Chapter 3. Present Environmental Conditions of the Objective Rivers

3.1 Anyang Chong

Present Condition of the Basin

The total length of the main course of Anyang Chong is 32.2 km. 14.4km of the total length is included within the Seoul Metropolitan area and was, therefore, the only area studied. The Anyang Chong basin extends in the NNW-SSE direction and has an area of 286 km^2 (see Fig. 3.1-1).

The valley plain of the Anyang Chong river becomes narrower in the middle reaches (near the boundary between Anyang-shi and Kwangmyong-shi) forming a boundary that separates the downstream area from the upstream area.

While the downstream area of Anyang basin consists mainly of schists, the upstream area is made up of granite and gneiss. The alluvium covering the valley plain is mainly made up of sand and gravel upstream, but is presumed to consist mainly of sand and silt downstream.

Aside from the Seoul Metropolitan area, the Anyang Chong basin includes the entire areas of Kwang-myong-shi, Anyang-shi, Kunpo-shi and Uiwang-shi and some parts of Shihung-shi, Puchon-shi, and Kwachon-shi. The metropolitan area included in the basin corresponds to 36% of the entire Anyang Chong catchment area.

The population in the upstream basin mainly occupied by Anyang-shi (518 thousand), Kunpo-shi (149 thousand), and Uiwang-shi (85 thousand), is estimated to be 800 thousand. The population in this area has increased remarkably since the 1980's.

On the other hand, the present population in the downstream basin

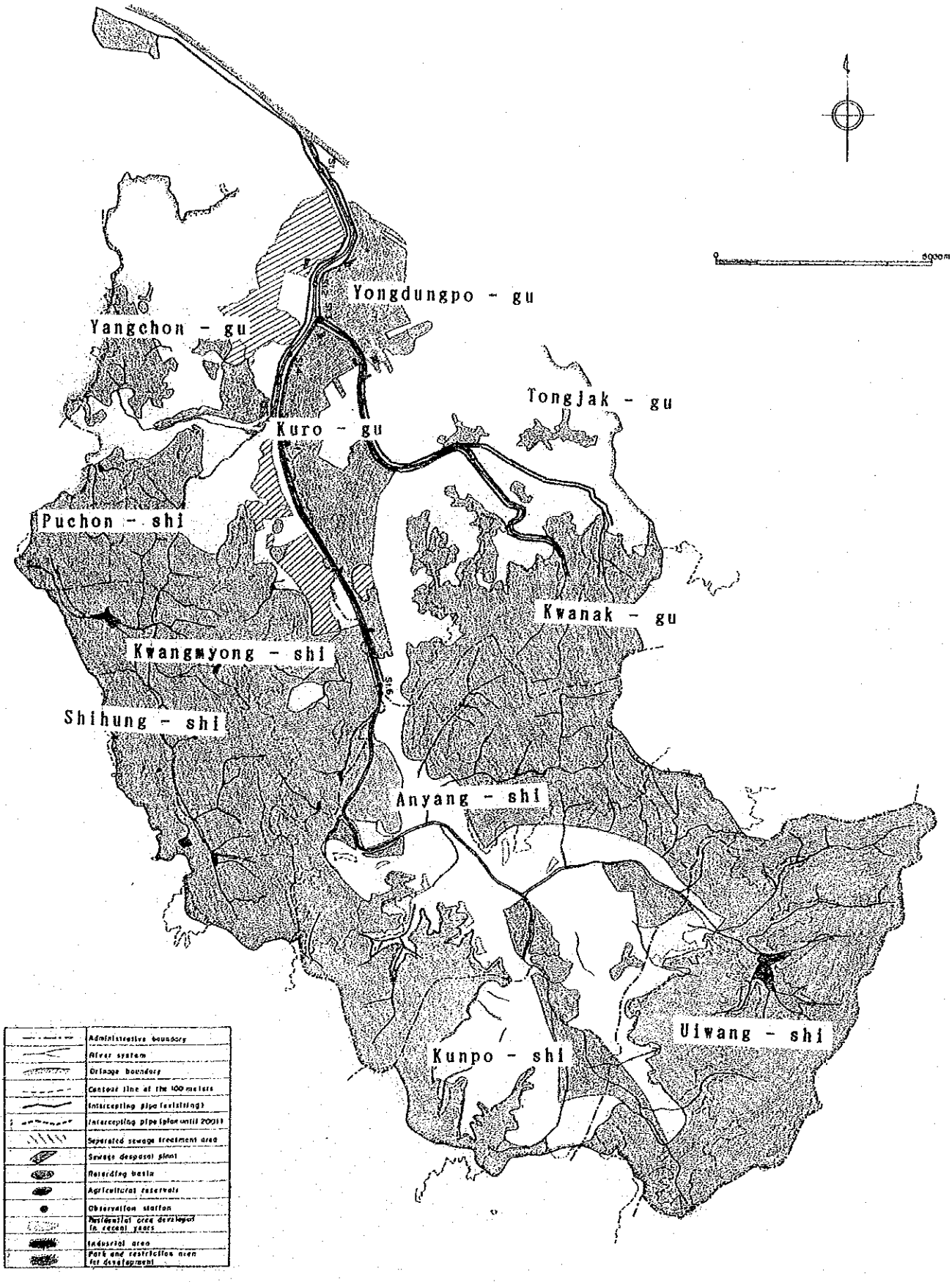

Fig. 3.1-1 Present Environmental Condition of Anyang Chong Basin

mainly occupied by Seoul Metropolitan (2.06 million) and Kwang-myong-shi (227 thousand) is estimated to be 2.3 million. Although the average population density of the Seoul Metropolitan area is about 200 persons/ha, the population density in residential areas is high at 500 - 700 persons/ha. Recently, the population in the left bank of Anyang Chong has rapidly increased.

Most of the areas in the slope with more than 100 m elevation in the upstream basin are development restricted areas. The forests in this area are preserved. The bowl-shaped lowland area below 100m in altitude is undergoing development and there are now large semi-industrialized areas in Anyang-shi and Kunpo-shi.

A semi-industrialized area (Kuro Industry Housing Development) has been developed on the right bank downstream, while large housing developments are built continuously on the left bank. The degree of industrial integration of the Kuro Industry housing development is the highest in the Seoul Metropolitan area, while the basins of Torim and Taebang Chongs are so densely populated leaving no extra space for future development. On the other hand, most of the area in the Kehwa Chong basin are development restricted areas made up of farmlands and forests.

Both of the banks of the Anyang Chong basin belong to the Seoul Metropolitan area and an immense difference can be recognized in the improvement of the park and green zone in the right and left bank downstream. The park area (6.0 m^2/head), green area ratio (37.7%), and green area(41.6 m^2/head) in the recently developed collective housing developments built continuously on the left bank are larger than the average calculated in Seoul, while those in the right bank where the Kuro Industry housing development is constructed are only 0.2 m^2/head, 1.9%, and 0.6 m^2/head, respectively.

The sewerage diffusion rate in the Seoul Metropolitan area is nearly 100%. A separate sewage system is adopted in the systematically developed areas of Moku Dong and Shinjong Dong, while a

combined sewage system is used in the other areas. There are intercepting sewers buried along the main course of Anyang Chong and Torim Chong, but none in Oryu Chong.

In Kwangmyong-shi, a separate sewage system is developed in Cholsan, while a combined sewage system is developed in other urbanized areas. A large part of Kehwa Chong are designated as development restricted areas, therefore, sewage systems are not installed here. At present, intercepting sewers are being installed at the left bank of Anyang Chong.

The sewage collected from the Seoul Metropolitan and Kwangmyong-shi areas through the intercepting sewers are sent to the Anyang Sewage Treatment Plant from where the sewage is discharged to the Han River after primary treatment. The BOD concentration of the treated water is 80 mg/l in average.

River Improvement and Utilization

The river bed of the main course of Anyang Chong is 1/1,500 to 1/1,600 in gradient in the Seoul Metropolitan area, about 1/600 in Anyang-shi area, and steeper than 1/250 in further upstream.

The width of the river channel is 130 - 270m and the cross section of the channel forms a double section over the entire length of the river channel planned. The construction of the embankments on both banks is nearly completed in the planned section and the height from the river bed to the crest of the embankment is about 10 m.

The intercepting sewers on the right bank are laid below the major bed at the intermediate area downstream between Kia Grand Bridge and Shihung Grand Bridge. On the left bank, they are buried in the ground below the major bed at the downstream area near Cholsan Bridge. The intercepting sewer has now been extended to a point near Shihung Grand Bridge.

The Anyang Chong downstream basin is habitualsre of flood origined by inside water, therefore, retarding basins and drainage pump stations are constructed at 17 places. The total catchment area covered and the total water storage capacity of the retarding basins are 12,000 ha and 1.1 x 10^6 m^3, respectively.

The Hakuun Reservoir (water storage capacity: 1,464,245 m^3) has been constructed in the upstream area of Hageui Chong, a tributary of Anyang Chong, for agricultural use. In addition to the reservoir, water in the upstream area of the Anyang Chong system was also used for agricultural purposes. However, no water has been utilized for any purpose in the section planned. On the other hand, the underflow is being considered for industrial purposes.

There is a large difference in the utilization of land in the right and left banks of the planned section and completely asymmetrical features can also be observed. On the right bank is the National Highway zone which runs near the downstream embankment from the Anyang Chong Bridge, and behind the highway is an inelegant industrial zone. The traffic condition in the National Highway zone is quite dense. There are railways and stations at the upstream embankment from the Anyang Chong Bridge that create ceaseless noises like the highway.

On the other hand, symmetrically built housing developments intermittently continue on the left bank except in the area between Kia Grand Bridge and Shihung Grand Bridge and the confluence of Kehwa Chong. Parks and playgrounds are also adequately distributed between high-storied buildings.

There are 31 drainage outlets in the planned section. Among these outlets, 15 were found to directly discharge sewage regularly into the river. The amount of discharge observed during the study was 3 m^3/sec, and 2/3 of these originated from drainage pump stations (Yangpyong Dong No.1 and Kaebong). Waste water from other drainage outlets are discharged into the intercept-

ing sewers during clear days, but flow directly into the river in rainy days as the installed weir overflows.

Flow Regime Characteristics

The water level and discharge curve line of each observation point was drawn based on the results of the actual discharge survey. The amount of discharge during the observation was calculated based on the relationship between the water level (H) and discharge (Q) obtained from the curve line.

The daily discharges estimated from the H-Q curve are rearranged as duration curves, and the 95, 185, 275 and 355-day discharges and specific discharges calculated from the same data are respectively shown in Tables 3.1-1 and 3.1-2. Table 3.1-3 shows the discharge measured at each observation point during clear days. St.1 and St.2 in Anyang Chong were affected by the changes in the tide, while the other stations were affected by sewage inflow resulting to a considerable change in the amount of discharge even within one day.

Table 3.1-1 Discharge in Anyang Chong

Unit:m^3/sec

Station	Catchment Area (km^2)	Discharge 95-day	185-day	275-day	355-day	Average
St.1	284.14	11.074	4.156	2.639	0.182	7.187
St.2	264.55	11.070	8.962	6.562	2.440	13.219
St.3	212.29	6.472	3.893	3.039	2.349	11.353
St.4	153.60	9.108	5.630	4.048	0.614	9.211
St.5	126.38	6.478	3.252	2.187	1.484	5.675
St.6	41.83	4.333	2.268	0.520	0.004	3.674

* Daily discharge / Jan.1 - Dec. 31 in 1990

Table 3.1-2 Specific Discharge in Anyang Chong

Unit:$m^3/sec/100km^2$

Station	Specific Discharge 95-day	185-day	275-day	355-day	Average
St.1	3.897	1.463	0.929	0.064	2.529
St.2	4.184	3.388	2.480	0.922	4.997
St.3	3.049	1.834	1.432	1.107	5.348
St.4	5.930	3.665	2.635	0.400	5.997
St.5	5.126	2.573	1.730	1.174	4.490
St.6	10.359	5.422	1.243	0.010	8.941
Yoju	2.408	1.119	0.505	0.207	

* Daily discharge / Jan.1 - Dec. 31 in 1990

Table 3.1-3 Discharge Measured in Anyang Chong in Drought Days

Unit:m^3/sec

Station	Dec. 14/15	May 23/24	May 29/30	June 3/4	June 7/8	
St.1	6.49	6.39	7.09	6.69	3.70	
St.2	5.38	1.09	3.49	3.43	3.26	
St.4	4.34	1.56	5.96	3.56	2.93	
St.5	3.98	2.37	4.60	2.83	3.07	
St.6	2.60	2.46	5.05	3.45	3.67	
St.3	0.91	0.06	0.04	0.10	0.10	Torim Chong
St.7	1.08	0.30	0.51	0.42	0.03	Kehwa Chong

The amount of discharge from St.6 to St.5 and from St.5 to St.4 has considerably decreased in spite of the enlargement of their catchment areas. Since surface water intake is not implemented in the area, the movement of the water through the subsurface material of the river is assumed to cause the decrease in discharge.

Anyang Chong basin has been suffering from inundation almost every year in the past 10 years. Most of the damages were caused by the overflowing of the inside water when the water gates and sluice ways were closed to prevent Anyang Chong, where the water level has increased due to the backwater of the Han River, from flowing backward to its tributaries and retarding basins. As of 1990, more than 80 ha is estimated to be habitually flooded in the Anyang Chong basin.

Pollution Characteristics

The results of the analysis of the river water samples taken once a month at each observation point along Anyang Chong are shown in Fig. 3.1-2.

The DO and BOD concentrations all year round were found to be much lower than the water quality standard Class V, and the TN concentration values were close to the high sewage values in the Metropolitan area.

The variations taking place regularly in the water quality of the downstream flow are not clearly indicated in Fig 3.1-2. As previously stated, this may be attributed to the large diurnal variations in the water quality and the influence of the underflow movements in the middle section.

However, a comparison between St.6 and St.2 shows that the BOD, COD, NH_4-N, and SS concentrations at St.2 are mostly higher than those at St. 6, and that the DO concentration at St.2 is lower than that at St.6. From these we can deduce that the water quality of Anyang Chong still continues to deteriorate even after it has entered the Seoul Metropolitan area.

Due to the results of the analysis of sediment samples taken on December 5, 1990, the CN, As, Cr(6+), and Pb contents of the samples are considerably lower than the results of the investiga-

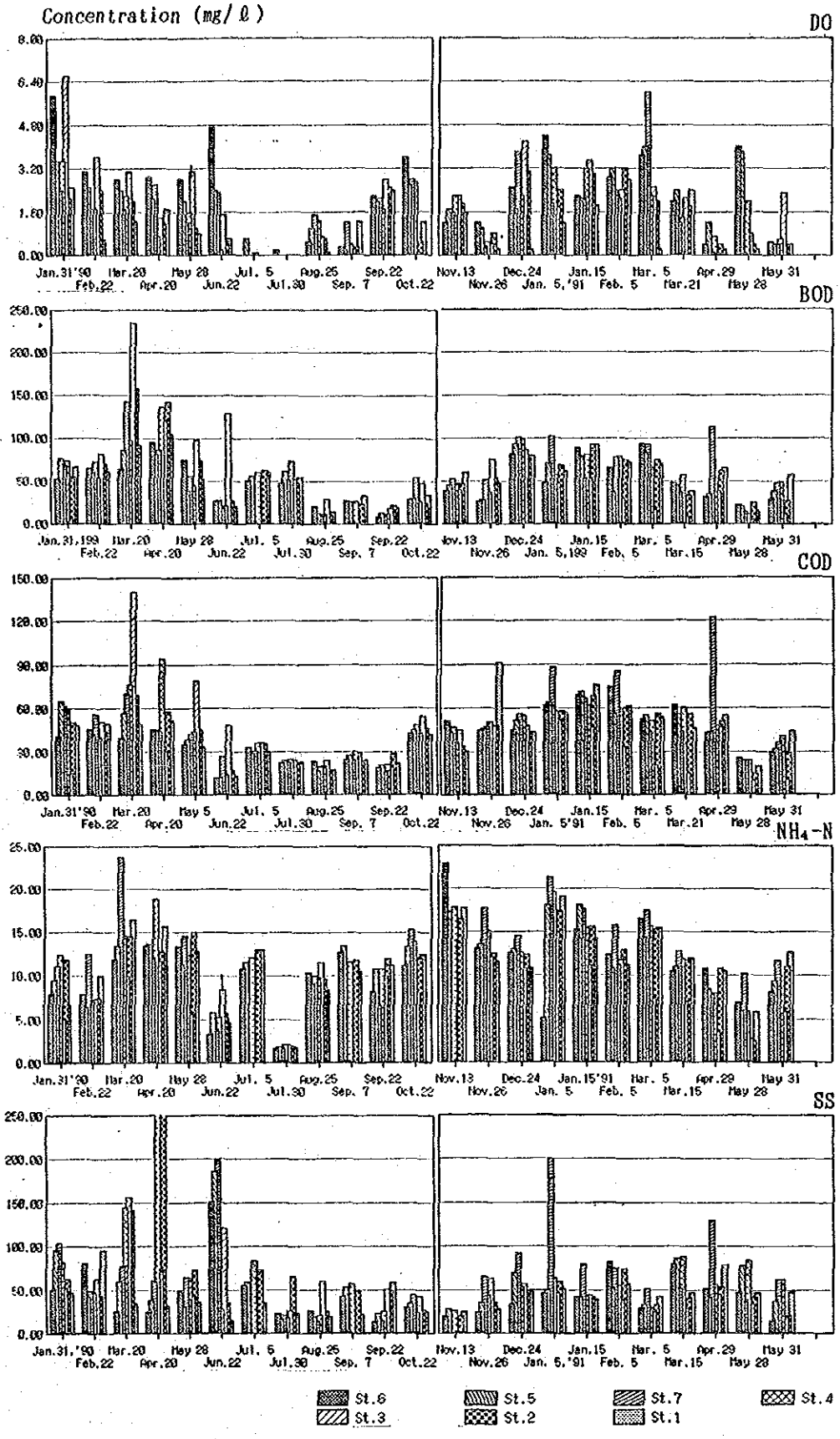

Fig. 3.1-2 Water Quality Fluctuation of Anyang Chong during the Study Period

tion carried out by the Environment Bureau in 1987, which means that the run-off conditions has improved to a certain extent. However, the levels of the CD and T-Hg contents showed almost the same results found in the 1987 investigation.

Sediment Run-off Characteristics

Slope failures scarcely develop in areas composed of gneiss or schists, but develop in areas where granite is distributed. According to the 1987 aerial photographs, the mountain side on the west of the dividing ridge which continues from Kwanakusan to Baegunsan via Kokuonhou is found to be rich in slope failures. Slope failures were found in 319 places with a total area of 1 km^2.

Immediately right after the September 1990 flood, sediments flowed in the upper reaches of the tributaries with many slope failures, natural banks were destroyed and sands were observed to flow into farms. Several sediment control facilities in Soksu Chong were particularly destroyed, and considerable amount of run-off sediments were deposited in the confluence of the main course of Anyang Chong and Soksu Chong.

3.2 Yangjae Chong

Present Condition of the Basin

Yangjae Chong has a total length of 14.35 km. The area belonging to Seoul Metropolitan measures 7.9 km and was the only Yangjae Chong area included in this study. Yangjae Chong basin is extended in the NE-SW direction and has an area of 59.12 km^2 (Fig. 3.2-1).

Except for the Kwanakusan mountain area at the upstream basin area where granite is distributed, the basin is mainly made of gneiss. Alluvium composed of sand and gravel covers the area along the main course, although this layer is covered with thick layers of earth downstream.

The downstream and upstream areas of Yangjae Chong respectively belong to Seoul Metropolitan and Kwachon-shi. The area included in Seoul Metropolitan is approximately 40% of the total Yangjae Chong catchment area. This area has been developed since 1980, and the population has increased to a little more than 62% within 5 years, from 1980 to 1985, making it then the most populated area within Seoul Metropolitan. At present, however, population growth in the area has decreased. The population and average population density in the entire basin as of 1990 are estimated to be about 240 thousand and 40 persons/ha, respectively.

The population and population density in the Seoul Metropolitan area are about 170 thousand and 73 persons/ha, respectively. Moreover, the population density per residential area is 300-400 persons/ha, one of the least populated area in Seoul Metropolitan.

Among the developed areas in the Yangjae Chong basin, those included in the Seoul Metropolitan area are mainly used for large housing developments, while government offices, schools, and

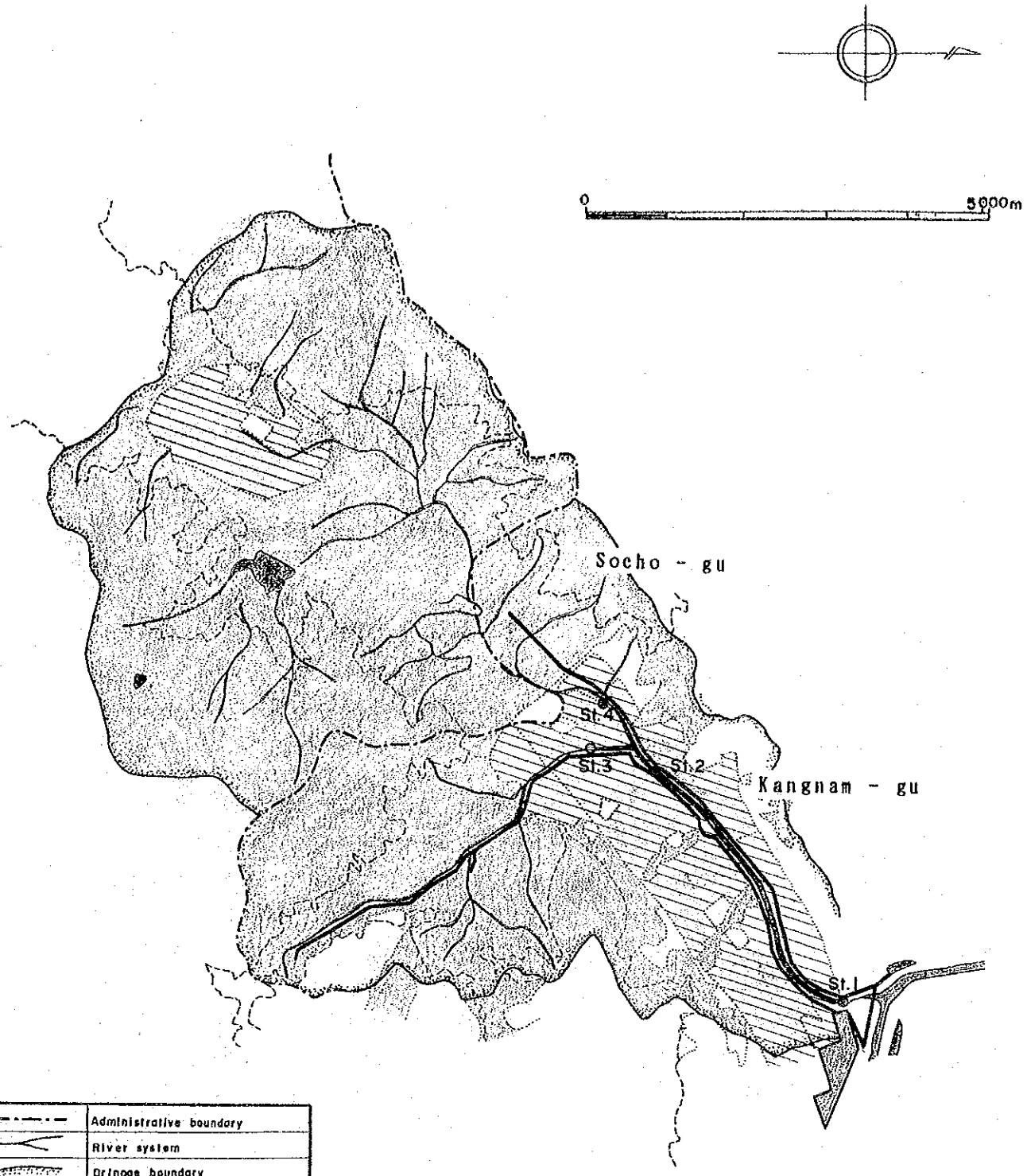

Fig. 3. 2-1 Present Environmental Condition of Yangjae Chong Basin

recreational facilities are prominently built in the Kwachon-shi area. Semi-industrial areas are not developed in the basin. The area in the middle of Yangjae Chong basin and Yoi Chong basin is an agricultural area made up of paddy fields, vegetable gardens and green houses growing foliage plants. Most of these agricultural areas are development restricted areas.

The park area of Seoul Metropolitan is 4.5 m^2/head, the green zone ratio is 48.1% and the green zone area is 47.4 m^2/head. All of these values considerably exceed the average value of the entire Seoul Metropolitan area.

Large parks such as, the Seoul Great Park, Horse Riding Park, etc., are developed in Kwachon-shi, and the green zones are well-preserved.

Separate sewage systems were installed in the systematically developed areas (Seoul Metropolitan and Kwachon-shi) of Yangjae Chong basin. Sewage systems were not installed in the other remaining areas because they are designated as development restricted areas.

Sewage from Kwachon-shi is conveyed to the treatment plant by the sanitary sewers buried below the roads. The treated water is then discharged into Yangjae Chong, and the water quality of the discharged water contains a BOD average of 20 mg/l. On the other hand, sewage from Seoul Metropolitan is conveyed to the Tan Chong Treatment Plant through the sewer pipes installed in both banks of the main Yangjae Chong course. After a secondary treatment, it is discharged into Tan Chong. The BOD concentration of the treated water is 15 mg/l in average.

River Improvement and Utilization

The average gradient of the river bed of the main Yangjae Chong course is 1/730 4 km upstream (Yondong 2nd Bridge) from the Tan

Chong confluence. From the Yondong 2nd Bridge up to the planned area located at the upstream end, the average gradient is 1/350.

The width of the river channel is 80 to 190 m. As a result of the construction of a high water channel upstream, the entire planned area is structured into double sections.

The construction of embankments on both sides of the bank is almost over, but raising is being carried out in one part of the embankment. The height from the river bed to the crest of the embankment is 4.5 m upstream, and is about 15 m downstream.

Separate sewage systems shall be installed in both banks of the planned area. Sewer pipes shall be installed below the major beds, too. However, intercepting sewer ports shall be installed in the sewer pipes which are misconnected to the storm pipes causing the outflow of sewage from the storm pipe.

The river water is used for agricultural purposes in the upstream area of the planned area. However, water intake is not being conducted in the planned area.

Vast paddy fields and green houses growing foliage plants can be seen in the areas adjacent to the embankments constructed upstream (area where Yangjae Chong flows along the boundary between Seoul Metropolitan and Kwachong-shi), while the areas on both of the banks downstream from Yondong 1st Bridge are mainly used for housing developments. Moreover, there are also hills covered with forests and civic parks adjacent to the embankment on the right bank of the area between the planned areas. The features in both banks are similar and spaces for parks, playgrounds, etc., are adequately distributed.

There are 9 sewage outlets in the planned areas, and 5 of these outlets are observed to discharge sewage regularly during the survey. The catchment area of the planned areas have separate sewage systems and only storm sewers directly face the rivers

with their open outlets. As previously stated, however, the misconnection of the storm sewer and the sewer pipe results in the discharge of sewage.

Flow Regime Characteristics

The water level and discharge curve line of each observation point was drawn based on the results of the actual discharge survey. The amount of discharge during the observation was calculated based on the relationship between the water level (H) and discharge (Q) obtained from the curve line.

The 95, 185, 275 and 355-day discharges and specific discharges calculated from the H-Q data are respectively shown in Tables 3.2-1 and 3.2-2.
Table 3.2-3 shows the discharge measured at each observation point during clear days. The flow rate at St.1 is sometimes less than that at St.2, but this may be attributed to the ongoing subway construction work and etc.

Table 3.2-1 Discharge in Yangjae Chong

Unit:m^3/sec

Station	Catchment Area (km^2)	Discharge 95-day	185-day	275-day	355-day	Average
St.1	59.12	1.132	0.736	0.341	0.008	3.112
St.2	51.74	0.992	0.645	0.299	0.007	2.726
St.3	36.35	0.875	0.397	0.170	0.057	1.678
St.4	12.18	0.293	0.152	0.079	0.013	0.564

* Daily discharge / Jan. 1 - Dec. 31 in 1990

Table 3.2-2 Specific Discharge in Yangjae Chong

Unit:m^3/sec/100km^2

Station	Specific Discharge 95-day	185-day	275-day	355-day	Average
St.1	1.915	1.245	0.577	0.014	5.264
St.2	1.917	1.247	0.578	0.014	5.269
St.4	2.407	1.092	0.468	0.157	4.616
St.3	2.406	1.248	0.649	0.107	4.630
Yoju	2.408	1.119	0.505	o.207	

* Daily discharge / Jan. 1 - Dec. 31 in 1990

Table 3.2-3 Discharge Measured in Yangjae Chong in Drought Days

Unit:m^3/sec

Station	Dec. 14/15	May 23/24	May 29/30	June 3/4	June 7/8	
St.1	0.62	3.28	2.23	1.01	0.92	
St.2	0.70	2.91	1.15	1.35	0.72	
St.4	0.51	1.97	0.76	1.03	0.67	
St.3	0.11	0.32	0.09	0.06	0.05	Yoi Chong

There are no remarkable inundation damages aside from the inside water flood damages at the lowland area near the Tan Chong confluence which was caused by the backwater of Tan Chong itself. This same area also suffered damages during the flood of September 1990.

Pollution Characteristics

The results of the analysis of river samples taken once a month at each observation point along Yangjae Chong are shown in

Fig.3.2-3.

The DO concentration is lower in summer and higher in winter, and is clearly categorized under Class III of Water Quality Standard in other seasons. The BOD and COD (Mn) concentration are generally categorized in Class III, but are lower than the values in Class V during winter and fall when there is less run-off. The TN concentration also varies as the amount of run-off varies with the season.

Fig. 3.2-3 compares the difference in the concentration values of St.4 and St.1, indicating that St.1 has lower DO concentration and mostly higher BOD and COD concentrations compared to those at St.4. It also indicates that the quality of the water in St.1 worsens as it flows downstream. This suggests that sewage flowing from the storm sewers into the area between the stations largely affect the water quality of the area.
On the other hand, compared to the other stations, St.3 showed higher DO concentration and lower BOD, COD, NH_4-H, etc., concentrations, indicating that, at present, Yoi Chong does not pollute the main stream of Yangjae Chong.

Although St.2 is located between St.1 and St.4, it does not indicate the intermediate values of both stations. This is because St.1 often shows abnormally high concentration values which may be attributed to the various works conducted in the river during the observation period.

In Yangjae Chong, the self-purifying capacity of the river was additionally surveyed with TKN, can be easily measured, because its influence was expected. It of the area between the Yongdong 2nd Bridge and the Yongdong 5th Bridge (flowing time: 74 minutes) was only measured once, and extremely high TKN values (4.20 and 5.21 1/day) were obtained. Since the flow velocity in the measured area was low and 46 - 85% of the SS were submerged substances, it is considered that large quantities of pollutants settled during the flow and in the process increased the self-

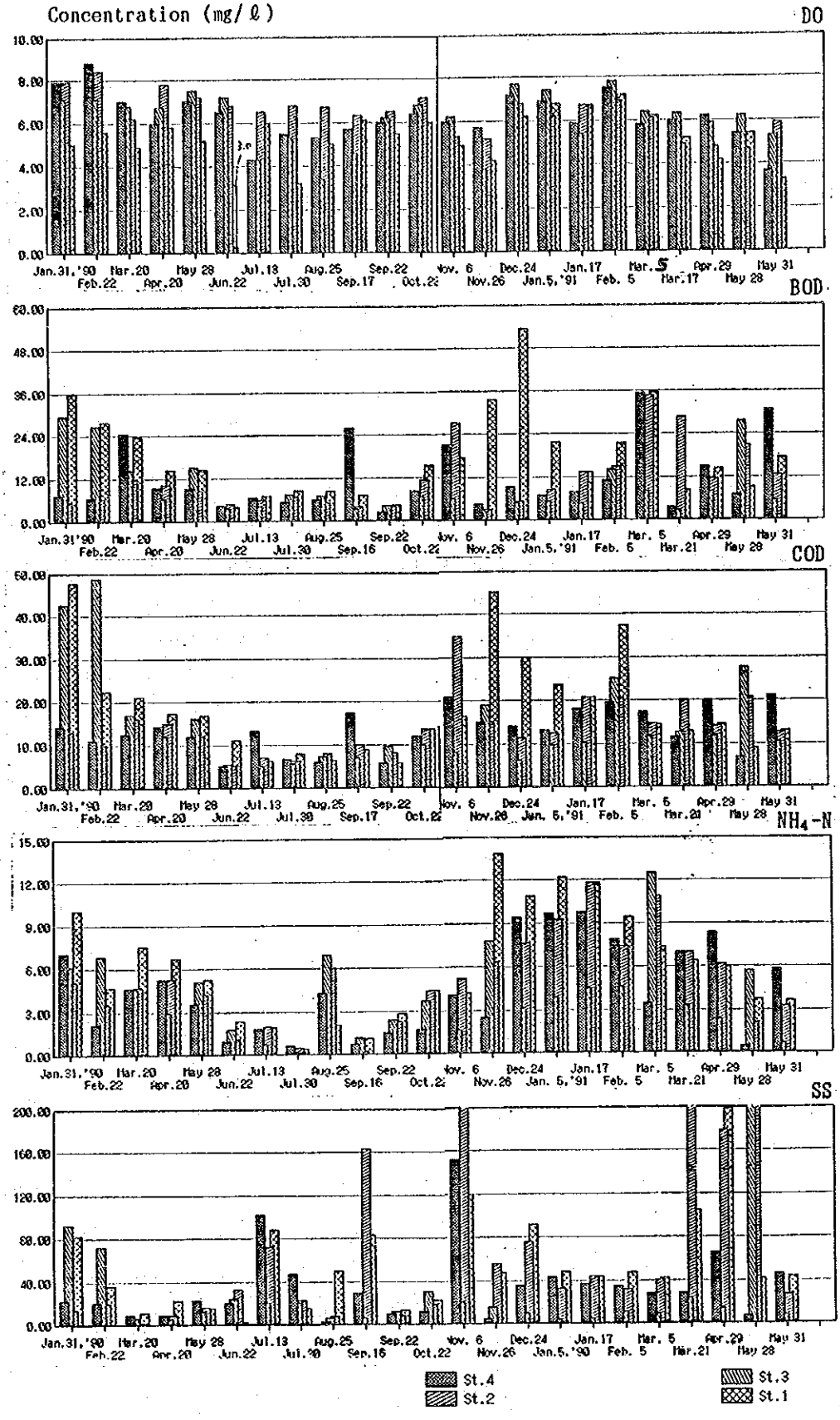

Fig. 3.2-2 Water Quality Fluctuation of Yangjae Chong during the StudyPeriod

purifying coefficient.

Due to the analysis results of the sediment samples taken on December 5, 1990, organic material content is high but concentrations of heavy metals and toxic substances are extremely low. This fact indicates that no pollution source which discharges harmful materials exists in this basin.

Sediment Run-off Characteristics

Slope failures scarcely develop in areas composed of gneiss or schists, but develop in areas where granite is distributed. According to the 1987 aerial photographs of the Yangjae Chong basin, the east mountain side of the dividing ridge of Anyang Chong and Yangjae Chong is rich in slope failures. These slope failures can be found in 148 places, and the slope failure area totals 0.45 km^2.

Immediately right after the flood of September 1990, sediments flowed into the river system rich in slope failures, and natural banks were destroyed in several places.

3.3 Ui Chong

Present Condition of the Basin

The total length of the main course of Ui Chong is 11.85 km. 8.3 km belongs to Seoul Metropolitan, and was, therefore, the only Ui Chong area included in the study. The Ui Chong basin extends in the NW-SE direction and narrows downstream (see Fig. 3.3-1).

The entire basin consists of granite and the narrow valley plain is thinly covered with alluvium.

The entire Ui Chong basin is included in the Seoul Metropolitan area. The basin has a population of approximately 32 thousand. Population growth is especially remarkable in the central area of the basin, while the downstream population tend to decrease. The average population density in the basin is approximately 120 persons/ha. The population density in residential areas, however, is extremely high indicating about 550 persons/ha.

The water source of Ui Chong above 100 m in altitude is included in the Pukansan National Park. The areas below 100m in elevation are mainly used for residential and commercial purposes. However, an industrial area has been discovered to exist for quite some time on the left bank of the middle reaches. Detached houses and low-storied house complexes are mainly predominant in the residential and commercial areas. Recently, however, large housing developments can be found on the right bank of the middle reaches. Food and printing factories make up the industrial area.

The park area and the green zone ratio upstream are 5.2 m^2/head and 63.8 m^2/head, respectively, values which are much higher than the average values of the entire Seoul Metropolitan due to the Pukansan National Park. On the other hand, the park area and green zone ratio downstream where a highly densened urban dis-

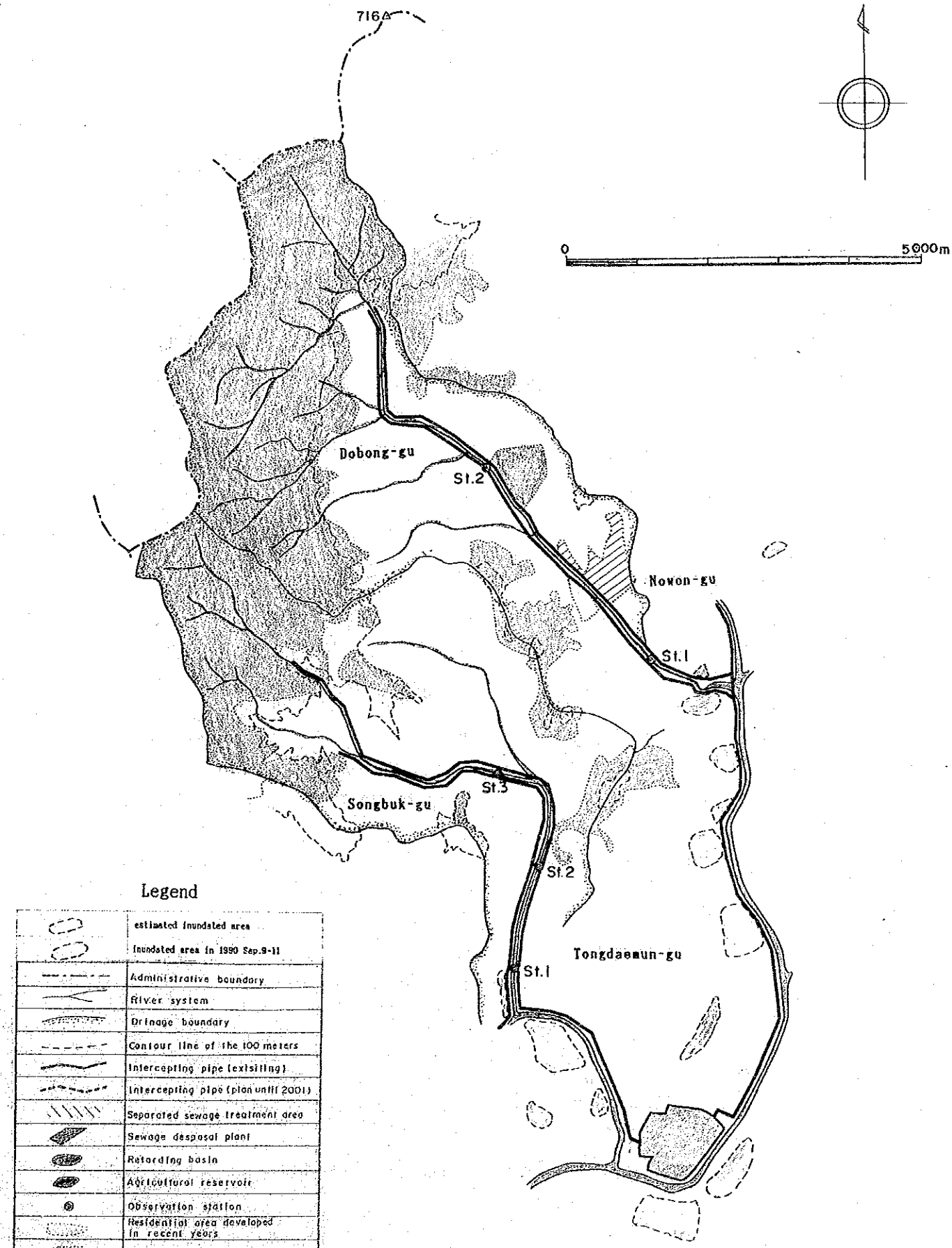

Fig. 3.3-1 Present Environmental Condition of Ui Chong Basin

trict can be found, are only 2.3 m^2/head and 3.3 m^2/head, respectively.

The diffusion rate of the Ui Chong Sewage System is almost 100%. A separate sewerage system is adopted in the developed area of the middle reaches, while a combined sewerage system is adopted in other areas. Sewage is sent to the Chungryang Sewage Treatment Plant through the intercepting sewers installed in both banks of the main course. It is then discharged into Chungryang Chong after secondary treatment. The treated water has a BOD average of 15 mg/l.

Improvement and Utilization

The average gradient of the Ui Chong river bed is 1/240 from the Chungryang Chong confluence up to 6 km upstream, and it is more than 1/70 further upstream. The width of the river channel is 40 - 60 m, and excluding the 1.2 km upstream and 1.8 km downstream planned areas, the cross section forms a double section.

The construction of the embankment (one part of which is a special embankment of parapet wall) on both sides of the bank of the planned area is almost completed. The height of its crest is 3.5 - 4 m upstream, and not more than 5.5 m downstream.

Intercepting sewers are only installed within 0.7 km on the upstream right bank area. From this area to the lower reaches, however, they are installed on both banks. The downstream area of Daedong Chong, Kwao Chong and Hwakohu Chong, the main tributaries of Ui Chong, are used as sewage rivers and are covered. Roads are constructed on these covered areas.

At present, the river water of Ui Chong is not utilized. However, underflow water is used as industrial water in some places.

There is a road constructed near the right bank embankment

between Shinchang Bridge and Anyang Bridge. Traffic in this road produces noisy sounds as it is heavy. The majority of the neighboring areas of the planned area are residential and commercial areas, and the old closely built small-sized houses were successively replaced with large residential houses. With the exclusion of the housing developments between Shinchang Bridge and Wolgye-ni Bridge, most of the residential and commercial buildings are 2 storied buildings. The renovated area shows streets lined with neat rows of stores and houses.

There are 11 sewage outlets in the planned area, and only one of the outlets regularly discharged sewage during the survey period. All the other sewage flow directly into the river over the weirs during rainy days.

Flow Regime Characteristics

The water level and discharge curve line of each observation point was drawn based on the results of the actual discharge survey. The amount of discharge during the observation was calculated based on the relationship between the water level (H) and flowrate (Q) obtained from the curve line.

The 95, 185, 275 and 355-day discharges and specific discharges calculated from the same data are respectively shown in Table 3.3-1 and 3.3-2. Table 3.3-3 shows the result of the discharge measurement during clear days while the results of the discharge measured in draught days are shown in Table 3.3-3.
In comparison to the other 3 rivers and Yoju, the values indicated in the measurements are abnormally high in this river. This indication may be attributed to the defect in the plotter.

The heavy rains that took place in the central region of ROK, which includes the Seoul Metropolitan area, early in September 1984 flooded Wolgye Dong and damaged 345 buildings in the area. Inundation occurred when the water level of Chungryang Chong

increased and its backwater flowed into Ui Chong.

Table 3.3-1 Discharge in Ui Chong

Unit:m^3/sec

Station	Catchment Area (km^2)	Discharge 95-day	185-day	275-day	355-day	Average
St.1	26.18	5.721	3.328	2.250	1.312	7.021
St.2	16.86	1.572	0.995	0.865	0.436	1.845

* Daily discharge / Jan. 1 - Dec. 31 1990
* As above values are abnormaly large, it is an adequate for the river planning from now on.

Table 3.3-2 Specific Discharge in Ui Chong

Unit:m^3/sec/100km^2

Station	Specific Discharge 95-day	185-day	275-day	355-day	Average
St.1	21.85	12.71	8.59	5.01	26.82
St.2	9.32	5.90	5.13	2.59	10.94
Yoju	2.408	1.119	0.505	0.207	

* Daily discharge / Jan. 1 - Dec. 31 1990

Table 3.3-3 Discharge measured in Ui Chong in Draught Days

Unit:m^3/sec

Station	Dec. 4	May 28	June 1	June 10	June 13
St.1	0.03	0.35	0.08	0.12	0.08
St.2	0.02	0.28	0.07	0.01	0.04

Pollution Characteristics

The results of the analysis of the river water samples taken once a month at each observation point along Ui Chong are shown in Fig. 3.3-2.

The DO concentration the whole year round is generally categorized in Class III of Water Quality Standard.

The BOD and COD concentration do not vary seasonally. Although they are extremely high in St.1, they are generally categorized in Class III.

Fig. 3.3-2 shows the difference in the values observed in St.2 and St.1. It indicates that the DO concentration in St.2 in the summer is higher than the latter, and usually has lower COD and BOD concentrations. The difference in the COD and BOD concentrations in both Stations is especially large in summer and winter. This may be attributed to the fact that organic matters are easily accumulated when water stands for a while in St.1 which is located in the upstream area of the major bed.

Due to the analysis results of the sediment samples taken on December 5, 1990, organic material content is high but concentrations of heavy metals and toxic substances are extremely low. This fact indicates that no pollution source which discharges harmful materials exists in this basin.

Sediment Run-off Characteristics

According to the 1987 aerial photographs, the area in Ui Chong basin which is rich in slope failures is the upstream area of the main river where the elevation is more than 200 m. Granites outcrop from the steep slopes of the area. There are 148 slope failures in the basin and their area totals 0.3 km^2.
Immediately right after the big flood of September 1990, sedi-

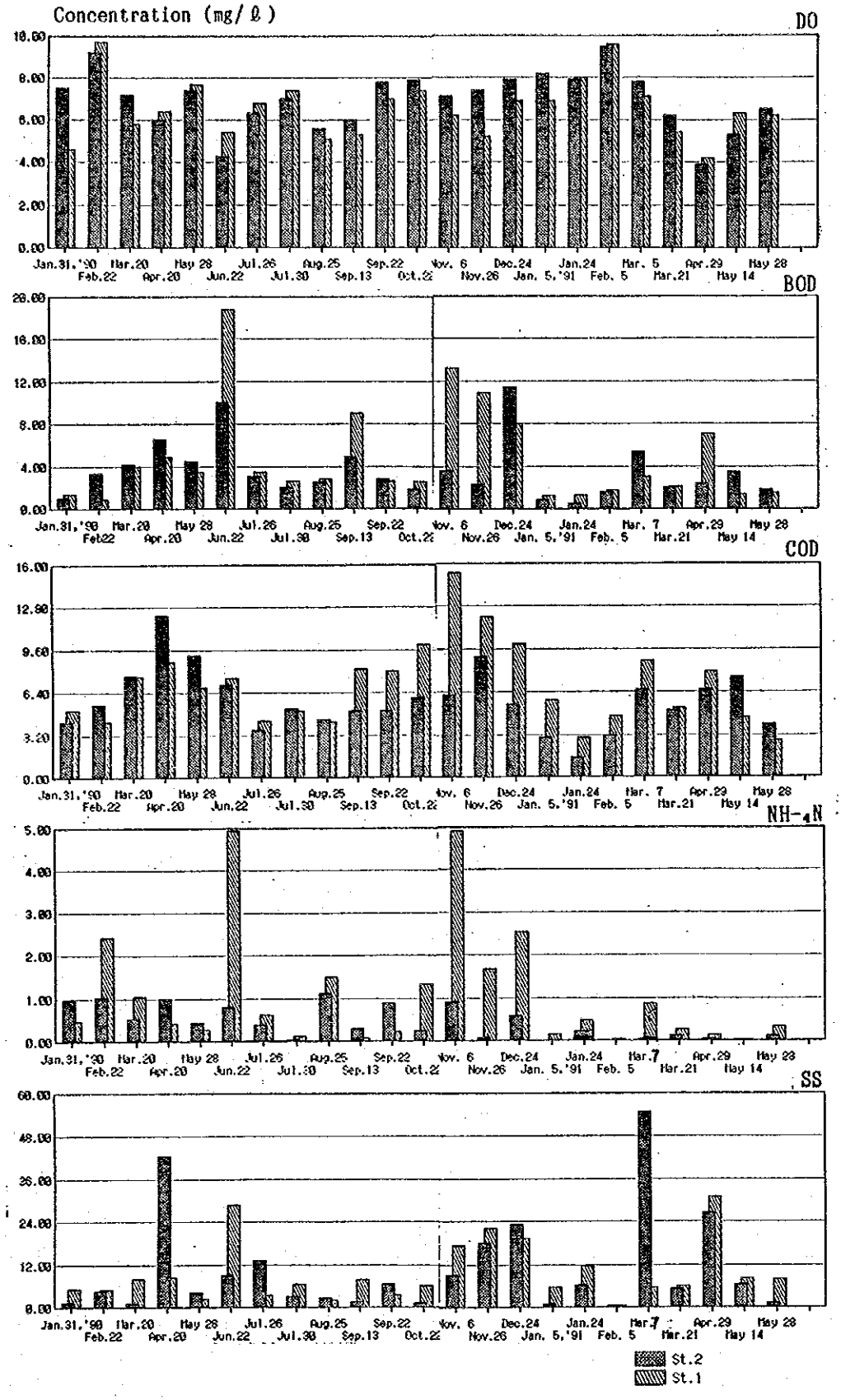

Fig. 3.3-2 Water Quality Fluctuation of Ui Chong during the Study Period

ments flowed in the upstream area of the main river and left numerous piles of sediments at the bottom of the mountain streams. With the future occurrence of another flood, there is a possibility that these sediments will be flown downstream.

3.4 Chungroung Chong

Present Condition of the Basin

The main stem of Chungroung Chong has a length of 10.85 km. The 7.6 km area downstream included in the Seoul Metropolitan area was, therefore, included in the study. Chungroung Chong basin extends in the E-W direction upstream and narrows in width in the N-S direction downstream. The catchment area of Chungroung Chong is 19.66 km^2(see Fig. 3.4-1).

The entire basin is composed of granite, and the narrow valley plain is thinly covered with alluvium.

The entire basin area is included in the Seoul Metropolitan area and the population is estimated at approximately 38 thousand. The average population density in the basin is 250 - 350 persons/ha, but the population density in residential areas is high at 500 - 600 persons/ha. Recently, however, the population tends to decrease just like the population in central Seoul Metropolitan area.

The water source of Chungroung Chong above 100 m in altitude is one of the Pukansan National Park areas. The areas below 100m in altitude are mostly densely populated residential and commercial areas. There are not much areas left in the basin for further development.
Due to Pukansan Park, the park area and the green area ratio in the upstream basin are high at 2.6 m^2/ha and 39.4%, respectively. The conditions downstream are considerably poor with only 0.7 m^2/ha of park area and 18% green area ratio.

The sewage diffusion rate in Chungroung Chong is nearly 100% and all areas adopt the combined sewage system. Through the intercepting sewers installed on both banks of the Chungroung Chong main stem, sewage is sent to the Chungryang Treatment Plant and

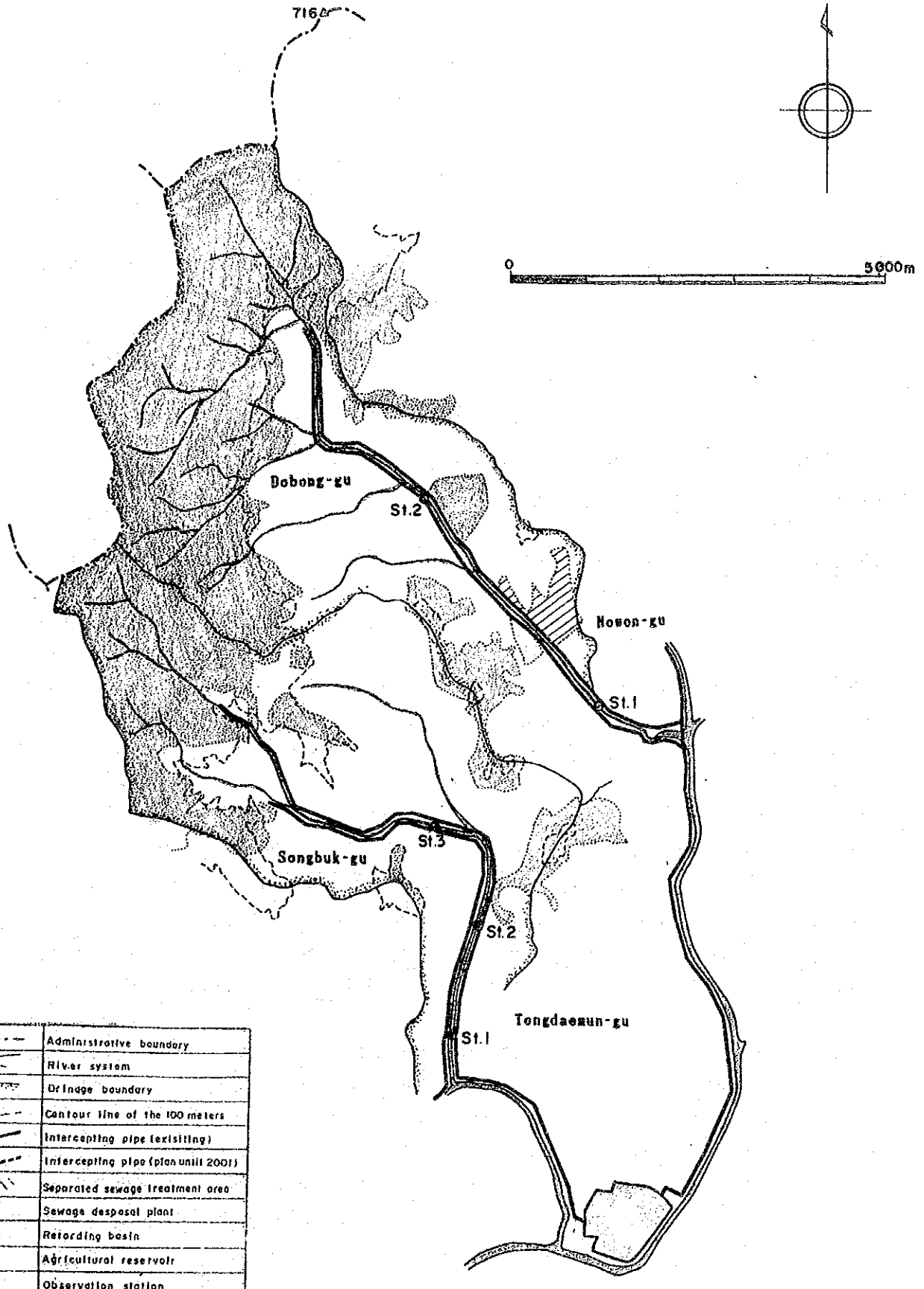

Fig. 3.4-1 Present Environmental Condition of Chungroung Chong Basin

then discharged to Chungryang Chong after secondary treatment. The average BOD concentration of the treated water is 15 mg/l.

River Improvement and Utilization

The river bed of Chungroung Chong has an average gradient of 1/180 from the Chonggye Chong confluence up to 2 km upstream. From here up to within 6.7 km, the gradient average is 1/130, and more than 1/30 further upstream.

There are no major beds within 0.7km of the upstream right bank of the planned area, but double sections can be found in other areas. The width of the river channel is 30 - 50 m.

The construction of embankment on both banks of the planned area is almost over, and the height from the river bed to the crest embankment is 4 - 5 m.

Intercepting sewers are installed below the major beds of the left and right banks, while open intercepting sewers are installed in areas without major beds parallel to the level of the low water channel.

A total of 2,766 m or 36% of the planned area is covered. Furthermore, the tributary Ryangohu Chong and the area upstream from the planned area are covered and used as sewage rivers. The spaces on the cover are used as roads.
At present, the river water of Chungroung Chong is not utilized.

Most of the areas adjacent to the river of the planned area are residential and commercial areas. Old closely built small-sized houses in this area were successively replaced with large houses. Narrow roads are constructed in the space between the river and the houses. The residents use the roads for communication and recreational purposes.

There are 17 sewage outlets in the planned area. 6 of these outlets discharged sewage during the survey. The total amount of sewage discharged into the river was about 0.01 m^3/sec.

Flow Regime Characteristics

The 95, 185, 275 and 355-day discharges and specific discharges calculated from the same data are respectively shown in Table 3.4-1 and 3.4-2.

Table 3.4-3 shows the results of the discharge measurement in clear days. The rate of flow is always largest in St. 3 upstream and decreases as it moves downstream. This occurrence may be attributed to the fact that river water flows under between St. 1 and St. 2, and that it is drawn into the open sewer on the right bank.

There are no records indicating significant flood occurrences in this basin.

Table 3.4-1 Discharge in Chungroung Chong

Unit:m^3/sec

Station	Catchment Area (km^2)	Discharge 95-day	185-day	275-day	355-day	Average
St.1	19.40	0.434	0.244	0.109	0.012	1.028
St.2	17.92	0.715	0.300	0.075	0.020	0.973
St.3	10.03	1.107	0.168	0.042	0.011	1.105

* Daily discharge / Jan. 1 - Dec. 31 in 1990

Table 3.4-2 Specific Discharge in Chungroung Chong

Unit:$m^3/sec/100km^2$

Station	Specific Discharge 95-day	185-day	275-day	355-day	Average
St.1	2.237	1.258	0.562	0.062	5.299
St.2	3.990	1.674	0.419	0.112	5.430
St.3	11.037	1.675	0.419	0.110	11.017
Yoju	2.408	1.119	0.505	0.207	

* Daily discharge / Jan. 1 - Dec. 31 in 1990

Table 3.4-3 Discharge Measured in Chungroung Chong in Drought Days

Unit:m^3/sec

Station	Dec. 4	May 28	June 1	June 10	June 13
St.1	0.71	0.03	0.005	--	0.012
St.2	0.29	0.08	0.004	0.01	0.04
St.3	0.47	0.23	0.19	0.19	0.10

Pollutant Characteristics

The results of the analysis of the river water samples taken once a month at each observation point are shown in Fig. 3.4-2.

The DO concentration for the whole year is generally cleared for Class III. The BOD and COD (Mn) concentrations, however, varies greatly and were usually lower than Class V. The NH_4-N and NO_3-N ratios of TN showed similar results to those found in the Seoul Metropolitan area.

The results of the analysis in St. 3 and St. 1 are compared and shown in Fig. 3.4-2. The graph shows that before November 1990,

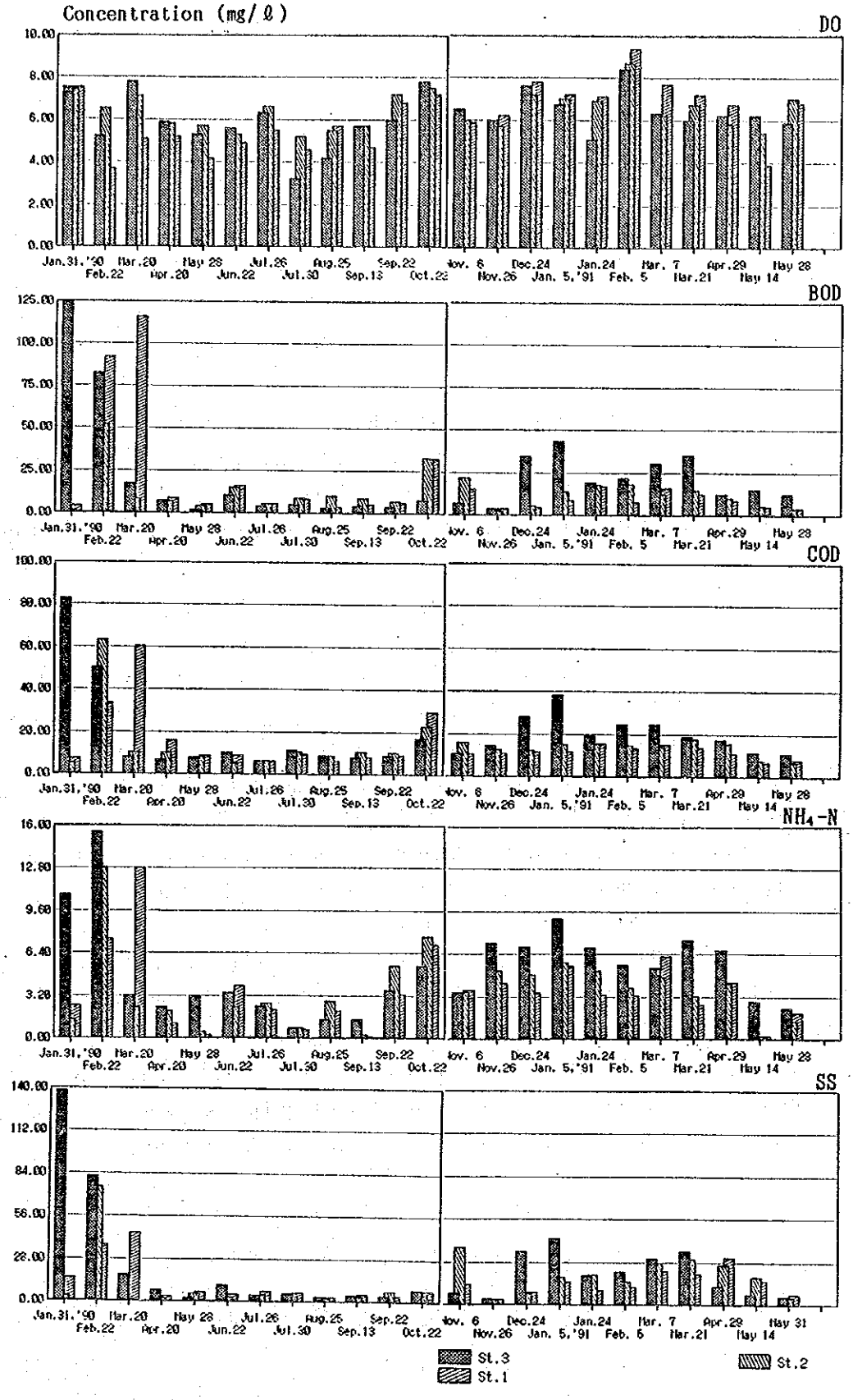

Fig. 3.4-2 Water Quality Fluctuation of Chungroung Chong during the Study Period

St.1 had higher DO and BOD concentrations than St.3, and that the changes in the upstream and downstream water quality did not indicate fixed patterns.

As previously mentioned, the change in the flow of Chungroung Chong is unnatural, and it is assumed that the underflow greatly affects the river flow as well as the changes in the downstream and upstream water quality.

Due to the results of the analysis of the sediment samples taken in December 5, 1990, the content of organic materials is high but the content of heavy metals and toxic substances is very low. Therefore, it is considered that no harmful matters exist in the basin.

Sediment Run-off Characteristics

According to the 1987 aerial photographs, there are only few slope failures in Chungroung Chong basin. These slope failures can be found on the east mountain side of the dividing ridge of Chungroung Chong and Hongje Chong. There are 34 slope failures in the basin and their area totals approximately 0.13 km^2.

Immediately right after the big flood of September 1990, sediment flow occurred. These sediments are presumed to originate not from the slope failures, but from the piles of sediments at the bottom of the mountain streams or from the banks of eroded streams. Most of the sediments are widely accumulated in the downstream area of St.3 and not at the 3 layered covered area.

3.5 Mechanism of River Pollution

Flow of Pollutant Load and Emission Load

Depending on the improved and maintained conditions of the sewerage, sewage removal systems, the flow regime characteristics of the river, etc., pollutants from the basin are discharged outside of the basin in various proportions through various routes. To improve the flow duration and the water quality of a river and to maximize the effect, the route and the volume of the pollutant load should be clarified and it is necessary to use techniques which are most appropriate in most suitable positions.

In order to study this conditions, the flow of the pollutant load in the basins of the 4 rivers were schematically outlined based on the present environmental conditions of the rivers aforementioned in Sections 3.1 to 3.4, and shown in Figs. 3.5-1 to 3.5-5.

The Anyang Chong basin is divided into 3 areas: the 1st area (Area A) is made up of Anyang-shi, Kunpo-shi, Uiwang-shi and Kwachon-shi, all of which are not provided with any sewerage system; the 2nd area (Area K) consists of Kwangmyong-shi, Shihung-shi, and Puchon-shi, each of which is partially provided with sewerage systems; the last (Area S) is the Seoul Metropolitan area which is almost entirely provided with sewerage systems. The areas with sewerage systems are again divided into 2: the area using separate sewerage systems, and the area using combined sewerage systems. Sewage exceeding the capacity of the intercepting sewers of the former area flows directly to Anyang Chong in rainy days. It was previously mentioned too, that some of the sewage which are not drawn into the intercepting sewers of Area S directly flows into Anyang Chong.

The Yangjae Chong basin is divided into 2: the Kwachon-shi area upstream, and the Seoul Metropolitan area downstream, both of which are provided with separate sewerage systems in their urban

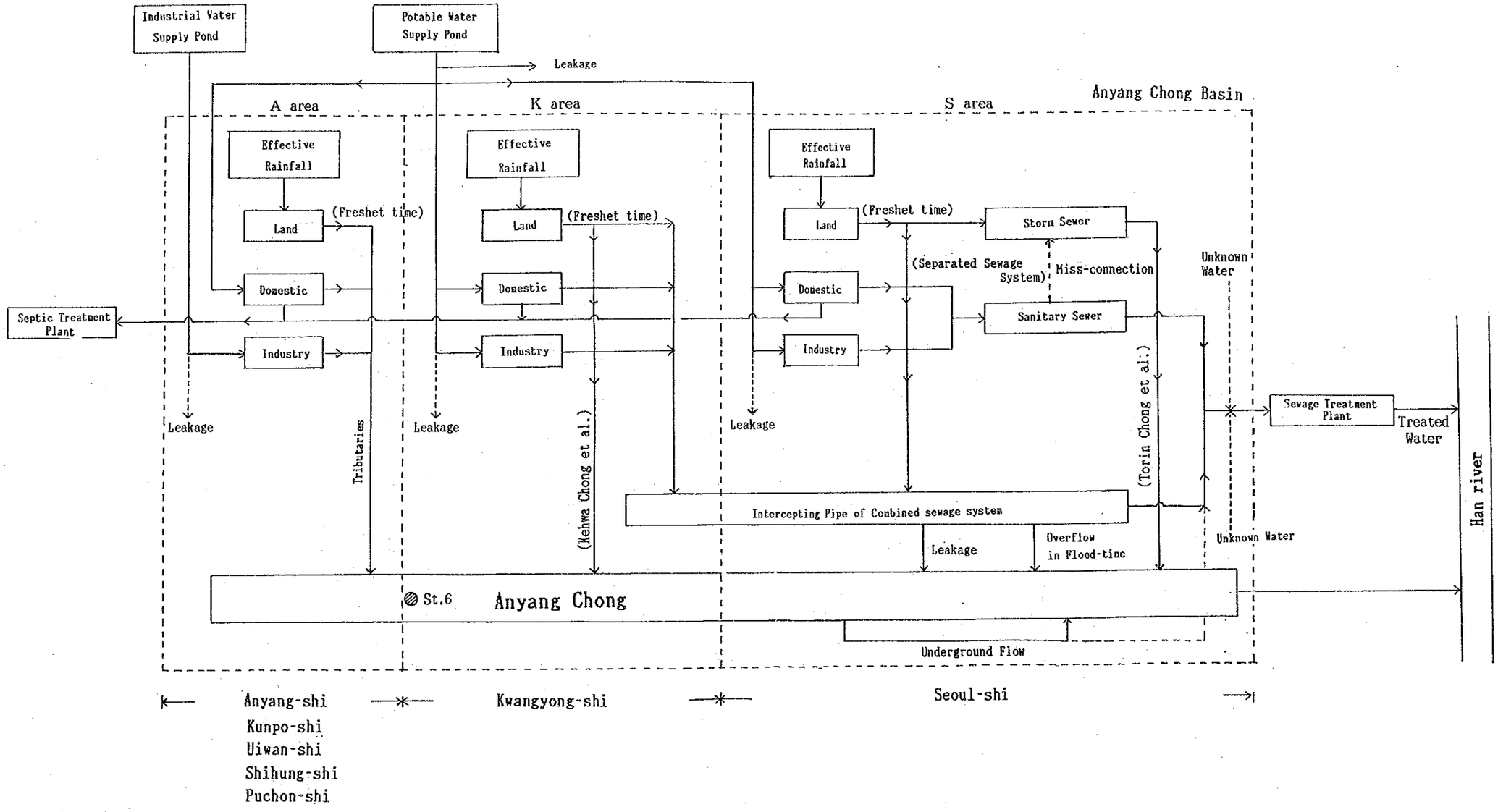

Fig. 3.5-1 Runoff Route of Pollutant in Anyang Chong Basin

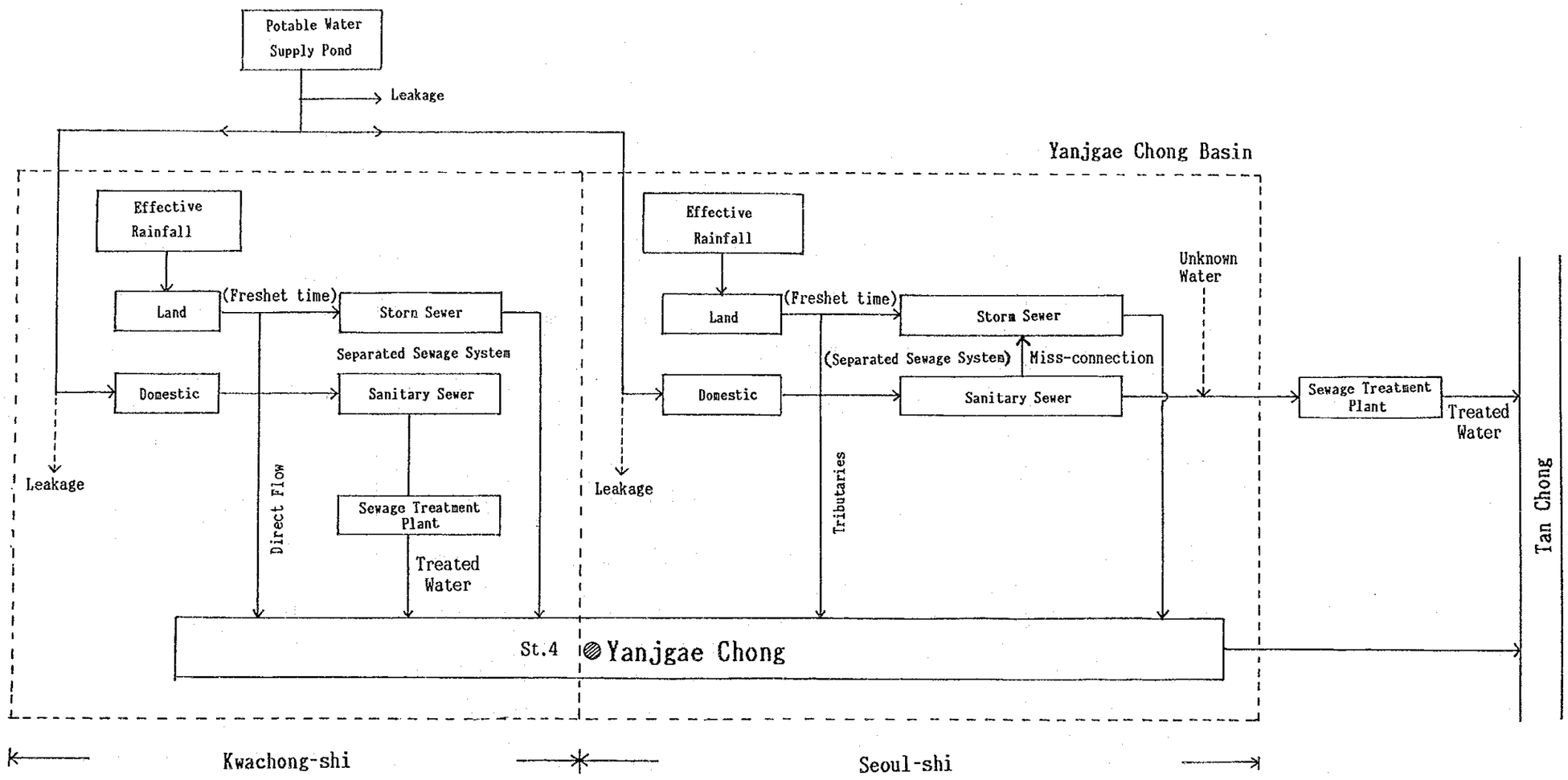

Fig. 3.5-2 Runoff Route of Pollutant in Yangjae Chong Basin

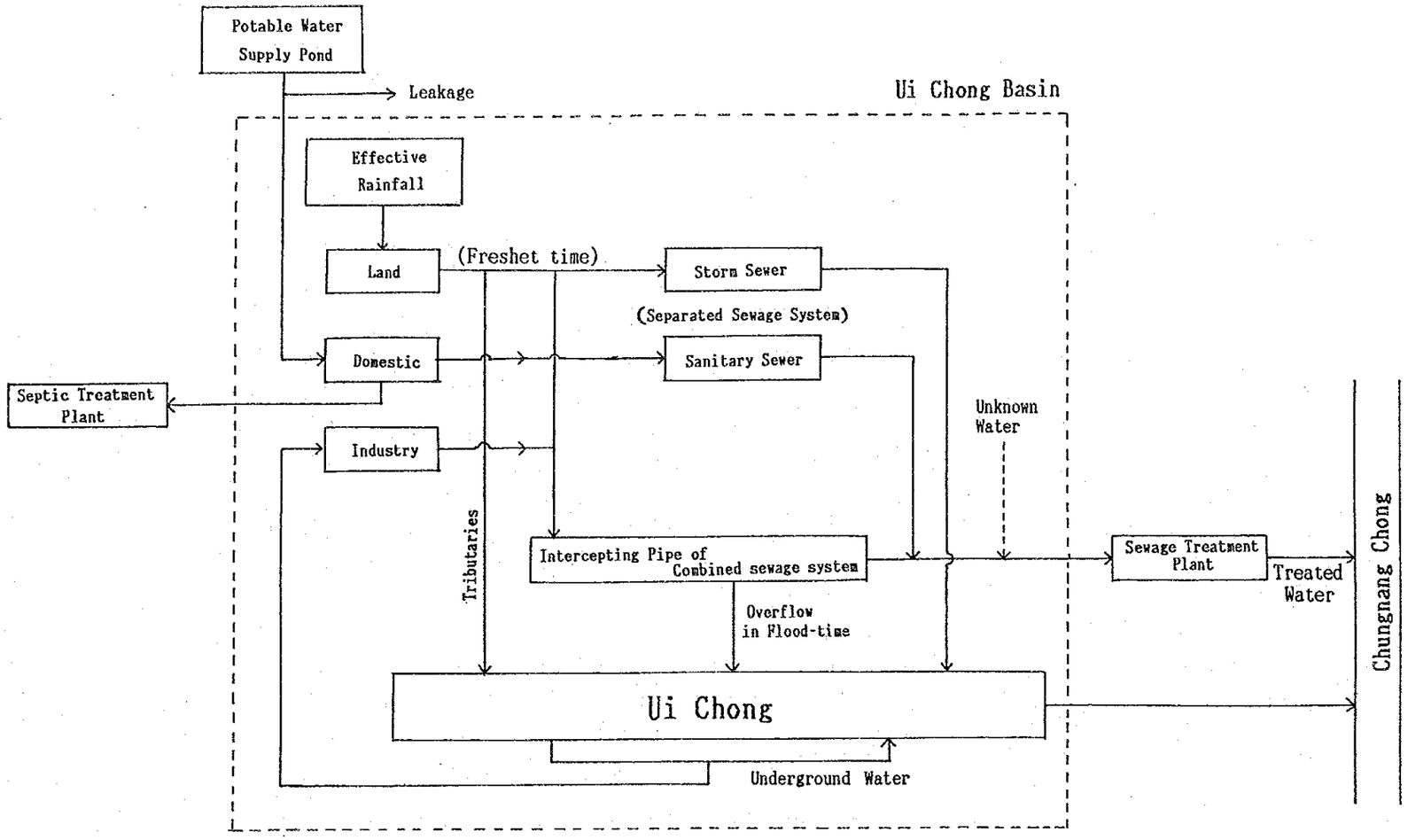

Fig. 3.5-3 Runoff Route of Pollutant in Ui Chong Basin

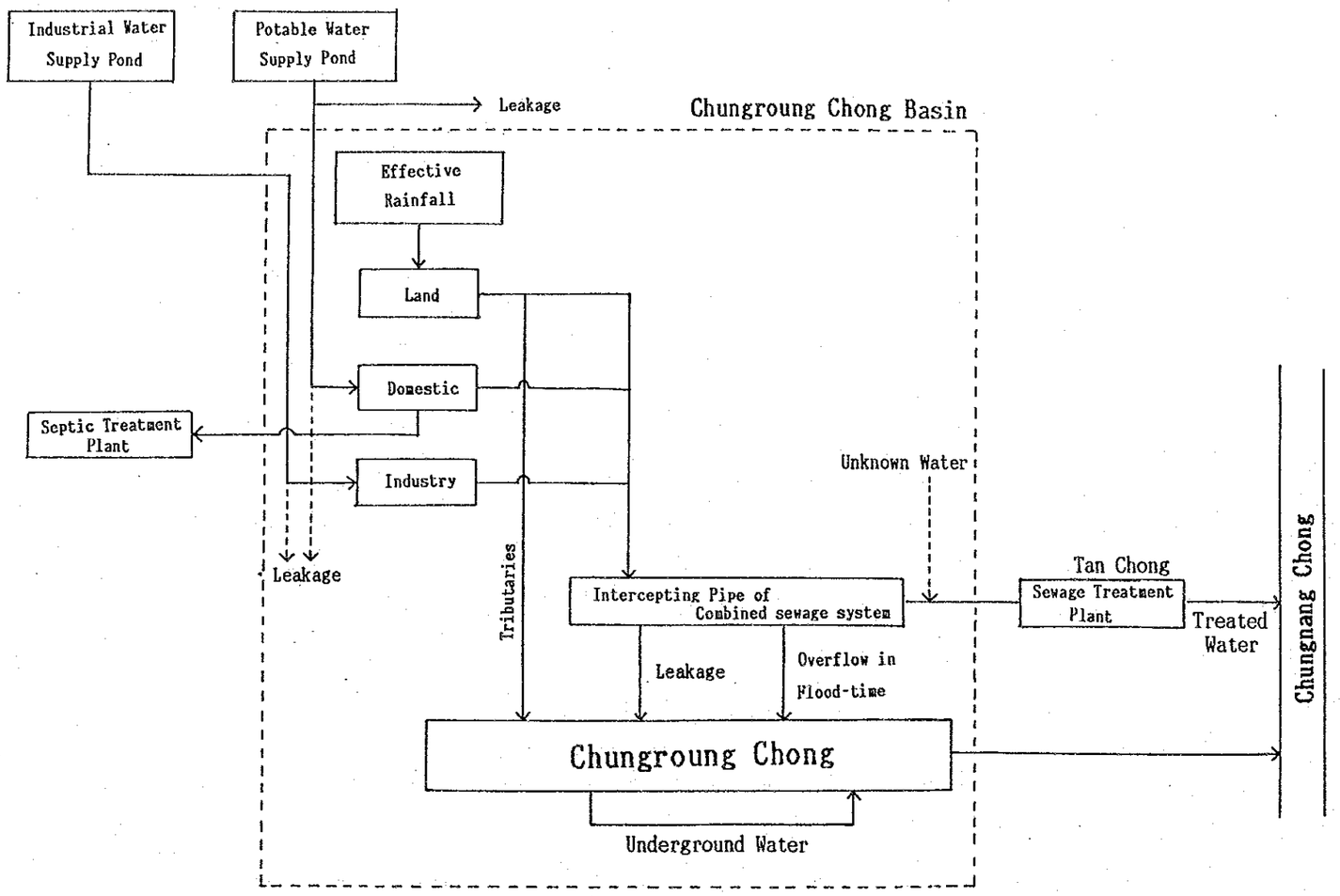

Fig. 3.5-4 Runoff Route of Pollutant in Chungroung Chong Basin

districts. There are areas within Seoul Metropolitan, however, using combined sewerage systems because the sewer pipes are misconnected to the storm sewers.

One part of the Ui Chong basin uses the separate sewerage system, while most of the area uses the combined sewerage system. Sewage exceeding the capacity of the intercepting sewers of the latter flows directly into Ui Chong in rainy days. However, little sewage inflow was observed in clear days based on the BOD/COD concentrations and the NH_4 - N/TN or TON/TN concentrations of the water quality, indicating that the intercepting sewers are kept in good conditions.

The entire Chungroung Chong basin is provided with a combined sewerage system. However, the visual observation results and water quality analyses indicated that large quantity of sewage flows regularly into Chungroung Chong both during rainy and clear days.

Generation Load in the Planned Section

The generation load largely influences the water quality of the river if the treatment of the pollutant sources and the improvement and maintenance of the sewerage facilities are insufficient. However, the method of calculation and its accuracy shall largely vary according to the base data. The method of calculation used is described in the Main Report, and the results are shown in Table 3.5-1.

Pollutant Load measured in the Planned Section

To calculate the pollution load flowing in the river, it is necessary to simultaneously obtain the discharge and the water quality of the river. Since this kind of observation was not implemented in the 4 rivers, we made use of the mean value (19),

excluding both maximum and minimum values, of the periodical observations conducted once a month from January 1980 to July 1991. The results are shown in Table 3.5-2.

The annual mean value of the measured pollution loads was not used this time because it was not highly reliable. Reliability shall improve though, as the number of measurements increases in future.

Apparent Run-off Ratio

Run-off ratio refers to the percentage of the pollution load discharged from the pollution source that has flowed into the river. It is originally defined as the ratio of the load actually measured at a survey point and the ratio of the load discharged from the basin. Since it was difficult to calculate the amount of load discharged from the planned area, the generation load was used instead, and the ratio of the generation load and the load actually measured became the apparent run-off ratio of pollution load.

In other words, the "apparent run-off ratio of pollution load" is the value obtained by dividing the measured pollution load by the load generated from the basin between each survey point. The ratio of the pollution load can be detected too when underflow occurs. The calculated results are shown in Table 3.5-3.

Table 3.5-1a Current Pollution Load Generation (BOD) in the Planned Section

Anyang Chong Unit:kg/day

Source	St. 1-2	St. 2-4	St. 4-5	St. 5-6	St. 3	Total
Domestic	16,298	10,175	30,898	17,929	66,797	142,097
Industrial	61,631	13,248	17,475	162,246	17,005	271,605
Non-point	1,031	147	1,664	1,188	2,123	6,423
Livestock	7	667	2,835	5,830	27	9,336
Total	79,237	24,237	52,872	187,193	85,952	429,491

Yangjae Chong Unit:kg/day

Source	St. 1-2	St. 2-4	St. 3	Total
Domestic	8,529	1,278	4,390	14,197
Industrial	54	31	0	85
Non-point	348	140	54	542
Livestock	0	113	264	377
Total	8,931	1,562	4,708	15,201

Ui Chong Unit:kg/day

Source	St. 1-2	St. 2-4	Total
Domestic	12,209	9,435	21,644
Industrial	5,561	5,622	11,183
Non-point	377	23	400
Livestock	0	1	1
Total	18,417	15,081	33,228

Chungroung Chong Unit:kg/day

Source	St. 1-2	St. 2-4	St. 3	Total
Domestic	4,640	19,922	989	25,551
Industrial	317	831	1,669	2,817
Non-point	107	465	288	860
Livestock	1	0	1	2
Total	5,065	21,218	2,947	29,230

Table 3.5-1b Current Pollution Load Generation (SS) in the Planned Section

Anyang Chong Unit:kg/day

Source	St. 1-2	St. 2-4	St. 4-5	St. 5-6	St. 3	Total
Domestic	17,897	11,173	33,928	19,687	73,348	156,033
Industrial	24,313	5,571	7,204	65,764	7,611	110,463
Non-point	3,367	364	4,144	3,509	5,497	16,431
Livestock	38	3,515	12,186	29,962	123	45,824
Total	45,615	20,623	57,462	118,472	86,579	328,751

Yangjae Chong Unit:kg/day

Source	St. 1-2	St. 2-4	St. 5-6	Total
Domestic	9,384	1,406	4,831	15,621
Industrial	27	16	0	43
Non-point	897	360	114	1,371
Livestock	0	536	1,510	2,046
Total	10,308	2,318	6,455	19,081

Ui Chong Unit:kg/day

Source	St. 1-2	St. 2-	Total
Domestic	13,322	10,295	23,617
Industrial	2,264	2,315	4,579
Non-point	974	36	1,010
Livestock	0	1	1
Total	16,560	12,647	29,207

Chungroung Chong Unit:kg/day

Source	St. 1-2	St. 2-3	St. 3	Total
Domestic	5,063	21,739	1,079	27,881
Industrial	131	406	759	1,296
Non-point	277	1,205	740	2,222
Livestock	1	0	2	3
Total	5,472	23,350	2,580	31,402

Table 3.5-2 Current Pollution Load Measured in the Planned Section

Anyang Chong Unit:kg/day

	St.1	St.2	St.4	St.5	St.6	St.3
BOD	32,119	41,010	18,678	31,807	22,406	154
SS	32,680	37,112	23,827	24,534	18,943	281

Yangjae Chong Unit:kg/day

	St.1	St.2	St.4	St.3
BOD	1,801	439	281	274
SS	4,540	1,713	323	1,336

Ui Chong Unit:kg/day

	St.1	St.2
BOD	1,327	264
SS	2,359	888

Chungroung Chong Unit:kg/day

	St.1	St.2	St.3
BOD	683	450	1,845
SS	453	226	1,106

Table 3.5-5 Current Apparent Run-off Ratio in the Planned Section

Anyang Chong Unit:%

	St.1	St.2	St.4	St.5	St.6	Total
BOD	0.001	0.231	0.065	0.170	--	0.002
SS	0.101	-0.395	0.229	0.269	--	0.003

Yangjae Chong Unit:%

	St.1	St.2	St.4	Total
BOD	0.215	-0.075	--	0.058
SS	0.435	0.023	--	0.050

Ui Chong Unit:%

	St.1	St.2
BOD	0.059	0.018
SS	0.089	0.070

Chungroung Chong Unit:%

	St.1	St.2	St.3
BOD	0.136	0.005	0.626
SS	0.139	-0.005	0.429

3.6 River Space Characteristics

Classification of the River Space

One of the important things in the river space improvement plan is the understanding of the characteristics of the planned areas. We, therefore, divided the planned areas into several small areas using the natural and social environment of the hinterlands previously stated in sections 3.1 to 3.4 as a basis. Accordingly, Anyang Chong was divided into 6 areas, Yangjae Chong into 3 areas, Ui Chong into 4 areas and Chungroung Chong into 2 areas.

Classification of Zone and Selection of Model Site

If the river space shall be utilized for recreational purposes, it is necessary to study the suitability of the purpose and the extent of the demand for the recreational use of the area.

The following 3 items were, therefore, generally evaluated in order to grasp the extent of the demand for the recreational use of the area:

(1) the population of the hinterland along the river bed,
(2) the movement of the population,
(3) the improved conditions of the park.

As for the suitability of the purpose, the (a) accessibility of the river, (b) preserved condition of the natural environment, and (c) the width of the major bed were evaluated.

Based on the results of the above mentioned evaluations, 3 model sites were selected in Anyang Chong, 2 in Yangjae Chong, and 1 each in Ui Chong and Chungroung Chong.

Chapter 4. Approach and Strategy of the River Environment Improvement Plan

4.1 Objective

The River Water Quality and Discharge Improvement Plan and the River Space Improvement Plan shall be settled separately based on the improved conditions of the river environment previously stated in the preceding chapter. The following items, however, should be clarified beforehand.

(a) The target year and the environmental level desired;
(b) The needs of the residents which should be indicated in the plan;
(c) The future water quality of the river which shall determine the design of the water quality improvement facilities;
(d) The type and applicability of the environment improvement technique;
(e) The prerequisites and restraints of other rival projects.

All of these items shall be settled in the 4 rivers and shall be generally dealt with in this chapter.

4.2 Target Year

The proposed river environment improvement plan consists of (a) a basic concept which formulates a long term over-all plan, and (b) a concrete working plan, based on the basic concept, for works that should be immediately implemented.

The period of time required to accomplish the various improvement works in a wide area with relative accuracy is estimated at 20 years. Therefore, the target year of the basic plan shall be the year 2010.

On the other hand, the 10-year working plan shall commence in 1992 and its target year shall be 2002. This target year nearly coincided with the Long Term Basic City Plan of Seoul Metropolitan formulated in 1981, since the latter set its completion year in 2001.

4.3 Environmental Target

Water Quality Target

The water quality target shall be established based on how water shall be used. As previously mentioned in Chapter 3, the water of the 4 rivers is not used for irrigation, domestic purposes, etc., and they merely exist as part of the residents living environment. The water quality target, therefore, should be set in Class V, one of the water quality standards determined by the Environment Bureau and a category which does not provide unpleasantness to the environment.

The water quality standard of Anyang Chong was categorized by the Environment Bureau under Class V. The water quality standard of the other 3 rivers was not determined because they are Class C rivers. However, the water quality standard of Tan Chong which is joined by Yangjae Chong belongs to Class II, and that of Chungryang Chong which is joined by Ui Chong and Chungroung Chong belongs to Class III. Consequently, the water quality targets for Yangjae Chong, Ui Chong and Chungroung Chong shall be Class II, III and III, respectively. These water quality targets, however, shall be reviewed if they prove to be technologically and economically difficult to achieve.

River Flow Target

There are 2 flows which are necessary in order to maintain the normal functions of the river. These are the reserved flow and the utilized flow. There is no need to conduct a study on utilized flow since the water of the 4 rivers are rarely used. Instead, it is necessary to settle the reserved flow so as to recover and activate water familiarity functions. No formula, however, has been established to estimate the amount of reserved flow.

The reserved flow was, therefore, calculated based on the width of the river forming a beautiful view. The means of securing the reserved flow was then studied. If this application is technologically and economically inappropriate, a second plan in which only the surface of the areas with demands for high water familiarity functions shall be structured, shall be formulated.

River Space Improvement Plan

The park improvement target of the Seoul Metropolitan in the year 2000 is 14.9 m^2 per capita. At present, however, the city park area is only 2.7 m^2/person (1988), and it is presumed that the difficulty in land acquisition might make the achievement of the target level difficult.

There is always a possibility that the river space could be flooded. However, the area shall bring about large socio-economical impacts if restructured as a park, because it can be acquired freely as well as the fact that it is rich in trees and greeneries.

The present park area per capita shall increase slightly or decrease in the target year when the entire planned area is improved. The results show that a little increase of per capita park area will be achieved for some sections, decrease of it will

also be achieved for other sections on the contrary.

The river space improvement plan shall cover the entire planned areas in the studied rivers.

4.4 Needs of the Residents

The results of the questionnaires distributed during the survey, indicate that most of the residents share the same opinion about the present condition of the 4 rivers studied. They stated that "the rivers are contaminated", "the river beds are devastated", and that "there is little familiarity with the river water". Moreover, about 70% of the residents stated that "the rivers are not suitable places for recreation and relaxation" and as "children's playground".

A few residents think that "the present condition of the rivers is okay", but more than 90% think that "the contaminated rivers should be cleaned" and that to do so, "necessary regulations should be actively stipulated". The common requests stated were "the transformation of the river spaces into parks for recreation and relaxation", "water quality must be improved and basic conditions must be provided to create familiarity with the river water", and "river spaces must be improved so that people can commune with nature". As for Ui Chong and Chungroung Chong, however, the demand "Cover the rivers" was stronger than the demand "to maintain the natural use of the rivers".

As above-mentioned, inhabitants fear the environmental deterioration of the four rivers and strongly hope to improve them as relaxational or water-familiar recreation place.

4.5 Future River Water Quality

The future river water quality was estimated at each observation point by using the "future generation load" which was calculated from the present condition and framework of the basin, and the "future apparent run-off ratio" which shall be influenced by the improvement and maintenance of the sewerage facilities.

The method of calculating the future generation load is stated in detail in the Main Report. Since a rehabilitation plan was not formulated for the existing facilities, the future apparent run-off ratio shall be assumed from the following cases.

Anyang Chong:

Case - 1: If the present maintenance methods of the sewerage facilities shall not be changed in the future.

Case - 2: The sewage treatment plan in the upstream area of St.6 shall be executed as scheduled, and the BOD concentration at the (St.6) upstream end of the planned section shall be improved to 23.7 mg/l (see Annex D-17 for future target). This plan shall only proceed, however, if case I is implemented.

Case - 3: While changes shall not be made in the sewage treatment located upstream of St.6, the sewerage facilities in the Seoul Metropolitan area shall be sufficiently improved and rehabilitated, and the "apparent run-off ratio" shall be improved to 0.02 in BOD and 0.07 in SS.

Case - 4: The sewerage treatment plan in the upstream area of St.6 shall be executed as scheduled, and the BOD concentration at the (St.6)upstream end of the planned section shall be improved to 23.7 mg/l. At the same time, the sewerage facilities in the Seoul Metropolitan

area shall be sufficiently improved and rehabilitated, and the "apparent run-off ratio" of the pollution load shall be improved to 0.02 in BOD and 0.07 in SS.

Yangjae Chong and Chungroung Chong:

Case - 1: Future changes shall not be made in the present maintenance methods of the sewerage facilities.

Case - 2: The improvement and rehabilitation of the sewerage facilities shall be sufficiently implemented, and the "apparent run-off ratio" shall be improved to 0.02 in BOD and 0.07 in SS.

The water quality and sewerage facilities in Ui Chong are considered as favorable, it shall be kept in the same condition in future, too.
The BOD estimates are shown in Table 4.5-1.

Table 4.5-1 Estimated Future River Water Quality (BOD)

Anyang Chong Unit:mg/l

		St. 1	St. 2	St. 4	St.5	St.6	St. 3
	1990	55.5	59.5	52.5	55.7	48.6	22.9
Case-1	2002	148.1	158.9	148.6	164.9	84.5	38.2
	2010	211.3	226.7	213.6	238.4	122.1	48.4
Case-2	2002	110.2	118.2	106.9	115.9	23.7	38.2
	2010	150.0	160.9	146.0	159.0	23.7	48.4
Case-3	2002	86.7	90.0	83.2	92.0	84.5	38.2
	2010	124.5	129.3	119.7	133.0	122.1	48.4
Case-4	2002	39.0	37.7	33.7	35.3	23.7	38.2
	2010	47.3	44.7	39.8	41.2	23.7	48.4

Yangjae Chong

		St. 1	St. 2	St. 4	St. 3
	1990	13.5	5.5	5.1	11.2
Case-1	2002	45.3	13.4	5.1	29.0
	2010	55.6	15.3	5.1	34.7
Case-2	2002	8.8	7.7	5.1	10.7
	2010	10.2	8.5	5.1	12.9

Ui Chong

		St. 1	St. 2
	1990	3.5	3.3
Case-1	2002	5.7	5.4
	2010	7.3	7.1

Chungroung Chong

		St. 1	St. 2	St. 3
	1990	14.0	11.2	19.0
Case-1	2002	25.5	20.2	34.0
	2010	32.4	26.3	44.5
Case-2	2002	6.4	5.5	1.3
	2010	7.6	6.7	1.6

4.6 The existing water quality and flow regime improvement techniques

Applicable Water Quality Improvement Technique

The water quality improvement techniques considered at present are broadly classified into (a) those applicable to pollution sources, (b) those applicable to the area between the pollution sources and rivers, and (c) those applicable to the river channels. Table 4.6-1 further classifies these three techniques, while their distinct characteristics, applicable conditions, and the necessary precautions to be taken are stated in detail in the Main Report.

Table 4.6.1 Water Quality Improvement Technique

(1)	Countermeasure at the source	1a	Restriction of installation
		1b	Restriction of discharge
		1c	Installation of wastewater treatment plant
(2)	Countermeasure between the river and source	2a	Sewerage improvement
		2b	Repair of existing sewer pipes
		2c	Removal of sludge in sewer pipes and retarding basin
(3)	Countermeasure at the river channel	3a	Removal of bed sediment in rivers
		3b	Sedimentation pond
		3c	Contact oxidation with cobble plant
		3d	Ground sill
		3e	Sheet flow channel
		3f	Aeration facility
		3g	Diluting with clean water

Evaluation of the Applicable Water Quality Improvement Technique

This study evaluated the technique applicable to the river chan-

nel (countermeasures that are feasible as river work) and the results are shown in Table 4.6-2.

Table 4.6-2 Evaluation of Water Quality Improvement Techniques Applicable to the River Channel

	Type of Investment	Possibility of Enlargement	Equivalent Evaluation	Experience
Removal of bed sediment in rivers	I	o	△	o
Sedimentation pond	I+R	o	o	△
Contact oxidation with cobble plant	I+R	o	o	o
Ground sill	I	o	x	△
Sheet flow channel	I	o	x	△
Aeration facility	I+R	△	△	△
Dilution with clean water	I+R	o	o	o

* The I and R of the "Type of investment" column mean "Initial cost type" and "Running cost type", respectively.
** Experience are those obtained in Japan.

Among the water quality improvement techniques applicable to the interior of the river channel, the quantitative effect of sedimentation treatment and contact oxidation with cobble plant was evaluated by using existing data and laboratory test results. The removed ratio of pollutant resulting from the evaluation is shown in Table 4.6-3.
The load removed ratio of composite treatments are also determined as the total removal ratio of unit treatment.

Table 4.6-3 Pollutant Removal Ratio of Unit Treatment

Kind of treatment	Pollutant removal ratio (%)		Treatment conditions	
	BOD	SS	Detention time	Surface loading ($m^3/m^2/day$)
[1]Sand settling	-	--	60 sec	1800
[2]Gravity settling	30	35	3.0 hr	25
[3]Flocculent Settling	50	50	3.0	25
[4]Pre-aeration C.O.C.	75	85	2.0	
[5]Aeration C.O.C.	90	80	3.0	

* In the flocculent settling 300 mg/l of $Al_2(SO_4)_3$ should be used.
* C.O.C.: Contact oxidation treatment with cobble.

Contact oxidation with cobble plant is one of the treatments used to eliminate organic matters. It was observed that to reduce organic activity water temperature must be kept low. It was also observed that the process reduces the removal ratio of BOD.

Table 4.6-4 Pollution Removal Ratio of Composite Treatment

Type	Treatment flow	Pollutant removal ratio	
		BOD	SS
Type 1	[1] + [3] + [5] + Re-aeration	95 %	90 %
Type 2	[1] + [2] + [5] + Re-aeration	93	87
Type 3	[1] + [2] + [4] + Re-aeration	82.5	90
Type 4	[1] + [5] + Re-aeration	90	80
Type 5	[1] + [4] + Re-aeration	75	85

* [1] + [5] : see Table 4.6-5

Applicable Flow Duration Improvement Technique

The flow duration improvement technique considered at present was broadly classified into (1) techniques to improve the rain water holding capacity of basins, (2) techniques to supply water from other resources, and (3) techniques to reshape the river surface. Table 4.6-5 further describes the distinct features of these techniques.

Table 4.6-5 Flow Duration Improvement Technique

(1)Countermeasure to enhance the water retaining capacity	1a	Conservation of Land Use
	1b	Improvement of River Structures
	1c	Improvement of Infiltration Ability of Land Surface
	1d	Reversion of Treated Water to Ground
(2)Countermeasure to supply water from another water source	2a	Utilization of Reservoir Water
	2b	Utilization of Groundwater
	2c	Utilization of Another River Water
	2d	Utilization of Patable or Industrial Water
	2e	Utilization of Treated Water of Sewerage Treatment Plant
(3)Techniques to keep water surface	3a	Improvement of Low Water Channel
	3b	Installation of Weir

The distinct features of these techniques, their applicable conditions and the precautions to take are discussed in detail in the Main Report. Table 4.6-6 shows the results of the evaluation.

Table 4.6-8 Evaluation of Flow Regime Improvement Techniques Applicable to the River Channel

	Type of Investment	Possibility of Enlargement	Equivalent Evaluation	Experience
Improvement of river structures	I	o	x	△
Use of storage water in reservoir	I	o	o	x
Use of groundwater	I+R	△	△	△
Water transfering from another river	I+R	o	x	△
Use of potable water	R	x	x	△
Improvement of low water channel	I	△	△	o
Installation of the weir	I+R	△	o	o

* The I and R of the "Type of investment" column mean "Initial cost type" and "Running cost type", respectively.
** Experience are those obtained in Japan.

4.7 Restrictions in River Space Utilization

Location and Use of River Space

River space is broadly classified into two, (a) the shore where the major bed and the weir are constructed, and (b) the space within the water where the regular flow resides. The use of the land space varies according to the characteristics of the location, the social conditions of the hinterland, the shape of the major bed and the natural conditions in the river space. In this plan, the following zones shall be established.

Multipurpose zone:
Places with relatively wide spaces for the establishment of playgrounds and health care facilities which shall be open not only to the local residents, but also to the residents of neighboring areas.

Family zone:
A zone which shall be constructed near residential areas to promote daily communication between the young and the old generation and between parents and children.

Natural zone:
This zone shall be constructed in a place blessed with good landscape and natural environment. This place shall encourage people to commune with nature, the sketching and viewing of the flora and fauna, and the pursuance of recreational activities such as bicycling.

Nature Preservation zone:
This zone shall be constructed in a place where the ecological system is still preserved. The protection of the system shall be a priority in this zone, and aside from river improvement works, artificial improvement works shall be restricted in this area, too.

Landscape Improvement Zone:
The river shall be the principal axis of rows of houses. The creation of a waterside landscape that blends with the rows of houses in this area is desirable.

Contrary to the above-mentioned land space uses, flood control functions shall take precedence over the water space uses. Objectives other than flood control shall be avoided to assure safety, because the water level suddenly rises at freshet time.

Flooded Frequency and Use of the Major Bed

The major bed is usually submerged when floods occur,and the frequency of inundation and its inundated condition largely affect the growth of plants and the maintenance of the various kinds of facilities. Planting in the major bed shall be, therefore, conducted in areas which are not directly affected by floods. Furthermore, facilities which are transferrable and can be structurally disassembled shall be chosen, and they shall be water-resistant and sterilized.

Coordination with a River Space Utilization Plan having Objectives other than Environmental Improvement

The demands for the use of the river bed space is considerably high in the Seoul Metropolitan area which is notably lacking in space. The Transportation Bureau is pressured with the immediate solution of traffic problems and consequently formulated a plan to cover the rivers and retarding basins and construct parking lots on them. On the other hand, the Construction Bureau plans to widen the highways and build new ones.

The use of the river space as land for road and parking lots, or its preservation as a part of nature has become a controversial issue.

The demand concerning the improvement of the living environment is presumed to escalate gradually in future in view of the rapid progress in the Seoul residents' standard of living. It would be wise, therefore, to improve and preserve the river space as a part of nature and not to use it for the construction of the planned roads and parking lots which are only beneficial for a short period of time.

Chapter 5. Fundamental View for the Basic Concept of the River Environment Improvement Plan

5.1 The Concept of the Water Quality Improvement Plan

Various water quality improvement techniques were introduced in section 4.6 and the most basic technique is the one that can reduce the discharge of pollution load to the least minimum quantity at each pollution source. However, as the pollution load moves farther from the source, it becomes more difficult to completely catch the load, and the mixture of clean water greatly affects the fluctuations in the water volume and the water quality and worsens the efficiency of the purifying facility.

The development restricted areas in Seoul Metropolitan contribute to the regulations concerning pollution sources. Therefore, as a first prerequisite to prevent the further deterioration of the river water quality, the designation should not be dissolved.

The improvement and the preservation of the sewerage facilities are very important measures between the pollutant sources and the river. Under the present conditions, however, the structural defects in the sewerage and the intercepting sewers installed in Seoul and the pollutant load that overflows in rainy days effectively worsens the water quality of the river.

Since a survey on the actual conditions of the pollutant sources and the sewerage was not conducted, the basic concept of river classification stated in Chapter 6 - 9 shall only study the water quality improvement technique applicable to the river channel. If the desired water quality is difficult to achieve, the pollution source countermeasure and the improvement and rehabilitation of sewerage facilities must be implemented.

5.2 The Concept of the Flow Regime Improvement Plan

The various techniques for the improvement of the flow regime of the river were previously discussed in Section 4.6, and among these is the technique to strengthen the water holding capacity in the river basin. However, this technique will require large amount of money and a long period of time before the results can be observed.

In addition, only little effect can be expected from the use of this technique, even if it is most applicable, in Ui Chong and Chungroung Chong, if the principal tributaries become sewage rivers where flow is intercepted by the sewers before it reaches the confluence, and where the volume of underflow is large in the main stem.

On the other hand, the countermeasure of supplying water from other sources is considered to be very effective in directly increasing the flow of the main river. However, this countermeasure can only be implemented if there is a nearby source with adequate flow and water quality.

Even if such water source were secured, if the benefit of water utilization cannot be expected in the target area like the Study area, it should be avoided to invest the high cost for the construction of intake and conveyance facilities and their operation and maintenance. In this regard, the conveyance of water from other rivers and the use of potable water are not considered as practical.

If the constant securement of regular flow is difficult due to restraints in the budget and problems with the water source, the use of the wide water surface of the area with limited but clean flow will have to suffice. The establishment of weirs and the improvement of low canals would be, therefore, effective in this situation.

5.3 The Concept of the River Space Improvement Plan

The use of the river space of each river shall be determined according to the characteristics of the areas classified on the basis of the present natural and social conditions of the catchment area and the river improvement and utilization conditions. In addition, areas with large and suitable demands shall be used as model sites, and facilities in these areas shall be considerably improved.

As for river space utilization, there is a need to generally inspect the degree of safety of the area against floods. However, the inspection was not conducted and the appropriate cross section for the river channel was not grasped, because the cross section data were not kept and changes were conducted everywhere in the embankment of each river. The river space improvement plan shall be formulated, therefore, under the premise that it shall be completely safe from floods. Furthermore, a utilization plan which shall change the features of the major bed and cause further deterioration in flow efficiency, shall not be adopted.

The major bed is assumed to be easily submergible. According to the results stated in Section 4.7, the area shall be used, therefore, in a manner that will assure less flood damages, and the facilities to be installed shall be water resistant and sterilized.

5.4 The concept of the Run-off Sediment Control Plan

If the planned area is affected by sediment run-off, it is necessary to formulate countermeasures that can appropriately protect the water quality improvement facilities and the river space utilization facilities from flood damages.

After the big flood in September 1990, driftwoods, sands and gravel accumulated in the upstream area of the 4 rivers. However, only Chungroung Chong was directly affected by sediment run-off, and the sediments that accumulated downstream of St. 3 were removed by hand. No influence was observed from the planned sections of the other rivers. The sediments that were accumulated upstream of the planned sections shall gradually move downstream along with the next flood or freshet and this occurrence shall only affect the planned sections slightly.

In spite of the assumptions made above that the run-off sediments accumulated upstream shall be gradually removed at every freshet, soil saving facilities must still be installed upstream as a permanent measure.

Chapter 6 Basic Concept of River Environment Improvement Plan for Anyang Chong

The water quality standard desired for Anyang Chong is Class V, and composite treatment which shall mainly implement contact oxidation with cobble plant shall be the basis of the water quality improvement plan for this river. Treatment facilities shall be installed successively toward the downstream area from St.6 while observing the improvement in the river water quality caused by the progress of the sewerage treatment works upstream. However, if the maintenance and improvement of the sewerage and intercepting sewers in the planned area remain unchanged, except for St.6, it would be difficult to achieve the desired water quality for this river. It is, therefore, necessary to concurrently conduct the repair of the defects in the sewerage and intercepting sewers, the removal of sludge accumulated within the pipes and the retarding basins and the installation of the treatment facilities. Furthermore, the removal of sludge in the river channel might increase the effectivity of the water quality improvement work conducted in the planned section.

There is no need to implement the flow regime improvement plan in Anyang Chong because it has enough flow to propagate water familiarity functions.

Since the demands for the use of the river space in the planned downstream section is high and the major bed is wide enough to accommodate various recreational activities, recreational zones are installed in 3 places in response to the needs of the residents. Of the 3 zones, two were structured into multipurpose utilization zones with health and sports facilities. The zone installed at the Anyang Chong and Kehwa Chong confluence was structured into a nature zone since the area is presumed to be habitually flooded. The facilities to be installed in this area shall be water resistant and sterilized.

Chapter 7 Basic Concept of the River Environment Improvement Plan for Yangjae Chong

The water quality standard desired for Yangjae Chong is Class II and composite treatment which shall mainly implement contact oxidation with cobble plant shall be the basis of the water quality improvement plan for this river. Due to the river space restrictions, the installation of treatment facilities at the upstream area of the Yangjae Chong and Yoi Chong confluence is difficult. The water quality in St.1 is expected to further deteriorate in future, and the installation of treatment facilities in this area will only affect 300 m of the area. The treatment facilities, therefore, shall be installed near St.2. The desired water quality standard in the St.2 area can be achieved despite the future increase in the pollution load from the upstream basin covering Yoi Chong. However, it is difficult to reach Class V if the misconnection of the cess pipe and the storm sewer in St.2 downstream is not repaired.

There is no need to implement the flow regime improvement plan in Yangjae Chong because it has enough flow to propagate water familiarity functions.

In contrast to the other rivers, the Yangjae Chong area is blessed with a rich natural environment. The quality of the water between St.1 and St.2 can be actually improved up to the desired level by 2010 if the misconnection of the cess pipe and the storm sewer is repaired. High water familiarity functions which are rarely attained, can be achieved through the implementation of an appropriate river space improvement plan. Plazas that will help propagate water familiarity functions shall be constructed in 2 places, the confluence of Yangjae Chong and Tan Chong shall be made into a nature zone for the consideration of the ecological system, and a zone for the preservation of the natural environment shall be constructed upstream from the confluence of Yangjae Chong and Yoi Chong.

Chapter 8 Basic Concept of the River Environment Improvement Plan for Ui Chong

The water quality in the planned Ui Chong area is presumed to be roughly maintained at Class III the year round, because the apparent run-off ratio of pollution load is low. Consequently, there will be no water quality improvement plan for this river. Only a flow regime improvement plan shall be formulated.

Flow maintenance in this river can be viewed through the recovery and activation of water familiarity functions since the river water is not used for particular purposes. However, it is estimated that about 0.1 m3/s of water supply is required when the water level is low. This water requirement can be supplied through water conveyance from Han River and the construction of a dam upstream. Both means, however, are considered as economically impractical. Therefore, a water surface with a fixed extent shall be formed by constructing a weir at the base where the demands for water familiarity functions are particularly high. As a safety precaution against floods, movable weirs shall be used, and to prevent the water from standing, water collected from the upstream tributaries shall be delivered to the upstream section of the weir.

In addition, the low water channel shall be modified to create a visually satisfying flow and, at the same time, to quickly remove sludge discharged from the sewer pipes during rainy days.
The water quality in St. 2 tends to deteriorate due to standing water. Therefore, the modification of the low water channel is expected to improve the water quality in this St..

A plaza shall be mainly constructed on the water surface aforementioned. The construction of the plaza is aimed to develop the interrelationship between the old and the young generation, or the new and the old residents. Perpendicular revetments can be found downstream from the weir, and since these revetments spoil the landscape, they shall be modified to improve the landscape.

Chapter 9 Basic Concept of the River Environment Improvement Plan for Chungroung Chong

The water quality of Chungroung Chong is bad. Accordingly, people think it should be covered to accommodate the construction of roads and parking lots. However, based on the estimate that the progress in the future standard of living of the residents will result to higher demands for better amenities, the water quality of the river shall be improved and an improvement plan shall be formulated.

The water quality standard desired for Chungroung Chong is Class III, and composite treatment which shall mainly implement contact oxidation with cobble plant shall be the basis of the improvement plan for this river. The installation of treatment facilities was planned at the upstream end of St.3. However, due to river space restrictions, they shall be installed below the river beds. With the treatment facilities, it is considered that the present condition of the sewerage and intercepting sewers can be maintained, and the desired water quality can be achieved by the year 2010.

According to the survey results conducted in clear days, St.3 in Chungroung Chong has more flow than St.2 in Ui Chong, although the flow downstream is extremely poor when the water level is low, due to the large volume of underflow. Furthermore, the flow when the water level is low shall not be secured because there are no inexpensive means of securement at present.

There are many sections in the river space with perpendicular revetments, and these revetments spoil the landscape. The improvement of the landscape, therefore, shall be given emphasis, and the model site of this river shall be improved creating an atmosphere that shall better the attachment of the residents, which is observed to have always been strong, toward the river.

Chapter 10 Project Outline

10.1 General Plan

The general plan formulated based on the basic concepts stated in Chapters 6 - 9 is shown in Table 10.1-1 and the areas where the plan shall be implemented are outlined in Figures 10.1 - 10.1-4. The order of project implementation shown in Table 10.1-2 was determined by considering the effects of the water quality improvement work, the ratio of the demands for river space use, and the administrative considerations. The yearly project expenses calculated based on the project outline and the order of implementation are shown in Table 10.1-3.

10.2 1st Project Phase

The completion of this project is scheduled for 2002.

10.3 Preliminary Design

Preliminary designs were made for the facilities of the 1st project phase. The decisive methods used in the preliminary design are stipulated in the Main Report, while the design of the main facilities are described in the Supporting Report.

The conditions of the design shall be reviewed based on the future results of the water quality and flow observation. There is also a need to establish a test plant and determine the most suitable facility design.

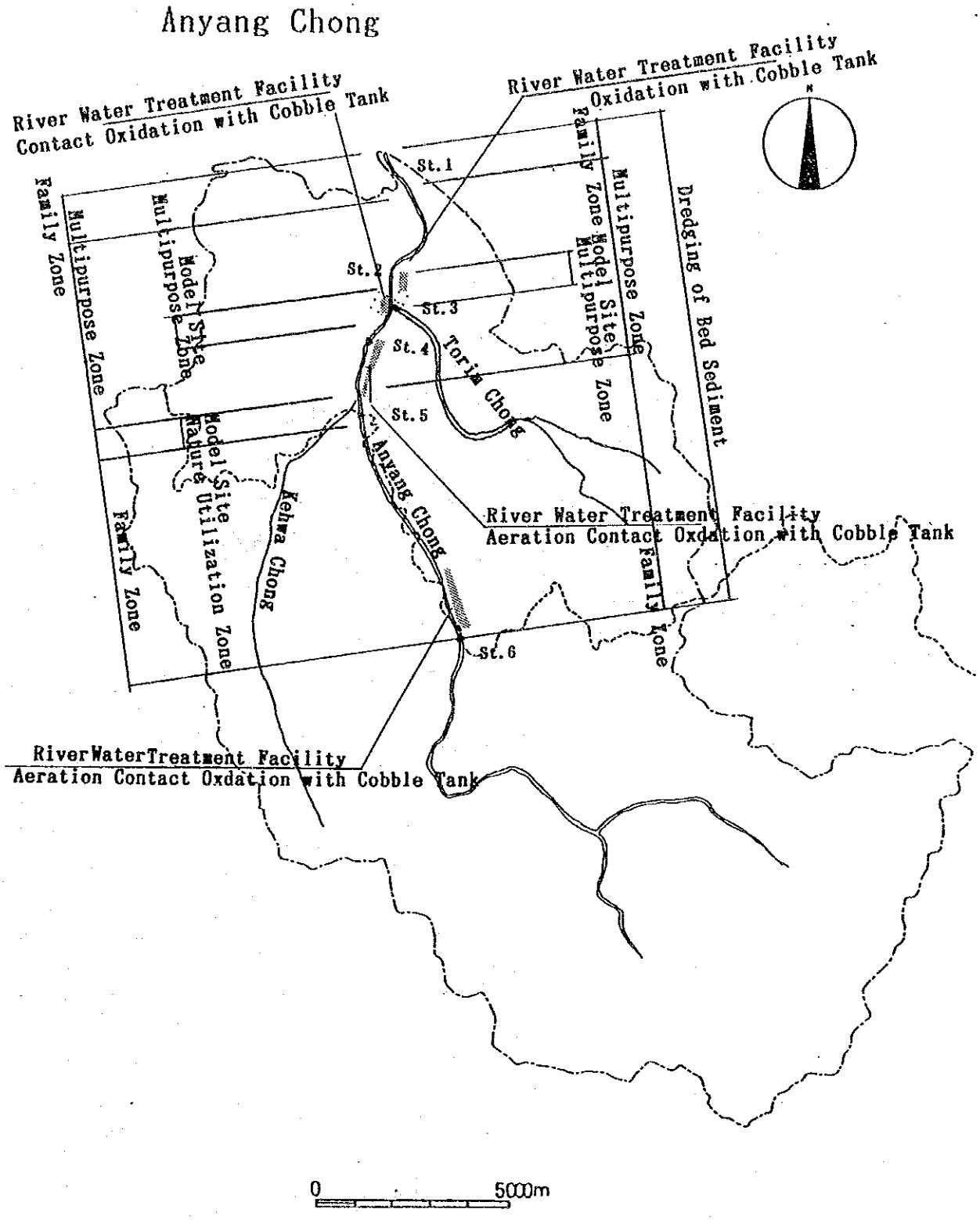

Fig. 6.3-1 River Space Zoning of Anyang Chong

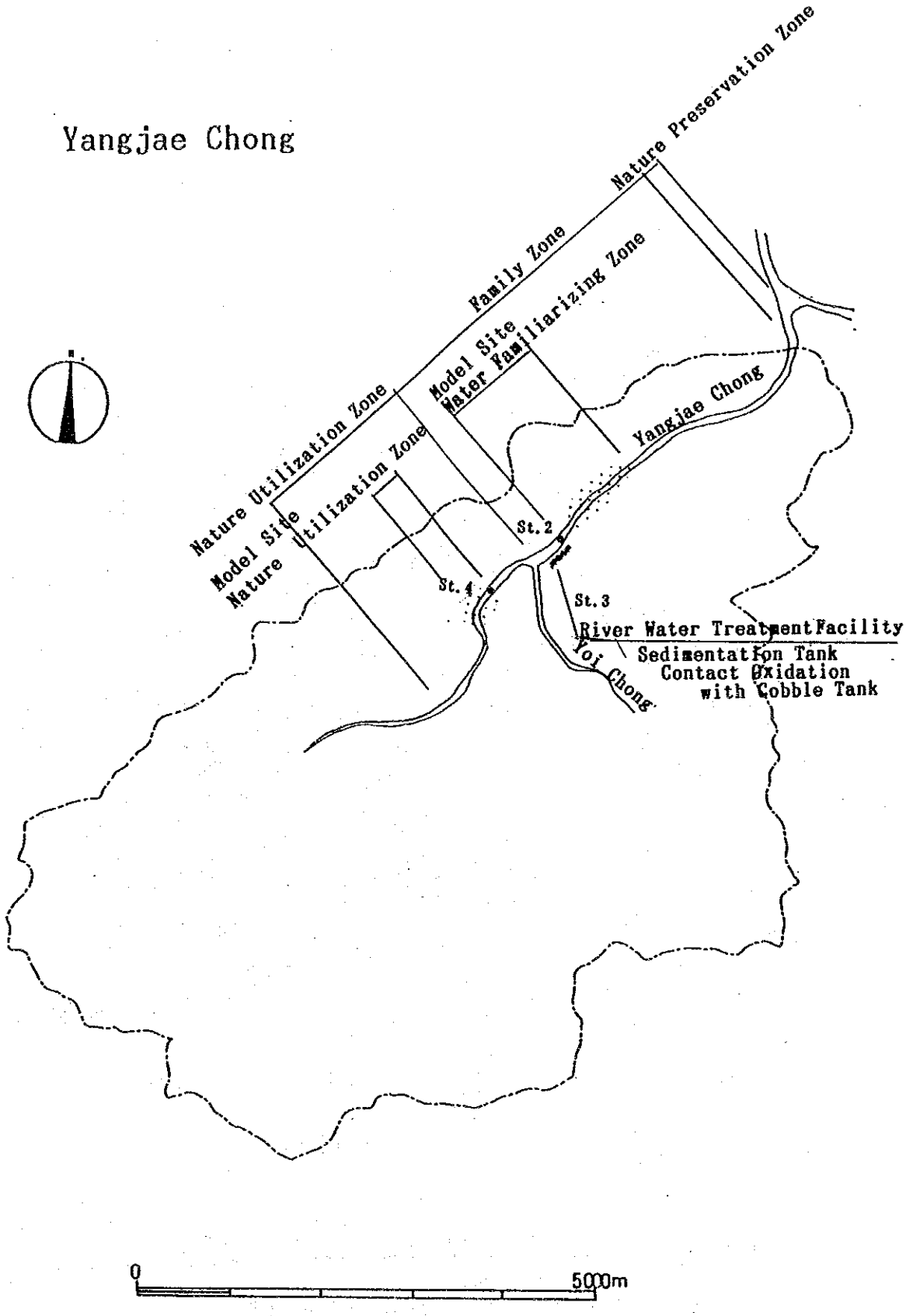

Fig. 7.3-1 River Space Zoning of Yangjae Chong

Ui Chong

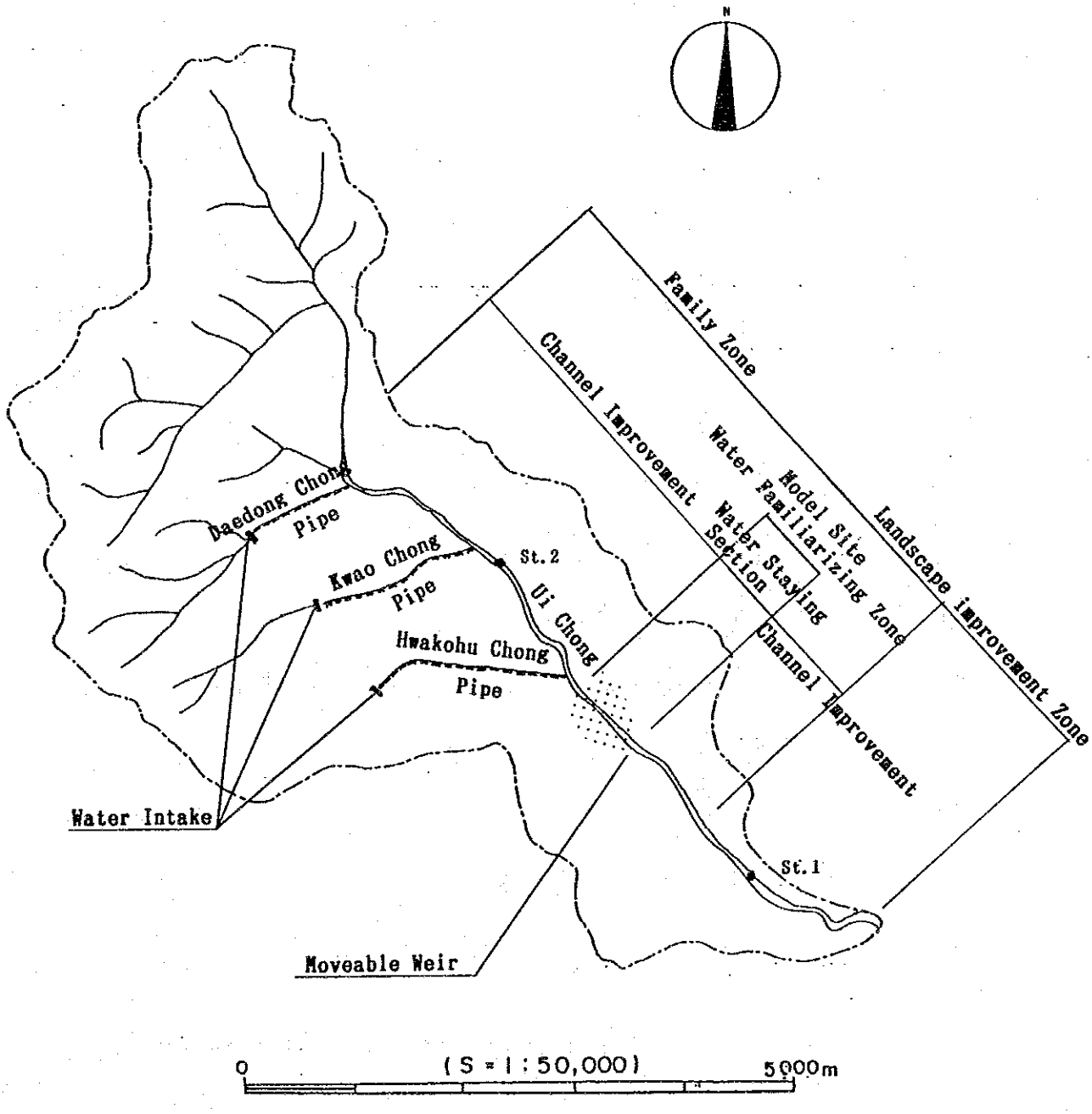

Fig. 8.3-1 River Space Zoning of Ui Chong

Chungroung Chong

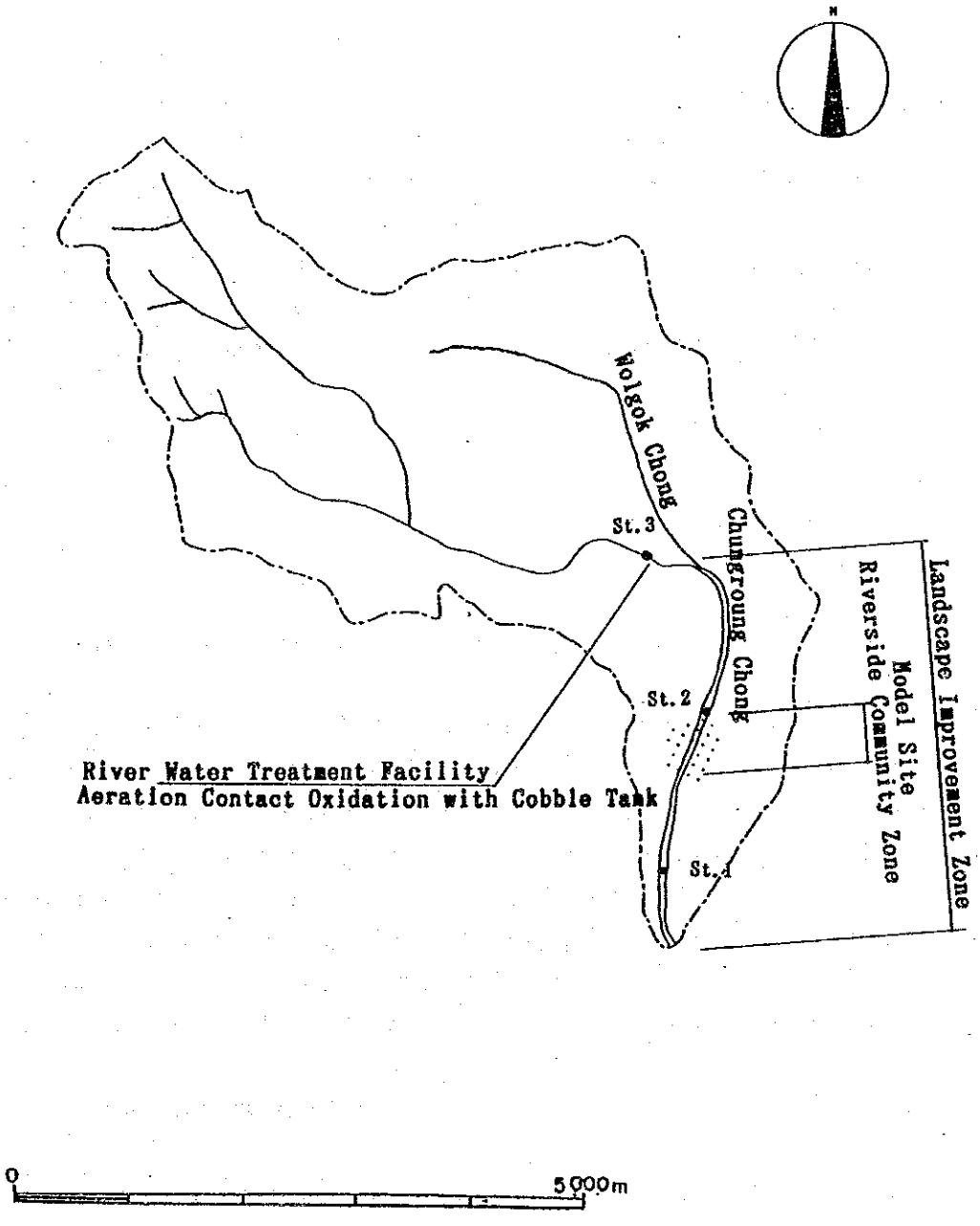

Fig. 9.3-1 River Space Zoning of Chungroung Chong

10.4 Construction Planning

Several prerequisites shall be formulated for the construction methods, bridge installation works and ground works, and the points to be considered in the operation of the main facilities shall be concluded.

The construction of the facilities below the major bed is difficult, because the construction work starts 6-8 meters below the ground. The order of construction begins with the contact oxidation with cobble plant treatment tank, then with the aeration tank, the settling tank, the settling basin, the grit chamber, and the storm overflow. Struts and steel sheet piles shall be constructed at the base of the underground works, and only drainage from the submergible pump shall be considered.

10.5 O/M

Water Quality Improvement Facilities

After the completion of the project, there is a need to continuously maintain and manage the (1) water quality, (2) the operation and preservation of various fixtures and equipments, and (3) restoration works after inundation. The work details for the maintenance and management personnel are written down in the Main Report. A managing organization made up of area residents should be established to take charge of occasions demanding increase in facilities and equipment and the need for special techniques.

Flow Regime Improvement Facilities

The flow regime improvement facilities proposed in this project only involve the movable weir, water conveyance pipe and the dam for water intake activities to be installed in Ui Chong. The

operation and maintenance of these facilities shall only incur few problems.

Facilities for River Space Use

The operation and maintenance of the river space shall involve (1) the management of the facilities and ecological system, (2) management of safety measures, (3) the management of the major bed when flooded, etc. At least 2 overseers shall be needed at each zone.

O/M Organization

The daily operation and maintenance works are basically the responsibility of each section. However, to cope with the budget and the technical guidance required in such undertaking, a new river environment system should be organized within the Flood Department.

10.6 Computation of Project Expenses

According to the General Price Information 1991 edition, the calculated project cost was about average. The overall project cost estimate, including the design and O/M costs, is approximately 440 billion won, and the cost estimate of the phase I project until 2002 is approximately 92 billion won. There is a need to calculate the cost of every project phase again though, because the above mentioned calculations were both based on the 1990 price conditions.

Table 10.1-1 Basic Plan of River Environmental Improvement

Description		Anyang	Yangjae	Ui	Chungroung	Remarks
①Primary factors of pollution						
Present		①Sewage from upper basin ②Sewage from the retarding basin	①Connecting sewer pipes to stormwater pipes ②Inflow from Yoi Chong	No particular water quality problem	①Sewage leakage from existing pipes	
Future	2002	Sewage leakage from exiting intercepting sewers	①Misconnection of sewer pipe to stormwater pipe	No particular water quality problem	①Sewage leakage from existing pipes	
	2010	Sewage leakage from existing intercepting sewers	①Misconnection of sewer pipe to stormwater pipe	No particular water quality problem	①Sewage leakage from existing pipes	
②Water Quality and Flow Regime Improvement Conceptual Plan						
1. Water quality target	2002	Class V for a certain length	Class III for most length	Class III for whole length	Class III for most length	V : BOD 10 mg/l III : BOD 6 mg/l II : BOD 3 mg/l
	2010	Class V for whole length	Class II for most length	Class III for whole length	Class III for most length	
2. Discharge target	2002	Not specified	Not specified	Forming water face as scenes	Not specified	
	2010	Not specified	Not specified	Forming water face as scenes	Not specified	
3. Countermeasures and improved level (BOD mg/l)						
	2002	①Settling sand, sedimentation, and pre-aeration cobble contact oxidation treatment at St.6 BOD 23.7 → 10.0 mg/l	①Settling sand and pre-aeration cobble contact oxidation treatment at St.2 BOD 13.4 → 10.0 mg/l	①Movable weir at St.1+1600m ②Introduction of water	①Aeration cobble contact oxidation treatment at St.3 BOD 34.0 → 6.0 mg/l	
	2010	①Settling sand, flocculent settling, aeration cobble contact oxidation treatment at St.5 BOD 41.2 → 10.0mg/l ②Settling sand and pre-aeration cobble contact oxidation treatment at St.4 & 2 St.4 BOD 39.8 → 10.0 mg/l St.2 BOD 44.7 → 10.0 mg/l ③Dredging of bed sediment	BOD 15.3 → 6.0 mg/l In case sewage inflow between St.2 and St.1 is stopped, it can attain 3.0 mg/l of BOD.	① Low Water Channel Improvement	BOD 44.5 → 6.0 mg/l	Regarding Anyang Ch. the sewage inflow to the river must be improved.
③River Space Improvement Conceptual Plan						
1. Studied length		28.2 km	13.2 km	14 km	7.8 km	
2. Target improve rate	2002	8.3% (L=2.35km, A=29ha)	33.3% (L=4.4 km, A=18 ha)	10% (L=1.4 km, A=4 ha)	12.8% (L=1 km, A=1 ha)	
	2010	100% (L=28km, A=212ha)	100% (L=13.2 km, A=55 ha)	100% (L=14 km, A=17 ha)	100% (L=7.8km, A=2 ha)	
3. Target improve Plan	2002	3 Improvement Model Sites M1 : 12 ha (L=0.8 km) M2 : 12 ha (L=0.9 km) M3 : 5 ha (L=0.65 km)	2 Improvement Model Sites M1 : 11 ha (L=2.4 km) M2 : 7 ha (L=2.0 km)	1 Improvement Model Site M1 : 4 ha (L=1.4 km)	1 Improvement Model Site M1 : 1 ha (L=1.0 km)	
	2010	Multipurpose Zone L=9.25 km Family Zone L=16.6 km Natural Zone L=0.65 km	Family Zone L=6.1km Natural Zone L=2.2km Nature Preserve. Zone L=0.5km	Family Zone L=9.1 km Landscape Improvement Zone L=3.5 km	Landscape Improvement Zone L=7.8 km	

Table 10.1-2 Implementation Program of Project

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Construction of Water Quality & Flow Regime Improvement Facility																			
Anyang Chong									St. 6			St. 5			St. 4		Dredging	St. 2	
Yangjae Chong						St. 2													
Ui Chong									Flow Regime										
Chongroung Chong					St. 3														
Construction of River Space Improvement Facility																			
Anyang Chong		M1		M2						M3									
Yangjae Chong						M2	M1												
Ui Chong									M1										
Chongroung Chong										M1									
Basic & Detail Design Schedule																			
Anyang Chong																			
Yangjae Chong																			
Ui Chong																			
Chongroung Chong																			
Monitoring (Water Quality & Discharge)																			
Remarks	←·····Phase I·····→																		
	←·····Basic Plan·····→																		

※ ~~~~ :Water Quality & Flow Regime Improvement Plan ——— :River Space Improvement Plan

Table 10.1-3a Annual Investment Schedule (Overall)

unit:million won

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Sub-total	2003	2004	2005	2006	2007	2008	2009	2010	Sub-total	Total	2011
Construction Cost																							
Anyang		1,459	1,459	1,267	1,267				14,065	15,475	15,475	50,467	35,216	35,216	35,216	27,765	27,763	51,182	30,457	30,457	273,272	323,739	
Yanjgae						9,628	8,144					17,772							4,553	4,552	9,105	26,877	
Ui								5,642				5,642						6,196	6,196		12,392	18,034	
Chongroung					3,066				1,604			4,670					792	792			1,584	6,254	
Sub-total		1,459	1,459	1,267	4,333	9,628	8,144	5,642	15,669	15,475	15,475	78,551	35,216	35,216	35,216	27,765	28,555	58,170	41,206	35,009	296,353	374,904	
Monitoring	200	200	200	200	200	200	200	200	200	200	200	2,200	200	200	200	200	200	200	200	200	1,600	3,800	200
Design	436			245	1,422		452	3,504	226		2,816	9,101			7,411	127	991	5,601			14,130	23,231	
Sub-total	636	200	200	445	1,622	200	652	3,704	426	200	3,016	11,301	200	200	7,611	327	1,191	5,801	200	200	15,730	27,031	200
Total	636	1,659	1,659	1,712	5,955	9,828	8,796	9,346	16,095	15,675	18,491	89,852	35,416	35,416	42,827	28,092	29,746	63,971	41,406	35,209	312,083	401,935	200
Maintenance Cost																							
Anyang			18	36	51	66	66	66	66	66	66	501	1,332	1,416	1,500	4,120	4,204	4,288	6,319	6,319	29,498	29,999	8,894
Yanjgae							70	349	349	349	349	1,466	349	349	349	349	349	349	349	404	2,847	4,313	459
Ui									25	25	25	75	25	25	25	25	25	25	99	99	348	423	99
Chongroung						92	92	92	92	111	111	590	111	111	111	111	111	121	131	131	938	1,528	131
Mainte Total			18	36	51	158	228	507	532	551	551	2,632	1,817	1,901	1,985	4,605	4,689	4,783	6,898	6,953	33,631	36,263	9,583
Total	636	1,659	1,677	1,748	6,006	9,986	9,024	9,853	16,627	16,226	19,042	92,484	37,233	37,317	44,812	32,697	34,435	68,754	48,304	42,162	345,714	438,198	9,783

Table 10.1-3b Annual Investment Schedule (Water quality and flow-regime Improvement project) million won

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Sub-total	2003	2004	2005	2006	2007	2008	2009	2010	Sub-total	Total	2011
Construction Cost																							
Anyang									14,065	14,065	14,065	42,195	28,176	28,176	28,176	20,725	20,725	51,182	30,457	30,457	238,074	280,269	
Yanjgae						3,779	3,778					7,557										7,557	
Ui								3,544				3,544										3,544	
Chongroung					3,066							3,066										3,066	
Sub-total					3,066	3,779	3,778	3,544	14,065	14,065	14,065	56,362	28,176	28,176	28,176	20,725	20,725	51,182	30,457	30,457	238,074	294,436	
Monitoring	200	200	200	200	200	200	200	200	200	200	200	2,200	200	200	200	200	200	200	200	200	1,600	3,800	200
Design				245	605		284	3,376				4,510			7,411			4,873			12,284	16,794	
Sub-total	200	200	200	445	805	200	484	3,576	200	200	200	6,710	200	200	7,611	200	200	5,073	200	200	13,884	20,594	200
Total	200	200	200	445	3,871	3,979	4,262	7,120	14,265	14,265	14,265	63,072	28,376	28,376	35,787	20,925	20,925	56,255	30,657	30,657	251,958	315,030	200
Maintenance Cost																							
Anyang													1,266	1,266	1,266	3,802	3,802	3,802	5,833	5,833	25,870	25,870	8,408
Yanjgae								227	227	227	227	908	227	227	227	227	227	227	227	227	1,816	2,724	227
Ui																							
Chongroung						92	92	92	92	92	92	552	92	92	92	92	92	92	92	92	736	1,288	92
Mainte Total						92	92	319	319	319	319	1,460	1,585	1,585	1,585	4,121	4,121	4,121	6,152	6,152	29,422	30,882	8,727
Total	200	200	200	445	3,871	4,071	4,354	7,439	14,584	14,584	14,584	64,532	29,961	29,961	37,372	25,046	25,046	60,376	36,809	36,809	281,380	345,912	8,927

Table 10.1-3c Annual Investment Schedule (River Space Improvement project)

unit:million won

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Sub-total	2003	2004	2005	2006	2007	2008	2009	2010	Sub-total	Total	2011
Construction Cost																							
Anyang		1,459	1,459	1,267	1,267					1,410	1,410	8,272	7,040	7,040	7,040	7,040	7,038				35,198	43,470	
Yanjgae						5,849	4,366					10,215							4,553	4,552	9,105	19,320	
Ui								2,098				2,098						6,196	6,196		12,392	14,490	
Chongroung									1,604			1,604					792	792			1,584	3,188	
Sub-total		1,459	1,459	1,267	1,267	5,849	4,366	2,098	1,604	1,410	1,410	22,189	7,040	7,040	7,040	7,040	7,830	6,988	10,749	4,552	58,279	80,468	
Design	436				817		168	128	226		2,816	4,591				127	991	728			1,846	6,437	
Sub-total	436				817		168	128	226		2,816	4,591				127	991	728			1,846	6,437	
Total	436	1,459	1,459	1,267	2,084	5,849	4,534	2,226	1,830	1,410	4,226	26,780	7,040	7,040	7,040	7,167	8,821	7,716	10,749	4,552	60,125	86,905	
Maintenance Cost																							
Anyang			18	36	51	66	66	66	66	66	66	501	66	150	234	318	402	486	486	486	2,628	3,129	486
Yanjgae							70	122	122	122	122	558	122	122	122	122	122	122	122	177	1,031	1,589	232
Ui									25	25	25	75	25	25	25	25	25	25	99	99	348	423	99
Chongroung										19	19	38	19	19	19	19	19	29	39	39	202	240	39
Mainte Total			18	36	51	66	136	188	213	232	232	1,172	232	316	400	484	568	662	746	801	4,209	5,381	856
Total	436	1,459	1,477	1,303	2,135	5,915	4,670	2,414	2,043	1,642	4,458	27,952	7,272	7,356	7,440	7,651	9,389	8,378	11,495	5,353	64,334	92,286	856

Chapter 11 Project Evaluation

11.1 The Priority of the River Environment Project in Seoul Metropolitan

The present policies in Seoul are ranked as follows: 1) transportation, 2) housing and 3) environment. As previously stated in Chapter 2, the shortage in large transportation remarkably worsens the city's traffic conditions and solving this problem is a matter of importance.

Environmental problems were hardly given a thought when production was given preference, however, the present increase in income and comforts in living aroused a strong interest within the citizens, and even the city actively wrestles with concerns such as the improvement of the air and river water quality, improvement of the parks, preservation of nature, etc.

The river environment project is one of the objectives involved in the environment improvement policies.

11.2 Project Evaluation

Social Benefits

The River Environment Improvement Project is generally considered to bring about the following benefits.

(1) Life Benefits (Reduction of calamities and Environmental pollution)

(2) Living Benefits (Landscape improvement, Air purifica-

tion, Improvement in the amenities, Increase in recreational opportunities)

(3) Socio-cultural Benefits (Activation of society, preservation of historical and cultural properties)

(4) Natural Preservation Benefits (Protection of animals and plants, Preservation of streams)

(5) Educational Benefits (Increase in educational opportunities concerning the environment and nature)

(6) Economical Benefits (Curtailment of park improvement expenses, Increase of land value, Reduction of medical costs, Increase in the production of related industries, Increase in employment opportunities)

The river Environment Improvement Project proposed in this plan is also estimated to bring about the same social benefits mentioned above.

Among these benefits, the increase in the number of parks and park area and the environmental improvement shall be quantified by using land cost as a proxy variable.

Benefits from the increase in the number and area of parks

By multiplying the model site land cost by the cost of the land in the vicinity, and by considering the flood damages when the water level is high, the benefits are estimated at 90%. The benefits that shall be gained from the improvement of the 7 model sites in the 4 rivers are estimated at approximately 464 billion won.

Benefits of an improved living environment

The construction of the model site is based from 5 factors namely, distance of the land from the environment and the city, traffic conditions, population density and land utilization. Through the use of the model and quantification method I, the degree of influence of each factor on official land prices were calculated. The results showed that the environmental factor carries an effect of 31% for residential areas and 28% for residential and industrial purposes.

Therefore, if the water quality of the river is improved during the 1st phase of the project, the cost of the land situated 100 m away from the river shall be increased at a rate of 5%, and approximately 199,710 million won can be gained.

Feasibility of the Project

As mentioned above, the benefits to be gained from the increase in the number and area of parks amount to 464.3 billion won, an amount which is approximately 17 times more than the Phase I improvement project cost and approximately 5 times more than the water quality improvement, flow improvement and operation and maintenance costs.

The benefits from the improvement of the living environment amount to 120 billion won, an amount which is twice the Phase I project cost.

Furthermore, the addition of other unevaluated benefits would indicate that the effects of the Phase I project shall counterbalance the costs.

Chapter 12 Considerations

12.1 Future monitoring and supplementary survey

It is necessary to fully understand the variations in every station, every discharge, water quality and topographic conditions of the rivers in this study and their causal factors, in order to decide a suitable scale and location for the water purifying facility, and in order to maintain the facility for a long period of time. With reasonable operation and maintenance cost, these factors are considered very important for the safe and effective use of the river space.

River discharge and water quality observation shall be continued until the design is implemented to gain a more accurate understanding of the variations in every river and their causal factors. There is also a need to repetitiously monitor the profile and cross section survey of the rivers' changing topographical conditions to understand the run-off patterns of rainfall and sandy soils, both of which directly influence river discharge and water quality.

It is also very important to conduct a study on the maintenance of the sewerage facilities.

The method and the result of these surveys are described in the Supporting Report.

The future projection of the appearance of new plants and animals may be investigated as one of the studies conducted in future.

12.2 Methods of Alteration

The basic concept and project plan proposed and formulated here are very restricted technologically and financially. The plan shall be modified as the preconditions undergo future alterations.

The progress in the improvement and reparation of sewerage facilities is considered to have the greatest influence on the technological aspect.

Facility design and project cost estimation are based on the estimated apparent run-off ratio. If the latter changes the former is changed, too. Countermeasures must be modified according to the results of the monitoring survey of the river's discharge and water quality as well as the progress of the improvement and reparation of the sewerage facilities.

Similar to other projects, the implementation of this project shall rely greatly on its financial resources. Since the river environment improvement project shall benefit the public, it is only natural to assume that it shall be financed generally. However, the enormity of the expenses makes the securement of funds from other related organizations difficult, and it is possible that the project shall take longer than scheduled. It is, therefore, necessary to look for other financial sources.

12.3 Propagation of River Environment Improvement Project

To promote environment related projects, it is important for the administrators to fully understand the nature of the environmental problems, and to establish an organization which shall deal with these problems.

The organization of a water quality improvement committee and a river utilization plan coordinating committee would be important for the promotion of this project.

The water quality improvement committee shall be in charge with formulating water quality countermeasures for river basins enveloping more than two cities. The entire municipalities within the basin participates in the formulation of countermeasures and the arrangement of works for the entire basin area.

The river utilization plan coordinating committee is made up of bureau people involved in concerns such as, water use, flood, drainage, space use, environment preservation, etc. This committee makes studies on the appropriate use of the river, and arranges project works.