D3. MASTER PLAN

This Master Plan covers flood control and drainage, and river/lake conservation. The former consists of two major schemes: flood control and drainage for the To Lich and Nhue River basins definitely separated by the natural levee along the To Lich River. The latter refers to several schemes for water quality betterment and environmental improvement along rivers and surrounding lakes in the study area.

3.1 Planning Conditions

3.1.1 Target Year

This Drainage Master Plan is formulated on the basis of the City Master Plan for the year 2010 that has been approved by the Government of Vietnam.

3.1.2 Protection Levels

The protection levels of the Drainage Master Plan have been set at a 10-year return period (10%) for the river/drainage channel system, and at a 5-year return period (20%) for the sewer system. This is because:

(1) The Nhue River improvement project and the projects of the Yen So pumping station and regulating reservoir have been established at a protection level of a 10-year return period; and

(2) The proposed protection levels can be compared similarly to those adopted in drainage projects for South East Asian capitals: 5- to 10-year in Manila, 2- to 15-year in Jakarta, and 10-year in Vientiane.

3.2 Fundamental Planning for Flood Control and Drainage

3.2.1 Common Items

This subsection presents the fundamental planning results for the succeeding alternative studies, pertaining to flood control and drainage issues, commonly applying to the river/drainage channel systems in the To Lich and Nhue River basins, and the sewer system in both basins.

(1) Structural and Non-structural Measures

Generally, there are two ways to mitigate flood damage:

(a) Structural Measures

- River/drainage channel improvement;
- Provision of pumping stations;
- Construction of regulating reservoirs;

- Installation of floodgates; and so on.

(b) Non-structural Measures

- Land use control;
- Flood forecasting and warning;
- Evacuation of residents; and so on.

However, the seriousness of flooding and the size of flood damage in the Hanoi City area realize the need of emphasizing structural measures that could bring more fundamental and urgent solutions to this area. Hence, the Master Plan will deal mainly with structural measures, although some non-structural measures are discussed in Subsection 3.5.2.

(2) Method and Directions of Drainage

In the To Lich River basin, it is nearly impossible to drain out the design flood using gravity to the Nhue River. This is easily proved by the following facts. The high water stage of over EL.5m lasted 5 to 20 days along the Nhue River in the 1978, 1984, and 1989 floods, hence the design high water level has been set approximately at EL.5.8 m in the stretches. To prevent serious inundation in the Hanoi City area, the water levels of the To Lich River basin should be confined to under EL. 3.5m as previous studies stated. When applying mechanical drainage for the To Lich River basin, the direction of the drainage, due to economics, will be towards the Red River from the Yen So site. Furthermore, to unload the capacity of the pumps economically, construction of regulating reservoirs near the pumping station should be taken into account.

On the other hand, both mechanical and natural drainage methods will be examined for the Nhue River basin (comprising four sub-basins) where the ground elevations (EL. 4.5 to 9.5m) are not as low in comparison to the high water level of the Nhue River (EL.5.8m approximately). Mechanical drainage, if applied, will be supported by the construction of regulating reservoirs for the same reason as above. The direction of the drainage must be limited by topography, towards the Nhue River.

The following table summarizes the above discussions:

River Basin	Present Land Use	Drainage Method	Direction of Drainage
To Lich	Urban	Mechanical drainage combined with regulating reservoirs	To Red River from Yen So site
Nhue	Suburban	Mechanical drainage combined with regulating reservoirs, or natural drainage combined with the same accompanied by land reclamation works	To Nhue River from the outlets of respective drainage basins

(3) Allowable Discharges to Nhue River

According to a brief report on the Drainage Project for the Nhue River and Hanoi Urban Area, the design bases for the Nhue River Improvement are:

(a) Protection Level : 10-year (10%)

(b) Design Discharges : Calculated at a specific discharge, 0.6 $m^3/s/km^2$

(c) High Water Level : EL. 5.8m at Hadong weir

Natural drainage from the To Lich River basin to the Nhue River is possible for small-scale floods. The maximum discharge from the To Lich River to the Nhue River should, even in small-scale floods, be limited at 0.6 $m^3/s/km^2$ judging from the above design basis of the Nhue River. For the Nhue River basin, on the other hand, discharges must always be confined to under 0.6 $m^3/s/km^2$, whether natural or mechanical drainage is applied. (This should be agreed officially by the Ministry of Water Resources in the near future.) The following table shows the allowable discharges so determined and the high water levels of the Nhue River at the outlets of the relevant basins:

Basin	Catchment Area (km^2)	Allowable Discharge (m^3/s)	HWL of the Nhue River at its Outlets EL. (m)
To Lich	77.5	45	5.7
Co Nhue	19.7	12	6.0
My Dinh	13.6	8	5.9
Me Tri	14.7	9	5.8
Ba Xa	9.9	6	5.7

It is highly recommended that to ensure the effectiveness of the Master Plan for the study area, the Nhue River improvement plan over its whole stretches be further examined and implemented as soon as possible. The river improvement work is foreseen to require many years and huge cost. It would be most practical to use a cost-minimum approach, such as a reduced protection level for the initial stage, polder dike protection for selected areas, use of low-lying areas as temporary retarding basins (including paddy field), etc.

(4) Interface between Drainage Channels and Sewers

In this Master Plan, it is premised that sewer systems will cover the areas where catchments are smaller than 1km^2, and drainage channels will be improved, or newly constructed to receive all the discharge from the sewer systems. (Sewers will be constructed beneath main roads.) This criterion is based on an economic consideration even taking into account the difficulty of land acquisition due to open channel construction in small areas. Delineated in Fig. D3.6 are the drainage channels to be provided in the Master Plan. The channel density is about 1 km/1km^2 almost for the whole study area (refer to Table D3.1).

(5) Conditions for Cost Estimation

Unit prices for the cost estimation of the Master Plan are listed in Table D3.2. Other conditions are as follows:

(a) Engineering Services Cost : About 15% of construction cost

(b) Administration Cost : 3% of construction cost

(c) Physical Contingency : About 10% of the cost for construction, land acquisition, engineering services, and administration

(d) Conversion Rates : US$1 = ¥105 = Dong 10,800 (As of mid 1994)

3.2.2 River/Drainage Channel System in the To Lich River Basin

(1) Treatment of West Lake

Drainage of the To Lich River basin will be achieved primarily by the combination of pump facilities and regulating reservoirs at the Yen So site. However, it is economically essential to limit as much as possible the floodwater flowing down to Yen So from the upper reaches. On the other hand, there are a lot of lakes/ponds in the basin, the most substantial being West Lake (5.7 km^2). In this case, when providing gate structures at the outlets of the lake to maintain the normal water level at EL. 6.0 m, all the floodwater from the catchment (9.3 km^2) can be contained under the high water level of EL. 6.5 m without affecting the shore areas. (As a matter of course, after the flood, the gates are opened and the water level of the lake returns to normal.) This gate structures will entail a minimal cost, but largely contribute the reduction of flood discharge at the Yen So site.

(2) Diversion of Upper Lu and Hoang Liet Basins

A bridge is now under construction along the National Road Route No.1 spanning the Kim Nguu River at 3.9 K Point. The bridge may not be large enough to pass all the floodwaters from the To Lich, Lu, and Hoang Liet basins towards the Yen So site. To cope with this restriction, the following two diversion plans are conceived:

(a) Diversion of the Upper Lu River basin to the Set River using the existing Lu floodway to the maximum extent of flow capacity of another bridge of National Road Route No.1 across the floodway; and

(b) Diversion of the Hoang Liet drainage basin to the Set River by expanding an existing box culvert under the National Road Route No.1.

(3) Normal and High Water Levels

The normal water level in the To Lich River system has been set up at EL. 3.5 m under an agreement among the agencies concerned. This water level results from coordinating the multipurpose use of the rivers including flood control, and water supply for agricultural lands and fishponds. This agreement will still be valid in this Master Plan, since lowering the water level below EL. 3.5 m must bring about an excessive draw down of water levels in the upper channels that is not recommended from the environmental point of view.

On the other hand, the design high water level is generally recommended not to exceed the ground elevations on both sides, to ensure easy drainage from the basin. Hence, the design high water levels of the To Lich River system were established starting from EL. 3.5m (same as the normal water level) at the Yen So site, with the following longitudinal gradients:

(a) To Lich River : 1/7,000 (1/15,000)

(b) Lower Lu River : 1/8,000

(c) Set River : 1/3,000

(d) Lu Floodway and Upper Lu River : 1/4,500

(e) Kim Nguu River : 1/1,500

However, to maximize the regulating capacity of the Yen So reservoir, the reservoir and relevant rivers have been planned to temporarily store floodwater of up to EL. 4.5m at the end of the flood (refer to Figure D4.2). The water level profiles at that time are also delineated in Fig. D4.8. These figures prove that even in this case, the water levels in the urbanized upstream reaches never exceed the design high water levels as set above. In the suburban downstream areas, the water levels are higher than the design ones, however this might only cause temporary inundation on the farm lands, inflicting minimal damage.

3.2.3 Drainage Channel Systems in the Nhue River Basin

(1) High Water Levels

High water levels at the outlets of the drainage channel systems in the Nhue River basin are determined by the ground elevations when applying mechanical drainage, while they are determined by the high water levels of the Nhue River when applying natural drainage, as follows:

Drainage Basin	High Water Level at Outlet, EL. (m)	
	In Case of Mechanical Drainage	In Case of Natural Drainage
Co Nhue	5.2	6.0
My Dinh	4.7	5.9
Me Tri	4.7	5.8
Ba Xa	4.5	5.7

Note: Longitudinal gradients of the drainage channels are commonly 1 / 5,000 in accordance with the average ground slope.

(2) Design Parameters of Pumping Stations and Regulating Reservoirs

(a) Locations

A pumping station, when applying mechanical drainage, and a regulating reservoir will be constructed at the outlet of each drainage system.

(b) Pump Capacities

The capacities of the pumping stations, if required, should be the same as the respective allowable discharges tabulated in Item (3) of Subsection 3.2.1.

(c) Dimensions of Regulating Reservoirs

Floodwaters exceeding the allowable discharge of each drainage system will be contained in the regulating reservoir, either applying mechanical or natural drainage methods. The normal water depth and the effective water depth for flood storage are 1.0 m and 4.0 m, respectively.

3.2.4 Sewer System

(1) Division of Drainage Zone

The urban drainage development plan for the sewer system is carried out for the five (5) river basins covering the whole study area: To Lich, Lu, Kim Nguu, Set and Nhue. These five (5) river basins cover 13,540 ha, including West Lake, with a population of 1.3 million. The river basins are divided into eleven (11) sub-basins as shown in Fig. D3.1. The study will be made based on the above sub-basins.

(2) Design Stormwater Flow

The design stormwater flow shall be calculated by using the rational formula, and the rainfall intensity formula worked out by the Ministry of Construction in Vietnam, which are given below :

$$Q = (1/360)CqA$$

$$q = [5416 (1 + 0.25 \times \log P \times t^{0.13})] / (t + 19)^{0.82}$$

where,

Q : Design stormwater flow (m^3/s)
C : Runoff coefficient
A : Drainage area (ha)
q : Rainfall intensity (l/sec/ha, or mm/ha if divided by 0.36)
P : Return period
t : Concentration time (min.)

The runoff coefficient is to be the overall runoff coefficient of each river basin calculated by runoff coefficients at each area with individual surface characteristics as shown Table D3.3.

(3) Deign Policy

The design policy of the sewerage system within the study area has been decided as follows :

(a) To apply the following corresponding regulations and standards :

- Design Standard for Works of Sewerage & Drainage System in Vietnam (1989);
- Environmental Protection Law in Vietnam (1994);
- Temporary Guidance for Environmental Impact Assessment (1993);
- Vietnam System of Environmental Standards (1993);
- Regulations on The Protection of City Environment in Hanoi Capital (1991);
- Sewerage Law in Japan (1976);
- Building Standard Law in Japan (1983); and
- Japan Sewage Works Association Standards (1984).

(b) To preserve the existing drainage basins.

(c) To adopt the combined system in the present urban area with the existing combined system, and a separate system in the other areas.

(d) To take adequate countermeasures against flood according to the local conditions.

(4) Design Criteria for Drainage System

(a) Design Flow

Sewerage facilities, including sewers, shall be, in principle, based on the design flow as follows :

Collection System	Facilities	Design Flow
Separate System	Sewer	DSF
	Pumping Station	DSF
Combined System	Combined Sewer	HMWF+DSF
	Pumping Station	
	- Combined Sewage	HMWF+DSF
	- Stormwater	> DSF-2·HMWF

Note : 1) HMWF : Hourly Maximum Wastewater Flow
2) DSF : Design Stormwater Flow

(b) Hydraulic Design for Sewer

The hydraulic design of the sewers is based on Manning's formula, which is given below :

$$Q = A \cdot V$$
$$V = (1/n) \cdot R^{2/3} \cdot I^{1/2}$$

where,

Q : Discharge (m^3/sec)
A : Sectional area of pipe (m^2)
V : Mean velocity (m/sec)
n : Roughness coefficient
R : Hydraulic radius (m)
I : Hydraulic gradient

(c) Roughness Coefficient

Reinforced concrete pipes will be used for the sewer. The roughness coefficient of the concrete pipe is taken at 0.013, taking into account a long-term operation.

(d) Allowable Flow Velocity

The minimum velocity shall not be less than 0.8 m/sec for the combined/stormwater sewer in order to avoid sedimentation and to keep consistency with the on-site road gradient as much as possible. The maximum velocity shall be limited to 3.0 m/sec in order to prevent the pipe from eroding.

(e) Allowance of Sewer Capacity

The allowance of the combined/stormwater sewer capacity will be 10 % to 20 % of the design flow. The allowance is generally applied to select sewer pipes in consideration of unexpected flow fluctuations and the prevention against the putrefaction of sewage. The minimum size of pipe to be selected will be 250 mm for the combined/stormwater sewer to secure the workability of maintenance & operation.

(f) Depth of Earth Covering

The minimum earth covering is determined at 1.0 m to prevent any collapse of the pipes . The maximum depth of earth covering is determined to be 7.0 m in order to minimize construction cost.

(g) Maximum Manhole Interval

Manholes shall be located where changes in flow direction, pipe gradient and diameter occur, and the originating point of the sewer pipeline and the junction of the pipes. The maximum manhole interval for each size of sewer is proposed as follows:

Sewer Diameter (mm)	Maximum Interval (m)
≤ Ø 300	50
≤ Ø 600	75
≤ Ø 1000	100
≤ Ø 1500	150
≤ Ø 1650	200

(h) Connection of Pipes

A pipe bottom connection is recommended in view of the depth of the pipe laying and construction cost. The hydraulic gradient along the sewer pipeline shall be kept below the ground surface.

(i) Hydraulic Gradient

Diameter of pipe	≤ 500 mm	:	2.0 ‰
– do –	≤ 1000 mm	:	1.0 ‰
– do –	≤ 1500 mm	:	0.7 ‰
– do –	> 1500 mm	:	0.6 ‰

(5) Development Plan of Drainage Zone

The resultant hydraulic design of the drainage sewered system is given in Table D3.4 based on the above design criteria. The layout plan of the urban drainage development system is shown in Figure D3.2.

The proposed development plan of the study area is composed of :

(a) Improvement works for existing pipes of the combined system, with a total length of 14 km, including manholes;

(b) Installation works for new pipes of the To Lich River basin consisting of four (4) sub-basins, To Lich, Lu, Kim Nguu, and Set, with a total length of 336 km;

(c) Installation works for new pipes of the To Lich River basin consisting of two (2) sub-basins, Hoan Liet, and Yen So with a total length of 136 km;

(d) Installation works for new pipes of the West Lake sub-basin with a total length of 41 km;

(e) Installation works for new pipes of the Nhue River basin consisting of four (4) sub-basins, Co Nhue, My Dinh, Me Tri, and Ba Xa, with a total length of 579 km; and

(f) Installation works for new street drains along the new road network, prepared by UPI, with a total length of 1,051 km.

(6) Cost Estimate

The direct construction cost of the sewer for the drainage development plan is estimated as shown in Table D3.5. The construction cost of the street drains is not included in the estimated cost of the proposed project as this construction usually belongs to the road network project.

3.3 Alternative Studies on Flood Control and Drainage

3.3.1 To Lich River Basin

(1) Alternatives Suggested

The most fundamental issues pertaining to the Drainage Master Plan for the To Lich River basin are the capacity of the pumping station, the flood control volume, and the location and sizes of the regulating reservoirs at (or near) the Yen So site. To settle this, an alternative study has been made on the premises that:

(a) A regulating reservoir at the Yen So site should be contained in the approved area of 203 ha (the net lake area is assumed to be 130 ha, approximately 65% of the lot area) because:

- The area and location of the Yen So reservoir have been fixed on the Hanoi City Master Plan already approved by the Government, so that land acquisition outside the area will cause difficulties; and

- The land use potential around the Yen So site is quite high taking into account the present city expansion toward the south, hence the reservoir should be as small as possible.

(b) If the area is insufficient to fulfill the hydrological requirements, the use of Linh Dam and Dinh Cong lakes should be examined, as opposed to expanding the Yen So reservoir area.

(c) Lake dredging to maintain the normal water level at EL. 3.5 m for flood control purpose should be studied at 18 major lakes in the city area. (Refer to Figure D3. 6.)

Taking into account the above, the following six alternatives were suggested, whose features are shown in Figure D3.3:

Alternative	18 Major Lakes in City Area	Use of Linh Dam Lake (103 ha): Channel to Yen So	Use of Linh Dam Lake (103 ha): Lake	Use of Dinh Cong Lake (25 ha): Channel to Linh Dam	Use of Dinh Cong Lake (25 ha): Lake
1	As they are	—	As they are	—	As they are
2	To be dredged	—	- do -	—	- do -
3	- do -	To be provided	- do -	—	- do -
4	- do -	- do -	To be dredged	—	- do -
5	- do -	- do -	As they are	To be provided	- do -
6	- do -	- do -	To be dredged	- do -	To be dredged

Note: The flood discharge, dimensions, and work quantities of each stretch of rivers and drainage channels are shown in Tables D3.6 to D3.8, respectively.

(2) Study and Conclusion

For each alternative, the cost, including operation and maintenance cost for the Yen So pumping station, was estimated by pump capacity (refer to Table D3.9). The pump capacity vs. cost curves were delineated as shown in Figure D3.4. As can be seen in the figure, the most economical is Alternative 6 with a pump capacity of 90 m^3/s. It is hence recommended to apply this idea to the Drainage Master Plan for the To Lich River basin. The features are as follows:

(a) Pumping Station : 90 m^3/s (together with inlet, outlet and ordinary drainage channels with lengths of 1.2 km, 1.6 km and 1.9 km, respectively)

(b) Yen So Regulating Reservoir

- Flood Control Volume : 3,870,000 m3
- Highest High Water Level : El 4.5 m
- Low Water Level : El 1.5 m
- Bottom Elevation : EL 0.5 m
- Net Lake Area : 130 ha
- Total Lot Area : 203 ha (221 ha including present river courses)
- Yen So Channel : 3.4 km

(c) Linh Dam and Dinh Cong Lakes

Item	Linh Dam	Dinh Cong
Flood Control Volume	1,070,000 m^3	250,000 m^3
High Water Level	EL. 4.5 m	EL. 4.5 m
Low Water Level	EL. 3.5 m	EL. 3.5 m
Lake Area	107 ha	25 ha

Note: Associated with Linh Dam and Dinh Cong channels with lengths of 1.0 km and 0.4 km, respectively.

3.3.2 Nhue River Basin

(1) Alternatives Suggested

The total lake/pond area in the Nhue River basin accounts for only 3% of its catchment (compared to 21% in the To Lich River basin, excepting the West Lake basin). In this case, even if dredging work is conducted for the lakes and ponds, the retarding effect will not increase very much. Hence, no alternative study concerning the dredging of lakes/ponds will be made for this basin.

Moreover, allowable discharges to the Nhue River have automatically been given from its design standard as presented in Item (3) of Subsection 3.2.1. Thus, no study is required to determine the optimal combination of pump capacities and regulating reservoir dimensions.

On the other hand, as described in Item (2) of Subsection 3.2.1, possibility of natural drainage should be examined, together with mechanical drainage. The natural drainage method entails reclamation works, construction of regulating reservoirs, and drainage channel improvement. The mechanical drainage method entails provision of pumping stations, constructing of regulating reservoirs and drainage channel improvements, the last two requiring the same dimensions and costs as for natural drainage. Further, the mechanical drainage method may necessitate the construction of the left levee of the Nhue River to prevent the Nhue floodwaters from intruding the study area. However, this will be reviewed in the feasibility study for the Nhue River basin drainage project suggesting several alternatives.

(2) Study and Conclusion

Capacities, dimensions and costs of structures necessary for the two alternatives, pump scheme and reclamation scheme, are tabulated below:

Alternative	Item	Drainage Basin				Total
		Co Nhue	My Dinh	Me Tri	Ba Xa	
1. Pump Scheme	Pump capacity (m^3/s)	12	8	9	6	35
	Cost* ($ mil)	9.4	6.7	7.3	5.2	28.6
2. Reclamation Scheme	Area to be Reclaimed (ha)	1,150	680	770	540	3,140
	Cost** ($ mil)	66.3	62.4	92.5	59.6	280.8
Common Structure	Regulating Reservoir*** ($1,000m^3$)	3,020 (76 ha)	1,590 (40 ha)	1,600 (40 ha)	1,070 (27 ha)	7,280 (183 ha)
	Drainage Channel	Refer to Table D3.10 for the design discharges, and Table D3.11 for the dimensions and work quantities.				

* Refer to Table D3.14

** Refer to Table D3.12.

*** Refer to Appendix (C) Hydrology.

As can be seen in the above table, the Reclamation Scheme costs about 10 times more than the Pump Scheme. In addition, reclamation work on the urbanized areas will cause problems for the industries and residents. The Pump Scheme is therefore also recommended to be applied for the Nhue River basin.

The pumping stations will be operated during the high water stage of the Nhue River, while when the water level is lower than the ground elevations, natural drainage will be utilized. For this purpose, floodgates are provided beside the pumping stations.

3.4 Alternative Studies on River/Lake Conservation Plan

There are several issues regarding the present condition of rivers and lakes in the study area. These have been discussed in Chapter 2, which are summarized as follows:

(a) Siltation / garbage disposal in rivers and lakes;

(b) Water quality deterioration due mainly to the inflow of domestic wastewater;

(c) House encroachment on banks and even on the water surfaces; and

(d) Improvement of the environment along and around rivers/lakes.

Countermeasures for the above issues are studied hereinafter.

3.4.1 West Lake

West Lake, which is the largest water body in the study area (its lake surface is approximately 5.7 km^2), has the most potential for water environment improvement. Indeed, even at present, the lake is widely used by people as it is one of the most famous recreational spots in the city of Hanoi. Hence, several projects can be expected to enhance the water environment, e.g., the lake shore road/park project, and the lake sediment dredging project. However, taking into account the following points, a comprehensive environmental study should be done prior to the commencement of these projects:

(a) Execution of dredging work may disturb the high value of tourism, recreation, and fishery for a long time (on account of its large water area), and may threaten the existence of a special species of the turtle living in the lake;

(b) The water quality is rather good compared to those in the city area lakes, so direct introduction of deluting water from other sources, e.g., the Red River, may make the water quality of the lake worse than now (particularly in turbidity);

(c) A part of the perimeter is provided with shoreline roads that somewhat contribute to the prevention of house encroachment on the lake even at present; and

(d) There are several parks, amenity zones, and recreational facilities surrounding the lake, which may not require further development at present.

3.4.2 Other Lakes and Rivers

(1) Water Quality Batterment

A fundamental solution to the worsening water quality of rivers and lakes in the To Lich River basin, as a matter of course, shall be achieved by preventing the wastewater inflow from their origins. This will be done by the construction of treatment plants and collecting systems. However, as studied in Appendix (E)

Wastewater Disposal Plan, this countermeasure entails a huge amount of cost and time. Hence, to temporarily increase the water quality in the basin, where it has reached a crucial stage due to heavy urbanization, by the time of completion of the wastewater treatment systems, the introduction of flushing water is examined hereunder.

The source of flushing water is presumed to be the Red River. It is located close to the To Lich river basin and has a large enough flow rate to supply the flushing water (3.5 m^3/s corresponding to the estimated wastewater discharge in the year 2010). Three alternative routes are studied, as shown in Figure D3.5. Characteristics and costs of the alternatives are presented in Table D3. 13.

As can be seen in the table, the most effective and economical route is Alternative 1. However, even this alternative requires about $10 million (direct cost only, year 1994 prices) not merely for the pipeline but also a settling basin to remove turbidity, pump facilities, and control gates/valves to regulate the outflow to the rivers. Besides, about $50 thousand is necessary for the annual operation. Moreover, the introduction of flushing water will only make half the BOD of 96 ppm (estimated in the year 2010). This level of water quality still remains under the allowable standard for better future environment. In conclusion, the Master Plan does not involve the idea of flushing water introduction, although there is some possibility of applying Alternative 1 when the construction of the wastewater treatment systems is delayed far beyond the year 2010.

(2) Improvement of Waterfront Environment

This item describes the study results on the improvement of the waterfront environment, including preventive measures against house encroachment, along and around rivers/lakes in the study area. The countermeasures suggested are as follows:

(a) Construction of riverine and lakeshore roads;

(b) Construction of environmental revetments;

(c) Planting trees; and

(d) Provision of parks and promenades.

Shown in Figures D4.10 and D4.11 are the cross-sections of rivers and lake banks designed to meet the above requirements.

3.5 Proposed Master Plan

3.5.1 Structural Measures

The structural measures in the proposed Master Plan comprise flood control and drainage facilities, and countermeasures for river and lake conservation, selected through the alternative studies in Sections 3.3 and 3.4, respectively. The features are as follows (for the locations, refer to Figure D3.6):

To Lich River Basin

(1) Yen So Pumping Station

(a) Pumping Station (Refer to Fig. D4.4)

- Pump Capacity : 90 m^3/s
- Design Pump Head : 10 m

(b) Outlet Sluiceway : 60 m^2 of steel roller gates

(c) Inlet Structure : 200 m wide

(d) Inlet/Outlet Channels : 1,200 m and 1,600 m

(e) Ordinary Drainage Channel : 1,900 m

(2) Yen So Regulating Reservoir (Refer to Figures D4.1 and D4.5)

(a) Regulating Water Volume : 3,870,000 m^3

(b) Bottom Elevation : EL 0.5 m

(c) Normal Water Level : EL 1.5 m (1.0 m water depth for the use of fish farming, recreation, etc.)

(d) High Water Level : EL 4.5 m (3.0 m water depth for flood control)

(e) Net Reservoir Area : 130 ha

(f) Total Lot Area : 203 ha (73 ha for park and housing areas)

(g) Spillway : 3 places (165 m in total with automatic deflating rubber gates)

(h) Yen So Channel : 3,400 m (to shift the Kim Nguu River along the western perimeter of the Yen So regulating reservoir)

(3) Linh Dam and Dinh Cong Lakes

	Linh Dam	Dinh Cong
(a) Flood Control Volume	1,070,000 m^3	250,000 m^3
(b) High Water Level	EL. 4.5 m	EL. 4.5 m
(c) Low Water Level	EL. 3.5 m	EL. 3.5 m
(d) Lake Area	107 ha	25 ha

Note : Associated with Linh Dam and Dinh Cong channels with lengths of 1.0 km and 0.4 km, respectively.

(4) River Improvement (Refer to Figures D4.7 to D4.9)

(a)	Lower Kim Nguu, To Lich and Lower Lu Rivers and Thank Liet Channel	: 22,100 m with 4 floodgates, 6 bridges and 11 box culverts
(b)	Set and Upper Lu Rivers, and Lu-Set Floodway	: 7,500 m with 8 bridges and one box culvert
(c)	Upper Kim Nguu River	: 3,400 m with 3 bridges
(d)	West Lake Basin	: 2 control gates at the outlets of West Lake
	Total	33,000 m with 6 gates, 17 bridges and 12 box culverts

(5) Drainage Channel Improvement (Figures D4.7 to D4.9)

(a)	To Lich and Lower Lu River Basins, and Hoang Liet Drainage Basin	: 16,400 m with a floodgate, 16 bridges and 24 box culverts
(b)	Set and Upper Lu River Basins	: 3,700 m with a bridge and 14 box culverts
(c)	Kim Nguu River Basin	: 10,700 m with 21 box culverts
	Total	30,800 m with a floodgate, 17 bridges and 64 box culverts

(6) Lake Dredging : 18 lakes (refer to Table D4.4)

(7) Lake Conservation Works : 11 lakes (other than Item (6) above)

(8) Sewer Construction (Refer to Figures D4.13 and D4.14)

(a)	West Lake Basin	: 480 ha
(b)	To Lich River Basin	: 2,000 ha
(c)	Lu River Basin	: 1,020 ha
(d)	Kim Nguu River Basin	: 1,280 ha
(e)	Set River Basin	: 710 ha
(f)	Hoang Liet Drainage Basin	: 460 ha
(g)	Yen So Drainage Basin	: 250 ha
	Total	6,200 ha

Nhue River Basin

(1) Pumping Stations

(a)	Co Nhue Drainage Basin	:	12 m^3/s
(b)	My Dinh Drainage Basin	:	8 m^3/s
(c)	Me Tri Drainage Basin	:	9 m^3/s
(d)	Ba Xa Drainage Basin	:	6 m^3/s
	Total		35 m^3/s

Note: Each with an outlet sluiceway for the outflow from the pumping station, and a floodgate for natural drainage.

(2) Regulating Reservoirs

Drainage Basin	Co Nhue	My Dinh	Me Tri	Ba Xa	Total
(a) Regulating Water Volume (1,000 m^3)	3,020	1,590	1,600	1,070	7,280
(b) Net Reservoir Area (ha)	76	40	40	27	183
(c) Total Lot Area (ha)	84	44	44	30	202
(d) Spillway (m)	55	26	31	14	126

Note: 1) Normal water depth 1.0^m
2) Flood control depth 4.0^m
3) Area other than the net reservoir area will be used as a park.

(3) Drainage Channel Improvement

(a)	Co Nhue Drainage Basin	:	$19{,}200^m$ with 30-bridge / culvert reconstruction
(b)	My Dinh Drainage Basin	:	$13{,}400^m$ with 24-bridge / culvert reconstruction
(c)	Me Tri Drainage Basin	:	$13{,}500^m$ with 22-bridge / culvert reconstruction
(d)	Ba Xa Drainage Basin	:	$8{,}700^m$ with 16-bridge / culvert reconstruction
	Total		$54{,}800^m$ with 92-bridge / culvert reconstruction

(4) Sewer Construction

(a) Co Nhue Drainage Basin	:	1,970 ha
(b) My Dinh Drainage Basin	:	670 ha
(c) Me Tri Drainage Basin	:	870 ha
(d) Ba Xa Drainage Basin	:	440 ha
Total		3,950 ha

3.5.2 Non-structural Measures

(1) Land Use Control

Generally, the land use control as a non-structural flood mitigation measure comprises two aspects, e.g., zoning control, and building and development control. For the study area, zoning control will entail some modification of the city development plan prepared by HPC. The application of this idea is not realistic because:

- The city development plan has been established after careful examination on not merely flood issues but all aspects to be considered; and
- Urbanization of the city toward the south and west (serious inundation areas) suggested in the city plan is inevitable, taking into account its strong and rapid expansion and limitation of land.

On the other hand, building and development control can be applied to the study area with the following measures.

(a) Control of Reclamation Height

Even after completion of the project works, inundation may take place in the low-lying areas presently used as paddy fields and fishponds. Therefore, when these areas are converted to residential areas, the agency should control the reclamation heights at the high water levels of rivers or drainage channels as follows:

- Higher than 4.5^m for the To Lich River basin, and Ba Xa drainage basin;
- Higher than 4.7^m for the My Dinh and Me Tri drainage basins; and
- Higher than 5.2^m for the Co Nhue drainage basin.

If such reclamation works are carried out simultaneously with the Project, soil from the excavation of the regulating reservoirs, etc. can be used as reclamation material.

(b) Provision of Access Roads

For newly developed areas, the agency should suggest to the developers to provide wide and high roads in order to ease relief activity expected in emergency flood cases.

(c) Flood Proofing of Building

Flood proofing of buildings is a generally expensive practice, and not realistic for the present condition of the study area. However, agencies concerned should at least remind the people to prepare materials and tools for the protection of their own buildings, for example, sand bags.

(d) Conservation of Rivers and Lakes

This idea is incorporated in the project works. However, even after completion of the Project, any encroachment of houses on the rivers, drainage channels, and lakes should be controlled. In particular, reclamation works for the lakes shall be prohibited to ensure their flood retarding function.

(e) Preservation of Paddy Fields and Fishponds

Paddy fields and fishponds located outside the zone to be urbanized in accordance with the city development plan should not be converted to residential areas. In this connection, the water levels of fishponds are recommended to be kept as low as possible by providing control gates at the outlets.

(2) On-site Storage

On-site storage refers to the measures to regulate the outflow from the catchment to rivers or channels, compensating the decrease of the flood retarding effect of the original land due to urbanization. This is mainly composed of the following.

(a) Retention Measures

Floodwater is held for considerable periods in the catchment and is slowly dissipated through infiltration, percolation, and evaporation. These measures are:

- Permeable pavement;
- Infiltration trench and catch basin;
- Infiltration well; and
- Infiltration gutter.

(b) Detention Measures

Floodwater is held for short periods in the catchment to reduce peak flow rates, and is discharged into rivers or drainage channels. These measures are:

- Storage pond for a development area;
- Ponding in an athletic field or parking lot; and
- Roof storage and rainwater tanks at individual houses.

Applicable among the above is the provision of storage ponds in newly developed areas. (Others are expensive compared to their effects on the present condition of the study area.) Hence, agencies concerned should direct the developers to construct (a) storage pond(s) when they are intending the development of new housing areas.

(3) Flood Forecasting and Warning

Flooding in the study area tends to start within some hours from the beginning of the rainfall. This condition poses difficulties on the evacuation of residents prior to flooding, and usual flooding claims few casualties. In this context, a flood forecasting and warning system has less meaning for the early evacuation of people against run-off within the study area although in the far future, the installation of radar rainfall guaging stations may be examined. However, with respect to the floods caused by the Red River, the establishment of this type of system is one of the most effective measures in offering relief to the study area. This should be examined in the anticipated study on the Red River Improvement Project.

On the other hand, there will be a rather complex network of flood control and drainage facilities that will require close coordinations (particularly, between the Yen So pumping station and the Thanh Liet floodgate). Hence, the following stations should be linked with a telemetering system, whose cost is included in the project cost (refer to Appendix (C) Hydrology):

(a) HSDC / MOWR Headquarters;

(b) Yen So pumping station;

(c) Thanh Liet floodgate;

(d) West Lake control gates (A) and (B);

(e) Co Nhue pumping station;

(f) My Dinh pumping station;

(g) Me Tri pumping station; and

(h) Ba Xa pumping station.

(4) Public Information and Education

Public information and education with respect to flood control and drainage may comprise the following items:

(a) Preparation of a flood risk map, showing the expected inundation depths for a certain flood magnitude, for which the inundation maps in the 1984 and 1989 floods delineated in this study might be helpful;

(b) Establishment of flood warning boards showing the maximum water levels in past major floods; and

(c) A campaign to provoke the awareness of people on how important the flood control and drainage projects are.

(5) Flood Fighting and Relief Activity

The present flood fighting organization and operation for the floods resulting from the Red River is adequate. There are watch houses along the dikes at intervals of approximately 1 km, near which materials and tools for the operation are stored.

Further, observation of water levels is done continuously, even at night, throughout the high water stage of the river.

On the other hand, for the flooding caused by local run-off within the study area, flood fighting is not beneficial judging from the nature of the topography. The only recommendation is the provision of vehicles and boats for relief activity.

(6) Flood Insurance

Flood insurance cannot mitigate flood damage, but enables individuals to disperse the expected losses uniformly over a long period of time, by paying premiums. Some countries apply this system, however taking into account the present condition of the study area, the flood insurance system is not recommended.

3.5.3 Project Cost and Implementation Schedule

(1) Project Cost and O/M Cost

The project cost, and annual operation and maintenance cost (O/M cost) required for the implementation of the Drainage Master Plan are estimated as shown in Tables D3.14 and D3.15, respectively, which approximate to:

(US$ million)

River Basin	Project Cost	Annual O/M Cost
To Lich	317.4	1.44
Nhue	206.7	0.73
Total	524.1	2.17

Note : Price level as of the year 1994

(2) Implementation Schedule

Shown in Table D3.16 is the implementation schedule for the Drainage Master Plan. The project components of each stage are as follows:

(a) To Lich River Basin, 1st Stage Construction

This stage of construction aims to relieve the To Lich River basin from floods with return periods of less than approximately 2-year. The construction works comprise:

- Yen So pumping station : $45m^3/s$
- Yen So regulating reservoir : 130 ha of a lake area and 203 ha of a total lot area
- Floodgates and control gates : 7 places
- River improvement for To Lich, Lu, Set, and Kim Nguu Rivers : 33 km in total
- Bridge/culvert re-construction along the drainage channels : 54 places
- Lake dredging : 4 lakes and aeration in 2 pilot lakes

- A part of rehabilitation works for sewer system : About 20% of the area required in the Master Plan
- Supply of dredging equipment : L.S.

(b) To Lich River Basin, 2nd Stage Construction

Through this stage of construction, all the works required in the Drainage Master Plan will be completed for the To Lich River basin. The protection level will become a 10-year return period.

(c) Nhue River Basin

Following the To Lich River basin, the Drainage Master Plan for the Nhue River basin will be realized in this stage by dividing it into four sub-basins, Co Nhue, My Dinh, Me Tri, and Ba Xa.

3.5.4 Legal and Institutional Aspects

(1) Related Organizations

(a) Hanoi Sewerage and Drainage Company (HSDC)

The main agency responsible for operation and management of the drainage and sewerage of Hanoi City is the Hanoi Sewerage and Drainage Company (HSDC).

HSDC was organized originally as a State-owned Enterprise established under the Decision No. 410/QD - TCCB dated 28th March 1973 of the Hanoi People's Committee (HPC). Since then, it has been responsible for dredging sewers, tunnels, channels and rivers in Hanoi City. Due to the rapid urbanization of the City, the demand for sewerage/drainage works has been increasing. Therefore, the Enterprise was reformed into a company under Decision No. 980/QD - TCCB dated 30th May 1991 of HPC. With this reforming of the organization, HSDC now has a wider scope of duties and responsibilities as described below:

- Manage, operate and maintain the sewerage and drainage system of Hanoi City, consisting of 120 km sewers, 38 km channels/canals, 36 km rivers (4 rivers), 592 ha lakes (16 lakes) and 2 local drainage pumping stations;

- Carry out bids and contracts for constructing and improving the sewerage/ drainage projects and wastewater treatment plants on demand;

- Have joint ventures and partnerships with foreign and local organizations (State and Private) to develop the sewerage and drainage networks; and

- Apply scientific and technical advances to drainage and wastewater treatment works, and propose effective measures for sewerage and drainage management.

Fig. D3.7 shows the present organization of the HSDC. The total number of HSDC is 1,196 as of December 1993. The breakdown of the number of personnel by section is shown in Fig. D3.7.

It is planned that HSDC will re-organize the current field service teams into five (5) subsidiary enterprises:

- Sewerage and drainage enterprise No. 1;
- Sewerage and drainage enterprise No. 2;
- Sewerage and drainage enterprise No. 3;
- Mechanical and electrical workshop enterprise; and
- Vehicles and construction enterprise.

This reforming will be effected by the year 1994.

(b) Supervising Authorities of HSDC

The supervising agency for HSDC is the Hanoi People's Committee (HPC). Within HPC, the Transport and Urban Public Work Service (TUPWS) acts as the supervising body over HSDC.

<u>HPC</u>

HPC is the highest authority of Hanoi City, whose controlling function includes the setting of development policies, approval of work plans and budget, and any other high level decisions. HPC directly controls TUPWS, and through them a number of implementing organizations including HSDC.

HPC is the agency to make all decisions concerning issues related to the development and administration of Hanoi City, authorized to have equal power to the Ministries at the national level. HPC is managed by a Chairman, four Vice Chairmen, and Directors of various Departments; one of which is TUPWS.

The administration headquarters of HPC is organized with some 110 staff (excluding various departments) consisting of leaders, permanent staff, and senior experts.

<u>TUPWS</u>

TUPWS has the overall responsibility for transport and urban public works sectors in Hanoi City, including drainage and sewerage. It controls over 30 companies (implementing organizations); one of which is SDC. One of the main roles of TUPWS is to act as a link between the HPC and the implementing organizations subordinated to it.

Fig. D3.8 shows the organization of TUPWS. The number of staff of TUPWS's headquarters accounts for 110 personnel (excluding the employees of various subordinating companies). Within TUPWS, one Vice Director is assigned to supervise the implementation and managing activities of the water sector, including drainage and sewerage.

(c) Subordinating Organizations under TUPWS

There are several agencies under the management of TUPWS, which are directly and indirectly related to sewerage and drainage. The important agencies are:

Hanoi Urban Environment Company (URENCO)

Similar to HSDC, URENCO is a subordinating company under the management of TUPWS . The responsibilities of URENCO include (Ref. UNDP report VIE/86/022):

- Collection and processing of domestic wastes, including solid wastes, nightsoil, and septic tank sludge;

- Management of public latrines; and

- Street cleaning.

URENCO also includes sewer engineering/management departments and a number of operational teams and enterprises. These enterprises include solid waste transport teams, street watering teams, nightsoil collection teams, a mechanical workshop, and a composting plant. The total number of employees is around 2,950, mostly comprising women (80 %) who are mainly used for nightsoil and waste collection.

The CIDA Report (Q061, January 1993) describes the current activities of the company. The following three paragraphs are reproduced from the report:

The company collects on a daily basis 980 m^3 of solid waste from an estimated total daily production of 1,980 m^3 from the urban area. Many of the larger industrial units dump their solid waste directly into the canals and rivers rather than contract with the company to collect the waste. The company also collects about 220 tons of nightsoil daily, which is about 50 per cent of the total daily produced. Most of the collection problems are related to the inability of residents, particularly in new large housing areas, to pay for the collection service. In these cases, the company will report violations to the environmental committee which has the responsibility for sending out inspectors and applying appropriate penalties.

The majority of company funds, 80 per cent, is supplied through budgetary appropriations from the People's Committee while the remaining 20 per cent is composed of fees collected from residents for waste collection, de-slugging of septic tanks, sales of nightsoil to farmers and their own commercial mushroom growing operation. The total funds supplied to the company in the 1992 financial year was 19.8 Billion Dong (US$ 1.8 million).

Capital expenditure is normally small and the funds are contributed from the Central Government, People's Committee and from company profits. For the 1991 financial year, the profit allocation from the company was 264 Million Dong (US$ 24,000) while the allocation from the People's Committee was 3.3 Billion Dong (US$ 300,000). The capital budget allocation for the years 1989 - 1992 provided about the same annual amount for capital expansion.

Currently, solid wastes disposed of on road surfaces and in canals/rivers, and overspills of untreated human waste are major sources of pollution in regard to the sewerage and drainage systems. For this reason, it is important to plan and operate the sewerage/drainage system in close coordination with URENCO's duties.

Hanoi Water Supply Company (HWSCo)

HWSCo is the key organization responsible for supplying water for domestic, industrial and public uses, operating and maintaining the water supply system, collecting the revenue, and providing related services.

The company consists of six administration/engineering departments and two enterprises. A production enterprise, operating eight major and minor water plants, and a distribution enterprise, consisting of six branches. The total number of employees in 1992 was around 1,600.

The expansion of the City's water supply capacity is being implemented by the Hanoi Water Supply Programme (HWSP) under a FINNIDA assistance program. HWSP envisages to expand the supply capacity from 330,000 m^3/day (1993) to 400,000 m^3/day (1995) and eventually to 685,000 m^3/day towards the year 2010.

This implies that future wastewater yields will increase and accordingly the sewerage development should be formulated with the water supply expansion programme.

Investment Company for the Development of Water Sector (INVESCo)

INVESCo was established by Decision No. 741/TCCQ of HPC in 1991 to replace the former Hanoi Water Supply Management Board. The decision defines the role of INVESCo as; "controlling the inputs which are allocated annually by the city and TUPWS (including foreign assistance) to serve for the construction and development of the city water sector according to the plan approved by HPC".

Originally INVESCo was solely dedicated to assist in the implementation of the Hanoi Water Supply Programme (HWSP). The majority of the present personnel, a little over 100 persons, is continuing this work. It includes preparation of work plans and budgets for capital construction works, writing of contract documents, making contract agreements with survey, design, and construction companies carrying out work for HWSP. An important role is the supervision and quality control of the contracted work. (Ref. Water Master Plan, FINNIDA)

The above description implies that the water supply sector is under the management of two separate organizations. Generally, INVESCo is in charge of dealing with capital construction works, while HWSCo manages operation and maintenance. There is a plan to unify the two organizations to improve efficiency.

Design and Construction Companies

There are two construction companies and one design company under the umbrella of TUPWS (see Figure D3.11). The design company, Hanoi Design Company (HSDCo), has been involved with HWSP in the designs of distribution pipelines and consumer connections.

(d) Other Related Agencies within HPC

Other than the institutions under TUPWS, there are several other agencies related to the drainage/sewerage sectors.

Hanoi Urban Planning Institute (HUPI)

HUPI prepares the city's development master plan including proposals for short and long term land use plans. HUPI is also dealing with the preparation of the drainage/sewerage master plan. HUPI plays a very important role in terms of coordinating the development plans of the various sectors.

Construction Department

This department is in charge of the construction of high-rise buildings and the issuance of building permits (UNDP VIE/86/022). It controls a number of construction and design companies, some of which are actively involved in the construction works of the water sector (e.g., the Machinery Installation Company for Water Works).

Land and Housing Department

This department allocates housing facilities to institutions, and is responsible for the maintenance of houses and high-rise buildings, including the maintenance of septic tanks. (UNDP VIE/86/022)

Agricultural Service

The lakes and ponds in Hanoi are intensively utilized for fish farming. The Agricultural Service is in charge of the use of city land and waters for food production. As a result, the major lakes are administered by the Agricultural Service. There are also five State-owned fishing companies providing supervision and technical advice to some 300 fishing cooperatives in Hanoi. (UNDP VIE/86/022)

(e) Central Government Level

As shown in Figure D3.10, HPC technically and administratively coordinates with the Ministries. Important Ministries concerned with drainage and sewerage are the Ministry of Construction, the Ministry of Water Resources, the Ministry of Science, Technology and Environment, the Ministry of Health, and the State Planning Committee. (NB: the following information is primarily based on UNDP report VIE / 86 / 022)

Ministry of Construction (MOC)

MOC is the leading institution in designing and implementing urban infrastructures such as water supply and drainage/sewerage and in developing the sector's policies. MOC also supervises project implementation through its design companies.

The most important MOC's companies/agencies related to the drainage/sewerage sector are as follows (CIDA Q061, January 1993):

- Design Company for Water Supply and Sanitation Systems in Hanoi (DCNSS).

  DCNSS is responsible for preparing designs for water supply and sanitation investments. Its main activities and earning are generated by planning, design, and site supervision of water and sewerage projects throughout the country. It has more than 260 employees, of which 150 are engineers. DCNSS also carries out activities and participates in national standardization, and design and manual criteria development.

- Water and Sewerage Construction Company No. 1 in Hanoi (WASECO 1).

  WASECO is MOC's main contractor in Hanoi with more than 3,500 employees including 200 engineers. In 1988, it carried out 38 construction projects related to the water sector; 28 water supply projects and 10 sewerage projects.

- Institute of Urban and Rural Planning (IURP).

  IURP is concerned with physical planning including city planning. In Hanoi, it closely coordinates with HUPI.

Ministry of Water Resources (MOWR)

MOWR is responsible for the development and balanced management of surface water resources. Due to the high priority given to increased agricultural production, MOWR mainly focuses on irrigation and flood control issues.

In the Study Area, MOWR is contemplating implementing the following three major projects relating to Hanoi drainage:

- The Yen So pump station project (30 m^3/s initially enlarging to 60 m^3/s);
- The Nhue River improvement project; and
- The Red River dike reinstatement project.

The organization is divided into a number of departments; including planning and management, science and research, irrigation and drainage, the water design institute, and dikes and flood control.

Ministry of Science, Technology and Environment (MOSTE)

This is a new ministry re-organized from the former State Committee for Science and Technology (SCST) in October 1992. The ministry's main role is to assist the Government in strategies and policy planning matters related to science, technology, and the environment.

Ministry of Health (MOH)

The tasks of this ministry relating to the sewerage/drainage sector are health education, promotion of appropriate water supply and sanitation, and water quality monitoring. The ministry is also directly responsible for the implementation of rural sanitation projects.

State Planning Committee (SPC)

SPC assists the Government in the long and short term planning of the country's socio-economic development. In association with the Ministry of Finance, it controls the country's capital investment and overseas purchases.

It assists the Government in setting development priorities of the various sectors through the allocation of investments. Most of the 14 departments of SPC deal with sector planning. Among them, the Economic Strategy Department is responsible for the overall prioritization and allocation of resources among the sectors, and the Department of Evaluation approves major capital investments.

(2) Present Laws and Regulations

(a) Sector Laws and Regulations

There is no comprehensive laws, like the water act, the river act, or the sewerage act, that exist in other countries. The important laws and/or regulations related to the sector include:

- Environmental Protection Law (President Decree No. 29 L/CTN), National Political Publishing House, January 1994; and

- Hygienic Regulations - Administrative Penalty in Health Services (Code No. 23 / HDBT), Council of Ministers, January 1991.

The control of water pollution has depended on permits and guidelines issued by the sectoral ministries of the industries concerned (e. g., the standards in water quality for recipients was established by the Ministry of Health).

The abstraction of water for human consumption is generally not subject to limitations except for certain rivers with special status. The Ministry of Water Resources has to be consulted before any measures are taken which might affect the regulation of flows of these rivers.(Ref. UNDP report, April 1990)

(b) Technical Regulations and Guidelines

There are number of technical regulations and guidelines, and design criteria related to drainage and sewerage. The important ones are:

- Design criteria for water supply;
- Design criteria for urban sewerage;
- Design criteria for house plumbing (water supply and sewerage);
- Technical regulations for labor safety in the operation of water and sewerage system;
- Technical regulations on the operation of water supply systems;
- Regulation for Management of Sewerage and Drainage System in Hanoi (Draft) May 1993;
- Design Standards for Sewerage and Drainage Systems and Works (Code No. 20 CTN - 51 - 84), Construction Publishing House, 1989; and
- Temporary Guidance for Environmental Impact Assessment of Technical Economic Project (No. 1485/ MTg), Ministry of Science, Technology and Environment, September 1993.

(3) Recommendations for Legal and Institutional Aspects

According to the Regulation for Management of Sewerage and Drainage System in Hanoi, the Hanoi Sewerage and Drainage Company (HSDC) is designated as the sole agency responsible for the same in Hanoi. In this regulation, it is also clearly defined that HSDC has a right to control not only the water bodies but the lands within 1m to 3m on both banks of the following (together with associated structures):

- To Lich, Lu, Set, and Kim Nguu rivers;
- Drainage channels (open canals);
- Sewers and side ditches; and
- 16 lakes in the city area.

The regulation has several further articles on the improvement, management, and operation of flood control and drainage works. Therefore, strict execution of the regulation should greatly contribute to the betterment of the flood and drainage status in the area of Hanoi. The following comments pertain to the legal and institutional aspects for flood control and drainage.

(a) Besides the 16 lakes under the present management of HSDC, there are a number of lakes and ponds in Hanoi City which belong to local authorities, the fishing company, etc. (refer to Table D2.2). Taking into account the multipurpose use of lakes/ponds, this situation is understandable. However, regarding flood control and drainage, HSDC should reserve the right of overall management of these lakes and ponds.

(b) The city development planning and land use control of Hanoi City area are the main tasks of the Hanoi Urban Planning Institute (HUPI). However, change of land use in the catchment area greatly influences flood control and drainage works. In this regard, new planning and substantial changes to the existing land use should be referred to HSDC prior to the approval of higher authorities. Moreover, the construction of waterfront parks is recommended to be done under the close coordination of HUPI and HSDC.

(c) Construction and re-construction of the bridges, roads, and utility lines intersecting the controlled areas of HSDC should be subject to the approval of the same. In this procedure, HSDC will assess whether or not these structures may damage the flood control and drainage function of the stretch or area in question.

(d) As mentioned before, solid waste disposal into the rivers, lakes and ponds have rapidly deteriorated flood control and drainage functions, and the aesthetics of the areas. Countermeasures need to be worked out under the cooperation of URENCO and HSDC.

(e) The floodwater and wastewater from the Hanoi area (under the management of HSDC) discharges into the Red River and Nhue River which are managed by the Ministry of Water Resources (MOWR). Both agencies are recommended to establish a coordinating body for the preparation of technical agreements concerning:

- Operation and management of the pumping stations and floodgates (especially the Yen So pumping station and the Thanh Liet floodgate);
- Flood fighting activities;
- Water quality control; and
- Exchange of data and information.

3.6 Flood Damage and Expected Benefit

At present, the study area is being seriously affected by flood, which causes various kinds of damage to the socio-economic life of the residents. In this study, direct damage to houses, household goods, shops, merchandise, public/government buildings, factories, farms, and fisheries is estimated through studying damage potential and flood frequency, and applying the damage ratio.

Indirect damage is also taken into account, including damage to transportation, communication, industry, and business. The indirect damage is estimated by evaluating the loss of regional products in the study area.

3.6.1 Damage Potential

The estimate of damage potential is made for evaluating direct flood damage in the following manner:

(a) An estimate of unit value of the properties including houses, shops, and public/government buildings, which have been affected by flood;

(b) Land use in the study area is classified into typical types; and

(c) Estimate the value of the damage potential for each different land use (damage potential per ha).

(1) Estimate of Unit Value of Properties

For estimating the value of the damage potential for each different land use in the study area, unit values of the major properties are estimated on statistical data and the results of the interview survey. Average sizes of houses and shops are estimated both for urban and suburban areas. Since there are no official data regarding the present value of houses, new construction costs for each type of houses are estimated using the unit construction cost. To estimate the current value of houses, the ratio of the residual value (after depreciation) is estimated in due consideration of the construction time. Current values of the houses in the study area are estimated, as presented below. Current values of the public/government buildings and factories are also calculated based on the unit construction cost and residual value ratio.

Item	Urban		Suburban			
	Urban house	Shop	Rural house	Shop	Public/ Gov	Factory
Floor area (m^2)	42	25	63	20	-	-
Unit const. cost ($/$m^2$)	125	120	65	75	300	210
Construction cost of house ($)	5,250	3,000	4,095	1,500	-	-
Residual value Ratio	0.65	0.65	0.65	0.65	0.50	0.50
Current value per house ($)	3,412	1,950	2,662	975	$150/$m^2$	$105/$m^2$

Current values of household goods and merchandise are also estimated on the basis of the results of the interview survey, considering the per capita income of Hanoi City. Common household goods in the study area include TV sets, radio-cassettes, carpet, furniture, bicycles, and kitchen equipment. Luxury goods including refrigerators, stereo, and motor cycles are also owned by residents in the center city.

Urban Area		Suburban Area	
Household Goods	Merchandise	Household Goods	Merchandise
$ 2,180	$ 2,500	$ 1,530	$ 1,750

(2) Land Use Classification

The damage potential is estimated for each different land use. For this, the study area is classified into the following seven categories:

(a) A type : Ancient area: old Hanoi City;

(b) B type: Urban residential area: residential area with shops;

(c) C type: Suburbs residential area: rural residential area with shops;

(d) D type: public/government area;

(e) E type: industrial area;

(f) F type: farm land; and

(g) G type: fishpond.

This land use classification was made on the basis of the available aerial photographs and the land use data supplied by the field investigation.

(3) Conditions of Estimating Potential Damage

The potential damage is estimated by the following assumptions and procedure.

(a) Number of Houses and Shops

The number of houses and shops is estimated on the basis of the population density, average number of people living in one house and the estimated share of shops among total household as presented below:

Item	A type	B type	C type
Population density	680/ha	240/ha	80/ha
Average No. of people in one house	5.5	5.5	5.4
Share of shops	15%	15%	5%

(b) For the estimate of the potential damage in the public/government area and the industrial area, only the buildings are taken into account. It is assumed that the plot ratios (building area / total area) for the public/government area and the industrial area are 60% and 30 %, respectively.

(c) For farm land, it is assumed that the main crop planted during the flood season is paddy. The average productivity and price of paddy are:

- Average productivity of paddy : 3.3 t /ha
- Price of paddy : $ 200 /t

(d) For fishponds, the following average productivity of fish and the average price are applied:

- Productivity of fish (one season) : 4.5 t /ha
- Price of fish : $ 300 / t (about 3,000 D/kg)

(4) Damage Potential

Based on the conditions mentioned above, the damage potential for different land use is estimated as follows:

(a) A type: $779,000
- house/shop: $461,100
- household goods/merchandise : $317,900

(b) B type: $284,100 / ha
- house / shop: $ 168,200
- household goods / merchandise : $115,900

(c) C type: $ 64,000 / ha
- house / shop: $ 40,100
- household goods / merchandise : $ 23,900

(d) D type: $ 900,000 / ha (building)

(e) E type: $ 315,000 / ha (building)

(f) F type: $ 660 / ha

(g) G type: $ 1,350 / ha

3.6.2 Flood Damage Rate

Since there is no authorized damage rate available in Vietnam, the established Japanese rate (standard damage rate prepared by the Ministry of Construction, Japan) is slightly modified for this study.

(1) Damage Rate on General Assets

Considering the average floor height in Vietnam, it is assumed that a flood over the floor starts at 20 cm depth of the water on the ground. The modified flood damage rate is presented below:

Kind of Assets	Flood Water Level on the Ground					
	Less than 20 cm	20 - 49 cm	50 - 99 cm	100 - 199 cm	200 - 299 cm	Over 300 cm
House/Shop/ Public/Factory	0.03	0.053	0.072	0.109	0.152	0.220
Household goods/Merchandise	0	0.086	0. 191	0. 331	0. 499	0.690

(2) Damage Rate for Farm Crops

Flood Depth	Duration of Inundation			
	1 - 2 days	3 - 4 days	5 - 6 days	Over 7 days
Less than 0.5 m	0.21	0.30	0.36	0.50
0.5 m - 0.99 m	0.24	0.44	0.50	0.71
Over 1.0 m	0.37	0.54	0.64	0.74

(3) Damage for Fishponds

Water Level	Damage Rate(%)
Less than ground elevation	0%
0 - 0.2 m	30%
0.2 - 0.5 m	50%
0.5 - 1.0 m	75%
over 1.0 m	100%

3.6.3 Flood Damage and Expected Benefit

The flood damage and benefit expected through the implementation of the drainage improvement plan are estimated, both for the To Lich and Nhue River basins, in the following manner.

(1) Firstly, based on the damage potential and the flood damage rates, the direct damage per hectare corresponding to the inundation depth was calculated for each land use (See Table D3.17).

(2) Secondly, using the present land use map prepared in this study, the area for each land use was measured for respective sub-basins (See Table D3.18).

(3) Based on the above data, the total direct damage with inundation water levels was calculated for each sub-basin as shown in Table D3.19.

(4) Besides the above direct damage, indirect damage is also taken into account for estimating the economic benefit of the project. The indirect damage includes damage to transportation, communication, industry, and business. The indirect damage is estimated by evaluating the loss of regional products in the study area during the past 1984 and 1989 floods. Based on the inundation areas (excluding farms and fishponds), population density, the inundation period, and per-capita GDP in Hanoi City, the indirect damage is estimated, which is equivalent to about 35 % of the direct damage. (Estimates of the indirect damage during these floods are presented in Table D2.12.)

(5) Based on the results of the inundation analysis, and the relationship between the inundation water level and direct and indirect flood damage, flood damage for different return periods was calculated for without-project and with-project conditions (Table D3.20).

(6) Annual average flood damage was estimated by applying average occurrence probability to the corresponding flood damage. The expected benefit was calculated as the difference between the damages without-project and that of with-project conditions (Table D3.21).

(US$ 1,000)

River Basin	Annual Average Flood Damage		Expected Benefit
	without-project	with-project	
To Lich	12,836	273	12,563
Nhue	2,787	99	2,688

3.7 Associated Projects

3.7.1 Nhue River Improvement Project

(1) Present Plan

Presently, all runoff from the study area finally discharges into the Nhue River, the river closely relating to the formulation of this Drainage Master Plan. Hence, the study team collected a brief report on the Nhue River Improvement Project. According to the report, the Ministry of Water Resources examined the above project twice in 1973 to 1974 and 1986 to 1987, and worked out the present plan for the Nhue River Improvement Project as follows:

(a) Catchment Area : 1,075 km^2

(b) Protection Level : 10-year (10%)

(c) Design Discharge : Calculated at a specific discharge (0.6 m^3/s/km^2)

(d) Design High Water Level

Phu Ly	:	EL. 5.24 m
Lung Co	:	EL. 5.37 m
Dong Quan	:	EL. 5.47 m
Ha Dong	:	EL. 5.80 m

(e) Facility Plan

The main stream of the Nhue River discharges into the Day River at the rivermouth (Phu Ly) by gravity flow. This plan entails heightening the existing levees on both banks along the entire stretches of the main stream. On the other hand, there are several diversion channels from the main stream towards the Day River that lighten the load of the main stream. At the lowest point of each diversion, a pumping station and a floodgate structure have been constructed, or are to be constructed as follows:

Name of Pumping Station	Capacity (m^3/s)	Remarks
Lac Trang	11	Completed
Que	13	Completed
Ngoai Do	33	Completed
Van Dinh	62	Completed
Yen Nghia	20	Proposed

(2) Recommendations

In spite of these efforts, shortage of finance, etc., have hindered the progress of the project. In regard to the Drainage Master Plan for the study area, we would like to make the following recommendations on the project:

(a) Review of the overall improvement plan for the whole Nhue River basin. (In this review, several alternatives should be studied to save construction cost, including reduction of the protection level for the initial stage, polder dike construction for selected areas, use of paddy fields and fishponds as temporary flood retarding basins.)

(b) Establishment of channel sections between the confluence of the To Lich River and the Lien Mac Dam, because the Master Plan may incorporate the construction of the left levee of the Nhue River (although this idea will be re-examined in the feasibility study on the Nhue River basin drainage project).

3.7.2 Red River Dike Reinstatement Project

(1) Scope of Works

The project envisages rehabilitation and reinforcement of the existing dike along the right bank of the Red River (built in the 11th century). The improvement area is about 45 km long between the locations immediately downstream of the bifurcation point to the Day River, and immediately downstream of the Yen So pumping station site. This ADB loan program amounts to about US$48 million.

The project will virtually upgrade the quality and stability of the existing dike. The method of the dike reinforcement will be a combination of (a) provision of an impervious walling in the dike body/foundation, (b) grouting in the foundations, and (c) clay facing on the dike slopes.

(2) Schedule

The progress of the project is now at the stage of selecting Consultants (expected to be appointed by the end of September 1994). The Ministry of Water Resources has already prepared most of the design, and wishes to commence construction work in the end of 1994.

The construction work will be carried out by employing local construction companies, and also by calling for ICB for some potions of the work. The total construction period is foreseen as five years.

Note: Information source - Ministry of Water Resources, Department of Dike Management and Flood Control.

(3) Interrelation between the Drainage Master Plan and this Project

The interrelation will be in the following areas:

(a) The proposed drainage project within the Master Plan will breach the dike temporarily (in 1997/1998 dry season) for the construction of the outlet sluiceways from the Yen So pump station; and

(b) A portion of the earth excavated from the Yen So regulating reservoir will be disposed of and embanked behind (inner land of) the dike, which will be beneficial to the dike in terms of increasing its stability.

D4. FEASIBILITY STUDY

In the Master Plan, some ten projects pertaining to flood control and drainage, wastewater disposal, and other issues were suggested and examined from technical and economical points of view. As a result, the drainage project for the To Lich River basin has been selected as the first priority project. (refer to Appendix (H) Project Evaluation). In this context, the present chapter deals with the feasibility study on the above project. All the planning conditions and basic strategies applied to the Master Plan are also valid for this feasibility study.

4.1 Preliminary Design

4.1.1 Yen So Pumping Station

(1) Location of Pumping Station

Two alternative locations of the Yen So pumping station were examined: one is the original location proposed by the Vietnamese side, and the other is a new site approximately 1.5 km southward from the original location (refer to Figure D3.3). However, the study has verified the advantage of the original plan for the following reasons:

(a) A bearing layer for the structures of the pumping station is found at almost the same elevation of -37 m in both locations;

(b) The outlet channel for the original location can be aligned to an existing channel, while that for the new site should pass through part of a village; and

(c) The original location has already been approved by HPC.

(2) Inlet and Ordinary Drainage Channels

In principle, floodwaters will be conveyed to the Yen So pumping station through the regulating reservoir, not directly from the river system. For this purpose, an inlet channel is provided from the reservoir to the pumping station. This layout has the following advantages:

(a) By operating pumps, the water stage of the reservoir, before floods, can be drawn down lower than the river water stage to ensure a larger flood control water depth; and

(b) A large regulating reservoir stabilizes the pump operation.

On the other hand, when the Thanh Liet floodgate is closed due to high levels of the Nhue River, all drainage water, including wastewater from the city area, comes to the Yen So site. It is not recommended that the reservoir receives this contaminated water because:

(a) The reservoir will be used for recreation and fishery, requiring very good water quality; and

(b) The water quality at the beginning of a flood is particularly bad.

Hence, the provision of an ordinary drainage channel directly connecting the river system to the pumping station is proposed to keep the water quality of the reservoir as clean as possible. The capacity of the channel is 15 m^3/s which is 3 times the wastewater volume in the To Lich River basin. As a result, the inlet channel has a capacity of 75 m^3/s (the pump capacity 90 m^3/s minus 15 m^3/s). An inlet structure will be provided at the conjunction between the inlet channel and the Yen So regulation reservoir for smooth connection. The layout of these structures are presented in Figure D4.1.

(3) Outlet Channel

An outlet channel will be constructed outside the Red River levee to convey a flow rate of 90 m^3/s. It is noted that there is a local levee, with an approximate elevation of 11.0 m (about 3 m lower than the main levee), protecting a village from the Red River's medium-scale floods. Therefore, the outlet channel should be provided with embankments on both sides whose crest elevations are approximately 11.5 m (higher than the local levee), to prevent overflow.

(4) Operation of Pumps, Reservoir and Floodgate

Fig. D4.2 shows the operation of pumps of the Yen So pumping station, the Yen So regulating reservoir, and the Thanh Liet floodgate for the design flood. The operation procedure is described as follows:

(a) When the water stage of the Nhue River theoretically rises to EL. 3.5 m (in reality, that may be a slightly higher elevation of 3.6 m), the Thanh Liet floodgate is closed. (Simultaneously, two other floodgates at Van Dien and Hoa Binh are also closed.) Then, not only floodwater but ordinary drainage water, including wastewater, flow to only the Yen So site.

(b) Floodwater less than 15 m^3/s, and of course ordinary drainage water, are drained out by pumps to the Red River through the ordinary drainage channel.

(c) Once the flow rate exceeds 15 m^3/s and the river water stage reaches EL. 3.7 m (0.2 m higher than EL. 3.5 m), the rubber gates deflate portion by portion to keep the river water stage lower than EL. 3.7 m.

(d) With the increase of an accumulative balance between the river inflow and the pump discharge (90m^3/s), the water stage of the reservoir rises (in the latter half, along with the river water level), finally reaching EL. 4.5 m about one day after the flood starts.

(e) In succession, the water stage of the reservoir recedes to the normal level (EL. 1.5 m) about two days after the outset of the flood, and the full-capacity operation of the pumps is terminated. Pumps are then operated according to the inflow water volume.

(f) When the flow rate of the river system decreases to 15 m^3/s, the rubber gates are again inflated and the river water level comes back to the normal level (EL. 3.5 m) about three days after the start of flooding.

Alternatively, shown in Figure D4.3 is the simulated annual operation of the pumps, the reservoir, and the Thanh Liet floodgate during the example year 1989. (For the detailed procedure in depicting this figure, refer to Appendix (C) Hydrology.) The results are summarized below:

Item	Days/Volume
Duration of Operation	
(a) Gate closure and pump operation	45 days
(b) Use of reservoir	24 days
Water Volume to be Drained	
(a) Pump drainage	
- Through ordinary drainage channel	50 x 10^6 m^3 (17%)
- Through reservoir	63 x 10^6 m^3 (21%)
Sub-total of (a)	113 x 10^6 m^3 (38%)
(b) Natural drainage through the Thanh Liet floodgate	181 x 10^6 m^3 (62%)
(c) Total	294 x 10^6 m^3 (100%)

(5) Hydraulic Boundary and Design Pump Head

The hydraulic boundary necessary for the design of pump facilities is tabulated as follows:

Unit: EL. (m)

Type of Water Level	Inlet Side		Outlet Side (Red River)*	
	To Lich River System	Yen So Regulating Reservoir	In Rainy Season	In Dry Season
High	4.5	4.5	13.5 at 100-yr recurrence (11.6 at 10-yr recurrence)	
Normal	3.5	1.5	5.5	3.0
Low	-	1.5	4.5	2.8
Lowest Low	-	-	3.2	2.6

* Refer to Appendix (c) Hydrology.

The design pump head is determined in accordance with the common practice as follows:

$$H = (\text{The larger of Ha and Hb}) + Hl$$

Where,

H : Design pump head (m)
Ha : HWL on the outlet side - HWL on the inlet side = 13.5 m - 4.5 m = 9.0 m
Hb : (HWL on the outlet side - LLWL on the inlet side) x 0.75 = (13.5 m - 1.5 m) x 0.75 = 9.0 m
Hl : Pipe loss in the pump facilities (1.0 m)

Consequently, the design pump head (H) is 10 m.

(6) Power Source and Type of Pumps

Determination of the power source and the type of pumps is an essential part of the design of a pumping station. These generally govern the structure of the civil works and architecture of the pumping station. Prior to detailed discussions concerning the power source and type of pumps, the following assumptions can be valid for this Project:

(a) The mixed flow type pump is suitable for a design pump head of 10 m; and

(b) With respect to the shaft direction of a traditional pump (meaning a non-submergible pump), the horizontal type is preferred to the vertical one as long as the space for the pumping station is not limited to a small area, because it is cheaper and maintenance work is easier.

The following table shows the alternative types of pumps in accordance with the power source applicable to the Yen So pumping station based on the above assumptions:

Power Source	Pump Type	
	Mixed Flow Horizontal Shaft Traditional Pump	Submergible Pump
Engine Drive	Alternative 1 (9 m^3/s x 10 units)	—
Motor Drive*	Alternative (9 m^3/s x 10 units)	Alternative 3 (3 m^3/s x 30 units)

* Emergency generators will be installed with a 50% capacity of the necessary total power.

A comparison of Alternatives 1 to 3 is detailed in Table D4.1. (For the cost comparison, refer to Table D4.2.) As can be seen in the tables, the submergible type of pumps should be recommended for the Project as they are economical and construction is relatively simple and quick. However, the final selection of the pump type will be made in the detailed design stage.

(7) Layout of Pumping Station

The layout of Yen So pumping station is shown in Figure D4.4. The main structure of the station is about 120 ^{m} wide and 20 ^{m} long without buildings on top of the civil structure. Two sluiceways will be constructed beneath the Red River levee each with three sets of steel gates at the exits. Three surge tanks are located between the main structure and the sluiceways to regulate the water pressure of the outflow of pumps. In addition, a box culvert is placed beside the main structure for natural drainage (although it has very less possibility), and for future intake from the Red River to the To Lich River basin. An operation building is provided near to the main structure. Finally, land area required for the pumping station is estimated at about 1.7 ha (90^m x190^m).

4.1.2 Yen So Regulating Reservoir

(1) Re-routing of the Kim Nguu River Course

The existing Kim Nguu River course is proposed to be re-routed alongside the northern and western perimeter of the Yen So regulating reservoir (see Figure D4.1) in order to:

(a) save construction costs by avoiding the need of a 200^{m} long siphon structure which would be required at the intersection of the existing Kim Nguu River and the proposed inlet channel ;

(b) reduce the total length of the separating levees required between the river courses and the reservoir (from 5.0 km to 3.4 km); and

(c) assure ease of construction.

The new river course is named the Yen So channel. This channel is designed for a flow capacity of 15 m^3/s corresponding to the design discharge of the ordinary drainage channel.

(2) Spillways

Spillways will be constructed on the separating levees at three locations, with lengths of 65 m, 50 m, and 50 m, respectively where the To Lich (Lower Kim Nguu), Set, and Upper Kim Nguu Rivers join the Yen So channel. The crest elevations of the spillways are all 3.0 m, using 1.0m high rubber gates to shorten the spillway lengths. (Refer to Figures D4.1 and D4.5.) The lengths, heights, and shape of the spillways should carefully be determined in the detailed design stage. For this end, it is recommended to carry out a hydraulic model test.

(3) Layout in Reservoir

The Yen So regulating reservoir will be used not only for flood control but for recreation and fishery, therefore the design is divided into three lake portions by irregularly shaped green zones. The lakes are connected to each other using box culverts, creating an aesthetic arrangement of lakes and islands. (See Figure D4.1.) The area of each lake and overall land allocation are as follows:

Zone	Area (ha)
(a) Reservoir Area	
- Lake No.1*	43
- Lake No.2	37
- Lake No.3	50
Sub-total of (a)	130
(b) Green Zone	73
Sub-total of (a) and (b)	203
(c) Yen So Channel	18
Total	221

* Now under construction by HPC

(4) Spoil Bank

The construction work for the Project will produce approximately 8 million cubic meters of excess soil. Although there will be several alternatives for the spoil bank areas and even possibilities of the use of the soil, the study recommends to embank most of the excess soil along the land side of the Red River levee (200 m wide, 10 m high, and 4,000 m long). This idea is effective for the reinforcement of the existing Red River levee, and for the supply of a resettlement area for the Project.

4.1.3 Linh Dam and Dinh Cong Lakes

The Linh Dam and Dinh Cong lakes, as described in Subsection 3.3.1, are intended to be excavated to complement the regulation function of the Yen So reservoir. This idea definitely requires two new channels to connect the Dinh Cong lake to the Linh Dam lake, and the Linh Dam lake to the Yen So site, resulting in a change of flow direction for the Lower Lu River basin (4.33 km^2). Presently this is discharged to the To Lich River, but in this plan, it will be discharged to the Yen So site directly. (See Figure D3.3.) The reasons why past of the floodwater of the To Lich River is not also diverted this way are as follows:

(a) These two lakes have achieved their flood control function at maximum extent by regulating the discharge from the Hoang Liet and Lower Lu basin (12.43 km2 in total), no clearance being expected; and

(b) According to the City Master Plan, the Linh Dam lake will in the future constitute a substantial part of the recreational zone, so that low quality water from the To Lich River basin cannot be allowed to flow into the lake.

Linh Dam and Dinh Cong channels need as small capacities as 8 m^3/s and 11 m^3/s, respectively. However, to assure 100 % of the flood regulating efficiency of the two lakes, the channels are designed to be as wide as possible in the extent of the available land.

The major dimensions of the two lakes are tabulated below:

Item		Linh Dam Lake	Dinh Cong Lake
Area	(ha)	107	25
Bottom Elevation	(EL. m)	2.5*1	2.5*1
Normal Water Level	(EL. m)	3.5*2	3.5*2
High Water Level	(EL. m)	4.5	4.5
Flood Control Volume	(m^3)	1,070,000	250,000

*1 The average excavation depth below the existing bottom is 0.8m to compensate for the normal water level lowering as below .
*2 The present normal water level is around EL. 4.5 m, which is lowered by 1m to create a flood control volume .

4.1.4 Floodgates and Control Gates

Seven floodgates and control gates will be re-constructed or newly constructed for the Project. Their features are presented in Table D4.3. A typical structure (Thanh Liet floodgate) is shown in Figure D4.6.

4.1.5 River and Drainage Channel Improvement

(1) Alignment

The proposed courses of rivers and drainage channels are aligned to the existing ones with the exception of several modifications of extreme bendings. Plans of the rivers and drainage channels are shown in Figure D4.7.

(2) Profile

In principle, the high water levels in the urbanized area are designed to be slightly lower than (at least approximately equal to) the both side's ground elevations to prevent any water stagnation in the basin. However, in the downstream stretches (suburban area), the high water levels exceed the ground elevations by about 0.5 m as the Yen So reservoir temporarily stores floodwater of up to EL. 4.5 m. This may only cause limited damage to the fishponds and agricultural lands on both sides. The design high water levels and also riverbeds (channel beds) resultingly incline with similar gradients of the topography.

The above philosophy is technically detailed as follows. The design high water level in each river, or channel, stretch is determined as the higher one of the succeeding two (refer to Figure D4.8) :

(a) Water level estimated by means of the uniform flow calculation corresponding to the design discharge, starting with a water level of EL. 3.5 m at the Yen So site; and

(b) Water level estimated by using the non-uniform flow calculation corresponding to the design pump capacity of 90 m^3/s (of which, the To Lich River shares 34 m^3/s, the Set 23 m^3/s, the Kim Nguu 24 m^3/s, and other minor basins 9 m^3/s), initiating with a water level of EL 4.5 m at the Yen So site.

Shown in Figure D4.8 are the profiles of the rivers and drainage channels that are delineated with dike freeboards of 0.6 m for the backwater stretches and 0.3 m for the other stretches.

(3) Determination of Flow Section

The flow section of each river or channel stretch is determined using Manning's uniform flow calculation formula:

$$Q = 1/n \times I^{1/2} R^{2/3} A$$

Where,

Q	:	Design discharge (m^3/s)
n	:	Roughens coefficient
		0.030 for earth channels

		0.025 for reveted channels
I	:	Gradient of riverbed or channel bed
R	:	Hydraulic radius (m)
A	:	Flow sectional area (m^2)

The calculation results are tabulated in Table D3.7 and the cross-sections are shown in Figure D4.9.

(4) Maintenance Roads

To facilitate maintenance, patrols, and repair work, roads are provided on either bank of the rivers and drainage channels. These roads will also be useful during the construction work. The effective widths are as follows:

(a) Rivers : 3 m on both side

(b) Drainage channels : 3 m and 1.5 m

(5) Revetment Types and Environmental Measures

The following three types of revetments are employed in the Project, together with respective environmental measures including provision of green belts and promenades (for details, refer to Figure D4.10):

(a) Wet masonry type with a slope of 1: 0.3;

(b) Riprap type with a slope of 1: 2; and

(c) Wet masonry type with a slope of 1: 2.

4.1.6 Lake Improvement

(1) Lake Dredging

18 major lakes in the city area will be dredged in the Project to regulate floodwaters and also to enhance the environment around the lakes. The dimensions of the works are listed in Table D4.4 and the standard cross-sections of the banks are shown in Figure D.11.

(2) Lake Conservation

For the other eleven (11) environmentally valuable lakes in the city area, the following conservation measures will be carried out in the Project:

(a) Excavation of sludge on the lake bottoms;

(b) Provision of riprap for protection of the slopes and prevention of house encroachment;

(c) Environmental measures as shown in Fig. D4.11; and

(d) Aeration of water in selected lakes.

4.1.7 Sewer Rehabilitation and Construction

(1) Flooding Condition of Roads in the Urban Area

A site inspection on the flooding condition of roads was carried out during the rainy season (from July to September) in 1994. Figure D4.12 shows the flooding condition of roads classified by rainfall per hour (mm/hr), on the assumption that the concentration time of the main sewer is 60 minutes.

The city traffic system in the urban area, especially in the Kim Nguu River sub-basin (K1), the Set River sub-basin (S1), and the Upper Lu River sub-basin (L1), is affected frequently by heavy rain during the rainy season because the paved road functions as a main drain instead of using a combined sewer.

(2) Existing Combined Sewer in Urban Area

The existing combined sewer in the urban area is shown in Figure D4.12. Overall runoff coefficients at each drainage sub-basin are calculated, as shown in Table D4.5, according to the future land use plan in the To Lich River basin. The existing capacity of the sewer corresponding to future overall coefficients is estimated, as shown in Table D4.6.

The results of the hydraulic calculation of the sewers, showed all the trunk sewers don't have sufficient capacity for rainfall of a five (5) years return period. The sewer in the old city, which was built prior to 1954, is not adequate even for stormwater of a one (1) year return period.

(3) Layout Plan for Sewer Rehabilitation and Construction

Layout plan for the urban sewer system is shown in Figure D4.13.

(4) Proposed First Stage Project of Sewer Rehabilitation and Construction

The proposed work will basically augment the existing sewer capacity in selected areas where flooding is habitual and there is an urgent need of improvement. The plan was formulated considering the following:

(a) Principally the work concerns the addition of new sewer pipes. The replacement of old pipes will be determined only after inspecting the condition of existing pipes revealed during the cleaning of sediments (scheduled to be carried out as urgent work after receiving dredging equipment).

(b) The augmentation of the sewer capacity under the 1st stage project is principally planned for trunk sewer lines, leaving the secondary and tertiary lines to be reinforced in the 2nd stage project.

(c) The work is proposed only for selected priority areas where habitual inundation takes place.

The first stage project of sewer rehabilitation and construction is proposed as shown in Figures D4.13 and D4.14. It consists of W1 of the West Lake sub-basin, K1 of the Kim Nguu river sub-basin, S1 of the Set River sub-basin, and L1 of the Upper

Lu River sub-basin, totaling 1,053 ha. Approximate work quantities are given in Table D4.7.

4.2 Implementation Schedule and Project Cost

4.2.1 Implementation Schedule

The Project requires more than US$ 360 million in total, therefore it is expected to be implemented in stages. In view of the cost and the limitation of time, the Project is recommended to be divided into two phases comprising the work items listed in Table D4.8. Completion of the 1st Stage Project will ensure a protection level of approximately a 2-year return period, while the completion of the 2nd Stage Project will achieve a 10-year return period. Detailed discussion of the implementation schedule is made in Appendix (G) Construction Plan and Cost Estimate, summarized as follows:

(1) 1st Stage Project : Year 1995 - 2000

(2) 2nd Stage Project : Year 2000 - 2004

4.2.2 Project Cost

Estimated project costs for the 1st and 2nd Stage Projects are summarized below:

Unit: US$ million

Stage	1st Stage Project	2nd Stage Project	Total
Base Cost	147.4	143.3	290.7
Import Tax	4.0	3.3	7.3
Price Escalation	13.5	33.3	46.8
Physical Contingency	14.4	16.8	31.2
Total	179.3	196.7	376.0

Note: For details, refer to Appendix (G) Construction Plan and Cost Estimate.

4.3 Organizations for Project Implementation and O/M

4.3.1 Executing Agency

The Executing Agency of the proposed project is the Hanoi People's Committee (HPC), which has the final responsibility for direction setting and decision making in proceeding the implementation of the project, referring important matters to the Government when necessary.

Within the HPC, the Transport and Public Works Service (TUPWS) is the technical department in charge of the Project. The Sewerage and Drainage company (SDC), a subordinate organization under the management of TUPWS, is the agency specifically responsible for the management and operation of sewerage/drainage in the city.

During the implementation of the Project, HPC, TUPWS, and SDC will play the leading role as the Executing Agency. Their organizational charts are included in Figures D3.7 and D3.8.

4.3.2 Project Implementation Organization

For the implementation of the Project, a new implementing organization is to be set up prior to commencement of the detailed design works. The proposed implementation organization is presented in Figure D4.15.

(1) Firstly, the Project Cooperation Committee (PCC) is to be established in the Hanoi People's Committee (HPC), dealing with the proposed drainage and environment improvement project. The main functions of the PCC are: (a) to provide a basic policy and guidelines for the implementation, (b) to approve fund disbursement, (c) to award construction contracts and to import equipment, and (d) to coordinate the agencies concerned.

Important matters like land acquisition and resettlement are also to be discussed and guided by PCC. The members of PCC consist of representatives from the following agencies:

- Hanoi People's Committee (HPC);
- Ministry of Construction (MOC);
- Ministry of Water Resources (MOWR);
- State Planning Committee (SPC);
- Ministry of Finance (MOF); and
- Ministry of Trade (MOT).

The PCC is to be headed by a chairman and an acting chairman who are assigned from the top management level of HPC and TUPWS, respectively, and are assisted by members selected from the coordinating agencies.

(2) Under PCC guidance, a Project Management Office (PMO) is to be established in TUPWS for implementing the detailed design work and construction.

PMO is to be headed by a representative of TUPWS and staffed with engineers and administrators assigned from the related companies and agencies. Technical and operational collaboration from the Sewerage and Drainage Company (SDC) is expected during the detailed design and construction stage. SDC will assist PMO in quality control and operation and maintenance. For the design and construction of the Yen So pumping station, technical input and assistance from the Ministry of Water Resources and the Ministry of Construction are indispensable.

PMO will consist of three departments, the Planning Dept., the Engineering Dept., and the Administrative and Accounting Dept., and will have the following functions:

- To conduct detailed design (in collaboration with consultants);

- To call tender bids and appraise tender results prepared by consultants;

- To prepare surveys for land acquisition/resettlement and prepare a resettlement plan (in collaboration with consultants);

- To supervise installation and construction works (in collaboration with consultants);

- To prepare disbursement schedule and to control cost disbursement; and

- To conduct administrative work.

For smooth implementation, a resettlement program is to be prepared by PMO's Planning Department during the earlier stage. During the detailed design, an inventory survey of the resettlement area is to be conducted to ascertain the number of households/population affected, and the number and kind of assets, in close cooperation with district offices.

The required number of staff in PMO is approximately 30 persons, including 15 engineers, 5 accounting/administrative staff, and 10 assistants/clerks. The Consultants' team will be separately organized.

An engineering consultant is to be employed during the detailed design and construction stage. The function of the consultant is not limited to providing engineering expertise for the detailed design and construction, but will include technical and operational assistance to PCC for the successful completion of the Project.

4.3.3 Operation and Maintenance Organization

After completion of the project construction works, all the drainage facilities, including the Yen So pumping station, will be transferred to SDC which is designated the agency responsible for operation and maintenance of the completed project facilities.

PCC (to be re-named the "Drainage Management Committee") will remain an important organization, coordinating other agencies concerned and making higher level decisions.

For operation and maintenance, coordination with the Ministry of Water Resources is important, particularly for the Yen So pumping station and the Thanh Liet floodgate. A telemeter, or a radio communication system, is proposed to be established to achieve drainage operation using an integrated operation system. See Figure D4.16 for the proposed organization during the operation/maintenance period.

Main activities for operation and maintenance are:

- Operation of the pump station, gates and regulating reservoir, and their maintenance;

- Seasonal maintenance/rehabilitation of levees, revetments, etc.;

- Daily patrol along the rivers, drainage channels, lakes, and ponds;

- Measurement and monitoring of rainfall, water level, flow discharge, and water quality; and

- Compilation of data and information regarding flood and flood damage.

For the operation and maintenance of the Project, the required number of staff will be 28 persons, including 7 engineers, 18 technicians/operators, and 3 administrative staff, covering all facilities as follows:

Personnel	Yen So Pumping Station	Thanh Liet Floodgate	West Lake Control Gate A	Total
Engineer	5	1	1	7
Technician	8	2	2	12
Operator	4	1	1	6
Administrative Staff	3	0	0	3
Total	20	4	4	28

Table D 2.1 FLOW CAPACITIES OF RIVER STRETCHES

Stretch	Flow Capacity		Discharge Distribution Corresponding to 1.2-year Flood* (m3/s)
	Discharge (m3/s)	Probability (year)	
A. To Lich River			
1. T0.0k to T1.0k (Nhue R.) (Kim Nguu R.)	170	5.30	58
2. T1.0k to T2.8k (Kim Nguu R.) (Lu R.)	75	2.90	34
3. T2.8k to T7.8k (Lu R.) (T5 D/C)	50	2.80	23
4. T7.8k to T12.2k (T5 D/C) (T2 D/C)	40	4.80	15
5. T12.2k to T14.6k (T2 D/C) (West L.)	10	5.00	3
B. Lu River			
1. L0.0k to L3.4k (To Lich R.) (Floodway)	12	1.20	13
2. L3.4k to L4.6k (Floodway) (L2 D/C)	8	1.10	9
3. L4.6k to L5.6k (L2 D/C) (Trung Tu L.)	3	1.40	2
C. Kim Hguu River			
1. K0.0k to K4.4k (To Lich R.) (H D/C)	45	1.70	28
2. K4.4k to K6.2k (H D/C) (Set R.)	35	1.50	26
3. K6.2k to K9.4k (Set R.) (K4 D/C)	25	1.60	17
4. K9.4k to K11.0k (K4 D/C) (K2 D/C)	15	1.60	10
5. K11.0k to K11.8k (K2 D/C)	8	1.70	5
D. Set River			
1. S0.0k to S3.4k (Kim Nguu R.) (Floodway)	7	1.06	10
2. S3.4k to S5.9k (Floodway) (Bay Man L.)	5	1.12	6

*: Assumed to be the overall flow capacity of the To Lich river system.
Note : For the locations, refer to Fig.D3.6.

Table D 2.2(1) CONDITIONS OF EXISTING LAKES AND PONDS (1/6)

No.	Name of Lake	Name of Sub-basin	Lake Area (ha)	Present Status of Surrounding Area	Management Body of Lake	Present Lake Use: Storm Water Drainage /Flood Control	Waste-Water Treat-ment	Fishery	Aqua Planting	Rice Growing	Washing	Recre-ation	Brick-making	Water Quality (As of Feb, 1994): Water Colour	Smell	pH	Condu-ctivity (micro S/cm)	Turbi-dity (FTU)	DO (mg/l)	Classifi-cation *	Remarks
W1	Truc Bach	W	22.0	Res.(M) Park	HSDC	X	X	X	X	-	X	X	-	Light green	Organic	7.30	505	29	0.21	A	
W2	West Lake	W	567.0	Res.(L) Park	Fishing Co.	X	-	X	X	-	X	X	-	Green	Organic	7.19	413	18	0.60	A	
T1	Bay Giau	T2	3.9	Res.(M)	Village Com./Fishing Co.	X	X	X	-	-	-	-	-	Green	Organic	7.41	793	58	0.74	B	
T2	Doi Can	T2	1.0	Bld.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	Already reclaimed
T3	Van Phuc	T2	2.7	Bld.	Cong Vi Com.	X	X	X	-	-	-	-	-	Brown Green	Light Organic	7.60	473	109	4.20	H	To be reclaimed
T4	Thu Le	T2	9.3	Park	HSDC	X	-	-	-	-	-	X	-	Light Brown	Organic	7.60	462	37	2.93	C	
T5	Lang Thuong 1	T4	2.5	Bld.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	Already reclaimed
T6	Lang Thuong 2	T4	3.3	Bld.	Lang Thuong Com.	X	X	X	-	-	-	-	-	Black Green	Domestic	8.00	579	40	7.60	H	To be reclaimed
T7	Giang Vo	T6	8.4	Park Bld.	HSDC/ Fishing Co.	X	X	X	-	-	-	X	-	Green	Organic	7.39	618	72	1.36	A	
T8	Ngoc Khanh	T6	4.5	Park Res.(H)	HSDC/ Fishing Co.	X	X	X	-	-	-	X	-	Green	Organic	7.39	592	33	1.39	A	
T9	Thanh Cong	T6	6.5	Park Res.(H)	HSDC/ Fishing Co.	X	X	X	-	-	-	X	-	Green	Organic	7.46	609	71	0.90	A	
T10	Hao Nam	T5	2.8	Res.(M) Bld.	Hao Nam Com.	X	X	X	X	-	-	-	-	Green	Domestic	7.40	538	62	1.76	B	
T11	Hoang Cau 1	T5	1.4	Res.(H)	O Cho Dua Com.	X	X	X	X	-	-	-	-	Black Green	Organic	7.40	994	130	0.57	H	To be reclaimed
T12	Hoang Cau 2	T5	4.2	Res.(H)	O Cho Dua Com.	X	X	X	-	-	-	-	-	Brown Green	Organic	7.50	608	102	1.45	H	To be reclaimed
T13	Dong Da 1	T5	18.6	Res.(H) Bld.	Fishing Co.	X	X	X	-	-	-	-	-	Dark Green	Organic Domestic	7.74	718	23	1.13	B	
T14	Dong Da 2	T5	16.9	Res.(H) Park	Fishing Co.	X	-	X	-	-	-	-	-	Dark Green	Organic Domestic	7.63	579	46	0.91	H	To be reclaimed
T15	Lang Ha	T6	1.6	Res.(M)	Lang Ha Com.	X	X	X	-	-	-	-	-	Green	Organic Domestic	7.80	506	94	7.13	B	
T16	Nghia Do 1	T3	5.2	Res.(M) Park	-	X	-	X	-	-	X	X	-	Green	Domestic	7.46	371	44	1.30	A	
T17	Nghia Do 2	T3	4.0	Agr. Res.(L)	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	I	Mostly used for housing
T18	Nghia Do 3	T3	3.8	Agr. Res.(M)	-	X	X	X	X	-	-	-	-	Brown	Organic	7.33	418	51	1.80	H	To be reclaimed

* A: Drainage(Wastewater)+Fishery+Recreation
B: Drainage(Wastewater)+Fishery
C: Drainage+Recreation
D: Drainage(Wastewater)+Rice Growing
E: Drainage(Wastewater)
F: Fishery
G: Brick-making
H: To be reclaimed by year 2010
I: Already reclaimed up to date

Table D 2.2(2) CONDITIONS OF EXISTING LAKES AND PONDS (2/6)

No.	Name of Lake	Name of Sub-basin	Lake Area (ha)	Present Status of Surrounding Area	Management Body of Lake	Present Lake Use: Storm Water Drainage /Flood Control	Waste-Water Treatment	Fishery	Aqua Planting	Rice Growing	Washing	Recreation	Brick-making	Water Quality (As of Feb., 1994): Water Colour	Smell	pH	Conductivity (micro S/cm)	Turbidity (FTU)	DO (mg/l)	Classification *	Remarks
T19	Ha Dinh 1	T8	1.5	Agr. Bld.	-	X	X	X	-	-	-	-	-	Green	Domestic	7.60	506	32	3.26	H	To be reclaimed
T20	Ha Dinh 2	T8	7.7	Agr. Res.(M)	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	F	
T21	Ao Lo Gach	T8	2.3	Agr. Res.(M)	Village Com.	-	-	X	-	-	-	-	-	Green	Organic	7.53	531	24	2.33	F	
T22	Ao Thuong	T9	1.7	Agr. Res.(M)	Village Com.	-	-	X	X	-	X	-	-	Green	Domestic	7.40	601	35	0.83	F	
L1	Giam	L1	0.8	Res.(M)	HSDC	X	X	-	X	-	-	-	-	Light Black	Domestic	7.30	727	18	0.13	E	
L2	Linh Quang	L1	1.8	Res.(M)	HSDC	X	X	-	X	-	-	-	-	Black	Domestic	7.30	851	22	0.08	E	
L3	Van Chuong	L1	4.1	Res.(H) Bld.	Fishing Co./ HSDC	X	X	-	X	-	-	-	-	Black	Domestic	7.20	672	25	3.75	E	
L4	Tho Quan	L1	1.5	Res.(H)	Kham Thien Com.	X	X	-	X	-	-	-	-	Black	Domestic	7.30	930	94	0.45	E	
L5	Ba Mau	L1	3.0	Park Res.(M)	HSDC/ Fishing Co.	X	X	X	-	-	-	X	-	Light green	Organic	7.60	704	45	1.05	A	
L6	Trung Tu	L1	5.1	Bld. Res.(H)	HSDC/ Fishing Co.	X	X	X	X	-	-	-	-	Green	Organic	7.80	755	120	0.60	B	
L7	Kim Lien	L3	2.1	Res.(H)	HSDC/ Fishing Co.	X	X	X	-	-	-	-	-	Green	Organic	7.60	920	90	3.60	B	
L8	Medical University Pond	L2	1.7	Bld. Res.(H)	Medical University	X	X	X	-	-	-	-	-	Green	Organic	7.72	493	51	3.04	H	To be reclaimed
L9	Khong Quan 1	L2	3.0	Bld.	Army	X	X	X	-	-	-	-	-	Green	Organic	7.03	383	8	0.85	H	To be reclaimed
L10	Khong Quan 2	L4	1.2	Bld.	Army	X	X	X	X	-	-	-	-	Green	Organic	7.70	670	27	1.52	H	To be reclaimed
L11	Phuong Liet 1	L4	5.6	Bld.	Phuong Liet Com.	X	X	X	-	-	-	-	-	Light brown	Light organic	7.50	608	10	1.94	B	
L12	Phuong Liet 2	L4	1.9	Res.(M) Ind.	Phuong Liet Com.	X	X	X	-	-	-	-	-	Green	Organic	7.10	960	19	0.52	B	
L13	Khuong Trung 1	L6	7.4	Bld. Res.(M)	K. Trung Com.	X	X	X	-	-	-	-	-	Green	Organic	7.29	1,080	14	0.20	B	
L14	Khuong Dinh	L6	25.6	Agr. Res.(M)	K. Dinh Com. /Fishing Co.	X	-	X	-	-	-	-	-	Green	Light organic	7.60	611	46	2.30	B	
L15	Khuong Trung 2	L6	9.3	Agr. Res.(M)	K. Trung Com. /Fishing Co.	X	-	X	-	-	-	-	-	Green	Organic	7.50	496	55	2.84	B	
L16	Khuong Ha	L6	9.7	Agr. Res.(M)	Khuong Ha Com.	-	-	X	-	-	-	-	-	Brown	Light organic	7.60	547	180	1.26	F	

* A: Drainage(Wastewater)+Fishery+Recreation
B: Drainage(Wastewater)+Fishery
C: Drainage+Recreation
D: Drainage(Wastewater)+Rice Growing
E: Drainage(Wastewater)
F: Fishery
G: Brick-making
H: To be reclaimed by year 2010
I: Already reclaimed up to date

Table D 2.2(3) CONDITIONS OF EXISTING LAKES AND PONDS (3/6)

No.	Name of Lake	Name of Sub-basin	Lake Area (ha)	Present Status of Surrounding Area	Management Body of Lake	Present Lake Use: Storm Water Drainage /Flood Control	Waste-Water Treat-ment	Fishery	Aqua Planting	Rice Growing	Washing	Recre-ation	Brick-making	Water Quality (As of Feb., 1994): Water Colour	Smell	pH	Conduc-tivity (micro S/cm)	Turbi-dity (FTU)	DO (mg/l)	Classifi-cation *	Remarks
L17	Dinh Cong 1	L6	25.3	Agr. Bld.(M)	Dinh Cong Com.	X	X	X	-	-	-	-	-	Light brown	Organic	7.50	633	14	1.43	B	
K1	Hoan Kiem	K1	11.9	Park Bld.	HSDC/ Fishing Co.	X	-	X	-	-	-	X	-	Green	Organic	7.98	206	133	4.60	A	
K2	Hai Ba Trung	K1	1.0	Park Res.(H)	HSDC/ Fishing Co.	X	X	X	-	-	-	X	-	Green	Organic	7.03	452	13	1.01	A	
K3	Thanh Nhan 1	K3	8.5	Res.(H) Park	HSDC/ Fishing Co.	X	X	X	-	-	-	X	-	Green	Organic	7.70	656	45	1.00	A	
K4	Thanh Nhan 2	K3	4.0	Res.(H)	HSDC/ Fishing Co.	X	X	X	-	-	-	X	-	Green	Organic	8.09	730	82	0.20	A	
K5	Mai Dong 1	K5	1.7	Park/Ind. Res.(M)	Mai dong Com.	X	X	X	-	-	-	-	-	Brown green	Organic	7.50	743	-	1.66	H	To be reclaimed
K6	Mai Dong 2	K5	1.5	Res.(M) Ind.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	Already reclaimed
K7	Vinh Tuy 1	K6	1.3	Agr. Res.(M)	Vinh Tuy Com.	X	X	X	-	-	X	-	-	Green	Organic	7.65	521	-	2.54	B	
K8	Vinh Tuy 2	K6	3.6	Res.(M)	Vinh Tuy Com.	X	-	X	-	-	-	-	-	Light brown	Organic	8.40	296	30	7.44	B	
K9	Thanh Tri	K6	2.0	Res.(M)	Thanh Tri Com.	X	X	X	-	-	-	-	-	Light green	Organic	7.50	610	-	1.69	B	
K10	Minh Khai	K5/6	86.0	Agr. Res.(L)	Minh Khai Com.	X	X	X	-	X	-	-	-	Green	Organic	7.70	366	-	6.45	D	To be Partly reclaimed
K11	Sen Chua-Giua	K6	20.4	Agr. Res.(L)	Viet Trung Com.	X	-	X	-	X	X	-	-	Light brown	Organic	8.00	474	-	6.50	D	
K12	Cao Lang	K6	16.8	Agr. Res.(L)	Viet Trung Com.	X	-	X	-	X	X	-	-	Brown	Organic	7.70	415	-	3.70	D	
S1	Thuyen Quang	S1	5.2	Res.(M) Park	HSDC/ Fishing Co.	X	X	X	-	-	-	X	-	Green	Organic	7.50	670	33	2.20	A	
S2	Bay Mau	S1	23.1	Park	HSDC/ Fishing Co.	X	X	X	-	-	-	X	-	Green	Organic	7.50	648	33	2.60	A	
S3	Truong Dinh	S2	3.0	Res.(H)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	Already reclaimed
S4	Trai Ca	S2	4.7	Res.(H)	Truong Dinh Com.	X	X	X	-	-	-	-	-	Green	Organic	8.09	686	89	8.50	B	
S5	Linh Tam	S3	1.9	Res(H)	Quang Trung Com.	X	X	X	-	-	-	-	-	Green	Organic	7.30	740	-	0.75	B	
S6	Hoang Van Thu	S4	5.5	Res.(M) Ind.	H.V. Thu Com.	X	X	X	-	-	-	-	-	Green	Organic	7.40	836	57	0.83	B	
S7	Thanh Liet	S3	13.2	Res.(M) Ind.	Thanh Liet Com.	X	X	X	X	-	-	-	-	Green	Organic	7.30	536	-	0.94	B	

* A: Drainage(Wastewater)+Fishery+Recreation
B: Drainage(Wastewater)+Fishery
C: Drainage+Recreation
D: Drainage(Wastewater)+Rice Growing
E: Drainage(Wastewater)
F: Fishery
G: Brick-making
H: To be reclaimed by year 2010
I: Already reclaimed up to date

Table D 2.2(4) CONDITIONS OF EXISTING LAKES AND PONDS (4/6)

No.	Name of Lake	Name of Sub-basin	Lake Area (ha)	Present Status of Surrounding Area	Management Body of Lake	Present Lake Use								Water Quality (As of Feb., 1994)						Classification *	Remarks
						Storm Water Drainage /Flood Control	Waste-Water Treatment	Fishery	Aqua Planting	Rice Growing	Washing	Recreation	Brick-making	Water Colour	Smell	pH	Conductivity (micro S/cm)	Turbidity (FTU)	DO (mg/l)		
S8	Dam Set	S3	3.6	Res.(H)	Giap Tu Com.	X	X	X	-	-	-	-	-	Black	Domestic	7.40	914	35	0.19	B	
H1	Dinh Cong 2	H1	3.2	Agr. Ind.	Dinh Cong Com.	X	X	X	-	-	-	-	-	Light brown	No Smell	7.53	588	300	2.69	H	To be reclaimed
H2	Giap Nhi	H1	21.3	Agr. Ind.	Thanh Liet Com.	X	X	X	-	X	-	-	-	Light brown	Light organic	7.44	699	47	1.24	H	To be reclaimed
H3	Linh Dam	H1	107.2	Agr. Res.(L)	Thanh Liet Com.	X	-	X	-	-	X	-	-	Brown	Light organic	7.50	390	210	6.02	B	
H4	Bang B	H1	1.2	Agr. Res.(M)	Thanh Liet Com.	X	X	X	-	-	X	-	-	Light brown	Organic	7.56	665	50	2.94	B	
H5	Quoc Bao	H1	2.5	Agr. Ind.	Tam Hiep Com.	X	X	X	-	-	-	-	-	Brown	Light organic	7.44	683	30	2.28	B	
H6	Nha Dao	H1	3.5	Agr. Bld.	Hoang Liet Com.	X	X	X	-	X	X	-	-	Green	Domestic	7.66	1,550	270	0.11	D	
H7	Tam Hiep 1	H1	1.2	Bld. Res.(M)	Tam Hiep Com.	X	X	X	-	-	-	-	-	Dark green	Organic	7.20	960	58	3.48	B	
H8	Tam Hiep 2	H1	1.2	Res.(M)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	Already reclaimed
H9	Dong Ben	H2	5.7	Agr. Ind.	Hoang Liet Com.	X	X	X	-	X	-	-	-	Green	Organic	7.30	2,010	48	1.74	H	To be reclaimed
Y1	Yen So Fishpond	S3,4/ H2/Y/ K4,5,6	830.4	Agr.	-	X	-	X	-	X	-	-	-	Light green	Organic	7.80	566	100	6.00	D	To be partly reclaimed
C1	Ao Ho Sinh	C1	2.4	Res.(M) Agr.	Village Com.	-	-	X	-	-	X	-	-	Brown	Organic	7.50	466	300	3.50	H	To be reclaimed
C2	Phu Thuong 1	C1	4.6	Agr. Res.(M)	Village Com.	-	-	X	-	-	X	-	-	Brown	Organic	7.50	522	173	2.44	F	
C3	Phu Thuong 2	C1	1.3	Res.(M)	Village Com.	-	-	X	-	-	X	-	-	Green	Organic	7.65	190	38	5.80	F	
C4	Ao Bau	C1	1.2	Agr. Res.(L)	Village Com.	X	X	X	-	-	X	-	-	Brown	Domestic	7.40	304	69	1.90	B	
C5	Ao Goc Gao	C1	2.6	Agr. Res.(L)	Village Com.	-	-	X	-	-	X	-	-	Brown	Organic & Oil	7.55	206	78	5.90	F	
C6	Dam Tay	C3	1.2	Agr. Res.(M)	Village Com.	-	-	X	-	-	X	-	-	Brown	Organic	7.90	202	270	6.80	F	
C7	Ai Bai	C3	2.6	Agr. Res.(M)	Village Com.	X	X	X	-	-	X	-	-	Brown	Domestic	7.50	485	51	1.40	H	To be reclaimed
C8	Thuy Phuong	C4	3.4	Res.(M) Agr.	Village Com.	-	-	X	-	-	X	-	-	Brown	Organic	7.40	401	95	1.00	F	
C9	Ao So	C10	5.8	Agr. Ind.	Agr. Insurance Co.	-	-	X	X	-	-	-	-	Green	Organic	7.06	269	75	1.73	F	

* A: Drainage(Wastewater)+Fishery+Recreation
B: Drainage(Wastewater)+Fishery
C: Drainage+Recreation
D: Drainage(Wastewater)+Rice Growing
E: Drainage(Wastewater)
F: Fishery
G: Brick-making
H: To be reclaimed by year 2010
I: Already reclaimed up to date

Table D 2.2(5) CONDITIONS OF EXISTING LAKES AND PONDS (5/6)

No.	Name of Lake	Name of Sub-basin	Lake Area (ha)	Present Status of Surrounding Area	Management Body of Lake	Present Lake Use: Storm Water Drainage /Flood Control	Waste-Water Treat-ment	Fishery	Aqua Planting	Rice Growing	Washing	Recre-ation	Brick-making	Water Quality (As of Feb., 1994): Water Colour	Smell	pH	Condu-ctivity (micro S/cm)	Turbi-dity (FTU)	DO (mg/l)	Classifi-cation *	Remarks
D1	Co Nhue	D1	1.8	Agr. Ind.	Village Com.	-	-	X	-	-	-	-	-	Brown	Organic	7.48	228	10	6.30	F	
D2	Ao Chuom	D2	2.2	Agr.	Village Com.	-	-	X	-	-	X	-	-	Brown	Organic	7.58	234	107	7.03	F	
D3	Ao Truong	D2	1.5	Res.(M)	University	X	-	-	-	-	-	X	-	Green	Organic	7.30	483	60	0.97	C	
D4	Ho Nghia Trus Mai Dich	D2	3.1	Agr. Park	-	X	-	-	-	-	-	X	-	Clear	No Smell	7.50	447	2	5.84	C	
D5	Ao Cong Hoa	D2	3.5	Agr. Res.(H)	Village Com.	X	-	X	-	X	X	-	-	Brown	Organic	7.76	345	280	6.16	H	To be reclaimed
D6	Dich Vong 1	D1	5.5	Agr.	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	G	
D7	Dich Vong 2	D1	7.4	Agr. Res.(M)	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	G	
M1	-	M1	2.6	Res.(M) Bld.	Village Com.	-	-	X	-	-	-	-	-	Brown	Domestic	7.91	607	274	7.20	F	
M2	-	M1	2.8	Res.(H) Bld.	Village Com.	-	-	X	-	-	-	-	-	Brown	Domestic	8.13	505	212	12.10	F	
M3	-	M1	1.4	Agr. Res.(M)	Village Com.	X	X	X	X	-	-	-	-	Brown	Domestic	7.38	411	70	4.17	B	
M4	-	M2	1.2	Agr. Res.(M)	Village Com.	-	-	X	-	-	-	-	-	Brown	Organic	7.48	564	10	4.35	F	
M5	Ao Khe	M1	1.9	Bld. Res.(M)	Village Com.	X	X	X	X	-	-	-	-	Green	Domestic	7.50	520	53	3.24	H	To be reclaimed
M6	Me Tri 1	M2	30.3	Agr. Ind.	Village Com.	-	-	X	-	-	-	-	-	Light Brown	Organic	7.53	460	10	4.21	F	
M7	Me Tri 2	M4	3.6	Agr. Res.(M)	Village Com.	X	X	X	-	-	X	-	-	Brown	Domestic	7.13	230	10	0.41	B	
M8	-	M4	1.2	Agr.	Village Com.	X	-	X	-	-	-	-	-	Brown	Organic	7.50	144	250	8.20	B	
M9	Ao Khoai	M4	1.4	Agr.	Village Com.	X	X	X	-	-	-	-	-	Black	Domestic	7.20	262	10	4.80	B	
M10	-	M4	2.2	Agr.	Village Com.	X	X	X	-	-	X	-	-	Brown	Domestic	7.60	152	70	7.48	B	
M11	Phu Do I	M4	5.9	Res.(H) Agr.	Village Com.	-	-	X	-	-	X	-	-	Green	Organic	7.60	443	10	4.80	F	
M12	Phu Do 2	M4	5.2	Agr.	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	G	
M13	Phung Khoang	M5	6.7	Agr. Ind.	Village Com.	X	X	X	-	-	-	-	-	Black	Domestic	7.50	1,460	38	0.44	H	To be reclaimed

* A: Drainage(Wastewater)+Fishery+Recreation
B: Drainage(Wastewater)+Fishery
C: Drainage+Recreation
D: Drainage(Wastewater)+Rice Growing
E: Drainage(Wastewater)
F: Fishery
G: Brick-making
H: To be reclaimed by year 2010
I: Already reclaimed up to date

Table D 2.2(6) CONDITIONS OF EXISTING LAKES AND PONDS (6/6)

No.	Name of Lake	Name of Sub-basin	Lake Area (ha)	Present Status of Surrounding Area	Management Body of Lake	Present Lake Use: Storm Water Drainage /Flood Control	Waste-Water Treat-ment	Fishery	Aqua Planting	Rice Growing	Washing	Recre-ation	Brick-making	Water Quality (As of Feb., 1994): Water Colour	Smell	pH	Condu-ctivity (micro S/cm)	Turbi-dity (FTU)	DO (mg/l)	Classifi-cation *	Remarks
B1	Roc Bun	B1	1.1	Agr. Res.(H)	Village Com.	-	-	X	-	-	-	-	-	Green	Organic	7.48	545	228	3.50	F	
B2	Cua Cai	B1	1.1	Agr. Res.(M)	Village Com.	-	-	X	X	-	-	-	-	Brown	Organic	7.37	632	63	2.60	F	
B3	Lo Gach 1	B1	1.2	Agr.	Village Com.	-	-	X	-	-	-	-	-	Green	Organic	7.49	591	141	4.15	F	
B4	Lo Gach 2	B1	1.7	Agr.	Village Com.	-	-	X	-	-	X	-	-	Green	Organic	7.49	691	141	2.01	F	
B5	Ba Xa	B1	11.5	Agr.	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	G	
B6	Ao Lang Trieu Chuc	B2	1.5	Agr.	Village Com.	X	X	X	-	-	-	-	-	Brown	Domestic	7.50	854	43	0.17	B	
B7	-	B3	1.5	Agr. Res.(M)	Village Com.	-	-	X	-	-	X	-	-	Brown	Organic	7.74	240	10	6.20	F	
B8	-	B3	17.9	Agr.	Village Com.	-	-	X	-	-	X	-	-	Green	Organic	7.50	547	26	4.81	F	
B9	Dai Thanh	B3	10.4	Agr. Ind.	Village Com.	-	-	X	-	-	X	-	-	Green	Organic	7.38	572	115	2.08	F	
B10	Roc	B3	7.9	Agr. Ind.	Village Com.	-	-	X	-	-	-	-	-	Brown	Organic	7.46	424	10	8.45	F	
B11	-	B3	1.3	Agr. Res.(H)	Village Com.	-	-	X	X	-	-	-	-	Brown	Organic	7.62	480	251	5.10	F	

* A: Drainage(Wastewater)+Fishery+Recreation
B: Drainage(Wastewater)+Fishery
C: Drainage+Recreation
D: Drainage(Wastewater)+Rice Growing
E: Drainage(Wastewater)
F: Fishery
G: Brick-making
H: To be reclaimed by year 2010
I: Already reclaimed up to date

Table D2.3 CLASSIFICATION OF EXISTING LAKES AND PONDS

Classi-fication	Present Lake Use Condition					Numbers of Lakes				
	Drainage (Waste-water)	Fishery	Recre-ation	Rice Growing	Brick-making	To Lich River Basin			Nhue River Basin	Total
						West Lake Basin	Other Basins	Total		
A	X	X	X			2	11	13	0	13
B	X	X				0	24	24	7	31
C	X		X			0	1	1	2	3
D	X			X		0	5	5	0	5
E	X					0	4	4	0	4
F		X				0	4	4	22	26
G					X	0	0	0	4	4
(Sub-total)						(2)	(49)	(51)	(35)	(86)
H	To be reclaimed by year 2010					0	14	14	5	19
I	Already reclaimed up to date					0	6	6	0	6
Total	-					2	69	71	40	111

Table D2.4. EXISTING MAJOR WEIRS AND GATES

Name of Basin	Name of Sub Basin	Location	Dimensions	Remarks
To Lich River	West Lake	Inlet of C1.9 Drainage Channel West side of Lake	2 m x 2 m x 2 gates	-
	To Lich	T K 1.0 Downstream of Confluence of To Lich & Kim Nguu	2 m x 2.5 m x 6 gates and 2 m Dia. pipe with gates	Thanh Liet Weir
	Lu	-	-	-
	Hoang Liet	-	-	-
	Set	-	-	-
	Kim Nguu	Outlet of K2 Drainage Channel at K K 9.0, Left Bank	2 m x 2.5 m x 2 gates	-
	Yen So	K K 7.7 Upstream of Confluence of Kim Nguu & Set	-	Not Operated
Nhue River	Co Nhue	Outlet of C1 Drainage Channel Left bank of Nhue River	-	-
		Confluence of C1 & C1.10	-	-
	My Dinh	Outlet of D1 Drainage Channel Left bank of Nhue River	-	For Pumping Station
	Me Tri	-	-	-
	Ba Xa	Outlet of B2 Drainage Channel Left bank of Nhue River	-	For Pumping Station
		Outlet of B1.2 Drainage Channel Right Bank of To lich River	-	-

Table D2.5 EXISTING DRAINAGE PUMPING STATIONS

Name of Basin	Name of Sub Basin	Location	Capacity	Remarks
To Lich	West Lake	-	-	-
	To Lich	-	-	-
	Lu	Inlet of L2 Drainage Channel	0.3 m3/s	-
	Hoan Liet	-	-	-
	Set	Tran Mai I	0.3 m3/s	-
	Kim Nguu	-	-	-
	Yen So	-	-	-
Nhue	Co Nhue	-	-	-
	My Dinh	Outlet of D1 Drainage Channel Left bank of Nhue River	3.0 m3 /s	With Flood Gates
	Me Tri	-	-	-
	Ba Xa	Outlet of B2 Drainage Channel Left bank of Nhue River	0.5 m3/s	Operation: 1 or 2 times / year
		Outlet of B1 Drainage Channel Left Bank of Nhue River	3.0 m3/s	Since 1990, 7 days operation

Table D2.6 EXISTING MAJOR IRRIGATION PUMPING STATIONS

(along river only)

Name of Basin	Name of Sub Basin	Location	Capacity	Remarks
To Lich	West Lake	-	-	-
	To Lich	Along B1.1 Drainage Channel, Right Side of To Lich River	-	-
	Lu	-	-	-
	Hoang Liet	-	-	-
	Set	-	-	-
	Kim Nguu	On the Dike of Red River	-	Supplies water to river side land of Red river
	Yen So	-	-	-
Nhue	Co Nhue	Uppermost of Nhue River, Left Side	0.5 m3/s	-
	My Dinh	My Dinh Left Bank of Nhue River	0.6 m3/s	-
		D1 Drainage Channel, 1 km from Nhue River	-	-
	Me Tri	Right Side of T2 Drainage Channel	-	-
	Ba Xa	Yen Xa Left bank of Nhue River	0.45 m3/s	-

Table D2.7 EXISTING ROAD CROSSINGS

Name of Basin	Name of Sub Basin	River / Channel	Number	
			For Vehicle and for Railway	For Pedestrian
To Lich River	West Lake	River	-	-
		Drainage Channels	-	-
	To Lich	To Lich River	15	6
		Drainage Channels	31	68
	Lu	Lu River	3	3
		Drainage Channels	11	15
	Hoang Liet	Kim Nguu River	-	-
		Drainage Channels	6 (1)	10
	Set	Set River	6	3
		Drainage Channels	4	17
	Kim Nguu	Kim Nguu River	8	6
		Drainage Channels	13	50
	Yen So	Kim Nguu & Set Rivers	1	-
		Drainage Channels	-	-
	Total	River	33(1)	18
		Drainage Channels	65	150
Nhue River	Co Nhue	River	-	-
		Drainage Channels	23 (3)	54
	My Dinh	River	-	-
		Drainage Channels	12	20
	Me Tri	River	-	-
		Drainage Channels	12	3
	Ba Xa	River	-	-
		Drainage Channels	8	24
	Total	River	-	-
		Drainage Channels	50(3)	101
G. Total		River	33(1)	18
		Drainage Channels	115(3)	251

Table D2.8 SERVICE COVERAGE

NAME OF DISTRICT	AREA (ha)	POPULATION (persons)	POPULATION DENSITY(p/ha)	LENGTH OF SEWER (m)	LENGTH OF OPEN CHANNEL (m)	COVERAGE PER CAPITA(m/p)	COVERAGE PER AREA(m/ha)	LENGTH OF ROAD (m)	COVERAGE PER AREA (m/ha)
BA DINH	1,095.7	188,437	172.0	24,191	9,140	0.18	30.4	54,860	50.1
HOAN KIEM	351.0	147,266	419.6	39,403		0.27	112.3	58,220	165.9
HAI BA TRUNG	1,035.0	286,212	276.5	34,838	10,650	0.16	43.9	44,280	42.8
DONG DA	1,484.6	334,356	225.2	21,575	12,710	0.10	23.1	29,530	19.9
SUB TOTAL	3,966.3	956,271	241.1	120,007	32,500	0.16	38.5	186,890	47.1
TU LIEM	5,523.5	172,355	31.2					65000	11.8
THAN TRI	3,719.5	84,632	22.8					40000	10.8
HA TAY	322.0	5,400	16.8					5600	17.4
TOTAL	13,531.3	1,218,658	90.1	120,007	32,500	0.13	11.3	297,490	22.0

Table D2.9 FLOW RATE OF EXISTING DRAINAGE SYSTEM (1/3)

Run-off Coefficient	Max.Industrial waste water	Mean Velocity	Roughness Coefficient
0.57	m3/sec/ha	0.8 m/sec	0.013

Line No.	Area Each Line (ha)	Area Accumu. (ha)	Length Each Line (m)	Length Ext. (m)	Con-Time (min)	Peak Flow P=1 years (m3/s)	Peak Flow P=2 years (m3/s)	Peak Flow P=5 years (m3/s)	Pipe Diameter (m)	Box Cuvert Width (m)	Box Cuvert Height (m)	E.L. (m)	Hydraulic Gradient	Velocity (m/s)	Flow Capacity (m3/s)
												7.024			
HK45	10.6	10.6	137	692	21.42	1.58	1.75	1.99		0.90	1.60	6.503	0.0038	2.07	2.98
To HK32												7.554			
HK64	13.5	13.5	284	284	12.92	2.44	2.69	3.03		0.70	1.00	6.503	0.0037	1.63	1.14
HK32	1.5	25.6	141	1117	30.27	3.23	3.61	4.11		0.90	1.60	6.145	0.0025	1.69	2.43
To HK21												6.609			
HK3	8.1	8.1	400	400	15.33	1.38	1.52	1.72		0.90	1.30	6.360	0.0006	0.79	0.93
HK70	11.2	19.3	257	2179	52.40	1.80	2.03	2.33		0.90	1.50	6.150	0.0018	1.40	1.88
HK77	9.1	28.4	450	3204	73.75	2.14	2.42	2.79		1.50	1.50	6.008	0.0003	0.71	1.60
HK71a	7.3	35.7	600	3804	86.25	2.42	2.75	3.18		1.50	1.50	5.978	0.0001	0.28	0.64
HK54d	5.6	41.3	340	4229	95.10	2.62	2.98	3.45		1.95	1.70	5.945	0.0001	0.45	1.49
To HK21												6.697			
HK11	35.3	35.3	523	1380	35.75	4.09	4.58	5.23		0.90	1.60	6.175	0.0010	1.06	1.53
HK21	9.975	112.2	158	7211	157.23	4.98	5.71	6.66		1.90	1.80	5.820	0.0022	2.12	6.63
HK80h	13.6	125.8	350	7671	166.81	5.35	6.13	7.17		1.95	1.70	5.441	0.0011	1.50	4.96
HK67b	0	125.8	340	8331	180.56	5.05	5.79	6.78		1.70	1.60	5.342	0.0003	0.73	1.98
To HB10b												7.561			
HK53	26.3	26.3	820	1750	43.46	2.74	3.07	3.52		1.10	1.60	6.890	0.0008	0.98	1.49
HK67a	13.4	39.7	200	3380	77.42	2.89	3.28	3.78		1.70	1.60	5.647	0.0062	3.36	9.13
To HB10a												5.914			
HK19	34.5	34.5	360	2200	52.83	3.20	3.60	4.14		0.80	1.60	5.647	0.0007	0.87	1.11
HB10a	59.0	133.2	460	9740	209.92	4.78	5.50	6.45		1.70	1.60	4.760	0.0019	1.87	5.09
To Kim Nhguu river												5.953			
HB24'	18.9	18.9	260	1620	40.75	2.04	2.29	2.62		1.00	0.80	5.582	0.0014	1.07	0.85
HB10b	7.9	152.6	1030	11611	248.90	4.81	5.55	6.53		1.70	1.60	4.760	0.0008	1.20	6.55
To Kim Nhguu river												6.485			
HB14	4.1	4.1	350	350	14.29	0.71	0.79	0.89	0.40			5.326	0.0033	0.95	0.12
HB14'	4.1	8.2	90	440	16.17	1.37	1.51	1.71	0.60			5.267	0.0007	0.56	0.16
HB14"	4.1	12.2	65	505	17.52	1.97	2.19	2.47	0.80			5.064	0.0031	1.47	0.74
To Hai Ba lake												5.500			
HB23	11.8	11.8	450	450	16.38	1.96	2.17	2.45	0.60			5.175	0.0007	0.58	0.16
HB33	7.7	19.5	250	975	27.31	2.59	2.89	3.29	0.80			5.171	0.0000	0.11	0.05
To Tran Khat Chan channele												5.921			
HK66	11.4	11.4	480	1130	30.54	1.43	1.60	1.82		1.16	0.72	5.199	0.0015	1.09	0.91
HK80-a.b	3.2	14.6	120	1610	40.54	1.58	1.77	2.02		0.80	0.80	5.152	0.0004	0.52	0.33
HK85	5.2	19.8	350	1960	47.83	1.95	2.19	2.51		1.80	1.00	4.950	0.0006	0.81	1.14
HK85'	2.4	22.2	200	2270	54.29	2.03	2.28	2.62		2.40	1.15	4.862	0.0004	0.86	2.37
To HK79'												5.669			
HK80c	8.5	8.5	270	560	18.67	1.34	1.49	1.68		0.58	0.61	4.919	0.0028	1.14	0.40
HK80e	13.8	13.8	320	570	18.88	2.16	2.40	2.72	0.80			4.919	0.0030	1.45	0.73
HK79	7.2	29.5	370	1860	45.75	2.98	3.35	3.84		1.50	1.05	4.869	0.0001	0.39	0.54
HK79'	13.2	42.7	320	5100	113.25	2.40	2.74	3.18		2.10	1.40	4.255	0.0019	1.89	5.56
HK79"	8.8	51.5	300	5400	119.50	2.79	3.18	3.70		1.50	1.40	4.000	0.0009	1.14	4.78
To Bay Mau lake															

Table D2.9 FLOW RATE OF EXISTING DRAINAGE SYSTEM (2/3)

Line No.	Area Each Line (ha)	Area Accumu. (ha)	Length Each Line (m)	Length Ext. (m)	Con-Time (min)	Peak Flow P=1 years (m3/s)	Peak Flow P=2 years (m3/s)	Peak Flow P=5 years (m3/s)	Pipe Diameter (m)	Box Cuvert Width (m)	Box Cuvert Height (m)	E.L. (m)	Hydraulic Gradient	Velocity (m/s)	Flow Capacity (m3/s)
												5.700			
HK43	6.9	6.9	740	740	22.42	1.01	1.12	1.27	0.60			5.200	0.001	0.56	0.16
HK43'	10.6	17.5	750	3760	85.33	1.20	1.36	1.57	0.80			4.552	0.001	0.77	0.39
To Bay Mau lake												5.894			
HB15	33.6	33.6	650	5450	120.54	1.81	2.06	2.40	1.00			4.810	0.002	1.25	0.98
HB15'	34.7	68.3	1070	7320	159.50	3.00	3.44	4.02	1.50			2.700	0.002	1.78	3.14
To Set river												5.056			
HK2	17.4	17.4	510	2820	65.75	1.41	1.59	1.83		2.37	1.84	3.300	0.003	2.91	12.69
To Tran Khat Chan												5.253			
HB9	2.9	2.9	40	295	13.15	0.52	0.57	0.65	0.60			5.074	0.004	1.45	0.41
To Tran Khat Chan												6.400			
B20	6.1	6.1	350	650	20.54	0.92	1.03	1.16	0.60			6.138	0.001	0.59	0.17
B27	6.1	12.2	340	990	27.63	1.61	1.80	2.05		0.85	0.85	5.532	0.002	1.09	0.67
To Truc Bach												7.233			
B21	12.1	7.9	590	870	25.13	1.09	1.22	1.38		1.40	0.70	5.891	0.002	1.37	1.24
To Truc Bach												6.454			
B21'	3.7	3.7	45	825	24.19	0.52	0.58	0.66	0.80			6.173	0.006	2.08	1.04
To Truc Bach												6.696			
B51	3.0	3.0	130	350	14.29	0.52	0.58	0.65	0.80			6.210	0.004	1.61	0.81
To Truc Bach												7.991			
B53	1.5	1.5	180	180	10.75	0.29	0.32	0.35	0.80			5.033	0.016	3.37	1.69
To Truc Bach												8.208			
B9'	5.5	5.5	135	205.0	11.27	1.03	1.13	1.27	0.80			6.545	0.012	2.92	1.47
B28-a'	11.1	22.5	730	1985.0	48.35	2.20	2.47	2.83		1.48	1.25	6.178	0.001	0.79	1.13
B28-a	28.0	50.5	700	2835.0	66.06	4.07	4.60	5.30		1.49	1.25	5.868	0.000	0.74	1.07
To B28-c												6.609			
HK26	27.9	27.9	350	350	14.29	4.85	5.37	6.05		0.90	1.10	6.484	0.000	0.38	0.19
B23	10.6	10.6	450	450	16.38	1.76	1.95	2.20	0.60			6.484	0.002	0.89	0.25
B28-b'	12.2	40.1	700	1500	38.25	4.47	5.02	5.73		1.55	1.67	6.125	0.001	0.94	2.03
To B28-b												7.540			
B8	12.3	12.3	450	450	16.38	2.04	2.26	2.55	0.60			6.631	0.002	0.98	0.28
B17	11.6	11.6	450	450	16.38	1.92	2.13	2.41	0.80			6.484	0.002	1.18	0.59
B28-b	13.3	77.3	750	3150	72.63	5.87	6.64	7.66		1.55	1.67	5.869	0.001	1.19	2.57
B28-c	15.5	149.2	520	6505.0	142.52	6.84	7.82	9.11		2.00	1.80	5.530	0.001	1.19	4.30
To Thuy Khue Channel												7.402			
HK68	9.1	3.2	500	500	17.42	0.52	0.58	0.65		1.00	1.20	6.705	0.001	1.21	1.45
												7.540			
B23	8.0	4.3	650	560	18.67	0.68	0.75	0.85	0.60			6.620	0.001	0.82	0.23
B31	25.9	33.4	650	1210	32.21	4.09	4.58	5.22		1.02	0.96	6.082	0.001	0.87	0.85
To B31												6.620			
B31'	9.8	9.8	750	750	22.63	1.41	1.57	1.79		1.40	1.12	5.999	0.001	1.02	1.59
To D13'												6.631			
B8'	14.8	14.8	550	550	18.46	2.34	2.60	2.94	0.80			6.082	0.001	0.83	0.42
B31	3.7	51.9	250	2010	48.88	5.05	5.68	6.51		1.02	0.96	5.999	0.000	0.55	0.54
To D13'												7.540			
B1	13.7	13.7	550	550.0	18.46	2.17	2.41	2.73	0.60			5.999	0.003	1.15	0.32
D13'	7.4	82.8	320	3630.0	82.63	5.78	6.55	7.57		1.10	1.05	5.626	0.001	1.15	1.27
D13	7.2	89.9	400	4030.0	90.96	5.88	6.68	7.73		3.12	1.65	4.608	0.003	3.05	14.88
To Nam Yen Lang Channel															

Table D2.9 FLOW RATE OF EXISTING DRAINAGE SYSTEM (3/3)

Line No.	Area Each Line (ha)	Area Accumu. (ha)	Length Each Line (m)	Length Ext. (m)	Con-Time (min)	Peak Flow P=1 years (m3/s)	Peak Flow P=2 years (m3/s)	Peak Flow P=5 years (m3/s)	Pipe Diameter (m)	Box Cuvert Width (m)	Box Cuvert Height (m)	E.L. (m)	Hydraulic Gradient	Velocity (m/s)	Flow Capacity (m3/s)
												5.376			
B3'	16.5	16.5	520	720	22.00	2.42	2.70	3.06	0.80			4.976	0.001	0.73	0.37
To B50												5.989			
B22	10.8	10.8	470	1420	36.58	1.24	1.38	1.58	0.80			4.976	0.002	1.22	0.61
B50	1.8	29.1	240	2380.0	56.58	2.59	2.92	3.35		1.50	1.70	4.413	0.002	2.02	5.14
To Ngoc Ha Channel															
B49	4.5	4.5	70	580	19.08	0.70	0.78	0.88				4.400	#VALUE!	#VALUE!	#VALUE!
To Ngoc Ha Channel												4.853			
D5'	2.1	2.1	70	470	16.79	0.35	0.39	0.44		1.67	1.29	4.710	0.002	1.77	3.82
D1	2.1	2.1	200	200	11.17	0.40	0.44	0.50	0.60			4.710	0.002	1.00	0.28
D5	2.1	6.4	220	890.0	25.54	0.88	0.98	1.11		1.70	1.30	4.600	0.001	0.88	1.95
To Nha Mat Cheo Channel															
D34	6.4	6.4	350	350.0	14.29	1.12	1.23	1.39							
D2	6.2	12.6	350	700.0	21.58	1.87	2.08	2.35							
To Hao Nam Yen Lang Channel															
B6	36.3	36.3	1100	1300	34.08	4.32	4.83	5.51							
To Dai Yen Channel															
D33	10.1	10.1	530	530	18.04	1.61	1.79	2.02							
To Giang Vo Lake															

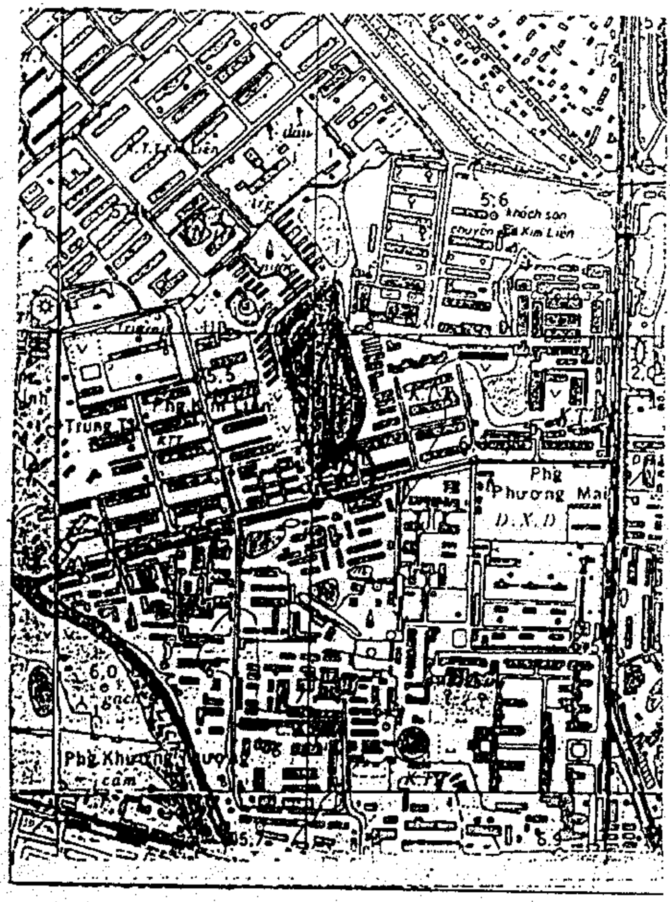
Table D2.10 Overall Runoff Coefficient

Individual Surface Characteristics	Area : Ai(ha)		Runoff Coefficient	Ai · Ci	
	1992	2010	Ci	1992	2010
Residential area	2,298	3,679	0.80	1,838.40	2,943.20
Industrial area	447	832	0.65	290.55	540.80
Commercial area	833	1,226	0.80	666.40	980.80
Green & Park	322	622	0.35	112.70	217.70
Lake & Pond	1,880	1,930	1.00	1,880.00	1,930.00
Utilities(Road & Squares)	379	967	0.90	341.10	870.30
Other area(Farmland,etc.)	7,381	4,284	0.35	2,583.35	1,499.40
Toatl	13,540	13,540		7,713	8,982
Overall Runoff Coefficient				0.57	0.66

Table D2.11 SEWERAGE LEDGER (PUMPING STATION RECORD)

Name	Location	Site Area	Operation Date	Catchment Area		Designed population	Capacity of Lift Pump			Name of Receiving water	Facility for landscape	Remark
				Wastewater	Stomwater		Wastewater at fine weather	Wastewater at rainy weather	Storm water			
Kim Lien	Kim lien Living quater	200 m2	1965	ha	3.5 ha	person	m3/min	33.33 m3/min	m3/min		m2	

Location Map of Pump Station (S= 1/10000)



Item	Unit	Quantity	Type	Size	Capacity	Construction Date	Remarks
Inlet Sewer	m	6	Circle	ø 200	m3/sec	1965	
Gate Chamber	room	1	Rectangle parallel-piped	LxBxH 12x3x5m		1965	
Gate	p.c.s						
Grit Chamber	unit				m3		
Screen	p.c.s	4	Rectangle	LxB 2.5x1.5m		1965	
Pump for waste water	p.c.s				m3/min		
Pump for storm water	p.c.s	2	Vietnam	DK 82-6	16.667 m3/min	1965	
Outlet Sewer	m				m3/sec		
Outlet Gate	p.c.s	1	Rectangle parallele piped	LxBxH 40x6x2.5 m		1965	
Control office	No.s	1		30m2	m2	1965	

Table D2.12 ESTIMATED DAMAGE FROM 1984 AND 1989 FLOODS

(To Lich River Basin except West Lake Basin)

Category of Damage	Basin	Sub-Basin	Lowest Ground Elevation (m)	1984 Flood Actual Inundation Water Level EL. (m)	1984 Flood Damage ($1000)	1989 Flood Actual Inundation Water Level EL. (m)	1989 Flood Damage ($1000)
Direct Damage	To Lich River Basin	T1	7.4	7.7	240	7.6 (7.8)*1	120
		T2	5.9	6.7	2,520	6.5 (6.4)	1,365
		T3	5.8	6.4	2,100	6.1 (6.1)	598
		T4	5.8	6.5	1,540	6.1 (6.1)	559
		T5	5.8	6.6	4,130	6.3 (6.1)	2,340
		T6	5.9	6.8	5,600	6.4 (6.1)	2,990
		T7	5.8	6.6	2,450	6.2 (6.0)	1,183
		T8	4.0	6.1	1,040	5.9 (5.5)	637
		T9	4.0	5.8	180	5.6 (5.5)	117
	Lu River Basin	L1	5.9	6.6	2,800	6.4 (6.1)	1,640
		L2	5.7	6.3	3,360	6.2 (6.1)	2,535
		L3	5.7	6.3	1,880	6.0 (5.8)	858
		L4	5.7	6.2	1,330	6.1 (6.0)	858
		L5	4.9	6.0	1,150	5.6 (5.5)	546
		L6	4.0	6.0	1,020	5.6 (5.5)	468
	Kim Nguu River Basin	K1	6.4	7.2	990	7.0 (7.4)	440
		K2	5.4	6.1	1,680	5.9 (5.8)	936
		K3	5.6	6.3	2,550	6.1 (6.0)	1,508
		K4	4.6	6.0	2,490	5.6 (5.5)	1,339
		K5	4.7	6.0	3,990	5.6 (5.5)	2,470
		K6	4.6	5.8	1,920	5.5 (5.5)	1,131
	Set River Basin	S1	5.9	6.7	1,650	6.4 (6.3)	610
		S2	5.3	6.2	2,380	6.0 (5.8)	1,300
		S3	4.6	5.8	3,680	5.4 (5.5)	2,080
		S4	4.0	5.8	1,710	5.4 (5.5)	884
	Hoang Liet Drainage Basin	H1	4.0	5.8	2,160	5.4 (5.5)	1,261
		H2	4.0	5.7	3,010	5.4 (5.5)	2,262
	Yen So Drainage Basin	Y	4.0	5.7	1,010	5.5 (5.5)	832
	Total($1000)			-	60,560	-	33,867
Indirect Damage ($1000)*2					22,479		11,239
Total Damage ($1000)					83039		45106
Rate of Indirect Damage vs. Direct Damage					0.37		0.33
					0.35 (on average)		

*1 Simulated Inundation Water Level

*2 G x P x A x D/365

where G : GDP per Capita in Hanoi ($565/head/year)

P : Population Dencity (241 head/ha)

A : Productive Area excluding Fishponds & Agricultural Land (4,304 ha)

D : Duration of Interruption for Production Activity due to Inundation (14 days in 1984 Flood and 7 days in 1989 Flood)

Table D3.1 CHANNEL DENSITY OF EACH BASIN

Basin	Channel *1 Length (km)	Cotchment Area (km2)	Channel Density (km/km2)
A. To Lich River Basin *2			
1. To Lich, Lower Lu & Hoang Liet	39.1	32.43	1.21
2. Set & Upper Lu	13.2	12.97	1.02
3. Kim Nguu	15.6	17.3	0.90
(Sub-total)	(67.9)	(62.7)	(1.08)
B. Nhue River Basin			
1. Co Nhue	19.2	19.7	0.97
2. My Dinh	13.4	13.6	0.99
3. Te Tri	13.5	14.7	0.92
4. Ba Xa	8.7	9.9	0.88
(Sub-total)	(54.8)	(57.9)	(0.95)
Total	122.7	120.6	1.02

*1 Total length of rivers and drainage channels
*2 Excluding West Lake basin

Table D3.2(1) UNIT PRICES FOR COST ESTIMATION (1/2)

Item	Unit	Unit Price (US$)				
		F.C		L.C		Total
A Construction Cost						
1 Earth Work						
(1) Excavation at Yen So/Hoang Liet areas	m3	2.4	(0.80)	0.6	(0.20)	3
(2) Excavation along rivers/drainage channels	m3	3.4	(0.80)	0.9	(0.20)	4.3
(3) Excavation in city area lakes	m3	3.2	(0.80)	0.8	(0.20)	4
(4) Embankment/Backfilling	m3	4	(0.80)	1	(0.20)	5
2 Structural Work						
(1) Reinforced conrete	m3	132	(0.60)	88	(0.40)	220
(2) RC pile	m	55	(0.55)	45	(0.45)	100
(3) PC pile,550mm diameter	m	90	(0.55)	80	(0.45)	170
(4) Steel pile,600mm diameter	m	225	(0.90)	25	(0.10)	250
(5) Steel sheet pile	m2	207	(0.90)	23	(0.10)	230
(6) Revetment, 1:0.3	m3	42	(0.45)	52	(0.55)	94
(7) Revetment, 1:2.0	m2	14	(0.45)	17	(0.55)	31
(8) Riprap	m3	8	(0.80)	2	(0.20)	10
(9) Gabions for fall structure	m3	13	(0.90)	2	(0.10)	15
3 Composite Structures						
(1) Bridge	m2	910	(0.70)	390	(0.30)	1300
(2) Bridge protection	pl.	1400	(0.45)	1700	(0.55)	3100
(3) Box culvert	m2	540	(0.60)	360	(0.40)	900
(4) Railway bridge	m	10400	(0.80)	2600	(0.20)	13000
(5) Steel gate structure	m2	20000	(0.80)	5000	(0.20)	25000
(6) Spillway with rubber gates	m	12000	(0.80)	3000	(0.20)	15000
(7) Control structure at outlet of city area lakes	pl.	7000	(0.70)	3000	(0.30)	10000
(8) Pumping station	pl.	(For the Master Plan study,the following curve is used)				
(9) Intake facilities	pl.	8400	(0.70)	3600	(0.30)	12000
(10) Drainage facilities	L.S.	1200	(0.60)	800	(0.40)	2000
4 Others						
(1) Land preparation	m2	2	(0.80)	0.5	(0.20)	2.5
(2) Environmental measures	m2	0.9	(0.30)	2.1	(0.70)	3