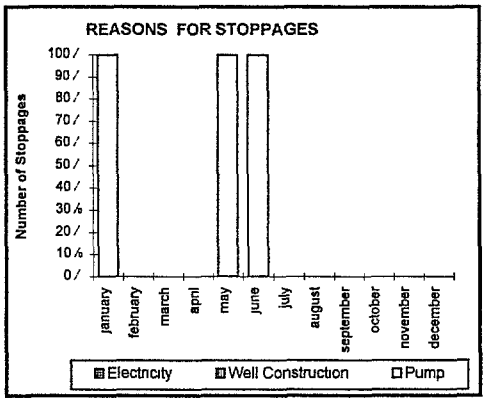


Figure A 7
North Well Field Analysis - Kunin

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\394\tg\indate\wf A xls/19Aug97

North Well Field Analysis Mokrotyn

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Mokrotyn	24 1	16 1	8

AQUIFER

Description Upper Cretaceous Deposits Fractured Siltstones and Chalks

Thickness of aquifer m	30
Static water level m	(+) 2 5 4 8
Pumping rate m³/day	1028 4320
Specific capacity m²/day	106 554
Transmissivity m²/day	870
Thickness of covering layer m	10 20
Thickness of clay within the covering layer m	10 20

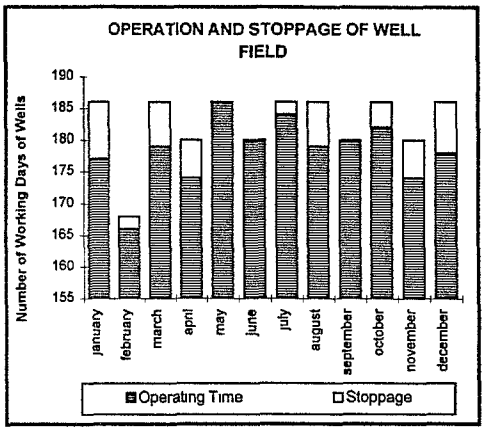
WELL FIELD (technical characteristics)

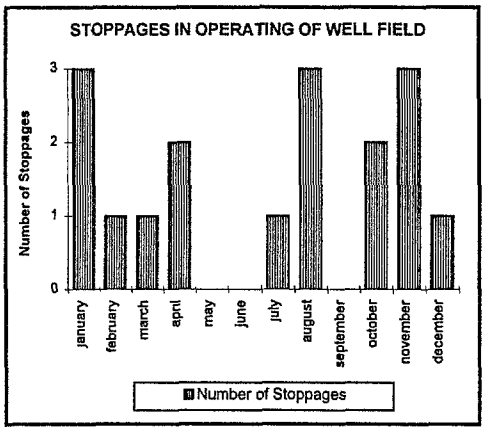
Number of wells	7
Depth of wells m	75
Diameter of wells mm	426
Type of pumps (and capacity kW)	
wells 1 2 3 4 6 5a	ЭЦВ10-120-65 (32)
wells 5	ЭЦВ8 25-70 (17)

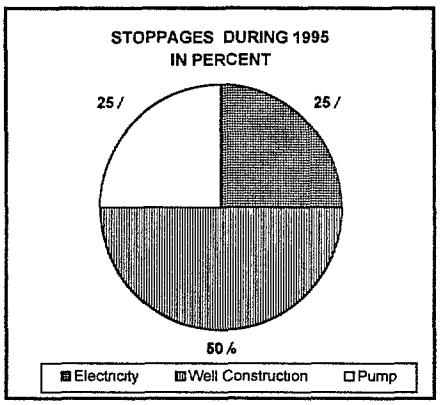
Criterion of operating effectiveness of well field 0 977

Probability of non stop work of well field 0 658

Percent of stoppages % 2 33







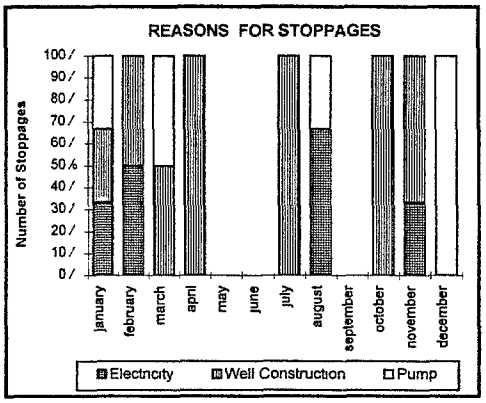


Figure A 8
North Well Field Analysis Mokrotyn

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lvlv\394\tg\undate\wf A.xls/19Aug97

North Well Field Analysis Zarudtsi

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Zarudtsi	27 7	19 7	8

AQUIFER

Description Upper Cretaceous Deposits Fractured Siltstones and Chalks

Thickness of aquifer m	30
Static water level m	(+) 2 5 4 8
Pumping rate m³/day	2250 7831
Specific capacity m²/day	171 257
Transmissivity m²/day	700
Thickness of covering layer m	10 15
Thickness of clay within the covering layer m	10 15

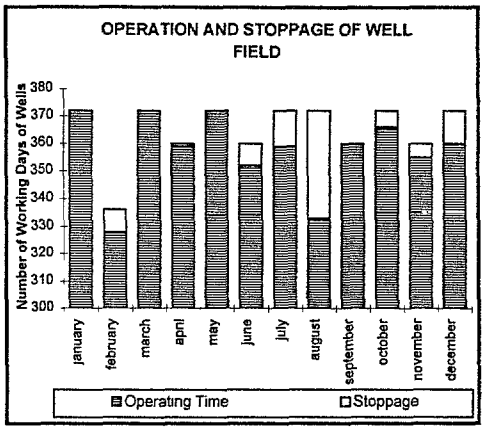
WELL FIELD (technical characteristics)

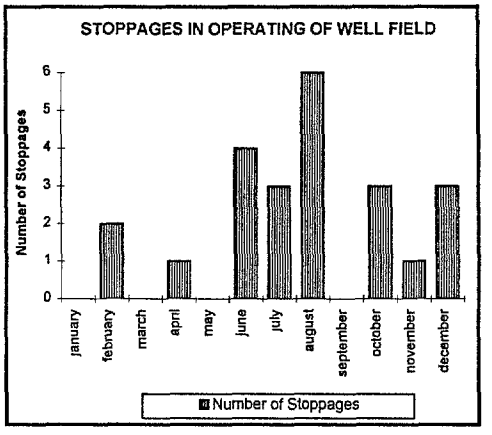
Number of wells	16	
Depth of wells m	70	
Diameter of wells mm	377	
Type of pumps (and capacity kW)		
Zarudtsy		
wells 1 3 5a 7 8	ЭЦВ10-120-65	(32)
wells 2 2a 4 5 6	ЭЦВ8-25-70	(17)
Zavadov		
well 1 1a 2 2a 3	ЭЦВ10-120-65	(32)
wells 1b	ЭЦВ8-25-70	(17)

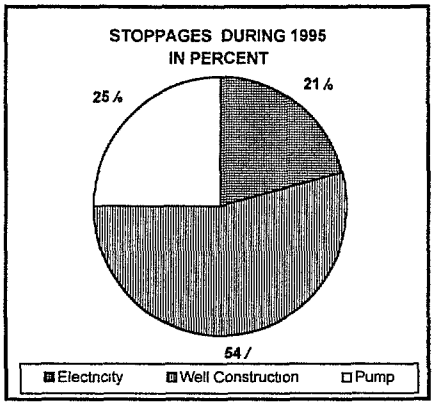
Criterion of operating effectiveness of well field 0 979

Probability of non stop work of well field 0 696

Percent of stoppages % 2 29







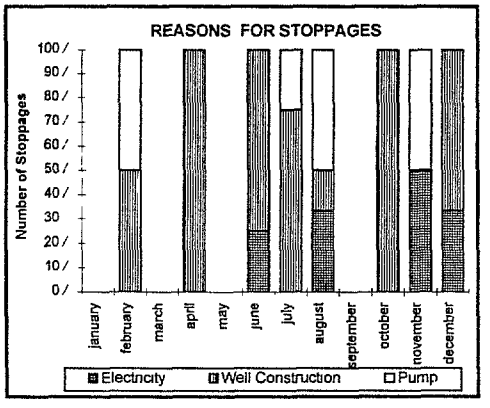


Figure A 9
North Well Field Analysis Zarudtsi

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lvnv\394\tg\ndate\wf A xls/19Aug97

East Well Field Analysis Remezivtsi

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Remezivtsi	59 3	34 5	24 8

AQUIFER

Description Upper Cretaceous Deposits
Fractured Siltstones and Chalks

Thickness of aquifer m	50
Static water level m	(+) 0 7 2 6
Pumping rate m³/day	3603 4320
Specific capacity m²/day	406 458
Transmissivity m²/day	2500
Thickness of covering layer m	10 15
Thickness of clay within the covering layer m	10 15

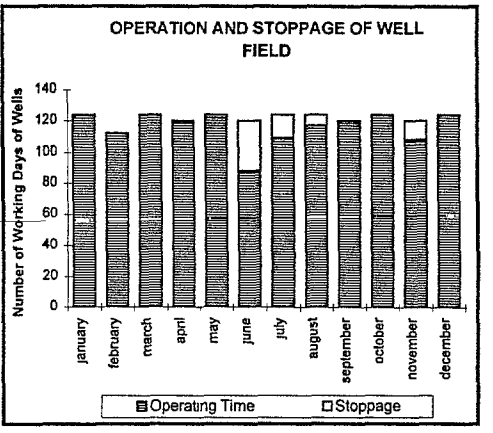
WELL FIELD (technical characteristics)

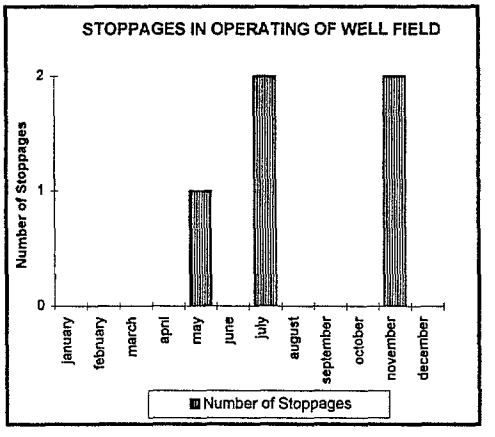
Number of wells		4
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 1 2	ЭЦВ10-120-60	(45)
wells 3 291	ЭЦВ12 210-60	(22)

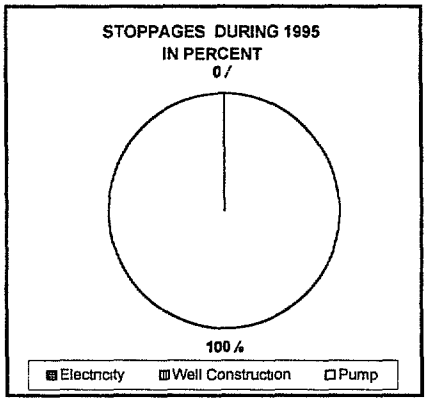
Criterion of operating effectiveness of well field 0 953

Probability of non stop work of well field 0 792

Percent of stoppages % 4 66







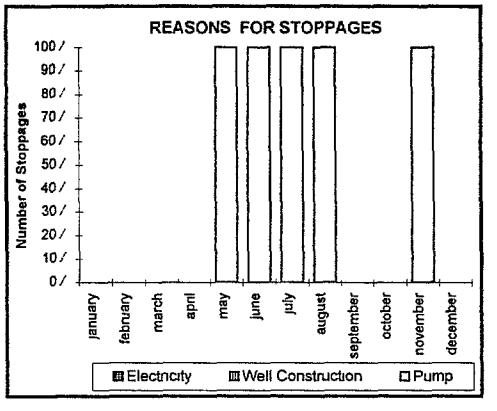


Figure A 10
East Well Field Analysis - Remezivtsi

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept lviv\394\tg\undate\wf A xls/19Aug97

East Well Field Analysis - Pluhiv

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Pluhiv	90	70	20

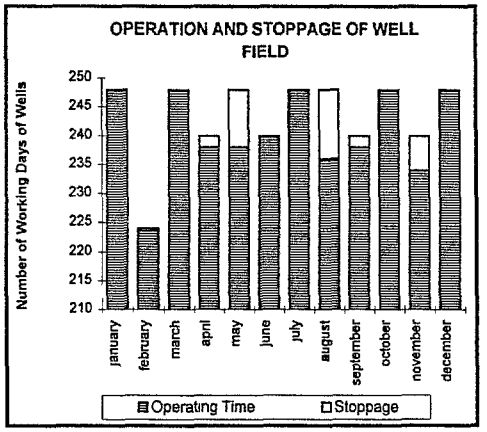
AQUIFER

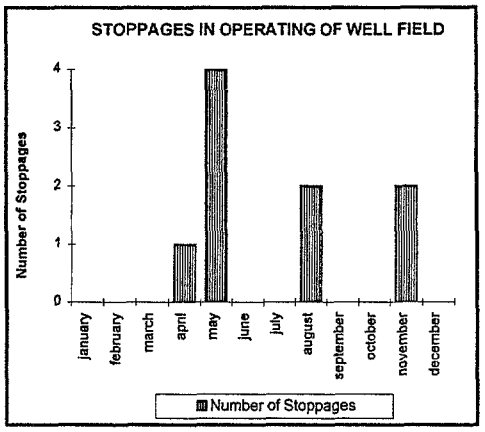
Description Middle Devonian Deposits
Fractured Limestones with layers of sand

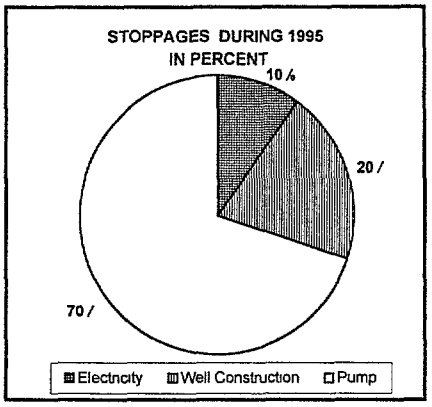
Thickness of aquifer m	100 350
Static water level m	(+) 22 8
Pumping rate m³/day	406 3600
Specific capacity m²/day	458 4320
Transmissivity m²/day	2070
Thickness of covering layer m	10 15
Thickness of clay within the covering layer m	10 15

WELL FIELD (technical characteristics)

Number of wells	8
Depth of wells m	200
Diameter of wells mm	426
Type of pumps (and capacity kW)	
wells 1 2 3 4 5 6 7 8 ЭЦВ12 255-30	(32)
Criterion of operating effectiveness of well field	0 989
Probability of non stop work of well field	0 906
Percent of stoppages %	1 10







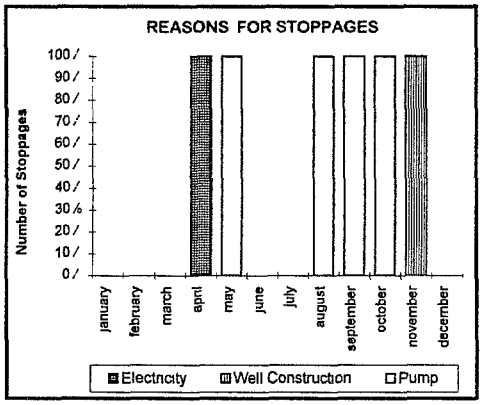


Figure A-11
East Well Field Analysis - Pluhiv

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\394\tg\indate\wf A xls/19Aug97

East Well Field Analysis Vilshanytsia

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Vilshanytsia	26 9	16 4	10 5

AQUIFER

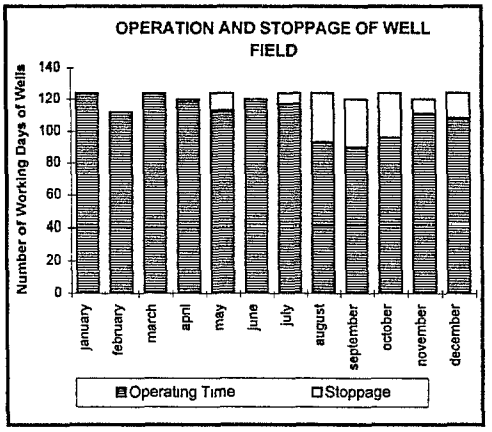
Description Upper Cretaceous Deposits
Fractured Siltstones and Chalks

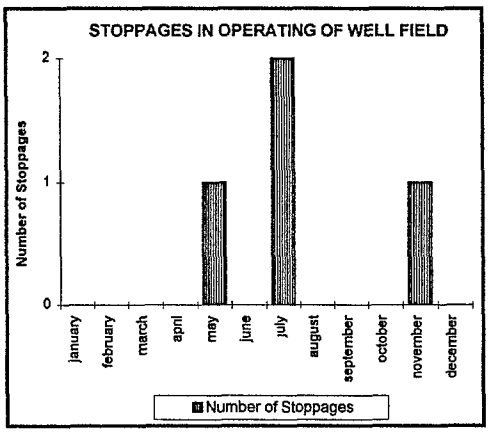
Thickness of aquifer m	50
Static water level m	(+) 3 0 5 0
Pumping rate m³/day	3603 4320
Specific capacity m²/day	406 458
Transmissivity m²/day	2500
Thickness of covering layer m	10 15
Thickness of clay within the covering layer m	10 15

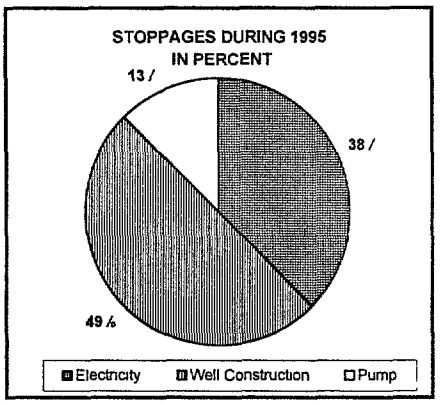
WELL FIELD (technical characteristics)

Number of wells		4
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (capacity kW)		
wells 1 2	ЭЦВ12 160-140	(90)
wells 3	ЭЦВ12 160-100	(65)
well 4	ЭЦВ10-63-110	(32)

Criterion of operating effectiveness of well field	0 91
Probability of non stop work of well field	0 696
Percent of stoppages %	9 04







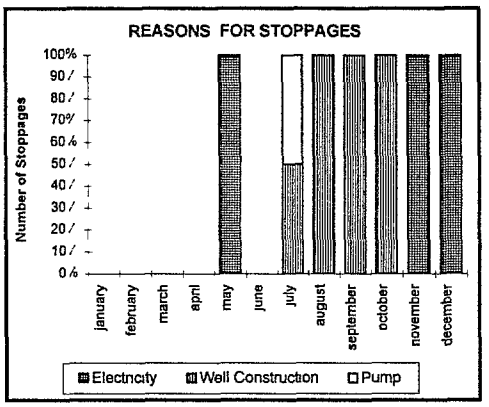


Figure A-12
East Well Field Analysis - Vilshanytsia

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lvnv\394\tg\indate\wf A xls/19Aug97

South Well Field Analysis Stryi

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Stryi	140	140	0

AQUIFER

Description Middle and Upper Quarternary Alluvium Complex

Sand Gravel Boulder in different proportions

Thickness of aquifer m	10 12
Static water level m	( ) 1 5 4 0
Pumping rate m³/day	1494
Specific capacity m²/day	1530
Transmissivity m²/day	1200
Thickness of covering layer m	3 5
Thickness of clay within the covering layer m	0

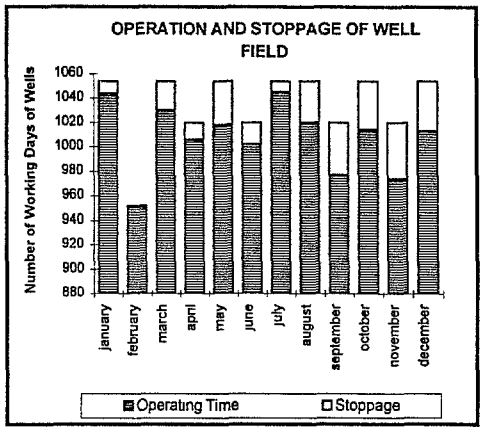
WELL FIELD (technical characteristics)

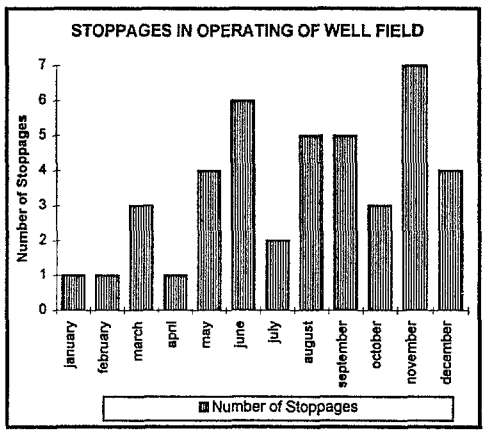
Number of wells		34
Depth of wells m		30
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 1 6 8 11	ЭЦВ12 160-65	(45)
wells 7	ЭЦВ10-63-65	(22)
well 12 26 28 34	ЭЦВ12 255-30	(32)
wells 27	ЭЦВ12 160-25	(45)

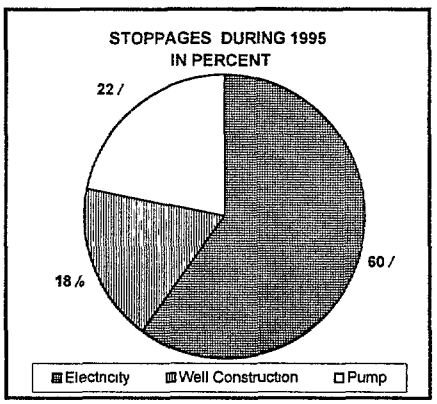
Criterion of operating effectiveness of well field 0 974

Probability of non stop work of well field 0 343

Percent of stoppages % 2 55







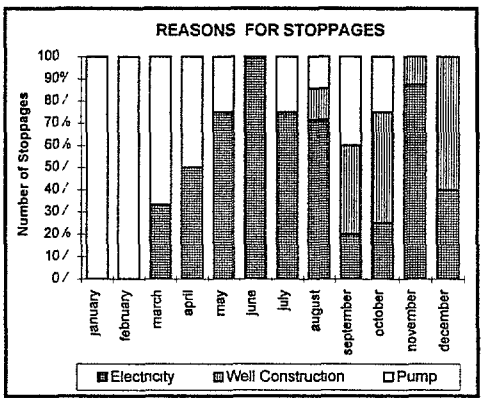


Figure A 13
South Well Field Analysis Stryi

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept lviv\394\tg\undate\wf A xls/19Aug97

South Well Field Analysis Hlynna Navaria

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Hlynna- Navana	19	14 7	4 3

AQUIFER

Description Upper Cretaceous Deposits
Fractured Siltstones and Chalks

Thickness of aquifer m	40
Static water level m	(+) 1 0 1 2
Pumping rate m³/day	1140 6333
Specific capacity m²/day	53 1330
Transmissivity m²/day	500
Thickness of covering layer m	15 20
Thickness of clay within the covering layer m	10 15

WELL FIELD (technical characteristics)

Number of wells	12
Depth of wells m	70
Diameter of wells mm	426

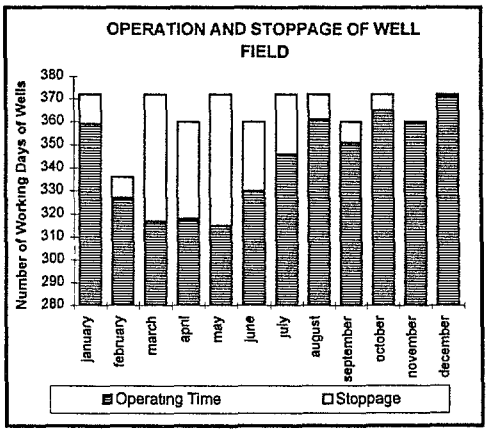
Type of pumps (and capacity kW)

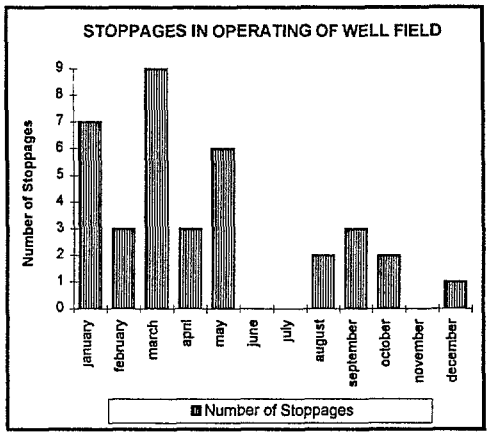
wells 1 1a 2a 4 5 7 7a	ЭЦВ10-63-110	(32)
well 2 3	ЭЦВ8-16-100	(17)
wells 6 6a 8	ЭЦВ12 160-100	(65)

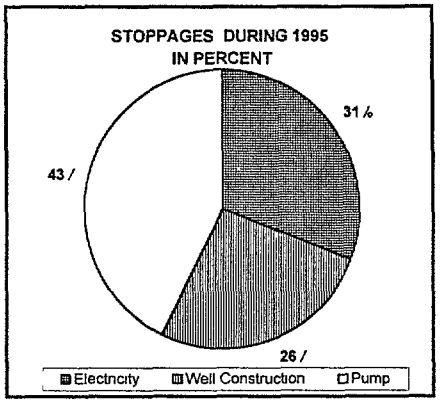
Criterion of operating effectiveness of well field 0 941

Probability of non stop work of well field 0 118

Percent of stoppages % 5 94







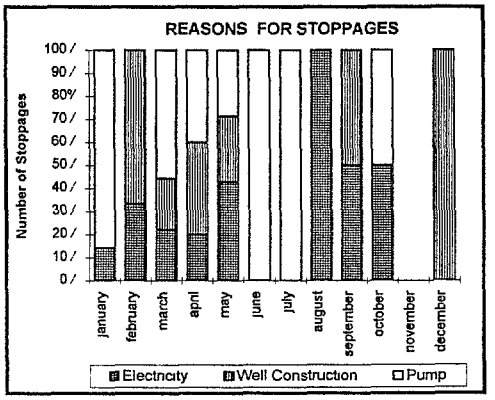


Figure A 14
South Well Field Analysis - Hlynna Navaria

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lvv\394\tg\vndate\wf A xls/19Aug97

South Well Field Analysis Bibrka

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Bibrka	20	13 3	6 7

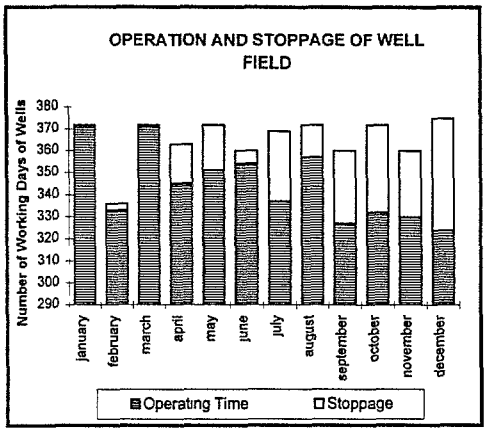
AQUIFER

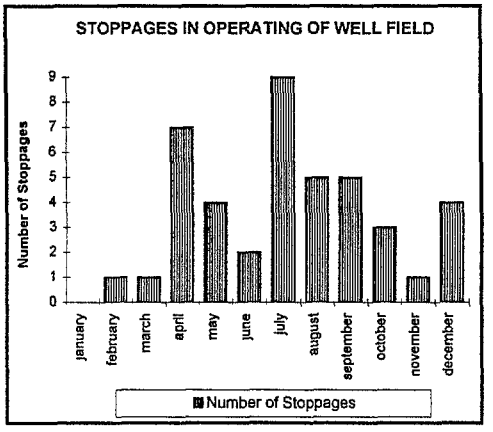
Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel

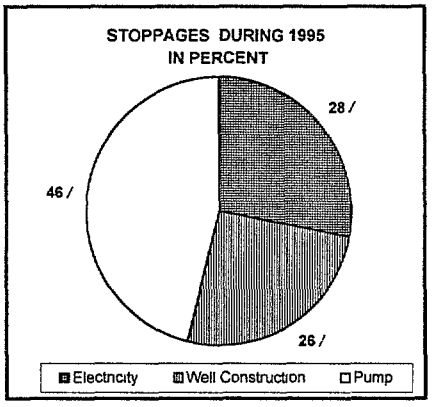
Thickness of aquifer m	40
Static water level m	(+) 1 7 4 5
Pumping rate m³/day	1780 5885
Specific capacity m²/day	88 720
Transmissivity m²/day	1070
Thickness of covering layer m	15 20
Thickness of clay within the covering layer m	15 20

WELL FIELD (technical characteristics)

Number of wells	12
Depth of wells m	75
Diameter of wells mm	426
Type of pumps (and capacity kW)	
wells 1 3 4 4a 6	ЭЦВ12 160 65 (45)
wells 1a 2a 6a 7 8 8a	ЭЦВ10-120-65 (32)
wells 2	ЭЦВ8-25-70 (17)
Criterion of operating effectiveness of well field	0 943
Probability of non stop work of well field	0 091
Percent of stoppages %	5 71







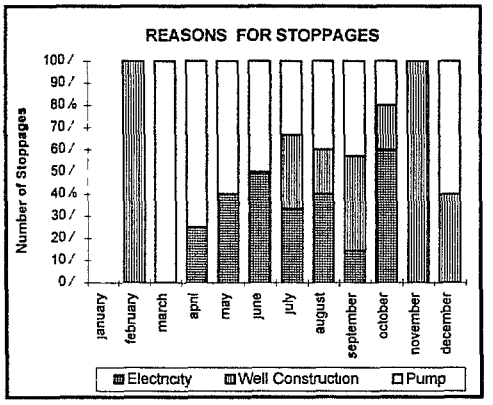


Figure A 15
South Well Field Analysis Bibrka

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept lvlv\394\tg\indate\wf A xls/19Aug97

South Well Field Analysis Malechkovychi

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Malechkovychi	5	5	0

AQUIFER

Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel
Upper Cretaceous Deposits
Fractured Siltstones and Chalks

Thickness of aquifer m	40
Static water level m	(+) 1 0 1 2
Pumping rate m³/day	3603 4320
Specific capacity m²/day	53 1330
Transmissivity m²/day	500
Thickness of covering layer m	15 20
Thickness of clay within the covering layer m	3 5

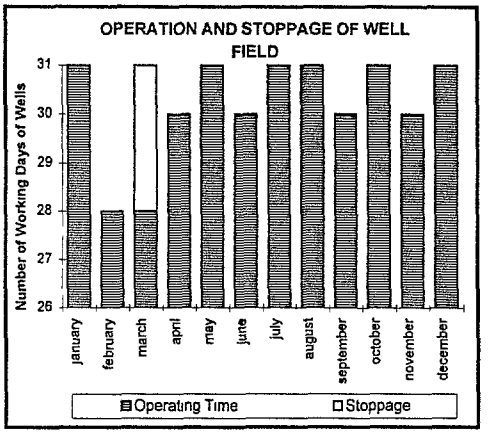
WELL FIELD (technical characteristics)

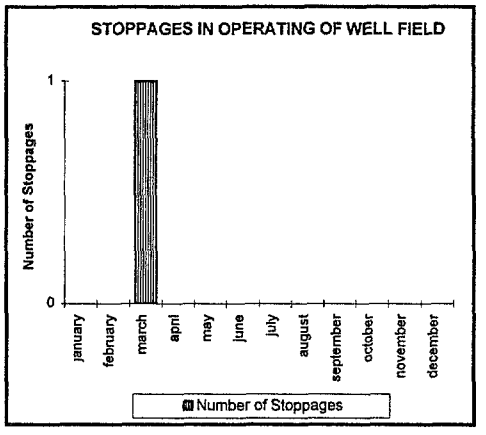
Number of wells	1
Depth of wells m	70
Diameter of wells mm	426
Type of pumps (and capacity kW)	
wells 1	ЭЦВ12 160-65 (45)

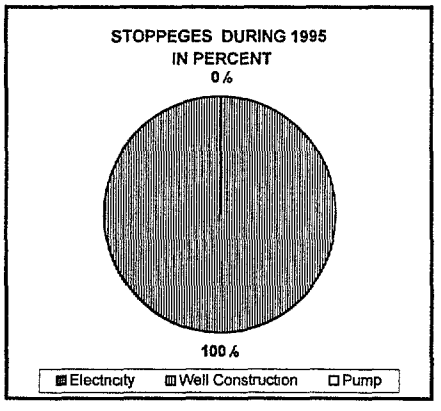
Criterion of operating effectiveness of well field 0 992

Probability of non-stop work of well field 0 992

Percent of stoppages % 0 82







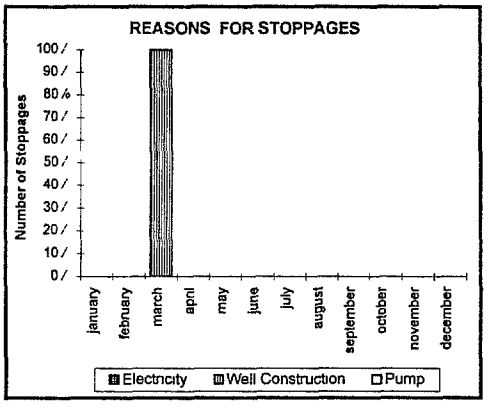


Figure A-16
South Well Field Analysis - Malechkovychi

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lvrv\394\tg\undate\wf A xls/19Aug97

West Well Field Analysis Volia Dobrostanska

YIELD 1 000 m³/day

	Total	Safe Yield	Added
Yield			
Volia Dobrostanska	22	18 5	3 5

AQUIFER

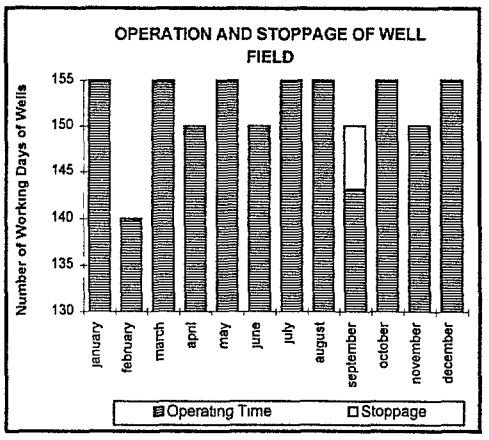
Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel

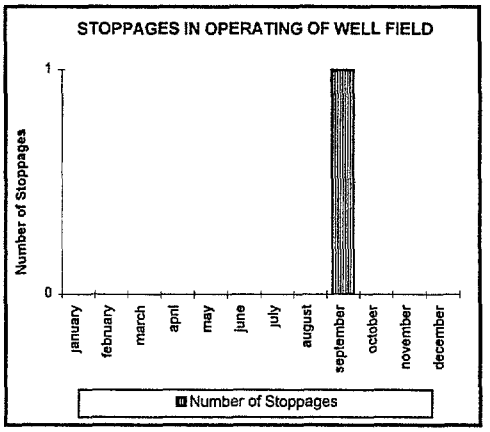
Thickness of aquifer m	35
Static water level m	( ) 3 5 15 0
Pumping rate m³/day	2073 6912
Specific capacity m²/day	458 1918
Transmissivity m²/day	690 2890
Thickness of covering layer m	5 15
Thickness of clay within the covering layer m	0 2

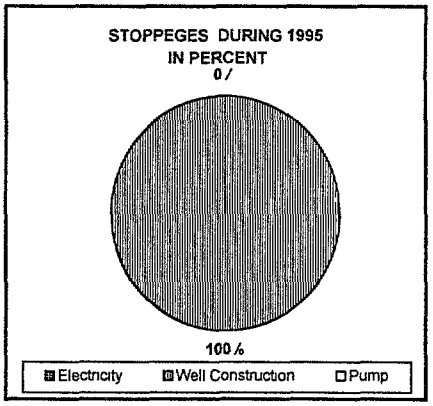
WELL FIELD (technical characteristics)

Number of wells		5
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 1 5 6 7	ЭЦВ12 160-65	(45)
wells 11	ЭЦВ10-63 65	(22)

Criterion of operating effectiveness of well field	0 996
Probability of non stop work of well field	0 996
Percent of stoppages %	0 38







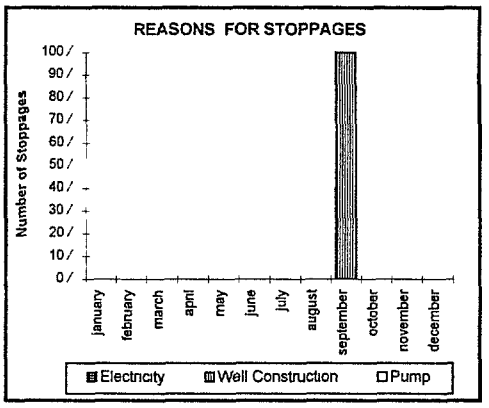


Figure A-17
West Well Field Analysis Volia Dobrostanska

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept lviv\394\tg\undate\wf A xls/19Aug97

West Well Field Analysis Velykopole

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Velykopole	13	8	5

AQUIFER

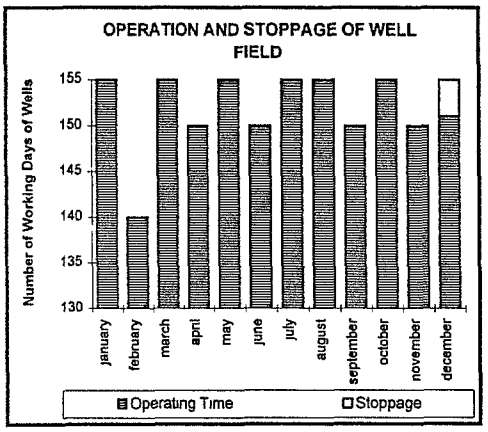
Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel

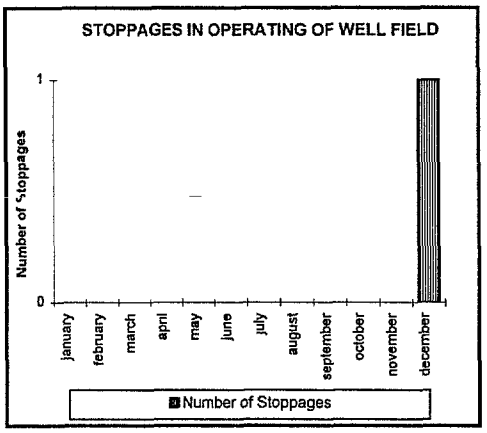
Thickness of aquifer m	35
Static water level m	( ) 3 8 5 6
Pumping rate m³/day	2073 6912
Specific capacity m²/day	458 1918
Transmissivity m²/day	690 2890
Thickness of covering layer m	10 15
Thickness of clay within the covering layer m	0

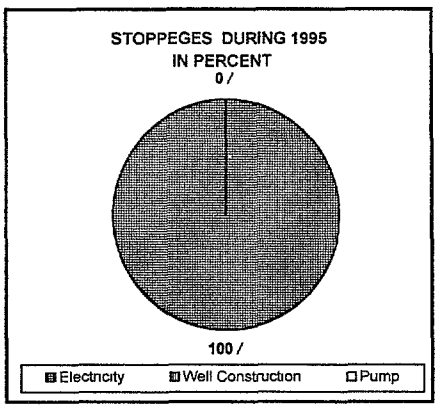
WELL FIELD (technical characteristics)

Number of wells		5
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 1 5	ЭЦВ10-120 65	(32)
wells 2 4	ЭЦВ12 160-65	(45)
well 3	ЭЦВ8-25-70	(17)

Criterion of operating effectiveness of well field	0 998
Probability of non stop work of well field	0 998
Percent of stoppages %	0 22







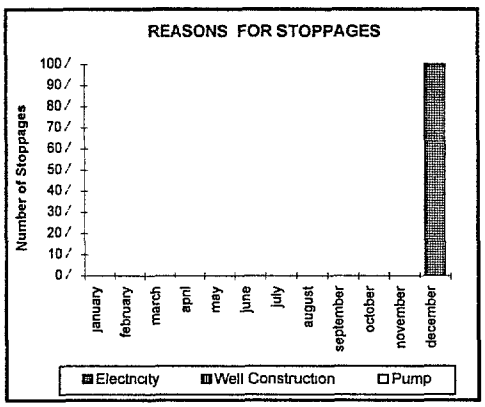


Figure A 18
West Well Field Analysis Velykopole

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\394\tg\ndate\wf A xls/19Aug97

West Well Field Analysis Kamianobrody

YIELD 1 000 m^3/day

	Total	Safe Yield	Added Yield
Kamianobrody	33	23	0

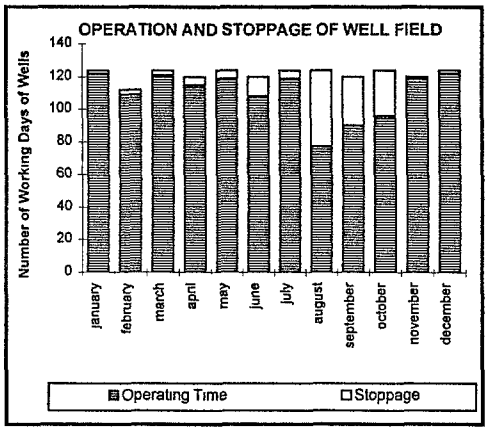
AQUIFER

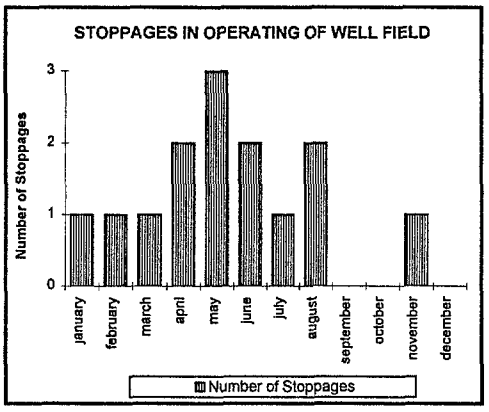
Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel

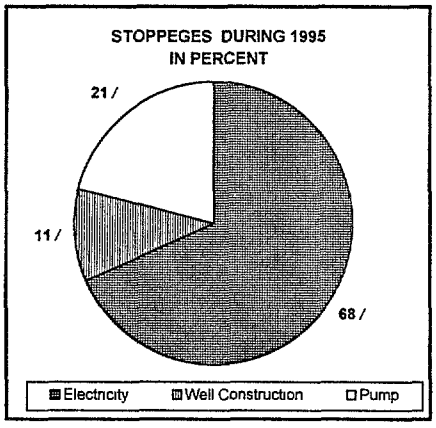
Thickness of aquifer m	25
Static water level m	( ) 2 2 3 6
Pumping rate m^3/day	1132 2402
Specific capacity m^2/day	353 600
Transmissivity m^2/day	1380
Thickness of covering layer m	10 15
Thickness of clay within the covering layer m	5 10

WELL FIELD (technical characteristics)

Number of wells	4
Depth of wells m	45
Diameter of wells mm	426
Type of pumps (and capacity kW)	
wells 1 2 3 4 ЭЦВ12 255-30	(32)
Criterion of operating effectiveness of well field	0 891
Probability of non stop work of well field	0 254
Percent of stoppages %	9 79







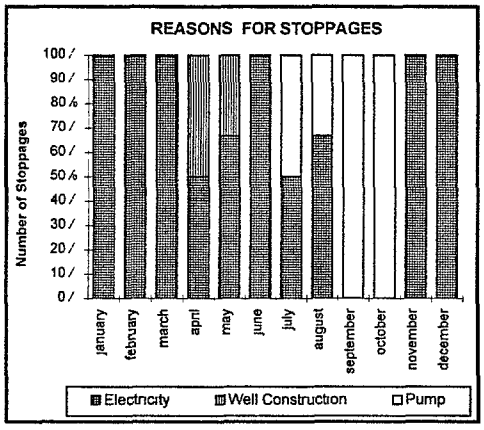


Figure A-19
West Well Field Analysis - Kamianobrody

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\394\tg\ndate\wf A xls/19Aug97

West Well Field Analysis Malchytsi

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Malchytsi	21 3	15 7	5 6

AQUIFER

Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel

Thickness of aquifer m	35
Static water level m	( ) 5 0 7 0
Pumping rate m³/day	2436 5450
Specific capacity m²/day	251 601
Transmissivity m²/day	650
Thickness of covering layer m	30 40
Thickness of clay within the covering layer m	5 10

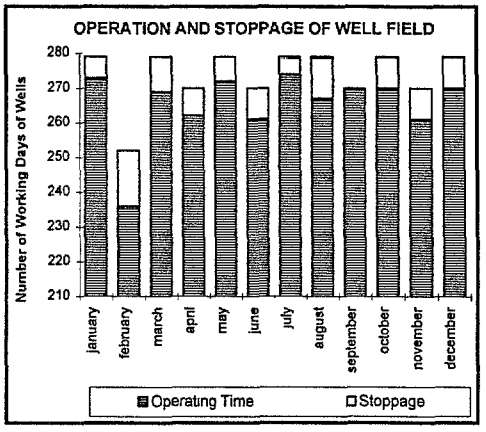
WELL FIELD (technical characteristics)

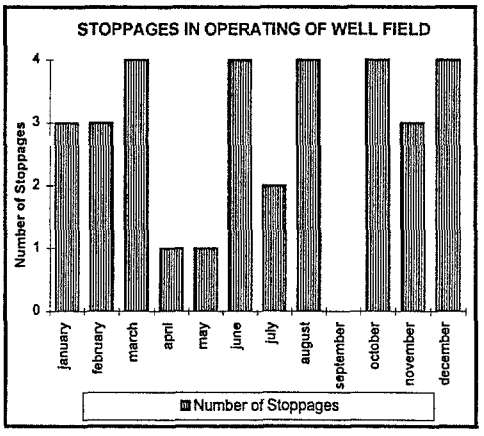
Number of wells		9
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 1 2a	ЭЦВ8-25-70	(17)
wells 2 3 3a 4a	ЭЦВ10-63-110	(32)
well 4 5 6	ЭЦВ12 160 65	(45)

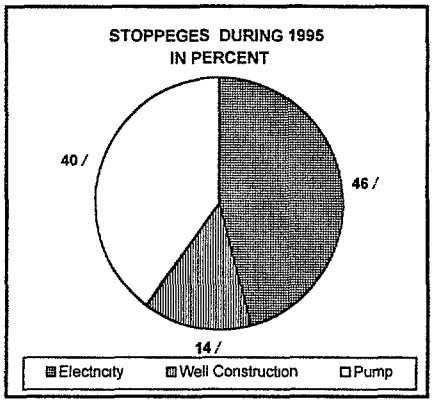
Criterion of operating effectiveness of well field 0 969

Probability of non stop work of well field 0 366

Percent of stoppages % 3 04







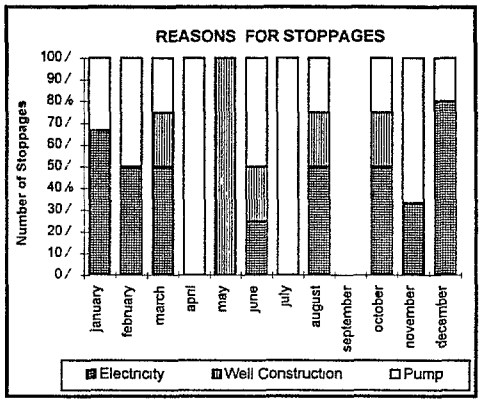


Figure A 20
West Well Field Analysis Malchytsi

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\394\tg\ndate\wf A xls/19Aug97

West Well Field Analysis Budzen

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Budzen	54 2	45 2	9

AQUIFER

Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel

Thickness of aquifer m	30
Static water level m	( ) 1 4 6 5
Pumping rate m³/day	720 3456
Specific capacity m²/day	124 1839
Transmissivity m²/day	2050
Thickness of covering layer m	15 50
Thickness of clay within the covering layer m	5 15

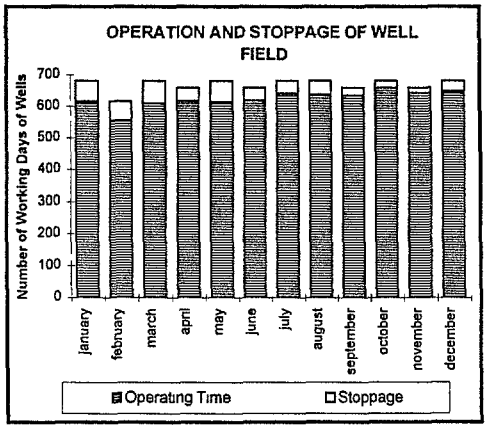
WELL FIELD (technical characteristics)

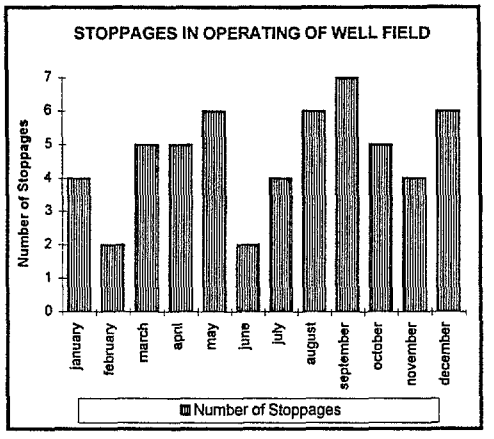
Number of wells	22
Depth of wells m	70
Diameter of wells mm	426

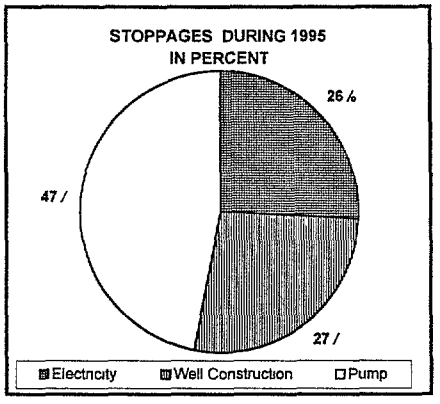
Type of pumps (and capacity kW)

wells 1 2 6a 7 7a 8 9 9a 10 10a 11 11a 12 13 13a 15a	ЭЦВ10-120-65	(32)
wells 5 5a 14a	ЭЦВ10-63-110	(32)
well 6 12a	ЭЦВ12 160-65	(45)
wells 17	ЭЦВ8-25-70	(17)

Criterion of operating effectiveness of well field	0 929
Probability of non stop work of well field	0 024
Percent of stoppages %	6 66







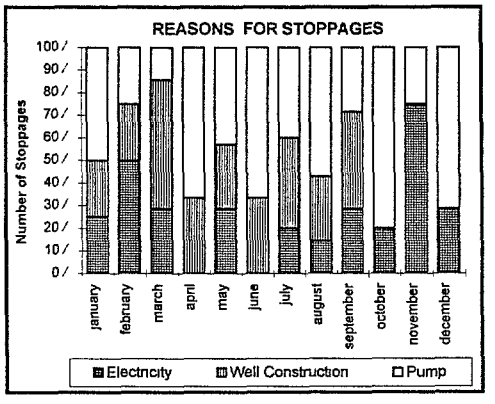


Figure A 21
West Well Field Analysis Budzen

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\394\tg\update\wf A xls/19Aug97

West Well Field Analysis Kernytsia

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Kernytsia	15 4	9	6 4

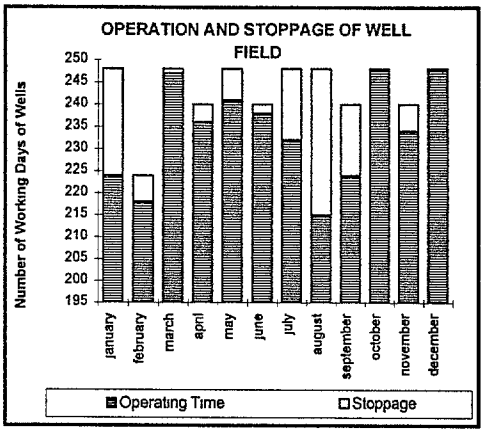
AQUIFER

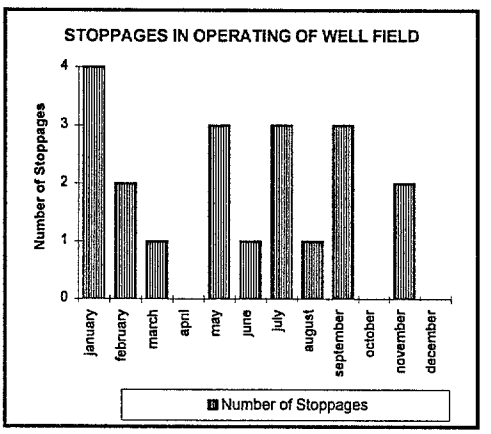
Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel

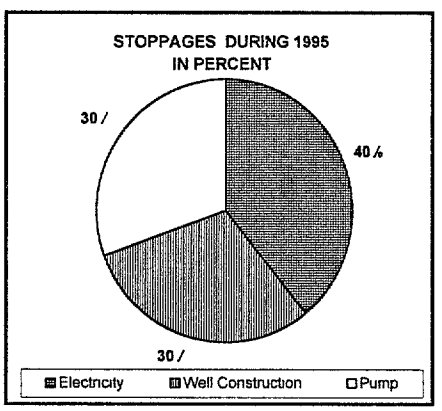
Thickness of aquifer m	35	
Static water level m	(+) 2 0	
Pumping rate m³/day	720	3456
Specific capacity m²/day	124	1839
Transmissivity m²/day	2050	
Thickness of covering layer m	15	50
Thickness of clay within the covering layer m	5	15

WELL FIELD (technical characteristics)

Number of wells	8	
Depth of wells m	85	
Diameter of wells mm	377	
Type of pumps (and capacity kW)		
wells 1 1a 3 3a 4 5 6	ЭЦВ10-120-65	(45)
wells 2	ЭЦВ12 160-65	(45)
Criterion of operating effectiveness of well field	0 961	
Probability of non stop work of well field	0 455	
Percent of stoppages %	3 94	







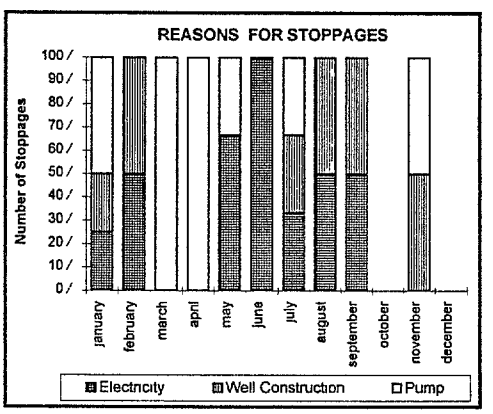


Figure A 22
West Well Field Analysis - Kernytsia

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept lviv\394\tg\ndate\wf A xls/19Aug97

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, m^3/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 supply
		1	27	ЕЦВ12 255 30	255	30	32	
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 water
		2	3 291	ЕЦВ12 210-60	210	60	22	
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	ЕОВ10 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

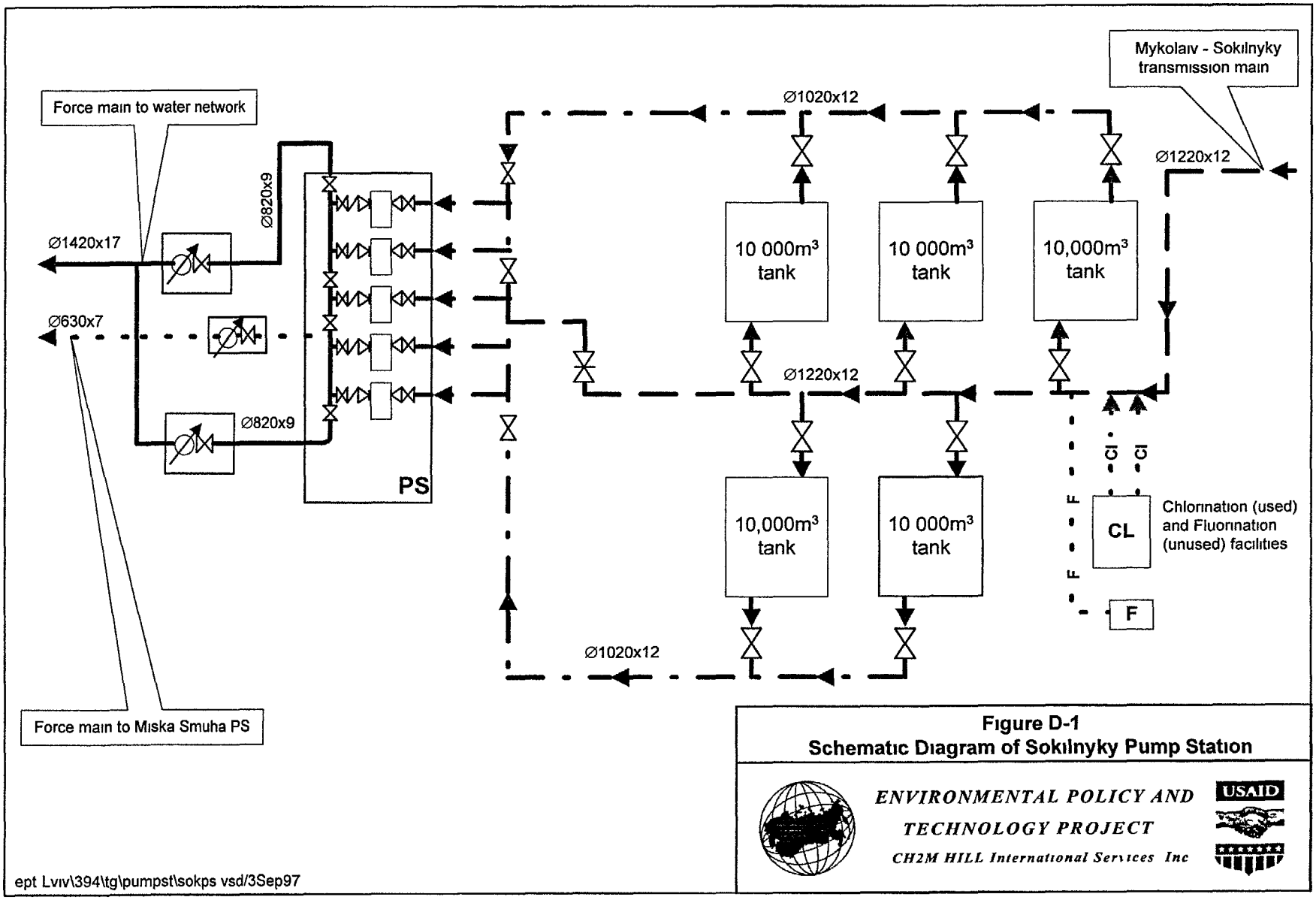
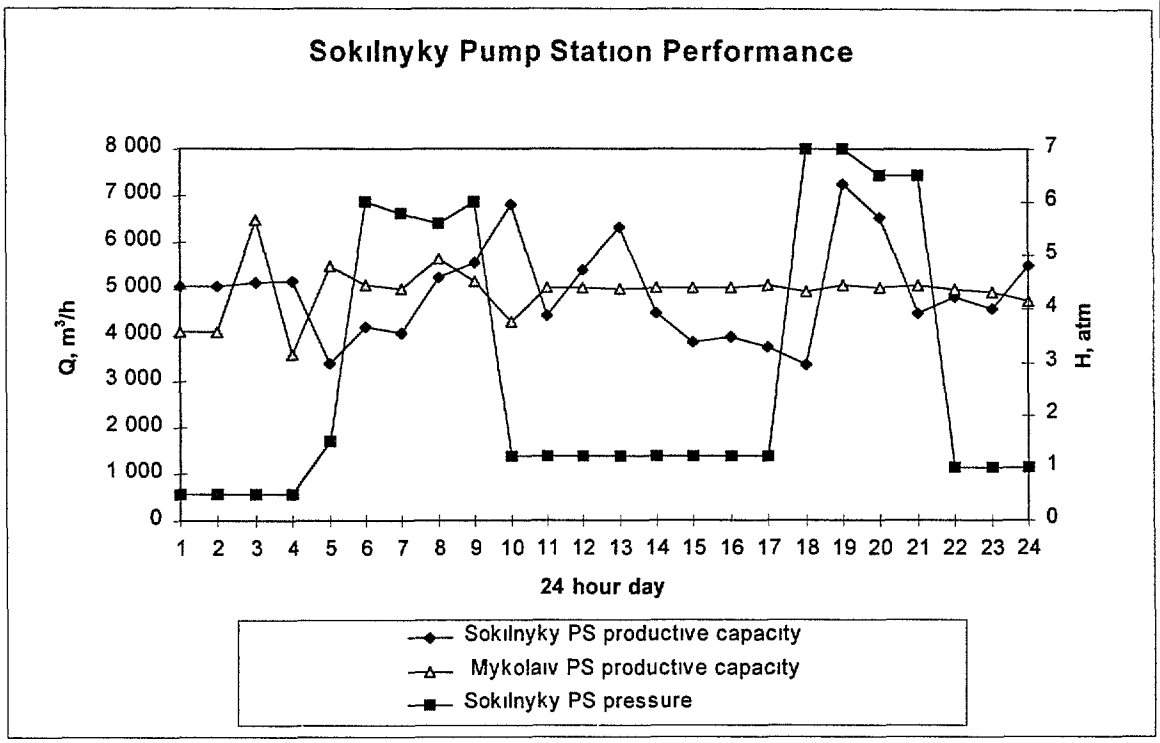


Figure D-1
Schematic Diagram of Sokilnyky Pump Station



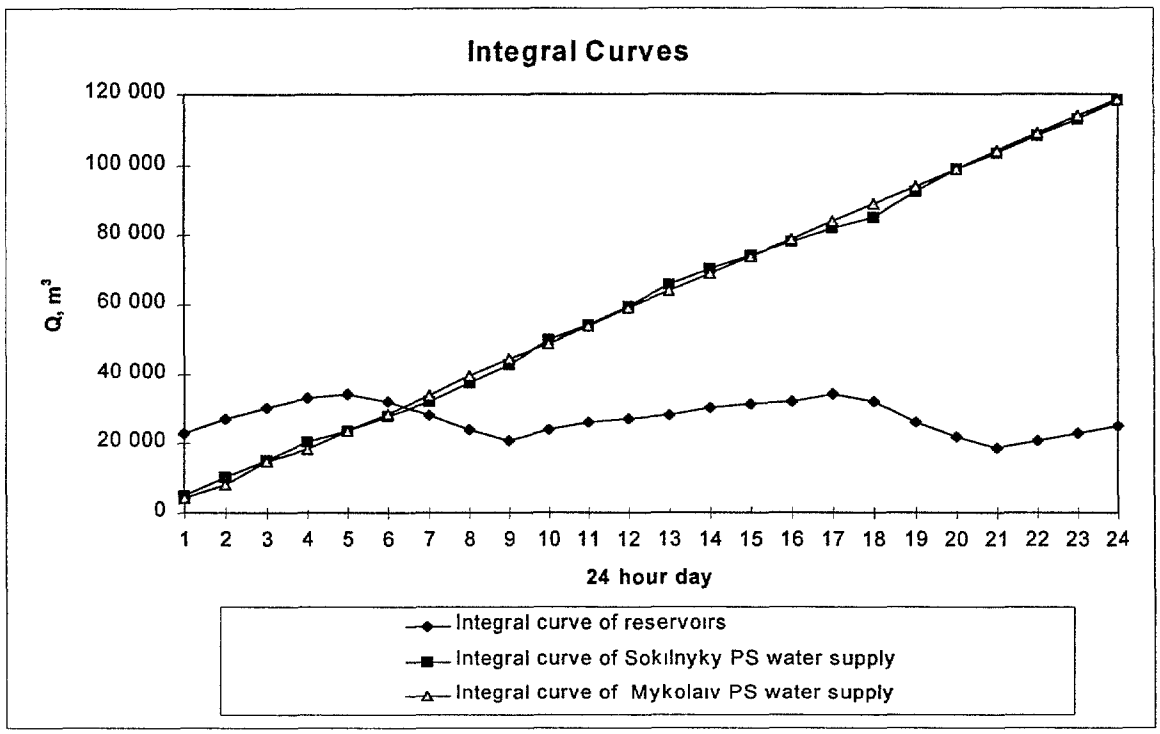


Figure D-2
Daily Flow and Pressure Curves for Sokilnyky PS

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept Lviv\394\tg\pumpst\sokps vsd/3Sep97

Appendix E

INFORMATION ON WATER QUALITY

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

Table E-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 E-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 F

AVERAGE DAILY WATER CONSUMPTION OF DISTRICT HEATING FACILITIES

This appendix provides the addresses of district heating facilities in Lviv and their average daily water consumption

Table F-1
Water Consumption by District Heating Facilities

No	Address	Average Consumption, m^3/d
	Halytsky District	
1	Karmanskoho, 19	235
2	Enerhetychna 14-20	274
3	Ternopilska, 4	71
4	Dunaiska, 32	152
5	Sykhivska, 10	389
6	Sykhivska, 24	438
7	Kavaleridze, 17	759
8	Dovzhenka 22a	390
9	Chervonoyi Kalyny 75a	268
10	Zubrivska, 36	552
11	Khotkevycha, 14a	763
12	Chukarina 1a	376
13	Chervonoyi Kalyny, 42a	363
14	Antonenka Davydovycha 3	322
15	Tesliuka 13	411
16	Antonenka Davydovycha, 22-30	240
17	Chervonoyi Kalyny 107	544
18	Chervonoyi Kalyny, 53-a	730
19	Chervonoyi Kalyny, 83-a	296
20	Chervonoyi Kalyny	472
21	Tryliovskoho, 1	380
22	Tryliovskoho 33	451
23	Kavaleridze, 8	85
24	Dovzhenka, 7	101
25	Tesliuka 23	48
26	Vuletska,	201
27	Khotkevycha 10	58
28	Zubrivska 26 28	101
	Frankivsky District	
29	Kniahyny Olgy 59-61	80
30	Volodymyra Velykoho, 32	558
31	Hrabianky, 7-13	254

No	Address	Average Consumption, m^3/d
32	Stryiska 78	84
33	Lazarenka, 7	162
34	Skoryny, 32	67
35	Bodnarska 16	55
36	Rubchaka 12 14	73
37	Rubchaka, 17	54
38	Volodymyra Velykoho, 5 15	195
39	Volodymyra Velykoho, 35	510
40	Volodymyra Velykoho 37-42	152
41	Volodymyra Velykoho 51	357
42	Volodymyra Velykoho 57	265
43	Naukova, 12	495
44	Naukova, 18	387
45	Volodymyra Velykoho 34 46	127
46	Volodymyra Velykoho, 61a	402
47	Volodymyra Velykoho, 83	334
48	Konovaltsia, 97-99	64
49	Naukova, 58	703
50	Naukova, 17-23	403
51	Naukova, 55-57	1,081
52	Puliuya, 3	782
53	Volodymyra Velykoho, 125	407
54	Naukova, 100	452
55	Naukova 116-a	299
56	Stryiska, 87	111
57	Stryiska, 101	626
58	Ostrohradskykh, 4-4a	93
59	Volodymyra Velykoho, 61	55
60	Naukova, 96	49
61	Volodymyra Velykoho 16	55
62	Volodymyra Velykoho 117	70
63	Naukova, 16	70
64	Puliuya 32	96
65	Stryiska, 71-a	74
66	Yuvileyna 4	71
67	Khutorivka 34	58
68	Broniova 2-a	469
	Zaliznychny District	
69	Horodotska 210	199
70	Horodotska 218	218
71	Kulparkivska, 130 a	54
72	Bashtanna, 7-a	580
73	Karadzhycha, 12-a	700
74	Horodotska, 241-a -243	414

No	Address	Average Consumption, m^3/d
75	Horodotska, 289	202
76	Vyhovskoho, 3-11	1 094
77	Vitriana, 9-a	408
78	Petliury, 47-53	75
79	Roksoliany, 21-31	778
80	Sirka, 21 23	282
81	Shevchenka 320	1 473
82	Shevchenka, 362-b	2,108
83	Shevchenka, 396	188
84	Shevchenka, 370-a	4,715
85	Liubinska, 98-104	491
86	Petliury, 24 30	134
87	Petliury, 2-a -4-a	377
88	Kulchytskoi, 3	57
89	Patona, 2 a	451
90	Velychka, 25-a	1,129
91	Patona, 2/4-a	152
92	Liubinska, 38	139
93	Shyroka, 68	725
94	Shyroka, 86-a	1,240
95	Povitriana 65	189
96	Povitriana, 92-94	795
97	Patona, 2/7	46
98	Vyhovskoho, 41	80
99	Petliury, 4	83
100	Liubinska 102	242
101	Siayvo 17-a	652
102	Vyhody, 27	777
103	Nyzynna, 58	1,416
104	Kulparkivska, 139	129
105	Shevchenka 327	233
106	Shevchenka, 430	1,167
107	Strilochna, 36	209
108	Patona 25-a	476
109	Vyhovskoho 47	65
110	Sadova 9-a	455
111	Shevchenka 366-a	197
112	Shevchenka, 364	192
113	Shevchenka 374-a	205
114	Vyhody 36	265
115	Shyroka 83-a	223
116	Roksoliany 33	291
117	Povitriana 68	254
118	Shevchenka, 472	248

No	Address	Average Consumption, m^3/d
119	Roksoliany, 18	66
120	Rokshany 4	62
121	Shevchenka, 318	11,686
122	Shevchenka, 348	467
	Shevchenkivsky District	
123	Shchurata 14	79
124	Zolota, 17	248
125	Linkolna, 45	58
126	Hvyliovoho, 54-a	507
127	Hvyliovoho 56-a	208
128	Mazepy, 15-19	111
129	Mazepy, 23-a	212
130	Mykolaichuka, 67-a	274
131	Mykolaichuka 75	60
132	Hrinchenka, 6-10	163
133	Masaryka, 3	63
134	Okunevskoho 1-3	124
135	Mykolaichuka, 106-a	372
136	Hmelnytskoho 267-269	353
137	Linkolna, 39-a	332
138	Hvyliovoho, 3	248
139	Mazepy 3	378
140	Tychyny, 11-a	59
141	Mazepy 13-a	237
142	Torfiana, 12	294
143	Torfiana, 39	461
144	Pancha, 18-a	265
145	Sorochynska 6-8	71
146	Mykolaichuka 90 92	990
147	Koshytsia 7	53
148	Masaryka, 8	53
149	Tychyny 17	54
150	Linkolna, 29	83
151	Tatarbunarska 5	261
152	Varshavska bichna 3	137
	Lychakivsky District	
153	Vashynhtona 5-a	55
154	Vashynhtona 13	287
155	Shafaryka 16-a	519
156	Pasichna, 98-a	318
157	Pasichna, 89-a	480
158	Lysenytska, 5-a	269
159	Kytayska, 12-a	517
160	Medova Pechera, 7	149

No	Address	Average Consumption, m^3/d
161	Pasichna, 70	20
162	Pasichna, 59	18
163	Pasichna, 53	76
164	Medova Pechera 69	450
165	Pasichna, 42	248
166	Hlymansky trakt 163	173
167	Sahaydachnoho, 3-a	179
168	Poliova, 29 a	206
169	Hlymansky trakt	2,016
	Total	**72,514**

Appendix G

WATER CONSUMPTION OF MAJOR INDUSTRIAL ENTERPRISES

This appendix contains data on water consumption of major industrial enterprises in Lviv

Table G-1
Water Consumption of Major Industrial Enterprises in 1995

No	Name of Enterprise	Average Consumption, m^3/d
1 1	Lviv Railway	19
1 2	Lviv Railway	1 612
1 3	Lviv Railway	6
1 4	Lviv Railway	118
1 5	Lviv Railway	1,181
2	Stock Company 'ISKRA' /electric supplies	1,598
3	Milk Plant	1,080
4 1	PA LvivKhimSilgospMash /agric chemical machine	266
4 2	PA 'LvivKhimSilgospMash' /agric chemical machine	22
4 3	PA LvivKhimSilgospMash /agric chemical machine	700
5 1	PA 'KINESKOP /TV tubes	323
5 2	PA "KINESKOP" /TV tubes	552
6	Lviv Fat-Products Plant	747
7	Leather Treatment Plant "SVITANOK'	743
8 1	Meat Plant	389
8 2	Meat Plant	521
9 1	House-Building Complex 2	329
9 2	House-Building Complex - 2	330
10	Lviv Bus Plant	665
11 1	State Plant "LANT' /fork lift trucks	81
11 2	State Plant 'LANT' /fork-lift trucks	164
11 3	State Plant LANT /fork-lift trucks	39
11 4	State Plant "LANT' /fork lift trucks	59
11 5	State Plant LANT /fork lift trucks	236
12	Stock Company KOLOS /brewery	587
13	PA "MicroInstrument'	482
14	Ceramics Plant	475
15	Gorilka Plant /vodka	551
16 1	SVITOCH Firm /confectionary	26
16 2	SVITOCH Firm /confectionary	345
16 3	SVITOCH Firm /confectionary	64
17 1	SPA ELECTRON' /TV	64
17 2	SPA "ELECTRON /TV	343
18	PA 'GALICH PHARM /acy	359

No	Name of Enterprise	Average Consumption, m^3/d
19	Joint Venture Coca Cola"	369
20 1	Bakery Factory #3	75
20 2	Bakery Factory #3	51
20 3	Bakery Factory #3	197
21	Bakery Factory #1	264
22	Locomotive Repair Plant	244
23	Stock Company "Lviv Insulator Plant	269
24	' LORTA' Plant /radio-technical equipment	168
25	FTA Plant /telegraph equipment	223
26	Railway Maintenance	201
27 1	Bio Phys Prylad Plant /biological & physical instruments	23
27 2	"Bio Phys Prylad' Plant /biological & physical instruments	156
28	Bakery Factory #5	157
29	Stock Company "RAIDUHA /glass-works	157
30	Lviv Ferro Concrete Plant #1	184
31	PA CONVEYOR"	148
32	Open Stock Company MechScloZavod /glass	145
33	Close Company ' ENZYME /yeast plant	158
34	PA ' Lviv Prylad" /instrument	150
35	PA ' Prikarpat Industrial Fittings '	132
36	Railway Administration	128
37 1	Furniture Firm "KARPATY	98
37 2	Furniture Firm KARPATY	16
38	Railway Cargo Station	102
39	Lviv Administration of Mechanization GALBUD	103
40	Lviv Instrumental Plant	106
41	Chemical Plant	104
42	Stock Company 'Electron-Riasne /color TV	94
43	MechScloZavod ' /tech glass/ for Galichpharm '	89
44	769 Plant of Prefabricated Ferro-Concrete Elem	93
45	Joint Venture "GALKA /coffee factory	91
46	Macaroni Factory	75
47	Stock Company PROGRES /foot-wear	76
48	Close Company LEVTEKS sport uniforms	67
49 1	Construction Materials Plant Administration	15
49 2	Construction Materials Plant Administration	19
49 3	Construction Materials Plant Administration	33
50	Prosthetic Appliances Plant	66
	Total	**19,917**

Appendix H

WATER CONSUMPTION BY THE LARGEST COMMUNAL ENTERPRISES

This appendix presents water consumption by the largest communal enterprises in Lviv

Table H-1
Water Consumption of the Largest Communal Enterprises in 1995

No	Consumer Name	Average Consumption, m^3/d
1	Lviv Vodokanal (WWTP), Sylikatna St 11	3,567
2	Lviv Vodokanal (Vynnyky PS) Vynnyky town	1,843
3	Cooperative, Kernytsia village	330
4	Lviv Vodokanal Zelena St , 62-64	279
5	Collective farm Stare Selo village	267
6	Cooperative Vodiane village	241
7	Collective farm, Krekhiv village	224
8	Kvity Lvova Agricultural Firm, Stryiska St , 195	187
9	Collective Farm Kunin village	176
10	Military Complex, Mechnikova St , 16	157
11	Collective farm, Tsytulia village	155
12	Research farm Maheriv village	149
13	Collective farm, Zavereshchytsia village	134
14	Cooperative, Porshna village	133
15	Park and Green Areas Trust Zamarstynivska St , 167a	126
16	Fire Fighting Headquarters, Vol Velykoho St 56	119
17	Agricultural Firm Provesin Trakt Hlymansky, 152	105
18	Collective farm Pidlissia village	103
	Total	**8,295**

Appendix I

WATER CONSUMPTION BY BUDGET INSTITUTIONS

This appendix presents water consumption by budget institutions -- medical institutions (Table I -1) and educational institutions (Table I -2)

Table I-1
Water Consumption by Lviv Medical Institutions in 1995

No	Name	Average Consumption, m^3/d
1	First aid hospital	1,762
2	Medical institute oblast hospital	967
3	Psychiatric hospital	809
4	Railway polyclinic	483
5 1	Oblast tuberculosis hospital	58
5 2	Hospital No 8	285
5 3	Polyclinic	113
6	Oblast military hospital	375
7 1	Hospital	192
7 2	Polyclinic No 1	47
7 3	Hospital No 3	48
8	Hospital No 5	318
9	Lviv oblast children s hospital	293
10	Military hospital 1120	288
11	Blood transfusion station	276
12	Railway hospital	223
13 1	Infectious diseases hospital	178
13 2	Infectious diseases hospital	30
13 3	Infectious diseases hospital	44
14 1	Oblast venerological dispensary	98
14 2	Oblast venerological dispensary	119
15 1	Hospital	47
15 2	Hospital	34
15 3	Hospital No 4	15
15 4	Orphanage	37
15 5	Children s sanatorium	41
15 6	Orphanage No 2	19
15 7	Polyclinic No 4	12
16 1	Psycho neurological dispensary	32
16 2	Psycho-narcological dispensary	33
16 3	Maternity hospital	105
16 4	Hospital No 6	51
17 1	Children s psycho-neurological dispensary	12
17 2	Dental polyclinic	190

No	Name	Average Consumption, m^3/d
18	Oncological dispensary	196
19	Hospital	191
20 1	Maternity hospital	31
20 2	Polyclinic No 4	118
20 3	Dermatological venerological dispensary	7
21	Hospital	154
22	Clinical and diagnostic center	147
23	Hospital	132
24	Oblast children's specialized hospital	100
25	Hospital No 5	91
26 1	Hospital	76
26 2	Polyclinic	13
27 1	Disinfection station	28
27 2	City sanitary epidemiological station	47
28 1	First aid station	18
28 2	First aid station	18
29	Polyclinic	33
30	Disinfection department	17
31	Medical division of Interior Ministry	16
32	City dental hospital No 3	11
	Total	**9,083**

Table I-2 Water Consumption by Lviv Educational Institutions in 1995		
No	Institution Name	Average Consumption, m^3/d
1 1	University Lviv Politekhnika ' dormitory	138
1 2	University Lviv Politekhnika ' dormitory	1,001
1 3	University Lviv Politekhnika" dormitory	52
1 4	University 'Lviv Politekhnika" garages	38
1 5	University 'Lviv Politekhnika building	382
1 6	University Lviv Politekhnika dormitory	828
1 7	University 'Lviv Politekhnika' dormitory	693
1 8	University 'Lviv Politekhnika dormitory	346
2 1	I Franko University building	128
2 2	I Franko University building	282
2 3	I Franko University garages	125
2 4	I Franko University main building	133
2 5	I Franko University building	116
2 6	I Franko University building	633
2 7	I Franko University building	122
2 8	I Franko University building	158
2 9	I Franko University building	181
2 1	I Franko University building	111
2 11	I Franko University building	149
2 12	I Franko University dormitory	665
2 13	I Franko University dormitory	41
2 14	I Franko University dormitory	365
3 1	Medical Institute building	248
3 2	Medical Institute dormitory	460
3 3	Medical Institute dormitory	147
3 4	Medical Institute dormitory	379
3 5	Medical Institute dormitory	87
4 1	Forestry University building	168
4 2	Forestry University special chair	294
4 3	Forestry University building	20
4 4	Forestry University dormitory	384
4 5	Forestry University dormitory	292
4 6	Forestry University canteen	94
5 1	Veterinary Academy building	227
5 2	Veterinary Academy dormitory	478
5 3	Veterinary Academy dormitories	237
6 1	Professional technical school No 27 building	150
6 2	Professional technical school No 27 building	197
6 3	Professional technical school No 27 dormitory	454
7 1	Commercial Institute building	92
7 2	Commercial Institute sport complex	25
7 3	Commercial Institute dormitory	156
7 4	Commercial Institute dormitory	358

No	Institution Name	Average Consumption, m^3/d
8 1	Physical Culture Institute building	114
8 2	Physical Culture Institute dormitory	231
8 3	Physical Culture Institute dormitory	201
9 1	Telecommunications College building	62
9 2	Telecommunications College dormitories	333
10 1	Land Reclamation College building	173
10 2	Land Reclamation College building	175
11 1	Professional technical school No 12 building	281
11 2	Professional technical school No 12 building	34
12 1	Professional technical school No 52 building	312
13 1	Cooperative Technical School building	46
13 2	Cooperative Technical School dormitory	215
14 1	Professional technical school No 64 building	155
14 2	Professional technical school No 64 dormitories	85
15 1	Housing Communal Technical College	122
15 2	Housing Communal Technical College dormitory	214
15 3	Housing Communal Technical College dormitory	93
16 1	Food Industry Technical College building	141
16 2	Food Industry Technical College dormitory	95
17 1	Cinema Technical College building	93
17 2	Cinema Technical College dormitory	134
18 1	Professional technical school No 17 building	152
18 2	Professional technical school No 17 dormitory	71
19 1	Water Sports Complex	212
20 1	Physical Culture School building	208
21 1	Military College building	199
22 1	Printing Institute building	101
22 2	Printing Institute dormitory	98
23 1	Professional technical school No 58 building	44
23 2	Professional technical school No 64 dormitories	134
24 1	Financial Technical College building	54
24 2	Financial Technical College dormitory	115
25 1	Professional technical school No 32 dormitories	164
26 1	Professional technical school No 48 building	146
26 2	Professional technical school No 58 dormitories	17
27 1	Light Industry College building	31
27 2	Light Industry College dormitory	119
28 1	Professional technical school No 26 building	77
28 2	Professional technical school No 26 dormitories	70
29 1	Krushelnitska musical school	145
30 1	Technical College dormitory	126
	Total	**17,228**

Appendix J

THE LARGEST 52 WATER CONSUMERS FROM ALL CATEGORIES

This appendix presents the 52 largest water consumers from all categories in Lviv The letters in the Category column stand for the following

P - population (Table F-1)
I - industry (Table G-1)
M - medical institutions (budget institutions, Table I-1)
E - educational institutions (budget institutions, Table I-2)
C - communal enterprises (Table H-1)

Consumer numbers coincide with the numbers in the respective tables

Table J-1
Water Consumption by Major Customers in Lviv

Category	No	Name and Address of Customer	Average Consumption, m^3/d
P	121	DHF (Shevchenka St , 318)	11,686
P	84	DHF (Shevchenka St , 370)	4,715
C	1	Lviv Vodokanal (WWTP), Sylicatna St , 11	3,567
P	82	DHF (Shevchenka St , 362 b)	2,108
P	169	DHF (Hlynianskyi Trakt St)	2,016
M	1	First aid hospital	1,762
I	1 2	Lviv Railway	1,612
I	2	Stock Company 'ISKRA /electric supplies	1,598
P	81	DHF (Shevchenka St 320)	1,473
P	103	DHF (Nyzynna St , 58)	1,416
P	94	DHF (Shyroka St 86-a)	1,240
I	1 5	Lviv Railway	1,181
P	106	DHF (Shevchenka St 430)	1,167
P	90	DHF (Velychka St , 25-a)	1,129
P	76	DHF (Vyhovskoho St 3-11)	1,094
P	51	DHF (Naukova St , 55 57)	1,081
I	3	Milk Plant	1,080
E	1 2	University Lviv Politekhnika dormitory	1,001
P	146	DHF (Mykolaichuka St 90 92)	990
M	2	Medical institute oblast hospital	967
E	1 6	University Lviv Politekhnika dormitory	828
M	3	Psychiatric hospital	809
P	96	DHF (Povitriana St , 92-94)	795
P	52	DHF (Pulua St 3)	782
P	116	DHF (Roksoliany St 21-31)	778
P	102	DHF (Vyhody St 27)	777

Category	No	Name and Address of Customer	Average Consumption, m^3/d
P	11	DHF (Khotkevycha St , 14-a)	763
P	7	DHF (Kavaleridze St , 17)	759
I	6	Lviv Fat-Products Plant	747
I	7	Leather Treatment Plant SVITANOK"	743
P	18	DHF (Chervonoi Kalyny St 53-a)	730
P	93	DHF (Shyroka St , 68)	725
P	49	DHF (Naukova St , 58)	703
P	73	DHF (Karadzhycha St 12 a)	700
I	4 3	PA LvivKhimSilgospMash /agricultural chemical machines	700
E	1 7	University " Lviv Politekhnika' dormitory	693
E	2 12	I Franko University dormitory	665
I	10	Lviv Bus Plant	665
P	101	DHF (Staivo St 17 a)	652
E	2 6	I Franko University building	633
P	57	DHF (Stryiska St , 101)	626
I	12	Stock Company "KOLOS' /brewery	587
P	72	DHF (Bashtanna St , 7-a)	580
P	30	DHF (Volodymyra Velykoho St 32)	558
P	10	DHF (Zubrivska St , 36)	552
I	5 2	PA 'KINESKOP / TV tubes	552
I	15	Gorilka Plant /vodka	551
P	17	DHF (Chervonoi Kalyny St 107)	544
I	8 2	Meat Plant	521
P	155	DHF (Shafaryka St , 16-a)	519
P	159	DHF (Kytaiska St , 12 a)	517
P	39	DHF (Volodymyra Velykoho St , 35)	510
P	126	DHF (Hvylovoho St 54-b)	507

Appendix K

NORMS OF WATER CONSUMPTION IN RESIDENTIAL AND PUBLIC BUILDINGS

This appendix contains norms of water consumption in residential and public buildings in Lviv Information was taken from Attachment No 3 to the Regulations on Using Systems of Water Supply and Wastewater in Cities and Villages of Ukraine, approved by the Ukrainian State Housing and Communal Committee on June 6, 1994 No 65

Table K -1
Water Consumption Norms According to the Construction Norms and Regulations 2 04 01-85 "Plumbing and Sewerage in Buildings"

No	Consumers	Unit	Water Consumption Norm, l/d
1	Residential buildings with running water and sewerage without bathtub	1 person	95
2	The same, with town gas supply	1 person	120
3	The same, with running water and sewerage bathtubs and water heaters on solid fuel	1 person	150
4	The same with gas water heaters for bathtubs	1 person	190
5	The same, with fast gas heaters for multipoint supply	1 person	210
6	Residential buildings with central hot water supply with hand washer sinks kitchen sinks shower-rooms	1 person	195
7	The same with sit in bathtubs and showers	1 person	230
8	The same with bathtubs from 1500 mm to 1700 mm long with showers	1 person	300
9	The same for buildings with more than 12 floors and higher requirements for services	1 person	400
10	Hostels without shower-rooms	1 person	60
11	Hostels with communal shower-rooms	1 person	100
12	The same, with communal shower-rooms, canteen and laundry	1 person	140
13	Hotels resorts and motels with communal bathrooms and shower rooms	1 person	120
14	Hotels with shower-rooms per room	1 person	230
15	Hotels with bathtubs-rooms in some rooms a) up to 25% of all rooms b) up to 75% of all rooms c) in all rooms	 1 person 1 person 1 person	 200 250 300
16	Hospitals, general-type sanatoriums and resorts (with communal bathrooms and shower-rooms)	1 bed	250
17	The same with 'mud-bath treatment	1 bed	500
18	Sanatoriums and resorts with bathtubs in all rooms	1 bed	350
19	Polyclinics and dispensaries	1 bed	15
20	Laundries /mechanized	1 kg of dry laundry	75

No	Consumers	Unit	Water Consumption Norm, l/d
21	Laundries /non mechanized	1 kg of dry laundry	40
22	Administrative buildings	1 employee	15
23	Educational institutions and general education schools with showers at sportshalls	1 pupil, 1 teacher/shift	20
24	Boarding schools	1 place	200
25	Kindergartens for day-time stay	1 child	75
26	Kindergartens for 24-hour stay	1 child	100
27	Pioneer camps	1 place/24 h	200
28	Public nutrition institutions a) preparation of meals handed to the enterprises, produce and dish washing b) the same, handed to homes	 1 meal 1 meal	 12 10
29	Food stores	1 employee	400
30	Hair-dressers	1 employee	120
31	Cinemas	1 seat	4
32	Clubs	1 seat	10
33	Theaters a) for spectators b) for actors	 1 seat 1 person	 10 40
34	Stadiums and sportshalls a) spectators b) sportsmen including taking shower	 1 seat 1 sportsman	 3 50
35	Swimming Pools a) fresh water adding b) for spectators c) sportsmen including shower taking	 % of a pool volume 1 seat 1 sportsman	 10 3 100
36	Public Bath a) soap washing in basins with shower rinsing b) soap washing in basins with massage c) shower cabin d) bathtub cabin e) cleaning of the bath area f) masseur's sink	 1 visitor 1 visitor 1 visitor 1 visitor m^2 1 tap	 180 290 440 540 6 15
37	Service staff in administrative buildings	1 person	25
38	Showers at enterprises, clubs, theaters	1 shower head	-
39	Motor vehicle washing a) non mechanical car wash in a garage trucks, buses trolleys cars hose-washing regardless of the parking place trucks busses cars motorcycles	 1 vehicle 1 vehicle 1 vehicle 1 vehicle 1 vehicle 1 vehicle	 1 500 1 000 500 500 300 50
40	Flushing and testing of plumbing systems	100 m^3 of a building	10 000
41	Residential buildings with sewerage	1 resident	150

No	Consumers	Unit	Water Consumption Norm, l/d
42	Public taps a) inside a court yard b) on a street	 1 resident 1 resident	 150 50
43	Fountains with water rotation	1% of the volume	100
43	Fountains without water rotation	According to the diameter of a supply pipe at the flow speed of 2 m per second	
44	Drinking fountains	1 fountain	72 m/h
45	Preparing Skating Rinks a) first filling b) consecutive fillings	 m^2 m^2	 50 10
46	Tonic water vending machines excluding wash stand for glasses a) with water cooling systems b) without water cooling systems	 1 machine 1 machine	 100 l/h 25 l/h
47	Wash-stands for glasses for tonic water beer, vending machines, etc)	1 wash-stand	50 l/h

Appendix L

INTERVIEW WITH LVK FLOW METER REPAIR CREW

Information for this appendix was obtained during interviews with

Mr Roman Pavlyshyn, LVK Metrology Department Chief
Mr Yuri Trusevych, LVK Repair Crew Chief
Mr Valentyn Parkhomenko, LVK Sales Department Chief

The interviews were conducted by Maria Tryliovska (CH2M HILL EPT/Lviv Engineer) on May 17, 1996

L 1 BACKGROUND

There are currently 26,166 kontos (taps to water main for primary user) in Lviv Ten percent of the total number of consumers are equipped with meters The population consumer group has 13,606 meters installed (69 percent of the total number of this consumer group, 50 percent of which were installed in the prewar period), 13,100 meters are not functioning There is no information about the number of meters installed at the other consumer groups Table L-1 presents data regarding functioning meters installed at various consumers groups

Table L-1
LVK Meters Reported

Consumer Group Name	Number of Consumers (kontos)	Meters Installed	Meters Operating	Percent Operating
Population	19 632	13 609	509	3
Budget organizations	987		260	33
Communal sector	2,058		675	26
Industrial sector	3 489		1 179	34
Total	**26,166**		**2,619**	**10**

L.2 REASONS FOR METER FAILURES

The major reasons for meter failure were reported to be

- meter propeller damaged - 60%
- propeller mechanism blocked with debris or sand - 25%
- bearing failure - 10%
- meter register failure - 5%

L 3 FACTORS THAT AFFECT METER SERVICE LIFE

The major factors that appear to affect service life include

- period of scheduled supply
- location relative to pipes
- presence of protective screen in front of the meters
- manufacturer

Meters in a location with a 24-hour water supply last longer than in a location with a six hour water supply Meters installed near pipe suctions tend to fail at a higher rate Meters with protective screens tend to last longer

Prewar meters (Austrian or Polish) have good quality cases and if a meter goes out of order its broken parts can be replaced by new parts (e g propeller, meter register) It is believed that these meters fail mainly because of worn parts since water flow has doubled since the time of their installation This is due to the fact that now every apartment has a kitchen with a gas heater and kitchen sink, and a bathroom with a bath tub and a toilet, at the time of the original meter installation an average flat only had one toilet (with two lavatory pans) for the whole floor, and the majority of apartments had only a kitchen sink

In the old apartment buildings one family lived in a large apartment (4 or 5 rooms) and the apartment had a complete set of plumbing equipment After 1945, these apartments were usually divided into two or three smaller apartments and each family had a complete set of plumbing equipment installed Thus where before 1940 about 10-20 people lived in a building, now the buildings usually have 20-30 residents

In Lviv there are a few prewar compound water meters that can automatically switch from a 25-mm diameter mode to a 80-mm diameter mode (with increased flow from a 20-mm diameter to a 50-mm diameter mode)

The postwar meters produced by the Dniepropetrovsk military plant are considered by the LVK to be of good quality, but the LVK has not kept in touch with the plant and does not know if the plant is still producing them Another plant that manufactured meters was the Kirovabad plant (Central Asia) Their meters are considered by the LVK to be less desirable because their cases cannot be repaired A plant at Lutsk has started producing meters but they are not considered to be good quality meters by LVK

According to the standards that are used for manufacturing meters in Ukraine, a meter's service life without repairs should be two years, but in the districts with a scheduled water supply they tend to fail sooner

L 4 REPAIRS OF WATER METERS

The LVK repair workshop is in charge of repair and calibration of all the meters in western Ukraine The workshop repair and calibration equipment was made before the war and has already been in use for 50-60 years The test rack is one of few that have remained in the

world (now only to be found in Austria, Lviv and Cuba)

The average length of time for repairs is

- 3 4 man hours - for 40 mm diameter meters
- 3 4 man hours - for 50-80 mm diameter meters
- 9 man hours - for 100 mm diameter meters
- 7 1 man hours - for 150-200 mm diameter meters

A meter repair cost is about 2 million kbv (about US $ 10) Calibration cost is 20 percent of the repair cost At the time of the interview they had 50 meters in their shop to be repaired The city administration has required ZhEKs to remove the meters that have not been working for 20-25 years and to deliver them for repairs to the LVK Many of the meters that were made after the war have become useless and cannot be repaired any more On the other hand, it is generally possible to repair the prewar meters if their non-working parts are replaced

At the present time, the repair workshop is using an existing old stock of spare parts but they are not being replenished There is a serious concern that when they run out of spare parts, they will have a problem with the repairs The biggest need is for replacement meter propellers

L.5 METER INSTALLATION AND REPLACEMENT PROCEDURE

Primary users must deliver the meters for repairs and calibration They remove and reinstall them on their own A design organization is responsible for making a plan for meter installation Before the installation of a new meter, a design organization makes a plan of the meter and agrees it with the LVK and the Water Inspectorate

After the installation, the primary user applies to the LVK with a request to register the meter Then an inspector comes on site, seals any bypass valves, seals the meter connection to the pipe and approves the meter registration The meter must have the seal of a state official, who is charge of calibrating

Appendix M

PIPE BREAKDOWN AND REPAIRS

This appendix presents graphical presentations of information regarding breakdown and repair of water distribution pipes in Lviv

141

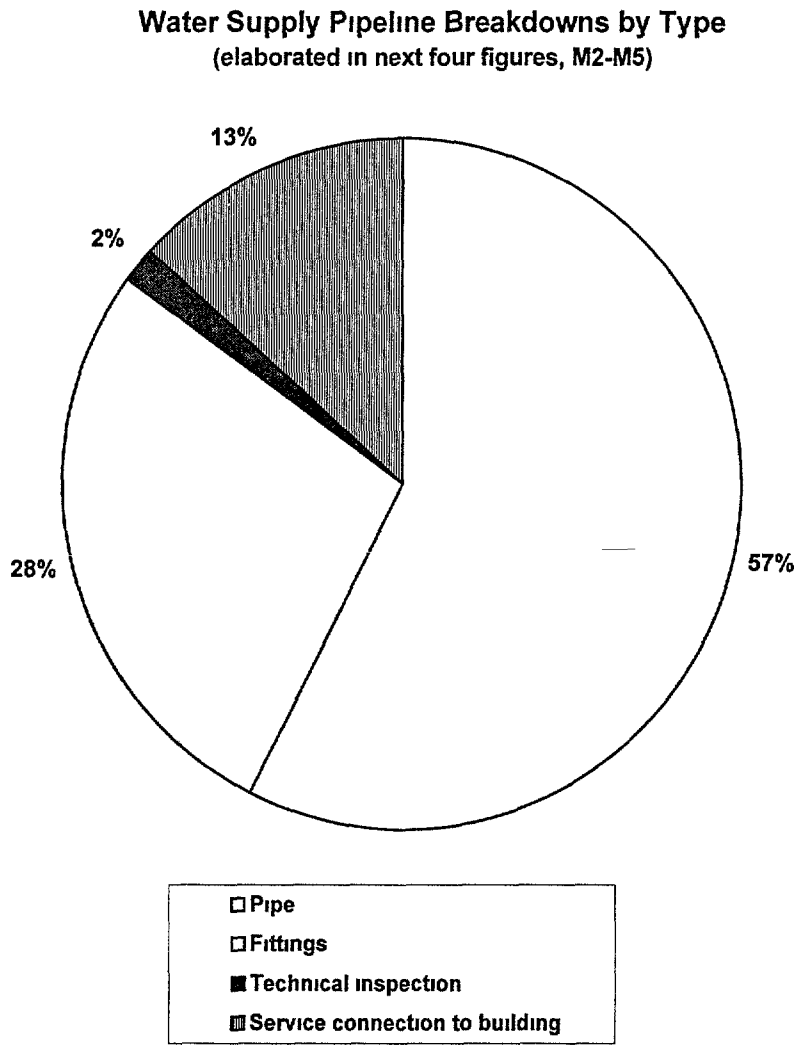


Figure M-1
Breakdown Rate in the Water Distribution System

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

USAID

ept lviv\390\ms\proh\excel\pipeline\avaria1 xls/15Aug97

142

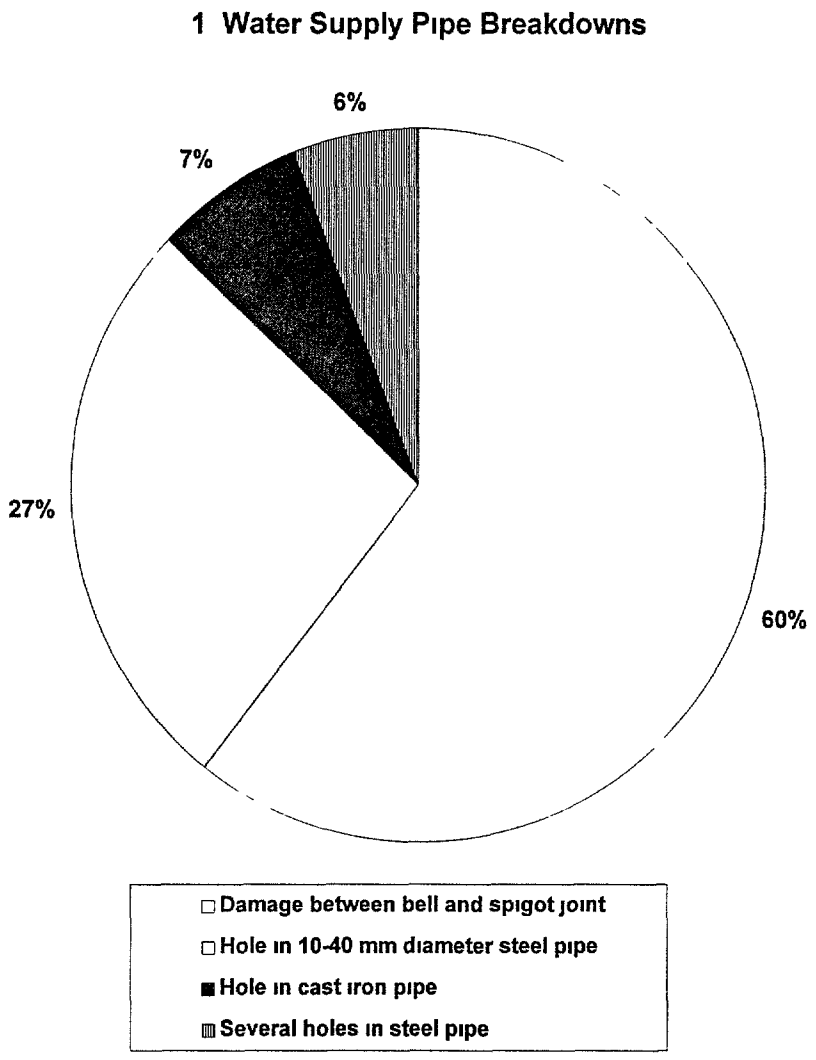


Figure M-2
Water Supply Pipe Breakdown

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lvnv\390\ms\proh\excel\pipeline\avaria1 xls/15Aug97

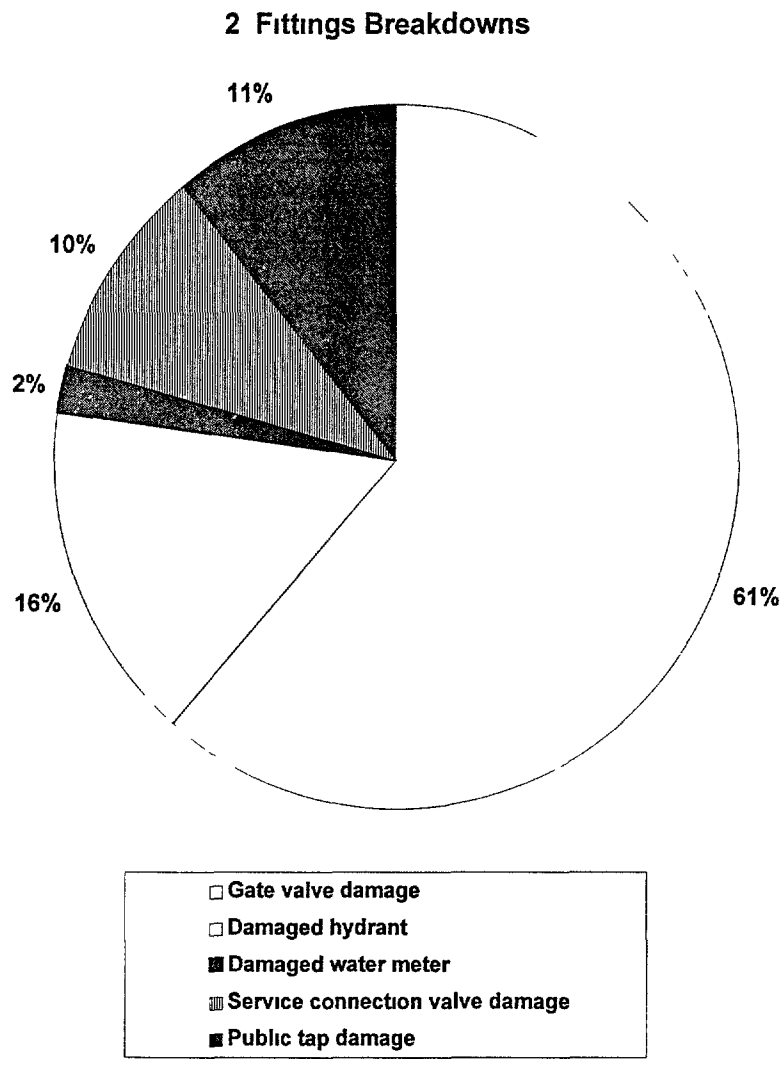


Figure M-3
Fittings Breakdowns

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Se vices Inc

ept lviv\390\ms\proh\excel\pipeline\avaria1 xls/15Aug97

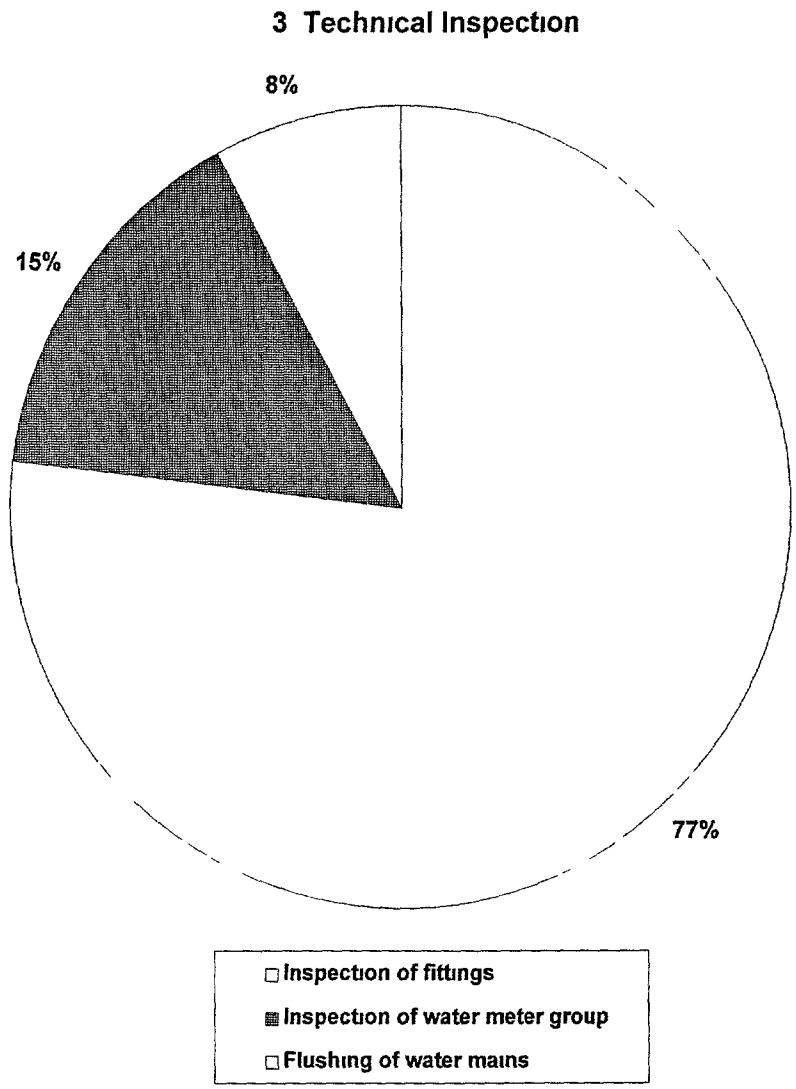
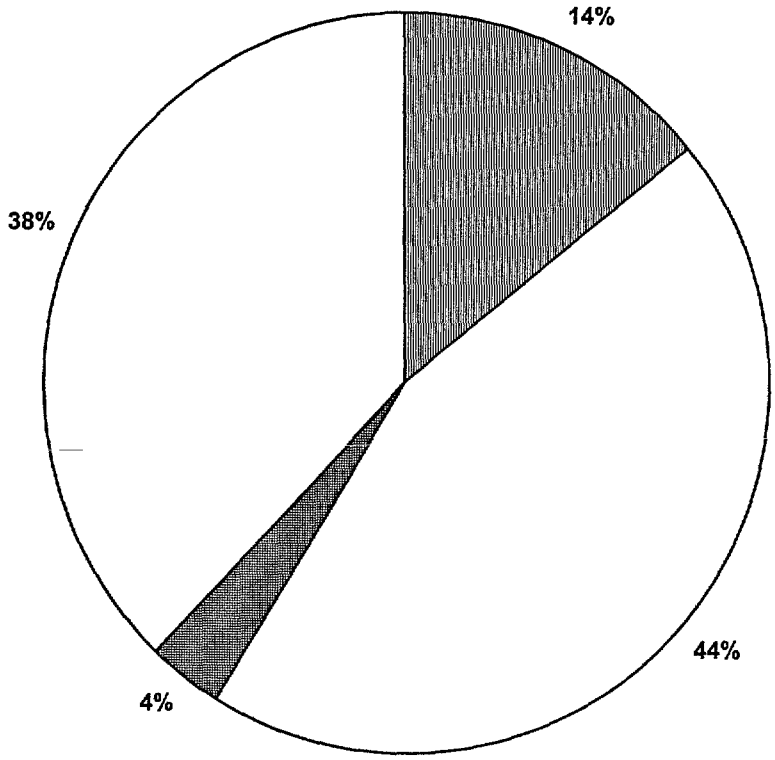


Figure M-4
Technical Inspection

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\390\ms\proh\excel\pipeline\avaria1 xls/15Aug97

4 Service Connection Breakdowns



- Damage between bell and spigot joint
- Hole in 10-40 mm diameter steel pipe
- Hole in cast iron pipe
- Several holes in steel pipe

Figure M 5
Service Connection Breakdowns

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

ept lviv\390\ms\proh\excel\pipeline\avaria1 xls/15Aug97

Appendix N

ENERGY CONSUMPTION

This Appendix contains data on energy consumption at various LVK well fields and pump stations during 1995 and 1996

Table N-1
LVK Well Field Power Consumption in 1995

Well Field Name	Jan-95		Feb-95		Mar-95		Apr-95		May-95		Jun-95	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Malchytsi	161,568	497,271	145,044	466,364	165 840	448,224	154,224	465 465	152 388	450 360	60 568	466,023
Maheriv*	296,500	993,705	280,000	994,015	272,500	897,344	292,000	961,651	275,500	930,660	270,000	932,635
Krekhiv*	270,000	590,519	260,000	590,798	232 000	533,008	360,000	590 302	308 000	570,990	278,000	590,395
Mokrotyn								434 868		450,420		496,682
Zarudtsi*	1 129 867	1 192,187	1,105,411	1 164,422	919,545	1 064,672	992 913	560,294	997,805	630,960	1 242,365	652,116
Stryi	896 400	3 746 191	878 400	4 126,966	860,400	3 553,904	986 400	4 145,594	900,000	4 021 295	1,008 000	4 292 179
Vilshanytsia	157 000	279 837	179 000	248 806	190 000	231 448	143 000	250 750	161 000	252 660	145 000	255 161
Total	2,911,335	7 299,710	2,847,855	7,591 371	2,640 285	6,728 600	2,928 537	7,408,924	2,794,693	7,307,345	3 003,933	7 685,191

* Note Maheriv = Maheriv + Rava Ruska
Krekhiv = Shostaky + Krekhiv + Kunin
Zarudtsi = Mokrotyn + Zarudtsi + PS Zarudtsi

Well Field Name	Jul-95		Aug-95		Sep-95		Oct-95		Nov-95		Dec-95	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Malchytsi	128,520	480,180	167,076	527,034	157,896	527,682	165,240	480,990	165,240	496,372	186,568	481,650
Maheriv*	274,500	963,690	310,000	992,096	261,000	992,992	250,500	961,350	255,000	992,434	318,720	962,090
Krekhiv*	242,000	570,530	356,000	589,095	262,000	590,612	292 000	570,480	286,000	589,248	457,000	570,750
Mokrotyn		480 030		496,064		497,364		480,330		496,124		480,720
Zarudtsi*	1,198,344	660,090	1,232 582	688,066	1,120 085	682,496	1,198,344	660,630	1,222,800	651,217	1,329,867	631,900
Stryi	828,000	3,717,530	888 000	4,048,520	925,200	3,945,847	900 000	3 750,701	792,000	3,154 179	817,200	3,624,051
Vilshanytsia	25,100	240 024	201,000	248,372	134,000	279 713	229 000	271,350	159,000	269,700	357,000	300,900
Total	2,696,464	7,112,074	3,154,658	7,589,247	2,860,181	7,516,706	3,035,084	7 175,831	2,880,040	6 649,274	3,466,355	7,052 061

Table N-2
LVK Outer Pump Station Power Consumption in 1995

Pump Station Name	Jan-95		Feb-95		Mar-95		Apr-95		May-95		Jun-95	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Volia Dobrostanska**	342,720	218,085	342 720	217,713	345,168	196,784	368,424	217 000	287 640	211 350	290 088	217 712
Velykopole**	192 168	217 682	193,800	217 341	177,286	196 448	199,512	217,000	193,188	210,210	197 880	217 372
Kamianobrody**	302 144	496,744	307,958	496 868	270 749	420,644	308,326	465,223	238,864	450 690	252 205	465 496
Budzen II**	1 289,966	1,440,505	1,303 776	1,325,844	1 059,898	1,317,140	1,273,342	1,426 000	1 282,601	1 351,680	985,325	1 394,628
Malechkovychi**	99,297	124 000	101,102	155,031	83,048	140,000	105 917	155 000	96 890	150,000	115 546	155,000
Mykolaiv	1 900 800	3,549 314	2,222 400	3,904,519	1 766,400	3 398,191	1,819 200	3,565 716	1 896 000	3 706 027	2 136 400	3 902,071
Hlynna-Navaria**	506,736	446,586	474 912	436 043	359,856	401,992	457,776	465 904	440 640	440 142	457 776	443 602
Stare Selo**	475,488	793,364	438,912	754 402	447 040	711,040	479,552	786,227	426 720	695 235	491 744	763 241
Pluhiv**	445,720	1,604 991	460 000	1 651,798	440,000	1,394 155	520,000	1 643,292	580 000	1 526,511	582 000	1 553,906
Subtotal	5,555 039	8,891,271	5 845,580	9 159,559	4 949,445	8,176,394	5,532,049	8,941 362	5,442,543	8,741 845	5,508,964	9,113,028

** Note Volia Dobrostanska = well field + pump station

Pump Station Name	Jul-95		Aug-95		Sep-95		Oct-95		Nov-95		Dec-95	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Volia Dobrostanska**	264 384	210 210	313 344	217,035	314,568	217,217	304 776	211 080	268 056	217 186	328 032	210 120
Velykopole**	190,536	210,030	194,203	217,014	194,820	217,093	180,132	210,066	178,500	217,093	245 333	210 090
Kamianobrody**	245,902	480,060	242,413	465 045	199,328	465,992	231,581	450 420	272 462	465,155	369 464	450,900
Budzen II**	1,248 343	1,220,770	1,296,021	1,389,482	1,282,636	1,224 633	1,260 382	1,224,560	1,235,189	1,224,488	1,442,058	1,156,034
Malechkovychi**	96,890	150,000	100,501	155,000	101,102	155 000	94,483	150,000	96,288	155,000	135 686	150,240
Mykolaiv	1,944,000	3 498,232	2,184,000	3,687,177	2,170,560	3,584,525	2,102,400	3,415,939	2,049,600	3,587,768	1,896,000	3,180,605
Hlynna-Navaria**	450 432	441,427	476,234	458,863	467,568	441,583	430,848	417,426	435,744	427,929	446,576	369,071
Stare Selo**	459,232	673,728	447,040	707,520	455,168	784 572	564,896	688,124	528,320	704,140	632,414	752,576
Pluhiv**	536,890	1,474,171	587,540	1,523,590	567,280	1,535,546	587,540	1,499,212	587,540	1,522 328	717,280	1,497,961
Subtotal	5,436,609	8 358,628	5,841 296	8,820,726	5,753,030	8 626,161	5,757,038	8,266,827	5,651,699	8,521,087	6,212 843	7,977,597

Table N-3
LVK Inner Pump Station Power Consumption in 1995

Pump Station Name	Jan-95		Feb-95		Mar-95		Apr-95		May-95		Jun-95	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Sokilnyky	1,094 400	3,367 029	1,404,000	4,690,225	1,224 000	3 248,244	1,188,000	3,749,371	1,149,200	3 499 218	1,216 800	3,546 644
Budzen III	262,311	989,832	268 382	886,608	246 523	871 296	224 664	1 049,239	180,946	954,513	59,506	1,023 735
Karachyniv	513 576	1,203 722	518 467	1 168,400	562 408	1,068,941	542 924	1 145,853	572,271	1 123,865	596,726	1,154 410
Zboisk	87 928	993,705	89 850	961,930	88,889	897 932	98,018	961 961	82,162	936,450	105,706	992,992
Sykhiv III	290,066	977 605	273 526	930 361	251,166	986,178	300,787	986 486	296 192	897 293	328 354	946 318
Vynnyky	616,684	1,906,907	704 490	1 988,805	673,860	1,739,346	763,708	1,900 000	735 120	1,889,378	612 600	1 880,312
Kryvchytsi***	904,682	1,449 565	898 589	1,458,357	606,593	1,304,165	830 513	1,320 000	837 525	1,383 000	824 356	1 351,600
Yanivska***	37,838	434,217	39 928	434,062	36,064	392,030	45,646	434 713	49,249	428,900	61,862	434,062
Telecentr***	900	17 296	1,080	17,155	995	17 155	1 020	17,860	870	16,920	1,890	17,860
Broneva***	7 200	33 480	9,000	33,480	7 349	28 080	12 600	33,480	10,800	32,400	6,000	33,480
Miska Smuha***	40 200	164 420	39,524	164 290	34,318	142 403	36,600	172 060	27,600	182,280	26 400	195,710
Total	3 855 785	11 537,778	4 246,836	12 733 673	3,732 165	10 695,770	4,044,480	11,771 023	3,941 935	11 344 217	3 840,200	11 577,123

*** Note Yanivska booster pump station

Pump Station Name	Jul-95		Aug-95		Sep-95		Oct-95		Nov-95		Dec-95	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Sokilnyky	1 151,900	3,377,849	1,188 000	3,297,508	1,152,000	3 387,207	1,101 600	3,280 222	1,152 000	3 137,150	1 123,200	3,315,692
Budzen III	131,155	859,966	205,234	944 588	183,374	916,941	205,234	867 985	205,234	833 975	263,734	995,295
Karachyniv	518,467	1,169,625	518,467	1,201 434	474,447	1 209,245	518,467	1,220,006	523,359	1,130,604	712,488	1,220,190
Zboisk	92 252	961,920	90,811	992 961	69,670	993,395	138,859	932,450	65,826	961,186	120,811	961,050
Sykhiv III	302,318	979,240	306,299	920,975	300,787	1,085,700	292,211	969,635	291,597	905,656	299,329	985,732
Vynnyky	722,868	1,812 115	767,792	1,962,300	784,128	2,089,271	778,202	1,838,717	824,968	1,907,770	1,103,614	1,799 185
Kryvchytsi***	850 937	1,376,000	561,642	1,462 100	976,999	1,437,600	950 223	1 575,257	925,978	1 557,988	973,370	1,355 450
Yanivska***	22,222	420 420	41,441	434,000	40,240	434,682	30,039	420,420	38 438	434,062	40,841	420,028
Telecentr***	1,110	15,980	1,470	16,920	1,230	15,980	1 020	15,800	1,040	15,040	1,230	16,928
Broneva***	4 200	32,400	3,600	33,480	6,900	33,480	9 600	32,400	11,400	33,480	10,800	30,600
Miska Smuha***	22,800	171,700	21,000	153,300	25,200	170,580	30 000	190 620	41,400	172,760	47,400	165,630
Total	3,820 229	7,799,366	3 705,756	11,419 566	4,014 975	11,774 081	4,055 455	8 063,290	4 081,240	11 089,671	4 696,817	7 950,088

Table N-4 Water Distribution Supply System Pump Station Power Consumption, 1995				
Pump Station Name	**Total-1995**			
	kWh	**m^3/yr**	**m^3/d**	**kWh/m^3**
North				
Maheriv*	3 356,220	11,574,662	31,711	0 29
Krekhiv*	3 603 000	6,946 727	19,032	0 52
Mokrotyn	-	4,312,602	11,815	-
Zarudtsi*	13 689,928	9,239,050	25,312	1 48
Zboisk	1,130 782	11,547 932	31,638	0 10
Subtotal	21,779,930		31 638	1 89
West				
Volia Dobrostanska**	3,769,920	2,561,492	7,018	1 47
Velykopole**	2,337,358	2,557,439	7,007	0 91
Kamianobrody**	3,241,396	5 573,237	15,269	0 58
Malchytsi	1,810,172	5,787,615	15,856	0 31
Karachyniv	6 572,067	14,016,295	38 401	0 47
Yanivska***	483,808	5,121,596	14,032	0 09
Subtotal	18,214,721		38,401	1 30
Budzen II**	14,959,537	15,695,764	43,002	0 95
Budzen III	2 436,297	11,193,973	30,668	0 22
Subtotal	17 395,834		30,668	1 55
South				
Stryi	10,680,000	46,126,957	126,375	0 23
Mykolaiv	24,087,760	42,980,084	117,754	0 56
Sokilnyky	14 145,100	41,896,359	114,785	0 34
Broneva***	99,449	390,240	1,069	0 25
Subtotal	49,012,309		114,785	1 17
Malechkovychi**	1,226,750	1,794,271	4,916	0 68
Subtotal	1,226 750		4,916	0 68
Hlynna-Navaria**	5 405,098	5,190 568	14 221	1 04
Stare Selo**	5 846,526	8 814 169	24 148	0 66
Sykhiv III	3,532,632	11 571,179	31,702	0 31
Subtotal	14,784,256		31,702	1 28
East				
Pluhiv**	6 611 790	18 427 461	50,486	0 36
Vilshanytsia	2 080 100	3 128 721	8 572	0 66
Vynnyky	9 088 034	22 714 106	62 230	0 40
Kryvchytsi***	1 014 407	17,031 082	46,660	0 06
Telecentr***	13,855	200 894	550	0 07
Subtotal	18 808,186		62,230	0 83
Center				
Miska Smuha***	392,442	2,045,753	5,605	0 19
Subtotal	392,442		5,605	0 19
Total	141,614 428		314,340	1 23

Table N-5
LVK Well Field Power Consumption in 1996

Well Field Name	Jan-96		Feb-96		Mar-96		Apr-96		May-96		Jun-96	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m3/mo
Malchytsi	159 732	497,116	205 240	527,434	155,668	493,087	161,568	527,372	128,520	510,690	152,388	496,961
Maheriv*	310 200	993,736	330,000	961,372	225,000	757,309	538,992	1,054 434	538 992	870,330	538 992	868,341
Krekhiv*	260,000	590,302	424,000	589,155	208,000	437 200	330 000	527,682	292,000	511 080	314 000	528 302
Mokrotyn		496,651		434 093		203 290		263 562		240 030		248 248
Zarudtsi*	997,805	688 744	1 308,629	651 124	628 789	464 021	1,178 779	682 434	1,159 214	600 420	1,188 562	620 992
Stryi	842,904	3 793,439	985,831	4,054,156	784 267	3,451 228	934 524	3 892,905	828,244	4,425,780	927,200	4 158,499
Vilshanytsia	170,000	311,581	185 000	310 093	193,000	290,000	217,000	310,465	204,000	297,124	147 000	170,562
Total	2,740,641	7 371,569	3,438 700	7,527,427	2 194 724	6 096 135	3 360 863	7 258,854	3 150,970	7 455,454	3 268,142	7 091 905

* Note Maheriv = Maheriv + Rava Ruska
Krekhiv = Shostaky + Krekhiv + Kunin
Zarudtsi = Mokrotyn + Zarudtsi + PS Zarudtsi

Well Field Name	Jul-96		Aug-96		Sep-96		Oct-96		Nov-96		Dec-96	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Malchytsi	139,500	480,330	132,192	434,645	141 370	496,093	15,422	480 420	152,388	465,713	148,716	450 420
Maheriv*	445,000	841,140	272,000	899,279	433 000	992,651	370 000	960,360	643,500	1,098,082	561,000	990,660
Krekhiv*	282,000	541,380	272 000	591,304	228,000	527,124	280,000	510,330	302 000	497,364	258 000	480,270
Mokrotyn	k	240,060		204 600		248,000		240,000		217,186		210,480
Zarudtsi*	1,056,000	600,420	885,310	672 359	919 546	558,186	1,085,684	570,000	1,061,390	559,798	851,069	510,360
Stryi	1,011,600	3,733 432	703 300	3 510,306	813,600	3,931,412	824,580	3,908,243	857,563	4,192,711	883,217	3,994,310
Vilshanytsia	60,000	156,900	64 000	98,461							128,000	330,000
Total	2,994 100	6,593,662	2,328,802	6,410,954	2,535,516	6,753,466	2,575 686	6,669 353	3,016,841	7,030 854	2,830 002	6,966,500

Table N-6
LVK Outer Pump Station Power Consumption in 1996

Pump Station Name	Jan-96		Feb-96		Mar-96		Apr-96		May-96		Jun-96	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Volia Dobrostanska**	297 616	217,147	213,048	217,124	251 766	203,174	342,720	217,093	372,096	210,390	379 072	217,713
Velykopole**	167,504	217,126	230,064	217 031	159,944	203,058	165,648	217,062	178,092	210,270	171,564	217 372
Kamianobrody**	280,846	466,023	309 647	465 713	273 955	493 348	301 777	527 279	196 880	510,090	250,002	496,682
Budzen II**	1,286,345	1,154 616	1,749 915	1,344,606	1,358 077	1,191,798	1,561,205	1,317,258	1,443,932	1,025,842	1,528,221	1,408,307
Malechkovychi**	100,782	155,000	112,899	131,084	78,836	129,893	102,908	165,695	96,890	191,620	88 465	186 310
Mykolaiv	2,265,600	3,464,328	2,068,800	3,719,409	1 675,200	3,140,335	2,145,600	3,585,096	2,040,000	3,886,036	1 780,000	3 425,931
Hlynna-Navaria**	391,680	383,990	575,120	422,727	381,520	383,566	421 056	436 264	435 744	426,512	509,184	504,712
Stare Selo**	520,464	704,140	528,320	663 024	447 040	678 550	471,424	744 515	410 464	696,062	487 580	727 637
Pluhiv**	537,616	1,574 862	642,242	1 550 062	547,020	1 392,392	575,384	1,488,682	560,000	1,450,920	579 436	1,691 960
Subtotal	5,848 453	8 337,232	6 430,055	8 730,780	5 173,358	7 816,114	6,087,722	8 698,944	5,734,098	8,607,742	5 773 524	8 876,624

** Note Volia Dobrostanska = well field + pump station

Pump Station Name	Jul-96		Aug-96		Sep-96		Oct-96		Nov-96		Dec-96	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Volia Dobrostanska**	285,200	210,960	275,400	165,800	290,088	217,341	189,048	210 090	302,328	435,984	307 224	420 330
Velykopole**	171,400	210,660	66,300	80,645	123,216	168,231	165,240	240,210	177,072	359,600	169,320	348,180
Kamianobrody**	213,960	480,090	235,740	453,176	55,998	93,050	18,238	0	208,264	300,000	257,346	345 060
Budzen II**	1,458,600	1,490,820	1,103,110	1,237,417	916,200	1,119,099	846 569	1,047,102	1,319,328	1,388,507	1,286,345	1 348,457
Malechkovychi**	99 900	213,840	98,100	210,180	92,075	217,186	93,028	180 090	93,279	186,000	95,686	165,000
Mykolaiv	2,198,400	3,702 967	2 409,600	4,083,876	1,953,600	3,615,288	2,487,178	4,019,249	1,704,000	4,010,835	2,332,800	3,812,751
Hlynna-Navaria**	448,000	432,606	443,100	421,621	249,696	420,467	430,848	436,480	406,368	458 386	433,296	451,199
Stare Selo**	500,000	732,390	508,000	769 230	463,296	6,222,074	475,488	533,850	414,528	535,765	447,040	537,325
Pluhiv**	567,300	1,629,468	587,540	1,697,104	587,540	1 737,486	587,540	1,693,511	628,060	1,752,177	587,540	1,573,707
Subtotal	5 942,760	9,103,801	5 726,890	9 119,049	4,731,709	13 810,22 2	5,293,177	8 360,582	5,253,227	9,427,254	5 916,597	9,002 009

Table N-7
LVK Inner Pump Station Power Consumption in 1996

Pump Station Name	Jan-96		Feb-96		Mar-96		Apr-96		May-96		Jun-96	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Sokilnyky	1,166,400	3,335,426	1 166,400	3,247,197	1 036,000	3 287 179	1,152 000	3,540,614	1,159,200	1 180 570	2 310 000	3 780 454
Budzen III	196 298	899,000	222 304	900,947	177,302	814 234	219 806	979,741	200,376	849,470	143 299	955 930
Karachyniv	535,317	1,468 554	696 944	1 357,331	530,426	1,225,070	591,835	1 322,285	552,706	1,225 112	601 617	1,342,718
Zboisk	70,150	930 000	91 261	923,800	141 261	1,536,099	76,516	1 798,310	106 306	1,590,253	98 258	1,612,620
Sykhiv III	173,737	578 534	304,030	900,093	281 256	1,009,200	276,589	1,054 713	292 210	738,930	311 814	744 713
Vynnyky	710,616	1,869 108	891,045	1 806 293	686 112	1,649,102	830,020	1,840 963	810 674	1,759 326	769 834	1,708,912
Kryvchytsi***	834,370	1,413 035	696,555	1 439 372	715 838	1,216,860	763,856	1,326,005	752 571	1,197 567	716 172	1 207 970
Yanivska***	40,341	434 000	34 234	403,062	20 631	219 240	36,637	392,212	38 651	420 000	45 045	434 062
Telecentr***	1,170	17,860	1 110	15,980	840	14,100	1 320	16 920	1,290	16,920	1,020	15 040
Broneva***	8,000	26,000	10 500	37 200	10,400	34,800	9,600	37 200	9 000	36 000	10 800	37,200
Miska Smuha***	36 200	164 370	36,200	156 800	28 200	132 990	37 800	153,080	24,000	155,430	24,600	176 100
Total	3,772,599	11,135 887	4,150,583	11 188,075	3,628,266	11,138 874	3,995 979	12,462,043	3,946,984	9,169,578	5,032 459	12 015,719

*** Note Yanivska - booster pump station

Pump Station Name	Jul-96		Aug-96		Sep-96		Oct-96		Nov-96		Dec-96	
	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo	kWh	m^3/mo
Sokilnyky	1,137,000	3,409,527	1,173,000	3,460,278	1,216,800	3,574,011	1,144,800	3,561,034	1,166,400	3,828,960	1 302 400	3 631 191
Budzen III	193,900	1,053,592	111,730	814,501	188,088	726 864	53,434	659,368	132,370	942,662	159,086	893,647
Karachyniv	547,800	1,184,363	410,860	851,224	303,254	877 615	313,037	750,685	733,680	1,051 687	513,576	946 730
Zboisk	87 800	1,587,407	92,610	1,584,026	71,592	1,393,295	83,363	1 658,290	92,973	1,667,546	88 409	1,481,447
Sykhiv III	280,300	620,620	283,630	890,129	258,876	820,709	259 159	832,161	292,516	844,254	288,841	912,580
Vynnyky	772,000	1,785,820	722 870	1,631,277	745,330	1,560,690	722 868	1,548,403	739,204	1,532,793	790,254	1 701,481
Kryvchytsi***	751 100	1,318,317	680,594	1 200,177	682,074	1,174,571	630,990	1,103,340	664,603	1,097 219	683 641	1,250 442
Yanivska***	45 000	420,000	39,640	390,000	36 000	434,093	34 835	434,042	29,235	418,500	36,036	420,060
Telecentr***	1,470	17,578	1,050	14,383	1,290	18,001	1 260	15,040	1,050	16,100	1,290	16,356
Broneva***	10,200	36,000	9,600	38,400	9,600	37,200	9 600	36,000	9,300	37,200	9,600	36,000
Miska Smuha***	25,200	185,490	24,600	181,170	26,400	173,340	33,000	191,970	36,000	166,190	39,600	152,740
Total	3,851 770	8,209 187	3,550,184	11 055,565	3,539,304	7 216 378	3,286 346	7,229,299	3,897,331	11,603,111	3,912,733	7,811,483

Table N-8 Water Distribution Supply System Pump Station Power Consumption, 1996				
Pump Station Name	**Total-1996**			
	kWh	**m^3/yr**	**m^3/d**	**kWh/m^3**
North				
Maheriv*	5,206,676	11,287,694	30,925	0 46
Krekhiv*	3,450,000	6 331 493	17,347	0 54
Mokrotyn	-	3,246,200	8,894	-
Zarudtsi*	12,320,777	7 178,858	19,668	1 72
Zboisk	1,100,499	17,763,093	48,666	0 06
Subtotal	22,077,952		48,666	1 24
West				
Volia Dobrostanska**	3,505,606	2,943,146	8,063	1 19
Velykopole**	1,945,364	2,689,445	7,368	0 72
Kamianobrody**	2,602,653	4 630 511	12,686	0 56
Malchytsi	1,692,704	5,860,281	16,056	0 29
Karachyniv	6,331 052	13 603,374	37,270	0 47
Yanivska***	436,285	4 819,271	13 203	0 09
Subtotal	16,513,664		37,270	1 21
Budzen II**	15,857,847	15 073 829	41,298	1 05
Budzen III	1,997,993	10 489,956	28,740	0 19
Subtotal	17,855,840		28,740	1 70
South				
Stryi	10,396,830	47 046,421	128,894	0 22
Mykolaiv	25,060,778	44,466,101	121,825	0 56
Sokilnyky	15,130,400	39 836,441	109 141	0 38
Broneva***	116,200	429 200	1,176	0 27
Subtotal	50,704,208		109,141	1 27
Malechkovychi**	1 152,848	2,131 898	5,841	0 54
Subtotal	1 152,848		5,841	0 54
Hlynna-Navaria**	5 125,612	5,178,530	14,188	0 99
Stare Selo**	5,673 644	13 544,562	37,108	0 42
Sykhiv III	3,302,958	9 946,636	27,251	0 33
Subtotal	14 102 214		27,251	1 42
East				
Pluhiv**	6 987 218	19 232 331	52 691	0 36
Vilshanytsia	1 368 000	2 275 186	6 233	0 60
Vynnyky	9 190 827	20 394 168	55 874	0 45
Kryvchytsi***	8 572 364	14 944,875	40,945	0 57
Telecentr***	14,160	194 278	532	0 07
Subtotal	26,132,569		55 874	1 28
Center				
Miska Smuha***	371,800	1,989,670	5,451	0 19
Subtotal	371,800		5,451	0 19
Total	148 911,095		312,782	1 30