3.3.3 Part 3: Surface Water Survey

Site	Parameter	Number of Samples
Two (2) sites near the former compost plant	Temperature, Water Temperature, Color, Turbidity, pH, Electric Conductivity (EC), Coliform Group Number, DO, COD, BOD, SS, T-N, T-P	2 samples/site × 2 sites = 4 samples Number of samples indicated above represent only numbers for one season. Total required number of samples is thus 8.
Two (2) sites near the existing final disposal site		2 samples/site × 2 sites = 4 samples Number of samples indicated above represent only numbers for one season. Total required number of samples is thus 8.
Two (2) sites on each illegal dumping site selected in the city		2 samples/site × 2 sites × 4 dumping sites = 16 samples Number of samples indicated above represent only numbers for one season. Total required number of samples is thus 32.
Two (2) sites along a river located closest to the existing transfer station		2 samples/site × 2 sites = 4 samples Number of samples indicated above represent only numbers for one season. Total required number of samples is thus 8.

3.4 SUMMARY OF THE SURVEY RESULTS

The results of the Survey are presented in Tables 3.1.1 to 3.1.4, Data Book 4 and summarized below.

3.4.1 Quality of Surface Water

The values of pH and dissolved oxygen (DO) of rivers flowing in the city present good conditions for inhabitants; that is, pH is recorded between 7.8 and 8.3 and DO is about 8 to 9 mg/dm^3 (milligram per cubic decimeter which is equivalent to milligram per liter: mg/l).

Apart from the Sultanka and Karasu rivers, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of the river water is around 5 to 8 mg/l, which is classified into Class D of the Japanese Standards. BOD and COD of Karasu River are the worst of all the river waters: 8 mg/l for BOD and 10 mg/l for COD. Seven (7) samples out of 16 for this river are beyond the allowable limit of BOD specified in the standards, i.e., 10 mg/l. Both parameters of Sultanka River, on the other hand, are comparatively low at about 2 or 3 mg/l, which is classified into Class B.

Compared with the above parameters, high values of turbidity and suspended solids (SS) were observed especially in the summer survey. This seems to have resulted from mudflows due to snow melting in the mountain area. SS of Vesnovka and Karasu was about 500 mg/l, while that of Sultanka was nearly 30 mg/l.

Total content of phosphorus (T-P) presents excellent values in all samples since it recorded at less than 0.01 mg/l. Total content of nitrogen (T-N) of all the rivers is also at an acceptable level, namely, between 2 and 6 mg/l, although that of Terenkara River is relatively high at around 8 to 9 mg/l.

3.4.2 Quality of Groundwater

Except Location No. G10, which is called as Well N3 in Ozet settlement near the former compost plant, all the groundwater samples are at acceptable levels under the Kazakhstan Standards. As to G10, mercury (Hg) and cadmium (Cd) are beyond the allowable levels; that is, less than 0.01 mg/l for the allowable limit of 0.0005 mg/l and less than 0.02 mg/l for the allowable limit of 0.01 mg/l, respectively. Although biochemical factors, such as NH_4, NO_3 and BOD, show low values in G10, the values for the other heavy metals, such as copper (Cu) and zinc (Zn), are also higher than those in other locations.

Among the remaining wells, No. G7, which is called as Well N21 located near the Gorky Park, presents the worst water quality. The average values of NO_3 and distillation residues are recorded at 18.2 mg/l and 652 mg/l, while the allowable limit specified in the Japanese Standards are 10 mg/l and 500 mg/l, respectively. In terms of NO_3, No. G3 and G4 which are both in Zetysu Cluster exceed this limit: 28.2 mg/l for G3 and 19.2 mg/l for G4 on average. In addition, chlorine (Cl) and SO_4^{2-} of G7 are also comparatively higher at around 40 mg/l and 190 mg/l, although the other samples show 6 to 7 mg/l and 10 to 50 mg/l, respectively.

It is particularly noted that the electric conductivity of the groundwater samples presents a considerably high value. The values for these samples are between 0.14 and 0.82 ($10^{-3}\Omega^{-1}cm^{-1}$), although it is said that dirty river water in Japan shows around 0.20 to 0.40 ($10^{-3}\Omega^{-1}cm^{-1}$). This level is almost equal to that of surface waters in the survey, and it is the unique characteristics of the groundwater here.

3.5 Impacts on the Surface and Ground Water Quality Due to Solid Waste

It is extremely difficult to evaluate impacts on the surface and ground water due to solid waste, because there are many pollutants along the rivers and near the wells that may result from not only wastewater of residential areas but also fertilizers of farms or feed for livestock. The following Table 3.5.1 shows a comparison between water quality of upstream and downstream of the surveyed rivers in terms of BOD and T-N. According to this table, the value of BOD at the upstream became worse at the downstream in just half locations. In terms of T-N, only one case out of six locations presents that the quality of the downstream has deteriorated compared with the upstream. Therefore, based on the result of this survey, it cannot be said that the solid waste has influence to some extent on the surface and ground water in the city.

Table 3.5.1 Comparison between BOD and T-N of Upstream and Downstream of the Surveyed Rivers

No.	Location (Name of River)		BOD (mg/l)		T-N (mg/l)	
S1	Compost plant	Upstream	5.33	A*1	2.21	B*2
S2	(Vesnovka)	Downstream	6.59		2.12	
S5	Illegal dumpsite,	Upstream	7.96	A	5.38	B
S6	Ostroumov St. (Karasu)	Downstream	8.14		4.15	
S7	Illegal dumpsite, AK-4	Upstream	4.86	B	5.73	B
S8	North Ryskulov Ave. *3	Downstream	4.39		5.58	
S9	Illegal dumpsite, Horse	Upstream	2.69	B	4.37	A
S10	Race Field (Sultanka)	Downstream	2.57		4.45	
S11	Illegal dumpsite,	Upstream	7.10	B	3.98	B
S12	Al-Farabi St. *3	Downstream	6.98		2.89	
S14	Transfer station	Upstream	5.46	A	8.38	B
S15	(Terenkara)	Downstream	6.41		8.30	

Note: *1 "A" means that the quality upstream became worse downstream.
*2 "B" means that the quality upstream became better downstream.
*3 Name of river is unknown.

3.6 LEACHATE QUALITY OF THE KARASAI DISPOSAL SITE

Eight (8) samples were taken from leachate retention ponds that are located in the downstream of landfilling area at Karasai. This section describes examination of the water quality of the retention ponds in comparison with typical composition of leachate in Japan and UK. The examination will contribute to design of improvement of the existing disposal site.

A comparison between the survey results and typical composition of leachate was carried out based on the above data. Table 3.6.1 shows that the quality of leachate of the Karasai site is quite good in terms of COD, BOD, SS and T-N compared with those of Japan and UK. In particular, a remarkable decrease of the COD, BOD and T-N values from the first retention pond to the second pond was observed in the summer survey. These parameters present the nutritious condition of the water, and the results clearly reveal that decomposition of the composition has smoothly proceeded.

It can be said that the leachate discharged from the second pond to the downstream has an acceptable level of water quality. That is, the values of COD and BOD are around 6 to 8 mg/l, and SS and T-N are 60-70 mg/l and 0.8-1.3 mg/l, respectively. This is almost equivalent to the water quality of the rivers flowing in the city. Therefore, it will be not necessary to construct a leachate treatment facility for the Karasai site if such a double retention system is introduced and the appropriate volume of leachate stored is secured.

Table 3.6.1 Comparison between the Survey Results and Typical Composition of Leachate

Item	Survey Results*1		Typical Composition	
	Leachate Retention Pond (Upstream)	Leachate Retention Pond (Downstream)	Japan*2	UK*3
Water Temperature (°C)	5.6 – 10.4	5.5 – 9.2	Not Applicable (NA)	NA
	28.7 – 28.8	28.7 – 28.8		
Color	Faintly yellow	Daffodil	Brown to light yellow	NA
	ditto	ditto		
Turbidity (mg/l)	63.0 – 96.0	53.0 – 60.0	NA	NA
	83.0	62.0 – 76.0		
pH	7.78 – 7.97	7.70 – 7.75	NA	7.5
	8.23 – 8.40	8.11 – 8.15		
Electric Conductivity ($10^{-3}\Omega^{-1}cm^{-1}$)	7.5 – 9.2	13.1 – 13.5	NA	NA
	16.0	12.0 – 13.0		
Coliform Group Number	90 – 23,000	90 – 23,000	More than 3,000	NA
	>23,800	>23,800		
Dissolved Oxygen (mg/l)	5.08 – 5.43	3.20 – 3.47	NA	NA
	4.17 – 4.31	3.05 – 3.35		
COD (mg/l)	39.60 – 39.78	25.50 – 26.40	480	1,160
	47.25 – 57.43	7.70 – 8.06		
BOD (mg/l)	33.41 – 33.70	21.34 – 23.84	1,200	260
	43.56 – 52.34	6.07 – 6.27		
SS (mg/l)	42.80 – 72.95	41.10 – 69.30	300	NA
	43.35 – 46.75	56.80 – 72.95		
NH_4^+-N (T-N) (mg/l)	38.77 – 44.28	0.87 – 1.56	480	370
	101.21 – 111.60	0.74 – 1.26		
T-P (mg/l)	< 0.01	< 0.01	NA	1.4
	< 0.01	< 0.01		

Note: *1 The upper rows of survey results represent the results of two surveys conducted on the 23rd and 25th of March, 1999, while the lower ones represent the results of two surveys conducted on the 28th of July and 3rd of August, 1999.
*2 The Japanese typical composition represents the value for combustible waste.
*3 The UK typical composition represents the value for aged waste.

CHAPTER 4 WASTE PICKERS SURVEY

4.1 OBJECTIVE OF THE SURVEY

The objective of the Waste Pickers Survey is to understand and ascertain the awareness and attitude of waste pickers towards improvement of disposal sites, and their manner of removing, recycling and reusing solid waste.

4.2 OUTLINE OF THE SURVEY

The survey was conducted using a questionnaire, which covers (1) general information on waste pickers; (2) waste pick-up activities; and (3) recycling of pick-up materials, etc.

4.2.1 Sample Selection

A total of 101 waste pickers were selected at random from the following three (3) ongoing disposal sites, i.e., more than 30 samples from each site:

(1) Spasskaya (31 samples);

(2) Former Transfer Station (35 samples); and

(3) Karasai disposal site (35 samples).

4.2.2 Key Components of the Questionnaire

The main items in the questionnaire include information as follows:

1) Basic Waste Pickers Data

Waste pickers' name, age, education, number of family members, living area, etc.

2) Waste Pick-up Activities

Years of experience, number of working days a week, place of pick-up, reason for waste pick-up, activity in case the site is closed, etc.

3) Recycling of Pick-up Materials

Price of pick-up materials, types and amount of pick-up waste, place of waste pick-up, etc.

4.2.3 Evaluation and Analysis of the Results and Survey Outputs

A suitable spreadsheeting tool was designed to capture and analyse the results of the survey. The Study Team captured and performed the basic analysis on the questionnaire data, and then evaluated and documented the results of the survey.

4.3 SUMMARY OF THE SURVEY RESULTS

The results of the Survey are summarized below.

4.3.1 Demographic Structure

(1) Fifty-seven percent (57%) of all interviewees were males, and 43% females, although 57% of waste pickers in the Spasskaya site were females. Figure 4.3.1 shows the proportion of sex for each site.

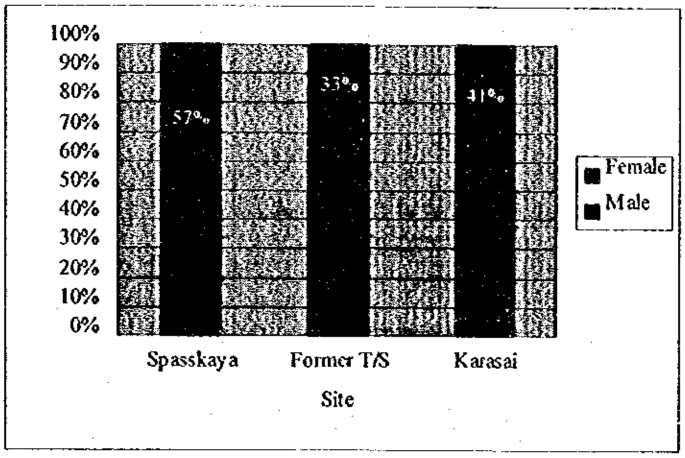


Figure 4.3.1 Proportion of Sex of Waste Pickers at Each Disposal Site

(2) The average age of waste pickers is around 36 to 40 years and the dominant age group consists of 31 to 50 years old, as shown in Figure 4.3.2.

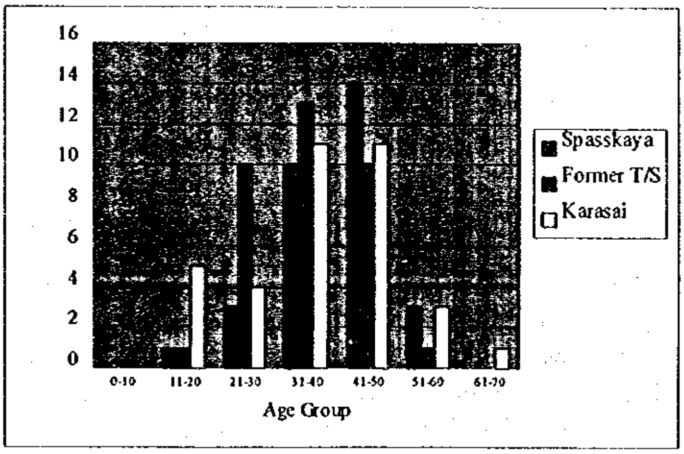


Figure 4.3.2 Age Profile of Waste Pickers at Each Disposal Site

(3) The average number of family members of waste pickers is 3 to 4. The average number of dependent is 2 to 3 people. There is no big difference among the three sites. Karasai shows the maximum number of both family and dependents, namely, 4.3 and 2.7, respectively. On the other hand, the former transfer station has the minimum number of 2.6 for family and 1.7 for dependents, as shown in Figure 4.3.3.

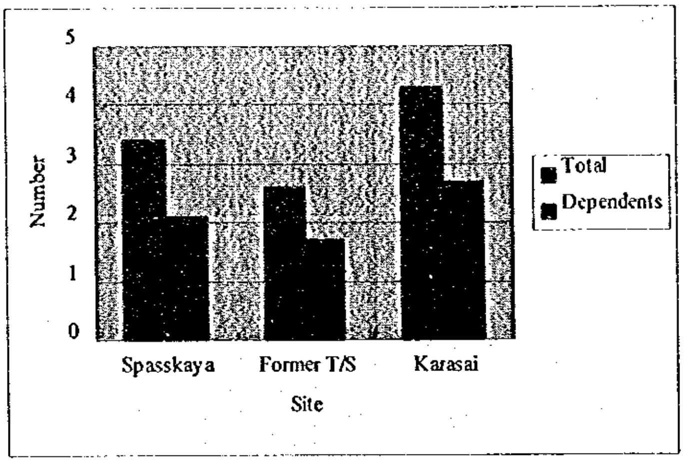


Figure 4.3.3 Average Number of Waste Pickers Family and Dependents at Each Disposal Site

(4) Educational attainment is shown in Figure 4.3.4. The population who finished secondary school is 80 to 90% of the interviewees.

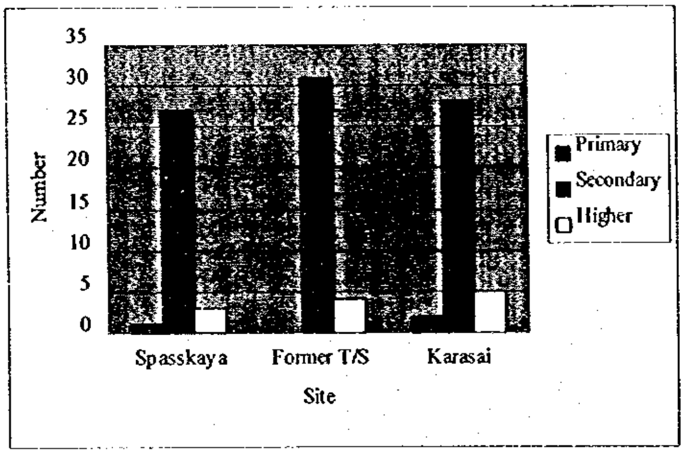


Figure 4.4.4 Age Profile of Waste Pickers at Each Disposal Site

(5) Figures 4.3.5 to 4.3.7 show the places where the interviewed waste pickers live. Forty-two percent (42%) of those at Spasskaya site live at the Pervomaika settlement. The waste pickers at the former transfer station (more than 65%) live at Ozhet and Ainabulak. Waste pickers at Karasai live at the Aitey and Ushterek settlements (30% each).

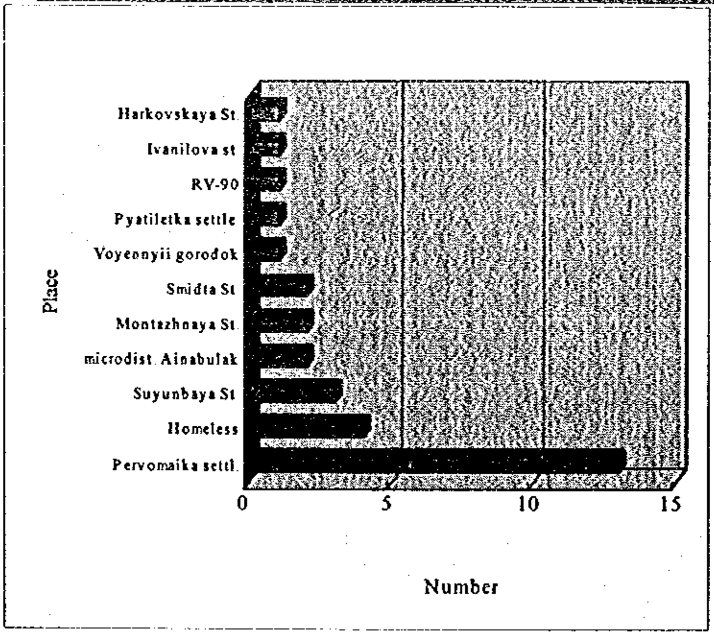


Figure 4.3.5
Place of Residence of Waste Pickers at Spasskaya

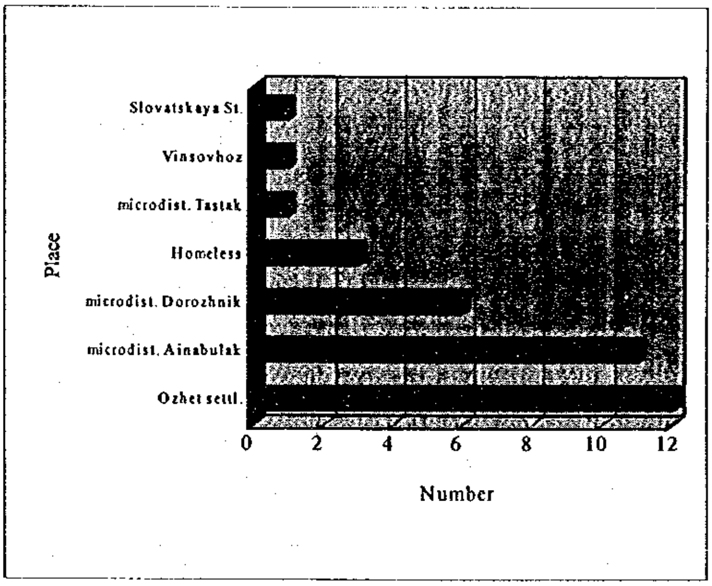


Figure 4.3.6
Place of Residence of Waste Pickers at Former Transfer Station

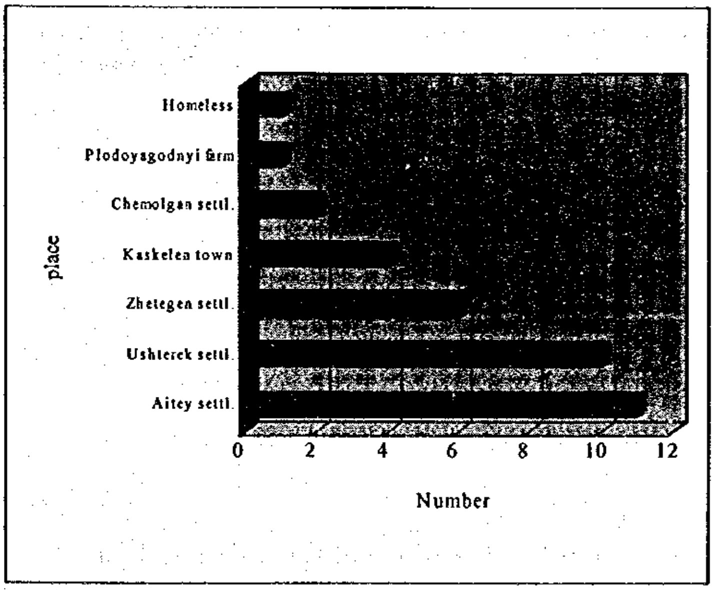


Figure 4.3.7
Place of Residence of Waste Pickers at Karasai Disposal Site

4.3.2 Waste Pick-up Activities

(1) A majority of the waste pickers have only 2 to 3 years experience, and the average working years is between 2.0 and 2.5, as shown in Figure 4.3.8. Figure 4.3.9 also shows the number of working days a week. More than 80% of the waste pickers work at least 5 days a week. Waste pickers who work 7 days a week are 74% at Spasskaya, 49% at the former transfer station and 34% at Karasai.

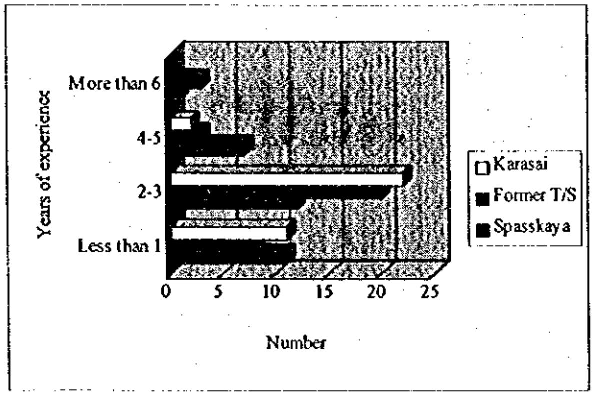


Figure 4.3.8 Average Working Years of Waste Pickers at Each Disposal Site

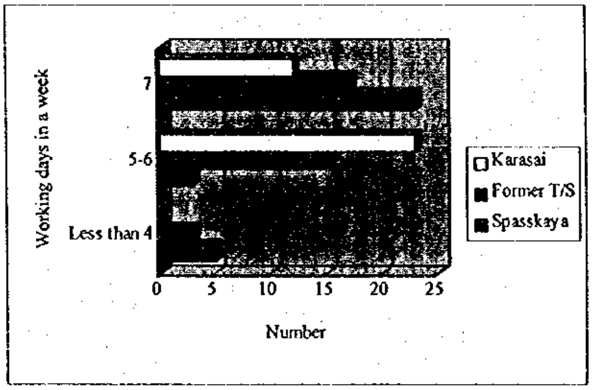


Figure 4.3.9 Average Working Days of Waste Pickers at Each Disposal Site

(2) Between 64 and 75% of the waste pickers work is groups or as families, as shown in Figure 4.3.10. Especially at Spasskaya, 50% pick up the waste in groups, while 61% at Karasai work as families.

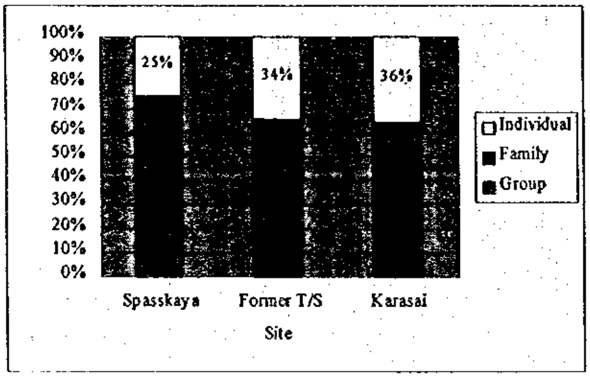


Figure 4.3.10 Working Organization of Waste Pickers at Each Disposal Site

(3) More than 80% of the waste pickers at all sites have to work due to unemployment. More than 90% of waste pickers at the former transfer station and Karasai agreed to give up their activities if the disposal site is closed and they are provided with another kind of job. However, 40% of the waste pickers at Spasskaya disagreed.

4.3.3 Recycling of Pick-up Waste

(1) Types of pick-up waste for recycling are mainly metal, glass and cloth. Metal is the most popular recycling material at all the sites, and more than 90% of the pickers deal with it. The average amount of pick-up metal is calculated at 4 to 9 kilogram (kg) for each waste picker. The average amount of glass and cloth is 130-180 pieces and 1-6 kg per person, respectively.

(2) The average unit price, i.e., the selling price of each material, is shown in Figure 4.3.11. The average selling price does not vary much among the sites. Although the prices of glass and cloth are relatively constant between 1 and 2 KZT per piece, and 5 and 6 KZT per kg, respectively, the price of metal probably depending on kind and shape is from 40 to 90 KZT per kg. Particularly, the average price of metal at Karasai is lower (52 KZT per kg) than that of the other two sites (72 to 74 KZT per kg).

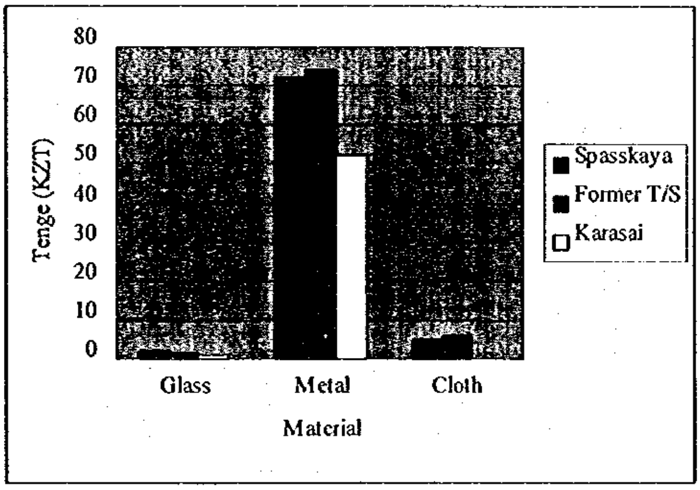


Figure 4.3.11 Average Selling Price of Each Material at Each Disposal Site

(3) Figure 4.3.12 shows the average income per day at each site. From this figure, the average income of 254 KZT/day, 177 KZT/day and 215 KZT/day is estimated by selling glass at Spasskaya, the former transfer station and Karasai, respectively. In addition, the average income from metal is estimated at 586 KZT/day, 305 KZT/day and 470 KZT/day at Spasskaya, the former transfer station and Karasai, respectively. The income from cloth is very small, around 6 to 12 KZT/day. The total income at Spasskaya is the largest at 777 KZT/day and the second is Karasai at 633 KZT/day. The lowest income is recorded at the former transfer station, which is 454 KZT/day.

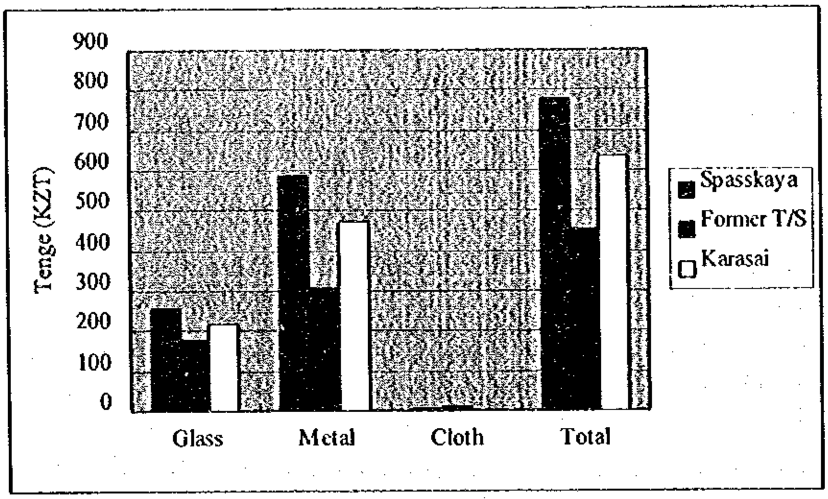


Figure 4.3.12 Average Daily Income of Waste Pickers at Each Disposal Site

(4) The income distribution is illustrated in Figure 4.3.13. The figure shows that a majority of the respondents at Spasskaya and Karasai earn 600-800 KZT/day. It is understandable that most of the waste pickers at the former transfer station get less than 600 KZT/day since the daily income there is the lowest of all the sites, as explained before.

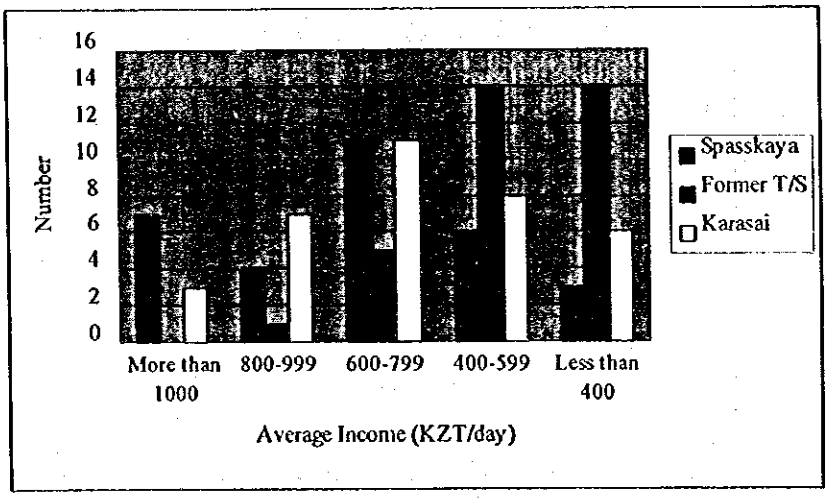


Figure 4.3.13 Income Distribution of Waste Pickers at Each Disposal Site

CHAPTER 5 TOPOGRAPHICAL, GEOLOGICAL AND HYDROGEOLOGICAL CONDITIONS OF ALMATY CITY AND SURROUNDING AREAS

5.1 GENERAL TOPOGRAPHICAL CHARACTERISTICS OF ALMATY CITY AREA

The Almaty City area is situated in a vast intermountain basin in a piedmont part of the Zailiyskiy Alatau mountain range that dominates the south of the area. The tops of certain mountain ranges have sharp, distinctly outlined shapes and covered with eternal snow and small glaciers. Their altitude actually reaches 4,000 to 5,000 meters (m) above sea level. Slopes are steep and cut by deep ravines. The average depth of ravines is 500 to 700 m and over.

From the north the mountains are bordered with a piedmont bench, "counters", which steeply fall from 200 m to the debris cone located in lower. "Counters" represent the hilly and rigidly elevated plain with an altitude of 900 to 1,600 m above sea level. Canyon-like river valleys heavily disjoint this plain. The bench is eroded here and there and the piedmont terrace gradually turns into the underlying surface of a piedmont tail.

The piedmont tail stretches north of the "counters", along the entire northern slope of the Zailiyskiy Alatau. Merged debris cones of mountain rivers form the tail. The surface of the tail is naturally wavy and sometimes slightly wavy with an altitude of 750 to 1,100 m. The tail surface is visibly inclined northward (inclination of 0.05 to 0.08). The average of relief contours reaches 10 to 15 m. The northern limit of the tail passes the point where numerous "Karasu" rivers start and intensive cropping out of groundwater to the surface is observed.

An inclined accumulative plain stretches north of the debris cones, right up to the Kapchagai water reservoir's shoreline. The altitude of the plain declines from south to north from 750-600 m to 475 m with an inclination of 0.09 to 0.04.

The Almaty debris cone is one of the biggest among the debris cones situated within the debris cones tail and formed by the merged debris cones of the Malaya Almatinka, Bolshaya Almatinka, Kargalinka and Aksai rivers. The peaks of the Almaty debris cone are located in the area of "counters" and their altitude is 1,000 to 1,100 m. The true altitude declines to 750 to 600 m towards the marginal area with an inclination of 0.04 to 0.05. At present the river valleys within the city limits are turned into canals.

Hydrographic network in the area is well developed and relates to the Iliyskiy basin. Numerous rivers depending on the alimentation conditions are divided into three groups:

a. Mountain type rivers;
b. Piedmont type rivers; and
c. "Karasu" rivers.

5.2 General Geological Characteristics of Almaty City Area

The geological composition of the area represents different-age geological formations, which form the Iliyskiy basin and its mountain border. The bed of the basin is formed by intrusive formations represented by granites, granodiorites and diorites, which crop out in the southern part of the area. The rocks are cut by breaks of sublatitudinal strike. Surface of the rocks is heavily fractured. Quaternary deposits of river valleys represented by fluvioglacial Lower Quaternary, alluvial slopewash Medium Quaternary and diluvial alluvial deposits lay directly on palaeozoic layers. Boulder pebbles with loamy, sandy-loamy aggregates represent the deposits with loamy and sandy loam interlayers to sandy aggregates.

In the lithologic aspect, extremely homogeneous coarse boulder-pebbled deposits form the cephalic part of piedmont-train of debris cones. North boundary of the debris cones is located around Raiymbek Avenue. Typical section of the area has horizontal low-pervious loamy deposits.

5.3 General Hydrogeological Characteristics of Almaty City Area

Hydrogeological conditions of the area are favourable due to a strong alimentation of the water-bearing horizon of Quaternary alluvial slopewash deposits. The general direction of the groundwater flow is north-northeast. The groundwater flow is formed by atmospheric precipitation, melting of glaciers and snow in the Zailiyskiy Alatau, as well as additional river surface run-off. Groundwater of Quaternary alluvial slopewash layers relates to the merged debris cones of the Malaya Almatinka, Bolshaya Almatinka, Kargalinka and Aksai rivers and forms a vast Almaty groundwater occurrence with the total area of over 350 square kilometres (km^2) together with an adjacent piedmont plain. Operating reserves of this water occurrence are used for domestic and drinking water supply of Almaty City.

The water-bearing horizon in the diluvial alluvial deposits is associated with beds and floodplains of the rivers, which run through the Almaty debris cone. The deposits are represented by loamy and sandy aggregates in boulder and pebble layers that are associated with groundwater flow. The groundwater can be found as deep as 0.9 to 16.6 m with mineralization up to 0.2 to 0.3 g/litre and hydro calcium carbonate composition. The infiltration factor of the water-bearing horizon of the diluvial alluvial slopewash deposits is 17.7 m/24 hours, water conductivity is 956 m^2/24 hours, water loss is 0.1, conductivity of layer is 9.6 to 10^3 m^2/24 hours, the average thickness of the layer is 54 meters. Long-term regular observations established a close link between surface and ground water of river valleys, as well as annual water supply of the groundwater reserves of the diluvial alluvial deposits during summer and autumn due to the infiltration of surface run-off.

The deposits of Almaty City area occur within the limits of debris cones of a variety of rivers and brooks, and adjacent southern part of the piedmont sloping plain of Ili intermountain area. These circumstances play a very important role in the formation of Almaty deposits of fresh groundwater territorially confined to the city boundaries. Flow recharge occurs in the cephalic part of the cone, the southern part of Almaty City, which is formed by high-pervious grounds made of boulder pebbles with the thickness over 600 m. The thickness of low-pervious loamy deposits here is a minimum and as for fluvial plains, these deposits cannot be seen at all.

In the northern part of debris cones, low-pervious loam exists considerably consistent in thickness, which leads to the separation of water-bearing complex by vertical line into a number of sufficiently isolated water-bearing horizons located in the form of layers. Part of groundwater flow is pinched out onto a day surface as ascending springs and swampy hollows that give rise to a great number of brooks and rivers. Lower horizons of water-bearing complex are keeping considerable heads on the strength of which the wells drilled further north than the zone of mass pinching out of ground water operate on a self-discharge system with the discharge of 0.03-0.05 m^3/s. Penetration of contaminating substances into these water-bearing horizons can be considered only as a result of the lateral filtration of groundwater along the lower water-bearing horizons.

Concerning the aggravation of the general ecological situation in Almaty City, the scheme of separate usage of groundwater was developed during the last decades. In accordance with this scheme, the contaminated groundwater in the upper hydrodynamic layer should be used only for technical purposes, such as watering of plants, not for drinking. The layer, less than 150 m in depth, exists within the limits of water-intake wells located on the debris cones, which is further south of Raiymbek Avenue. For drinking water supply, non-contaminated water of the middle (depth of 150-300 m) and lower (depth of 300-500 m) hydrodynamic layers within the limits of debris cones are used.

As for water intakes located within the limits of the piedmont plain in the zone of headwater (further north Raiymbek Avenue), operating water-bearing horizons contain head underground water separated from the contaminated upper water-bearing horizon by sufficiently thick horizons of low-pervious loamy deposits. The hydrodynamic situation is determined here by the presence of filtration in the direction from bottom upwards from head water-bearing intervals to the ground water-bearing horizon. Thus, the presence of any kind of contamination in the upper ground horizon in no way influences upon the quality of groundwater of head water-bearing intervals.

5.4 General Geological and Hydrogeological Characteristics of the Surrounding Area

5.4.1 Twenty to Twenty-Five Kilometres North of Almaty City Limits, Along the Route to Kapchagai of Iliyskii Rayon (Enbek Site)

An acting solid domestic wastes stockpiling field of Enbek LLP is situated 20 kilometers north of Energeticheskii village to collect solid domestic wastes from neighboring populated areas and liquid effluents from TK Gallaher Kazakkhstan JSC.

From the hydrogeological point of view, Upper Quaternary alluvial slopewash layers of piedmont lowland characterize the landfilling area. Subsoil water can be found as deep as 2 to 8.7 meters depending on the area relief. The water is fresh with mineralization up to 1 kg/m^3. Medium loam, sandy loam and sand lithologically represent the aeration zone. The thickness of poorly penetrable layers is 1.5 to 7.4 meters. Groundwater is virtually exposed. Observation boreholes to observe the level, temperature and chemical composition of the groundwater are not in place.

5.4.2 Three Kilometers West of the City Limits, Three to Four Kilometers North of Kaskelen Route in Octyabrskii Rural District of Karasaiskii Rayon (Nika Site)

The landfill site for solid domestic waste operated by Nika LLP is situated 3.5 kilometers northwest of Put' Il'icha village in Oktyabrskiy rural district of Karasaiskii Rayon.

From the hydrogeological standpoint, the area is characterized by Medium Quaternary alluvial slopewash layers of piedmont lowland, northwest off the outlying segment of the Almaty groundwater occurrence. Groundwater can be found as deep as 3 to 10 meters and characterized by an abundant water supply. Water is fresh with mineralization of 0.5 kg/m^3. Medium and heavy loam and gravelly sands lithologically represent the aeration zone. Thickness of poorly penetrable layers varies from 3 to 6 meters. The groundwater is poorly protected, and observation boreholes are not in place.

5.4.3 Ten kilometers West of the City Limits, Three to Four Kilometers North of Kaskelen Route, in KIZ of Karasaiskii Rayon (Barys Site)

The solid domestic waste landfill site of Barys LLP is situated 1.3 kilometers northeast of Politotdel village.

From the hydrogeological standpoint, Medium Quaternary alluvial slopewash layers of piedmont lowland characterize the area. Groundwater can be found as deep as 5.3 to 20 meters depending on the area relief. Water is fresh with mineralization of 1 kg/m^3 with hydro calcium carbonate composition. Loam and gravelly sands lithologically represent the aeration zone. Thickness of poorly penetrable layers varies from 4.5 to 17 meters. The groundwater is poorly protected, and observation boreholes are also not in place.

CHAPTER 6 EVALUATION OF CURRENT CONDITIONS AND REQUIRED ACTIVITIES FOR IMPROVEMENT

6.1 EVALUATION OF CURRENT CONDITIONS

6.1.1 Final Disposal System

1) Totally Uncontrolled Dumpsites

Large or small, legal or illegal, all dumpsites in and surrounding Almaty City are categorized into open dumping; that is, there are neither cover soil nor drainage facilities in the site. This poses a risk from a sanitary point of view that the dumped waste can affect directly the operators of the landfill site, waste pickers and surrounding residents. These sites also constitute breeding grounds for different organisms that are sometimes carriers of diseases, such as typhoid, dysentery, etc.

There is a need for introduction of sanitary landfill and additional heavy equipment to manage the daily landfilling work and to improve the situation. The unloaded wastes are to be firstly compacted and then removed to a suitable tipping area, and then covered with soil. Proper drainage facilities are also required in the site if possible.

In this sense, the ongoing dumpsite for the city and those in Oblast Territory should meet the standards set in their original design. In addition, the dumpsites where the remaining waste is still on the loose should be reclaimed in a proper manner.

2) Insufficient Monitoring and Inspection

The number of staff who should be involved in monitoring and inspecting the final disposal is not enough to complete their mission. Additionally, it seems that duties and responsibilities among the Almaty City Department of Environmental Protection (ACDEP), Oblast Department of Environmental Protection, Almaty Akimate and National Environmental Center (NEC) are not clearly defined in terms of final disposal system in the city and its environs. This results in insufficient monitoring and inspection for the system and thus accelerates illegal dumping anywhere in and out of the city. Even if the laws, norms and regulations prescribe a strict manner of operation and management of final disposal sites, without proper monitoring and inspection, discontinuance of illegal dumpsites could not be achieved.

From environmental viewpoints as stated below, the ongoing illegal dumpsites that are still receiving the city's waste, such as a site near Spasskaya Street, north side of residential area between drainage and KNS DKP in Turksibskii Rayon, should stop their operation immediately.

6.1.2 Environmental Conditions Due to Solid Waste

1) Water and Soil Pollution by Leachate and Elution from the Solid Waste

Delays in waste collection for a long time generate a smell of black liquid called leachate, which is considered as highly pollutant when it reaches watercourses due to its high concentration of SS, BOD, COD and chemicals. The leachate can also penetrate into the soil and pollute the groundwater. Although the actual impact to the surface and ground water cannot be observed clearly based on results of the Environmental Survey, domestic and industrial wastes may introduce not only organic matter but also toxic elements to the soil. Their pollutants will finally contaminate the groundwater.

2) Air Pollution Due to Smoke and Dust from the Solid Waste

Spontaneous combustion in the dumpsites often breaks out and produces smoke. The major complaints given by persons living near the former compost plant and transfer station were those related to smoke and smell. Physical reduction of the amount of waste by means of burning has been often observed as a common practice in Almaty City. This habit can also contribute to deteriorate the air quality. Moreover, limited waste collection services and lack of container capacity brings about the scattering of waste and dust into the air, thus additionally worsening air quality.

3) Landscape

Indiscriminate dumping of waste can be seen along the roadsides, in open spaces, vacant lots and riverbanks. This contributes to the degradation of the environmental quality of the places from an aesthetic point of view.

6.2 Recommendations for Improvement of the Final Disposal System

6.2.1 Introduction of Sanitary Landfill

Sanitary landfill system should be introduced to improve and sustain the conditions for the Karasai disposal site. The sanitary level of landfill system varies from country to country. Although appropriate level for the Karasai site will be determined depending on financial viability and degree of environmental conservation, the following actions are recommended as a minimum:

- Controlled tipping;
- Berm construction;
- Daily cover soil; and
- Effluent control of leachate and monitoring.

6.2.2 Establishment of Proper Operation and Management System of the Disposal Site

To operate and maintain the above landfill system, increase in number of heavy equipment, inspectors and operators should be required. In addition, proper organizational structure should be established to constantly sustain the system. Record keeping on dumped volume of solid waste and a comparison between collection and the dumped records will be also necessary. These data should be reported as daily, monthly and annual reports and submitted to the designated authority that is responsible for supervision of the site.

6.2.3 Closure and Reclamation of the Existing Illegal Dumpsites

Apart from small trash in the city, the existing illegal dumpsites should be closed and reclaimed in a proper manner to avoid negative impacts on the environmental quality due to accumulated waste on the sites. Scattered waste will be firstly gathered to a designated area or trench and covered with soil. The site will then be graded and compacted. Leachate and gas treatment will be installed if required. Finally, a post-closure land use plan will be made in consideration of topographic and geological condition, and regional and city planning.

6.2.4 Strengthening of Monitoring and Inspection for the City's Environment

Monitoring of the city's environmental condition should be carried out at least once a month. The monitoring will focus on not only natural conditions, such as surface and ground water but also possible site condition for dumping. The result of the monitoring should be reported to the Director of the authority. The report will be very effective to understand the current conditions of the city and to consider countermeasures to environmental pollution. Needless to say, strict inspection should be conducted and the authority should be heavily fined for illegal dumping.

CHAPTER 7 INITIAL ENVIRONMENTAL EXAMINATION

7.1 INTRODUCTION

It is of great importance to give sufficient consideration to the environment in the implementation of a project. In general, the Environmental Impact Assessment (EIA) is required to study, forecast, and evaluate the environmental impacts of a project since the implementation of the project could adversely affect some components of the environment.

Procedures of EIA in the Republic of Kazakhstan are slightly different from those of Japan and the details will be examined in the following study period in Japan. The National Standards, *Provisional Instruction on Assessment Procedure of Economic Activity on Environment* (called *'OVOS/EIA'* in Russian abbreviation), RND 03-02-01-93 provides the basic assessment procedures of EIA. According to *OVOS/EIA*, EIA is, without exception, mandatory for all kinds of economic activity and has the following four (4) stages:

(1) Review of Environment Status

(2) Preliminary EIA

(3) EIA

(4) Environment Protection Section

It is considered that the Initial Environmental Examination (IEE) that is shown in this section will be similar to the above stages (1) and (2).

7.2 OBJECTIVES OF THE IEE

The Initial Environmental Examination (IEE) has the following two objectives:

(1) To evaluate whether the Environmental Impact Assessment (EIA) is necessary for the project and, if so, to define its contents; and

(2) To examine, from an environmental viewpoint, the measures for alleviating the effects of the project which requires environmental consideration but not a full-scale environmental impact assessment.

7.3 PROCEDURE OF THE IEE

The IEE includes the analysis of the following components, which may mostly cover the requirements of *OVOS/EIA*:

(3) Project Description

(4) Site Description

(5) Screening

(6) Scoping

(7) Overall Evaluation

7.4 EXECUTION OF THE IEE

7.4.1 Sites for Solid Waste Management Facilities to be Examined

Available candidate sites for solid waste management (SWM) facilities in the Master Plan are assumed to be considered based on the result of field trips during the first study period in Kazakhstan, although the candidate sites should be primarily nominated by the Kazakhstan side.

1) Required SWM Facilities

In the Master Plan stage, required SWM facilities for Almaty City are assumed to be the following two:

a. Transfer station
b. Final disposal site

2) Possible Candidate Sites

At the end of the first study period in Kazakhstan, the possible candidate sites for the preceding facilities were assumed to be as follows:

a. Sites for Transfer Station

- Near HES #2 (referred to as "HES #2" in the following text)
- Near Horse Race Field (referred to as "Horse Race Field" in the following text)

b. Sites for Final Disposal Site

- Site for NIKA (referred to as "NIKA" in the following text)
- Site for BARYS (referred to as "BARYS" in the following text)
- Site for ENBEK (referred to as "ENBEK" in the following text)

7.4.2 Project Description

1) Construction of Transfer Station

The proposed project is the construction of a new transfer station to improve efficiency of collection and transportation operations by reducing the transportation time. Currently, the existing transfer station is not functioning for the original purposes very well. Taking into consideration the distance of the final disposal site in Karasai from the city area, this project will be worth one of the priority projects.

The total amount of waste to be transferred in this station is assumed to be 800 to 1,000 tons per day, which are not yet fixed at present. Other project details, such as the executing agency, transport methods, types of waste to be transferred, number of incoming and outgoing vehicles, etc., are also not yet decided.

2) Improvement of Final Disposal Site

Some of the existing final disposal sites are required to improve their condition, i.e., the concept of sanitary landfill will be introduced. The landfill site mainly consists of the following components:

a. Fence
b. Building
c. Truck scale
d. Roads
e. Ramps
f. Drainage
g. Gas and leachate control system
h. Wells for groundwater monitoring
i. Structures for solid waste retention

7.4.3 Site Description

1) Location

a. HES #2

The place is located at 1.6 km (kilometer) northwest of Kainar village, 1 km east of the heat-and-electric-supply station (HES) #2, 1 km south of a cemetery in Auezovskii Rayon.

b. Horse Race Field

The site is located at the northern side of Kulagher residential area, close to Sultanka River and a horse riding field in Zhetysuskii Rayon.

c. NIKA

The place is located at 3 km (kilometer) west from the city boundary and about 4 km north from a highway to Kaskelen, in Oktybar Selsky Okrug, Karasai Rayon.

d. BARYS

The place is located at 10 km west from the city boundary and approximately 3.5 km north from a highway to Kaskelen, Kazakhstan Agricultural Institute (KIZ) Posyolok, Karasai Rayon.

e. ENBEK

The site is located at 21 km north of the city boundary, along the highway to Kapchagai, Illi Rayon.

2) Other Items

Other items, such as inhabitants, land use, topography, fauna and flora, are described in Tables 4.1.1 to 4.1.5 of Data Book 4.

7.4.4 Screening

Screening is carried out to evaluate whether or not it will be necessary to include an environmental consideration in a proposed project in general. In the above-mentioned projects, the environmental consideration is indispensable because of the requirements of *OVOS/EIA*. Thus, screening examination was conducted to clarify possible environmental impacts by the implementation of the project. The results of the screening are presented in Tables 4.2.1 to 4.2.5 of Data Book 4. From these, it is concluded that all of the assumed projects require EIA.

7.4.5 Scoping

The purpose of the scoping examination at this stage is to identify the important environmental impacts and to define the study items of EIA depending on the degree of impacts. The results of the scoping are presented in Tables 4.3.1 to 4.3.5 of Data Book 4. According to the results, public health, groundwater, fauna and flora, and landscape are major concerns in terms of social and natural environment for the projects. There are many items associated with pollution to be considered; especially, water pollution and offensive odor that may be predicted to bring serious impacts by the disposal projects in addition to the other concerns on air, and noise and vibration.

7.4.6 Overall Evaluation

Through the screening and scoping examinations, it becomes clear which environmental items should be taken into consideration more deeply and carefully. This overall evaluation describes not only the identification of each environmental impact to be considered but also the outline of further study for these items. In addition, adequate measures to alleviate or avoid these possible environmental impacts are presented. The following table summarizes the evaluation results of the IEE. Detailed description is presented in Tables 4.4.1 to 4.4.5 of Data Book 4.

Table 7.4.1 Summary of Overall Evaluation of the IEE

Environment Item	HES #2	Horse Race Field	NIKA	BARYS	ENBEK
Resettlement	C	C	B	B	C
Economic Activity	B	C	-	-	-
Traffic and Public Facilities	C	B	-	-	-
Water Rights and Common Rights	-	-	-	C	C
Public Health Condition	B	B	B	B	B
Groundwater	C	C	B	B	B
Hydrological Situation	-	-	-	C	C
Fauna and Flora	B	B	B	B	B
Landscape	B	B	B	B	B
Air Pollution	B	B	B	B	B
Water Pollution	C	C	A	A	A
Soil Contamination	C	C	C	C	C
Noise and Vibration	B	B	B	B	B
Offensive Odor	B	B	A	A	A

Legend A: Serious impact is expected.
B: Some impacts are expected.
C: Extent of impact is unknown (Examination is needed. Impact may become clear as study progresses.).
D: No impact is expected.

CHAPTER 8 FORMULATION OF FINAL DISPOSAL PLAN

8.1 ACTION PLAN FOR THE FINAL DISPOSAL SYSTEM IN ALMATY CITY

8.1.1 Phased Implementation for Improvement of the Final Disposal System

To improve the final disposal system of Almaty City, action plans will be made in accordance with recommendations as described in Chapter 6 of this report. Considering the financial situation of the city, it seems to be very difficult to carry out all the actions required in a short period. Phased implementation will be thus introduced.

In this sense, the Master Plan is divided primarily into two (2) stages: Phase I, present to year 2005 and Phase II, year 2006 to 2010. Priority projects that are selected with high priority will be carried out in the first stage, i.e., Phase I. The remaining work will be completed in the succeeding Phase II. This step-by-step planning will make the financial burden of the city lighter and the first step will provide precious experience and data for preparation of the next step.

8.1.2 Project Components of the Final Disposal Plan

The components of the final disposal plan are formulated based on the required actions as the following two projects:

(1) Karasai Disposal Site Improvement Work Project

(2) Illegal Dumpsites Reclamation Project

The first project comprises introduction of sanitary landfill system including procurement of new heavy equipment and vehicles, improvement of the existing facilities, and establishment of proper operation and management system. The second project covers major illegal dumpsites in the city to be closed and reclaimed.

8.1.3 Urgent Improvement Project for Final Disposal Site

The condition of the Karasai disposal site should be improved and sustained by ensuring that the access road and dumping points are kept constantly clear, and consequently periodical landfilling and land reclamation of the existing dumping area is carried out.

Parasat, the company operating and managing the site, has introduced four (4) units of bulldozers to the site to push the dumped waste down to a depression area. Although the use of heavy equipment is the most effective way to improve the site conditions, their activities in the site do not demonstrate this. The main reason is that the equipment used in the site is obsolete and their ages are thought to be over 15 years.

From an environmental viewpoint, the introduction of a sanitary landfill system is a minimum level of requirement. Accordingly, the reasonable number of heavy equipment at the site should be procured to implement the sanitary landfill system. This project will be done on an urgent basis, so that the procurement of heavy equipment for the Karasai disposal site will be independently made as one of the urgent improvement projects.

8.1.4 Implementation Schedule of the Final Disposal Plan

As stated earlier, the final disposal plan is composed of two (2) main projects. In terms of the implementation schedule, however, the plan can be described as follows:

(1) Urgent Improvement Project (2000~2001)

(2) Priority Projects (2002~2003)

  a. Karasai Disposal Site Improvement Work Project

  b. Spasskaya Illegal Dumpsite Reclamation Model Project

(3) Master Plan Projects (2006~2010)

  a. Illegal Dumpsites Reclamation Project

Details regarding the Illegal Dumpsites Reclamation Project will be discussed later in Chapter 11. Based on this component and schedule, each project will be developed in the following chapters.

8.2 ALTERNATIVES TO FINAL DISPOSAL SITE

8.2.1 Policy of Formulation

The existing ongoing dumping sites in the Oblast Territory will be the alternative disposal sites in this Study. Since it may take a long time to authorize a new site for final disposal because of political and institutional constraints, it is extremely difficult to decide the site or to come to some conclusions during this Study period. Additionally, selection of a new final disposal site is out of the scope of this Study. The existing ongoing dumping sites in the Oblast Territory may not necessarily require such a long procedure because the Almaty Oblast Department of Environmental Protection already authorized these sites.

8.2.2 Alternatives of Potential Sites

There are six (6) sites in the Oblast Territory that are operating and receiving waste from the city. Three (3) of them, i.e., Nika, Barys and Enbek, are selected as alternatives of the final disposal site in view of the following reasons based on the field reconnaissance in the first study period:

(1) Karasu disposal site is located in a sandbank in between two rivers; therefore, it is not suitable to establish the final disposal site in such a floodplain.

(2) Boraldiy disposal site is lying in a low land, which is naturally swampy. This is also not recommendable as final disposal site because of potential adverse impacts to the environment.

(3) Rikki disposal site is situated just 600 m north of Enbek. Carried waste is dumped into a dry ravine. Dimensions of the ravine are estimated at 6-8 m in height, 50-100 m in width and 300 m in length; hence, approximately 160,000 cubic meter[1] (m^3) of waste can be disposed. This amount would be equivalent to

[1] The volume of the ravine is calculated as follows:
7 x 75 x 300 = 157500 m^3, which is about 160,000 m^3

only one or two year volume of waste to be collected[2] and be considerably small for a final disposal site.

8.2.3 Recommendable Alternative Disposal Site for Evaluation

As a result of the Initial Environmental Examination (IEE) as stated previously in Chapter 7, the Environmental Impact Assessment (EIA) is required to be carried out for the remaining three (3) sites, namely Nika, Barys and Enbek. This means that there is not much difference among these three sites from viewpoints of natural and social conditions. On the other hand, appropriate location of another disposal site will be generally determined by efficiency of transportation. In this sense, taking into account the location of Karasai disposal site that is in the west of the city center, Enbek is the most favorable location among the three. While Nika and Barys are located in the same direction of Karasai, Enbek is in the north of the city. Details are discussed in Supporting Report, Section D, Collection and Transportation.

8.3 INTRODUCTION OF SANITARY LANDFILL

8.3.1 Concept of Sanitary Landfill

The purpose of landfill disposal is to stabilize the solid waste and to make it hygienic through proper dumping of waste and use of natural metabolic function. It is therefore important to select a practical method of disposal that can be decided upon by local conditions and organizational situation. In making this decision, it is necessary to take into account the type, form, composition of waste, location of landfill site, and geological, hydrological and climatic conditions of the site.

8.3.2 Sanitary Level of Landfill System

The sanitary level of landfill system can be classified into four (4) levels, as tabulated below. Appropriate sanitary level of the system will be determined in consideration of financial viability and degree of environmental conservation.

Table 8.3.1 Classification of Sanitary Level of Landfill System

Level 1	Controlled tipping
Level 2	Berm construction and daily cover soil
Level 3	Effluent control of leachate and monitoring
Level 4	Leachate treatment and liner system

The sanitary level of landfill system, its target and so on, are as further summarized below:

1) Level 1

(1) Target

a. Introduction of controlled tipping

[2] If 250 tons of waste are collected and carried to the site daily, the life of disposal site will be as follows:
160,000/250/365 = 1.75 years

(2) Achievement Level

a. Establishment of access to site
b. Introduction of cover material in order to prevent fire, littering of wastes and odor
c. Introduction of inspection, control and operational records of incoming wastes

(3) Further Improvement to Next Level

a. Establishment of site boundary
b. Introduction of environmental protection facilities
c. Introduction of amenities for the staff such as sanitary facilities and locker room
d. Introduction of a semi-aerobic landfill

(4) Environmental Issue

In this level, environmental protection measures are not established except the provision of cover material. Impact of landfill operations on the surroundings is great and may include the following:

a. Surface and groundwater pollution by leachate
b. Littering and dust
c. Breeding of insects and rodents
d. Unpleasant view of landfill
e. Noise
f. Odor

2) Level 2

(1) Target

a. Berm construction and daily cover soil

(2) Achievement Level

a. Establishment of site boundary to distinguish the disposal site and to eliminate scavenging
b. Application of sufficient cover to disposed waste
c. Establishment of disposal site by construction of berm or enclosing dike
d. Introduction of divider for unloading areas and working place
e. Establishment of drainage system to divert storm water and seepage from surrounding areas and to reduce leachate
f. Introduction of environmental protection facilities to lessen direct impact on surroundings, such as buffer zone, litter control and gas removal facilities
g. Introduction of semi-aerobic landfill through the installation of gas removal facilities
h. Introduction of amenities for staff

(3) Further Improvement to Next Level

a. Improvement of semi-aerobic landfill
b. Establishment of leachate control
c. Establishment of leachate treatment

(4) Environmental Issue

In this level, since the disposal site and drainage system is already established, landfill operations can be controlled efficiently. Furthermore, with the application of sufficient cover and introduction of some environmental protection facilities, impacts from landfill operations are much reduced than Level 1. Besides, the installation of gas removal facilities introduces a semi-aerobic landfill system. However, leachate is still not controlled and a monitoring system has yet to be established.

3) Level 3

(1) Target

a. Effluent control of leachate and monitoring

(2) Achievement Level

a. Establishment of leachate control by the installation of effluent collection, storage and monitoring facilities

(3) Further Improvement to Next Level

a. Introduction of leachate treatment system
b. Establishment of semi-aerobic landfill

(4) Environmental Issue

Leachate accumulated at the bottom of landfill is discharged through drainpipes, i.e., leachate collection pipes. These pipes also permit the natural inflow of air to promote semi-aerobic condition for the decomposition of waste. To achieve favorable improvement, the monitoring and control of leachate levels and checking for malfunctioning of leachate collection pipes are essential.

4) Level 4

(1) Target

a. Leachate treatment and liner system

(2) Achieved Level

a. Establishment of leachate treatment by the installation of oxygenation pond, etc.
b. Establishment of seepage control by liner system
c. Establishment of semi-aerobic landfill

(3) Further Improvement to Next Stage

a. Establishment of high-level treatment system
b. Introduction of service system to the surrounding residents

(4) Environmental Issue

The installation of seepage control facilities and oxygenation pond with aerator for the leachate treatment would achieve the landfill sanitary level.

8.3.3 Appropriate Sanitary Level of Landfill System for Almaty City

A complete landfill system requires a large amount of capital investment. Taking into consideration the size of Akimate's annual budget and its financial situation, various problems with regard to funding a complete landfill system will be expected to ensue. It is thus more realistic now to accomplish a complete landfill system systematically; in other words, staged construction will be introduced.

The primary target of disposal system for the Master Plan should be Level 3+ (plus), according to a result of the Environmental Survey. Level 3 is defined, in this study, as introduction of controlled tipping, berm construction and daily cover soil, and effluent control of leachate and monitoring. Treatment of leachate will be added to these components so as to fulfill the required level in this case, i.e., Level 3+.

The result of the Survey shows that the water quality of leachate retention ponds at Karasai disposal site is slightly worse than that of rivers flowing in the city, as described in Section 3.6 previously. However, the water quality of the retention pond is still within the acceptable level under the Japanese Standards while the quality standards of discharged water in Kazakhstan has not been obtained. In terms of the biochemical oxygen demand (BOD), for example, around 21 to 24 milligrams per litter (mg/l) was recorded at the downstream retention pond although the limit of BOD in the Japanese Standards is 160 mg/l. Therefore, the existing retention ponds will be improved in compliance with volume of leachate to be treated, which can be managed with low maintenance costs. In addition, a leachate re-circulation system will be considered to mitigate the capacity of retention ponds, if appropriate.

8.3.4 Method of Filling

Depending on details of site operation and conditions, variations in landfilling techniques can be distinguished by the following three methods:

1) Trench method

This involves the excavation of a trench into which waste is deposited. The excavated material is then used as cover. This technique is a variation of the cell method described below and is ideally suited to areas where an adequate depth of cover material is available at the site where the water table is not near the ground level.

2) Area method

Waste may be deposited in layers and form terraces over the available area. This method is applied to the terrain that is unsuitable for the excavation of cells or trenches in which to place the solid waste because of, for example, high groundwater conditions.

3) Cell method

This technique involves the deposition of waste within pre-constructed bunded area. At a shallow site it is considered preferable to place one daily cell on top of another so that the larger cell is brought up to final level before moving onto the next larger cell thereby.

Among these methods, Karasai site will be suitable for the cell method since the site is still ongoing and already has a large amount of deposited waste. Consequently the foundation is very weak and it is very difficult to excavate a trench. Meanwhile, a combination of the trench and cell methods will be recommendable for Enbek site. Since the site is naturally formed at several depressions and also has plain areas where the solid waste is dumped, it will be a great advantage to make use of these existing conditions from an economical viewpoint. Details of each method are also discussed in Chapter 12 of this report.

CHAPTER 9 DEVELOPMENT OF FACILITY PLAN FOR IMPROVEMENT OF THE KARASAI DISPOSAL SITE

9.1 DESIGN CONCEPT OF LANDFILL DISPOSAL

9.1.1 Sanitary Landfill Operation

With the present open dumping method, the waste-dumping height is limited and cannot exceed the height to which new wastes can be dumped on the existing waste from the truck unless a bulldozer is employed to compact the waste. A further problem is that since the waste is not spread and leveled, the range in which waste can be dumped is limited to the area that is accessible to the truck. As a result, the landfill site as a whole is not used effectively and the required disposal volume cannot be secured. In addition, the height of the landfill will increase as the amount of waste disposed of on the landfill site grows. Due to this increase in the height of the landfill, it will take longer for the waste to dry, as compared with the present. This has a detrimental effect on the surrounding environment due not only to the generation of offensive odors and gases but also to the associated problem of insects and animal pests.

Meanwhile, based on the Environmental Survey for Environmental Impact Assessment, it is found that the groundwater of the existing disposal site is polluted by heavy metals, such as Mercury, Lead and Cadmium. This groundwater pollution may result from infiltration of leachate. Therefore, the leachate generated in the landfill site should be collected and drained immediately. Simultaneously, the landfill area should be covered with soil, and this will contribute to reduction of the leachate volume as well.

For the above reasons, consideration should be given to the procurement of such equipment as will be capable of performing the following tasks to assure sanitary conditions for landfill operation.

Table 9.1.1 Major Tasks and Requirements for Landfill Operation

Major Tasks	Requirements
Cover soil spreading	Intermediate cover (0.2 m) Final cover (0.5 m minimum)
Landfill zoning	The landfill site should be divided into one-year zones and dumping operation should move on successively from one zone to the next on a yearly rotation basis. This would facilitate management of the landfill site and assist in leachate volume control.
Leachate collection/discharge and leachate detention pond	The leachate generated during rainfall and snow melting should be collected and drained as quickly as possible. Collected leachate should be stored in a reservoir pond. In dry weather, the leachate liquid can be sprinkled on the landfill site to let it evaporate.

9.1.2 Landfill Disposal Method

With the cell method, intermediate cover soil is spread on the same day to a height of 0.2 m on each waste layer. After the waste layers have been completed, a final cover layer whose height is 0.5 m is applied. Details of the cell method are described in the following Subsection 12.6.2.

9.1.3 Landfill Site Road (Access Road)

In addition to the site road built going down to the landfilling area for transporting the wastes, it will be necessary to provide a transport track by filling a 1.0 m thick layer of sand and soil on the landfill waste itself.

9.1.4 Topsoil Removal, Transportation, Disposal and Leveling

Topsoil is taken from the unused landfill zones of the landfill site and transported to the landfill zone to be used where it is discharged and leveled out.

9.2 REQUIRED FACILITIES AND FACILITY LAYOUT

9.2.1 Outline of the Major Facilities

The following descriptions give an outline of the major facilities of the site.

1) Waste Retaining Structures (Earth Dams)

Waste retaining structure (earth dam) will be erected in general to store the waste at the upstream of the structure. The existing site does not require such kind of structure because of proper landfill volume and its high construction costs. Other retaining structures will be constructed at each of the downstream of retention pond and leachate treatment pond.

2) Leachate Collection and Drainage Facilities

At the bottom of landfill zones, a clayey soil layer should be prepared to prevent the leachate from infiltrating the underground. On the clay lining, a water permeable layer should be provided with the use of cobblestones and gravel, to retain and drain the percolated leachate.

3) Leachate Retention Pond

The leachate collected from the leachate drainage facilities during rainfall and snow melting periods should be totally retained in the leachate retention pond. The required retention volume is estimated based on the meteorological data in consideration of precipitation and evaporation.

To avoid pollution of the groundwater by leachate stored in the pond, a liner system comprising a clay liner and a synthetic membrane liner should be provided.

4) Leachate Treatment Pond

As a result of the Environmental Survey, water quality of leachate retained in the existing detention pond at the site is not so bad compared with the typical leachate composition; specifically, BOD and COD is measured at around 21 to 26 mg/l (milligram per litter). Results of the Environmental Survey are described in Tables 3.1.1 to 3.1.4, Data Book 4. Therefore, simple treatment, such as anaerobic pond will be recommended because of ease of operation and maintenance. The generated leachate stored in the retention pond will then be discharged to accelerate its aerobic treatment in another pond located in the downstream.

5) Rainwater (Surface Water) Collection Gutter

The surface water from the unused landfill zones and the used landfill zones with the final cover layer should be discharged through gutters.

6) Gas Exhaust Equipment

Gas exhaust equipment should be installed to extract various gases and vapors evolving the decomposition of organic materials in the waste. The equipment is composed of a perforated PVC pipe covering crashed stones wrapped with a wire basket.

7) Access Road

The about 2 km stretch from the Almaty-Bishkek highway to the disposal site was already paved; however, site road from the site entrance to the landfill area is not paved. To reduce the wear and tear on the transport vehicles and improve the travel speed of the vehicles, it would be desirable to surface this distance with a simple asphalt pavement. In addition, a gravel or crushed stone-paved road should be created within the landfill site compound. This road would be used for access by the vehicles delivering wastes and topsoil to the landfill and also the vehicles used for site management.

8) Groundwater Monitoring Wells

Since the leachate is stored in the leachate retention pond throughout the year, there is a high risk that the leachate may seep into the groundwater with time. It is therefore necessary to monitor the groundwater quality on an ongoing basis in order to check for groundwater pollution due to leachate seepage.

9) Site Office

To assure sanitary landfill conditions, management tasks will be required. These include the weighing of the wastes, the demarcation of the landfill zones (cells), the checking of the landfill height, adjustment of the water content, and monitoring of the leachate volume and water quality. For this purpose, the existing site office building will need to be reconstructed to house the landfill supervisors permanently stationed at the site.

10) Truck Scale (Truck Weighing System)

The waste amounts delivered to the disposal site each day should be weighed on a truck scale (weighing capacity: 30t) and the weights need to be recorded. For the time being, however, the waste amount may be estimated from the number of waste transportation vehicles.

9.2.2 Disposal Site Capacity Requirement

An attempt was made to estimate capacity of the site needed for future landfill from 2000 till 2010 based on the future waste collection volume which is shown in Table 9.2.1. A total of 3.96 million cubic meters (m^3) is required for capacity of the disposal site in Karasai up to the year 2010.

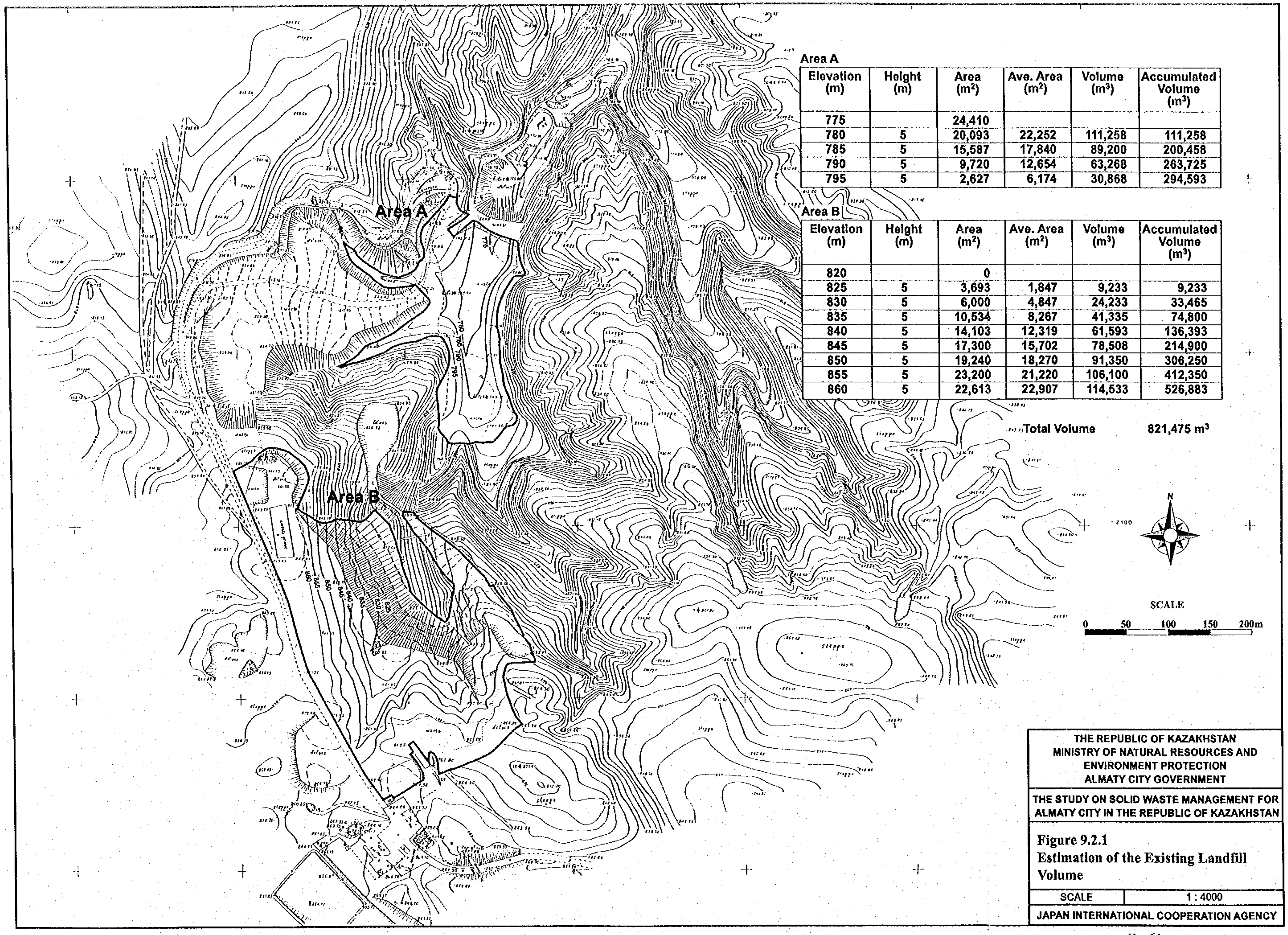
Table 9.2.1 Capacity Requirement for the Disposal Site in Karasai

Year	(1) Waste Amount*1 (m^3/day)	(2) Street Sweeping Amount*2 (m^3/day)	(3) Landfill Waste Amount (m^3/year) (1) × 365 + (2) × 365/2*2	(4) Cover Soil Amount (m^3/year) (3) × 0.12*3	(5) Total Disposal Amount (m^3)
2000	539	78	210,970	-	210,970
2001	547	78	213,890	-	424,860
2002	800	79	306,418	36,770	768,048
2003	893	80	340,545	40,865	1,149,458
2004	904	81	344,743	41,369	1,535,570
2005	916	82	349,305	41,917	1,926,791
2006	924	82	352,225	42,267	2,321,283
2007	958	83	364,818	43,778	2,729,879
2008	957	84	364,635	43,756	3,138,270
2009	955	85	364,088	43,691	3,546,048
2010	961	86	366,460	43,975	3,956,483
Total	-	-	3,578,095	378,388	3,956,483

Note: *1 Bulk density of waste in the site varies from 0.4 to 1.7, so that it is assumed to be 1.0 in the estimation. This amount excludes a collection amount of street sweeping.
*2 Street sweeping for landfilling will be carried out half of the year. The total amount of landfill waste is slightly different from the result of this equation due to rounding.
*3 Sanitary landfill system with application of cover soil will be undertaken from year 2003. The total amount of cover soil is assumed to be 12% of disposed waste.

9.2.3 Estimation of the Existing Landfill Volume

The solid waste is presently dumped in two areas of the Karasai site. Based on the results of the topographic survey in the second study period, the present waste dumped in the site is estimated at approximately 820,000 m^3 as shown in Figure 9.2.1.



Area A

Elevation (m)	Height (m)	Area (m²)	Ave. Area (m²)	Volume (m³)	Accumulated Volume (m³)
775		24,410			
780	5	20,093	22,252	111,258	111,258
785	5	15,587	17,840	89,200	200,458
790	5	9,720	12,654	63,268	263,725
795	5	2,627	6,174	30,868	294,593

Area B

Elevation (m)	Height (m)	Area (m²)	Ave. Area (m²)	Volume (m³)	Accumulated Volume (m³)
820		0			
825	5	3,693	1,847	9,233	9,233
830	5	6,000	4,847	24,233	33,465
835	5	10,534	8,267	41,335	74,800
840	5	14,103	12,319	61,593	136,393
845	5	17,300	15,702	78,508	214,900
850	5	19,240	18,270	91,350	306,250
855	5	23,200	21,220	106,100	412,350
860	5	22,613	22,907	114,533	526,883

Total Volume 821,475 m³

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Figure 9.2.1
Estimation of the Existing Landfill Volume

SCALE	1 : 4000

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9.3 DESIGN OF THE FACILITIES

9.3.1 Results of Soil Investigation Survey

Geological conditions of the candidate site are key elements for the design of the final disposal site. Details of the investigation result are shown in the soil investigation survey report. This section summarizes the important results. The location map of boring points and the geological columns of each point are also given in the soil investigation survey report.

1) Geological Structure

The Paleozoic rock foundation has the common immersion from south to north of the site. The rock deposit bedded on the depth of 1000 m. This Paleozoic foundation is covered with Neogene and Quaternary deposits whose thickness mounts up to 400 m.

The site is located in a ravine that is a plane of a temporary water stream. The water flow can be seen in the period of melting snow or raining in spring. Unsagging loam is widely shown up to the depth of 30 to 50 m while unsagging silty loam is covered on it with 0.5 to 11 m in thickness.

Groundwater level in the north part of the site is measured at 0.5 – 1.52 m in depth and 8.95 – 16.32 m in depth at the south. The highest level of the groundwater is usually between May and June.

2) Laboratory Test

Permeability tests were undertaken by using soil samples in each borehole. The test results are shown in Table 9.3.1.

The results suggest that the loam has a 1×10^{-6}~10^{-5} cm/sec order of permeability, which is evaluated as low.

Table 9.3.1 Permeability of the Loam at the Karasai Disposal Site

Borehole	Depth	4.0m	7.0m	13.0m	16.0m	25.0m	-	-	-
No. 1	K	1.5×10^{-5}	1.2×10^{-6}	1.2×10^{-6}	1.2×10^{-6}	1.2×10^{-6}	-	-	-
Borehole	Depth	2.2m	11.0m	-	-	-	-	-	-
No. 2	K	1.2×10^{-6}	1.2×10^{-6}	-	-	-	-	-	-
Borehole	Depth	29.0m	35.0m	41.0m	47.0m	-	-	-	-
No. 3	K	3.5×10^{-6}	3.5×10^{-6}	3.5×10^{-6}	1.2×10^{-6}	-	-	-	-
Borehole	Depth	15.0m	21.0m	27.0m	30.0m	33.0m	39.0m	42.0m	45.0m
No. 4	K	1.2×10^{-6}	1.2×10^{-6}	1.2×10^{-6}	2.3×10^{-6}	2.3×10^{-6}	1.2×10^{-6}	1.2×10^{-6}	1.2×10^{-6}

Note: K means "Coefficient of Permeability" whose unit is cm/sec.

Physical characteristics of the loam are as shown in Table 9.3.2 based on laboratory analysis.

Table 9.3.2 Physical Characteristics of the Loam at the Karasai Disposal Site

Indices	Type of Soil	Unit	Number of Samples	Maximum	Minimum	Average	Confidence Limit		Coefficient of Variation
							85%	95%	
Plastic Limit, W_p	Above 762m	%	21	19.2	15.9	17.3			
	Blow 762m	%	26	18.1	16.3	17.3			
Plasticity Index, PI	Above 762m	%	21	11.9	7.9	8.7			
	Blow 762m	%	26	11.6	8.1	9.2			
Water Content, W_n	Above 762m	%	21	30.5	13.8	21.4			
	Blow 762m	%	26	23.3	16.2	20.5			
Liquid Index, I_L	Above 762m	-	21	0.95	-0.34	0.47			
	Blow 762m	-	26	0.63	-0.16	0.37			
Degree of Saturation, S_r	Above 762m	%	21	100	95.1	99			
	Blow 762m	%	26	100	97.3	99.8			
Void Ratio, e	Above 762m	-	21	0.814	0.352	0.56			
	Blow 762m	-	26	0.607	0.417	0.536			
Unit Weight, γ_m	Above 762m	t/m^3	21	2.27	1.95	2.10	2.09	2.08	0.02
	Blow 762m	t/m^3	26	2.22	2.06	2.12	2.11	2.10	0.02
Dry Unit Weight, γ_d	Above 762m	t/m^3	21	2.0	1.49	1.73			
	Blow 762m	t/m^3	26	1.91	1.68	1.76			
Modulus of Deformation, E	Above 762m	MPa	7	6.0	3.3	4.6			
	Blow 762m	Mpa	7	5.8	3.7	4.7			
Specific Cohesion, C_V	Above 762m	KPa	6	40	10	22	14	10	0.2
	Blow 762m	KPa				38	30	26	0.17
Angle of Internal Friction, θ	Above 762m	degree	6	24	19	22	21	20	0.05
	Blow 762m	degree				23	22	21	0.05

In addition, results of grain size analysis are presented in Table 9.3.3, and the results show that the loam is categorized into clay or silty clay.

Table 9.3.3 Results of Grain Size Analysis at the Karasai Disposal Site

Borehole No.	Depth (m)	Quantity (%)					
		200-0.25 mm	0.25-0.1 mm	0.1-0.05 mm	0.05-0.01 mm	0.01-0.005mm	<0.005 mm
No. 1	4.0	-	-	22.2	45.0	13.2	19.6
	13.0	-	-	22.2	45.3	13.5	19.0
	25.0	-	-	13.8	51.3	13.7	21.2
No. 2	2.2	-	3.0	9.2	52.5	11.0	24.3
	11.0	-	-	14.8	49.8	16.4	19.0
	21.0	-	-	11.1	47.6	16.4	24.9
	27.0	-	0.5	11.7	47.6	15.3	24.9
No. 3	23.0	-	-	17.5	47.6	15.3	19.6
	29.0	-	-	17.5	47.6	15.3	19.6
	38.0	-	-	6.9	47.7	16.8	28.6
No. 4	27.0	-	-	20.1	46.6	11.6	21.7
	33.0	-	-	20.1	52.4	9.5	18.0
	42.0	-	-	15.9	55.0	13.2	15.9

9.3.2 Calculation and Determination of Facility Dimension

1) Access Road

The planned access road will use the existing site road. The bearing capacity of the access road is planned to be 10 tons of axle load. Final approach to the landfill site and site for the ponds will be reconstructed to improve accessibility. The design width of the access road is 7 m in accordance with Kazakh standards.

2) Dike (Retaining Structure)

The retaining structure is planned to be placed at the downstream of a leachate retention pond and a leachate treatment pond. The dike is designed to be of trapezoidal section with the following basic dimensions:

- Width of top: 5 m (Downstream of the retention pond) and 2 m (Downstream of the treatment pond)
- Gradient of slope: 1:3

Material of dikes should be selected to ensure stability at low cost. From this viewpoint, it is desirable that materials should be acquired from the landfill site. However, the excavated loam are unsuitable to use as dike material because it contains too fine materials according to the results of the grain size analysis. Therefore, the site soils should be adopted with a mixture of coarse materials, such as sand and gravel, whose grain size is to be between 0.1 and 150 mm.

It is necessary to provide a lining on the surface of the retention pond to prevent or reduce contamination of the groundwater by leachate since the groundwater has been polluted by leachate. Synthetic membrane like a HDPE (high density polyethylene) sheet will be used for the liner system.

3) Leachate Collection Facility and Gas Exhaust Equipment

The leachate collection facility and the gas exhaust equipment have the following functions:

(1) To supply air into the solid waste layer to facilitate aerobic decomposition;

(2) To discharge gaseous substances generated in the solid waste layer; and

(3) To collect and take out leachate from the solid waste layer to a leachate retention pond by the horizontal and vertical drain network.

To perform these functions, vertical gas exhaust equipment and horizontal underdrains will be installed beside the network. The gas exhaust equipment and underdrains are composed of porous materials, such as crushed stone and porous PVC (polyvinyl chloride) pipes. In this case, the gas exhaust equipment consists of crushed stone installed in wire baskets. Underdrains consist of porous PVC pipes imported from the outside of Kazakhstan.

The diameter of collection and drainpipes for leachate is determined as follows.

(1) Conditions for Calculation

Discharge Volume of Leachate (Q)

The discharge volume of leachate is derived from the following equation (Rational Formula):

$$Q = (1/360) \times C \times I \times A \qquad \text{Equation (1)}$$

Where,

Q : Discharge volume of leachate (m^3/sec)
C : Seepage coefficient = 0.5
I : Rainfall intensity = 20 mm/hr
(This rainfall intensity was assumed from available precipitation records in the last ten years, i.e., 1988-1997.)
A : Landfill area covered by drainpipes (ha)

Flow Capacity (Q')

Flow capacity is derived from the following equation (Manning's formula):

$$V = (1/n) \times R^{2/3} \times T^{1/2} \qquad \text{Equation (2)}$$

$$Q' = V \times A \qquad \text{Equation (3)}$$

Where,

Q': Flow capacity (m^3/sec)
N : Roughness coefficient = 0.009 for PVC pipe
R : Hydraulic radius (m)
T : Pipe slope
A : Cross sectional area of the pipe (m^2)
V : Flow velocity (m/sec)

When effective cross section area ratio of the pipe is 100%, Equations (2) and (3) are derived from the following equation:

$$Q' = (1/0.009) \times (D/4)^{2/3} \times T^{1/2} \times (D^2 \times 3.14) / 4 \qquad \text{Equation (4)}$$

Where, D : Diameter of pipe (m)

(2) Calculation Results

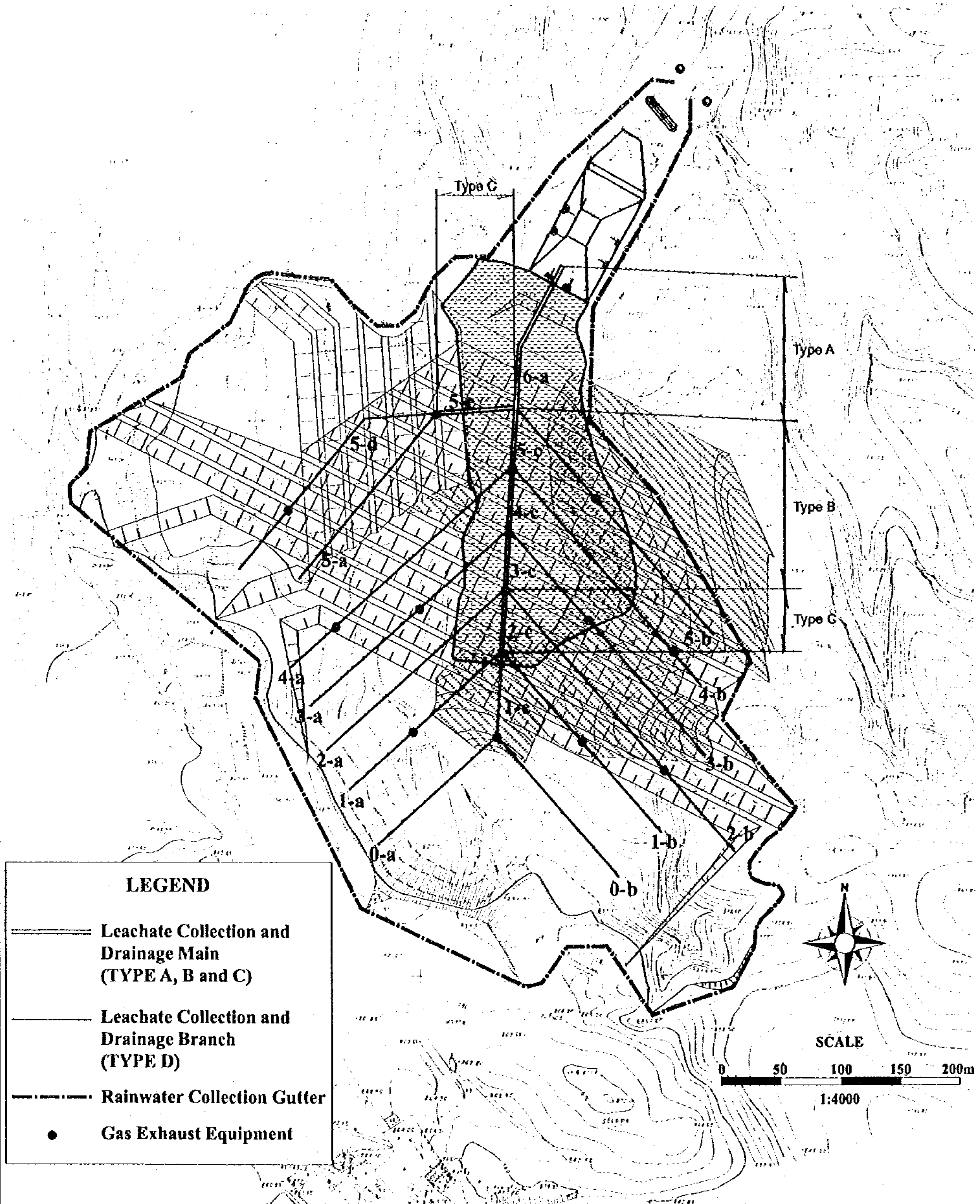
Pipe diameter (D) is determined as Q × P (where P is the number of pipes per line), assuming that the flow capacity (Q') is more than the discharge volume of leachate (Q). It is assumed that the diameter of the PVC pipe available in Kazakhstan is less than 400 mm. Additionally, the minimum diameter of the pipe should be 200 mm to prevent from blockage. The calculation results are shown in Table 9.3.4 below, and layout of the leachate collection pipes and the structure are illustrated in Figure 9.3.1.

Layout of the gas exhaust equipment is also shown in Figure 9.3.2. The number of gas extraction wells is determined as one well per approximately 1 to 1.5 hectares based on the other project experiences.

Table 9.3.4 Diameter of Leachate Collection Pipe

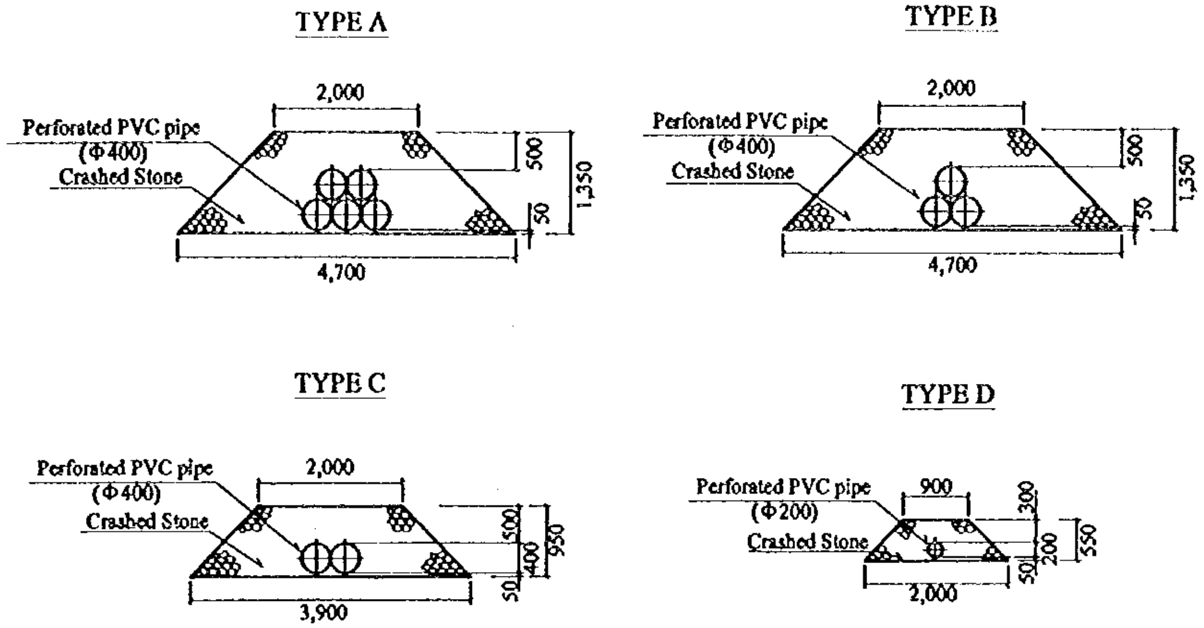
No. of Drain Line	Discharge Volume of Leachate Q (m^3/sec)	Pipe Slope T (-)	Diameter of Pipe D (mm)	Number of Pipes per Line P (pipes/line)	Flow Capacity Q' (m^3/sec)	Type of Drain*
0-a	0.060	0.148	200	1	0.182	D
0-b	0.029	0.071	200	1	0.126	D
1-a	0.021	0.32	200	1	0.268	D
1-b	0.033	0.18	200	1	0.201	D
1-c	0.194	0.51	200	1	0.338	D
2-a	0.026	0.275	200	1	0.248	D
2-b	0.035	0.20	200	1	0.212	D
2-c	0.260	0.002	400	2	0.268	C
3-a	0.026	0.217	200	1	0.221	D
3-b	0.019	0.18	200	1	0.201	D
3-c	0.313	0.002	400	3	0.402	B
4-a	0.018	0.232	200	1	0.228	D
4-b	0.021	0.18	200	1	0.201	D
4-c	0.364	0.002	400	3	0.402	B
5-a	0.028	0.239	200	1	0.231	D
5-b	0.030	0.154	200	1	0.186	D
5-c	0.398	0.002	400	3	0.402	B
5-d	0.062	0.176	200	1	0.199	D
5-e	0.204	0.176	200	2	0.268	C
6-a	0.602	0.002	400	5	0.670	A

Note: * Type of drain is shown in Figure 9.3.1.



LAYOUT PLAN OF LEACHATE COLLECTION AND DRAINAGE SYSTEM

LEACHATE DRAIN (1:100)



LEACHATE RETENTION POND
(STANDARD SECTIONAL VIEW)

(SCALE=NONE)

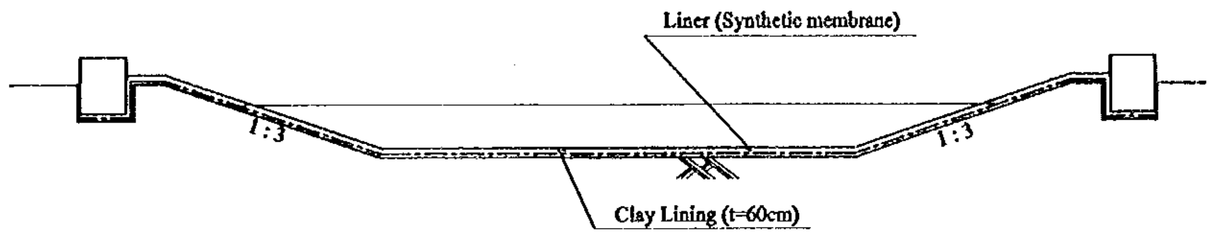


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Figure 9.3.1 **Leachate Collection and Drainage System of the Karasai Dispoal Site Improvement Work**
SCALE: 1 : 4000, 1:100
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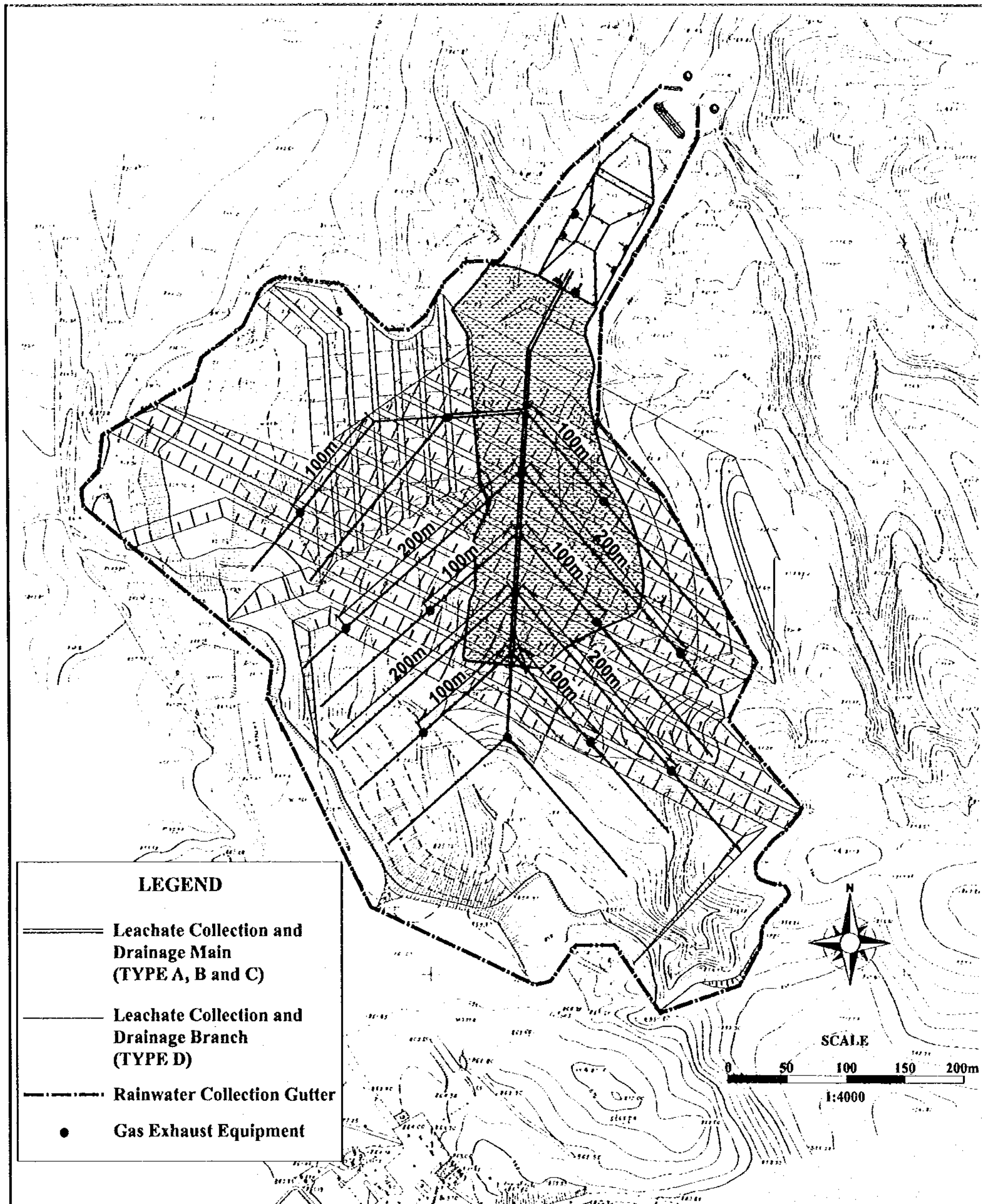

LAYOUT PLAN OF GAS EXHAUST EQUIPMENT

GAS EXHAUST EQUIPMENT(1:50)

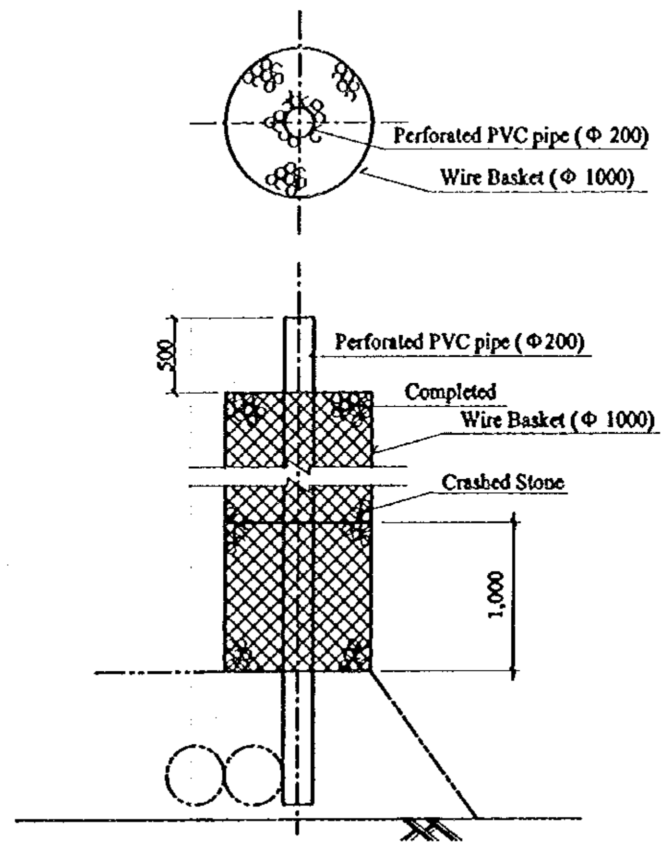

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Figure 9.3.2 Gas Exhaust Equipment of the Karasai Dispoal Site Improvement Work	
SCALE	1 : 4000, 1:50
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