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For the New Independent States
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By
A USAID Project Consortium Led by CH2M HILL

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Prepared by
Ukraine, Belarus & Moldova Regional Office
Environmental Policy and Technology Project
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PREFACE

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

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

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

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)

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ABBREVIATIONS, ACRONYMS & GLOSSARY

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

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

Section 1

INTRODUCTION

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

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

> *The Contractor will produce an outline of the basic data that should be collected on a utility system in order to begin to analyze operations and prepare a strategic plan for system improvement This will include the source of water, treatment system, storage, distribution, pressure zones, metering, billing as well as facilities for repair, maintenance, engineering and construction, water quality and financing*
>
> *Using this guideline and existing, readily available data from the Lviv Vodokanal, the Contractor will characterize (quantity, size, location) the general components of the Lviv water system*
>
> *Devise a methodology to collect and present data on the critical aspects of the physical facilities, operation, water quality, repair and maintenance of a Vodokanal*
>
> *Use this methodology to collect and present data for the Lviv system*
>
> *The methodology shall include an evaluation of the existing operation strategy, capabilities to implement repairs, identify existing constraints to making repairs and present recommendations for improving current repair and maintenance capacity to the level required by the condition of the Vodokanal's facilities*
>
> Present the data as contract deliverables in a series of reports
>
> - *Summary of initial data on the current system*
> - *Summary of interim data on the current system*
> - *Summary of final data on the current system*

This is the first (initial) 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

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 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

2.2 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 2.1 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 2 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 2 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

[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

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 2 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

2.2.2 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

2.2 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 2 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 2 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 2 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

2.2.4 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 2.5 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

2.3 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

2.3 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 3.2 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

2.3.3 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 3.4 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 4 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**

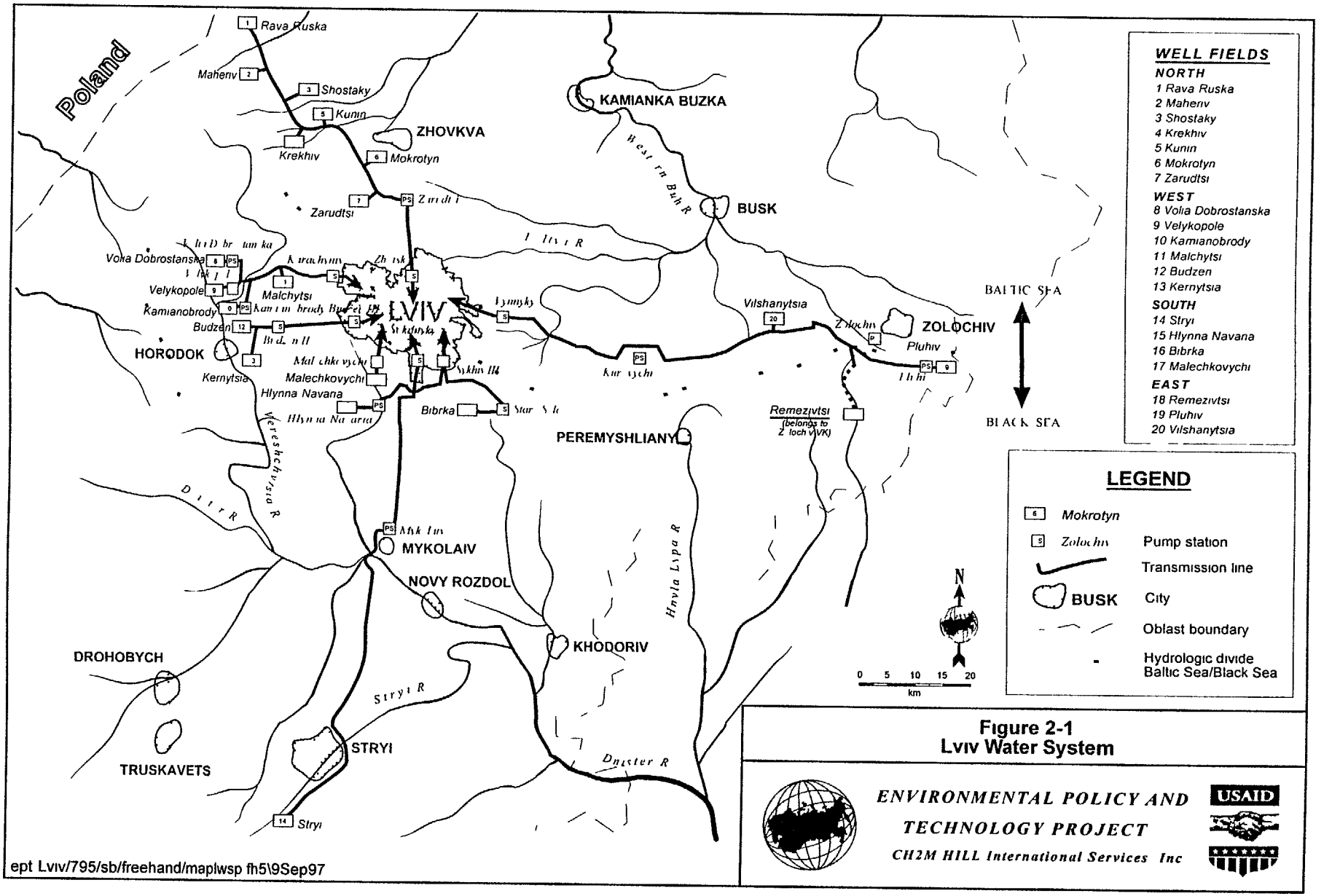

Figure 2-1
Lviv Water System

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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			Average Daily Production		Problem Constituents	Number of Operating Personal	Remarks
						Safe Yield	Added Yield	Total	1987	1995			
				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

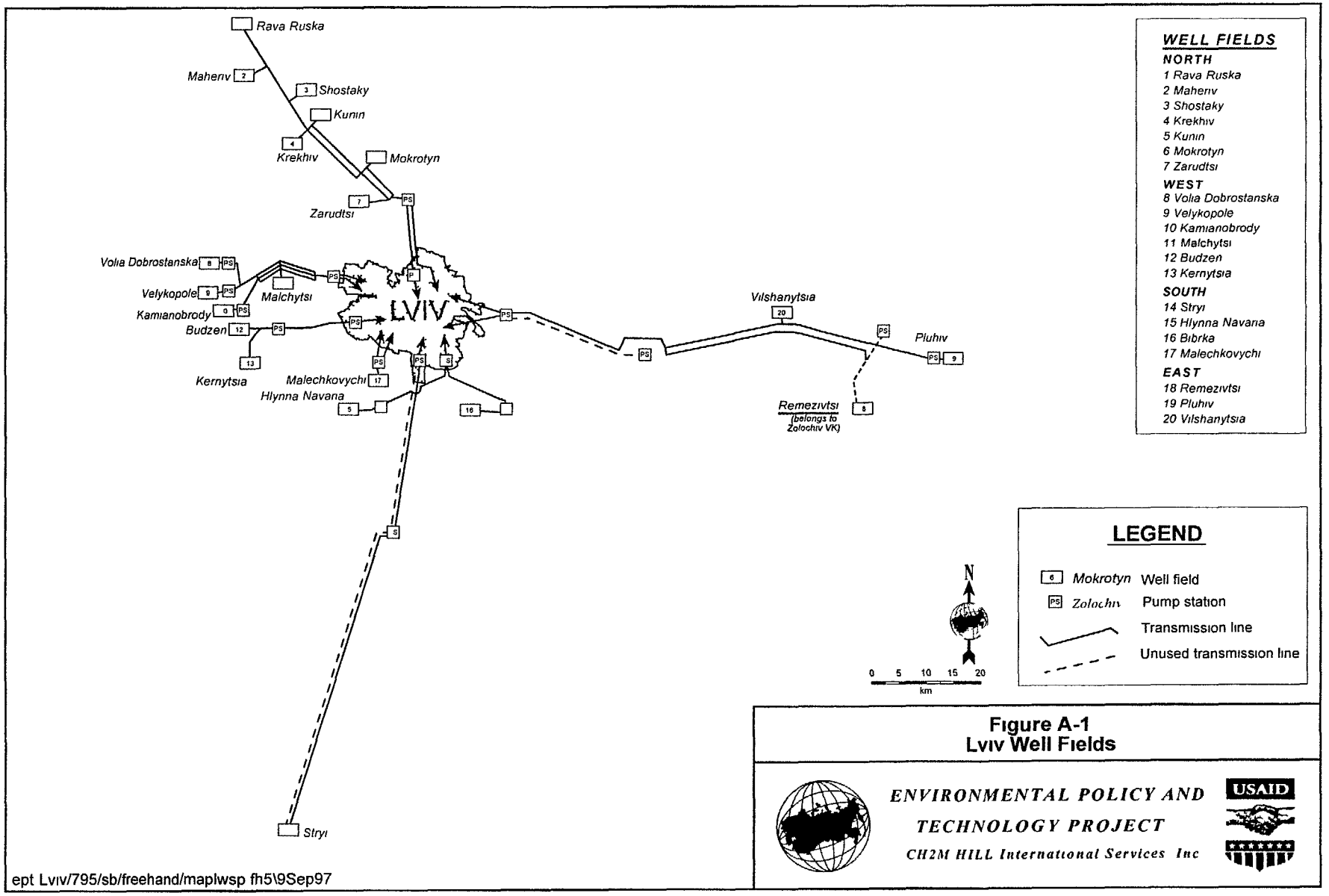

Figure A-1
Lviv Well Fields

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
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Typical Well Design at Stryi Well Field

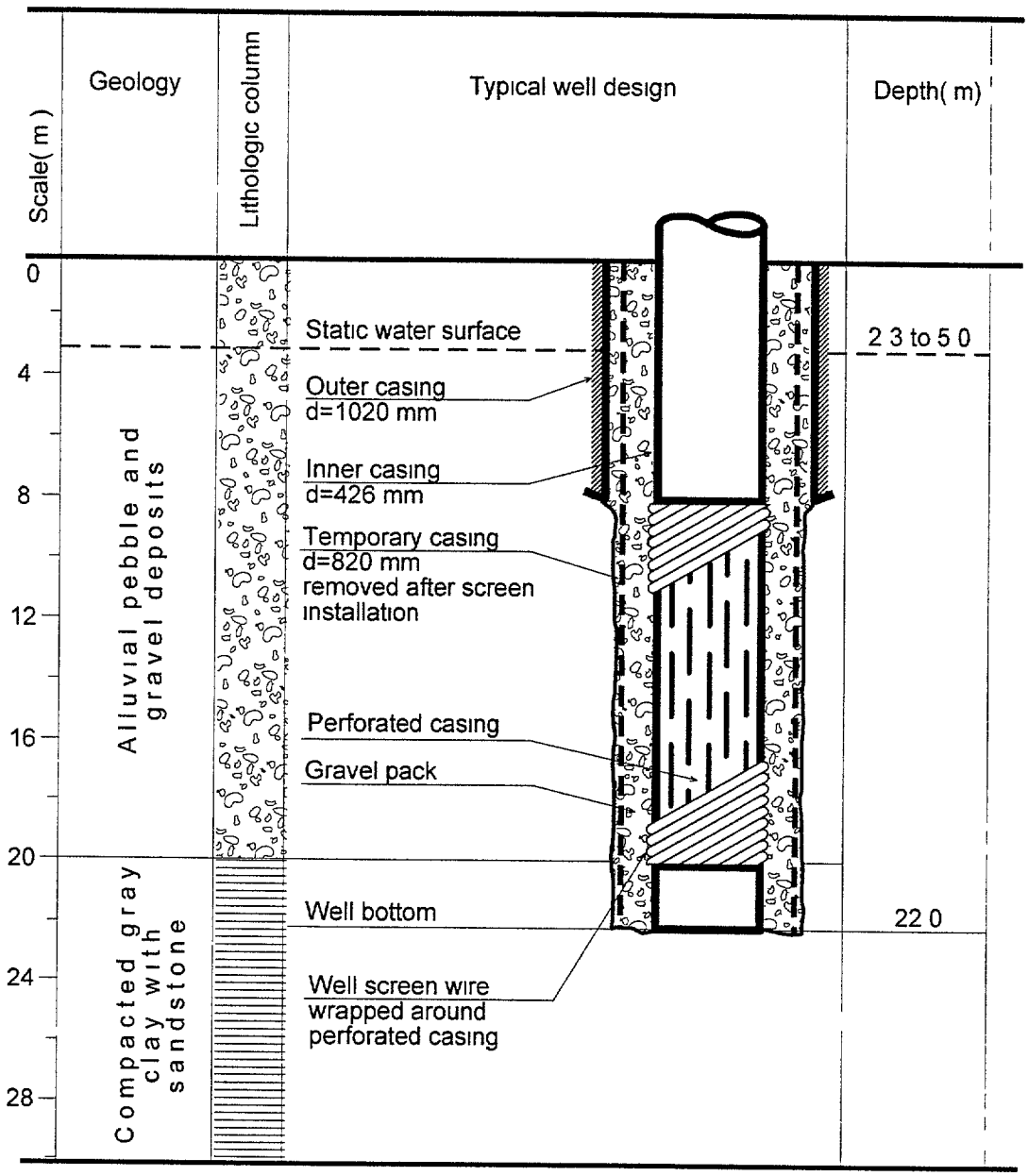

Figure A-2
Geological Profile and Well Design

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

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North Well Field Analysis Rava-Ruska

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Rava Ruska	17	17	0

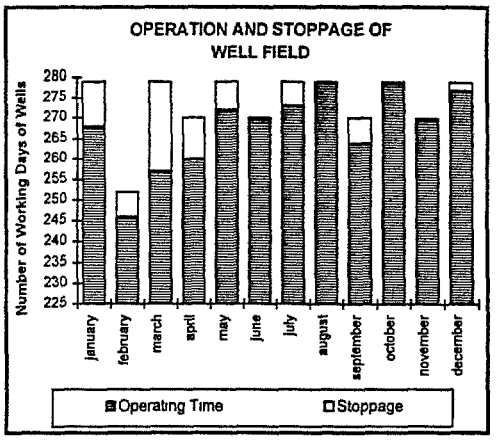
AQUIFER

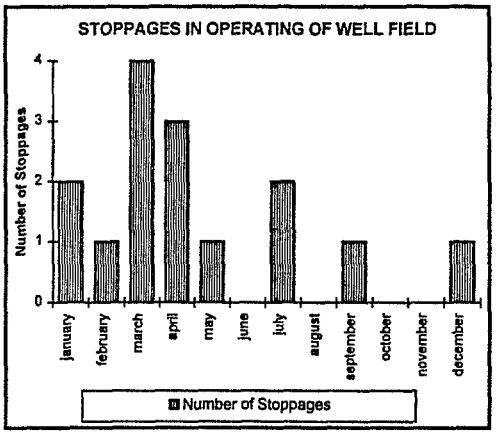
Description Upper Cretaceous Deposits Fractured Siltstones and Chalks		
Thickness of aquifer m	30	
Static water level m	(+) 2 5	4 8
Pumping rate m³/day	4294	8856
Specific capacity m²/day	1010	2573
Transmissivity m²/day	820	
Thickness of covering layer m	10	80
Thickness of clay within the covering layer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

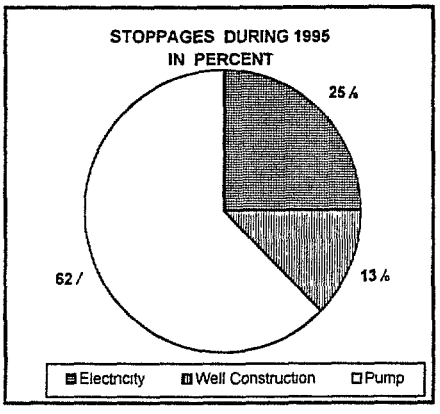
WELL FIELD (technical characteristics)

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







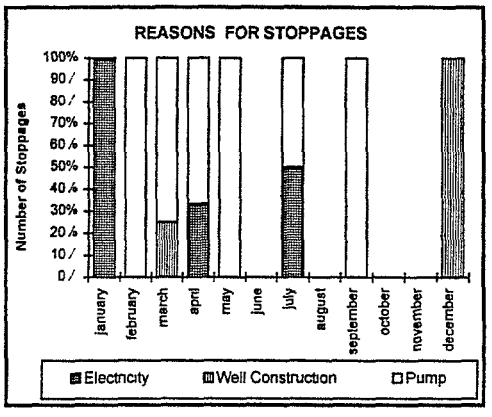


Figure A 3
North Well Field Analysis - Rava Ruska

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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

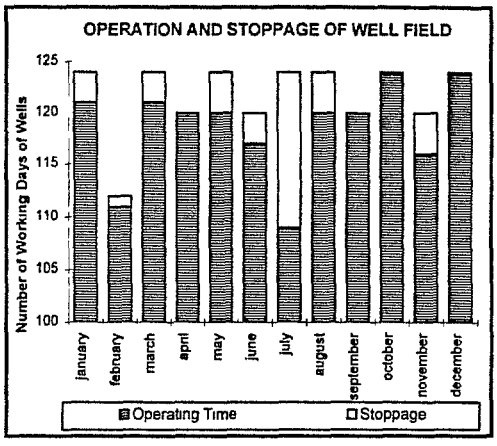
WELL FIELD (technical characteristics)

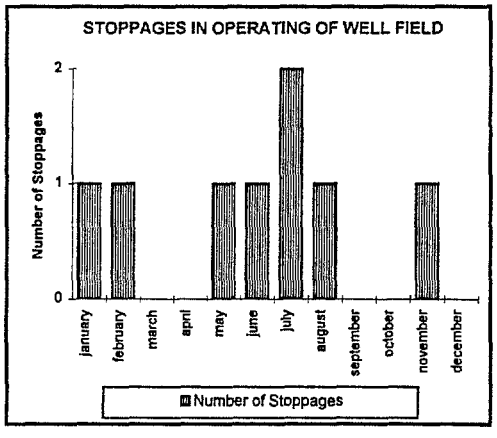
Number of wells		4
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 4 5	ЭЦВ12 160-100	(65)
wells 4a	ЭЦВ10-63-110	(32)
well 6	ЭЦВ8-25-70	(17)

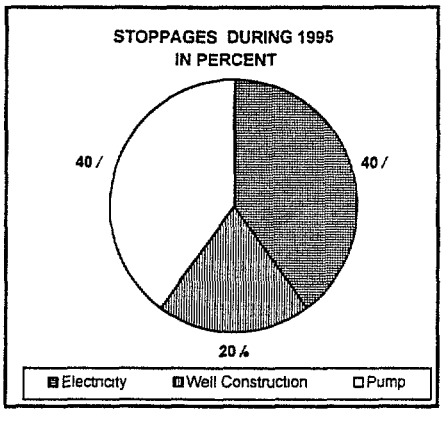
Criterion of operating effectiveness of well field 0 974

Probability of non stop work of well field 0 816

Percent of stoppages % 2 53







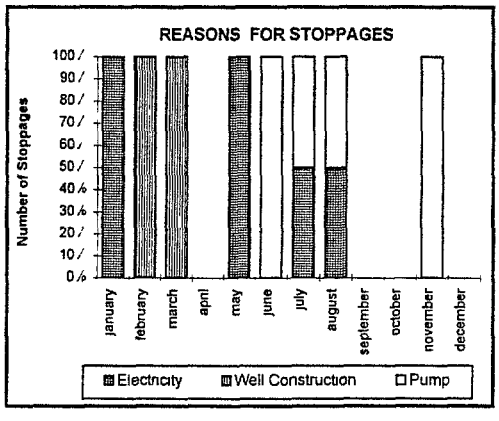


Figure A-4
North Well Field Analysis - Maheriv

ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
CH2M HILL International Services Inc

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North Well Field Analysis Shostaky

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Shostaky	3 4	3 4	0

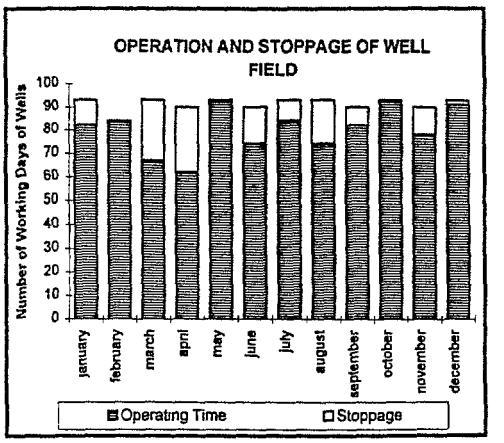
AQUIFER

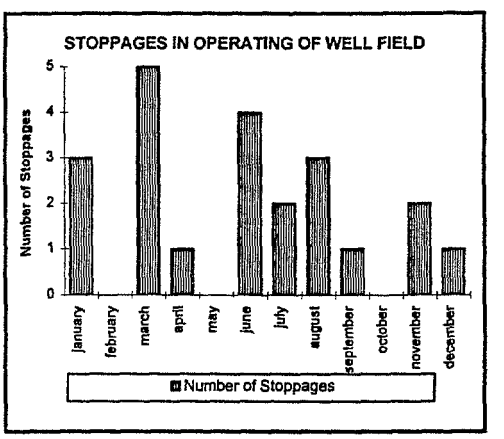
Description Upper Cretaceous Deposits Fractured Siltstones and Chalks

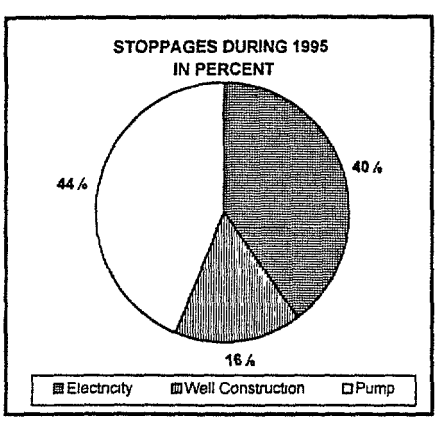
Thickness of aquifer m	30
Static water level m	(+) 2 5 4 8
Pumping rate m³/day	1395 6006
Specific capacity m²/day	276 1456
Transmissivity m²/day	300 1300
Thickness of covering layer m	10 20
Thickness of clay within the covering layer m	0 3

WELL FIELD (technical characteristics)

Number of wells	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







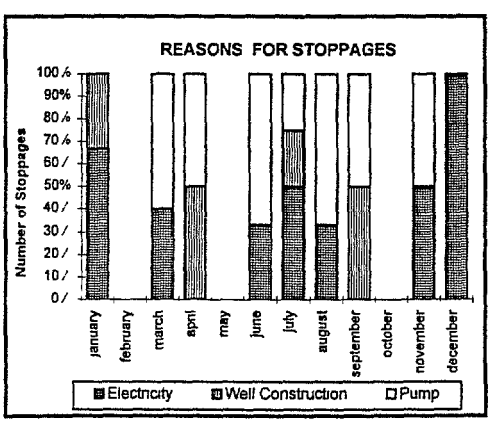


Figure A-5
North Well Field Analysis - Shostaky

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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

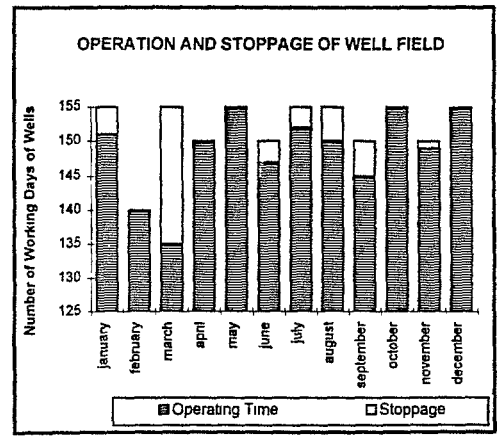
WELL FIELD (technical characteristics)

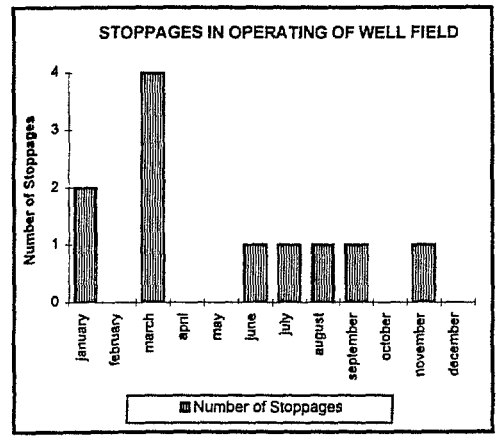
Number of wells		5
Depth of wells m		60
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 1 3 5	ЭЦВ12 160-100	(65)
wells 4	ЭЦВ8-16-100	(17)
well 2	ЭЦВ10-63-110	(32)

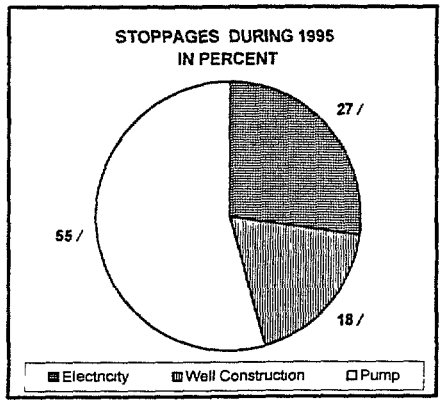
Criterion of operating effectiveness of well field 0 977

Probability of non stop work of well field 0 724

Percent of stoppages % 2 25







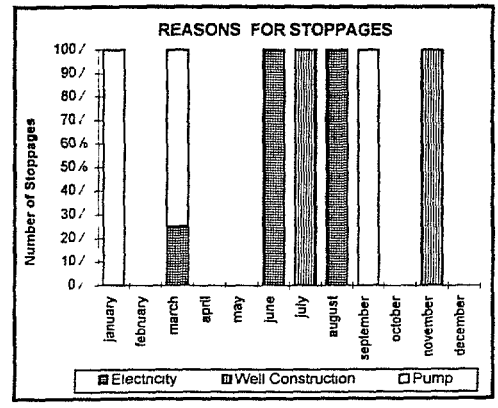


Figure A-6
North Well Field Analysis - Krekhiv

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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 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	2	20

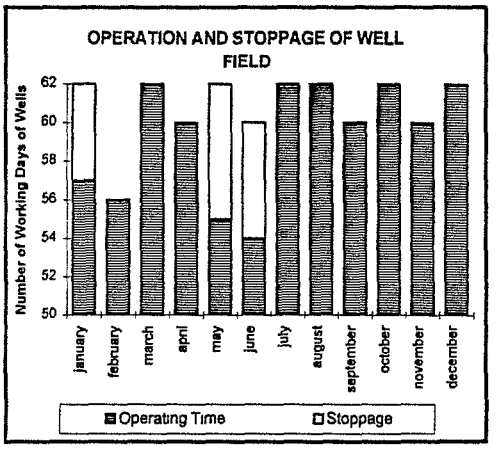
WELL FIELD (technical characteristics)

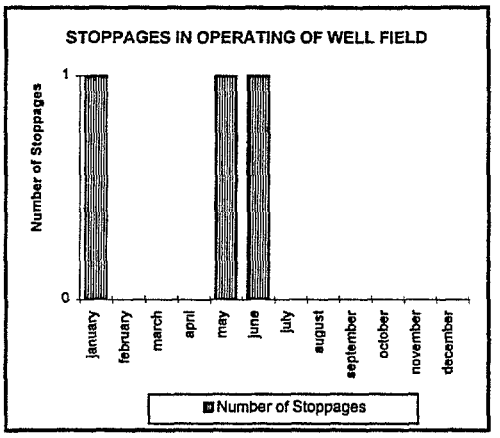
Number of wells		2
Depth of wells m		60
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 6 7	ЭЦВ12 160-100	(65)

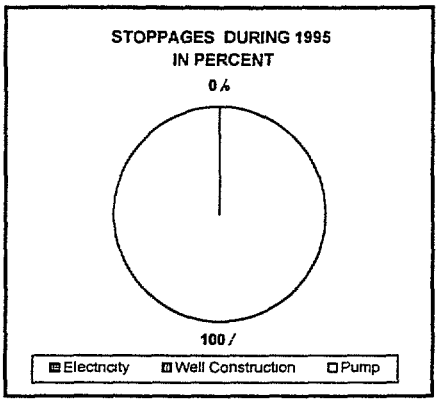
Criterion of operating effectiveness of well field 0 975

Probability of non stop work of well field 0 929

Percent of stoppages % 2 46







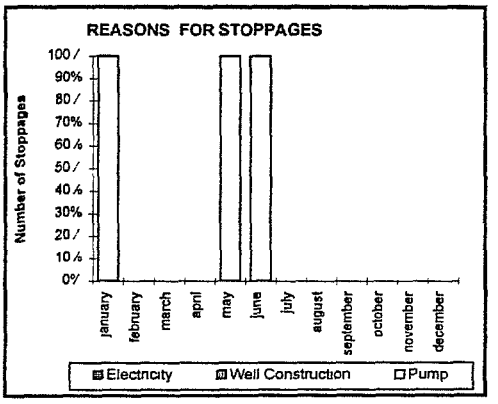


Figure A-7
North Well Field Analysis Kunin

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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

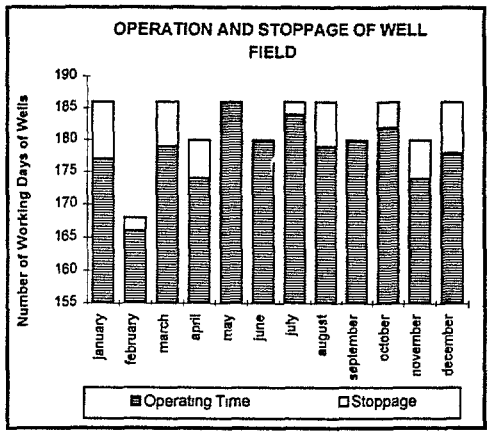
WELL FIELD (technical characteristics)

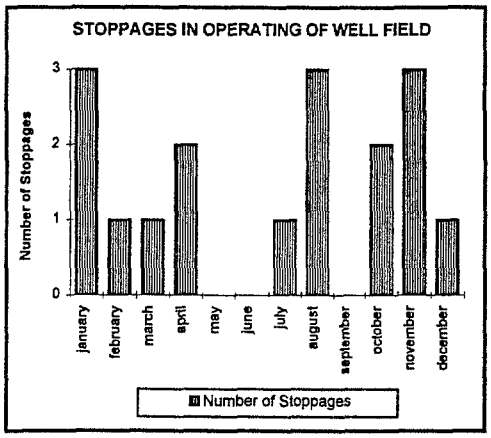
Number of wells	7
Depth of wells m	75
Diameter of wells mm	426
Type of pumps (and capacity kW)	
wells 1 2 3 4 6 5a ЭЦВ10-120-65	(32)
wells 5 ЭЦВ8-25-70	(17)

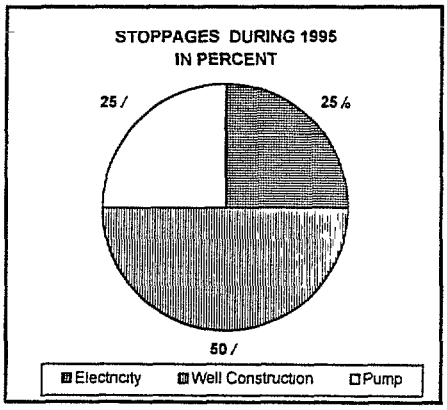
Criterion of operating effectiveness of well field 0 977

Probability of non stop work of well field 0 658

Percent of stoppages % 2 33







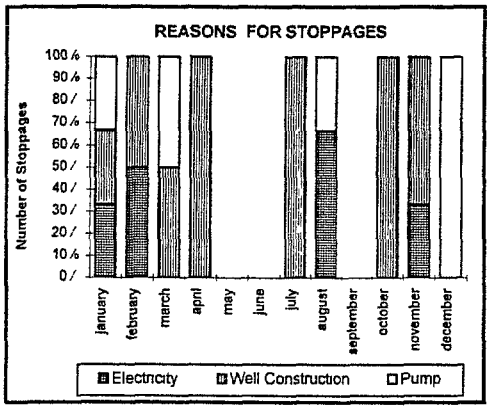


Figure A 8
North Well Field Analysis Mokrotyn

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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

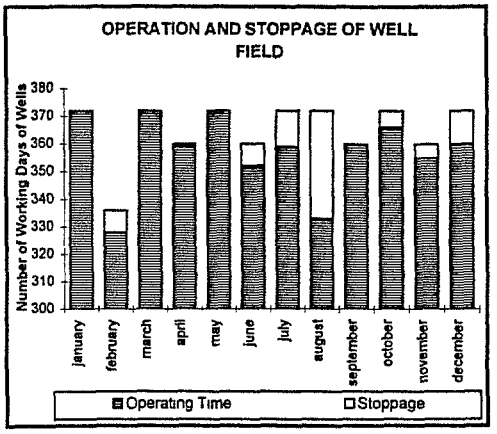
WELL FIELD (technical characteristics)

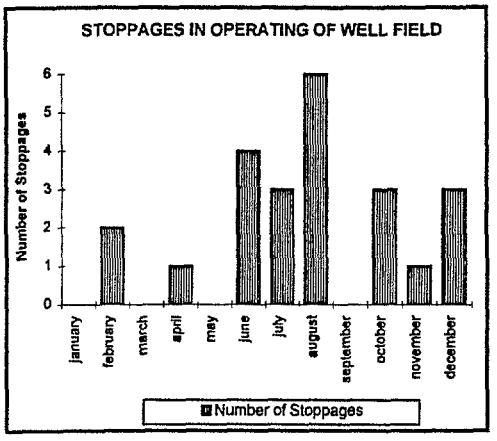
Number of wells	16	
Depth of wells m	70	
Diameter of wells mm	377	
Type of pumps (and capacity kW)		
Zarudtsy		
wells 1 3 5a 7 8	ЭЦВ10-120-65	(32)
wells 2 2a 4 5 6	ЭЦВ8-25-70	(17)
Zavadov		
well 1 1a 2 2a 3	ЭЦВ10-120-65	(32)
wells 1b	ЭЦВ8-25-70	(17)

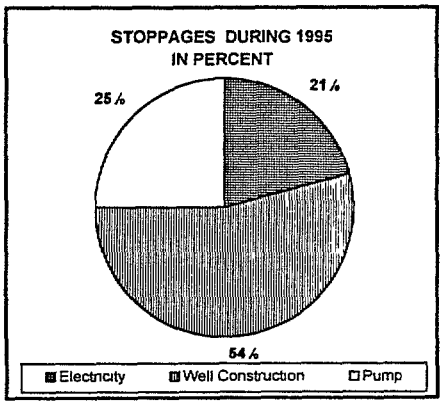
Criterion of operating effectiveness of well field 0 979

Probability of non stop work of well field 0 696

Percent of stoppages % 2 29







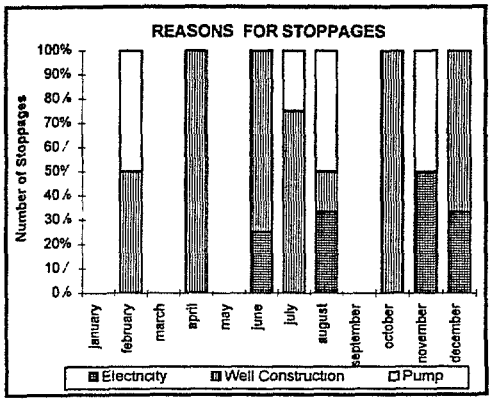


Figure A 9
North Well Field Analysis - Zarudtsi

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East Well Field Analysis Remezivtsi

YIELD 1 000 m³/day

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

AQUIFER

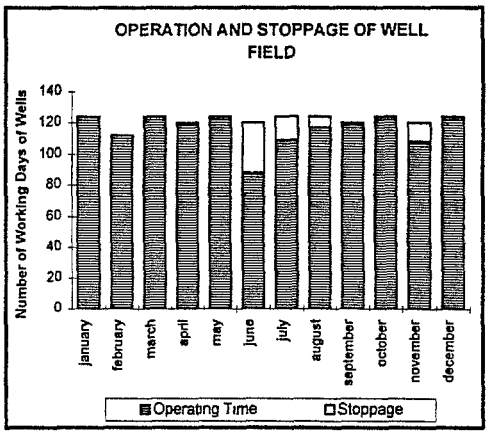
Description Upper Cretaceous Deposits
Fractured Siltstones and Chalks

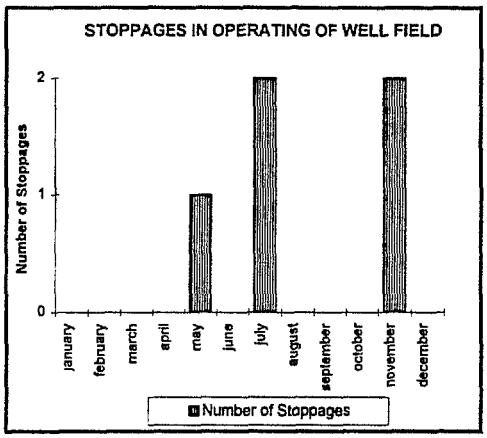
Thickness of aquifer m	50
Static water level m	(+) 0 7 2 6
Pumping rate m³/day	3603 4320
Specific capacity m²/day	406 458
Transmissivity m²/day	2500
Thickness of covering layer m	10 15
Thickness of clay within the covering layer m	10 15

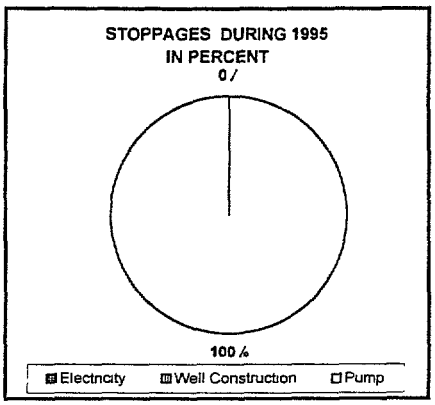
WELL FIELD (technical characteristics)

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







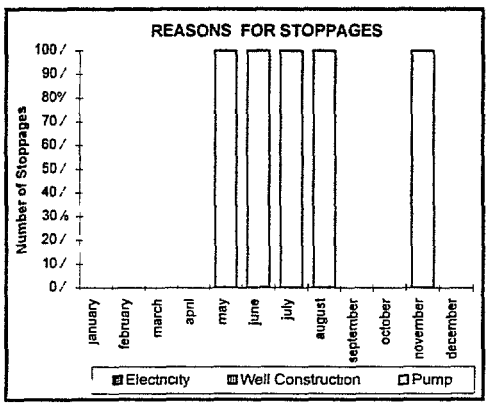


Figure A 10
East Well Field Analysis - Remezivtsi

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East Well Field Analysis Pluhiv

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Pluhiv	90	70	20

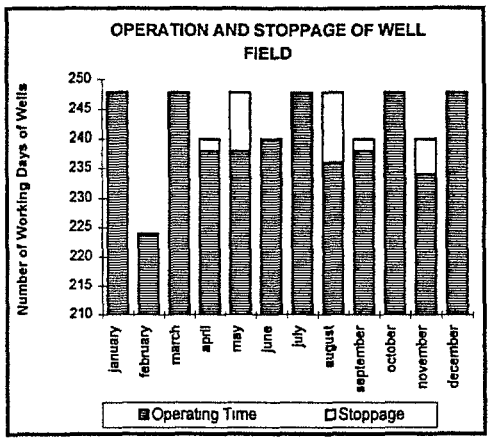
AQUIFER

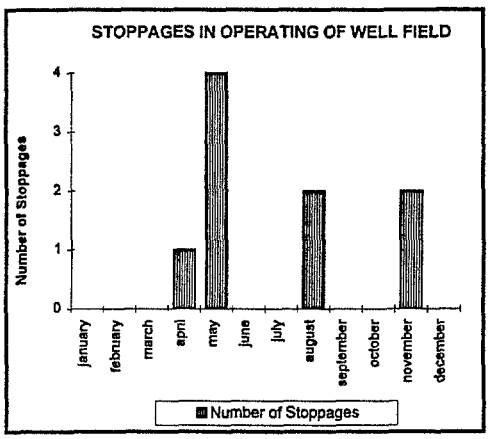
Description Middle Devonian Deposits
Fractured Limestones with layers of sand

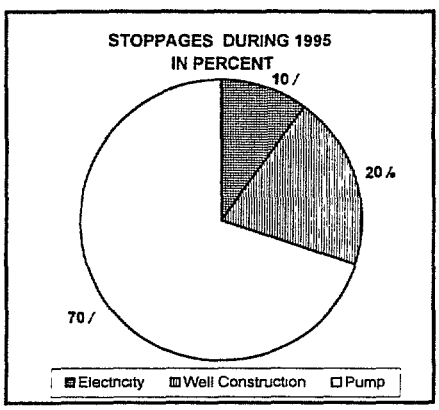
Thickness of aquifer m	100 350
Static water level m	(+) 22 8
Pumping rate m³/day	406 3600
Specific capacity m²/day	458 4320
Transmissivity m²/day	2070
Thickness of covering layer m	10 15
Thickness of clay within the covering layer m	10 15

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







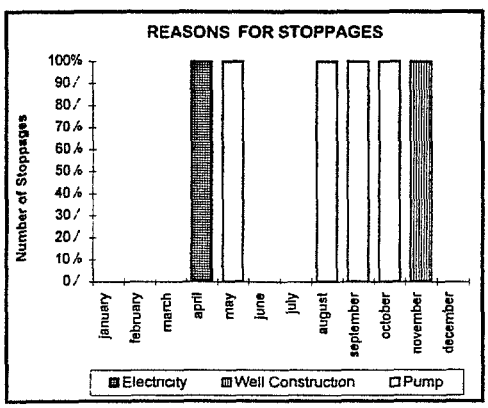


Figure A-11
East Well Field Analysis Pluhiv

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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

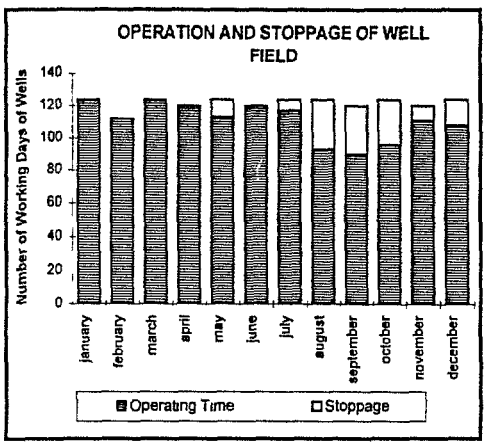
WELL FIELD (technical characteristics)

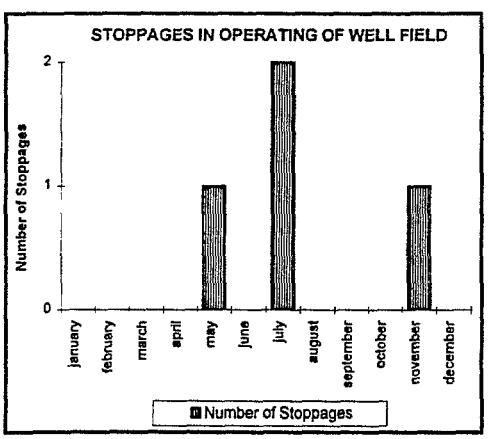
Number of wells		4
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (capacity kW)		
wells 1 2	ЭЦВ12 160-140	(90)
wells 3	ЭЦВ12 160-100	(65)
well 4	ЭЦВ10-63-110	(32)

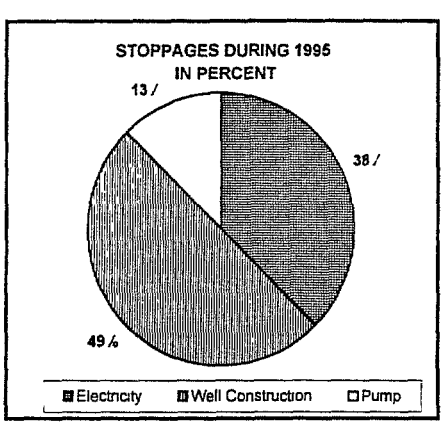
Criterion of operating effectiveness of well field 0 91

Probability of non stop work of well field 0 696

Percent of stoppages % 9 04







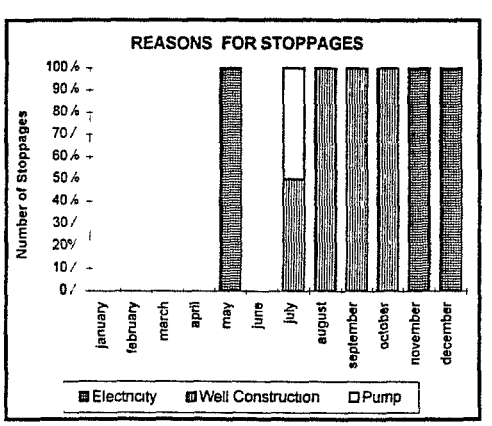


Figure A-12
East Well Field Analysis - Vilshanytsia

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South Well Field Analysis Stryi

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Stryi	140	140	0

AQUIFER

Description Middle and Upper Quaternary Alluvium Complex

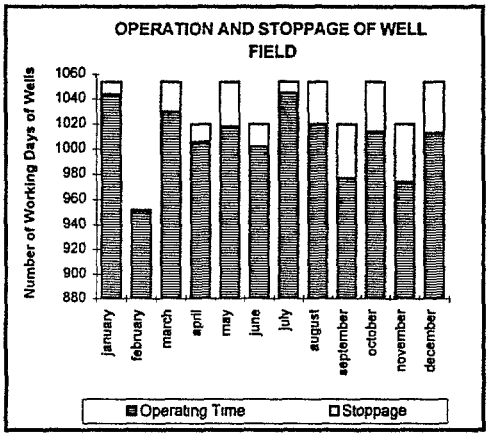
Sand Gravel Boulder in different proportions

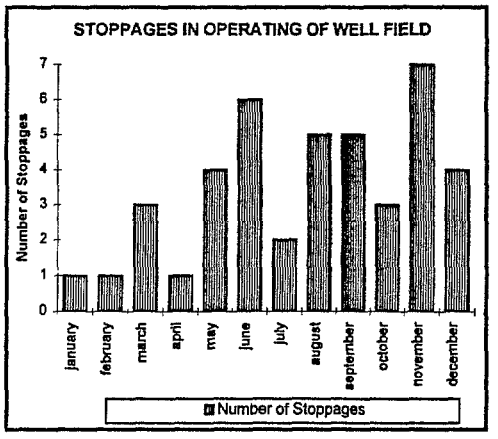
Thickness of aquifer m	10 12
Static water level m	( ) 1 5 4 0
Pumping rate m³/day	1494
Specific capacity m²/day	1530
Transmissivity m²/day	1200
Thickness of covering layer m	3 5
Thickness of clay within the covering layer m	0

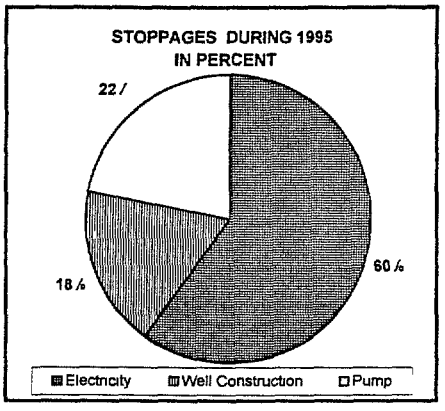
WELL FIELD (technical characteristics)

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







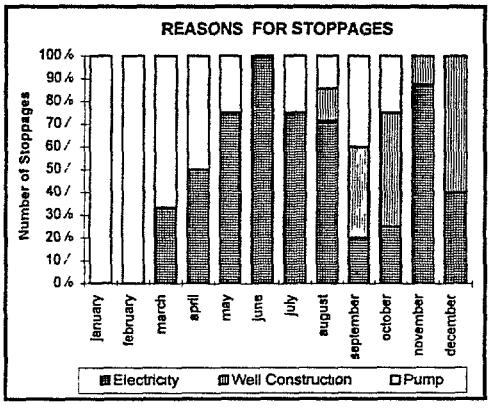


Figure A-13
South Well Field Analysis - Stryi

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South Well Field Analysis Hlynna Navaria

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Hlynna Navaria	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 m /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

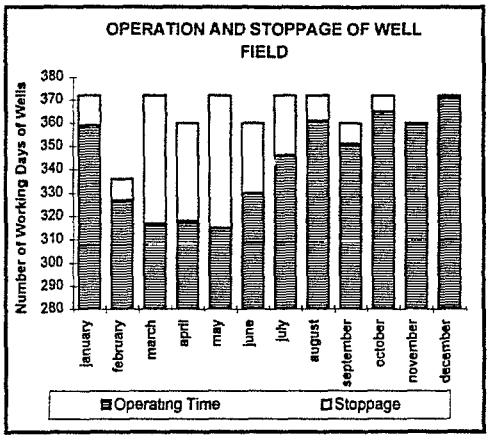
Type of pumps (and capacity kW)

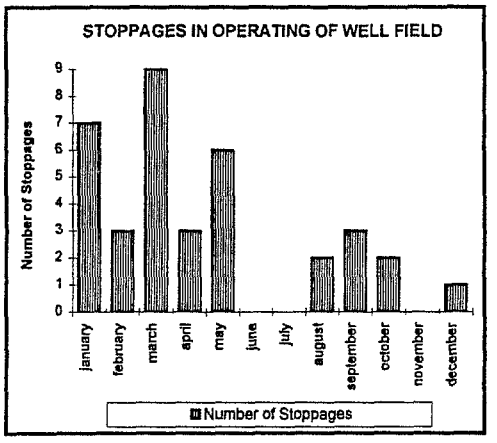
wells 1 1a 2a 4 5 7 7a	ЭЦВ10-63-110	(32)
well 2 3	ЭЦВ8-16-100	(17)
wells 6 6a 8	ЭЦВ12 160-100	(65)

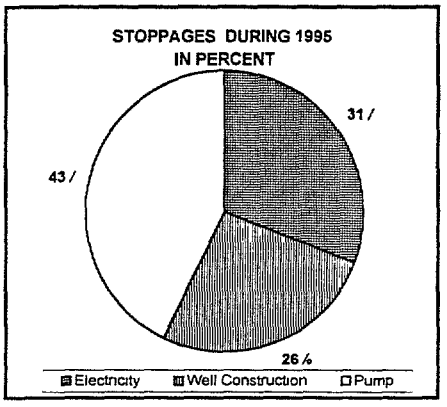
Criterion of operating effectiveness of well field 0 941

Probability of non stop work of well field 0 118

Percent of stoppages % 5 94







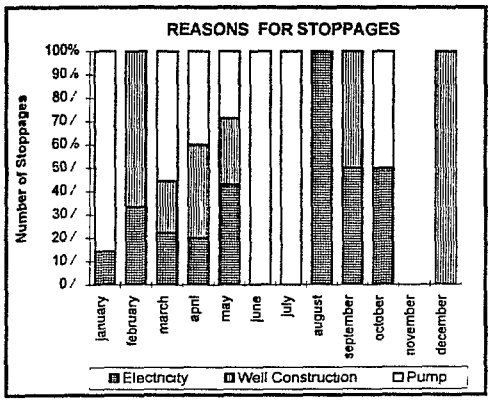


Figure A-14
South Well Field Analysis - Hlynna Navaria

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South Well Field Analysis Bibrka

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Bibrka	20	13 3	6 7

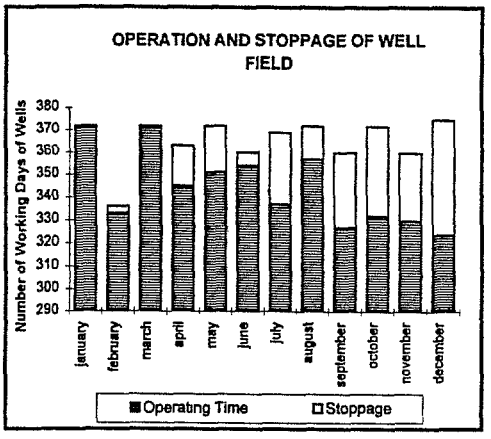
AQUIFER

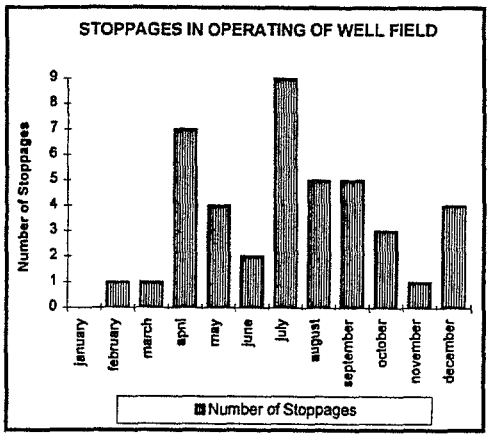
Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel

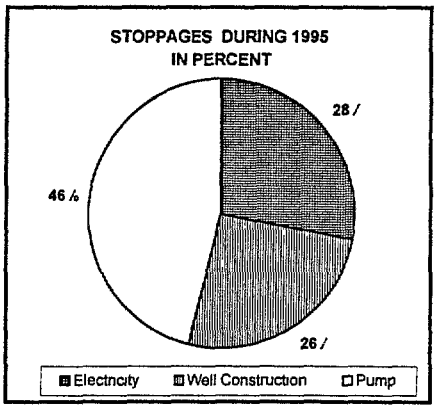
Thickness of aquifer m	40
Static water level m	(+) 1 7 4 5
Pumping rate m³/day	1780 5885
Specific capacity m²/day	88 720
Transmissivity m²/day	1070
Thickness of covering layer m	15 20
Thickness of clay within the covering layer m	15 20

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







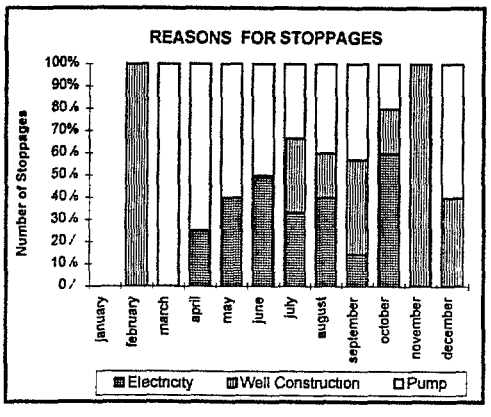


Figure A-15
South Well Field Analysis - Bibrka

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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

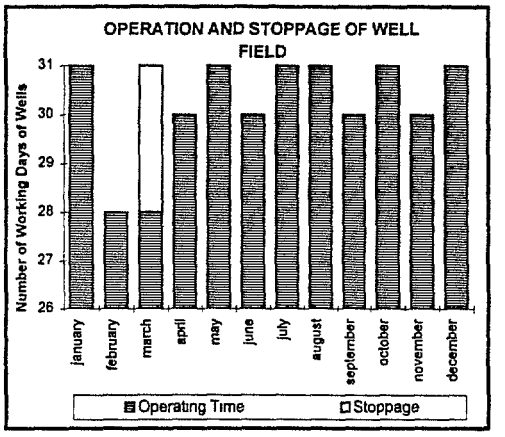
WELL FIELD (technical characteristics)

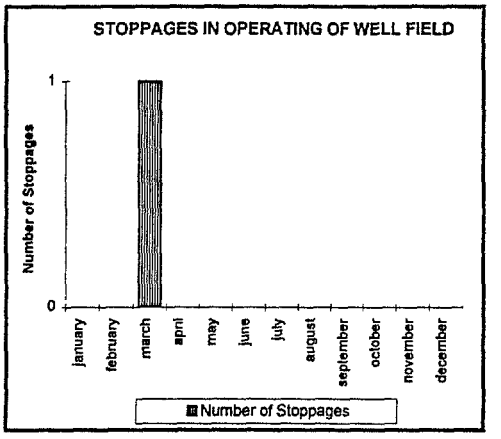
Number of wells	1
Depth of wells m	70
Diameter of wells mm	426
Type of pumps (and capacity kW)	
wells 1 ЭЦВ12 160-65	(45)

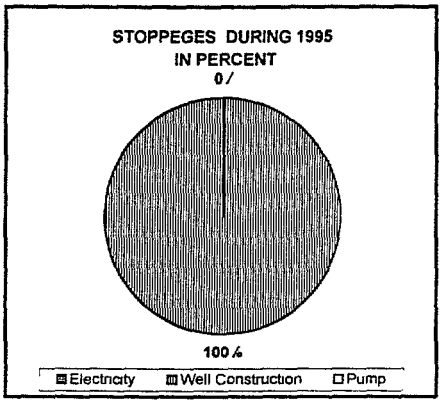
Criterion of operating effectiveness of well field 0 992

Probability of non stop work of well field 0 992

Percent of stoppages % 0 82







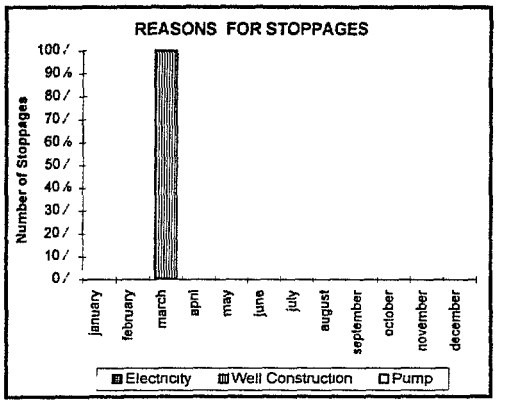


Figure A-16
South Well Field Analysis - Malechkovychi

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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 m^3/day	2073 6912
Specific capacity m^2/day	458 1918
Transmissivity m^2/day	690 2890
Thickness of covering layer m	5 15
Thickness of clay within the covering layer m	0 2

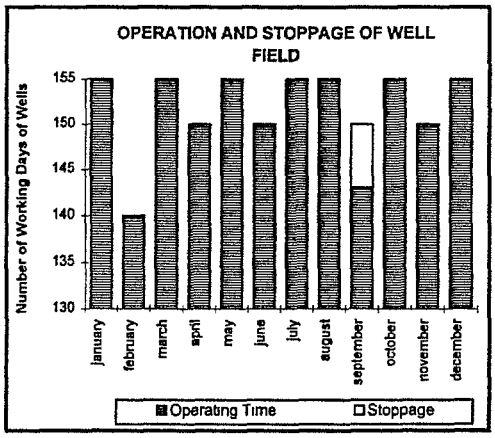
WELL FIELD (technical characteristics)

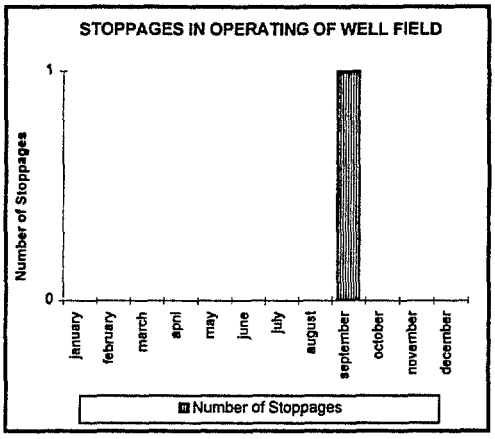
Number of wells		5
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 1 5 6 7	ЭЦВ12 160-65	(45)
wells 11	ЭЦВ10-63-65	(22)

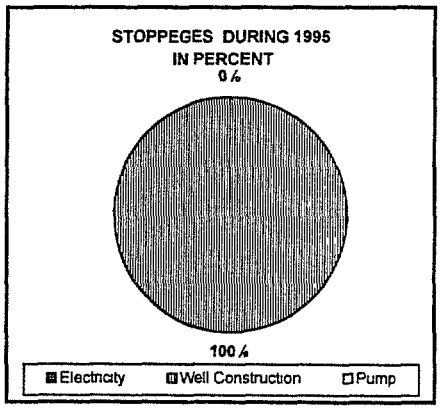
Criterion of operating effectiveness of well field 0 996

Probability of non stop work of well field 0 996

Percent of stoppages % 0 38







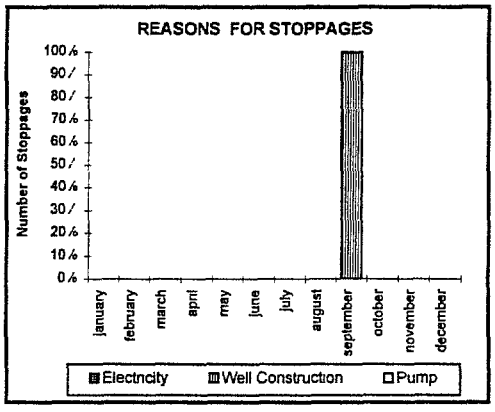


Figure A-17
West Well Field Analysis - Volia Dobrostanska

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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 m /day	690 2890
Thickness of covering layer m	10 15
Thickness of clay within the covering layer m	0

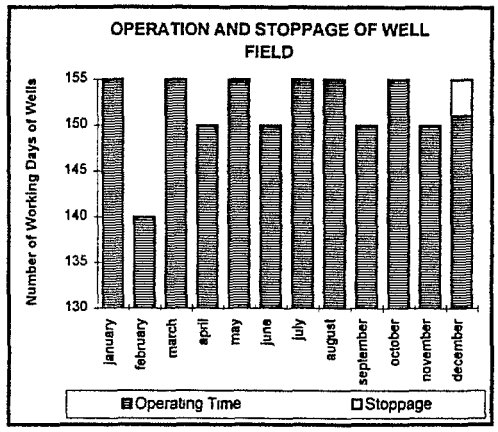
WELL FIELD (technical characteristics)

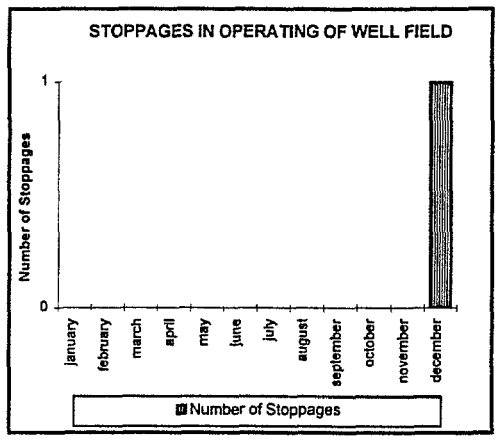
Number of wells		5
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 1 5	ЭЦВ10-120-65	(32)
wells 2 4	ЭЦВ12 160-65	(45)
well 3	ЭЦВ8-25-70	(17)

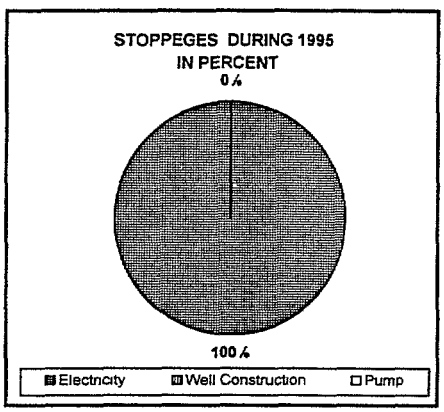
Criterion of operating effectiveness of well field 0 998

Probability of non stop work of well field 0 998

Percent of stoppages % 0 22







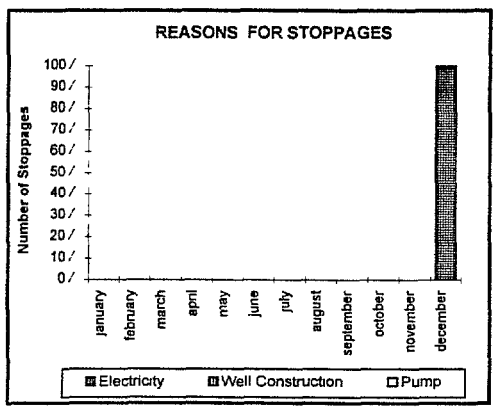


Figure A 18
West Well Field Analysis Velykopole

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West Well Field Analysis Kamianobrody

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Kamianobrody	33	23	0

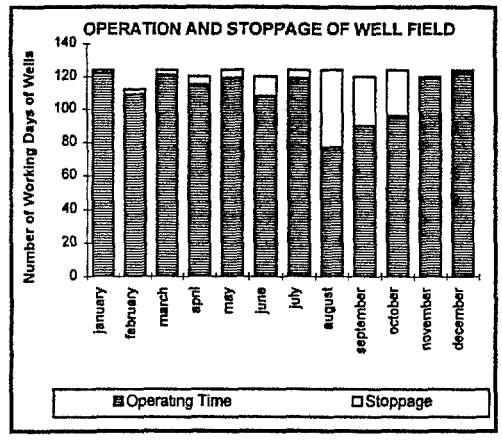
AQUIFER

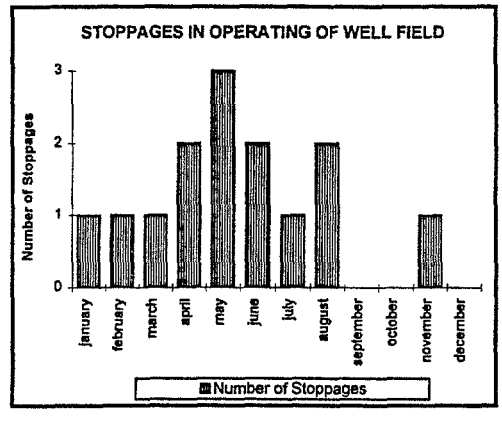
Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel

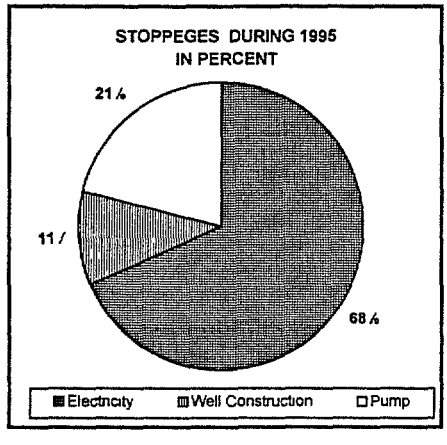
Thickness of aquifer m	25
Static water level m	( ) 2 2 3 6
Pumping rate m³/day	1132 2402
Specific capacity m²/day	353 600
Transmissivity m²/day	1380
Thickness of covering layer m	10 15
Thickness of clay within the covering layer m	5 10

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







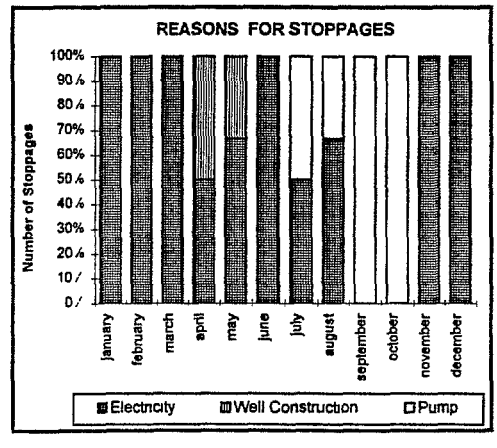


Figure A-19
West Well Field Analysis - Kamianobrody

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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

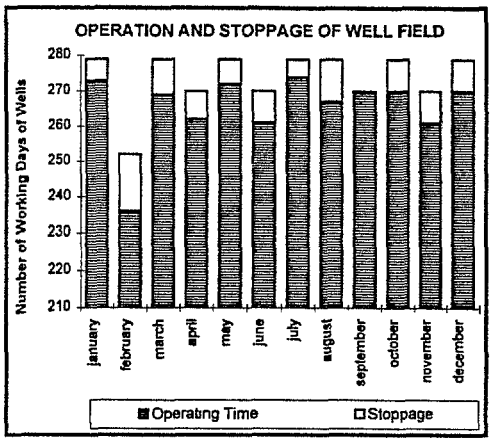
WELL FIELD (technical characteristics)

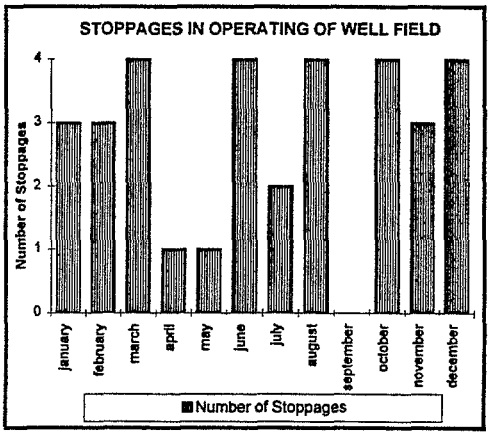
Number of wells		9
Depth of wells m		70
Diameter of wells mm		426
Type of pumps (and capacity kW)		
wells 1 2a	ЭЦВ8-25-70	(17)
wells 2 3 3a 4a	ЭЦВ10-63-110	(32)
well 4 5 6	ЭЦВ12 160-65	(45)

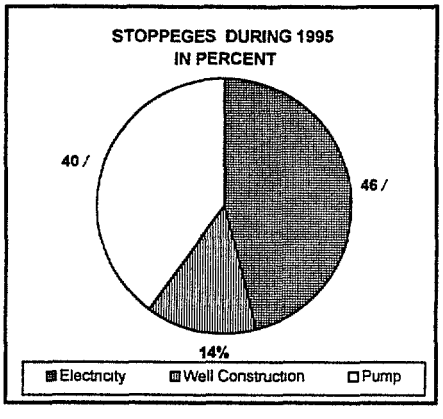
Criterion of operating effectiveness of well field 0 969

Probability of non stop work of well field 0 366

Percent of stoppages % 3 04







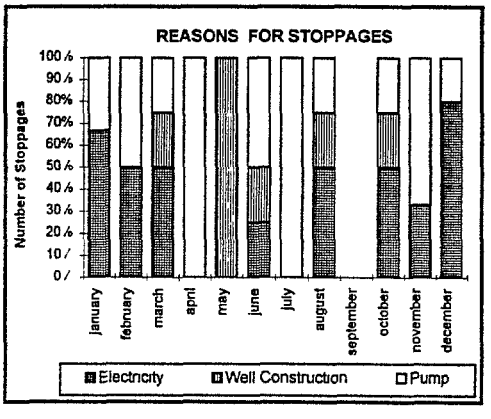


Figure A-20
West Well Field Analysis - Malchytsi

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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

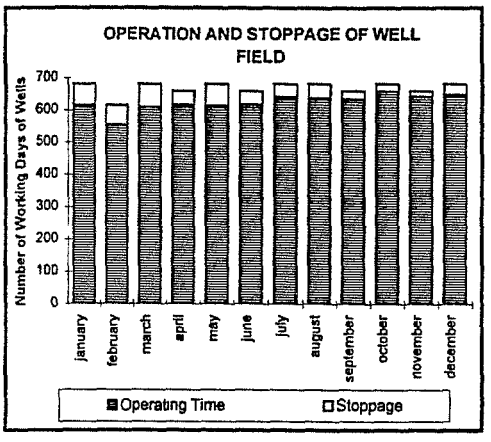
WELL FIELD (technical characteristics)

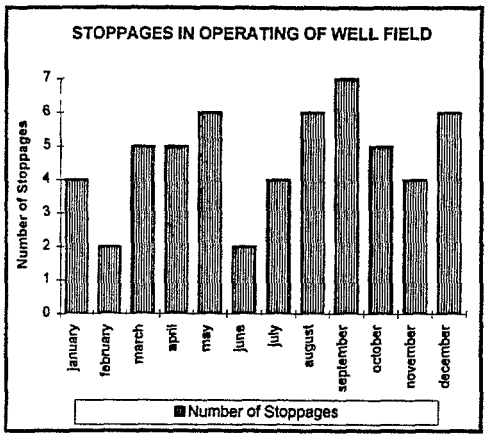
Number of wells	22
Depth of wells m	70
Diameter of wells mm	426

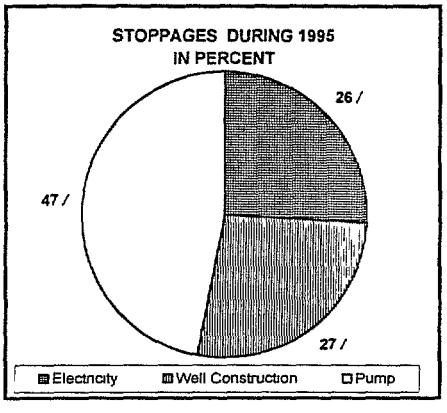
Type of pumps (and capacity kW)

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







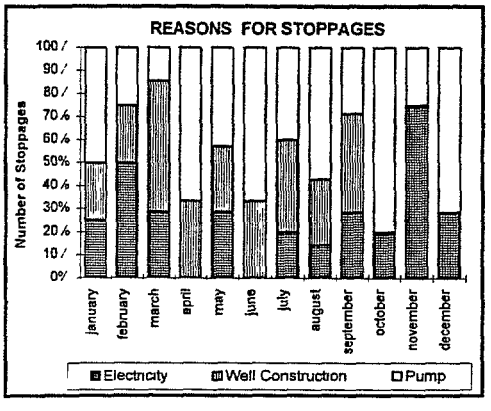


Figure A-21
West Well Field Analysis - Budzen

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West Well Field Analysis Kernytsia

YIELD 1 000 m³/day

	Total	Safe Yield	Added Yield
Kernytsia	15 4	9	6 4

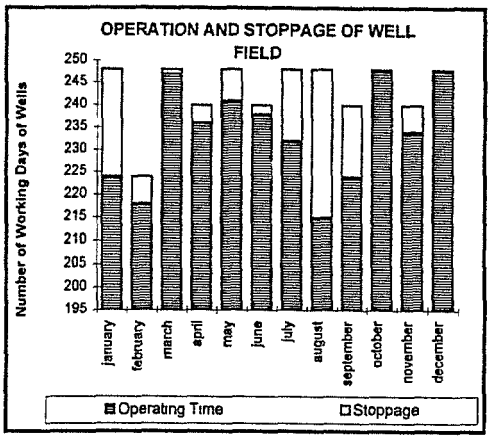
AQUIFER

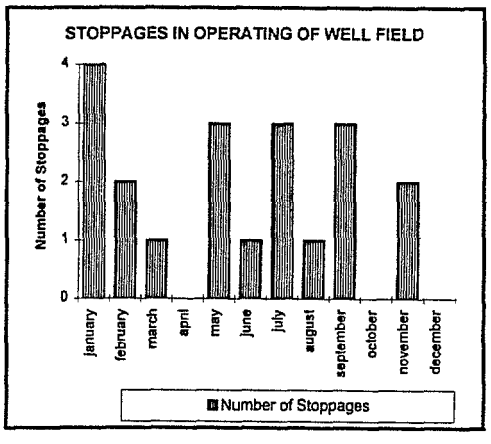
Description Miocene Complex mostly Sandstones sometimes weathered and washed to Sand and Gravel

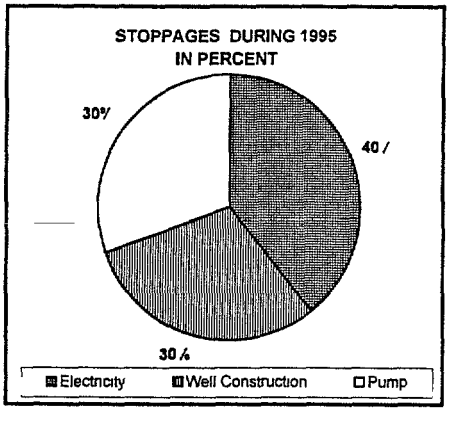
Thickness of aquifer m	35
Static water level m	(+) 2 0
Pumping rate m³/day	720 3456
Specific capacity m²/day	124 1839
Transmissivity m²/day	2050
Thickness of covering layer m	15 50
Thickness of clay within the covering layer m	5 15

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







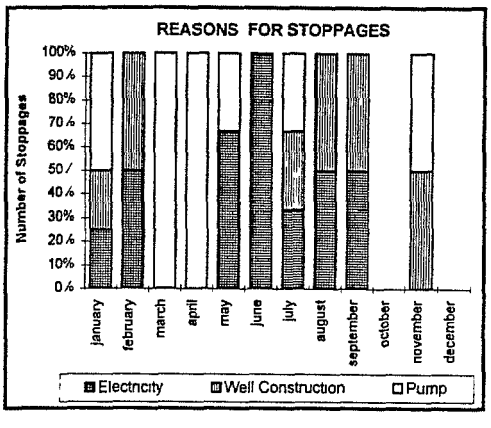


Figure A 22
West Well Field Analysis - Kernytsia

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

CH2M HILL International Consortium of Subcontractors Center for International Environmental Law Clark Atlanta University/Historically Black Colleges Universities and Minority Institutions Technology Consortium Consortium for International Development Ecojuris Environmental Compliance Inc Harvard Institute for International Development Hughes Technical Services Company International Programs Consortium International Resources Group Interfax K&M Engineering Ogden Environmental and Energy Services Price Waterhouse the World Wildlife Fund and numerous local subcontractors and cooperators throughout the NIS

Environmental Policy and Technology Project
A USAID Project Consortium led by CH2M HILL

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P O Box 24548 Denver Colorado 80224 U S A