Environmental Policy and Technology Project

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UKRAINE

Proposal to Demonstrate an Improvement to Water Supply Operations in the City of Lviv

Delivery Order #09, Task U2
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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
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NOTE ON TRANSLITERATION

Ukrainian personal, institutional, and place names used in this report have been transliterated into English from the Ukrainian (not Russian) language, 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*, 5 volumes (University of Toronto Press, 1984-1993) and O Subtelny's authoritative *Ukraine A History* (University of Toronto Press, 1993, 2nd Edition)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS, ACRONYMS & GLOSSARY

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)
DO	Delivery Order
EPT	Environmental Policy & Technology (Project) A USAID-funded program to provide environmental assistance to New Independent States of the former Soviet Union
km	Kilometer(s)
LVK	Lviv Vodokanal
m	Meter(s)
mm	Millimeter(s)
m^3	Cubic meters
m^3/d	Cubic meters per day
oblast	A government territorial-administrative unit in the former Soviet Union that is still in use following Ukraine's independence A U S analogue would be something between a state and a county
PADCO	Planning & Development Collaborative, Inc (a U S -based consulting firm under contract to USAID to implement part of the U S government's assistance program to Ukraine's housing and communal services sector)
USAID	U S Agency for International Development
vodokanal	A quasi-government agency responsible for municipal water supply and wastewater collection and treatment A U S analogue would be a water utility
WB	World Bank (International Bank for Reconstruction & Development)
zhek	A municipal entity responsible for operation and maintenance of houses and multi-apartment buildings owned by city administrations, as well water, sewerage, gas, electricity, and heating systems within them Zhek is a Russian/Ukrainian abbreviation, used in the former Soviet Union, of a city's department of housing and communal services that continues to be used

SUMMARY

Background

As part of a 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 a series of tasks to assist the water utility (vodokanal) in the west Ukrainian city of Lviv to strengthen its operations and improve service to its customers One of these tasks is for CH2M HILL to propose a project(s) that would demonstrate means of improving Lviv Vodokanal (LVK) operations

A project is proposed herein that would demonstrate a means of improving the LVK water distribution system The proposal was developed as a result of work conducted by CH2M HILL since October 1995, in conjunction with the LVK CH2M HILL is prepared to implement the demonstration project if approved and funded by USAID

Objective

At present, some 70 percent of the 800,000 residents of the City of Lviv receives water only 6 hours per day, and three portions of the city (with about 85,000 residents) receive water for considerable less periods These locations -- Pasichna, Varshavska, and Zolota -- are viewed as having a "severely deficient" water service (Figure 3)

The objective of the proposed project is to segregate a portion of the city's water distribution system, the Pasichna area (Figure 5), in order to demonstrate how creation of a water distribution subsystem would improve water delivery in a part of the city that currently suffers from severe water deficiency

Demonstration Project Overview

The city obtains its drinking water from about 170 wells in some 20 well fields (Figure 1) outside the city boundary Water reaching Lviv's perimeter from the well fields is then pumped by 10 large pumping plants (Figure 2) into the city water distribution network

Construction of the "Dovha" pump station to improve water service to the Pasichna area was started several years ago, but has not been completed because of financial difficulties faced by the City administration and residents The Dovha pump station was to include a pump house with several pumps, motors, controls, and electrical power connection, three water storage tanks, and water pipelines So far, one storage tank and the water pipelines have been installed, and the pump house and other two tanks partially completed (Figure 6)

A two-phase project would result in a significant improvement to water service in the Pasichna area by making use of the substantial preparatory work already undertaken at the Dovha pump station location (Figures 6 and 7) Service would be improved in the short term (Phase 1) by

installing valves in existing water pipes to form the Pasichna water distribution subsystem, completing the two remaining storage tanks, and installing a modular (temporary) pumping station In the longer term, the modular pumping station would be replaced with more durable and permanent facility (Phase 2)

Auxiliary projects to further enhance work at the Dovha site would include

- improving water supply by rehabilitating wells at the water source
- replacing poor quality water distribution pipe with that of improved quality, thereby reducing breakage and leakage and saving energy
- improving the billing and collection process, in order to fund the improved water service

Responsibilities

A provisional division of responsibilities regarding the project has been proposed, and is presented in Appendix B as a draft *Cooperation Agreement* To oversee implementation of the project, it is suggested that a joint Ukrainian-U S Committee be established In general, USAID would fund the project design and major items of equipment, and the City of Lviv would be responsible for funding of and undertaking all major on-site construction

Benefits

The proposed Pasichna water delivery subsystem project is locally sustainable and replicable, and is enthusiastically supported by the City of Lviv administrative and vodokanal authorities It will directly improve water service to about 35,000 Lviv residents in the Pasichna area that currently experience severe water deficiencies, and demonstrate that sometimes it is possible to significantly improve water service by undertaking relatively minor improvements in water delivery infrastructure and system optimization

The project is expected to bolster LVK management and staff by having them develop and implement, in a short period, a small yet meaningful project that will provide a significant improvement in water deliveries to a segment of their customers, and so stimulate the utility to move ahead on its own with other improvements as funds permit Further, it is expected that LVK will initiate a readily manageable improvement to its billing and collection procedures for Pasichna area customers, which can then be extended to other areas, thereby improving the overall financial condition of the utility This is turn will demonstrate to international financial institutions, such as the World Bank, that LVK is able to implement measures that would improve its financial viability, in order to qualify for operational and capital improvement loans from such institutions which may ultimately enable LVK to be privatized

The project will accentuate the presence of USAID's assistance activities in Ukraine by providing a rapid, politically popular, and highly visible project It can also leverage other

USAID-sponsored energy and housing assistance programs in Lviv, such as demonstrating the application of energy-efficient pumping equipment, and possibly stimulating the conversion of apartments into condominium associations as the value of apartments could increase because they would have a more reliable water service

Section 1

INTRODUCTION

1.1 BACKGROUND

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 under Delivery Order (DO) No 9 Under Task U2 (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 U2 includes a requirement (Subtask 3 3, Subsection 3 3 1)[1] for CH2M HILL to propose several possible projects that would demonstrate means of improving Lviv Vodokanal (LVK) operations

> *Development of Alternatives the contractor shall develop alternative plans for a demonstration program which would lead to the improvement in the economic* [sic] *and/or operation of the Lviv water system relative to energy or water use The contractor shall recommend two or more programs as alternatives to be selected for demonstration*

This report is in response to the USAID requirement The demonstration project proposed herein relates to improving operation of the LVK water distribution system Other proposals to demonstrate improvements to the LVK system, especially to the water source and transmission portion, are outlined in a separate document titled *Proposals for Demonstration Projects That Would Improve Water Metering and Measurement in the City of Lviv*, dated May 1996

The proposal was developed as a result of work conducted by CH2M HILL since October 1995 in developing an understanding of the LVK system, through presentation and discussion of the interim results of this effort in workshops[2] held at the Lviv Vodokanal office on 27-28 March 1996, and regular discussions between representatives of LVK and CH2M HILL concerning improvements to Lviv's water supply CH2M HILL is prepared to implement the demonstration project if approved and funded by USAID

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[1] Appendix A presents an excerpt of a portion of the DO #9 Task U2 scope of work regarding demonstration project proposals

[2] See the report *Ukraine Summary Report on Lviv Vodokanal Workshops 3 &4* submitted by CH2M HILL's EPT Project under separate cover to USAID

4

1.2 OBJECTIVE AND BENEFITS OF DEMONSTRATION PROJECT

Water is conveyed from remote well fields (Figure 1) to Lviv's perimeter, from where it is pumped into the city water distribution system (Figure 2) that is essentially operated as a single unit At present, some 70 percent of the city receives water only 6 hours per day, and three portions (Figure 3) of the city (with about 85,000 residents) receive water for considerable less periods These locations -- Pasichna, Varshavska, and Zolota -- are viewed as having a "severely deficient" water service

The objective of the proposed project is to segregate a portion of the city's water distribution system, the Pasichna area (population about 35,000), in order to demonstrate how creation and operation of a water distribution subsystem would improve water delivery in a part of the city that currently suffers from severe water deficiency Development of the subsystem would be conducted through the completion of partially constructed tanks and installation of new energy-efficient pumps and a series of valves

The proposed Pasichna water delivery subsystem project is locally sustainable and replicable, is enthusiastically supported by the City of Lviv administration and the LVK which is a component of the City's Engineering Department, and is anticipated to have the following benefits

- directly improve water service about 35,000 Lviv residents in the Pasichna area that currently experience severe water deficiencies
- demonstrate to LVK, the City of Lviv administration, and other vodokanals, that instead of undertaking massive capital investments in new water sources, relatively minor improvements in water delivery infrastructure and system optimization, such as creation of distribution subsystems, can significantly improve water service
- use less energy to pump water to Pasichna area customers than is presently required
- lower the cost of delivering water to Pasichna area customers than at present
- bolster LVK management and staff by having them develop and implement, in a short period, a small yet meaningful project that will provide a significant improvement in water deliveries to a segment of their customers that have the least service, and so stimulate the utility to move ahead on its own with other improvements as funds permit
- encourage LVK to initiate a readily manageable improvement to its billing and collection procedures for Pasichna area customers, which can then be extended to other areas, thereby improving the overall financial condition of the utility
- demonstrate to international financial institutions, such as the World Bank, that LVK is able to implement measures that would improve its financial viability, in order to qualify for operational and capital improvement loans from such institutions

- leverage other USAID-sponsored assistance programs in Lviv
  - **energy sector assistance** demonstrate the application of energy-efficient pumps
  - **housing sector assistance** improvement of water service in the Pasichna area may increase the value of apartments, which could in turn stimulate their conversion into condominiums
- accentuate the presence of USAID's assistance activities in Ukraine by providing a rapid, politically popular, and highly visible project

Section 2

EXISTING LVIV WATER SYSTEM

The water system for the city of Lviv includes remote water sources, conveyance from the sources to the city, and distribution within the city This system is described below, using information obtained by CH2M HILL from files of the Lviv Vodokanal and the Lviv Institute for the Design of Communal Services, as well as limited field observations

2.1 OVERVIEW OF LVIV WATER SYSTEM

Lviv, over 700 years old, currently has a population of about 800,000 people Its present public water supply and distribution system was started about 100 years ago Many parts of the Lviv Vodokanal service area receives water for only about 6 hours a day, and some receive water for even shorter periods The water system infrastructure needs substantial replacement, in 1995, nearly 6,000 breaks occurred in the water conveyance and distribution network Revenues to the LVK do not meet expenses associated with system operation and maintenance

Under the previous Soviet administration, the central government was responsible for planning, funding, and implementing water supply and wastewater treatment and disposal systems Since independence in late 1991, the government of Ukraine has transferred this responsibility to local governments (in this case, to the City of Lviv), together with ownership of water supply and wastewater treatment and disposal assets As with most local governments, the Lviv City administration is struggling with its new technical, financial, and legal responsibilities regarding water and wastewater (together with other public utilities such as district heating, garbage collection and disposal, transport, and street lighting), its new links with national-level agencies, and the new relationships that must be formed between City officials and water agencies The City administration is responsible for funding capital projects that could improve water supply LVK, as a component of the City's Communal Administration within the Department of Engineering, is responsible for delivering water to Lviv residents, using infrastructure owned by the City The vodokanal collects revenues from water tariffs to maintain and operate the existing water supply and delivery infrastructure

The city's drinking water source is groundwater pumped from a series of well fields outside the city perimeter (Figure 1) Water from these well fields is conveyed to the city in transmission pipelines (mains) These mains generally terminate at large pumping facilities at the city boundary (Figure 2), where additional pressure is added in order to distribute water within the city Electricity used to pump water makes up about 70-80 percent of the total LVK operating expenditure, and this cost is rising as national government policies and regulations force an increase in energy prices

2.2 WATER SOURCE AND TRANSMISSION

The city obtains its drinking water from about 170 wells in some 20 well fields located outside the city boundary The earliest public well field serving the city was developed about 1900 In order to obtain sufficient suitable water, the more-recent well fields have been established as far away as 100 kilometers (km) from the city center Depth to groundwater is generally about 70 meters (m) for most wells, but older wells obtain water from gravel layers at about 25 m deep, whereas some of the newer wells draw water from depths of over 300 m The use of groundwater has kept the supply system reasonably simple, and the only treatment that water receives is disinfection by chlorination

Approximately 600 km of steel, cast-iron, and reinforced-concrete transmission lines convey water from wells to 10 large pump stations and associated reservoirs that encircle the city Much of this piping is of inferior quality, with many leaks and frequent breaks At the pump stations, water is chlorinated before being distributed to customers within the city

Expansion of the water infrastructure in Lviv occurred to match growth of the city In general, this was done by establishing and/or expanding well fields adjacent to the side of the city where new development was to occur This avoided the need to transfer water across the center of the city, a task which became more difficult as the city grew The overall system of supply now resembles a wheel, with the city being the hub and the spokes being the supply lines bringing-in water (see Figures 1 and 2) The result is that the water infrastructure can supply and deliver water into the old (central) city, which is generally at a lower elevation, but it is very difficult, due to the capacity of pipes in the center and the higher elevations at some parts of the distribution area, to move significant quantities of water from one side of the city to the other

2.3 WATER DISTRIBUTION

The city, located on a series of low hills, has an elevation difference of about 120 m The water system within the city includes some 800 km of steel and cast-iron distribution mains, and 250 km of residential connection piping LVK authorities claim that the water distribution system reaches 99 percent of the Lviv population through service connections and about 60 public stand-pipes Much of the pipe is of poor quality and subject to frequent breaks A moratorium has been imposed on new water service connections, although many people are reported to have illegally hooked-up to the system

Water reaching Lviv's perimeter from the well fields is pumped by the 10 large pumping stations (Figure 2) into the city water distribution network, which includes pipes, and several additional (booster) pumps, and storage tanks Water engineers planned to establish a series of "isolated" subsystems within this distribution system By using a series of additional booster pumps, valves, and large tanks within the city, water from the large pump stations at the city perimeter would be delivered to customers by operating these subsystems in a manner that would optimize water supply against demand For example, at night, during periods of low

Section 3

DESCRIPTION OF "PASICHNA" WATER DISTRIBUTION IMPROVEMENT DEMONSTRATION PROJECT

This section presents an outline of a project that, if implemented, would demonstrate a means of improving the delivery of water to residents in the "Pasichna" area of the City of Lviv who currently experience severely deficient water supplies Improvements in water deliveries to two other areas of the city that also experience severely deficient supply, Varshavska and Zolota, are outlined in Appendix D The demonstration projects were identified and developed using readily available construction drawings, water record maps, recorded flow and charts, and other data, with limited field verification by CH2M HILL staff Engineering information was most readily available for the Pasichna location, and this is the most advanced in terms of conceptual planning Considerably more data collection and engineering design will be needed in order to design and cost proposals located in the other two areas of water deficiency

3.1 DEMONSTRATION CONCEPT

Average water supplied to the city from the well fields is about 300,000 cubic meters per day (m^3/d) Assuming half of this amount is used for non-residential purposes, Lviv's population of about 800,000 people receives about 190 liters of water per day, which is comparable to other parts of the world where a large portion of the population live in high-rise apartment complexes

In spite of this generally high volume of water, actual delivery to many areas is low The city's water distribution system is essentially operated as a single entity As a result, water tends to gravitate to lower elevations, so that customers on elevated terrain and upper portions of high-rise apartments suffer from poor water pressure and daily water shortages Three areas of the city can be categorized as having "severely deficient" water service, received water 0-3 hours per day

To partly overcome this situation, the distribution system should be segregated into subsystems that are operated on a quasi-independent basis This can be accomplished by redistributing the available water through installing a series of tanks, booster pumps, gauges, and valves Water delivered to higher areas can be stored in tanks, with valves preventing outflow to lower portions Although city water engineers wanted to create the distribution subsystems, these were never established due to lack of funding

A demonstration of this concept is proposed for one portion of the city that suffers severe water deficiency If these are successful, the City administration may wish to fund the creation of additional water distribution subsystems to further improve water deliveries

3.2 OVERVIEW OF AREAS HAVING SEVERELY DEFICIENT WATER SERVICE

The three parts of the city of Lviv which have severely deficient water service (see Figure 3) have been called

- Pasichna, with a population of about 35,000 people (Figure 5)
- Varshavska, population about 40,000 (Figure 8)
- Zolota, population about 10,000 (Figure 9)

The part of the city where the demonstration would be most-effective is Pasichna, because it may also indirectly improve water service to an adjacent area (called Sykhiv, with a population of 75,000), which together would have the greatest number of beneficiaries Further, the demonstration would take advantage of utilitizing partially completed infrastructure (Figure 6)

The distribution of land use in each area is as follows

Subsystem	Residential (%)	Industrial (%)	Institutional (%)	Open Space (%)
Pasichna	60	3	5	32
Varshavska	77	5	0	18
Zolota	52	16	13	19

The general location of the major water mains and pumping stations in the Pasichna, Varshavska, and Zolota subsystems areas are shown in Figures 5, 8 and 9 There are approximately 33 km of 50-mm to 500-mm diameter water distribution pipes in these areas, with Pasichna having about 10 km, Varshavska about 16 km, and Zolota about 7 km

LVK operates and maintains 10 large pumping stations (Figure 2) within the city distribution system Two stations are associated with the Pasichna water distribution subsystem (Sykhiv III and Kryvchytsi), one for the Varshavska and one for the Zolota subsystems (respectively Zboisk and Yanivska pump stations) An additional pump station, adjacent to the Dovha tank (Figures 5 and 6) has not been completed

3.3 PASICHNA SUBSYSTEM MODIFICATIONS

3.3.1 Project Concept

Municipal water supply to the Pasichna area is only available flow from the Sykhiv III pump station Since Pasichna is at a relatively high elevation in the outlying portion of the Sykhiv III pump station service area, and the water distribution pipes are also connected to lower parts of the city, water tends to flow to the lower portions so that little of it is available for the

multi-story apartment buildings within the Pasichna location Improvement to water service in the Pasichna area can be conducted in two phases

- **Phase 1** Develop a Pasichna water distribution subsystem by installing several large valves inside water pipes in order to reduce the amount of water lost to lower elevations, increase the amount of water available for distribution by upgrading water storage capacity, establish a modular (temporary) pump station to slightly increase water pressure within the subsystem, and use booster pumps to lift water to higher sections of apartment buildings

- **Phase 2** Further improve the level of water service by creating a permanent facility and adjusting the pressure of water to optimize delivery to consumers

3.3.2 General Subsystem Characteristics

3 3 2 1 Location

The Pasichna subsystem is situated in the Lychakivsky administrative district in eastern Lviv The core water distribution alignment serving the residential area includes piping along Medova Pechera, Kytaiska, Lysenytska, Maiorivka, Shafaryka, and Washington streets Ground-level elevations vary from 320-380 m, and are generally higher than the rest of Lviv As a result, water pressure in the subsystem is low, creating difficulty in delivering water to local residents, most of whom live in typical high-rise (9-14 story) apartment buildings (Figure 5)

3 3 2 2 Water Supply, Pumping, and Storage

Two well fields, Bibrka and Hlynna Navaria, provide water to the Sykhiv III pumping station (Figures 2 and 5), which then further distributes water to an area that includes Pasichna (population about 35,000) and the adjacent Sykhiv (population about 75,000 people) In addition, the Pluhiv well field provides water to the Vynnyky pumping station, which then lifts water to the Dovha tank #1, from where it gravitates to the adjacent Sykhiv area Some 20 small booster pumps operated by LVK and housed in 10 district heating plants (Figure 7) located in the Pasichna area, are supposed to provide additional pressure to raise water to the high-rise apartments These booster pumps are frequently not turned on, in part because the heating plants use the limited available electricity to pump hot water, or because they are unserviceable

The City planned to fund improvements to water storage and pumping capability in the area that includes Pasichna by constructing three large tanks (10,000 m^3 each), and a pumping station at Dovha (Figure 5) This was part of a scheme to transfer additional water from an expanded Pluhiv well field into the city's distribution system The Dovha pump station and tank complex was to increase pressure of water in order to provide better service to customers

on the upper floors of high-rise apartment buildings, especially those without booster pumps Construction of this complex commenced in 1989, but the Pluhiv well field was not expanded and construction at the Dovha site ceased in 1992 At present, LVK operates one completed 10,000 m^3 storage tank at Dovha, unfinished are the pump station and two other tanks (Figure 6)

3 3 2 3 Water Distribution Pipelines

The water distribution network in the Pasichna subsystem includes about 7,000 m of water mains with 100-mm to 200-mm diameter pipes, and approximately 2,800 m of pipe from 300-mm to 500-mm in diameter General characteristics of these pipes are presented in Table 1

In 1995, some 286 pipeline breaks were reported in the Pasichna area (Table 2) About 60% of these breaks were characterized by LVK as damage to the joints (bell-and-spigot type joints) that link pipe-segments, and the remainder due to holes that developed in the pipe

3 3.3 Overview of Subsystem Modifications

To enhance water deliveries to customers in the Pasichna residential community, the following improvements can be made at the Dovha site (Figure 6) and surrounding areas (Figure 7)

- segregate a portion of the overall Lviv distribution system by installing gate valves to establish the Pasichna water distribution subsystem (Figure 7)
- establish a pump station
  - to bring some rapid improvement of water service, a modular pumping plant can be constructed inside a portable building and connected to previously installed water mains
  - in the longer term, finish the partially completed pump station building, install energy-efficient pumps with associated meters and controls, and either incorporate parts of the modular pumping plant into the new pump station or use it to meet other LVK needs (such as developing another water distribution subsystem [see Appendix D], or emergency pumping capacity)
- complete construction of the two water storage tanks
- bring high-voltage electrical power to the site
- install connecting pipes and valves between the pumps, tanks, and water distribution mains

These improvements can be undertaken in two phases, as outlined below

3.3.4 Phase 1. Immediate Modifications

The Phase 1 improvements would install valves to create a distribution subsystem to reduce the volume of water moving out of the Pasichna area, increase water storage capacity in the area, and then pressurize the extra water, using a temporary pumping plant, so that it can be more readily used by area customers While not ideal, this will result in an improvement to the minimal service that customers now experience It will demonstrate to LVK the concept of distribution subsystems to improve water service by being able to control pressure in specific portions and reduce the loss of water when it flows uncontrolled from higher into lower elevations Water in this subsystem must be distributed at a relatively low pressure as pipes are subject to frequent breaks (see Tables 1 & 2) Small "booster pumps" associated with individual buildings can then be used to increase water pressure within the buildings This control of pressure should reduce overall water leakage and save energy

To quickly improve water delivery to the Pasichna area, a prefabricated (modular) pump house would be either in Ukraine or the U S , shipped to the Dovha site, and then assembled at the site The modular pump station would have installed, for example, two or three energy-efficient pumps (each of about 350 to 400 m^3 per hour capacity), pump motors, control center, and power transformer

Associated with the modular pump station would be completion of one (or, if possible, both) of the Dovha tanks, an electrical power connection via a new high-voltage transmission line, and on-site water pipes and valves connecting the new pumps with existing storage tanks and water mains

An evaluation would be made to assess whether any of the small booster pumps, housed in district heating plants (see Figure 7), would have to be upgraded If so, they would also be locally procured (if available) and installed

The overall goal would be to noticeably increase piped delivery of water to most consumers However, water may not be delivered to all potential consumers, nor would it be intended to meet supply and storage requirements for fire-fighting needs

3.3.5 Phase 2· Subsequent Modifications

During the period that the modular pumping plant is being procured, assembled, and delivered, the existing, partially constructed, pump-house would completed by the City of Lviv At the same time, additional pumps, motors, controls, transformers, etc , would be procured for subsequent installation in the completed pump-house This would further improve the level of service by increasing the capacity to pump the additional water stored in the three Dovha tanks at a pressure optimized to better serve water consumers The overall goal will be to make water available to most customers in the Pasichna area during the LVK's scheduled six hours per day of delivery It would not be the intention to meet peak flow demands during the scheduled water service, nor meet fire-fighting demands The pressure would probably still need to be kept at a reduced level in the distribution subsystem as portions

are prone to failure due to pressure (see further below for an auxiliary project that would address a large part of this problem)

The design would need to be sufficiently flexible to allow for possible changes in contributions by City administration For example, the City may not be able to complete the tanks or install the connecting pipes and electricity line during Phase 1 Alternatively, the City may not have readily available funding, and USAID may only be able to fund a portion of the proposal

3.3.6 Distribution of Responsibilities

A preliminary allocation of responsibilities for project funding and implementation is presented in the draft Cooperation Agreement in Appendix B This draft is to serve as a basis for subsequent negotiation and agreement of responsibilities

3.3.7 Cost Opinion for USAID-Funded Equipment

An opinion on the cost is presented in Appendix C

3.3.8 Anticipated Project Schedule

The anticipated project schedule is as follows

- end November 1996 -- complete Phase 1
- end August 1997 -- complete Phase 2

This schedule assumes the following

- USAID immediately authorizes CH2M HILL to proceed with the project
- USAID waives its procurement and subcontracting regulations in order to allow sole-source purchase of equipment, sole-source construction contracting, and purchase of equipment manufactured outside the U S or the NIS
- equipment is readily available
- delivery of imported equipment is not held up by Ukrainian customs or taxation agencies
- the City of Lviv agrees to responsibilities as outlined in Subsection 3 3 6 (above)
- the City of Lviv undertakes its responsibilities in a timely manner

3.4 AUXILIARY DEMONSTRATION PROJECTS

To improve overall water delivery to Pasichna area customers, several additional projects could be undertaken Altogether, these projects would provide an integrate approach to water service improvements Further, each can viewed as a small-scale, readily implementable demonstration, related to the Pasichna area, which can be expanded to other parts of the Lviv water service area as circumstances allow These additional demonstrations, outlined in more detail below, are

- improve water supply by rehabilitating wells at the water source
- improve the quality of pipe used to distribute water, thereby reducing breakage and leakage, and saving energy
- improving the billing and collection process, in order to pay for the improved water supplies

3 4.1 Project#1. Improve Water Supply

The Lviv water supply is based on groundwater Water for the Pasichna and surrounding area is obtained from the Bibrka, Hlynna Navaria and Pluhiv well fields In general, all well fields providing water to Lviv perform poorly, due to a combination of various circumstances such as

- clogged well screens
- incorrectly sized well diameter
- poor pumping equipment that frequently breaks down
- inefficient well pumps
- improper hydraulic configurations

Several cost-effective measures can be implemented aimed at increasing well field water supply and reducing the consumption of electricity per unit of water produced (and thereby reducing LVK operating costs) These measures include

- **Rehabilitate existing wells** This can be achieved by increasing well diameter, and cleaning or replacing existing well screens in order to obtain better operational characteristics
- **Redrill wells** Where rehabilitation of existing wells does not appear possible, new wells would be drilled adjacent to them and fitted with high-grade components, including screens and pumps
- **New pumps** The existing pumps would be replace with energy-efficient units that have high quality components which do not corrode as quickly as those presently installed

15

- **Improve hydraulics** Modify the piping in the well fields to improve the flow characteristics of the pumps and connecting piping

Some additional engineering data may by required to ensure the implementation of these improvements For example, hydrological investigations to evaluate water availability in the well field, water production rates before and after well rehabilitation, and energy usage

3.4.2 Project#2: Improve Pipe Material

One of the major problems facing most vodokanals in Ukraine (and possibly throughout the former Soviet Union) is that locally made cast-iron and steel pipe manufactured after 1965 for use in water supply systems was of very poor quality, and subject to rapid corrosion leading to considerable leakage and frequent breaks In the foreseeable future, water pipelines in Ukraine will increasingly fail due to poor materials, and this will adversely affect the supply and quality of water for the general population

The Pasichna area suffers from poor pipe material and weak pipe connections, for example, in 1995, some 286 breaks occurred in the water distribution network (Table 2) The Pasichna subsystem demonstration project will be enhanced if improved water pipe is evaluated, and if appropriate pipe is available, then have it procured and installed within the distribution area Such pipe could be ductile iron, which is similar in appearance to cast-iron, improved-quality thicker-wall steel (both with a protective coating to reduce corrosion), or plastic pipe The use of ductile iron, coated steel pipe, or plastic pipe, would require different tools and techniques for installation, connecting services, and repair Ductile iron pipe is apparently manufactured in Ukraine, but not widely used for water supply

Therefore, the Pasichna demonstration project can show how a Ukrainian product could be used to solve a tremendous problem in the delivery of water not only in Lviv but throughout Ukraine The following steps will be undertaken

- identify relevant specifications for ductile iron and thick-wall steel, with protective coatings, and plastic pipe

- identify and inspect factories that manufacture iron, steel, and plastic pipe, and protective coatings, to evaluate whether pipe and coatings can be produced according to relevant specifications

- conduct a preliminary cost-benefit analysis regarding additional cost of pipe (above that currently purchased by LVK) against the extended service life of the pipe

- independently test pipe and coatings to ensure that they meet accepted international standards and specifications

- if pipe and coatings are acceptable, and the preliminary cost-benefit analysis is favorable, purchase some improved quality pipe and train LVK crews in the correct installation and repair The length of pipe to be procured and installed will depend on available funds from USAID

A major portion of the water pipeline infrastructure in Ukraine will need to be replaced in the next ten years or so If locally manufactured improved quality pipe proves to be suitable (the extended service life benefit outweighing any additional pipe cost), it would provide a considerable stimulus to Ukraine's iron and steel or plastic industry, while increasing the reliability of water supply

3.4.3 Project#3: Improve Billing and Collection of Payments

In addition, the project can provide an incentive to LVK to initiate a readily manageable revision to its billing and collection procedures for customers in the Pasichna area If this proves successful, the revised procedures can be gradually extended to other LVK customers, thereby improving the overall financial condition of the water utility The following events are envisioned

- form a municipal committee, representing the Mayor's office, zheks (municipal entities responsible for operation and maintenance of multi-residential dwellings), and LVK, to formulate a policy and options for handling of non-payment of water bills
- customers in the Pasichna and Sykhiv areas are informed that water deliveries will improve
- customers in these areas are also informed that they will be expected to pay higher water tariffs, within the limits as set by the national government, for the improved service
- one option would be for LVK to contract with individual zheks in the Pasichna and Sykhiv areas to deliver water to apartment buildings, and receive payment for such deliveries from the zheks, the zheks are to be responsible for collecting payment from apartment occupants and paying LVK[1]
- if full payment from a zhek is not received, the LVK would reduce or shut-off water service to the building, and install a "stand pipe" at a nearby publicly accessible location in order to provide essential water supply to building occupants
- for those customers who cannot pay their water bill due to difficult financial circumstances, a subsidy or emergency fund scheme is to be established from which to reimburse the LVK

---

[1] At present apartment occupants are individually billed by LVK for water consumption Residential high-rise buildings do not have ready means to separately shut-off water to individual apartments Apartment dwellers do not have any incentive to pay their water bills as their water supply will not be disconnected Without the ability to disconnect LVK does not the means to enforce payment by its customers An increase in water tariffs will likely lead to further reduction in payments particularly if customers do not receive an improvement of service

17

Appendix A

SCOPE OF WORK

DELIVERY ORDER 9
TASK 3 DEVELOP PROGRAM TO INCREASE SHARE OF USER CHARGES
Subtasks 3 1 - 3 3 of Task U-2

The following text is excerpted from the USAID contract with CH2M HILL on the EPT Project for Delivery Order 9 The term "the contractor" refers to CH2M HILL International Services, Inc

Subtask 3 1 Collect Data on Metering Billing and Revenues

3 1 1 Metering Devise a methodology to present and field verify existing data in a Vodokanal on the installation and condition of meters in a Vodokanal's distribution system This would include information on the following

- *a the total number of connections from the water system to users, including information on the size and type of pipe material of the connections, whether they have valves to isolate the connection from the system, and the category of user served by the connection (industrial, commercial, public or residential)*
- *b by category of user, prepare an inventory of the number, size, type, and condition of water meters*
- *c by category of user, indicate the total amount of water billed to users in 1993 and 1994, the amounts actually recorded on functioning meters, and, for the amounts estimated, the basis for those estimates*
- *d determine and evaluate existing policies related to metering, including determination of size and type of meters required, procurement, frequency of periodic removal and replacement of meters for calibration, and installation procedures*
- *e evaluate existing capabilities, responsibilities and practices for the calibration, repair and production of meters*

Use the above methodology and information available from the Lviv Vodokanal to display the data on the Lviv system

3 1 2 Billings and Revenues Devise a methodology to present data on the billings and revenues for a Vodokanal's distribution system which would utilize existing information from the Vodokanal, with selected verification as appropriate This would include data on various aspects of water related revenues, including the following

a *the amounts of billed revenues in previous years, by category of user, and the amounts of revenue actually received in those periods*

b *the amount and source of all other income or funds received, including such sources as 1) fees for installation of water, 2) funds for capital construction projects from external governmental authorities, whether loans or grants, or 3) any other funds received from any other sources*

c *describe and evaluate the existing procedures for the preparation and distribution of bills to customers for water, including the types of equipment and systems utilized, the length of the billing period by category of customer, the time required from the end of the billing period to the issuance of bills, and the average delay from issuance of bills to receipt of revenues*

d *determine and evaluate the role of the Zheks in public housing units relative to the collection of revenues from apartment residents for water services, and to the distribution of these revenues once collected, including the timing and extent to which revenues are returned to the Vodokanal*

Using data from PADCO's study, use the methodology described above to display the data on billings and revenues from the Lviv Vodokanal for 1993 and 1994

Data from Subtask 3 1 will be used as part of the evaluation of the system and formulation of a strategy for upgrading of the system

Subtask 3 2 Study Problems of System Measurement

The contractor would use Lviv as a case study to investigate the problems of measurement of water and energy in the water system These data and experiences would be used and discussed in the manual produced in Subtask 2 4 2

3 2 1 <u>Identify Where Improved Measurement Would Improve Analysis and Operation</u> Using the schematic, data gathered earlier in the subtasks and data provided by PADCO on the distribution of costs across the system, the Contractor will identify areas where improved measurement would enhance the analysis of system operation and efficiency Where improved measurement is shown to be important to the upgrading of the system it will be included in the prioritized tasks to be performed to improve revenue recovery

3 2 2 <u>Water Entering the System</u> The Contractor would investigate the means presently being used for measuring the water supply entering the system to ascertain the general accuracy of the estimate of water produced

3 2 3 <u>Distribution of Water in the System</u> The Contractor would identify the guidelines being used to guide the decision-making process in the distribution of water in the system at times of shortage and the means used to monitor these operations

3 2 4 Major Energy Usage in System The Contractor would investigate the means presently being used for monitoring the energy use of major components of the water supply and distribution system to ascertain if this data is reliable and available and if it falls within expected levels (based on experience with utilities in the U S)

3 2 5 Identify Major Water Users in the System The Contractor would identify what appear to be major classes of current water users and investigate the means presently being used for

a) measuring and billing for the water being used

b) the prioritizing of investment and revenue recovery related to major classes of water users

Subtask 3 3 Develop and Implement a Demonstration Program

3 3 1 Development of Alternatives Based on the findings from subtask 3 1 and 3 2, the contractor shall develop alternative plans for a demonstration program which would lead to the improvement in the economic and/or operation of the Lviv water system relative to energy or water use The contractor shall recommend two or more programs as alternatives to be selected for demonstration

3 3 2 Review of Recommended Alternatives The alternatives recommended for demonstration under 3 3 1 shall be discussed with senior Vodokanal officials, appropriately adapted based on that input and reviewed with USAID/Kiev prior to taking any action on implementation of the demonstration program

3 3 3 Implementation of Demonstration Program The contractor shall develop, estimate the costs, design and implement the approved demonstration program, with the assistance of the Vodokanal, which will continue for a period of time agreed upon by the Contractor, Vodokanal and USAID The results of the demonstration program will be described in a 50-page report in English and Ukrainian

Subtask 3 4 Coordinate Efforts regarding Feasibility Study

The contractor shall coordinate all findings and recommendations under Task 3 with any party identified by USAID engaged or expected to be engaged to conduct a feasibility study for the Lviv Vodokanal Such coordination shall be dependent upon the condition that the feasibility study be conducted concurrently during the period when the contractor is implementing Subtask 3 in Lviv

Appendix B

DRAFT COOPERATION AGREEMENT

The following is a draft Cooperation Agreement for the City of Lviv and USAID to consider in implementing the Pasichna water supply improvement project The agreement includes the following components

- modular pumping plant
- permanent pump station
- well field improvements
- improved pipe quality

COOPERATION AGREEMENT

between the United States Agency for International Development and the City of Lviv Ukraine on Implementation of a Joint Project on Water Supply Improvement for Pasichna Area of the City of Lviv

BACKGROUND

Of the approximately 800,000 residents in Lviv, about 70% receive water for 6 hours a day, and about one-third even less than that One part of the city that has severely deficient water service is the district bordered by Maiorivka, Pasichna, Washington, and Shafaryka streets, hereafter termed the "Pasichna" area, where residents on upper floors of multi-story apartment buildings receive water for less than one hour a day

Construction of the "Dovha" pump station to improve water service to the Pasichna area was started several years ago, but has not been completed because of financial difficulties faced by the City of Lviv administration and residents The Dovha pump station was to include a pump house with several pumps, motors, controls, and electrical power connection, three water storage tanks, and water pipelines So far, one storage tank and the water pipelines have been installed, and the other two tanks and a pump station partially completed

The Administration of the City of Lviv, and the water and sewerage agency (Vodokanal) within the City's Department of Engineering, together with the United States Agency for International Development (USAID), believe there is a real possibility to improve water service to Pasichna area in a relatively short period by making use of the substantial preparatory work already undertaken at the Dovha pump station location Water service to the 35,000 Pasichna residents would be improved in the short-term by completing the storage tanks and installing a modular (temporary) pump station, and in the longer term by replacing the modular pump station with more durable and powerful equipment and replacing existing leaking water pipes with those of better quality

PURPOSE OF COOPERATION

Acknowledging the

- *seriousness of the water supply problem that the City of Lviv is facing,*
- *need to improve social and environmental health conditions of Lviv residents,*
- *intention to combine efforts for the purpose of resolving the water supply problems,*

the Lviv City Administration and the USAID have agreed to implement a joint project on improving water service to the Pasichna area of the City of Lviv in the shortest possible period of time

RESPONSIBILITIES OF COOPERATING PARTIES

The Lviv City Administration and USAID have agreed to cooperate on improving water service to the Pasichna area under the following conditions

- ***Joint Ukrainian-U S Committee*** *this will be established to supervise implementation of the cooperation project, and is to comprise representatives from the City of Lviv Administration, the City of Lviv Vodokanal (LVK), the USAID Regional Office in Kyiv, and USAID's Environmental Policy & Technology Project contractor, CH2M HILL International Services, Inc*

- ***City of Lviv Administration*** *takes responsibility for the following provisions*

  - *inform USAID when it has authorized funding for that portion of the project for which it is responsible*

  - *procure relevant materials and equipment, including*

    - *pipe to connect tanks to pumping plants to distribution grid*
    - *cement and other construction materials for tanks, and modular and permanent pump houses*

  - *unload, store in a weather-proof area, and guard equipment and materials provided by USAID and its contractors*

  - *install all equipment (including that provided by USAID) associated with the Phase 1 and 2 projects, including*

    - *concrete foundation for modular pump plant*
    - *pipe connections*
    - *tank interior sealant (purchased by USAID)*
    - *gate valves (purchased by USAID)*
    - *high-voltage electrical transmission cable (purchased by USAID) to connect pump site to electricity grid*
    - *electricity transformer (purchased by USAID)*

- *booster pumps (purchased by USAID) located inside district heating facilities and high-rise apartment buildings*
- *any new pipe (purchased by USAID) to improve the water distribution system*

- *complete construction of Dovha tanks #2 and #3, including sealing of the tank interiors to prevent water seepage*

- *complete construction of the Dovha pump house*

- *pay electricity usage charges for construction and operation of the project, including operation of all pumps (modular pumping plant, Phase 2 pump station, and booster pumps)*

- *follow all relevant Ukrainian regulations (including fire and building codes), and obtain all necessary permits and approvals*

- *instruct district heating plant operators to allow cold water booster pumps to be replaced, if necessary, and the operation of these pumps when needed by the Lviv Vodokanal*

- *if necessary, assist with customs clearance of all imported equipment and materials, and obtaining waivers on Ukrainian taxes*

- *allow the CH2M HILL Lviv project office to remain in its existing Lviv Vodokanal premises, rent free, until the end of USAID's overall vodokanal assistance project*

  allow the Lviv Vodokanal to undertake any responsibilities required under this agreement, including allocating the necessary funds for it to perform such responsibilities

  guard the Dovha pump station complex (including tanks and pump houses), and prevent unauthorized access to any portion of the complex, including the tanks

- *operate and maintain the Dovha pump station and Pasichna water supply distribution subsystem*

- ***U S Agency for International Development*** *takes responsibility for the following provisions*

  - *provide overall project management*
  - *undertake all engineering design, in cooperation with the City of Lviv*
  - *procure and deliver the modular pumping plant, including transportable pump house, pumps, motors, and controls, to the site*
  - *purchase gate valves*
  - *purchase high-voltage electrical transmission cable*

- *evaluate condition of booster pumps, and purchase any needed replacements*
- *purchase and deliver Phase 2 pumps, motors, and controls*
- *purchase and deliver water meters for apartment buildings, in order to help improve LVK billing and payment collection*
  purchase and deliver improved quality water pipe
- *train pump plant operators*
- *evaluate possible well field improvements, and purchase and deliver appropriate well field improvement equipment*

SCHEDULE OF COOPERATION

Both sides declare their commitment to successful accomplishment of the joint project on water service improvement for the Pasichna area in the shortest feasible term, and aim for the following schedule of project implementation

•	*12 August 1996*	*Mayor appoints task coordinator*
•	*15 August 1996*	*City allocates necessary budget, authorizes completion of the two remaining Dovha tanks, engages contractor to commence completion, and provides USAID with written notice of these actions*
•	*25 October 1996*	*City completes two Dovha tanks, and installs high-voltage electrical power transmission cable to modular pump plant site and gate valves to create distribution subsystem*
•	*29 November 1996*	*modular pump plant is installed*
•	*1 May 1997*	*City completes structural work on the permanent Dovha pump house and installs high-voltage electrical transmission cable to this facility*
•	*1 July 1997*	*City installs replacement water pipes*
•	*1 July 1997*	*well field rehabilitation completed*
•	*1 September 1997*	*permanent pump plant is operational*

Signed in Lviv, Ukraine, on August ___, 1996

U S Agency for International Development

Mr Gregory F HUGER
Missions Director

City of Lviv

Mr Vasyl Kuybida
Mayor, Chairman of the Lviv City Administration

Appendix C

OPINIONS OF COST

An opinion on the cost of the USAID-funded portion of the Pasichna project is presented in this appendix, based on assumed responsibilities as outlined in Appendix B Costs of the Auxiliary Projects regarding improvements to water supply, pipe quality, and billing and collection of payments, and the Projects outlined in Appendix D regarding the Varshavska and Zolota subsystems, are not included Costs for the Ukrainian (City of Lviv) contribution are also not included as they cannot be estimated with any reasonable degree of accuracy because

- little published (sales-tested) data are available on the price of services and equipment, particularly as so few of Ukraine's manufactured goods are sold for cash in the international market
- at this time, it is technically unsound to take previous (old) prices of Ukrainian services and equipment and index them for inflation, because so many items were cross-subsidized (such as electricity)
- the correlation between the productivity of Ukrainian and U S labor is not known at this time, so that the actual number of hours to accomplish a task cannot be gauged with any degree of accuracy based upon U S labor estimates

PHASE 1 COST OPINION[1]

Expat tech labor (in U S and Ukraine) 200 days @ $700/day	=	$140,000
CCN[2] labor 400 days @ $100/day	=	$40,000
CH2M HILL WDC 10% of LOE = 60 days @ $500/day	=	$30,000
Procurement specialist(s) 90 days @ $500/day	=	$45,000
Subtotal labor cost	=	$255,000
Other direct costs=10% of total labor cost	=	$25,500
Additional office equipment	=	$50,000
Expat lodging & per diem in Ukraine 100 days @ $160/d	=	$16,000
Airfare (3 trips)	=	$9,000
Equipment		
2-3 pumps, motors, controls, spares, valves, gauges, etc	=	$150,000
prefabricated pump house	=	$50,000
shipping (including containers)	=	$50,000
20 small booster pumps	=	$30,000

[1] All equipment costs include a 5% fee in accordance with USAID s EPT Project contract with CH2M HILL

[2] CCN means "cooperating country national , in this case, Ukrainian personnel

high-voltage electrical cable (assumed price)	=	$50,000
electricity transformer (assumed price)	=	$40,000
Subtotal (including fee)	=	$470,500
Total Phase 1 cost	=	$725,500

PHASE 2 COST OPINION

Expat tech labor (in U S and Ukraine) 250 days @ $700/day	=	$175,000
CCN labor 500 days @ $100/day	=	$50,000
CH2M HILL WDC 10% of LOE = 75 days @ $500/day	=	$37,500
Procurement specialist(s) 90 days @ $500/day	=	$45,000
Subtotal labor cost	=	$307,500
Other Direct Costs=10% of total labor cost	=	$30,800
Expat lodging & per diem in Ukraine 150 days @ $160/d	=	$24,000
Airfare (6 trips)	=	$18,000
Equipment		
4-5 pumps, motors, controls, spares, valves, gauges, etc	=	$330,000
shipping of pumps, etc (including containers)	=	$70,000
Subtotal (including fee)	=	$472,800
Total Phase 2 cost	=	$780,300
Subtotal estimated Phase 1&2 cost	=	$1,505,800
Contingency 10%	=	$150,000
TOTAL ESTIMATED PHASE 1&2 COST	=	$1,655,800

Appendix D

ADDITIONAL WATER SUPPLY IMPROVEMENTS

As indicated in Figure 3, three areas of Lviv receive minimal water deliveries

- Pasichna
- Varshavska
- Zolota

Means of providing modest improvements to water deliveries in the Varshavska and Zolota areas are outlined below

D1 VARSHAVSKA SUBSYSTEM MODIFICATIONS

D1.1 General Subsystem Characteristics

The Varshavska subsystem (Figures 3 and 8) is situated in the northern part of Lviv It includes the Pidholosko residential area and the following streets Varshavska, Torfiana, Pancha, and Sosiury The variation in ground elevation in the area is 90 m (from 250 to 340 m) and it consists of predominantly 9-12 story residential buildings The population is about 40,000 people, with just 12,000 people receiving water according to the 6-hour daily schedule, as water can only reaches the third floor of many apartment buildings

The Zboisk pump station provides water to the area of this subsystem from the northern well fields The water distribution subsystem consists of different diameter pipes about 9,500 m of 50-100 mm water mains and approximately 6,000 m of pipe 200-300 mm in diameter

D1 2 Subsystem Modifications

In initial assessment of the subsystem indicated that in order to improve water supply conditions and to provide the residents with scheduled minimum of six hour water supply, the following improvements should be undertaken

- rehabilitate the northern well fields to stabilize their performance
- install new valves in order to isolate a distribution subsystem, and pressure sensors and recorders to monitor performance of the subsystem
- rehabilitate the Zboisk pump station by replacing the old worn-out pumps
- modify the water delivery schedule to service the Varshavska subsystem independent of other areas supplied by the pump station
- improve maintenance of the existing water supply pipelines from the well fields to the city

- replace much of the existing small-diameter distribution pipes with larger-diameter pipes

Rehabilitation of the northern well fields can best be accomplished by improving the water yield of existing wells This can be achieved through various means, including increasing well diameter, cleaning existing pipes, installing energy-efficient well pumps, improving well field pipeline hydraulics, and replacing poorly functioning well screens with those having better operational characteristics These improvements would reduce unit electricity costs, resulting in operational savings

Some additional engineering study will be required before implementing these modifications For example, additional hydrogeologic investigations to evaluate water availability in the well field, water production rates before and after well rehabilitation, and energy usage

Well rehabilitation equipment may have to be provided, such as a large-diameter rotary drilling rig, additional tools, and improved pumps, in addition to training of crews to operate the drill rig, clean wells, and maintain and repair the pumps

Evaluation of pressure along the water transmission pipelines from the well fields to the city perimeter will be needed in order to assess locations of excess pressure that leads to line failures Pressure-reducing values will then need to be installed at appropriate locations

D2 ZOLOTA SUBSYSTEM MODIFICATIONS

D2.1 General Subsystem Characteristics

The Zolota subsystem (Figures 3 and 9) is situated in the Shevchenkivsky district of Lviv, and includes 12 streets situated between Shevchenka Street (even-numbered houses N° 14-116), Kleparivska Street (odd-numbered houses N° 3-17), and Zolota Street The population of this area is about 10,234 people

Ground elevation varies from 295-334 m The apartment buildings mostly have 3-4 stories in Shevchenka, Khorvatska, Yatskova, Sosenka, and Turianskoho streets, and 4-9 stories in Zolota Street

The Karachyniv pump station is to provide this area with water according to the regulated 6-hour supply In fact, some 60% of the residents are supplied with water according to this schedule, and 40% (4,000 people) receive water only 2-3 hours per day

The water distribution subsystem consists of several different diameter pipes There are about 6,500 m of water mains from 80-100 mm diameter, and about 1,500 m with 200-300 mm diameter

D2.2 Subsystem Modifications

An initial assessment of the subsystem indicated that in order to improve the water deliveries to this residential area, it will probably be necessary to

- install 500 m of a new 150-mm diameter, 2,000 m of 200-mm diameter, and 500 m of 300-mm diameter water delivery pipelines along Yeroshenko and Zolota streets in order to join them with the existing 200-mm diameter pipe

- modify the existing water supply network into a separate subsystem and connect it with the existing Yanivska pump station

- modify the water delivery schedule of this residential area in order to stabilize the Yanivska pump station performance

This initial assessment will have to be further evaluated if this subsystem is selected for improvement as part of USAID's program in Lviv If subsequent engineering evaluations indicate the need for additional pumping capacity, it may be feasible to relocate the modular pump plant from the Pasichna subsystem

Appendix E

TABLES AND FIGURES

This appendix contains the following tables and figures

Tables

Figures

Table 1
PASICHNA AREA WATER DISTRIBUTION PIPELINE CHARACTERISTICS

Street Name	Number of Breaks (1995)	Pipe Diameter (mm)	Pipe Material	Service Life (years)
Washington	20	300, 400	steel, cast-iron	10
Kashtanova		100, 200	steel	15
Kytaiska	15	100, 200, 300	steel, cast-iron	15
Lysynytska	27	100, 200	steel	15
M Pechery	80	100, 150, 200	steel, cast-iron	15
Maiorivka	11	150	steel, cast-iron	12
Pasiky Halytski	3	150, 200	steel, cast-iron	12
Pasichna	106	150, 400, 500	steel, cast-iron	15
Sadivnycha	3	100	steel	12
Sadova	4	200	steel	15
Sokolyna	2	200	steel	15
Tupikova		100	steel	15
Shafaryka	15	150, 200	steel, cast-iron	12
Yaroshynskoi		100	steel	15
Total	286			

Table 2
PASICHNA AREA WATER DISTRIBUTION PIPELINE BREAKS, 1995

Type of Damage	Type of Repair	Breaks	
		Number	%
Damage between bell-and-spigot joint	Calking of bell-and-spigot joint	173	60
Hole in 10-40 mm diameter steel pipe	Install welded saddle	76	27
Hole in cast iron pipe	Install mechanical clamp	20	7
Several holes in steel pipe	Replace pipe	17	6
Total		286	100

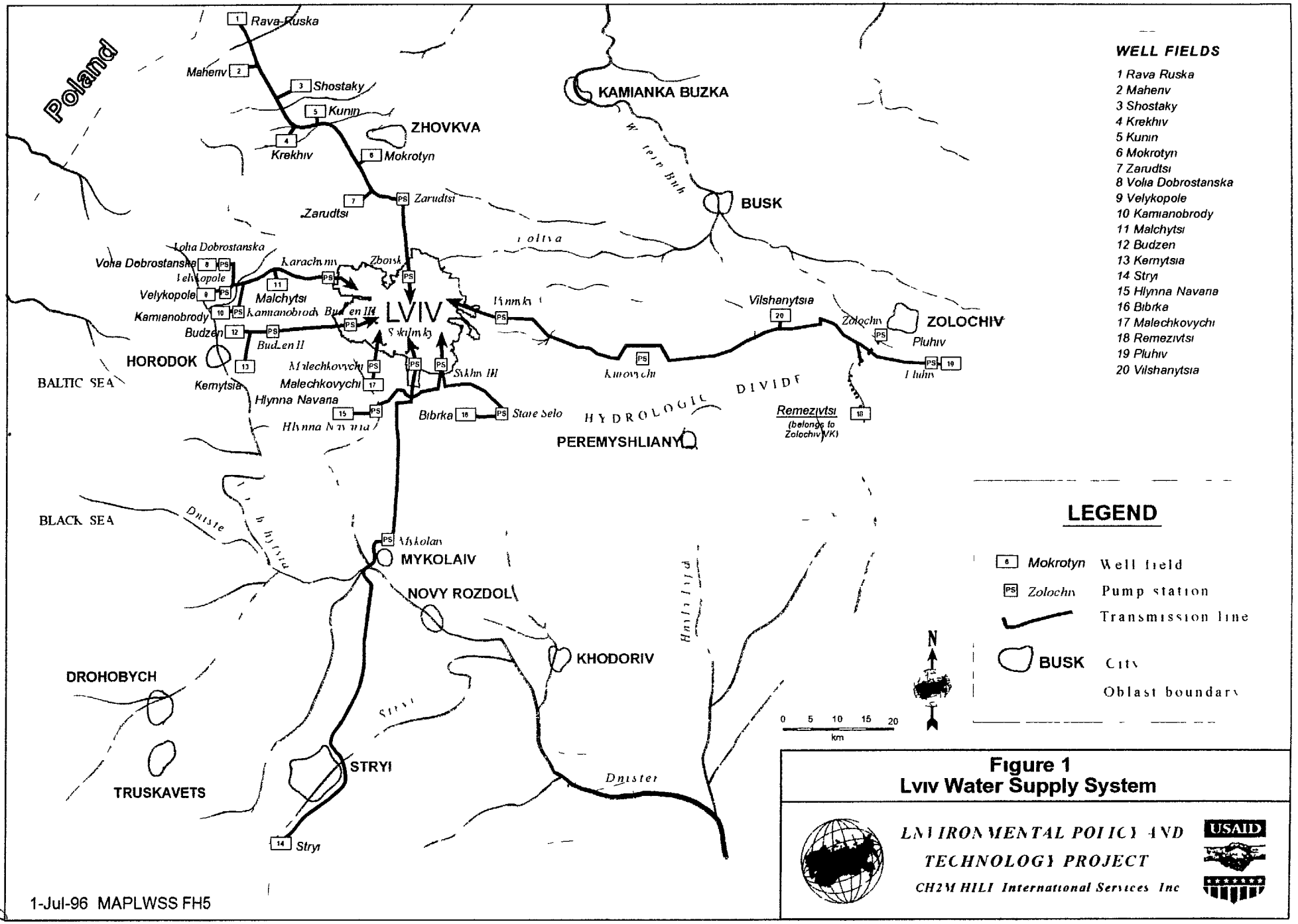


Figure 1
Lviv Water Supply System

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc
USAID

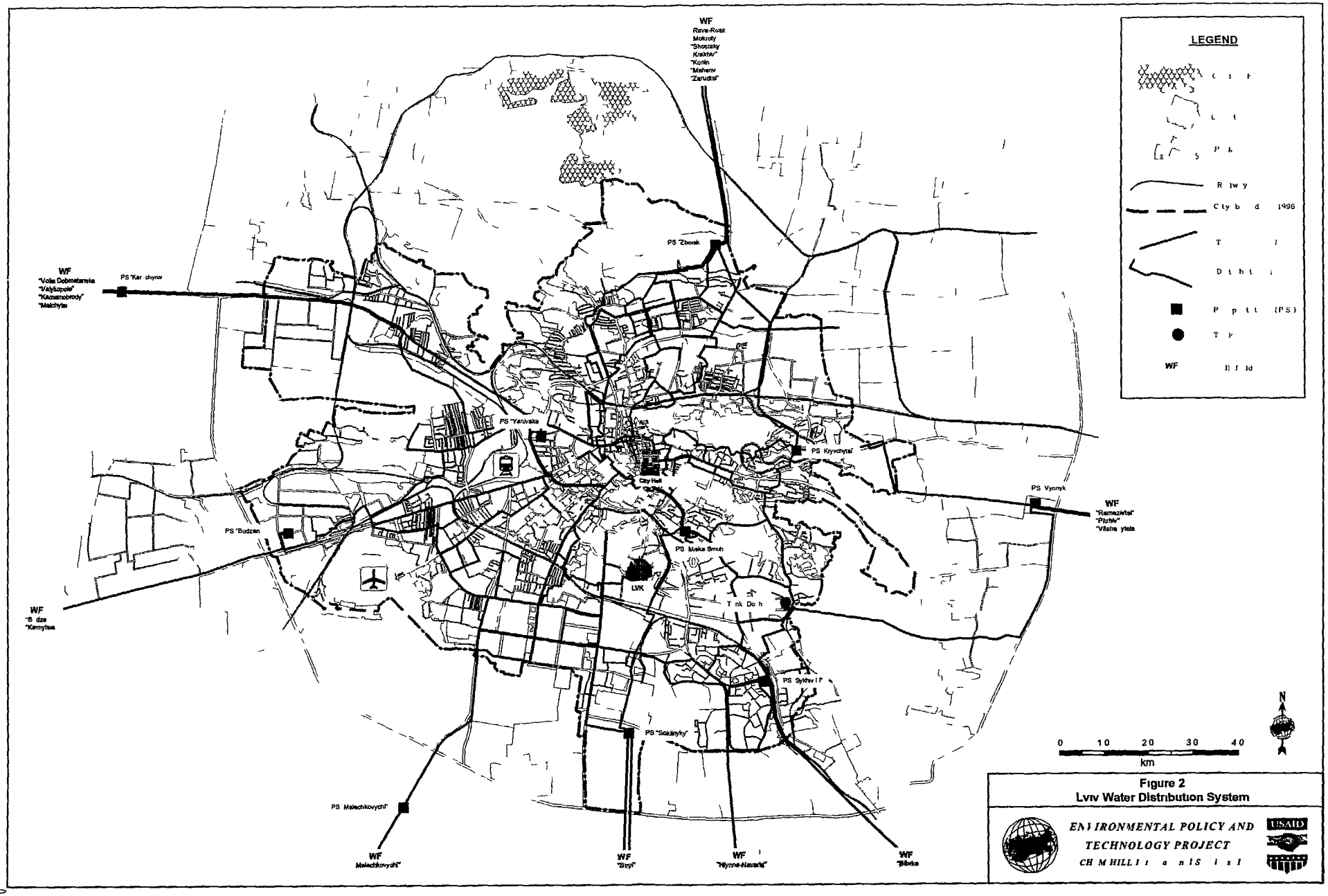
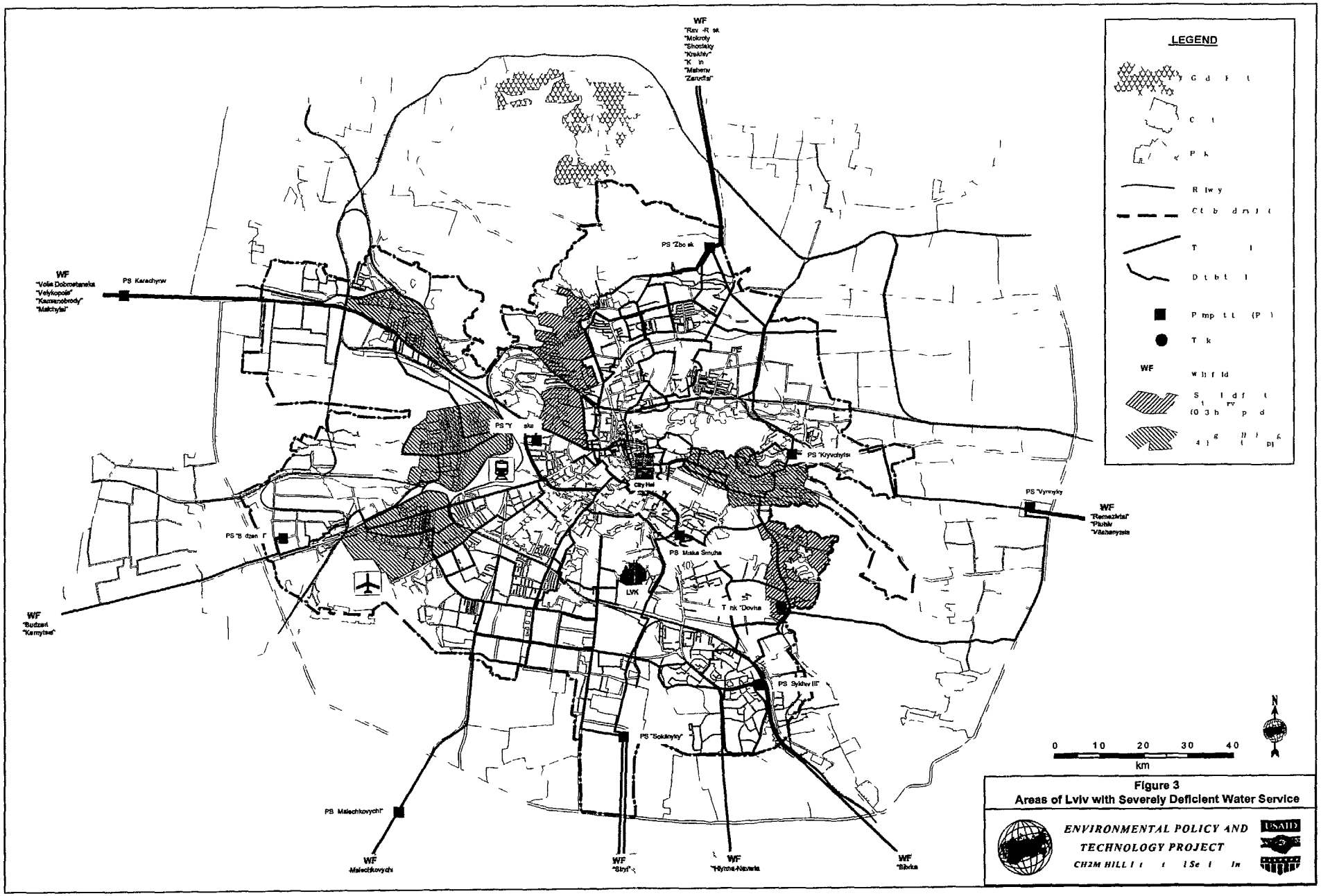
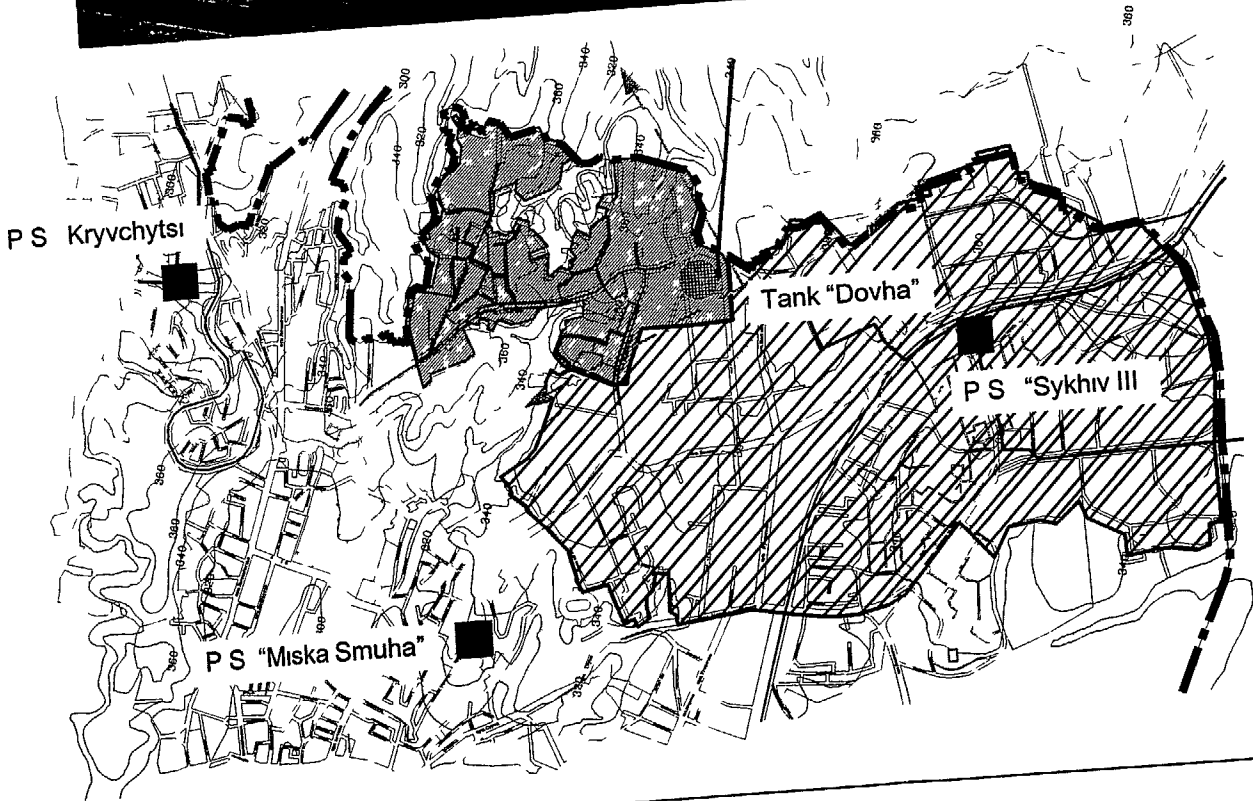


Figure 2
Lviv Water Distribution System

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH MHILL
USAID


LEGEND
WF
PS Karachyniv
PS Zbo sk
PS Y ako
PS Kryvchytsi
PS Vynnyky
PS B dzan r
PS Maka Smuha
LVK
T nk "Dovha
PS Sykhiv III"
PS "Sokolnyky"
PS Malechkovychi"
WF "Rav -R sk "Mokroty "Shodsky "Krekhiv" "K in "Mahera "Zarudtsi"
WF "Volia Dobrostaneka "Velykopole" "Kamenobrody" "Malchytsi"
WF "Budzani "Kernytsi"
WF "Remezkivtsi" "Plekhiv "Vilshanytsia
WF Malechkovychi
WF "Stryi"
WF "Hlynna-Navaria
WF "Bibrka
0 10 20 30 40
km
N
Figure 3
Areas of Lviv with Severely Deficient Water Service
ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
USAID



LEGEND

- Tank
- Pump station
- Water main pipe
- Water distribution pipe
- Pasichna – Area to have directly improved water service
- Sykhu – Area to have indirectly improved water service
- Field of view of photograph

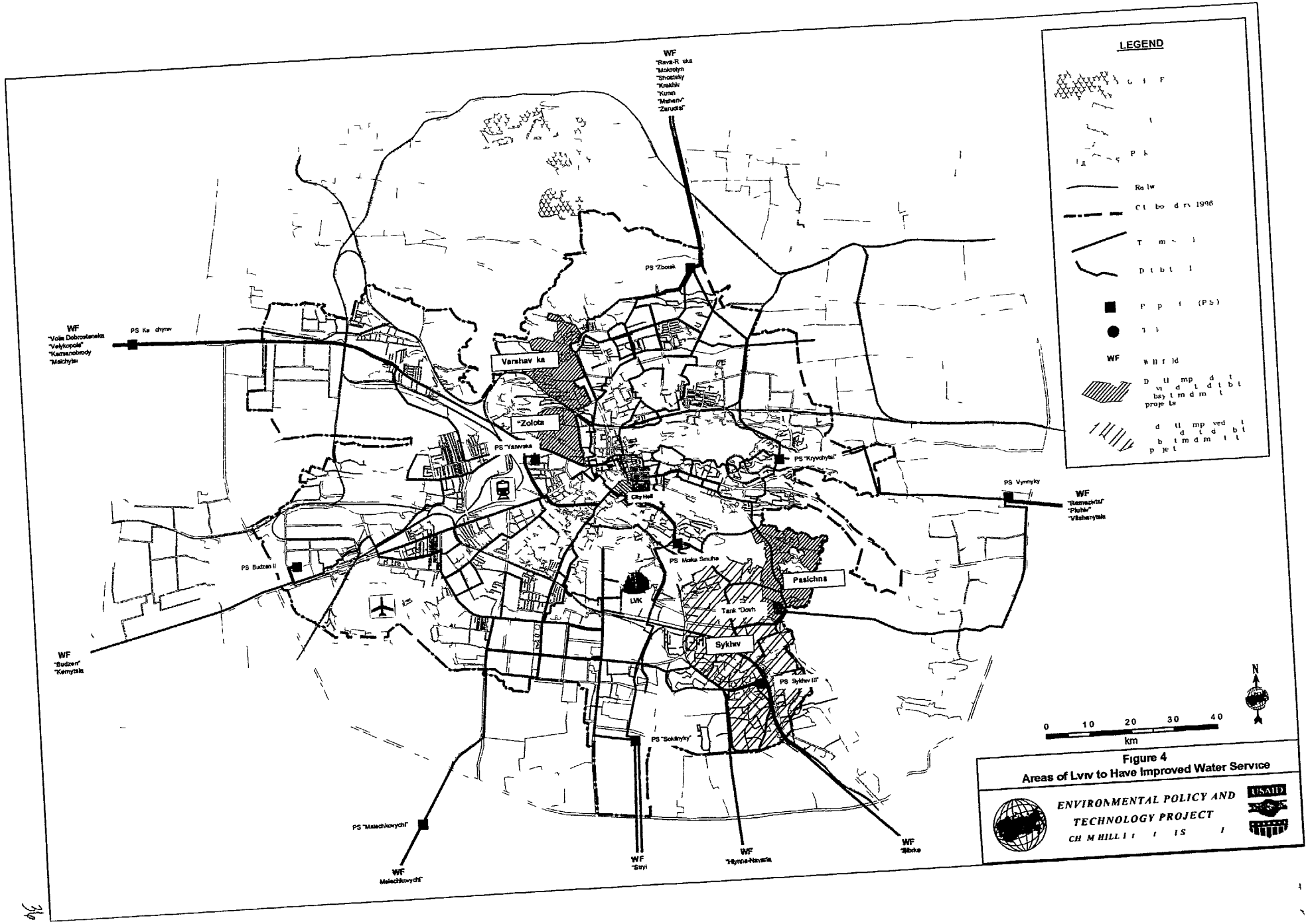
0 05 10 15 20
km

Figure 5
Pasichna Subsystem

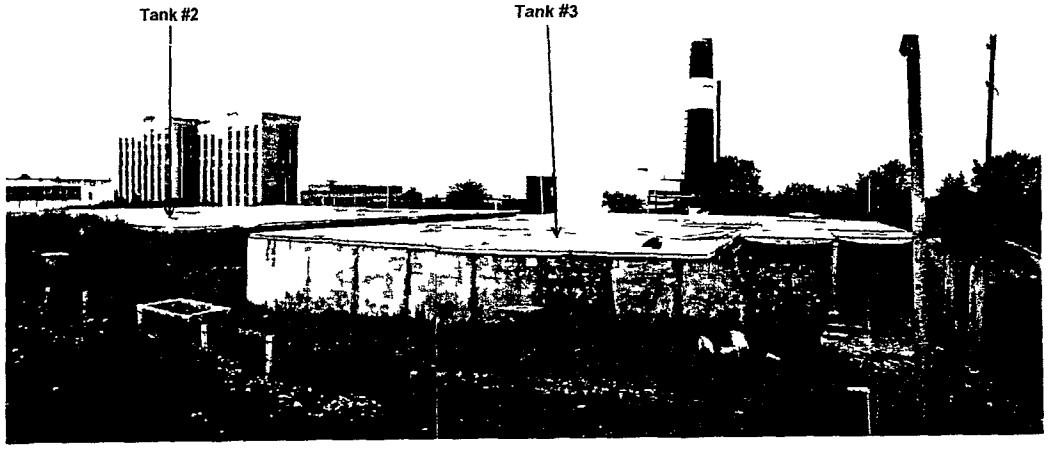
ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL Inte tion US rvi s I c

USAID

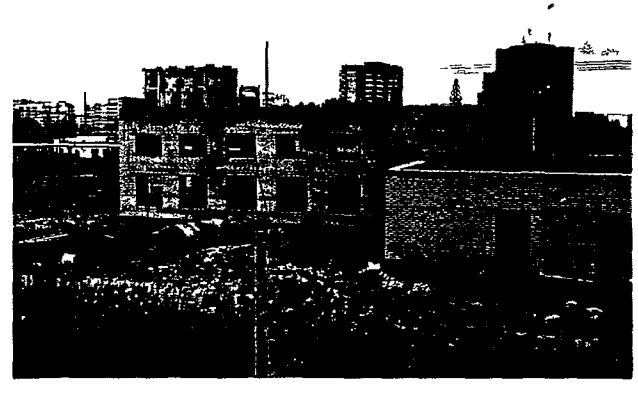
29-Jun-96 PASIKS2 PPT


LEGEND
WF
PS "Zborak"
PS Ka chyny
WF
"Volia Dobrostanska"
"Velykopole"
"Kamenobrody"
"Malchytsi"
Varshav ka
"Zolota
PS "Yanivska
PS "Kryvchytsi"
PS Vynnyky
WF
"Ramazivtsi"
"Pluhiv"
"Vilshanytsia
City Hall
PS Budzen II
PS Maka Smuha
Pasichna
LVK
Tank "Dovh
Sykhiv
PS Sykhiv III"
PS "Sokilnyky"
PS "Malechkovychi"
WF
Malechkovychi"
WF
"Stryi
WF
"Rava-R ska
"Mokrotyn
"Shostaky
"Krekhiv
"Kurnyn
"Mshanv"
"Zarudtsi"
WF
"Budzen"
"Kemytsia
WF
"Rymno-Novosilka"
WF
"Birka
0 10 20 30 40
km
Figure 4
Areas of Lviv to Have Improved Water Service
ENVIRONMENTAL POLICY AND
TECHNOLOGY PROJECT
USAID

Partially Constructed Water Tanks



Partially Constructed Pumping Station



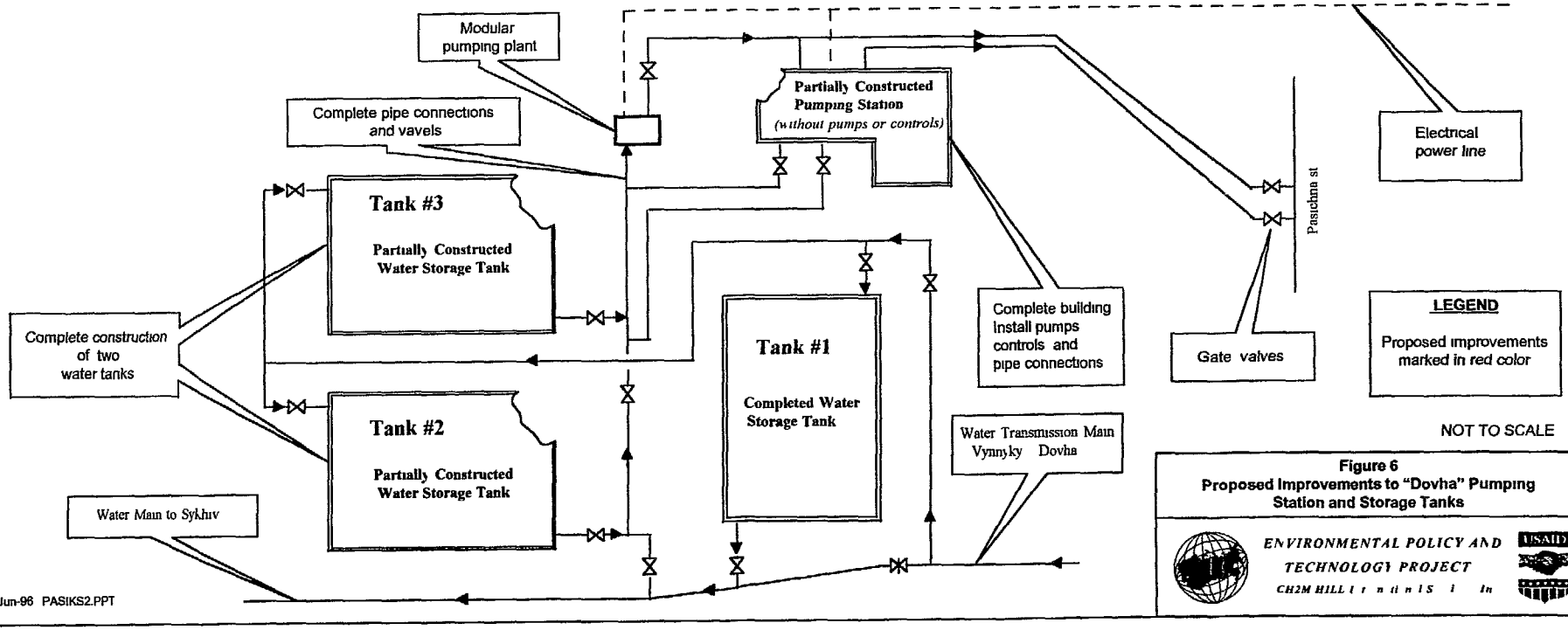


Figure 6
Proposed Improvements to "Dovha" Pumping Station and Storage Tanks

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CH2M HILL Intrados Inc
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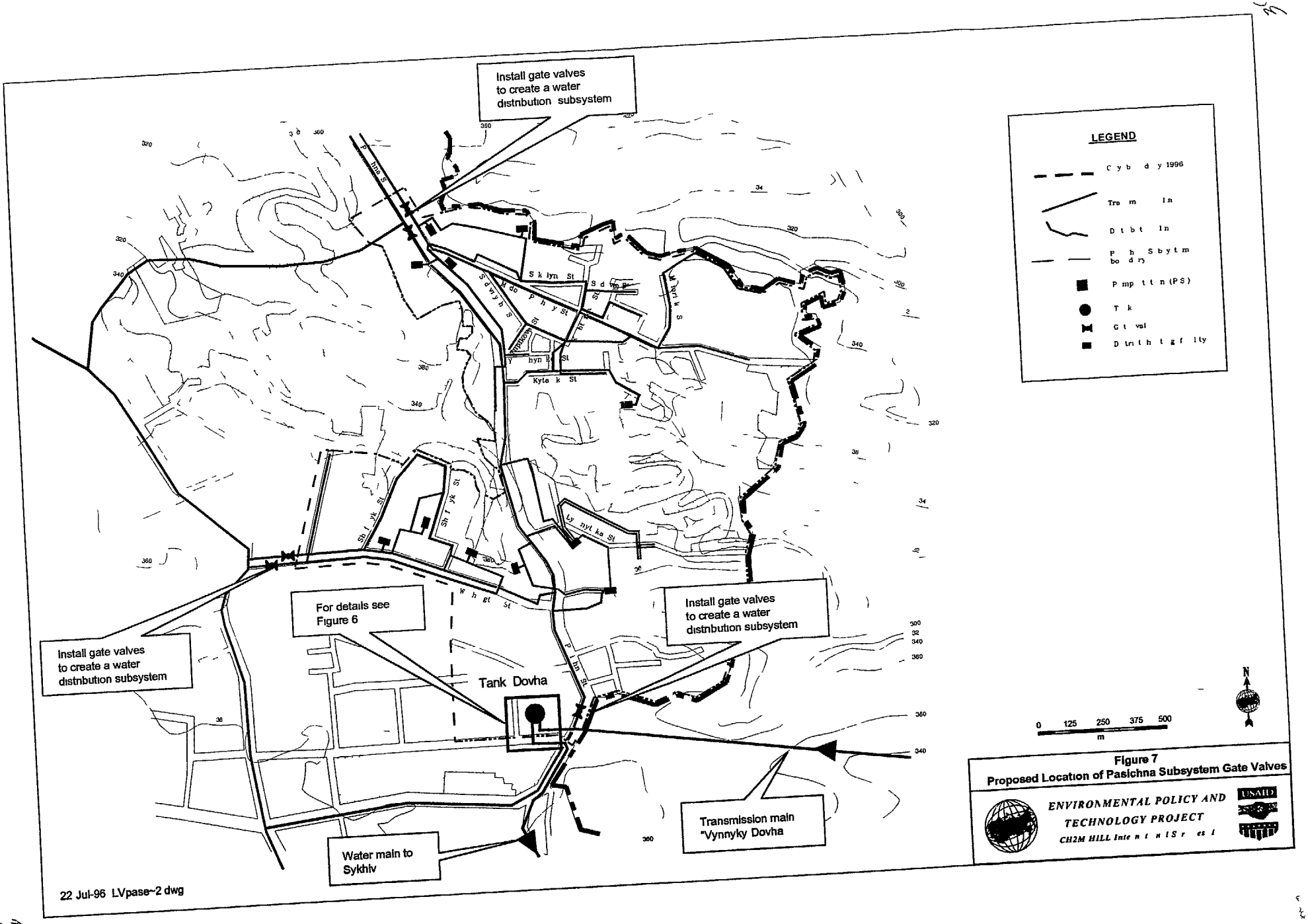
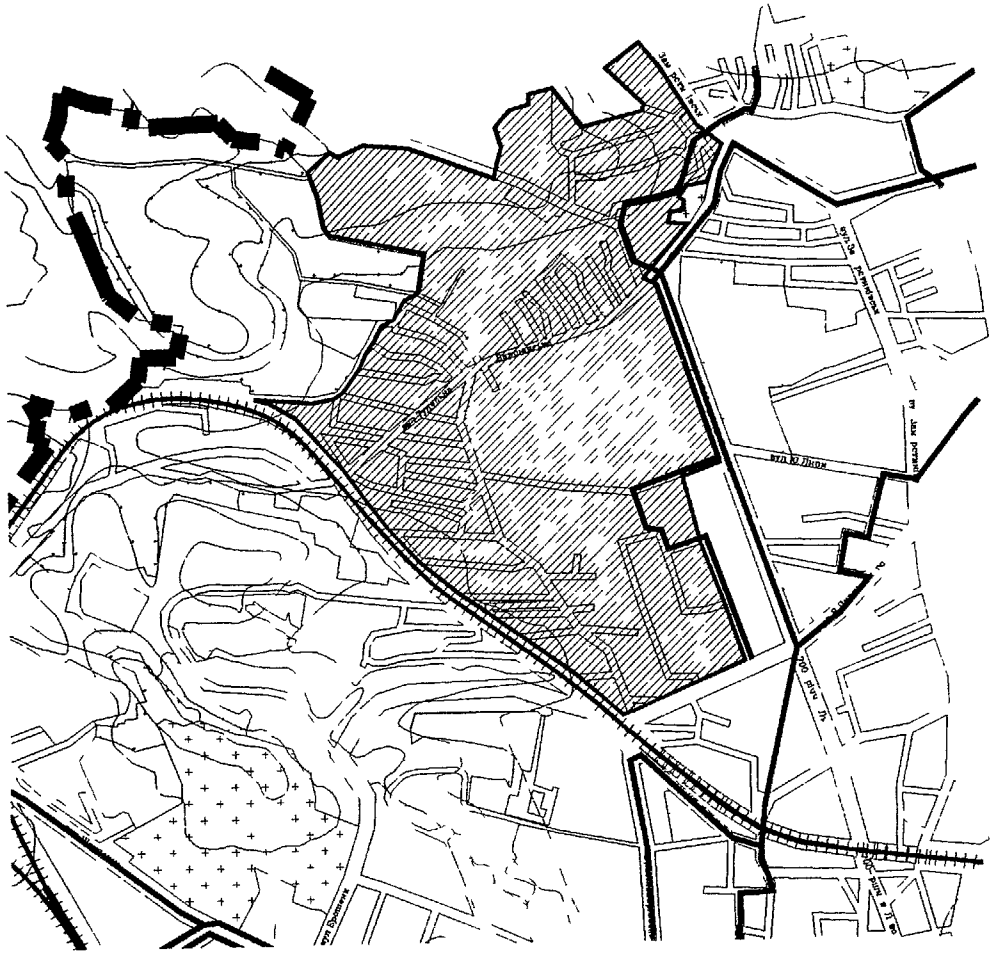

Install gate valves to create a water distribution subsystem
For details see Figure 6
Install gate valves to create a water distribution subsystem
Install gate valves to create a water distribution subsystem
Tank Dovha
Transmission main "Vynnyky Dovha
Water main to Sykhiv
LEGEND
Cyb d y 1996
Tra m In
D t b t In
P h S b y t m bo d ry
P mp t t n (PS)
T k
G t val
D tri h t g f lly
0 125 250 375 500
m
N
Figure 7
Proposed Location of Pasichna Subsystem Gate Valves
ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL Inte n t n lS r es t
USAID
22 Jul-96 LVpase~2 dwg



P S "Zboisk"

LEGEND

Varshavska -- area to have improved water service

Pump station

Water main pipe

City boundary

N

0 05 10 15 20

km

Figure 8
Varshavska Subsystem

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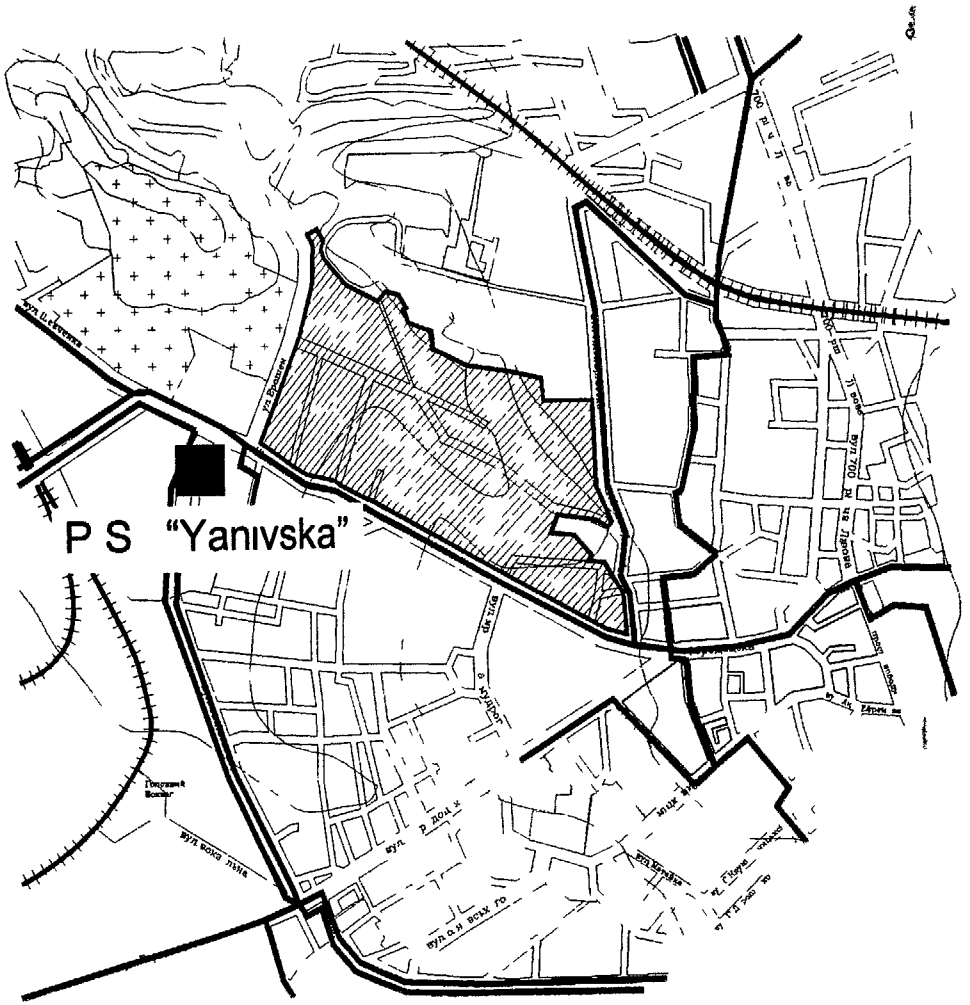

LEGEND

Zolota -- area to have improved water service

Pump station

Water main pipe

N

0 05 10 15 20

km

Figure 9
Zolota Subsystem

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