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HAN RIVER BASIN ENVIRONMENTAL MASTER PLAN

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ABSTRACT

The Han River Environmental Master Plan Project was initiated in March 1982 and concluded in September 1983. The study area involved contains one-quarter of the area of the Republic of Korea and one-third of the country's population. This project represents one of the first integrated environmental efforts where environmental quality improvements in the fields of water, air and land (solid and hazardous waste disposal) were considered at the same time.

The objectives of the Master Plan were to develop long-term strategies for controlling pollution within acceptable limits for the Han River Basin area to the year 2000, to develop short-term measures capable of early implementation to improve present environmental conditions, and to assess the impact of the environmental strategies selected and ensure that beneficial impacts in one environmental field would not conflict with environmental goals in other fields.

The present environmental quality of the study area, the environmental improvement strategies considered, and the recommended plan are described.

1. INTRODUCTION

The Republic of Korea comprises the southern portion of the Korean peninsula and covers an area of 99,000 sq km. The population was estimated to be 40 million in July 1982. The study area (Figure 1) covered a quarter of the land of the Republic or approximately 27,000 sq km, and included all the Han River drainage basin, except for a portion north of the Demilitarized Zone.

The largest cities included are Seoul, the capitol city, and Incheon with mid-1982 populations of 8.8 and 1.2 million, respectively. Based on estimated current population the project area contains nine other cities with populations of about 100,000 to 400,000; four cities in the range of 50,000 to 90,000; 10 towns in the range of 20,000 to 40,000; and an additional 15 smaller towns with a population of at least 10,000. The population of the project area is approximately 14.0 million, or one-third the total population of Korea. About 8,000 industries lie within the study area; many plants being located in 16 industrial complexes. From 1970 to 1982, the population of Seoul and other cities in the western study area grew by 3 to 10 percent annually, while the central and eastern study area grew at natural growth rates or decreased in population.

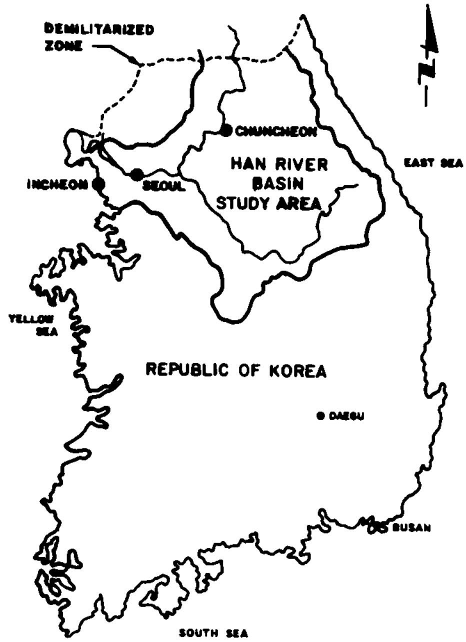

Figure 1. Map of South Korea Showing the Han River Basin Study Area

During the past twenty years the Korean economy has sustained a remarkedly high rate of growth. Gross National Project (GNP) grew at an average annual rate of 7.7 percent from 1970 to 1980. The per capita GNP rose from 204,000* to 429,000 Won (constant 1975 prices) during that period. The growth was achieved principally by well-directed industrialization and export promotion.

This rapid growth has been accompanied by a deterioration in the quality of the environment, particularly in the larger urban and industrial areas. In these areas the amounts of domestic and industrial wastes discharged far exceed the capacity of the environment to assimilate them, and serious pollution problems have resulted.

In recent years, there has been extensive development of the Han River Basin, particularly in its lower reaches. However, even in the upper reaches of the river there are environmental problems, caused by mining, agriculture, water resources development, etc. Major efforts are required to improve the present conditions and to establish regulations, procedures and facilities necessary to maintain a clean, healthful and pleasant environment.

The Korean Government has recognized this situation and already has taken significant steps toward reducing further pollution. These have included:

- Enactment of the Environment Preservation Law which established procedures for the adoption and enforcement of environmental quality standards, the preparation of environmental impact assessments, and the designation of special countermeasure zones.

* 1000 Korean Won equals (approx.) US$ 1.43

The law also authorized an Environmental Conservation Committee to function under the prime minister for the purpose of reviewing master plans, setting policies, and coordinating inter-ministerial problems.

- Formation of the Office of Environment as the central agency responsible for the protection of air and water quality and other matters related to environmental protection.

- Implementation of specific measures for reducing pollution such as the reduction in the sulfur content of petroleum derived fuels used for industrial processes and space heating within the Seoul-Incheon region from 3.8 percent to 1.6 percent. This action resulted in the immediate decrease in the amount of air pollution caused by one of the major pollutants -- sulfur dioxide -- and so provided a direct improvement to ambient air quality.

- Restrictions on commercial, institutional, and industrial development within Seoul.

- Establishment of Green Belts in major cities to constrain urban expansion.

- Construction of the Seoul Subway to reduce traffic congestion.

In addition, the government perceived the need for long range planing for environmental preservation and allocated funds for the preparation of an environmental master plan for a major priority area - the Han River Basin.

2. OBJECTIVES

The main objective of the project was to develop a long-term integrated Master Plan for protecting and improving environmental quality in the Han River Basin to the year 2001 covering the water, air and solid wastes sectors. Within the long-term Master Plan, a Priority First Phase was identified as the period from 1984 to 1988.

The following items were included in order to achieve the objectives of the Master Plan:

- summarize recent and future population, and land use

- collect and summarize inventories of wastes

- forecast future pollution and identify projects, operations, and administrative and legal arrangements required to meet environmental standards

- prepare conceptual design and feasibility studies for needed pollution control projects

- develop economic feasibility and financial plans for Master Plan and First Phase Projects

The project also included a significant training component for local personnel and for transfer of technology and ideas.

3. STUDY APPROACH

The project team was based in Seoul; the team consisted of personnel from three companies, Engineering-Science, Hyundai and Hyosung, augmented by foreign and local specialists for specific assignments. The project was initiated in March 1982 and concluded in September 1983.

Available information and prior studies were obtained and evaluated. Where gaps were found to exist, programs to gather the additional data were formulated and implemented. These programs included extensive field studies in each of the environmental, water, air, and solid wastes sectors. Major studies included water quality monitoring of the Han River, air quality monitoring and emission source testing, and solid waste composition surveys. Other studies were conducted for housing and services, trends in population, land use and waste generation, financial data, and environmental concerns.

Forecasts of population and land use were prepared. Waste loads were developed which were directly related to the forecasts. Unit generation rates, population and development forecasts were integrated taking into account the probable impact of future living standards on the types and quantities of wastes generated. This stage of the study defined the extent of the future pollution loads which are likely to be generated throughout the study area.

In modern urban communities some pollution is inevitable. The desired upper limit for such pollution is defined by establishing specific standards. For some pollutants the government had already prescribed standards. Where standards had not been prescribed, guidelines were developed for use in the preparation of the Master Plan. In many cases, the existing and future quantities of waste loads would cause environmental pollution to exceed the standards and guidelines.

The amount by which the forecast level of pollution exceeded the standard or guideline, in effect, defined the magnitude of the problem for each pollutant. Alternative strategies were developed to reduce the wastes discharges to a degree such that the qualities of the receiving waters or the ambient air would meet the applicable standard or guideline. The alternatives were then evaluated according to several criteria which included:

- effectiveness in reducing pollution
- technical feasibility
  - state-of-the-art
  - appropriateness of the technology
  - reliability
- capital and operating costs
- ease of implementation
  - financial constraints
  - institutional constraints
  - social constraints
- cross-media effects (to determine how an alternative formulated for one environmental sector might affect the other sectors)

The recommended optimum alternative was selected to form the Master Plan and an implementation program for the period 1984 to 2001 was prepared.

4. WATER QUALITY

4.1 Existing Conditions

As is the case in most Asian countries, the sewerage systems in Korea have developed from systems in which nightsoil (fecal solids) was collected in vaults or septic tanks for use on agricultural fields and liquid wastes were discharged to the surface drains. In 1982 about 60 percent of the project area population had flush toilets with a connection to the drainage system. In Seoul almost all of the drains are covered; in the rest of the project area about one-half of the drains are open channels.

There were only two functioning sewage treatment plants in the project area in 1983, both in Seoul. Only 30 percent of the wastes of the sewered population is treated. The rest is discharged untreated to the Han River system.

In 1982 nightsoil systems were used by about 6 million people in the project area. Nightsoil in the cities is usually collected with vacuum trucks except in the older, more congested areas where traditional manual methods must be used. Nightsoil may be treated at nightsoil treatment facilities, stored in dumps, or, in the more rural areas, spread on agricultural fields.

In the vicinity of Seoul the quality of the waters of the Lower Han River is poor, as shown in Figure 2. Dissolved oxygen concentrations are extremely low, particularly in the areas nearest the central city, where during warm weather at low tide the river is nearly anaerobic, with typical dissolved oxygen concentration of 1.0 mg/L, and fecal coliform levels approaching those of untreated sewage. However, concentrations of metals in the water and sediments are low. Many of the tributaries to the Lower Han River are heavily polluted and are anaerobic during low flows.

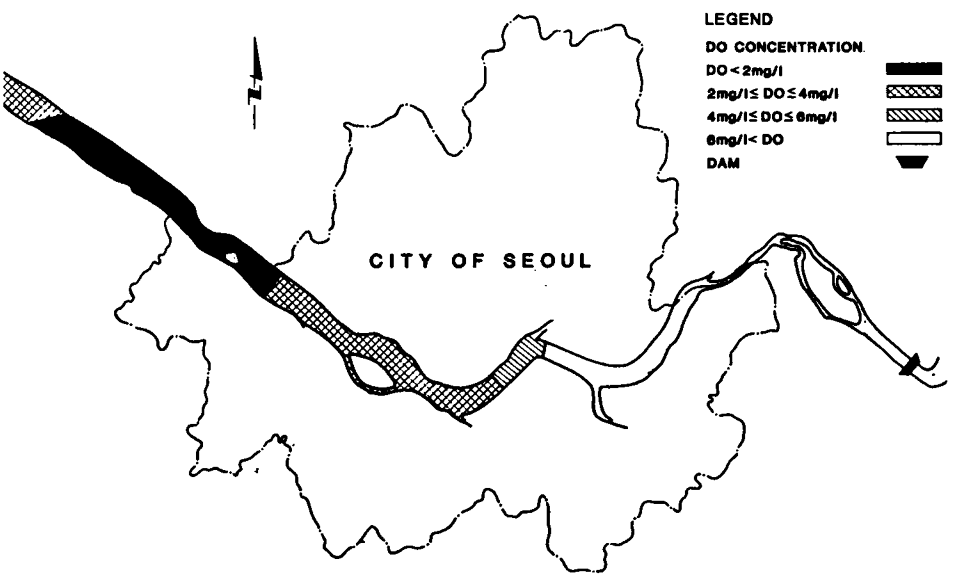

Figure 2. Present Water Quality in the Lower Han River

The North Han River is essentially a series of lakes. In general, the water quality is excellent and suitable for any intended purpose. Of some concern, however, is the level of nutrients (particularly phosphorus) in the two lower lakes. Both of these lakes have phosphorus concentrations that are judged to be very near the level at which algal blooms will occur and cause problems. The wastewaters from the City of Chuncheon are the primary contributor of nutrients.

The water quality in the free-flowing South Han River is good; dissolved oxygen levels are at or above saturation along its length. However, animal feedlots, particularly pig farming, are a present pollution problem. The metals content of the South Han River waters and sediments is also high immediately downstream of a coal mining area, although the concentrations decrease to natural levels within a short distance.

Generally, the natural quality of the groundwater is suitable for most uses. The total dissolved solids content is low, around 200 to 300 mg/L. The water tends to be soft to moderately hard, and with the exception of geothermal waters, the pH is generally between 6.2 and 8.0. In the Seoul area the most extensive use of groundwater is for industrial purposes. Serious contamination of shallow aquifers has occurred. Factory wells have been polluted by oils and dyes, and in many cases, have experienced high ammonia levels.

Sewage pollution is also a regular occurrence, particularly outside the urban areas and in the poorer villages where shallow wells are dug close to privies. In 1966, a typhoid epidemic occurred at Shihung resulting in 120 cases and two deaths. The cause was sewage from privies that had contaminated shallow, hand-dug wells. In April 1982, an outbreak of dysentery affecting 100 persons was reported in the Anyang Cheon Valley. According to the Ministry of Health and Social Affairs, the cause of the outbreak was sewage-contaminated well water. In general, the well water in the alluvial deposits is free from bacterial contamination at depths greater than five metres.

4.2 Water Pollution Control Alternatives

The degree of treatment required to meet the effluent standards was the same for all the treatment plant locations. The alternative secondary treatments include conventional activated sludge and biological filtration. However, biological filtration systems were not considered for the Greater Seoul area as they require substantially larger areas of land than conventional activated sludge processes and sufficient land was not available.

Sewage treatment processes produce sludge of varying amounts and characteristics which depend upon the treatment system adopted. For the Greater Seoul area, three disposal options were considered, namely, marine disposal by barge, dewatering and landfill disposal, or incineration and residue burial at landfills.

Sewer systems were studied for Greater Seoul, Incheon, and other major cities. Feasible alternatives are limited by the topography, the existing sewer or drainage network, and the urban development areas. Alternatives were formulated to retain as much of the existing sewer systems as possible and to account for sewer facilities that are now being implemented; stormwater overflows were included in all cases.

The natural drainage basins that flow to the Lower Han River in the Greater Seoul area are very complex. Because of the topography and the existing and future urban development, major interceptors to serve these basins would have to be placed along the major tributaries to the Han River.

The grouping of drainage areas into sewerage areas that could be served by separate sewage treatment facilities depends on the availability of sites for the treatment facility. It was determined that there were five possible treatment sites for major treatment plants to serve the Seoul area.

The possibility of collecting all of the sewage from Greater Seoul and carrying it through a tunnel or force main to Incheon for disposal in the sea was also studied. However, the costs of this scheme were much larger than the costs of any alternative involving more localized treatment and disposal in the vicinity of Seoul.

Water quality simulation studies of the alternatives considered were made using computer models to determine the levels of sewage treatment required. The primary water quality objective to be met in the Lower Han River was the prevention of anaerobic conditions in the water. To assure that this condition would be met at all times, a target dissolved oxygen concentration of 2 mg/L in all river segments was used. The simulation studies showed that secondary treatment at each of the treatment plants would be required and would be adequate to meet the target dissolved oxygen criterion.

4.3 The Recommended Water Pollution Control Plan

The recommended Master Plan for water pollution control for the study area up to the year 2001 involves replacing nightsoil septic tank systems by sewers and sewage treatment facilities in the major cities. The recommended sewer systems are based on existing networks.

Sewage treatment facilities are essentially the same in each city and are based on conventional activated sludge using surface aerators. Digested sludge will be mechanically dewatered using presses, then disposed of in landfills in conjunction with refuse, although it will also be available for agricultural purposes (arable crops, rice paddies, orchards).

The desired water quality goals in the Greater Seoul area could be achieved using four high-capacity sewage treatment plants, treating an average flow of 5 million m^3/day and 1,000 ton/day of biochemical oxygen demand (BOD). These plants could be served by a redesigned sewer system featuring 230 km of interceptors, parallel to the Han River and its major tributaries.

The final effluents discharged to the Lower Han River will have BOD and suspended solids concentrations of 20 and 30 mg/L, respectively. About 445 ton/day of dewatered sludge will transported to Nanjido landfill in 1991 and 810 ton/day in 2001.

When the entire sewered area is eventually provided with a separate system, there will be about 7,300 km of secondary and 10,200 km of tertiary sewers. A total of 240,000 nightsoil conversions will be required to ensure complete elimination of nightsoil by 2001.

To meet the desired water quality goals in time for the Olympic Games in 1988 all the main interceptors and the first phase of two new sewage treatment plants should be commissioned by that date.

5. AIR QUALITY

5.1 Present Levels

There are more than 100 air quality monitoring stations in the study area. These stations were established and are operated by the Public Health Institutes of Seoul, Incheon, and three provinces. Additional stations were set up by the project, and air quality data were collected between October 1982 and March 1983; the latter were particularly valuable for suspended particulates, because of uncertainty about the representativeness of the sampling method previously used.

Total suspended particulate concentrations in the study area generally exceed the recommended guidelines of 150 ug/m^3 on an annual basis and 300 ug/m^3 for 24 hours. The mean annual value was 331 ug/m^3.

Particle size determinations were made in Seoul to estimate the proportions in the total suspended particulates of the respirable particulates (less than 10 um) and the fine particulates (less than 2.5 um). The recommended guideline for fine particulates (150 ug/m^3 for 24 hours) was exceeded at most Seoul stations. It appears, therefore, that suspended particulates are a major air quality problem in the study area.

The sulfur dioxide levels in Seoul and in some of the industrial areas also generally exceed the Korean standard of 0.05 ppm (annual arithmetic mean). Outside the City of Seoul, but still within the Seoul-Incheon metropolitan area, the sulfur dioxide concentrations varied but were near or slightly over the standard. Outside of this metropolitan area the sulfur dioxide levels are not a problem.

Although there were several stations at which the recommended guidelines for carbon monoxide were exceeded, ambient concentrations of carbon monoxide are not considered to be a problem in the study area. Carbon monoxide, however, is a serious contaminant in many Korean traditional homes using the "yeontan" or under floor heating system. This consists of slow-burning, high-ash coal briquettes combusted in a stove located below the floor level, with the flue gas exiting through a pipe network built into the floor. System leaks can lead to carbon monoxide poisoning of the room occupants.

Primary sources of suspended particulates, sulfur dioxide, and carbon monoxide, and their relative contributions are presented in Table 1.

Table 1. - Sources of Air Pollutants Exceeding Air Quality Standards in the Study Area and Relative Percent Contributions

Source	Total Suspended Particulates	Sulfur Dioxide	Carbon Monoxide
Yeontan	5	40	84
Residual oil	11	51	< 1
Industrial	5	1	< 1
Fugitive dust	37	-	-
Motor vehicles	42	8	15

Although the data are imcomplete, there is no evidence of problem levels of nitrogen dioxide in the study area. Additional and continuing monitoring should be carried out.

Hydrocarbon data were insufficient to draw any conclusions. Only five stations in Seoul monitored hydrocarbons, and incomplete data were reported.

It is difficult to draw firm conclusions about ozone and oxidant levels in the study area. Four chemiluminescent ozone analyzers were added to the monitoring network in Seoul in late 1981 and were operated for about 20 percent of the time. The available ozone data and the nitrogen dioxide data suggest that there is not a significant oxidant problem in the study area. However, the total oxidant data (measured using the buffered potassium iodide method) suggest otherwise. More monitoring stations and data will be required before this question can be resolved.

5.2 Air Pollution Control Alternatives and Recommended Plan

The pollution control strategies considered for major sources and their relative emission reduction effectiveness are outlined in Table 2.

The evaluation of the control strategies and the selection of those that should be implemented were based on a number of factors. Cost-effectiveness was a major consideration. Another important factor was the speed with which a measure could be implemented. As mentioned above, the air quality in the Seoul-Incheon area is poor now, and timely remedial measures should be instituted. Measures that required relatively small capital expenditures (even with high operational costs) and that could be implemented with a short lead time were preferred.

The five strategies listed below were recommended to reduce particulates emissions:

1. Replace present fuels used for industrial and other combustion with clean fuels.

2. Improve industrial processes, combustion, and motor vehicle efficiency by conservation, improvements, and better maintenance.

3. Reduce the particulates loading from exhaust gases from stationary and mobile sources.

4. Implement fugitive dust programs for construction sites, roads, and unpaved areas.

5. Relocate major point sources of particulates outside the Seoul-Incheon area.

Analysis of the six control strategies developed for controlling sulfur dioxide showed that all six would be required, as listed below:

1. Replace existing fuels used for energy production with cleaner fuels such as natural gas.

2. Reduce fuel consumption with conservation and improved combustion efficiency.

3. Reduce the impacts of emissions by fuel switching based on forecasts of air quality conditions.

4. Reduce the sulfur content of present fuel types.

5. Reduce the sulfur content of flue gases.

6. Relocate major point sources outside the Seoul-Incheon area.

Table 2. Effectiveness of Air Pollution Control Strategies

Strategy	Overall Emission Reduction (in percent)				
	SO_2	TSP	CO	NO_2	HC
Yeontan:					
Modify burner for over-fire air	-	-	12	-	-
Coal modification-add limestone	15	-	-	-	-
Coal blending-add limestone	15	-	-	-	-
Lower caloric specs-add limestone	15	-	-	-	-
Convert to yeontan hot water heating	4	21	19	-	1
Convert to distillate oil hot water heating	5	1	28	-	1
Convert to LNG hot water heating	11	1	25	-	1
Insulation and energy conservation	8	1	17	-	1
Residual Fuel Oil:					
Use imported, low-sulfur fuel oil	23	5	-	-	-
Desulfurize fuel oil in Korea	23	5	-	-	-
Convert to additional LNG fuel	23	5	-	-	-
Boiler upgrading and improved O&M	-	4	-	5	-
Boiler operation at more constant rate	-	3	-	5	-
Install particulate control devices	2	5	-	-	-
Flue gas desulfurization	6	1	-	-	-
Staged combustion of NO_x control	-	-	-	2	-
Ammonia injection for NO_x control	-	-	-	2	-
Insulation and energy conservation	7	2	-	3	-
Increase stack height at large sources	-	-	-	-	-
Relocate large sources	-	-	-	-	1
Industrial Processes:					
New or modified control equipment	-	8	-	-	-
Improved O&M with existing equipment	-	2	-	-	-
Relocate large sources	-•	2	-	-	-
Fugitive Dusts:					
Additional street sweeping-washing	-	15	-	-	-
Paving-stabilization of unpaved areas	-	23	-	-	-
Control growth of motor vehicles	-	8	-	-	-
Motor Vehicles:					
Limit emissions without catalysts	-	-	2	5	11
Limit emissions with catalysts	-	-	4	12	18
Reduce-eliminate lead in gasoline	-	-	-	-	-
Redesign diesels to reduce smoke	-	1	-	-	-
Improve maintenance of buses	-	1	-	-	-
Particulate controls on HD vehicles	-	2	-	-	-
Improve vehicle inspection program	-	-	3	-	5
Non-adjustable engine parameters	-	-	7	*	3
Opacity regulations-enforce on-the-road	-	1	-	-	-
Eliminate two-cycle motorcycles	-	-	-	-	1
Limit VKT in congested areas	-	1	3	12	7
Controlled Open Burning	-	<1	-	-	-
Volatile Organic Carbon:					
Control storage and transfer	-	-	-	-	1
Control large users of solvents	-	-	-	-	-

• Increases NO_x emissions
LNG - Liquefied natural gas
O&M - Operation and maintenance
VKT - Vehicle-kilometres travelled

Five strategies were recommended for control of carbon monoxide emissions:

1. Replacement of gasoline with LPG for automobiles.

2. Reduce fuel consumption by conservation and improved efficiency.

3. Modify vehicle engine designs.

4. Limit vehicle use in congested areas.

5. Modification of yeontan burners to provide overfire air.

Although hydrocarbon and nitrogen oxide emission reduction is not presently required, it was recommended to institute simple storage and transfer procedures which would greatly reduce volatile organic carbon emissions.

6. SOLID AND HAZARDOUS WASTE DISPOSAL

6.1 Present Practices

Solid wastes in the study area are presently disposed of at open dumps. The waste materials are leveled by hand, by truck traffic, or with bulldozers. The wastes are not covered except when the site is closed. There is no odor or rodent control. Spraying is used at the Nanjido site near Seoul for control of flies.

The lack of cover has not been a serious problem in the past because of the high content of ash in the refuse. However, in 1981 the government ordered the separate collection of ash and other refuse. The intent of this order was to create a waste that could be burned in incinerators, but secondary benefits were that the ash could be used as fill material and that the life of the dump sites was extended because of the smaller volume of wastes. On the negative side, however, is the fact that with the higher paper and vegetable material content, there is a greater potential for both fires and vector problems at the dump sites.

Resource recovery and recycling are important in the residential and commercial solid waste collection and disposal system. Private salvage collectors in the cities collect waste materials for resale. Metals, glass, rags, and paper products are the materials most in demand. The government's Korea Resource Recovery and Reutilization Corporation encourages recycling of plastics (and to a lesser extent, paper and iron) by purchasing these materials and reselling them for processing and reuse.

There is also salvaging in the collection and disposal operations. Handcart laborers select and set aside materials. Wastes are picked over by scavengers at transfer points, and scavengers pick over the wastes after they are delivered to the dumps.

Forty solid waste disposal sites in the Han River Basin were investigated.

Approximately 500 industries in the study area may be producing solid or sludge wastes that would be considered hazardous or toxic under provisions contained in the Korean Environmental Preservation Law and corresponding regulations. It further appears that 200 to 300 industries are producing hazardous or toxic liquid wastes unsuited for sewer discharge. Some of these industries produce both liquid and solid wastes.

Under the terms of the Environment Preservation Law provisions are made for private enterprises to be licensed as Industrial Waste Disposal Businesses (commonly referred to as consignment companies). There are 21 licensed operators serving the study area. Most of the hazardous wastes generated by the industries are hauled and disposed of by these consignment companies, although some industries (about five percent) haul and dispose of their own hazardous wastes. The consignment companies must meet certain specified standards including qualifications for technical personnel, criteria for incinerators, tanks for storage, neutralization, separation, etc. Specialized devices are used depending upon the types of wastes to be handled. In addition, the waste disposal companies must have broad laboratory capabilities.

6.2 Solid Waste Management Alternatives and Recommended Strategy

The following solid waste management technologies were considered as having potential application in the study area:

- Pyrolysis
- Anaerobic digestion
- Combustion of refuse-derived fuel
- Mass incineration
- Composting
- Sanitary landfill with and without methane gas recovery.

Incineration (mass burning), composting, and sanitary land filling were considered feasible in the study area. These three alternatives were the object of a detailed study where technical, economic, and environmental factors were considered. The value of the power (or steam) generated on incineration and the soil conditioner produced on composting were included in the evaluation.

It was concluded that a sanitary landfill is the recommended alternative because of the lower cost, greater reliability, and the availability of landfill sites.

6.3 Hazardous Waste Management Alternatives and Recommended Strategy

Ideally, all hazardous waste should be reused, detoxified, or destroyed. Numerous hazardous waste treatment procedures have been applied or suggested; many of these, however, only change the characteristics of the waste. Incinerator ash and waste water treatment sludges are examples of treatment residuals containing concentrated amounts of contaminants which must still be disposed of safely.

A hazardous waste treatment plant could be used as a supporting facility operated in conjunction with the existing private consignment companies. Such a plant would handle only special wastes that were difficult to treat or too expensive for the private companies. The facility could also serve as a replacement of the consignment companies in case they failed to provide their designated function.

However, it was concluded that there was only one basic disposal method that would be suitable for general application in the study area. This was the construction and operation of well-designed, secure hazardous waste landfills.

7. COSTS

The total capital requirements of the Master Plan amount to about 4.8 trillion Won (US$ 6.9 billion) in 1982 prices over the 18-year planning period. The greatest capital requirements fall in the years 1984 to 1991 when the averrage annual capital required will be about 330 billion Won (US$ 470 million) per year.

Economic feasibility of the Master Plan was judged based on (1) possible allocations (0.5 to 2 percent) of the projected Gross National Product to pollution control in Korea and assumed allocation of available capital to the project area and (2) projections of fixed capital formation in the project area. These analyses showed that although it was reasonable to assume the availability of the needed capital over the planning period, there would be a shortage of capital until the late 1980s. Thus, priorities will have to be established to help decide which projects can be implemented in the first few years.

8. CONCLUSIONS

The Han River Basin Environmental Master Plan Project represents one of the first integrated environmental efforts where environmental quality improvements in the fields of water, air and land (solid and hazardous waste disposal) were considered at the same time. This permitted the evaluation of cross-media impacts (such as air pollution generated on incineration of solid waste) which are often neglected.

The strategies recommended would bring about on implementation considerable improvements in the overall enviromental quality and, thereby, in the general health and welfare of a major portion of the South Korean population.

This project, whose total expenditures have reached US$ 5.4 million, of which about US$ 3 million was loaned by the Asian Development Bank, represents a laudable effort by the Government of South Korea to mitigate the environmental effects of industrialization and increasing urbanization and balance the need for economic development with the equally basic need for a clean environment.