FIELD REPORT

PREFEASIBILITY STUDY: SEVLIEVO, BULGARIA

WASH Field Report No. 451
December 1994

WATER AND SANITATION for HEALTH PROJECT

Sponsored by the U.S. Agency for International Development
Operated by CDM and Associates

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PREFEASIBILITY STUDY: SEVLIEVO, BULGARIA

Prepared for the ENI Bureau
U.S. Agency for International Development
under WASH Task No. 541

by

William Hogrewe

December 1994

Water and Sanitation for Health Project
Contract No. DPE-5973-Z-00-8081-00, Project No. 936-5973
is sponsored by the Bureau for Global Programs, Field Support, and Research
Office of Health and Nutrition
U.S. Agency for International Development
Washington, D.C. 20523

RELATED WASH REPORTS

Water Quality Pre-Investment Studies in the Yantra Basin in Bulgaria. August, 1993. Field Report #408. Prepared by Max Clark, David Laredo, and William Hogrewe.

DEMDESS 1994 Summary Report. November, 1994. Field Report #441. Prepared by Tim Bondelid.

Pollution Prevention Assessment: Sevco Tannery, Sevlievo, Bulgaria. November, 1994. Field Report #449. Prepared by Thomas C. Thorstensen.

ABOUT THE AUTHOR

William Hogrewe is a registered professional engineer with over 19 years of experience in the management of hazardous, industrial, and domestic waste. He has supervised and participated in the planning, funding, design, construction, operation, and maintenance of wastewater facilities for government and industry in the United States and abroad. Dr. Hogrewe was the industrial waste specialist for the WASH Pre-Investment Studies conducted in Bulgaria in 1992 and 1993 and participated in additional WASH teams in Hungary, Slovakia, Bulgaria, and Romania in 1994. He holds a B.A. in Chemical Engineering and an M.S. and Ph.D. in Civil/Environmental Engineering. Dr. Hogrewe is currently an Environmental Protection Specialist with the Environmental and Natural Resources Division of USAID's Bureau for Europe and the New Independent States.

CONTENTS

Materials and data for Configurations I and II are available on request. Configuration I covers Municipal treatment information and community data. Configuration II gives data on the tannery treatment system and annual costs. For copies of this material, contact EHP, 1611 N. Kent St., Ste., 300, Arlington, VA 22209.

TABLES

FIGURES

Acronym	Definition
BOD_5	Biochemical Oxygen Demand (executed in five days)
Cd	Cadmium
COD	Chemical Oxygen Demand
Cr	Chromium
Cr_T	Total Chromium
Cu	Copper
DEMDESS	Danube Emissions Management Decision Support System
Fe	Iron
MOE	Ministry of Environment
NGO(s)	Nongovernmental Organization
NH_3	Ammonia
Ni	Nickel
NO^-_2	Nitrite
NO_3^-	Nitrate
N_{org}	Organic Nitrogen
N_T	Total Nitrogen
O&G	Oil and Grease
O&M	Operations and Maintenance
Pb	Lead
P_T	Total Phosphorous
Qualze	U.S. EPA's Standard Water Quality Model
S^{-2}	Sulfide
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WAWTTAR	Water and Wastewater Treatment Technologies Appropriate for Reuse
Zn	Zinc

EXECUTIVE SUMMARY

Sevlievo is a town located in north central Bulgaria with a population of approximately 30,000. The existing sewerage system serves 60 percent of the town's population and discharges into the Rositza River. Seven major industries discharge to the river, either directly or through the sewer system. The tannery is the town's largest single source of organic and nutrient loading. Instream water quality and effluent data indicate that the discharges from the municipality (10,000 cmd) and industries (3,000 cmd) which include organics, solids, and nutrients, have a major impact on the water quality of the Rositza River.

Objectives

The objectives for this study of Sevlievo are as follows:

- obtain and promote community input and involvement on wastewater management facilities decisions;
- identify and characterize cost and performance of wastewater treatment alternatives for municipal and industrial wastewaters;
- identify wastewater reuse options;
- evaluate feasible configurations for cost, performance, and flexibility; and
- demonstrate the WAWTTAR computer program in a situation charactorized by industrial wastes and limited community resources.

A previously conducted pre-feasibility study identified only one alternative that met the criteria set by the Ministry of Environment (MOE) for discharge to the stream. A very expensive conventional treatment system which was unaffordable for the population, even with large industrial subsidies. Several non-conventional treatment systems and reuse options had to be considered to determine the appropriate level of treatment for the communitiy's financial resources. Theses include less expensive, more land intensive, natural systems and industrial pre-treatment options.

The WAWTTAR computer program which can quickly look at several treatment trains, estimating the performance, cost, flexibility, and appropriateness to discharge standards and community resources, was modified to include industrial, as well as a large number of municipal wastewater treatment processes. It is important to note that this program is just a tool to assist in numerous engineering and economic calculations and screening alternatives and to offer a range of options for decision makers. The program allows the investigation of non-conventional technologies and the identification of their advantages and disadvantages.

The DEMDESS program was also modified to help predict the environmental and economic impacts of alternative waste management schemes and to provide a convenient method for presenting results.

As a test case for WAWTTAR, an in-town treatment site was compared with an out-of-town site and the questions became how and where to treat organic and nutrient contamination.

A complete decision process will require cinsideration of many other factors and contingencies and all of the parties involved — MOE, municipality, community, NGOs, and industry — must work together to gather additional information. Even though some money has already been spent on design of the proposed municipal wastewater treatment plant, reconsideration now may save large amounts of capital and O&M costs in the future.

All of the water in the Rositza River is used during the irrigation season; therefore the wastewater has value as irrigation water and could be reused for agricultural purposes and possibly in fisheries and industries. Unfortunately, little data was available to evaluate the reuse options, so more investigation is needed. The economic evaluation of the use of wastewater for irrigation is significantly influenced by the regulations which require treatment to Class II standards, which require removal of nutrients to tertiary treatment levels even though the nutrients may be useful for crops.

The example to be evaluated for this study was described by two configurations. Configuration I consisted of a single municipal wastewater treatment plant (WWTP) for domestic and industrial wastewater. The industrial wastewater would be pre-treated only to a level sufficient to prevent damage to the municipal treatment plant. The plant could be located at the tannery site (in-town) or at the out-of-town site. The in-town site was limited to less than 5 ha. The out-of-town option requires a lift station and transmission line. In configuration II, the tannery's wastewater was treated on site and discharged to the river, while the municipal and other industrial wastewater was treated at a site outside of town.

Several levels of treatment were examined for each configuration, including treatment adequate for agricultural reuse and treatment to the Class II stream standards. The results of the WAWTTAR runs were reviewed for cost, performance, and appropriateness for the community. This review led to the following conclusions and recommendations:

Conclusions and Recommendations

The conclusions from this study can be summarized as follows:

- The tannery wastewater contains a larger mass of oxygen — demanding compounds than all of the municipal and other industrial wastes combined, necessitating the greatest attention to decreasing this waste stream and optimizing its treatment.

- Minimization of other industrial wastes can reduce the need for treatment.

- Possible changes to the tannery's effluent quality could drastically alter the treatment facilities needed.

- Treatment of tannery organics at the municipal plant takes advantage of economies of scale, with the annual cost of the treatment system for the combined waste stream (Table 8) using activated sludge below the cost fpr two separate systems.

- The construction costs for treatment at a location outside town is approximately equal to the in-town option when the collector is included.

- Nutrient removal costs are very high, with the cost of the Vodocanal system several times higher than that for any other option for either the combined or separate tannery treatment.

- Regulations that require high quality water for agricultural reuse or discharge undiluted to the stream also require very expensive treatment systems.

- The selection criteria must include economics (cost of capital and O&M costs), technical feasibility, and ability of the local community to sustain the effectiveness of the facilities.

- The results of this study must be fine-tuned, taking into account changes in the local situation and actual construction costs.

Recommendations

- Waste minimization should be studied at all industries.

- Wastewater reuse options should be investigated for both agriculture and industry.

- Both the MOE and the community must continue the process of analysis. A workshop on WAWTTAR would be very useful.

- Methods of financing any option must be investigated, including funding of facility construction and O&M by domestic and industrial users.

- Effluent regulations need to be evaluated and phased implementation considered.

- Accurate measurement of domestic and industrial flows needs to be developed, along with confirmation of water quality data.

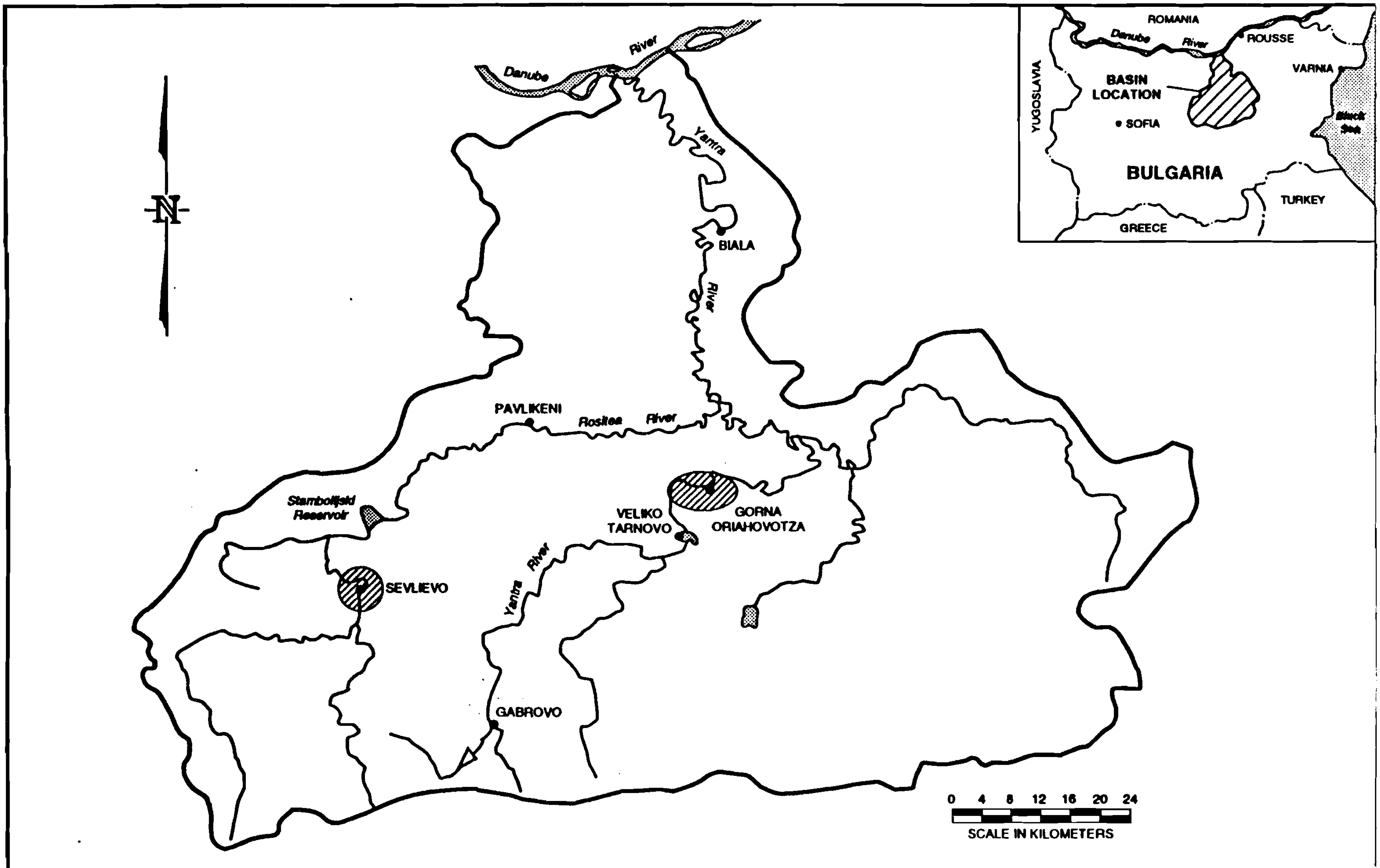

Figure 1
Location Plan of the Yantra Basin in Bulgaria

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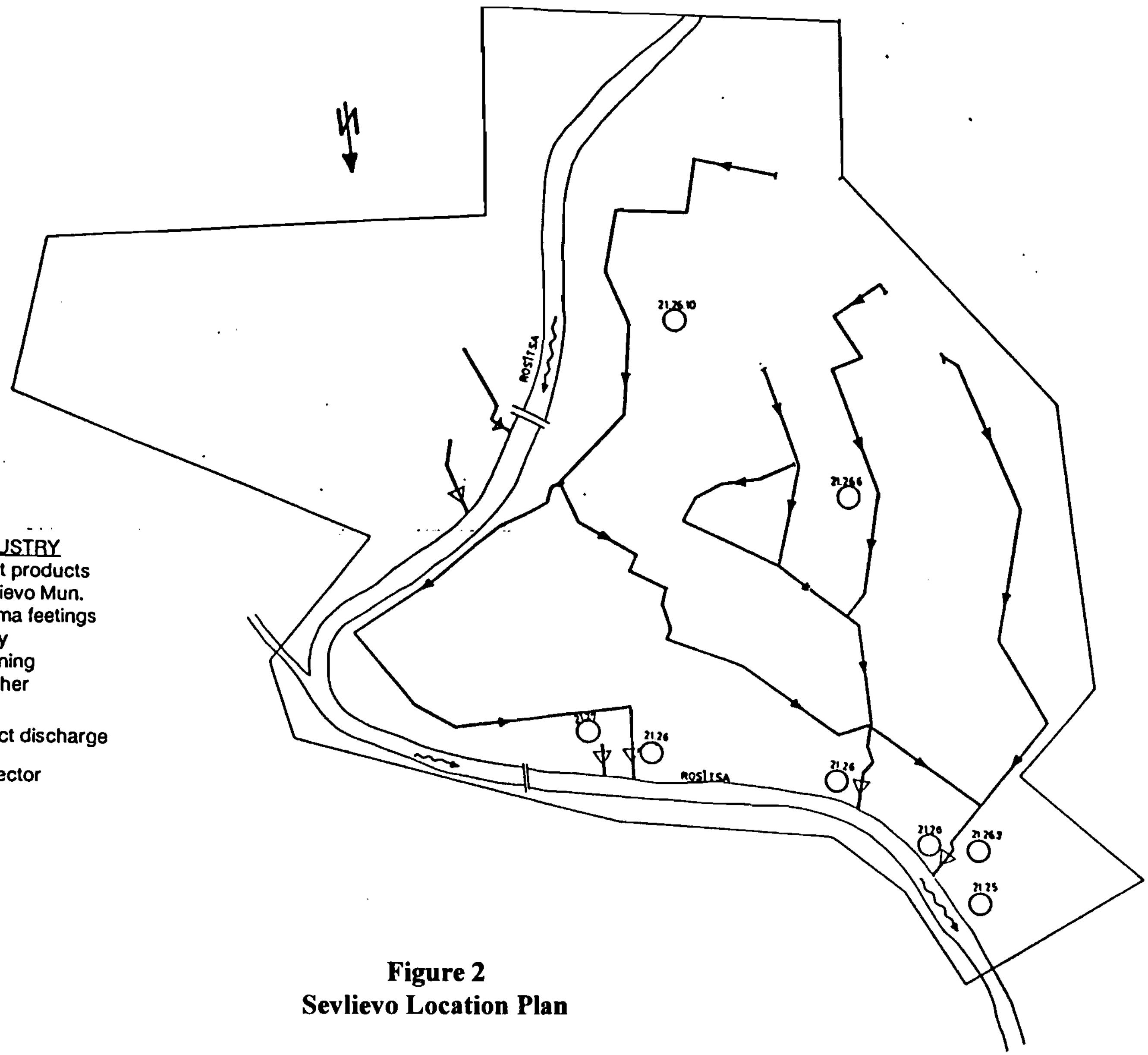

LEGEND

ID NO.	INDUSTRY
21.25	Meat products
21.26	Sevlievo Mun.
21.26.10	Vidima feetings
21.26.3	Dairy
21.26.6	Canning
21.27	Leather

—▷— Direct discharge

—▶— Collector

Figure 2
Sevlievo Location Plan

Chapter 1

GENERAL BACKGROUND

The background information and population projections in this study are taken from the August 1993 document, *Water Quality Pre-Investment Studies in the Yantra Basin in Bulgaria* (WASH Field Report No. 408). The objectives of the current study for Sevlievo are as follows:

- obtain and promote community input and involvement;
- identify and characterize cost and performance of wastewater treatment alternatives for municipal and industrial wastewaters;
- identify wastewater reuse options;
- evaluate feasible configurations for cost, performance, and flexibility; and
- demonstrate the WAWTTAR computer program (a computerized analytical tool developed in the Danube basin studies conducted by the Water and Sanitation for Health Project. The acronym stands for "Water and Wastewater Treatment Technologies Appropriate for Reuse").

1.1 Service Area and Projected Population

Sevlievo's existing sewerage system is shown schematically in Figure 2. The town is located on relatively flat, somewhat hilly terrain. Development has occurred predominantly on the left bank of the Rositza River — where all industry is located — and relatively few geographic obstacles impede the town's growth. Sevlievo contains seven significant industrial dischargers, of which the tannery is the major one. Population growth within the service area is expected to be slight over the foreseeable future: the population estimated for 1993 is 30,000; for 2000, 32,000; and for 2010, 35,000.

Sevlievo's existing sewerage system serves 60 percent of the town's population and contains three major discharge points into the Rositza River. To increase the customer base of the wastewater treatment plant at a small marginal cost, a service target of 90 percent has been adopted for the years 2000 and 2010. (The topography of the towns and their lightly settled peripheries will prevent 100 percent coverage.) In addition, a major collector along the left bank is needed to pick up the municipal and industrial discharge points.

1.2 In-stream Water Quality

The water quality profiles for the Rositza River downstream of Sevlievo show large increases in BOD_5 and nutrient concentrations, and a decrease in DO (dissolved oxygen) concentration is predicted using the QUAL2e mode U.S. EPA's standard water quality model. These data indicate that Sevlievo's municipal and industrial discharges have a major impact on the water quality of the Rositza River. The Rositza is a Class II stream, according to the Ministry of Environment (MOE). Because of the low stream's flow during parts of the year, the MOE requires that discharges to the stream meet the Class II stream standards without dilution. Stream standards are given in Table 1.

Table 1
Water Quality Standards

		Class		
		I	II	III
Parameter	**Units**	**Upper Limit or Range**		
Ammonia	mg/l	0.1	2	5
BOD_5	mg/l	5	15	25
COD	mg/l	25	70	100
Dissolved oxygen	mg/l	6	4	2
Dissolved solids	mg/l	700	1,000	1,500
Suspended solids	mg/l	30	50	100
Coliform	#/100ml		10	
Cadmium	mg/l		0.01	
Copper	mg/l		0.1	
Chrome (Trivalent)	mg/l		0.5	
Chrome (Hexavalent)	mg/l		0.05	
Cyanide (Decomposable)	mg/l		0.05	
Cyanide (Total)	mg/l		0.5	
Extractable Substances	mg/l		3	
Iron	mg/l	0.5	1.5	5
Lead	mg/l		0.05	
Manganese	mg/l	0.1	0.3	0.8
Nickel	mg/l		0.2	
Nitrate	mg/l	5	10	20
Nitrite	mg/l		0.004	
Phosphate	mg/l	0.2	1	2
pH	pH	6.5-9	6-9	6-9

[1] Stream Class I: drinking water supply; Class II: irrigation, recreation, and fisheries; Class III: non-potable industrial use.

Chapter 2

DISCHARGERS IN THE SEVLIEVO AREA

The projected wastewater flows have been estimated in part from recent metered water consumption records provided by the town's municipal water company and in part from previous studies on Sevlievo's water supply and wastewater systems. Table 2 summarizes the wastewater flows for current conditions and projects flows for the years 2000 and 2010.

Several studies provide the design basis of the municipal and industrial wastewater systems in Sevlievo were designed on the basis of several studies of the area. The sewer system was surveyed in 1970, and flow and water quality data were collected on industrial emissions from 1970 to 1975. Additional studies of industrial and domestic waste were made in 1979, 1980, 1985, and 1989 and were used to design the town's industrial wastewater treatment plants. In 1991, a design was prepared for the Sevco tannery wastewater treatment plant, and construction is now underway.

The industrial flow rate for 1993 reflects the fact that current production rates are approximately one-half of total production capacity; the industrial flow for 2000 represents the wastewater that would be generated at full industrial production using existing facilities. The industrial flow is expected to decrease by 20 percent in 2010 as a result of in-plant water reuse and conservation practices. The tannery flows in Table 2 for 2000 and 2010 reflect an increase in production capacity that will result from current construction.

Table 2
Projected Wastewater Flows for Sevlievo

Source	Year		
	1993	2000	2010
	Wastewater Flow, cmd		
Household and public water use	6,000	8,000	10,000
Industrial water use (dairy, meat processing, canning, auto repair, etc.)	3,300	10,000	8,000
Tannery	1,300	2,500	2,500
TOTAL	10,600	20,500	20,500

2.1 Municipal Discharge

For the purposes of this study, it was assumed that the domestic (household and public water) component of the wastewater stream — i.e., without the input of industrial wastes — contains contaminants in the concentrations listed in Table 3. The design flow is assumed to be 10,000 cmd for municipal wastewater only.

Table 3
Estimated Municipal Wastewater Concentration

Parameter	Concentration
BOD_5	208 mg/l
TSS	275 mg/l
TDS	450 mg/l
Total coliform	10^7/100ml
O&G	100 mg/l
NO_3^-	1 mg/l
Ammonia	12 mg/l
Total nitrogen	40 mg/l
Phosphorous	2 mg/l

2.2 Industrial Pretreatment Facilities

There are 11 major industrial wastewater emissions to the Sevlievo collection system. In addition, a tannery, a meat processing plant, and an auto repair facility in the area discharge directly to the Rositza River. The industries that discharge to the municipal system account for a combined flow of 3,000 cmd, a BOD_5 loading of 347 kg/day, total suspended solids of 655 kg/day, and total nitrogen of 51 kg/day.

The following sections discuss the possible changes for each industry which would reduce the contaminant load on the Sevlievo municipal system and on the proposed municipal wastewater treatment plant. This information was compiled from studies of industrial emissions performed by the Ministry of Environment and from site visits. Table 4 also summarizes this information.

Sevco, Ahmed Tatarov (I.D. No. 21.27)

Sevco Tannery treats pig leather with calcium hydroxide, sodium sulfide, chromium, ammonia, cleaners, and pigments. Its existing wastewater treatment plant was sized for 1,300 cmd to remove metals and suspended solids. Equipment includes screens, settlers, a mixing tank, reagent mix tanks, a reaction tank, and a settler. The treatment process uses ferrous sulfate, calcium hydroxide, and a flocculent. Sludge production is approximately five tons per day and is disposed of at the old town landfill near the Rositza River. The treated wastewater is discharged directly to the Rositza. Treatment is incomplete, and emissions exceed the limits for BOD_5, COD, ammonia, and total nitrogen. The tannery's emissions also contain large concentrations of dissolved and suspended solids. Occasionally, high levels of trivalent chromium, cadmium, lead, nickel, and copper are present in the effluent.

The existing treatment plant is in poor repair, and a new treatment plant, currently under construction, will treat existing flows and wastewater from expansion of the production process, also underway. The flow rate from the expanded production facility is expected to total 2,500 cmd. The new treatment plant includes the following equipment: fine screen, sand and oil separator, flow equalization basin, chemical coagulator, final settler, sludge thickener, and mechanical sludge dewaterer.

D. Hinkov (I.D. No. 21.26.11)

This manufacturing plant produces garment fasteners. The production process includes electroplating of zinc and nickel. The wastewater treatment facility is designed for 4 cmd and includes neutralization and precipitation in three settling tanks. The treated wastewater is discharged to the town system. Currently, emissions exceed the limits for zinc and nickel. High concentrations of total suspended solids and ammonia are also present. The production processes should be evaluated for waste minimization opportunities. Additional wastewater treatment facilities or modifications to existing facilities should be evaluated to reduce the loading of metals, solids, and ammonia to the proposed municipal treatment facilities. Sludge management should also be a priority.

Vidima Ideal (I.D. No. 21.26.10)

Vidima Ideal manufactures plumbing fixtures in a process that includes operations for plating with chromium, nickel, and gold, as well as enameling. The company's wastewater treatment plant is sized for 35 cmd and includes equipment for chromium reduction with sodium bisulfite, neutralization and precipitation of metal hydroxides, and sludge dewatering. Sludge is generated at the rate of 600 kg/day and is disposed of in the town landfill, and treated wastewater is discharged to the town system.

It appears that this facility has good treatment (except for occasional high levels of nitrate), and that modifications are unnecessary. However, metals containing sludge should be properly managed.

Elprom Avangard (I.D. No. 21.26.5)

This plant produces electric motors and switches. Its process includes cadmium and silver plating and pickling. Three separate wastewater streams are treated here: cyanide (CN^-) waste, chromium waste, and acid/alkaline waste. The existing 30 cmd wastewater treatment facility includes CN^- destruction with sodium hypochlorite, chromium reduction with sodium bisulfite, neutralization, and precipitation. Wastewater treatment sludge is disposed of at the town landfill, and treated wastewater is discharged to the town system. Wastewater quality exceeds the limits for copper, cadmium, and lead. Waste minimization should be investigated to reduce the metals loading to the industrial pre-treatment plant. Treatment facility operation and equipment improvements should be identified, and sludge management should be improved.

Rositza Auto Repair (I.D. No. 21.29)

This automobile repair facility contains a car wash, battery shop, and welding shop. The company operates a 70 cmd wastewater treatment facility with oil removal, pH adjustment, and wastewater evaporation. The resulting sludge is disposed of at the town landfill, and treated wastewater is discharged directly to the Rositza River. Occasionally, oil limits are exceeded. Waste minimization and improved oil removal should be investigated.

Sevly Conserve (I.D. No. 21.26.6)

Sevly Conserve produces canned fruits and vegetables and occasionally canned meat products. Its wastewater treatment facilities were designed for 1,730 cmd with screening, grit removal, and drum sieves. The removed material is disposed of in the town landfill, and the treated wastewater is discharged to the town system. The treated wastewater meets the limits except when meat is canned (the cannery's treatment facilities are not designed to handle the waste resulting from meat canning). Overall waste minimization, and treatment of meat wastes in particular, should be investigated. Proper disposal of sludge should be ensured by implementing sludge management practices.

St. Peshev (no identification number available)

According to the regional inspectorate, this machine manufacturer with metal finishing operations has a very good industrial pretreatment plant. Currently it transports its wastewater to the town landfill twice each month. The sludge from the wastewater treatment operation is stored at the factory.

Dynamo (I.D. No. 21.26.1)

Dynamo manufactures diesel generators. Its wastewater treatment facilities include neutralization of caustic solutions and currently treat 145 cmd, which are discharged to the town system. The wastewater contains some heavy metals, most notably lead, zinc, and copper.

General

The waste minimization needs at the industries in Sevlievo were identified in WASH Field Report No. 408 and are reproduced in Table 4 below. It is not the purpose of this study to refine this listing; however it is reproduced here to underscore the need to address the industrial waste pretreatment issues before municipal wastewater facilities are built in order to avoid unnecessary expenses.

Table 4
Industrial Pretreatment for Sevlievo

Industry	Description	Flow Rate	Major Contaminants	Possible Actions
Sevco	Tannery	1,300 cmd	BOD_5, TSS, total nitrogen, Cr	Waste minimization Physical chemical treatment BOD_5 removal facilities Sludge management
D. Hinkov	Garment fasteners	4 cmd	Ni, Zn	Waste minimization Improved metals-removal facilities Sludge management
Vidima Ideal	Plumbing fixtures	35 cmd	Good treatment	Waste minimization Sludge management
Elprom-Avangard	Electric motors	30 cmd	Cu, Cd, Pb	Waste minimization Improved metals-removal facilities Sludge management
Rositza Auto Repair	Car washes	70 cmd	Oil, TDS	Waste minimization Improved oil removal
Sevly Conserve	Canning	1,730 cmd	Good treatment	Treatment for meat canning operations Sludge management
St. Peshev	Machine manufacture			Further industry evaluation
Dynamo	Diesel generators	145 cmd	Pb, Zn, Cu	Waste minimization

Chapter 3

REUSE OPTIONS

3.1 Agricultural

All of the water in the Rositza River is used during the irrigation season; therefore, the wastewater has a value as irrigation water. Collection, storage, and delivery systems were not investigated for this study, so it is not possible to make an accurate cost estimate for water reuse. However, ample irrigation facilities are in place to utilize the water stored in the Stambolijski Reservoir.

Fish farming is also an alternative use of the wastewater. There is a new fish farming operation (reportedly growing carp) in the valley very close to Sevlievo.

The economic evaluation of the use of wastewater for irrigation is significantly influenced by the regulations which require treatment to Class II standards. These standards require removal of nutrients to tertiary treatment levels, even though these nutrients may be useful for crops.

3.2 Industrial Reuse

Industrial reuse options were not identified. However, further investigation on the part of the industries may uncover viable options. The MOE and the municipality could encourage these investigations through technical assistance or with tariffs on increased water use and wastewater disposal.

3.3 WAWTTAR as an AnalysisTool

The previous prefeasibility study was able to identify only one alternative that met the criteria for discharge to the stream. This option was a very expensive conventional treatment system which was shown to be unaffordable for the population, even with large industrial subsidies. Over 20 percent of the per capita income would be needed to purchase, operate, and maintain this system. It was not feasible to use normal approaches for estimating cost and performance of many treatment options. The situation called for the consideration of several nonconventional treatment systems and reuse options to determine what level of treatment would coincide with the community's financial resources. Less expensive, more land-intensive natural systems needed to be evaluated, along with industrial pretreatment options.

The WAWTTAR program was modified to include industrial as well as a large number of municipal wastewater treatment processes. This computer program can quickly look at several treatment trains, estimating the performance, cost, flexibility, and appropriateness to discharge standards and community resources. It is important to note that this program is just a tool to assist in numerous engineering and economic calculations and screening of constraints. It does not provide an absolute optimum solution but offers a range of options for the decision-makers to choose from, based on other considerations. Nonconventional technologies, which are often ignored, can easily be investigated and their advantages and disadvantages identified. The DEMDESS program[1] was also modified to assist in the prediction of environmental and economic impacts of alternative waste management schemes.

Input from the community is very important and should include not only technical data that characterize the waste streams, but also information on land constraints, financial resources, construction and operation resources, and general community preferences.

The strategy used in this study was to:

- determine community constraints and resources;
- characterize the waste streams;
- identify reuse possibilities;
- identify treatment alternatives; and,
- estimate cost and performance of feasible alternatives.

It should be noted that the modifications to DEMDESS will assist in the evaluation of the environmental and economic impacts of the alternatives.

The following sections detail the steps in the strategy:

Determine Community Constraints and Resources

A community-wide meeting was held to obtain input from the municipal government, the water and sewer operating agency, NGOs, regional water groups, the local inspectorate, and industries. Participants expressed several concerns and described many details. In addition, much information had already been gathered from the MOE and on previous trips to the community. Some of this information is discussed below.

The Bulgarian government did an Environmental Impact Assessment. The assessment reviewed plans to site the municipal wastewater treatment plant in town next to the tannery and found that this was an unacceptable option, based on public health considerations. The review cited several factors, including air pollution, air-borne pathogens, and dangers of methane gas production and storage.

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1 Danube Emissions Management Decision Support System is a computer-based emissions management system developed by the WASH Project and applied in various central and eastern European areas since 1991.

The alternative to an in-town plant is one outside of town that will require a collection system costing approximately $3,000,000. The design for this plant was done by Vodocanal, and the total construction cost is estimated at $13,000,000. The mayor's office feels that if construction of this plant is required, then nothing will be built for more than 10 years because of lack of funding.

This information lead to the decision to use in-town vs. out-of-town treatment as a test case for WAWTTAR. It was assumed that some minimal degree of waste reduction and pretreatment of industrial discharge would be provided in order to protect the operation of the receiving municipal wastewater treatment plant. By reducing or eliminating heavy metals and other industry-related compounds from the influent wastestream, treatment decisions could focus directly on ordinary organic and nutrient contamination.

Many other factors and contingencies must be considered for a complete decision process. All of the parties involved — MOE, municipality, community, NGOs, and industry — must work together to gather additional information for the decision. Even though some money has already been spent on design of the proposed municipal wastewater treatment plant, reconsideration now may save large amounts of capital and O&M costs in the future.

Characterization of Waste Streams

Table 5 provides industrial wastewater concentrations from MOE sampling data. The flow rates are assumed values for full production at each industry.

Table 6 shows the theoretical combined municipal and industrial wastewater flow and concentration. These values are derived from the wastewater generated at full industrial production, as given in Table 5, and municipal wastewater data, given in Table 2. The data in Table 6 represent the wastewater that would need to be treated if all of the industrial and municipal flows were combined.

Table 7 represents the wastewater to be treated by two separate treatment facilities. The municipal treatment plant would be located outside of town and would treat all of the municipal and industrial wastewater with the exception of the tannery, which would be treated on site at a separate treatment plant.

Table 5
Raw Industrial Effluent Data

Parameter	Dairy	Meat Processing	Tannery	Canning	Fittings
Flow, cmd	300	450	2,500	1,800	450
BOD_5, mg/l	582	697	1,976	262	6
TSS, mg/l	164	1,480	766	258	40
TDS, mg/l			5,780		
Coliform, #/100ml			100		
O&G, mg/l	20	20	20	2	10
Cd, mg/l			0.01		0.03
Cr_T, mg/l			81		0.5
Cu, mg/l			0.47		0.12
Fe, mg/l					0.5
Pb, mg/l			0.17		0.07
NO_3^-, mg/l	0.2		0.48	0.76	37
NO_2^-, mg/l	0.03				0.16
NH_3, mg/l	16	15	59.2	12.3	0.82
N_T, mg/l	84		215	36.5	38.2
P_T, mg/l	4.1		0.12	2	2
Zn, mg/l			0.01		1
COD, mg/l	930	1,150	3,264	435	40
Ni, mg/l			0.1		0.08
N_{org}, mg/l	68		155	23.5	.25
S^{-2}, mg/l			24		

Table 6
Configuration I
Combined Municipal and Industrial Wastewater

Parameter	Combined Wastewater
Flow, cmd	15,500
BOD_5, mg/l	515
TSS, mg/l	378
TDS, mg/l	1,223
Coliform, #/100ml	6×10^6
O&G, mg/l	11.2
Cd, mg/l	
Cr_T, mg/l	13
Cu, mg/l	0.1
Fe, mg/l	0.01
Pb, mg/l	0.03
NO_3^-, mg/l	1.9
NO_2^-, mg/l	0.1
NH_3, mg/l	19
N_T, mg/l	67
P_T, mg/l	1.7
Zn, mg/l	.03
COD, mg/l	630
Ni, mg/l	0.02
N_{org}, mg/l	29
S^{-2}, mg/l	4

Table 7
Configuration II
Combined Municipal and Industrial Wastewater
with Tannery Treated Separately

Parameter	Combined Wastewater	Tannery Only
Flow, cmd	13000	2500
BOD_5, mg/l	234	1976
TSS, mg/l	304	766
TDS, mg/l	346	5780
Coliform, #/100ml	8×10^6	100
O&G, mg/l	9.5	20
Cd, mg/l		0.01
Cr_T, mg/l	0.02	81
Cu, mg/l		0.47
Fe, mg/l	0.02	
Pb, mg/l		0.17
NO_3^-, mg/l	2.2	0.48
NO_2^-, mg/l	0.08	
NH_3, mg/l	12	59.2
N_T, mg/l	39	215
P_T, mg/l	2	0.12
Zn, mg/l	0.03	0.01
COD, mg/l	123	3264
Ni, mg/l		0.1
N_{org}, mg/l	4.8	155
S^{-2}, mg/l		24

Identify Reuse Possibilities

Large quantities of water could be used for agricultural reuse in the area. There is also the possibility of reuse in fisheries and in the various industries. More investigation is needed on this subject.

Identify Treatment Alternatives

The example to be evaluated for this study was described by two configurations. Configuration I consisted of a single municipal wastewater treatment plant which would treat all domestic and industrial wastewaters. The industrial wastewater would be pretreated only to a level sufficient to prevent damage to the municipal treatment plant. The plant could be located at the tannery site (in-town) or at the out-of-town site. The in-town site was limited to less than 5 ha. The out-of-town option would require a lift station and transmission line.

In Configuration II, the tannery's wastewater would be treated on site and discharged to the river, while the municipal and other industrial wastewater would be treated at a site outside of town.

Several levels of treatment were examined, including treatment adequate for agricultural reuse and treatment to the Class II stream standards. The Vodocanal design was included in the analysis to provide a comparison of this technology to a range of others and to compare the cost and performance estimates predicted by WAWTTAR to the predictions of the designers.

An interesting outcome of this part of the analysis was that most of the total phosphorous from the town was from the canning and fittings factories, and most of the oil and grease ("O&G") was from the dairy, meat, and tannery operations. This indicates that waste minimization activities at these industries would greatly reduce the need for nutrient removal from the combined wastewater stream.

Estimate Cost and Performance of Feasible Alternatives

Tables 8 and 9 provide the cost and performance estimates from WAWTTAR for the treatment plants in the two configurations. A 10 percent interest rate for funds was used, rather than the current 100 percent rate, with the assumption that 10 percent loans could be made available. Land cost was estimated at $10,000/ha and is included in the annualized capital cost but not in the construction cost estimate. The municipal treatment trains reported in Tables 8 and 9a are as follows:

Ponds — bar screen, facultative pond, gas chlorination with dechlorination;

Wetland — bar screen, grit chamber, facultative pond, free surface wetland, gas chlorination with dechlorination;

Vodocanal Design — bar screen, grit chamber, low lime primary, activated sludge with nitrification and denitrification, gas chlorination with dechlorination, gravity thickening of sludge, open sludge digestion, sludge drying beds;

Conventional Activated Sludge — bar screen, grit chamber, primary settling, activated sludge, gas chlorination with dechlorination, gravity thickening of sludge, open sludge digestion, sludge drying beds;

Aerated Lagoons — bar screen, aerated lagoon, gas chlorination with dechlorination.

The tannery treatment trains in Table 9b are:

Trickling Filter — flow equalization, gravity oil removal, sedimentation, super high rate trickling filter, gravity thickening of sludge, two stage anaerobic sludge digestion, sludge belt filter press;

Extended Aeration Activated Sludge — flow equalization, gravity oil removal, sedimentation, extended aeration activated sludge, gravity thickening of sludge, two-stage anaerobic sludge digestion, sludge belt filter press;

Aerated Lagoons — flow equalization, gravity oil removal, sedimentation, aerated lagoon;

Land Application — flow equalization, gravity oil removal, sedimentation, overland flow.

All of the treatment trains for the tannery wastewater include $1 million in construction costs for flow equalization facilities (which is $500,000 per year in capital costs) and $80,000 per year in O&M costs.

Table 8
Configuration I
Combined Municipal and Tannery Wastewater
Cost and Performance (20,000 cmd)

Treatment Description	Construction Cost	Annualized Capital Cost	Annual O&M Cost	Total Annual Cost	Land Area Required	Level of Treatment
Ponds	$1.7M	$200K	$130K	$330K	203 ha	BOD_5 < 75 mg/l
Wetland	$3.8M	$440K	$170K	$610K	260 ha	BOD_5 < 20 mg/l
Vodocanal Design	$5.9M	$680K	$1,300K	$1,980K	<5 ha	BOD_5 < 20 mg/l
Conventional Activated Sludge	$4.6M	$530K	$340K	$870K	<5 ha	BOD_5 < 50 mg/l
Aerated Lagoons	$0.71M	$80K	$160K	$240K	30 ha	BOD_5 < 100 mg/l

Table 9
Configuration II
Municipal and Tannery Wastewater
Tannery Treated Separately

a: Municipal Cost and Performance (18,000 cmd)

Treatment Description	Construction Cost	Annualized Capital Cost	Annual O&M Cost	Total Annual Cost	Land Area Required	Level of Treatment
Ponds	$1.6M	$190K	$120K	$310K	84 ha	BOD_5 < 40 mg/l
Wetland	$3.5M	$400K	$150K	$550K	140 ha	BOD_5 < 20 mg/l
Vodocanal Design	$5.5M	$630K	$1,200K	$1,830K	<5 ha	BOD_5 < 20 mg/l
Conventional Activated Sludge	$4.3M	$500K	$310K	$810K	<5 ha	BOD_5 < 20 mg/l
Aerated Lagoons	$0.67M	$80K	$150K	$230K	12 ha	BOD_5 < 50 mg/l

b: Tannery Cost and Performance (2,500 cmd)

Treatment Description	Construction Cost	Annualized Capital Cost	Annual O&M Cost	Total Annual Cost	Land Area Required	Level of Treatment
Trickling Filter	$3.1M	$770K	$400K	$1,170K	<1 ha	BOD_5 < 150 mg/l
Extended Aeration Activated Sludge	$3.6M	$820K	$440K	$1,260K	<1 ha	BOD_5 < 70 mg/l
Aerated Lagoons	$2.0M	$630K	$350K	$980K	<5 ha	BOD_5 < 100 mg/l
Land Application	$2.3M	$670K	$360K	$1,030K	<27 ha	BOD_5 < 70 mg/l

Chapter 4

CONCLUSIONS AND RECOMMENDATIONS

The conclusions from this study can be summarized as follows:

- The tannery wastewater contains a larger mass of oxygen-demanding compounds than all of the municipal and other industrial wastes combined. Therefore, the greatest attention should be paid to decreasing this waste stream and optimizing its treatment.

- Minimization of other industrial wastes can reduce the need for treatment. For example, process changes at the cannery and fittings plant could decrease the discharge of phosphorous compounds to the municipal system, thus eliminating the need for phosphorous removal at the municipal plant.

- Possible changes to the tannery's effluent quality could drastically affect the decision regarding what treatment facilities are needed. A parallel WASH report, Field Report No. 449, *Pollution Prevention Assessment, Sevco Tannery, Sevlievo, Bulgharia,* identified alterations to the tanning process that could decrease the quantity of proteinaceous compounds in the effluent. This change would result in a significantly smaller need for wastewater treatment to remove organics and nitrogen compounds.

- Treatment of tannery organics at the municipal plant takes advantage of economies of scale. The total annual cost of conventional activated sludge for municipal wastewater alone is estimated at $810,000 per year (Table 9a). The cost of tannery waste treatment must be added (a minimum of $980,000 per year for aerated lagoons) for a minimum annual total of $1,790,000 for the two separate treatment systems. This is compared to an annual cost of $870,000 per year for the treatment system for the combined waste stream (Table 8) using activated sludge.

- The construction cost for treatment at a location outside town is approximately equal to the in-town option when the collector is included. The construction cost of the conventional activated sludge plant for the combined tannery and municipal wastewater is $4.6 million. This cost is approximately the same as the total for a pond system, $1.7 million, and collector, $3 million. However, the operating costs of the pond system would be much lower.

- Nutrient removal costs are very high. The cost of the Vodocanal system, which is typical of a mechanical nutrient removal system, is several times higher than that of any other option for either the combined or separate tannery treatment.

- Regulations that require high quality water for agricultural reuse or discharge undiluted to the stream also require very expensive treatment systems.

- The selection criteria must include economics (cost of capital and O&M costs), technical feasibility, and ability of the local community to sustain the effectiveness of the facilities.

- The results of this study must be fine-tuned, utilizing changes in the local situation and actual construction costs. This study is just an example and must be refined.

Recommendations

- Waste minimization should be studied at all industries.

- Wastewater reuse options should be investigated for agriculture and industry.

- The MoE and the community must continue the process of analysis. A workshop on WAWTTAR would be very useful. An analysis of the sensitivity of the results to changes in parameters is needed. It is necessary to coordinate the interim results with NGOs, industries, the municipality, MoE, etc. To improve predictions, cost data in WAWTTAR need to be adjusted for actual construction and operating costs.

- Methods of financing for any option must be investigated, including funding of facility construction and O&M costs from domestic and industrial users.

- Effluent regulations need to be evaluated and phased implementation considered.

- Accurate measurement of domestic and industrial flows needs to be developed, along with confirmation of water quality data.

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THE WASH PROJECT

With the launching of the United Nations International Drinking Water Supply and Sanitation Decade in 1979, the United States Agency for International Development (A.I.D.) decided to augment and streamline its technical assistance capability in water and sanitation and, in 1980, funded the Water and Sanitation for Health Project (WASH). The funding mechanism was a multi-year, multi-million dollar contract, secured through competitive bidding. The first WASH contract was awarded to a consortium of organizations headed by Camp Dresser & McKee International Inc. (CDM), an international consulting firm specializing in environmental engineering services. Through two other bid proceedings since then, CDM has continued as the prime contractor.

Working under the close direction of A.I.D.'s Bureau for Science and Technology, Office of Health, the WASH Project provides technical assistance to A.I.D. missions or bureaus, other U.S. agencies (such as the Peace Corps), host governments, and non-governmental organizations to provide a wide range of technical assistance that includes the design, implementation, and evaluation of water and sanitation projects, to troubleshoot on-going projects, and to assist in disaster relief operations. WASH technical assistance is multi-disciplinary, drawing on experts in public health, training, financing, epidemiology, anthropology, management, engineering, community organization, environmental protection, and other subspecialties.

The WASH Information Center serves as a clearinghouse in water and sanitation, providing networking on guinea worm disease, rainwater harvesting, and peri-urban issues as well as technical information backstopping for most WASH assignments.

The WASH Project issues about thirty or forty reports a year. WASH *Field Reports* relate to specific assignments in specific countries; they articulate the findings of the consultancy. The more widely applicable *Technical Reports* consist of guidelines or "how-to" manuals on topics such as pump selection, detailed training workshop designs, and state-of-the-art information on finance, community organization, and many other topics of vital interest to the water and sanitation sector. In addition, WASH occasionally publishes special reports to synthesize the lessons it has learned from its wide field experience.

For more information about the WASH Project or to request a WASH report, contact the WASH Operations Center at the above address.