4) Retention Pond and Leachate Treatment Facility

(1) Quantity of Leachate

The retention and the treatment ponds are designed to confine leachate water. These facilities are expected to confine the leachate even in rainy and snow melting season. Therefore, their sizes should be determined to have enough capacity to contain the leachate without discharging the untreated leachate.

The characteristics of precipitation and evaporation in Karasai area are summarized in Table 9.3.5 and Table 9.3.6, respectively. The quantity of leachate is related to the meteorological parameters, as derived from the following equations:

$$Q_0 = 0 \quad \text{Equation (5)}$$

$$Q_n = \{(C_0 \times A_0 + C_1 \times A_1) \times I_n - A_0 \times E_n\}/1000 + Q_{n-1} \quad \text{Equation (6)}$$

Where,

- n : n-th day from the beginning of rainy or snow melting season (April)
- Q_n: Quantity of confined leachate in ponds at the end of the n-th day
- I_n : Precipitation intensity during the n-th day
- E_n : Evaporation intensity during the n-th day
- A_0: Area of retention pond and treatment pond, assumed at 5,000 m^2
- A_1: Landfilling area, assumed at 150,000 m^2
- C_0: Leachate production rate out of rainfall at pond area, set at 1.0
- C_1: Leachate production rate out of rainfall at landfilling duration area, set at 0.61 according to Table 9.3.7.

Table 9.3.5 Monthly Precipitation by Uzun-Agach[*1] Meteorological Station, Almaty Oblast from 1988 to 1997

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1988	25.0	22.2	27.1	62.4	94.3	38.5	133.4	19.6	28.9	36.3	17.8	37.4	542.9
1989	22.0	24.8	20.0	50.7	55.5	13.4	35.1	23.9	27.0	45.4	38.1	38.9	394.8
1990	31.3	9.1	42.6	100.1	60.4	29.9	45.8	25.9	1.3	53.7	55.5	16.1	471.7
1991	27.7	24.8	23.1	10.0	20.6	39.8	34.1	22.0	0.3	16.2	17.2	44.0	279.8
1992	11.9	25.9	39.0	86.9	104.7	78.9	23.5	52.3	22.9	16.1	6.9	59.3	528.3
1993	11.8	46.3	87.5	61.5	61.2	115.7	79.4	19.3	22.1	15.1	75.5	34.4	629.8
1994	25.4	30.8	40.8	161.6	70.3	19.5	19.1	18.2	6.0	3.5	73.6	51.1	519.9
1995	13.1	26.0	47.9	1.7	50.9	4.9	63.3	42.2	17.6	60.6	23.7	19.3	371.2
1996	20.1	41.8	52.9	127.3	80.7	37.5	56.1	4.6	29.5	32.7	28.6	17.2	529.0
1997	42.5	23.5	19.9	39.9	122.7	19.3	19.6	8.6	0.4	5.8	64.6	24.5	391.3
Ave.[*2]	23.1	27.5	40.1	70.2	72.1	39.7	50.9	23.7	15.6	28.5	40.2	34.2	465.9

Source: Republican Fund of Hydrometeorology and Environmental Pollution

Note: [*1] Uzun-Agach is located in 15 km southwest of the Karasai disposal site, which is the close observation point from the site.

[*2] The number of precipitation day in a month.

Table 9.3.6 Evaporation (mm/day) by Aidarly[*1] Meteo Station, Almaty Oblast in 1993

Average period	Evaporation (mm/day)	Air temperature (°C)	Wind velocity (m/sec)	Precipitation sum (mm)
April				
I (1 - 10)	3.0	11.0	0.9	-
II (11 - 20)	4.1	12.8	2.1	28.7
III (21 - 30)	4.4	13.8	2.3	8.2
Month	-	-	-	-
May				
I (1 - 10)	4.2	11.9	1.5	11.6
II (11 - 20)	5.3	13.7	1.1	0.0
III (21 - 31)	4.6	18.2	1.5	26.8
Month	4.7	14.7	1.4	38.4
June				
I (1 - 10)	6.6	22.8	1.6	4.4
II (11 - 20)	8.8	24.6	1.7	7.3
III (21 - 30)	8.0	25.2	1.7	3.6
Month	7.8	24.2	1.7	15.3
July				
I (1 - 10)	8.6	27.0	1.6	9.9
II (11 - 20)	7.5	26.0	1.8	29.4
III (21 - 31)	8.2	24.8	2.2	13.9
Month	8.1	25.9	1.8	53.2
August				
I (1 - 10)	6.9	31.5	0.9	1.5
II (11 - 20)	7.2	23.7	1.7	18.7
III (21 - 31)	5.9	22.4	1.3	10.3
Month	6.7	22.5	1.3	30.5
September				
I (1 - 10)	6.6	17.4	1.5	0.0
II (11 - 20)	5.4	19.3	1.2	1.8
III (21 - 30)	4.1	13.7	1.3	17.6
Month	5.4	16.8	1.3	19.4
October				
I (1 - 10)	3.3	11.0	1.1	7.0
II (11 - 20)	2.7	11.3	1.0	-
III (21 - 31)	2.4	6.9	1.7	9.9
Month	-	-	-	-

Source: Republican Fund of Hydrometeorology and Environmental Pollution

Note: *1 Evaporation data in 1993 is only available as the latest records in the closest observation point, Aidarly, which is 50 km northwest from the Karasai disposal site. Evaporation data between November and March was not recorded, so that the evaporation rate during this period is assumed at 2.0 mm/day for simulation analysis.

Table 9.3.7 Leachate Production Rate out of Rainfall

Month	Temperature[*1] (°C)		Leachate Production Rate out of Rainfall in Sapporo[*2]	
	Sapporo	Almaty	C_1	C_2
Jan.	-4.6	-5.5	0.96	0.58
Feb.	-4.0	-5.1	0.89	0.53
Mar.	-0.1	1.9	0.72	0.43
Apr.	6.4	10.9	0.35	0.21
May	12.0	16.2	0.01	0.01
Jun.	16.1	21.1	0.23	0.14
Jul.	20.2	23.7	0.21	0.13
Aug.	21.7	22.2	0.57	0.34
Sep.	17.2	16.8	0.70	0.42
Oct.	10.8	9.1	0.81	0.49
Nov.	4.3	1.8	0.90	0.54
Dec.	-1.4	-3.1	0.96	0.58
Year	8.2	9.2	0.61	0.37

Source: [*1] Maruzen, "Rika Nenpyo," *Chronological Scientific Tables 1998*, edited by National Astronomical Observatory, Tokyo, Japan, 1997.

[*2] Japan Waste Management Association, "Explanation of Design Guidelines of Solid Waste Final Disposal Site," May 1993.

Note: C1: Rate of area to be landfill; C2: Rate of landfilled area

Under these circumstances, the leachate volume confined in the pond is calculated by daily simulation based on the meteorological data between 1988 and 1997. In these ten years, daily precipitation records in 1993 are used for the simulation since the year records indicate largest rainfall in ten years. The size of ponds are given in due consideration of the share of each facility component and topographic condition of the site.

The simulation result is summarized in Table 9.3.8 and daily fluctuation of leachate volume stored in the pond is shown in Figure 9.3.3. With three cases of simulation depending on the quantity of untreated leachate (T_c) per day, namely, T_c=0 m^3, T_c=100 m^3 and T_c=150 m^3, the maximum quantity of untreated leachate appears to be 52,794 m^3, 15,893 m^3 and 10,987 m^3, respectively.

Table 9.3.8 Quantity of Leachate Production and Capacity of Leachate Treatment

Month	Days in month	Precipitation* (mm/mo.)	Days of Precipitation in month*	Evaporation* (mm/mo.)	Maximum Quantity of Leachate		
					Untreated Leachate [Tc=0] (m^3)	Untreated Leachate [Tc=100] (m^3)	Untreated Leachate [Tc=150] (m^3)
Apr.	30	61.5	13	115.0	4,862	3,462	2,762
May	31	61.2	17	145.6	10,018	5,418	3,118
Jun.	30	115.7	17	234.0	20,046	12,937	10,237
Jul.	31	79.4	23	251.2	26,493	15,893	10,987
Aug.	31	19.3	10	205.9	27,492	15,752	10,402
Sep.	30	22.1	7	161.0	28,654	13,485	6,585
Oct.	31	15.1	8	86.4	29,710	11,828	3,413
Nov.	30	75.5	14	60.0	36,634	4,333	3,340
Dec.	31	34.4	14	60.0	39,643	4,947	3,268
Jan.	31	11.8	8	60.0	40,614	4,118	1,015
Feb.	28	46.3	17	60.0	44,690	2,694	2,094
Mar.	31	87.5	17	60.0	52,794	5,184	4,084
Total	365	629.8	165	1,499.1	-	-	-
Max.	-	115.7	23	251.2	52,794	15,893	10,987

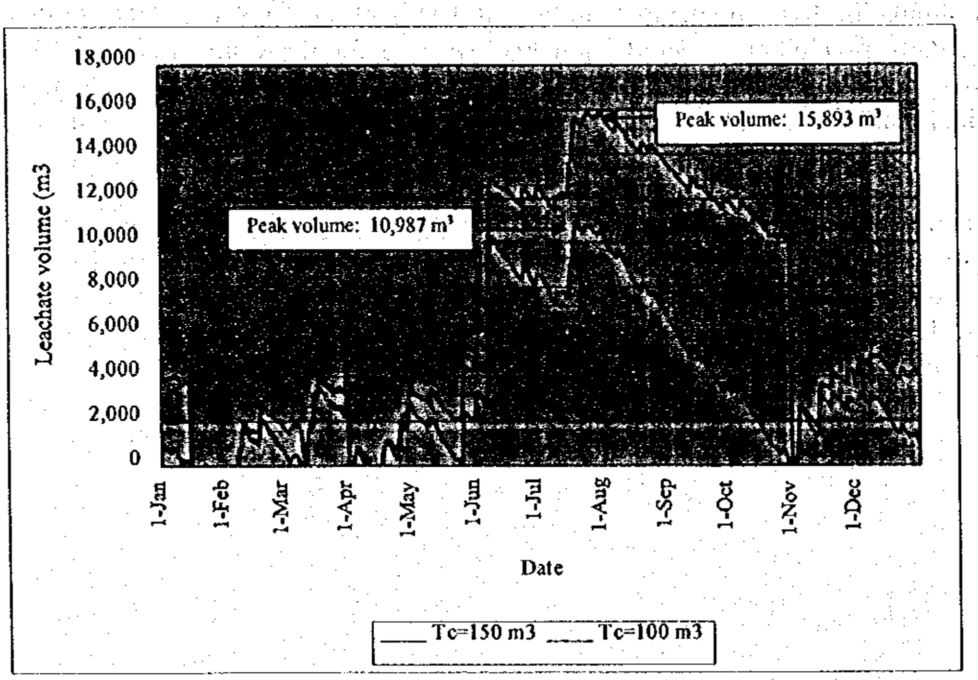


Figure 9.3.3 Daily Fluctuation of Leachate Volume Stored in the Retention Pond (Rainfall Pattern of 1993)

(2) Volume of Retention Pond

From the above simulation, the capacity of the leachate retention pond is to be set up at more than 16,000 m^3 if the volume of untreated leachate is 100 m^3/day. The dimension of the retention pond is set up as shown in Table 9.3.9 in consideration of topographical features of the site.

Table 9.3.9 Dimension of the Leachate Retention Pond

Bottom	Elevation	773 m
	Width	18.0 m
	Length	25.0 m
	Area	450 m^2
Top	Elevation	784 – 786.5m
	Width	40 – 45 m
	Length	98.5 m
	Area	4,186 m^2
Free board		1.0 m
Design Water Depth		10.0 m
Design Volume		16,500 m^3

(3) Volume of Treatment Pond

Volume of the treatment pond is determined to have enough capacity to satisfy aerobic treatment procedures. An aerobic pond is designed to receive a high organic loading that is completely devoid of dissolved oxygen. Retention time is planned to be five (5) days to treat the effluent from the retention pond. Thus, the required volume of the treatment pond is estimated at 100 m^3/day × 5 days = 500 m^3.

The design water depth of the treatment pond is set up at 50 cm to accelerate the oxidation process in the pond. The required area for the pond is thus estimated at 500 m^3 / 0.5 m = 1,000 m^2.

5) Rainwater Drainage

(1) Conditions for Calculation

Rainwater runoff (Q) is derived from Equation (1), and flow capacity of drainage gutters is also estimated by using Equations (2) and (3), both as stated earlier.

$Q = (1/360) \times C \times I \times A$ .... Equation (1)

Where,

Q : Rainwater runoff (m^3/sec)
C : Seepage coefficient = 0.5
I : Rainfall intensity = 20 mm/hr
A : Drainage area (ha)

$V = (1/n) \times R^{2/3} \times I^{1/2}$ .... Equation (2)

$Q' = V \times A$ .... Equation (3)

Where,

Q' : Flow capacity (m^3/sec)

N : Roughness coefficient = 0.03 for open channel
R : Hydraulic radius (m)
T : Channel slope
A : Cross sectional area of the channel (m^2)
V : Flow velocity (m/sec)

Drainage area covered by each channel or gutter and its length are estimated based on the topographic map and as shown in Table 9.3.10 below.

Table 9.3.10 Drainage Area and Channel Length

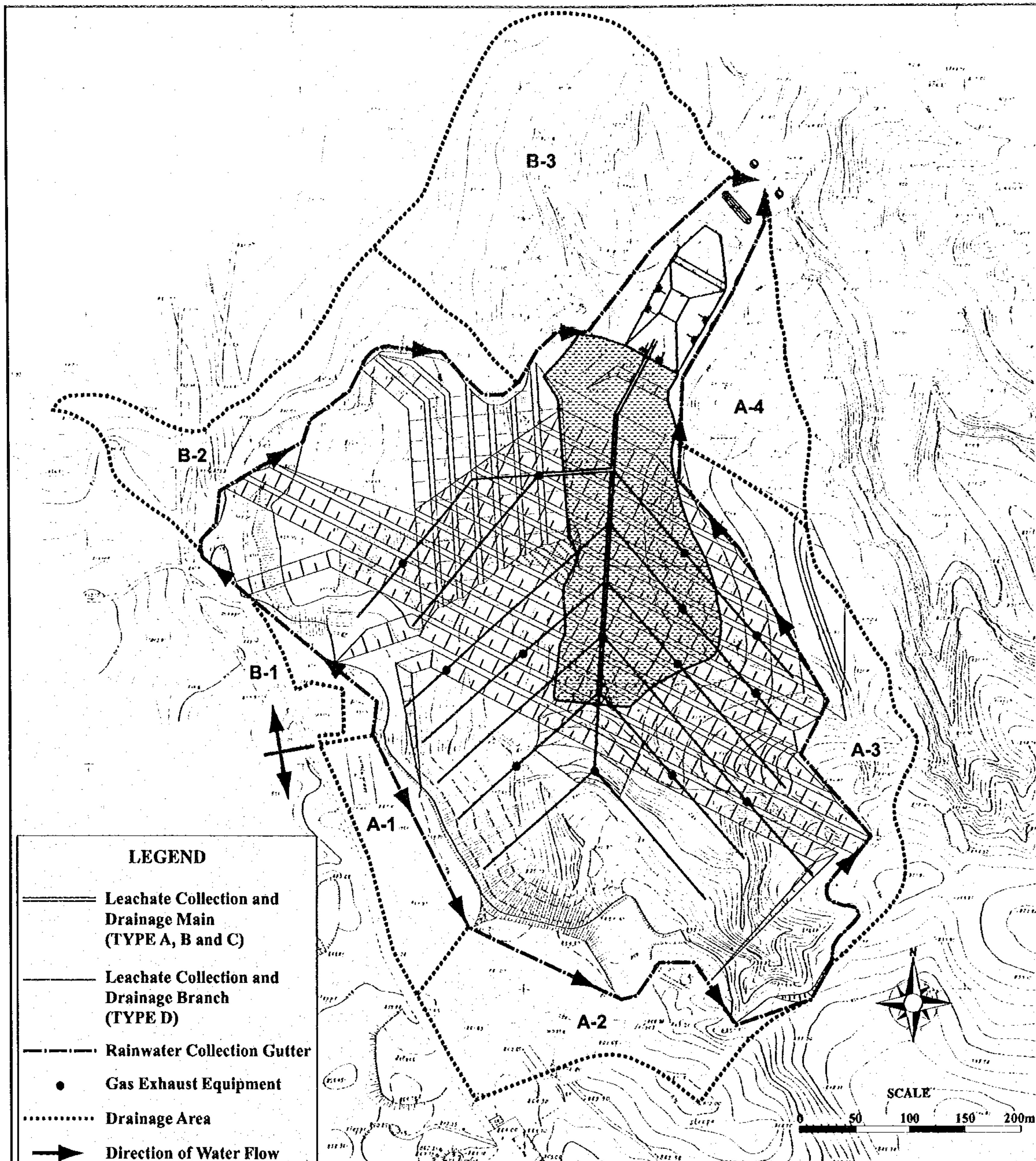
Channel Section	Channel Length (m)	Channel Slope	Drainage Area (ha)
A-1	195	0.010	1.280
A-2	383	0.024	2.715
A-3	620	0.084	2.676
A-4	246	0.093	1.720
B-1	236	0.064	0.324
B-2	423	0.092	2.760
B-3	312	0.100	6.014

(2) Calculation Results

The size of channel is determined by comparing Flow Capacity (Q') to Rainwater Runoff (Q). The Flow Capacity (Q') of the channel must be larger than the Rainwater Runoff (Q). The calculation results are as shown in Tables 9.3.11, and layout of the rainwater drainage is illustrated in Figure 9.3.4

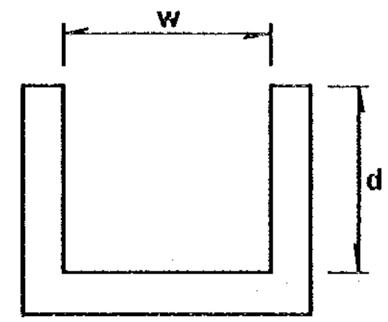
Table 9.3.11 Dimensions of Gutter

Channel Section	Rainwater Runoff (m^3/s)	Flow Capacity (m^3/s)	Width of Gutter (mm)	Depth of Gutter (mm)
A-1	0.036	0.039	300	300
A-2	0.075	0.150	400	400
A-3	0.185	0.186	350	350
A-4	0.233	0.297	400	400
B-1	0.009	0.098	300	300
B-2	0.086	0.118	300	300
B-3	0.253	0.308	400	400



LAYOUT PLAN OF RAINWATER COLLECTION GUTTER

CROSS SECTION OF GUTTER



Channel Section	Channel Length (m)	Channel Slope	Drainage Area (ha)	w (mm)	d (mm)
A-1	195	0.010	1.280	300	300
A-2	383	0.024	2.715	400	400
A-3	620	0.084	2.676	350	350
A-4	246	0.093	1.720	400	400
B-1	236	0.064	0.324	300	300
B-2	423	0.092	2.760	300	300
B-3	312	0.100	6.014	400	400

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MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT PROTECTION
ALMATY CITY GOVERNMENT

THE STUDY ON SOLID WASTE MANAGEMENT FOR ALMATY CITY IN THE REPUBLIC OF KAZAKHSTAN

Figure 9.3.4
Layout Plan of Rainwater Collection Gutter of the Karasai Dispoal Site Improvement Work

SCALE	1 : 4000

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9.3.3 Layout of the Facility

Layout plan and cross section of the Karasai disposal site are designed as shown in Figures 9.3.6 and 9.3.7, respectively.

9.3.4 Design Landfill Capacity and Useful Life

The elevation of final cover is set at 860 m taking into consideration the surrounding topographical features. The design landfill capacity is thus calculated at 3,991,900 m^3. The relationship between the elevation and design landfill volume is shown in Figure 9.3.5. This capacity is enough to store the total amount of solid waste carried in the site until 2010, which is calculated at 3,956,483 m^3. On the basis of this calculation, the useful life of the disposal site is extended until the beginning of year 2011.

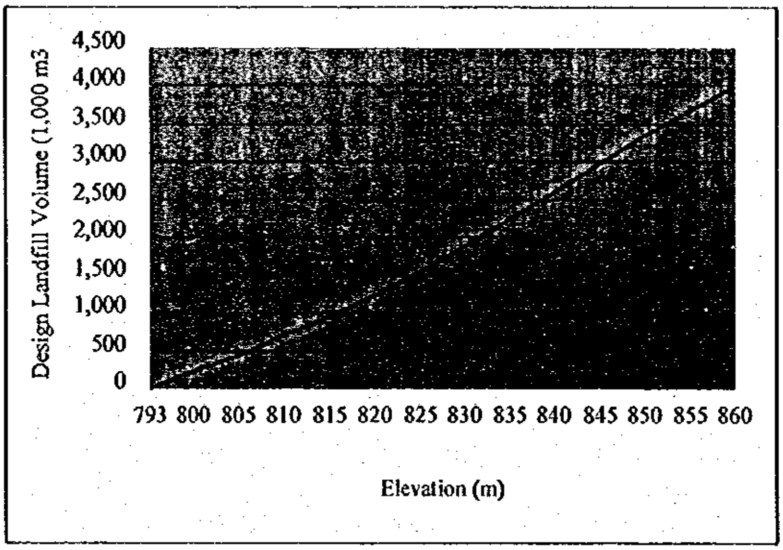
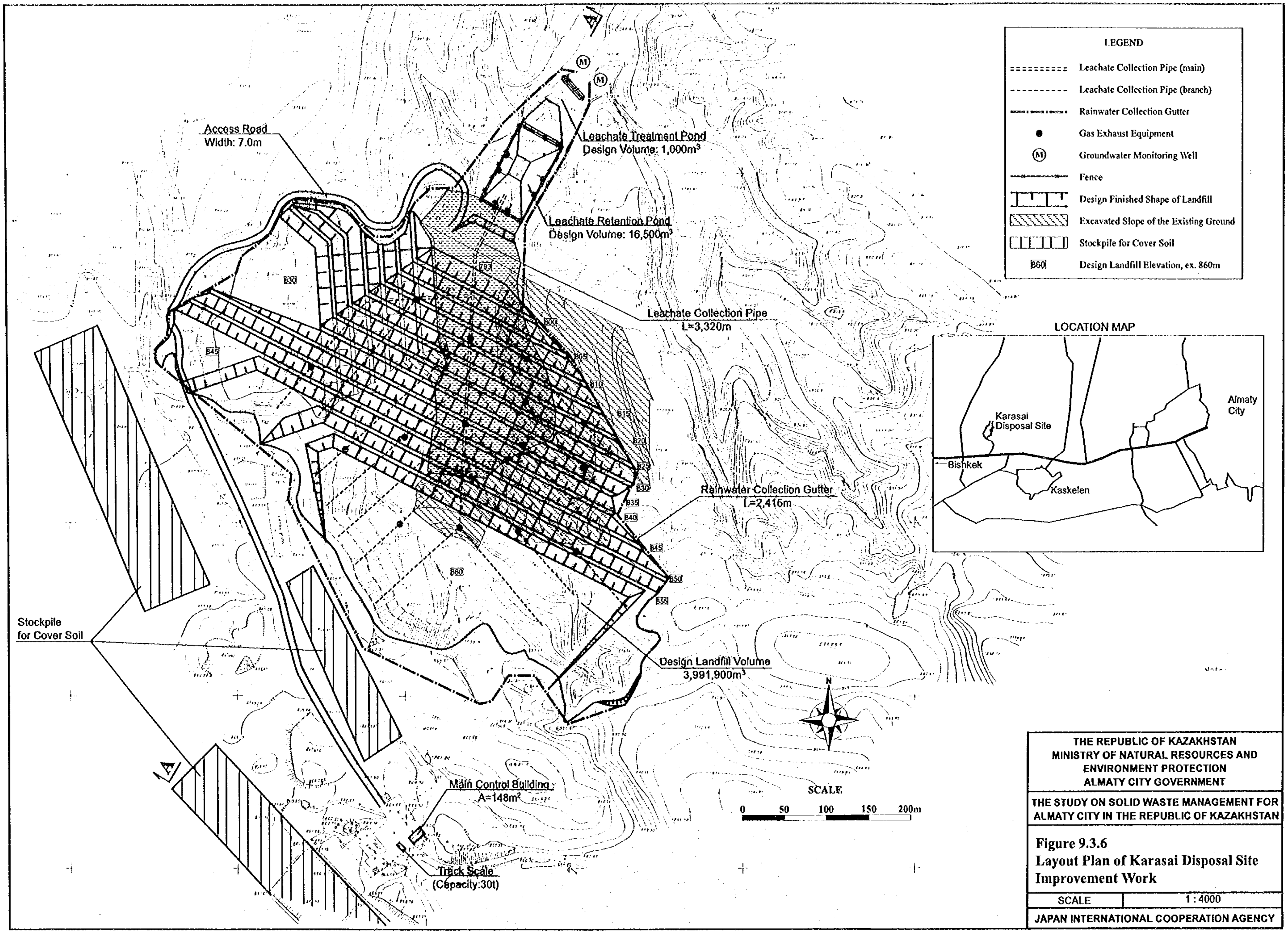


Figure 9.3.5 Relationship between Elevation and Design Landfill Volume of Karasai Disposal Site



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ALMATY CITY GOVERNMENT

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Figure 9.3.6
Layout Plan of Karasai Disposal Site Improvement Work

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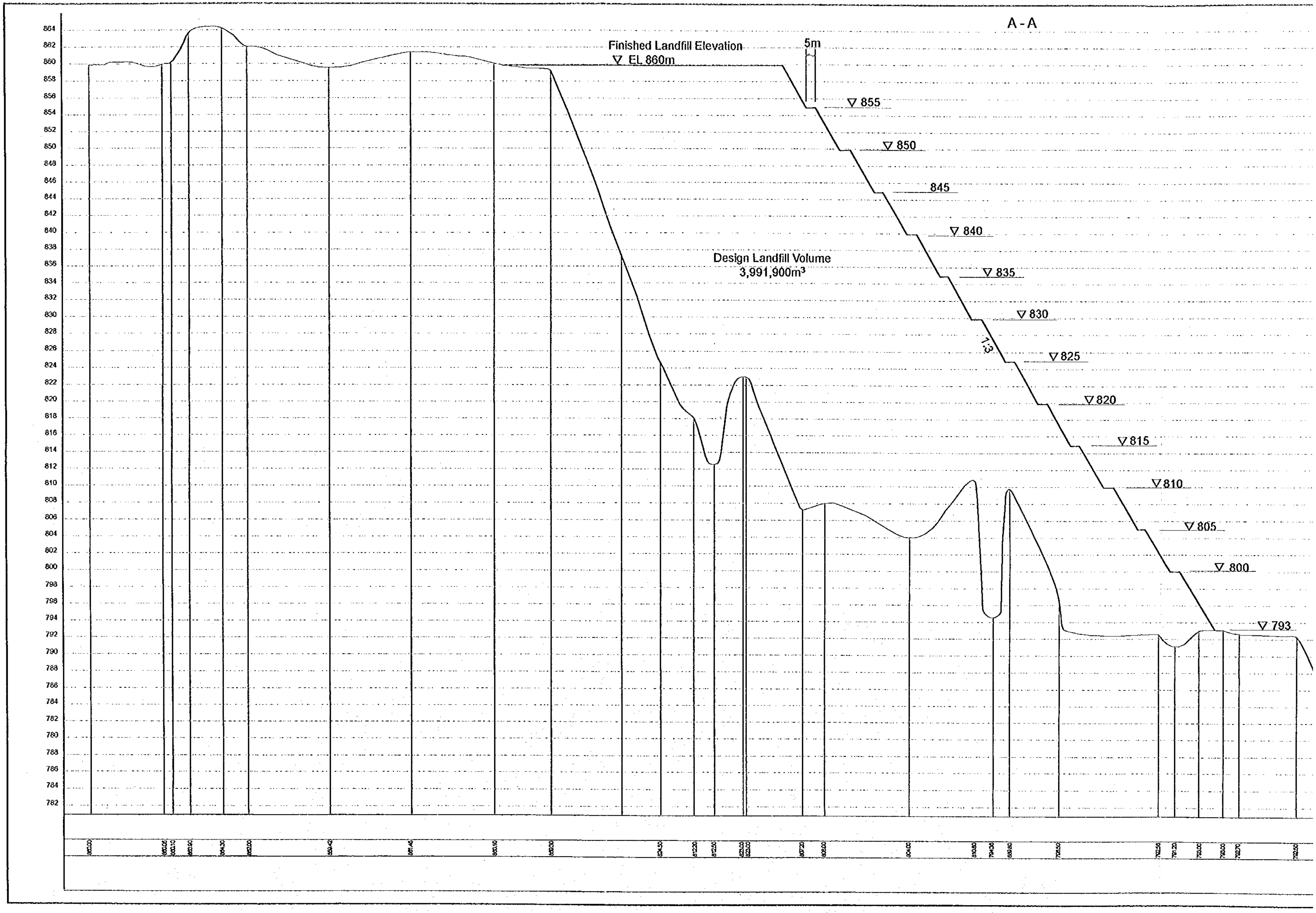

A - A
Finished Landfill Elevation
▽ EL 860m
5m
▽ 855
▽ 850
845
▽ 840
▽ 835
▽ 830
1:3
▽ 825
▽ 820
▽ 815
▽ 810
▽ 805
▽ 800
▽ 793
Design Landfill Volume
3,991,900m³
864
862
860
858
856
854
852
850
848
846
844
842
840
838
836
834
832
830
828
826
824
822
820
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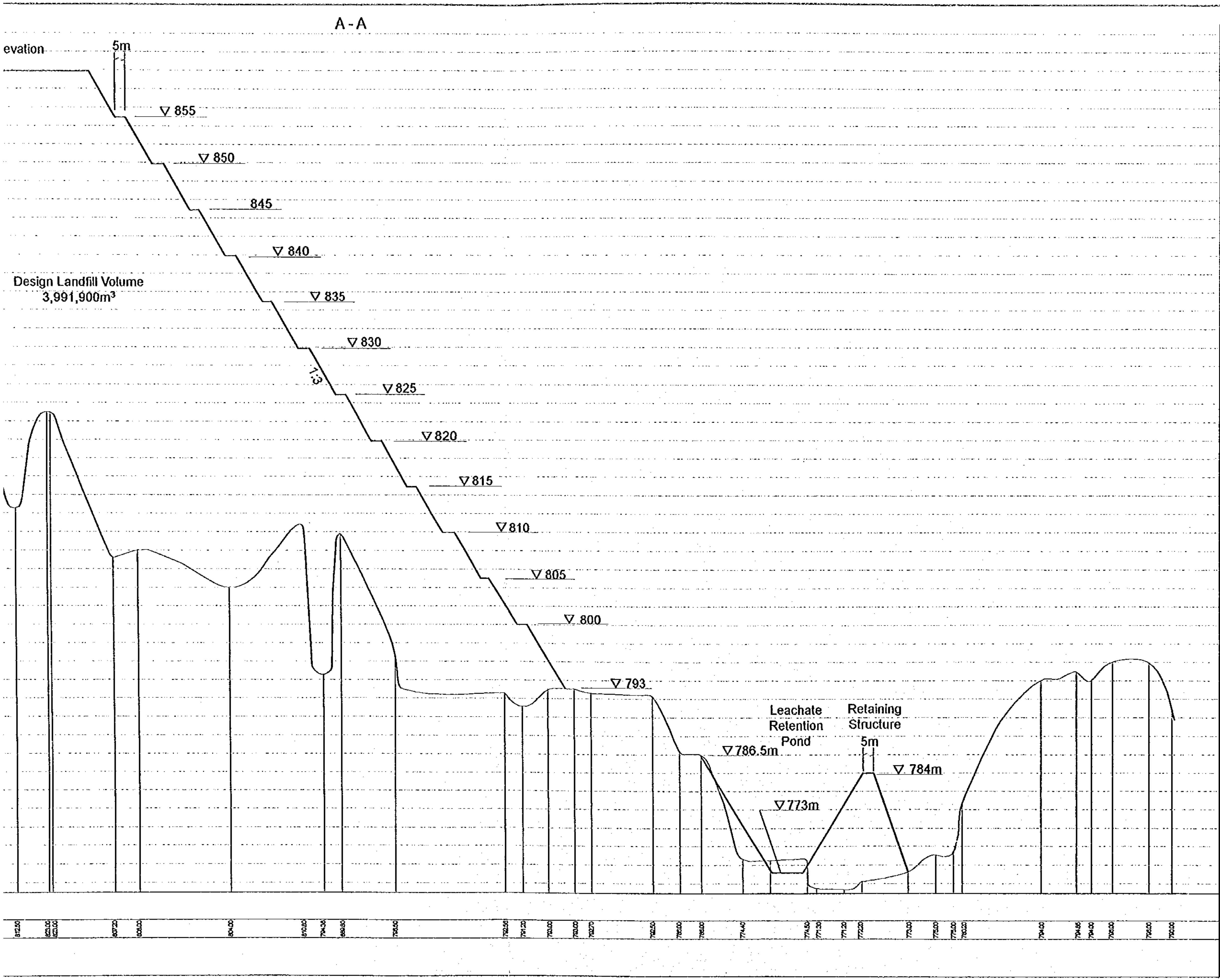
786
784
782
780



Horizontal 1/2000
Vertical 1/400

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ALMATY CITY GOVERNMENT

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Figure 9.3.7
Longitudinal Section of Karasai Disposal Site Improvement Work

SCALE	H 1 : 2000, V 1:400

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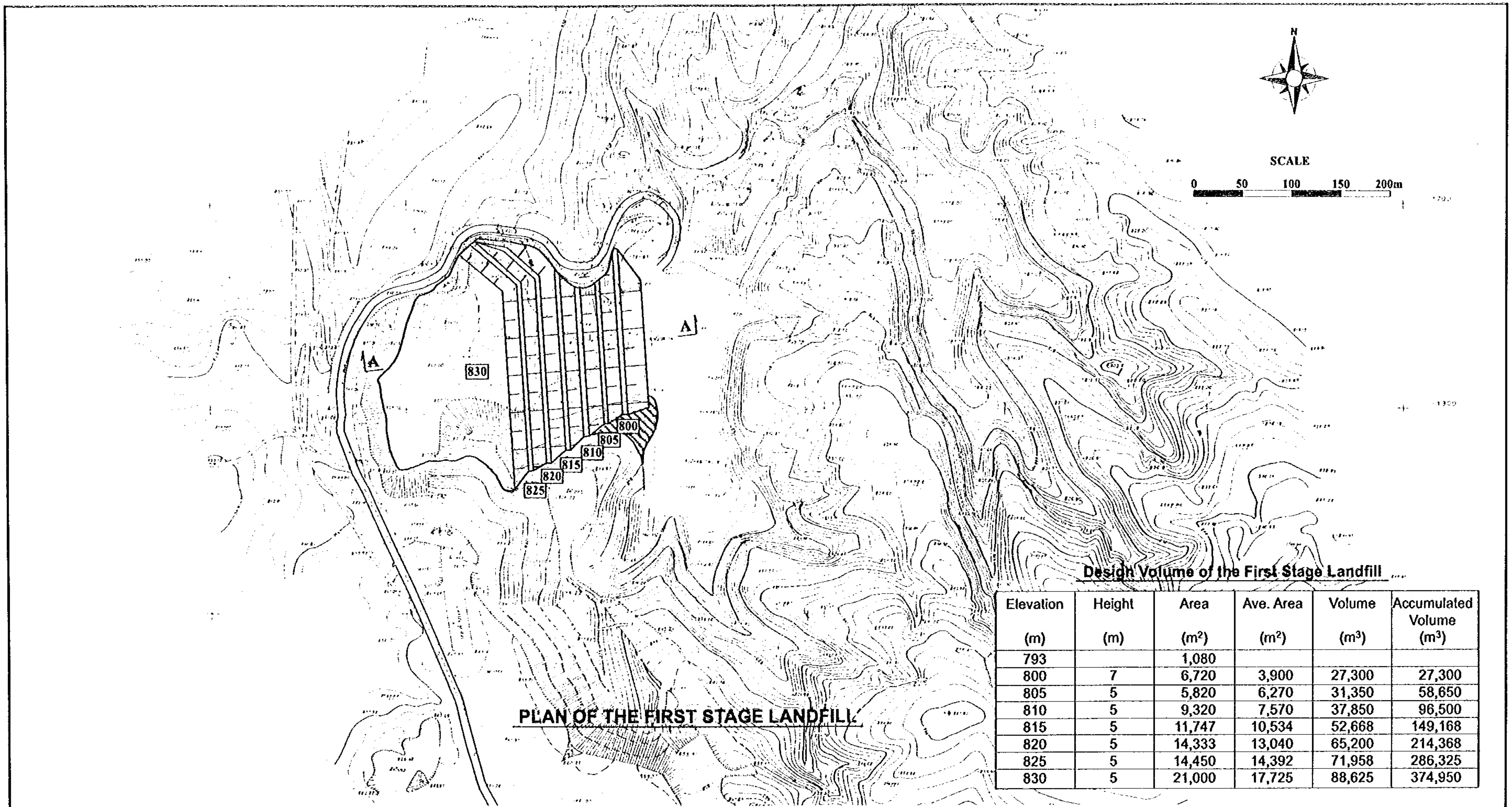
9.4 CONSTRUCTION SCHEDULE AND COST ESTIMATE

9.4.1 Construction Schedule

The new collection and transportation system will be operated from year 2002; simultaneously the sanitary landfill operation should be started using heavy equipment. Therefore, within year 2002 the improvement work of the site, which takes more than 8 or 9 months, should be completed.

On the other hand, the present landfill operation will have been continued until the heavy equipment is procured. The existing operating equipment in the site is assumed to be 2 bulldozers, 1 excavator and 2 dump trucks.

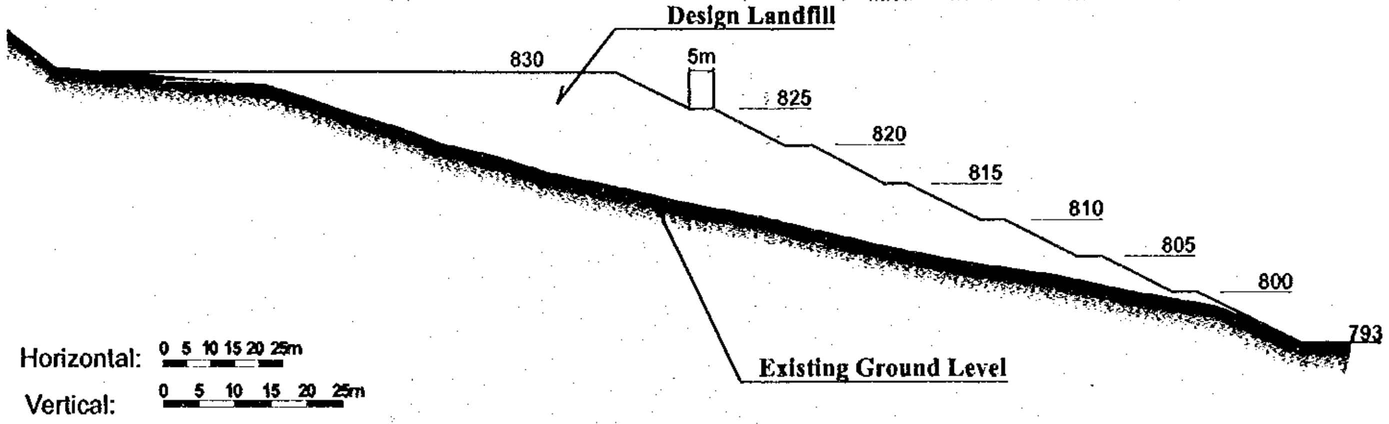
Before starting the landfill operation by the new heavy machine and equipment procured in 2002, incoming solid waste is planned to be filled at the western side of the site up to the elevation of 830 m. This first stage of landfill plan is shown in Figure 9.4.1.



PLAN OF THE FIRST STAGE LANDFILL

Design Volume of the First Stage Landfill

Elevation (m)	Height (m)	Area (m^2)	Ave. Area (m^2)	Volume (m^3)	Accumulated Volume (m^3)
793		1,080			
800	7	6,720	3,900	27,300	27,300
805	5	5,820	6,270	31,350	58,650
810	5	9,320	7,570	37,850	96,500
815	5	11,747	10,534	52,668	149,168
820	5	14,333	13,040	65,200	214,368
825	5	14,450	14,392	71,958	286,325
830	5	21,000	17,725	88,625	374,950



CROSS SECTION (A-A)

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Figure 9.4.1
First Stage(Year 2000-2001) of Landfill Plan of the Karasai Disposal Site Improvement Work

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9.4.2 Cost Estimate

1) Capital Investment

The capital cost for the improvement work is estimated at KZT874,524,000 (US$7,604,557) based on the local conditions. Major work items and each cost are as shown in Table 9.4.2.

2) Annual Disposal Expenditure

The annual expenditure for the improvement work, including procurement cost for heavy equipment described in the following Chapter 10, is estimated as shown in Table 9.4.1.

Table 9.4.1 Annual Expenditure for the Karasai Disposal Site Improvement Work

Year	Cost (Thousand KZT)				
	Design*	Construction	Heavy equipment	O/M Cost	Total Cost
2000	12,439			22,912	35,351
2001	43,726		248,784	22,912	315,422
2002		874,524		64,645	939,169
2003				188,091	188,091
2004				188,091	188,091
2005	1,691			188,091	189,782
2006			33,816	188,091	221,907
2007				198,808	198,808
2008				198,808	198,808
2009				198,808	198,808
2010				198,808	198,808
Total	57,856	874,524	282,600	1,658,065	2,873,045

Note: *Design cost is estimated at 5% of the construction or heavy equipment costs.

Table 9.4.2 Cost for the Karasai Disposal Site Improvement Work

Work	Item	Unit	Quantity	Unit Price (KZT)	Amount (thousand KZT)	Remarks
Preparatory Work	Excavation	m^3	378,500	1,200	454,200	
	Slope adjusting	m^2	71,300	420	29,946	
	Intermediate clay laying	m^3	37,200	800	29,760	
Sub total		LS			513,906	
Waste Retaining Structure	Banking	m^3	720	1,850	1,332	
	Side slope adjusting	m^2	650	420	273	
Sub total		LS			1,605	
Retention Pond	Backfilling	m^3	12,790	1,850	23,662	
	Banking	m^3	16,400	1,850	30,340	
	Side slope adjusting	m^2	4,390	420	1,844	
	Liner laying	m^2	4,390	3,000	13,170	Synthetic membrane
	Clay laying	m^3	2,640	800	2,112	thickness: 60 cm
Sub total		LS			71,127	
Leachate Treatment Pond	Backfilling	m^3	1,200	1,850	2,220	
	Banking	m^3	140	1,850	259	
	Side slope adjusting	m^2	135	420	57	
	Clay laying	m^3	750	800	600	thickness: 60 cm
Sub total		LS			3,136	
Leachate Collection and Drainage	Piping work (Type A)	m	50	35,000	1,750	D400mm, n=5
	Piping work (Type B)	m	155	23,000	3,565	D400mm, n=3
	Piping work (Type C)	m	125	14,000	1,750	D400mm, n=2
	Piping work (Type D)	m	2,990	7,000	20,930	D200mm, n=1
Sub total		LS			27,995	
Rainwater Collection and Drainage	Gutter installation (300x300)	m	854	3,000	2,562	Concrete U-shape
	Gutter installation (350x350)	m	620	3,500	2,170	-ditto-
	Gutter installation (400x400)	m	941	4,000	3,764	-ditto-
Sub total		LS			8,496	
Gas Exhaust Equipment	Extraction well	nos.	13	80,000	1,040	
Access Road	On-site road construction	m	340	11,900	4,046	Crashed stone, t=300mm, w=7m
	Road improvement	m	120	40,600	4,872	Reconstruction
Sub total		LS			8,918	
Goundwater Monitoring Well		nos.	2	9,126,000	18,252	
Fence	Net fence installation	m	305	6,000	1,830	
Gate		nos.	1	292,500	293	
Administration Facilities	Main control building	m^2	148	44,100	6,527	Reconstruction
	Shelter for workshop	m^2	216	3,050	659	-ditto-
	Truck scale	nos.	1	5,850,000	5,850	30t
	Fuel warehouse	m^2	46	4,000	184	Reconstruction
	Toilet	nos.	1	148,000	148	-ditto-
	Stormwater retention	m^2	12	61,500	738	
	Sewage discharge pond	m^2	14	70,400	986	
	Shelter over the pit	m^2	144	7,100	1,022	For the biothermal dead animals pit
Sub total		LS			16,114	
Total		-	-	-	672,711	
Auxiliary Work		LS	1	-	201,813	30% of Total
Direct Cost Total		-			874,524	

Note: *This US dollar amount is indicated by applying currency exchange rate of US$1 = KZT115.

CHAPTER 10 DEVELOPMENT OF EQUIPMENT PLAN FOR IMPROVEMENT OF THE KARASAI DISPOSAL SITE

10.1 PLANNING POLICY

Waste disposal on a landfill site involves work on soft ground overlying the waste. It is therefore essential to select crawler type bulldozers with outstanding maneuverability as the main equipment. The auxiliary equipment should include an excavator. The waste carried by the waste transportation vehicles is dumped in the disposal yard and the damped waste is shoved and leveled by a bulldozer. Since the bulldozer travels on the waste, it will also have a compaction effect. The excavator is used for building the transportation route on the landfill waste and for ancillary jobs that are difficult to carry out with a bulldozer. In practice, the excavator is used for duties such as leveling of waste piles, transfer of waste on a large scale, building up of soil banks, building of a transportation route on the landfill waste, and for digging water drainage trenches on the landfill site.

To strip the topsoil it would be appropriate to use a bulldozer with ripper attachment for the excavation and collection of the topsoil. For the loading work wheel loaders should be used since they offer outstanding maneuverability in favorable ground conditions. It is planned to use dump trucks for loading and transportation.

Except for the short rainy periods, the ground at the site is extremely dry and spontaneous combustion normally can be seen here and there. It will therefore be necessary to adjust the moisture of the ground; that is, the topsoil and earth fill, during compaction and to sprinkle water on the access road on the site.

Most of the facilities and services on the site are provided by earthwork and construction work. The work can therefore be conducted gradually in accordance with the landfill zones that are being worked at any particular time. For this reason, it would also be possible to make use of the equipment normally employed for the topsoil work to perform the construction tasks.

10.2 PLANNING CRITERIA

The following planning criteria are applied in determining types and major specifications of the equipment required in the site.

10.2.1 Design Waste Amount to be Disposed

The design waste amount to be disposed is summarized in Table 9.2.1 in the previous Chapter.

10.2.2 Working Hours

It is assumed that waste collection starts at 7 in the morning and the trucks arrive at the landfill site around 9 a.m. Landfill disposal work is finished at 6 p.m., including the topsoil work.

Topsoil excavation and transportation begins when the waste disposal work on the landfill site is half-finished. The topsoil is dumped on the landfill waste. When the waste disposal on the landfill has been completed, the dumped topsoil is spread out and the ground is leveled. The working time is scheduled as shown in Table 10.2.1.

Table 10.2.1 Working Time Schedule

Time	8	9	10	11	12	13	14	15	16	17	18	Working Time
Waste disposal on landfill		━	━	━	━	━	Break	━	━			7 hours
Same-day topsoil coverage												3 hours
Soil excavation/ transportation									━	━		(2 hours)
Spreading out/ leveling										━		(1 hour)
Servicing (Earth/civil work)		━	━	━	━	━						5 hours

10.2.3 Availability of Heavy Equipment and Personnel

In view of the need for repair in case of breakdowns and maintenance/management and in view of a break for drivers, heavy equipment could not be operated at 100% of their capacity all the time. Based on the study results for similar projects, the availability factor for heavy equipment have been set up as follows:

Heavy equipment : 90%

For the personnel involved in the disposal work, a total of 7-day breaks in a month can be considered because of their holidays and leaves. Thus, the availability is:

Personnel : 80% (23 ÷ 30 = 0.8; 80%)

10.3 Calculation of the Required Quantities of Equipment

10.3.1 Alternatives 1 & 2 of the Master Plan

1) Landfill Equipment

(1) Bulldozers (21t)

- Scheduled work volume per day = Waste volume[1] + Topsoil volume[2]
  = 1,192.0 × (1 + 0.12) = 1,335 m^3/day
- Work volume per hour = 70 m^3/hr

[1] Waste volume is the total amount of solid waste that will be carried to the Karasai site in 2010.
[2] Topsoil volume is assumed at 12% of the waste volume.

The work volume per hour can be calculated as follows in accordance with the *Calculation Standards for Civil Engineering Work* by the Ministry of Construction of Japan. (These Standards also apply to the calculation below.)

1. Leveling of Ground

$$Q_1 = 10E(18D+13) = 10\times0.6\times(18\times0.30+13) = 110\ m^3/hr$$

where,
D: Finished thickness 0.30m (0.50m spreading thickness)

2. Compaction

$$Q_2 = (V\times W\times D\times E)/N = (3{,}500\times0.9\times0.30\times0.8)/4 = 189\ m^3/hr$$

where,
V: 3,500m/hr, W: 0.9m, D: 0.30m, E: 0.8, N: 4 times

3. Composite Work (1 and 2 above)

$$Q = (Q_1\times Q_2)/(Q_1+Q_2) = (110\times189)/(110+189) = 69.5\ m^3/hr \rightarrow \underline{70\ m^3/hr}$$

- Actual working time = 7 hr/day
- Work volume per day = 490 m^3/day
- Required number of bulldozers = 1,335 ÷ 490 ÷ 0.9 = 3.1; Say, 4 bulldozers

(2) Excavators (0.6m³)

Excavators are used to support the work of the bulldozers and are assigned to the following tasks:

a. Leveling out the waste piles that are difficult to spread with a bulldozer and transporting of waste on a large scale;
b. Finishing of banks (dam slopes) and compaction duties (Compacting banks with the bucket attachment.); and
c. Excavation of drainage trenches on the landfill site.

- Work volume per day = 50% of work volume = 1,335 × 0.5 = 668 m^3/day
- Work volume per hour = 60 m^3/hr.

Essentially used for excavation and loading work

$$Q_E = (3{,}600\times q\times f\times E)/Cm = (3{,}600\times0.59\times1.0\times0.8)/30 = 56.6\ m^3/hr \rightarrow \underline{60\ m^3/hr}$$

where,
q: 0.59 m^3, f: 1.0, E: 0.8, Cm: 30 sec

- Actual working time = 7 hr/day
- Work volume per day = 420 m^3/day
- Required number of excavators = 668 ÷ 420 ÷ 0.9 = 1.8;
  Say, 2 excavators

3) Water Tanker

The capacity of a water tanker is assumed at 6,000 to 8,000 liters, sprinkling width 4 m, and water supply 12 minutes.

- Scheduled work area per day = On site: 150,000m^2; On roads: 2 km
- Speed = 10 km/hr
- Sprinkling time per day = 150,000/4.0 + 2 km = 39,500 m = 39.5 km
  39.5/10 × 60 + 12 = 249 min.
  → 4 hours; 1 water tanker is enough.

2) Topsoil Stripping Equipment

(1) Bulldozers (21t)

- Scheduled work volume per day = 1,192.0 × 0.12 = 143 m^3/day
- Work volume per hour = 80 m^3/hr

1. Ripping Work

Q_R = (60×a×L×E)/Cm
= (60×0.40×20×0.60)/1.08
= 266.7 m^3/hr
where,
a: 0.40, L: 20m, E: 0.60
Cm: 1/24×L+0.25 = 1/24×20+0.25 = 1.08min

2. Excavation and counterweight filling work

Q_B = (60×q×f×E)/Cm
= (60×2.81×1.0×0.9)/1.33
= 114.1 m^3/hr
where,
q: 2.81m^3 (ground soil volume), f: 1.0, E: 0.9
Cm: 0.027×L+0.79 = 0.027×20+0.79 = 1.33min

3. Composite Work (1 and 2 above)

Q = $\{Q_R \times (Q_B + N \times Q_B)\}/(Q_R + Q_B)$
= (266.7×114.1)/(266.7+114.1)
= 79.9 m^3/hr →80 m^3/hr

- Actual working time = 2 hr/day
- Work volume per day = 160 m^3/day
- Required number of bulldozers = 143 ÷ 160 ÷ 0.9 = 1.0;
  Say, 1 bulldozer

(2) Wheel Loaders (2.0m³: for Loading work)

- Work volume per day = $1,192.0 \times 0.12 = 143$ m³/day
- Work volume per hour = 100 m³/hr

$$Q = (3,600 \times q \times f \times E)/Cm$$
$$= (3,600 \times 1.66 \times 1.0 \times 0.65)/40$$
$$= 97.1 \text{ m}^3/\text{hr} \rightarrow \underline{100 \text{ m}^3/\text{hr}}$$

where,
q: 1.66m³ (ground soil volume), f: 1.0, E: 0.65 (Cobble soil)
Cm: 40 sec

- Actual working time = 2 hr/day
- Work volume per day = 200 m³/day
- Required number of wheel loaders = $143 \div 200 \div 0.9 = 0.8$; Say, 1 excavator

(3) Dump Trucks (10t Class: for Transportation duties)

- Work volume per day = $1,192.0 \times 0.12 = 143$ m³/day
- Work volume per hour = 16 m³/hr

$$Q_B = (60 \times q \times f \times E)/Cm$$
$$= (60 \times 5.5 \times 1.0 \times 0.9)/18.4$$
$$= 16.1 \text{ m}^3/\text{hr} \rightarrow 16 \text{ m}^3/\text{hr}$$

where,
q: 5.5m³ (ground soil volume)
$\gamma = 1.8$t/m³ (ground soil volume Compacted soil volume)
f: 1.0, E: 0.9, Cm: $4.8 \times L + \alpha = 4.8 \times 0.5 + 16 = 18.4$ min

- Actual working time = 2 hr/day
- Work volume per day = 32 m³/day
- Required number of wheel loaders = $143 \div 32 \div 0.9 = 5.0$; Say, 5 dump trucks

10.3.2 Alternative 3 of the Master Plan

1) Landfill Equipment for the Karasai Site

(1) Bulldozers (21t)

- Scheduled work volume per day = Waste volume + Topsoil volume = $759.8 \times (1 + 0.12) = 851$ m³/day
- Work volume per hour = 70 m³/hr
- Actual working time = 7 hr/day
- Work volume per day = 490 m³/day
- Required number of bulldozers = $851 \div 490 \div 0.9 = 1.9$; Say, 2 bulldozers

(2) Excavators (0.6m³)

• Work volume per day	=	50% of work volume
	=	851 × 0.5 = 423 m^3/day
• Work volume per hour	=	60 m^3/hr.
• Actual working time	=	7 hr/day
• Work volume per day	=	420 m^3/day
• Required number of excavators	=	423 ÷ 420 ÷ 0.9 = 1.1; Say, 2 excavators

(3) Water Tanker

• Scheduled work area per day	=	On site: 150,000m^2; On roads: 2 km
• Speed	=	10 km/hr
• Sprinkling time per day	=	150,000/4.0 + 2 km = 39,500 m = 39.5 km 39.5/10 × 60 + 12 = 249 min. → 4 hours; 1 water tanker is enough.

2) Topsoil Stripping Equipment for the Karasai Site

(1) Bulldozers (21t)

• Scheduled work volume per day	=	759.8 × 0.12 = 91 m^3/day
• Actual working time	=	2 hr/day
• Work volume per day	=	160 m^3/day
• Required number of bulldozers	=	91 ÷ 160 ÷ 0.9 = 0.6; Say, 1 bulldozer

(2) Wheel Loaders (2.0m³: for Loading work)

• Work volume per day	=	759.8 × 0.12 = 91 m^3/day
• Work volume per hour	=	100 m^3/hr
• Actual working time	=	2 hr/day
• Work volume per day	=	200 m^3/day
• Required number of wheel loaders	=	91 ÷ 200 ÷ 0.9 = 0.5; Say, 1 excavator

(3) Dump Trucks (10 t Class: for Transportation duties)

• Work volume per day	=	759.8 × 0.12 = 91 m^3/day
• Work volume per hour	=	16 m^3/hr
• Actual working time	=	2 hr/day
• Work volume per day	=	32 m^3/day
• Required number of wheel loaders	=	91 ÷ 32 ÷ 0.9 = 3.2; Say, 4 dump trucks

3) Landfill Equipment for the Enbek Site

(1) Bulldozers (21t)

- Scheduled work volume per day = Waste volume + Topsoil volume
  = 450.3 × (1 + 0.12) = 504 m^3/day
- Work volume per hour = 70 m^3/hr
- Actual working time = 7 hr/day
- Work volume per day = 490 m^3/day
- Required number of bulldozers = 504 ÷ 490 ÷ 0.9 = 1.1;
  Say, 2 bulldozers

(2) Excavators (0.6m³)

- Work volume per day = 50% of work volume
  = 504 × 0.5 = 252 m^3/day
- Work volume per hour = 60 m^3/hr.
- Actual working time = 7 hr/day
- Work volume per day = 420 m^3/day
- Required number of excavators = 252 ÷ 420 ÷ 0.9 = 0.7;
  Say, 1 excavator

(3) Water Tanker

- Scheduled work area per day = On site: 120,000m^2; On roads: 1 km
- Speed = 10 km/hr
- Sprinkling time per day = 120,000/4.0 + 1 km = 31,000 m = 31.0 km
  31.0/10 × 60 + 12 = 198 min.
  → 3 hours; 1 water tanker is enough.

4) Topsoil Stripping Equipment for the Enbek Site

(1) Bulldozers (21t)

- Scheduled work volume per day = 450.3 × 0.12 = 54 m^3/day
- Actual working time = 2 hr/day
- Work volume per day = 160 m^3/day
- Required number of bulldozers = 54 ÷ 160 ÷ 0.9 = 0.4;
  Say, 1 bulldozer

(2) Wheel Loaders (2.0m³: for Loading work)

- Work volume per day = 450.3 × 0.12 = 54 m^3/day
- Work volume per hour = 100 m^3/hr
- Actual working time = 2 hr/day
- Work volume per day = 200 m^3/day

- Required number of wheel loaders = 54 ÷ 200 ÷ 0.9 = 0.3;
  Say, 1 excavator

(3) Dump Trucks (10t Class: for Transportation duties)

- Work volume per day = 450.3 × 0.12 = 54 m^3/day
- Work volume per hour = 16 m^3/hr
- Actual working time = 2 hr/day
- Work volume per day = 32 m^3/day
- Required number of wheel loaders = 54 ÷ 32 ÷ 0.9 = 1.9;
  Say, 2 dump trucks

10.3.3 Alternative 4 of the Master Plan

1) Landfill Equipment

(1) Bulldozers (21t)

- Scheduled work volume per day = Waste volume + Topsoil volume
  = 689.0 × (1 + 0.12) = 772 m3/day
- Work volume per hour = 70 m^3/hr
- Actual working time = 7 hr/day
- Work volume per day = 490 m^3/day
- Required number of bulldozers = 772 ÷ 490 ÷ 0.9 = 1.8;
  Say, 2 bulldozers

(2) Excavators (0.6m^3)

- Work volume per day = 50% of work volume
  = 772 × 0.5 = 386 m^3/day
- Work volume per hour = 60 m^3/hr.
- Actual working time = 7 hr/day
- Work volume per day = 420 m^3/day
- Required number of excavators = 386 ÷ 420 ÷ 0.9 = 1.1;
  Say, 2 excavators

(3) Water Tanker

- Scheduled work area per day = On site: 150,000m^2; On roads: 2 km
- Speed = 10 km/hr
- Sprinkling time per day = 150,000/4.0 + 2 km = 39,500 m = 39.5 km
  39.5/10 × 60 + 12 = 249 min.
  → 4 hours; 1 water tanker is enough.

2) Topsoil Stripping Equipment

(1) Bulldozers (21t)

- Scheduled work volume per day = $689.0 \times 0.12 = 83\ m^3/day$
- Actual working time = 2 hr/day
- Work volume per day = $160\ m^3/day$
- Required number of bulldozers = $83 \div 160 \div 0.9 = 0.6$;
  Say, 1 bulldozer

(2) Wheel Loaders (2.0m³: for Loading work)

- Work volume per day = $689.0 \times 0.12 = 83\ m^3/day$
- Work volume per hour = $100\ m^3/hr$
- Actual working time = 2 hr/day
- Work volume per day = $200\ m^3/day$
- Required number of wheel loaders = $83 \div 200 \div 0.9 = 0.5$;
  Say, 1 excavator

(3) Dump Trucks (10t Class: for Transportation duties)

- Work volume per day = $689.0 \times 0.12 = 83\ m^3/day$
- Work volume per hour = $16\ m^3/hr$
- Actual working time = 2 hr/day
- Work volume per day = $32\ m^3/day$
- Required number of wheel loaders = $83 \div 32 \div 0.9 = 2.9$;
  Say, 3 dump trucks

10.3.4 Number of Required Equipment during the Planning Period

Based on the same calculation procedure described in the previous section, as well as the planning period of the Master Plan, i.e., year 2000 to 2010, the required number of equipment is estimated as shown in Table 10.3.1.

Table 10.3.1 Number of Required Equipment during the Planning Period

	Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Alternative 1 & 2												
Waste Amount	t/day	693.1	701.7	998.2	1107.7	1121.3	1135.4	1145.3	1185.9	1185.1	1183.5	1192.0
Bulldozer	No.	3	3	4	4	4	4	4	5	5	5	5
Excavator	No.	2	2	2	2	2	2	2	2	2	2	2
Wheel loader	No.	1	1	1	1	1	1	1	1	1	1	1
Dump truck	No.	3	3	5	5	5	5	5	5	5	5	5
Water tanker	No.	1	1	1	1	1	1	1	1	1	1	1
Alternative 3												
Karasai site												
Waste Amount	t/day	685.7	694.4	618.1	722.6	735.9	732.5	741.1	783.0	782.2	750.9	759.8
Bulldozer	No.	3	3	3	3	3	3	3	3	3	3	3
Excavator	No.	2	2	2	2	2	2	2	2	2	2	2
Wheel loader	No.	1	1	1	1	1	1	1	1	1	1	1
Dump truck	No.	3	3	3	4	4	4	4	4	4	4	4
Water tanker	No.	1	1	1	1	1	1	1	1	1	1	1
Enbek site												
Waste Amount	t/day	19.4	19.8	392.7	398.8	399.3	418.8	419.1	418.9	419.8	449.6	[illegible]
Bulldozer	No.	2	2	2	3	3	3	3	3	3	3	[illegible]
Excavator	No.	1	1	1	1	1	1	1	1	1	1	[illegible]
Wheel loader	No.	1	1	1	1	1	1	1	1	1	1	[illegible]
Dump truck	No.	1	1	2	2	2	2	2	2	2	2	[illegible]
Water tanker	No.	1	1	1	1	1	1	1	1	1	1	[illegible]
Alternative 4												
Waste Amount	t/day	692.7	701.8	998.0	619.0	633.0	651.0	658.0	666.0	673.0	682.0	[illegible]
Bulldozer	No.	3	3	4	3	3	3	3	3	3	3	[illegible]
Excavator	No.	2	2	2	1	1	1	1	1	1	2	[illegible]
Wheel loader	No.	1	1	1	1	1	1	1	1	1	1	[illegible]
Dump truck	No.	3	3	5	3	3	3	3	3	3	3	[illegible]
Water tanker	No.	1	1	1	1	1	1	1	1	1	1	[illegible]

10.4 CALCULATION OF THE REQUIRED MANPOWER

10.4.1 Administrative Staff

The required number of administrative staff is estimated based on the operational organization given in Figure 10.4.1. This organization is required as minimum level for one site to operate and manage the sanitary landfill system.

The total number of staff excluding operators and drivers is nine (9).

Table 10.3.1 Number of Required Equipment during the Planning Period

	Year	2000	2001	2002	2003	2004	**2005**	2006	2007	2008	2009	**2010**
Alternative 1 & 2												
Waste Amount	t/day	693.1	701.7	998.2	1107.7	1121.3	**1135.4**	1145.3	1185.9	1185.1	1183.5	**1192.0**
Bulldozer	No	3	3	4	4	4	**4**	4	5	5	5	**5**
Excavator	No	2	2	2	2	2	**2**	2	2	2	2	**2**
Wheel loader	No	1	1	1	1	1	**1**	1	1	1	1	**1**
Dump truck	No	3	3	5	5	5	**5**	5	5	5	5	**5**
Water tanker	No	1	1	1	1	1	**1**	1	1	1	1	**1**
Alternative 3												
Karasai site												
Waste Amount	t/day	685.7	694.4	618.1	722.6	735.9	**732.5**	741.1	783.0	782.2	750.9	**759.8**
Bulldozer	No	3	3	3	3	3	**3**	3	3	3	3	**3**
Excavator	No	2	2	2	2	2	**2**	2	2	2	2	**2**
Wheel loader	No	1	1	1	1	1	**1**	1	1	1	1	**1**
Dump truck	No	3	3	3	4	4	**4**	4	4	4	4	**4**
Water tanker	No	1	1	1	1	1	**1**	1	1	1	1	**1**
Enbek site												
Waste Amount	t/day	19.4	19.8	392.7	398.8	399.3	**418.8**	419.1	418.9	419.8	449.6	**450.3**
Bulldozer	No	2	2	2	3	3	**3**	3	3	3	3	**3**
Excavator	No	1	1	1	1	1	**1**	1	1	1	1	**1**
Wheel loader	No	1	1	1	1	1	**1**	1	1	1	1	**1**
Dump truck	No	1	1	2	2	2	**2**	2	2	2	2	**2**
Water tanker	No	1	1	1	1	1	**1**	1	1	1	1	**1**
Alternative 4												
Waste Amount	t/day	692.7	701.8	998.0	619.0	633.0	**651.0**	658.0	666.0	673.0	682.0	**689.0**
Bulldozer	No	3	3	4	3	3	**3**	3	3	3	3	**3**
Excavator	No	2	2	2	1	1	**1**	1	1	1	2	**2**
Wheel loader	No	1	1	1	1	1	**1**	1	1	1	1	**1**
Dump truck	No	3	3	5	3	3	**3**	3	3	3	3	**3**
Water tanker	No	1	1	1	1	1	**1**	1	1	1	1	**1**

10.4 CALCULATION OF THE REQUIRED MANPOWER

10.4.1 Administrative Staff

The required number of administrative staff is estimated based on the operational organization given in Figure 10.4.1. This organization is required as minimum level for one site to operate and manage the sanitary landfill system.

The total number of staff excluding operators and drivers is nine (9).

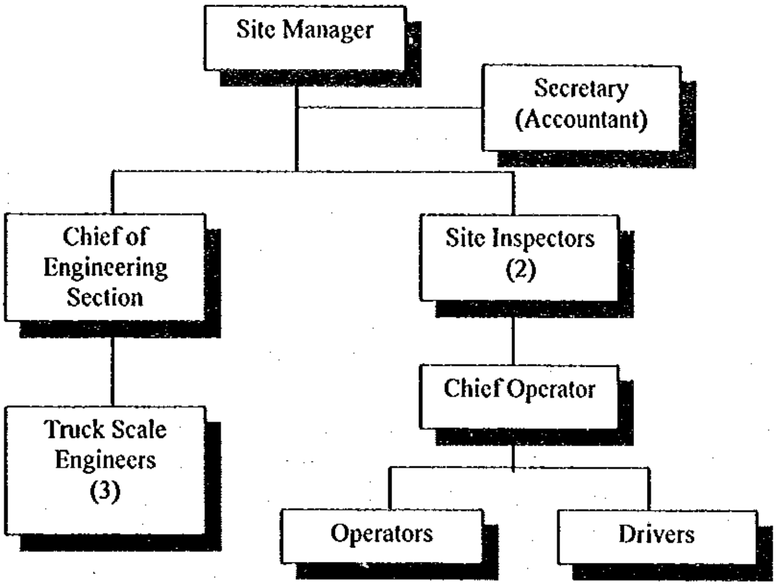


Figure 10.4.1 Operatinal Organization of a Disposal Site
Note: Numbers in parenthesis indicate the number of staff required in the position.

10.4.2 Operators and Drivers

The required number of operators and drivers is estimated considering their availability because of holidays and leaves. As stated earlier, the availability is set up at 80%. Therefore, the required manpower is automatically calculated based on the required number of heavy equipment as shown in Table 10.4.1.

Table 10.4.1 Number of Required Manpower during the Planning Period

	Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Alternative 1 & 2												
Administrative	No.	9	9	9	9	9	9	9	9	9	9	[illegible]
Operators	No.	9	9	10	10	10	10	10	12	12	12	[illegible]
Drivers	No.	4	4	9	9	9	9	9	9	9	9	[illegible]
Total	No.	22	22	28	28	28	28	28	30	30	30	[illegible]
Alternative 3												
Karasai site												
Administrative	No.	9	9	9	9	9	9	9	9	9	9	[illegible]
Operators	No.	9	9	8	9	9	9	9	9	9	9	[illegible]
Drivers	No.	4	4	6	7	7	7	7	7	7	7	[illegible]
Total	No.	22	22	23	25	25	25	25	25	25	25	25
Enbek site												
Administrative	No.	9	9	9	9	9	9	9	9	9	9	[illegible]
Operators	No.	7	7	7	8	8	8	8	8	8	8	[illegible]
Drivers	No.	2	2	5	5	5	5	5	5	5	5	[illegible]
Total	No.	18	18	21	22	22	22	22	22	22	22	22
Alternative 4												
Administrative	No.	9	9	9	9	9	9	9	9	9	9	[illegible]
Operators	No.	9	9	10	8	8	8	8	8	8	9	9
Drivers	No.	4	4	9	6	6	6	6	6	6	6	6
Total	No.	22	22	28	23	23	23	23	23	23	24	24

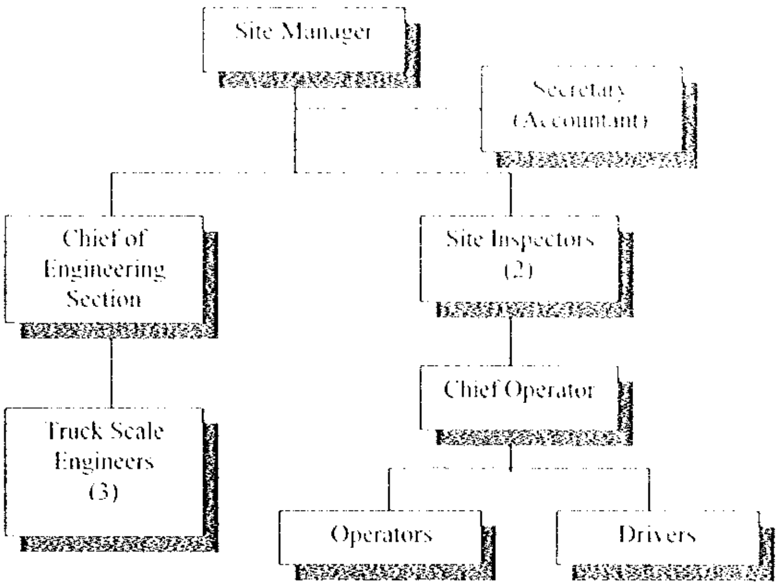


Figure 10.4.1 Operatinal Organization of a Disposal Site
Note: Numbers in parenthesis indicate the number of staff required in the position

10.4.2 Operators and Drivers

The required number of operators and drivers is estimated considering their availability because of holidays and leaves. As stated earlier, the availability is set up at 80%. Therefore, the required manpower is automatically calculated based on the required number of heavy equipment as shown in Table 10.4.1.

Table 10.4.1 Number of Required Manpower during the Planning Period

	Year	2000	2001	2002	2003	2004	**2005**	2006	2007	2008	2009	**2010**
Alternative 1 & 2												
Administrative	No.	9	9	9	9	9	**9**	9	9	9	9	**9**
Operators	No.	9	9	10	10	10	**10**	10	12	12	12	**12**
Drivers	No.	4	4	9	9	9	**9**	9	9	9	9	**9**
Total	No.	22	22	28	28	28	**28**	28	30	30	30	**30**
Alternative 3												
Karasai site												
Administrative	No	9	9	9	9	9	**9**	9	9	9	9	**9**
Operators	No.	9	9	8	9	9	**9**	9	9	9	9	**9**
Drivers	No.	4	4	6	7	7	**7**	7	7	7	7	**7**
Total	No.	22	22	23	25	25	**25**	25	25	25	25	**25**
Enbek site												
Administrative	No.	9	9	9	9	9	**9**	9	9	9	9	**9**
Operators	No.	7	7	7	8	8	**8**	8	8	8	8	**8**
Drivers	No.	2	2	5	5	5	**5**	5	5	5	5	**5**
Total	No.	18	18	21	22	22	**22**	22	22	22	22	**22**
Alternative 4												
Administrative	No.	9	9	9	9	9	**9**	9	9	9	9	**9**
Operators	No.	9	9	10	8	8	**8**	8	8	8	9	**9**
Drivers	No.	4	4	9	6	6	**6**	6	6	6	6	**6**
Total	No	22	22	28	23	23	**23**	23	23	23	24	**24**

10.5 PROCUREMENT SCHEDULE AND COST ESTIMATE

10.5.1 Procurement Schedule

Immediate actions should be required to improve the existing site condition at Karasai since the groundwater is contaminated by leachate. While it is recommended that the improvement work explained in Chapter 9 is to be conducted as one of the priority projects in the earlier stage of the Master Plan, the financial situation of the government may not allow the expenditure for the project. Therefore, it is assumed that heavy equipment required for sanitary landfill operation, which is classified into the urgent improvement project, is firstly procured by foreign aid.

Considering preparation including engineering and contracting, the heavy equipment will be procured by the beginning of fiscal year 2002 if the preparatory work is carried out within year 2001. In addition, one bulldozer will be additionally required before the start of fiscal year 2007 due to increase of the waste amount in Alternatives 1 & 2 of the Master Plan. The procurement schedule for Alternatives 1 & 2 of the Master Plan is as summarized in Figure 10.5.1.

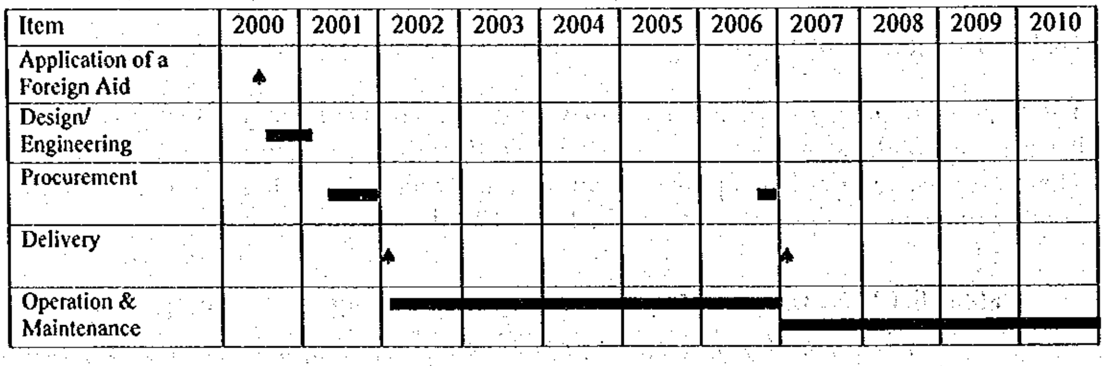


Figure 10.5.1 Procurement Schedule for Alternatives 1 & 2 of the Master Plan

10.5.2 Cost Estimate

1) Unit Cost of Heavy Equipment

The following table shows unit cost of heavy equipment examined in the preceding sections. All the equipment cost is estimated on the assumption that equipment is procured from the Japanese market.

Table 10.5.1 Unit Cost of Heavy Equipment

No.	Item	Capacity	Unit Cost (KZT)
1	Bulldozer	70-80 m^3/hour	33,816,268
2	Excavator	60 m^3/hour	22,544,178
3	Wheel Loader	100 m^3/hour	26,741,536
4	Dump Truck	16 m^3/hour	7,055,739
5	Water Tanker	6000-8000 liter	6,409,992

Note: All cost is originally estimated at Japanese price and converted into Kazakhstan Tenge whose rate is as follows: US$1.00 = KZT 115 , US$1.00 = Japanese Yen 121.10

2) Operation and Maintenance Costs

(1) Personnel Cost

Monthly payment for personnel involved in waste disposal services is assumed, as given in Table 10.5.2.

Table 10.5.2 Monthly Personnel Cost for Waste Disposal Services

Job Type	Monthly Payment (KZT)
Site Manager	19,900
Secretary	14,000
Chief of Engineering Section	18,550
Truck Scale Engineer	14,000
Site Inspector	18,000
Chief Operator	14,000
Operator	12,000
Driver	12,000

(2) Cost for Fuel and Oil/Lubricant

Fuel and oil/lubricant cost is calculated based on daily diesel consumption of each vehicle and machine. Particularly, oil and lubricant cost is estimated as 20% of total fuel cost. Table 10.5.3 shows the annual fuel and oil/lubricant cost for each vehicle and equipment planned in the preceding options.

Table 10.5.3 Annual Fuel and Oil/Lubricant Cost for Each Vehicle and Equipment

Equipment	Qty	Consumption (liter/day)	No. of Days	Fuel costs (KZT)*3	Oil/Lubricant costs (KZT)	Total (KZT)
Bulldozer for landfill*1	1	210	276	1,449,000	289,800	1,738,800
Bulldozer for topsoil*1	1	60	276	414,000	82,800	496,800
Excavator*1	1	140	276	966,000	193,200	1,159,200
Wheel Loader*1	1	60	276	414,000	82,800	496,800
Dump Truck*2	1	20	276	220,800	44,160	264,960
Water Tanker*2	1	40	276	441,600	88,320	529,920

Note: *1 These machines run on diesel.
*2 These machines run on gasoline.
*3 Fuel cost is calculated based on the assumption that the gasoline and diesel costs are 40 KZT and 25 KZT per liter, respectively.

(3) Repair and Overhaul Cost

The cost required for servicing and repairing/overhauling the equipment is determined to be in proportion to the basic equipment cost. On the premise that service facilities are provided under the project which will be implemented by procurement of the equipment and allowing for the fact that some of the service tools and spare parts are included in the standard accessories, it is fair to assume that the annual repair and overhaul cost would be about 10% of the equipment cost.

CHAPTER 11 CLOSURE AND RECLAMATION OF ILLEGAL DUMPSITES

11.1 MODEL RECLAMATION PROJECT FOR SPASSKAYA

11.1.1 Required Project Components

The required work and facilities to reclaim the Spasskaya site are outlined as follows.

1) Preparatory Earthwork

Scattered wastes have to be firstly got together to a designated area or trench, and subsequently the dumpsite will be graded and compacted. This work will reduce the waste distributed area. Especially, a large amount of waste is still exposed on the north side depression area. The scattered waste should be put in this area and cover the soil with the waste.

Simultaneously, the northwestern slope of the site should be banked or excavated to make an alignment in accordance with the same direction of the river flow.

In either area, the cover material should be graded and compacted to prevent surface water from ponding.

2) 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. 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.

Waste dumped in the site is not a large amount and new waste will not be allowed after the reclamation work. Any treatment work is thus not included since quality of generated leachate is unlikely contaminated to a great degree.

The location of the pond will be the lower side of the dumping area or north of the slope to make discharge of effluent from the pond to the river easier.

3) Leachate Collection and Drainage Facilities

At the bottom of the depression area, leachate collection and drainage pipes should be prepared to collect and drain the leachate before infiltrating it to the ground. Currently, it is considered that production of leachate cannot be observed in the site. Most of the surface water discharged through the waste seems to flow into the river or infiltrate to the ground.

4) Rainwater (Surface Water) Collection Gutter

The surface water should be discharged through gutters to reduce the amount of leachate. The catchment area is assumed to be an area between the northern part of Spasskaya Street and the top of slope of the existing dumping site.

5) Gas Exhaust Equipment

Gas exhaust equipment should be provided to extract gaseous bodies generated from decomposition of organic materials in the waste and reduce the amount of leachate. The equipment is composed of a perforated PVC pipe covering crashed stones installed in a wire basket.

6) Access Road

To approach the retention pond after closure of the site, an access road should be made from the existing public road, Spasskaya Street. The existing site road to the lower side will be buried, so that a new road should be constructed along a small path passing from east to north of the site. The road length is estimated to be 195m.

11.1.2 Calculation and Determination of Facility Dimension

1) Access Road

The planned access road will not be used for transporting waste. Therefore, the design width of the access road is enough at 6 m.

2) Leachate Collection Facility and Gas Exhaust Equipment

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):

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

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):

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

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

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:

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

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 11.1.1 below, and layouts of the leachate collection pipes and the structure are illustrated in Figure 11.1.1. Layout of the gas exhaust equipment is also shown in Figure 11.1.1.

Table 11.1.1 Diameter of Leachate Collection Pipe

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*
0.031	0.067	200	1	0.123	D

Note: * Type of drain is shown in Figure 11.1.1.

3) Leachate Retention Pond

(1) Quantity of Leachate

The quantity of leachate is related to the meteorological parameters such as precipitation and evaporation. The site for reclamation is, however, quite small covering only 2 ha or so. It is thus assumed that the maximum rainfall of consecutive five days is applied for estimation of the leachate quantity.

The maximum five-day precipitation was recorded at 85.1 mm in May 1993. The seepage coefficient is assumed at 0.5. The area for leachate collection covers 1.1 ha. Therefore, the leachate quantity is calculated as follows:

$$Q = 0.5 \times 0.0851 \times 11{,}000 = 468\ m^3$$

(2) Volume of Retention Pond

From the above calculation, the capacity of the leachate retention pond is to be set up at more than 470 m^3. The dimension of the retention pond is set up as shown in Table 11.1.2 in consideration of topographical features of the site.

Table 11.1.2 Dimension of the Leachate Retention Pond

Bottom	Elevation	647 m
	Width	18.0 m
	Length	24.0 m
	Area	432 m^2
Top	Elevation	648 m
	Width	22.0 m
	Length	28.0 m
	Area	616 m^2
Free board		0.05 m
Design Water Depth		0.95 m
Design Volume		493 m^3

4) Rainwater Drainage

(1) Conditions for Calculation

Rainwater runoff (Q) is derived from Equation (1), and flow capacity of drainage gutters is also estimated by using Equations (2) and (3), both as stated earlier. In Equation (2), the roughness coefficient of 0.03 is applied for an open channel in this case.

Drainage area covered by each channel or gutter and its length are estimated based on the topographic map and as shown in Table 11.1.3 below.

Table 11.1.3 Drainage Area and Channel Length

Channel Section	Channel Length (m)	Channel Slope	Drainage Area (ha)
A-1	195	0.006	2.950
A-2	188	0.027	1.060
B-1	60	0.265	0.148
B-2	115	0.013	0.971
C-1	217	0.041	1.670
C-2	160	0.081	0.580

(2) Calculation Results

The size of channel is determined by comparing Flow Capacity (Q') to Rainwater Runoff (Q). The Flow Capacity (Q') of the channel must be larger than the Rainwater Runoff (Q). The calculation results are as shown in Tables 11.1.4, and layout of the rainwater drainage is illustrated in Figure 11.1.2.

Table 11.1.4 Dimensions of Gutter

Channel Section	Rainwater Runoff (m^3/s)	Flow Capacity (m^3/s)	Width of Gutter (mm)	Depth of Gutter (mm)
A-1	0.082	0.110	450	450
A-2	0.029	0.064	300	300
B-1	0.117	0.718	450	450
B-2	0.144	0.160	450	450
C-1	0.046	0.079	300	300
C-2	0.093	0.180	350	350

5) Landscaping

Tree planting and lawn installation should be considered to improve the surrounding environment. Gardening with trees will be carried out at the boundary of a place enclosed with concrete walls located south of the site. A space along the access road will also be planted with trees.

The slope generated by banking and excavating with turf will be lain to protect the slope as well as to make the outward appearance much better. These landscaping plan is illustrated in Figure 11.1.2

11.1.3 Layout of the Facility

Layout plan, including the above designed facilities, and cross section of the Model Reclamation Project for Spasskaya are given in Figures 11.1.3 and 11.1.4, respectively.

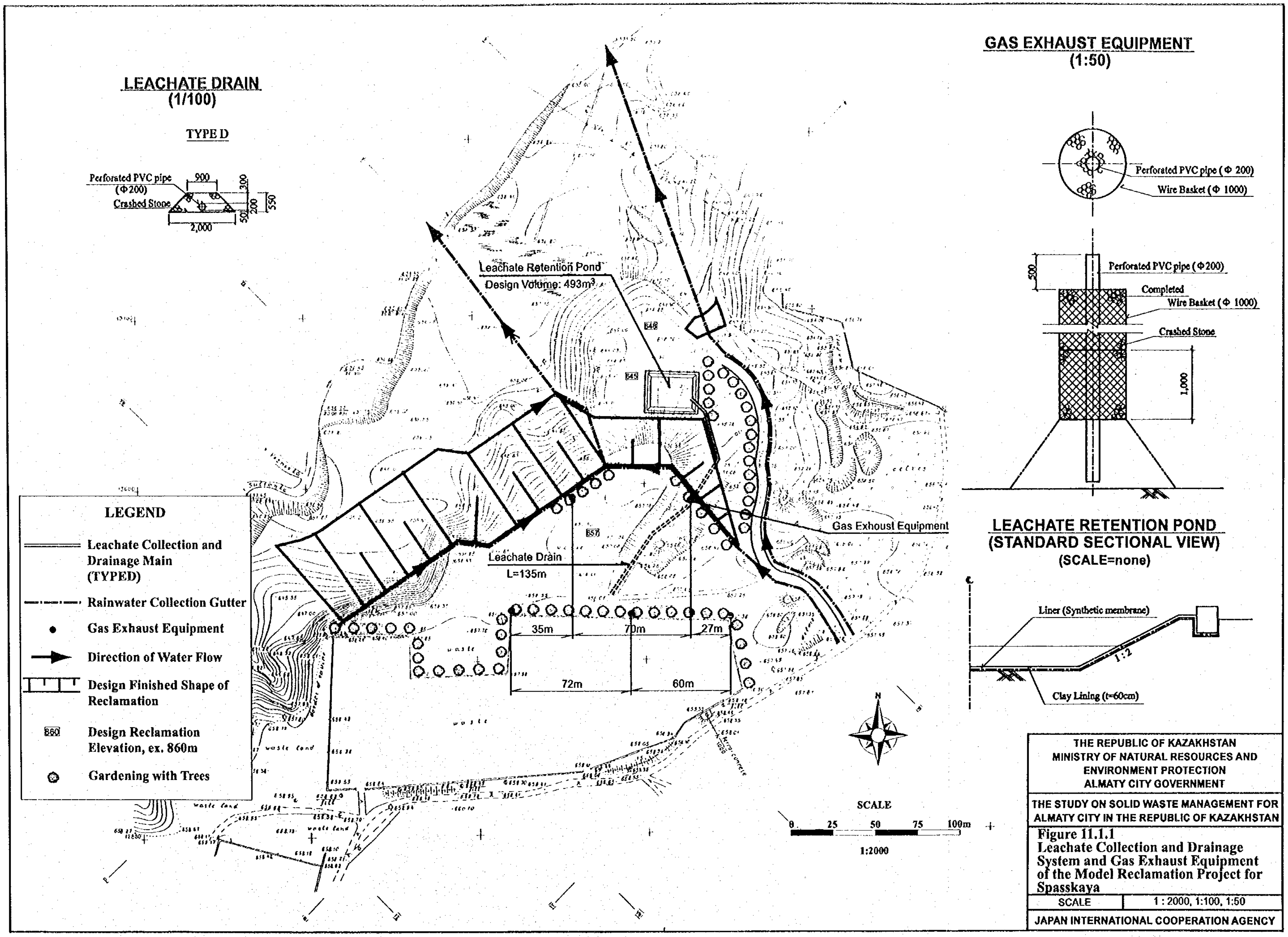
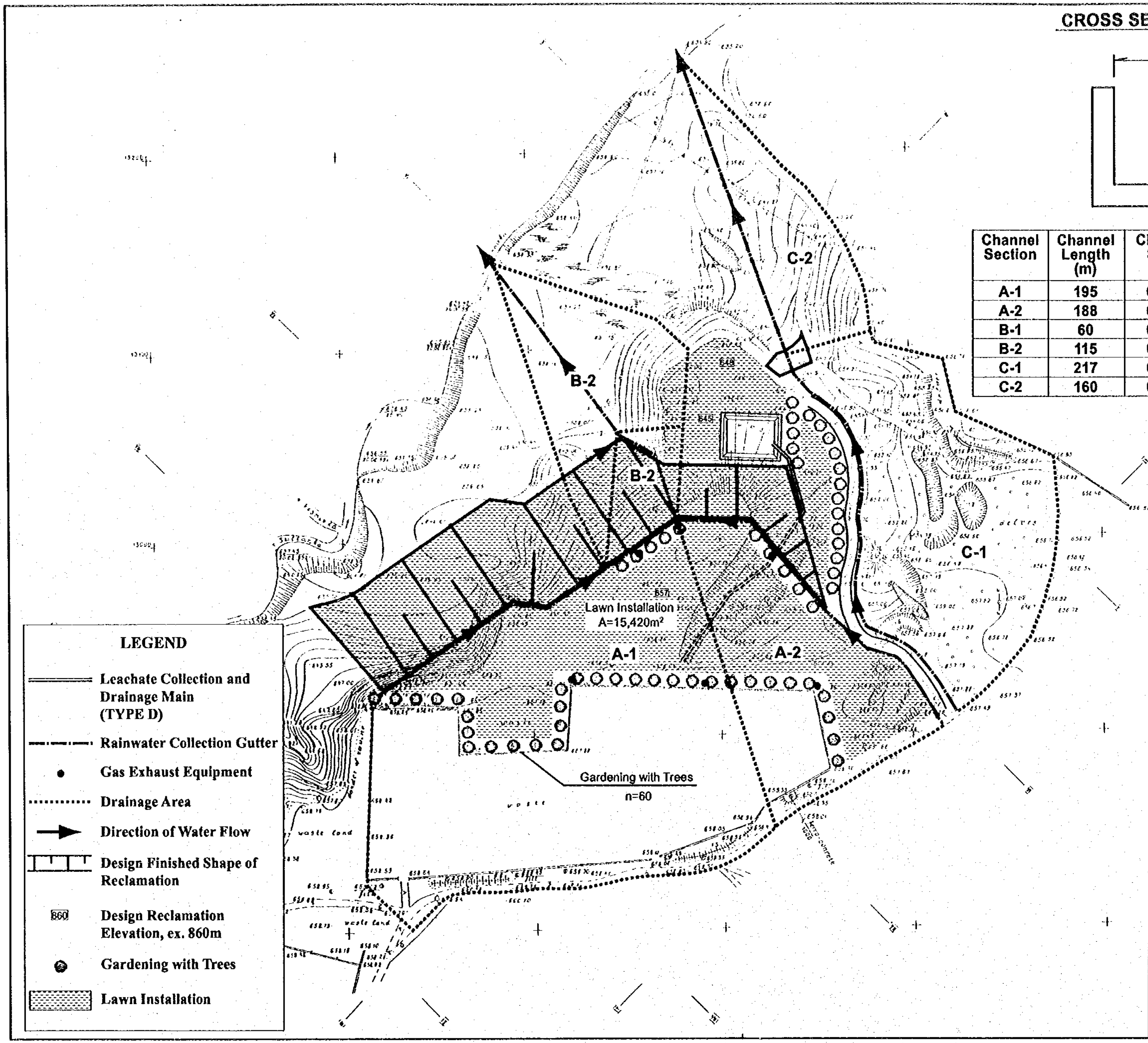


Figure 11.1.1 Leachate Collection and Drainage System and Gas Exhaust Equipment of the Model Reclamation Project for Spasskaya



Channel Section	Channel Length (m)	Channel Slope	Drainage Area (ha)	w (mm)	d (mm)
A-1	195	0.006	2.950	450	450
A-2	188	0.027	1.060	300	300
B-1	60	0.265	0.148	450	450
B-2	115	0.013	0.971	450	450
C-1	217	0.041	1.670	300	300
C-2	160	0.081	0.580	350	350

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Figure 11.1.2
Layout Plan of Rain Water Collection Gutter and Landscaping of the Model Reclamation Project for Spasskaya

SCALE	1 : 2000

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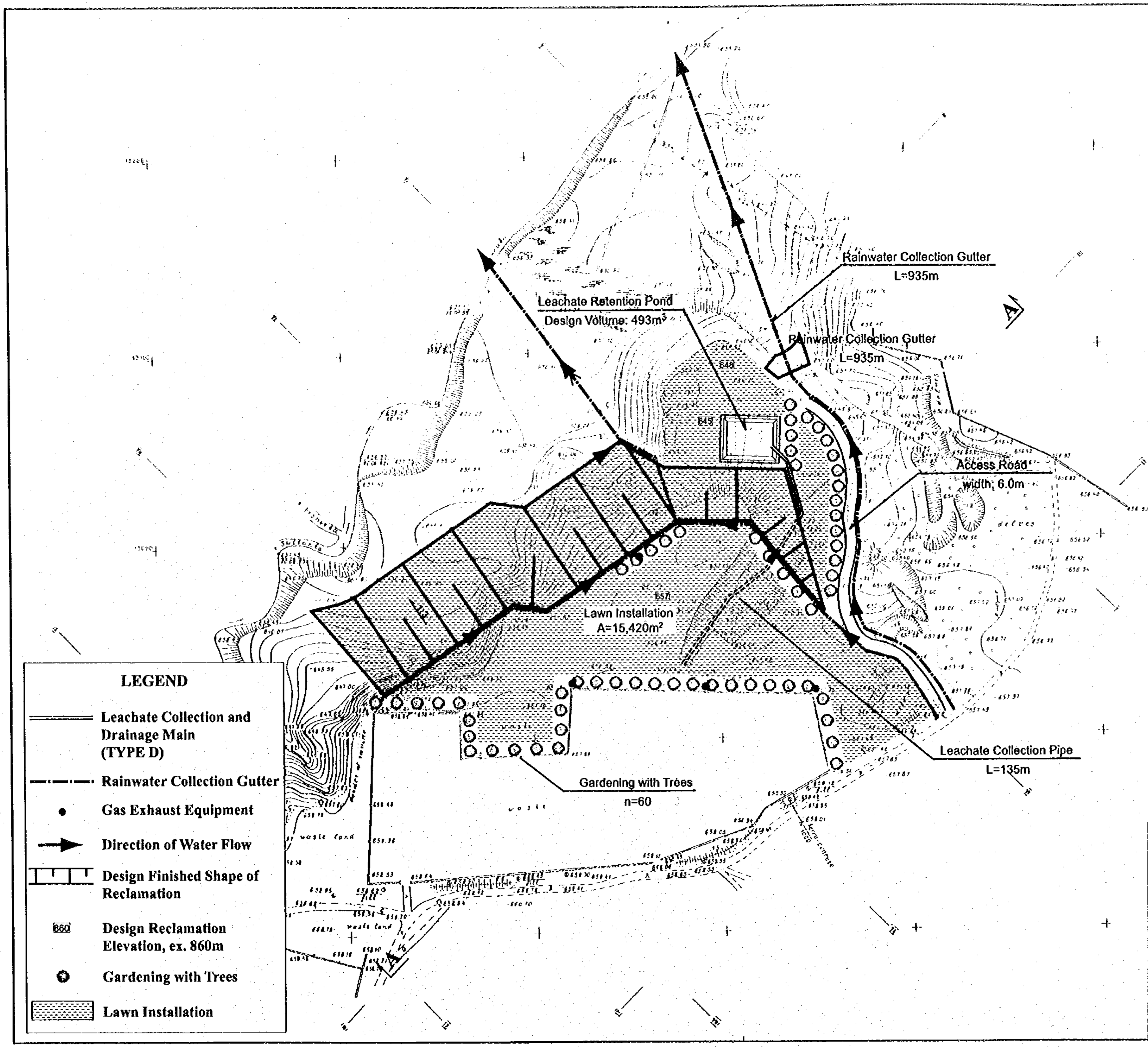

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Figure 11.1.3
Layout Plan of Model Reclamation Project for Spasskaya

SCALE	1 : 2000

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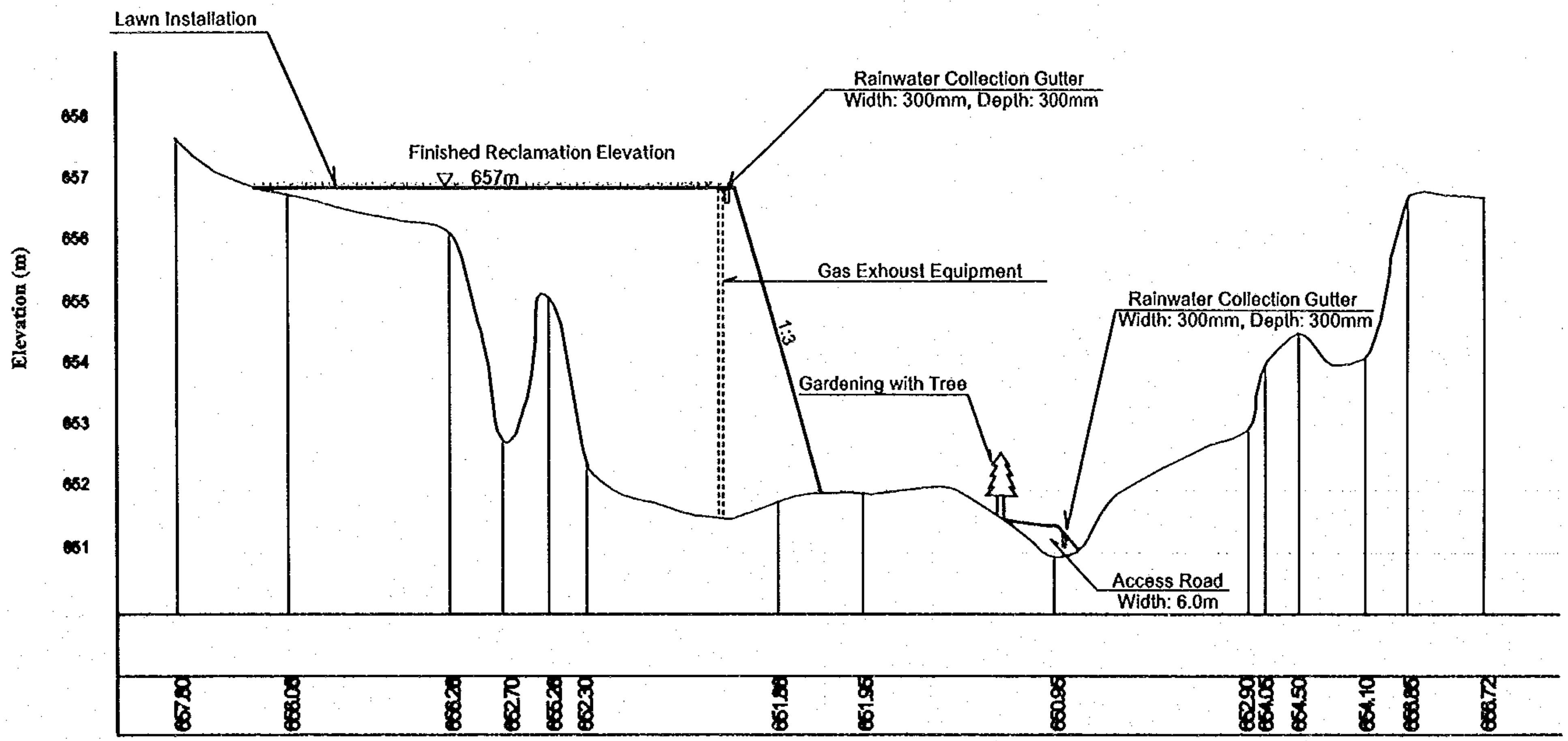
A - A



Horizontal 1/1000
Vertical 1/100

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Figure 11.1.4
Typical Cross Section of Model Reclamation Project for Spasskaya

SCALE	H 1 : 1000, V 1:100

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11.2 RECLAMATION OF THE OTHER DUMPSITES

The other illegal dumpsites including the existing transfer station should also be reclaimed subsequently. However, the reclamation work is not so urgently required since these sites do not show adverse impacts to the surrounding environment according to the result of the Environmental Survey. Reclamation of the other dumpsites is planned to take place after year 2005.

Major facilities required are the same as those of the Spasskaya Model Project, i.e., land reclamation, final cover, and leachate and gas management. The scope of each work should be determined in the future engineering stage.

11.3 CLOSURE AND RECLAMATION SCHEDULE

The closure and reclamation work for the Spasskaya site will be undertaken in fiscal year 2003, if design and engineering of the work is carried out in 2002. The reclamation work for the other illegal dumpsites including the existing transfer station will be subsequently started after year 2006 up to 2010, as scheduled in Table 11.3.1.

Table 11.3.1 Reclamation Schedule for Spasskaya and the Other Sites

Year	Name of Site to be Reclaimed
Up to 2005	Spasskaya (2003)
2006	Raiymbek north
2007	Existing Transfer Station
2008	Ryskulov north
2009	Zhetysu south-west, Near the sludge retention pond
2010	Kulagher north

11.4 PROJECT COST ESTIMATE

The total cost for reclamation work including design and engineering is estimated at KZT504,607,000 (US$4,387,887): KZT207,997,000 (US$1,8082,670) for Spasskaya and KZT296,610,000 (US$2,579,217) for the other sites. The annual expenditure for the work is shown in Table 11.4.1. Major work items and costs of Spasskaya site and other sites are shown in Tables 11.4.2 to 11.4.8.

Table 11.4.1 Schedule of Annual Expenditure for Illegal Dumpsite Reclamation

Year	Name of Site to be Reclaimed	Cost (thousand KZT)		
		Engineering*	Reclamation Work	Total
2000	-			0
2001	-			0
2002	-	9,905		9,905
2003	Spasskaya		198,092	198,092
2004				0
2005		883		883
2006	Raiymbek north	9,582	17,662	27,244
2007	Existing Transfer Station	1,653	191,633	193,286
2008	Ryskulov north	1,456	33,053	34,509
2009	Zhetysu south-west, Near the sludge retention pond	551	29,120	29,671
2010	Kulagher north		11,018	11,018
Total		24,029	480,578	504,607

Note:* Engineering cost is estimated by applying 5% of the cost for reclamation work.

Table 11.4.2 Major Work Items and Cost of Model Reclamation Project for Spasskaya

Work	Item	Unit	Quantity	Unit Price (KZT)	Amount (thousand KZT)	Remarks
Preparatory Work	Banking/Backfilling	m^3	22,500	1,850	41,625	
	Excavation	m^3	19,100	1,200	22,920	
	Slope adjusting	m^2	13,550	420	5,691	
Sub total		LS			70,236	
Cover Soil	Grading	m^3	9,075	250	2,269	
	Compacting	m^2	18,150	420	7,623	
Sub total		LS			9,892	
Retention Pond	Excavation	m^3	5,110	1,200	6,132	
	Side slope adjusting	m^2	1,120	420	470	
	Liner laying	m^2	2,320	3,000	6,960	Synthetic membrane
	Clay laying	m^3	1,395	800	1,116	thickness: 60 cm
Sub total		LS			14,678	
Leachate Collection and Drainage	Piping work (Type D)	m	135	7,000	945	D200mm, n=1
Rainwater Collection and Drainage	Gutter installation (300x300)	m	405	3,000	1,215	
	Gutter installation (350x350)	m	160	3,500	560	
	Gutter installation (450x450)	m	370	4,800	1,776	
Sub total		LS			3,551	
Gas Exhaust Equipment	Extraction well	nos.	5	80,000	400	
Fence	Net fence installation	m	198	6,000	1,188	h=1.6m
Access Road		m	195	10,200	1,989	Crashed stone, t=300mm, w=6m
Landscaping	Gardening w/tree	nos.	60	12,870	772	
	Installation of lawn	m^2	15,420	3,160	48,727	
Sub total		LS			49,499	
Total		-	-	-	152,379	
Auxiliary Work		LS	1	-	45,714	30% of Total
Direct Cost Total		-			198,092	

Table 11.4.3 Cost for Illegal Dumpsite Reclamation for Raiymbek North

Work	Item	Unit	Quantity	Unit Price (KZT)	Amount (thousand KZT)	Remarks
Preparatory Work	Site clearing and leveling	m^3	5,000	1,150	5,750	
Cover Soil	Grading	m^3	5,000	250	1,250	
	Compacting	m^2	10,000	420	4,200	
Sub total		LS			5,450	
Rainwater Collection and Drainage	Gutter installation (300x300)	m	400	3,000	1,200	
Gas Exhaust Equipment	Extraction well	nos.	10	80,000	800	
Landscaping	Gardening w/tree	nos.	30	12,870	386	
Total		-	-	-	13,586	
Auxiliary Work		LS	1	-	4,076	30% of Total
Direct Cost Total		-			17,662	

Table 11.4.4 Cost for Illegal Dumpsite Reclamation for Existing Transfer Station

Work	Item	Unit	Quantity	Unit Price (KZT)	Amount (thousand KZT)	Remarks
Preparatory Work	Site clearing and leveling	m^3	20,000	1,150	23,000	
Cover Soil	Grading	m^3	107,500	250	26,875	
	Compacting	m^2	215,000	420	90,300	
Sub total		LS			117,175	
Gas Exhaust Equipment	Extraction well	nos.	10	80,000	800	
Landscaping	Gardening w/tree	nos.	500	12,870	6,435	
Total		-	-	-	147,410	
Auxiliary Work		LS	1	-	44,223	30% of Total
Direct Cost Total		-			191,633	

Table 11.4.5 Cost for Illegal Dumpsite Reclamation for Zhetysu South-West

Work	Item	Unit	Quantity	Unit Price (KZT)	Amount (thousand KZT)	Remarks
Preparatory Work	Site clearing and leveling	m^3	5,000	1,150	5,750	
Cover Soil	Grading	m^3	5,000	250	1,250	
	Compacting	m^2	10,000	420	4,200	
Total		-	-	-	11,200	
Auxiliary Work		LS	1	-	3,360	30% of Total
Direct Cost Total		-			14,560	

Table 11.4.6 Cost for Illegal Dumpsite Reclamation for Ryskulov North

Work	Item	Unit	Quantity	Unit Price (KZT)	Amount (thousand KZT)	Remarks
Preparatory Work	Site clearing and leveling	m^3	15,000	1,150	17,250	
Cover Soil	Grading	m^3	7,500	250	1,875	
	Compacting	m^2	15,000	420	6,300	
Total		-	-	-	25,425	
Auxiliary Work		LS	1	-	7,628	30% of Total
Direct Cost Total		-			33,053	

Table 11.4.7 Cost for Illegal Dumpsite Reclamation for Near the Sludge Retention Pond

Work	Item	Unit	Quantity	Unit Price (KZT)	Amount (thousand KZT)	Remarks
Preparatory Work	Site clearing and leveling	m^3	5,000	1,150	5,750	
Cover Soil	Grading	m^3	5,000	250	1,250	
	Compacting	m^2	10,000	420	4,200	
Total		-	-	-	11,200	
Auxiliary Work		LS	1	-	3,360	30% of Total
Direct Cost Total		-			14,560	

Table 11.4.8 Cost for Illegal Dumpsite Reclamation for Kulagher North

Work	Item	Unit	Quantity	Unit Price (KZT)	Amount (thousand KZT)	Remarks
Preparatory Work	Site clearing and leveling	m^3	5,000	1,150	5,750	
Cover Soil	Grading	m^3	2,500	250	625	
	Compacting	m^2	5,000	420	2,100	
Total		-	-	-	8,475	
Auxiliary Work		LS	1	-	2,543	30% of Total
Direct Cost Total		-			11,018	