CHAPTER 7 PEKAN NENASI LANDFILL SITE (PAHANG)

7.1 LANDFILL OPERATIONS AND SITE CHARACTERISTICS

The brief description of the landfill operations and site characteristics are summarised in **Table 7.1.1**.

Table 7.1.1 Pekan Nenasi Landfill Operations and Site Characteristics

Operational Characteristics	Site Characteristics
⇒ Started operations in 1988 ⇒ About 30 tonnes of waste are disposed at the landfill daily ⇒ In 2002, upgrading work was carried out to provide the control building and workshop, weighbridge station and opening of the Phase I at the western part ⇒ The site expected to be used for a long period phased expansion	⇒ Located south of Pekan town, by the side of the east coast trunk road ⇒ Located on a wetland area ⇒ The site occupied an area of about 22ha

7.2 THE SAFE CLOSURE PLAN

For the Pilot Project, the Cell 1 of Phase I of the Western part of the landfill will be upgraded to a semi-aerobic landfill system in order to provide improved post-closure conditions in the future. The leachate collection system, gas venting pipes, leachate aeration pond and re-circulation system will be provided.

7.3 PILOT PROJECT IMPLEMENTATION AND SCHEDULE

(1) Topography Survey

The topography survey for the Pekan Nenasi PP focused on the active landfill section where the Pilot Project works will be conducted. The survey was carried out in August 2003 and produced the final survey plan that included the following:

- Locations of the 2 survey control point benchmarks
- Plane table survey (spot levelling, approx. 5 hectares) and mapping (1:1,000 scale)
- Cross section and longitudinal section levelling and mapping (1:1,000 scale for horizontal direction and 1:100 scale for vertical direction)
- Indication of existing salient features on the site such as buildings, pipelines and etc.

(2) Soil Investigations

The soil investigations exercise was carried out from July 31 to August 5, 2003. The fieldwork required the drilling and sampling at 3 locations, and the installation of 3 water-monitoring wells. The undisturbed soil samples and selected disturbed Standard Penetration Test (SPT) soil samples were taken to the laboratory for analysis.

The site is relatively flat and located along the coastal area. The summary of the fieldworks and types of laboratory tests for the Pekan Nenasi PP is tabulated in **Table 7.3.1**. The information for soil stratifications are summarised in **Table 7.3.2**.

Table 7.3.1 Soil Investigation Borehole Specifications and Test Results

Boreholes	PN-W1	PN-W2	PN-W3	Total
1. Geographical coordinates				
North	3°26'58.4"	3°26'54.6"	3°26'57.7"	-
East	103°25'2.9"	103°25'15.1"	103°25'21.1"	-
Elevation (RL m)	4.2	3.2	3.3	-
2. Fieldwork				
Total drilling (m)	31.45	20.45	21.45	73.35
Standard Penetration Test (no.)	23	17	16	56
Undisturbed Soil Samples (no.)	8	3	5	16
3. Laboratory Tests (numbers)				
Unit weight	8	3	5	16
Moisture content	11	11	10	32
Specific gravity	11	11	10	32
Atterberg limit	9	5	7	21
Grain size analysis	11	11	10	32
Consolidation test	8	3	5	16
Unconfined Compression Test	8	3	5	16

Table 7.3.2 Soil Stratification at Pekan Nenasi Landfill Site

Layer	Description
Miscellaneous fill	The miscellaneous fill material covered the entire top surface area of the landfill site varying from 1.85m thick in PN-W3 to 3m thick in PN-W1. The fill material comprises of yellowish brown mottled grey, brownish grey to dark grey clay or sandy silt and waste with presence of sand, decayed roots and wood.
Quaternary deposits	Composed of five sub-layers.
a) Very Soft to Soft Clay	This layer covered the entire subsoil level of the project site. It comprises of greenish grey to grey, dark grey silt with the presence of seashell fragments, organic materials and traces of fine sand. The layer thickness varied from 3.4m in PN-W2 to 15.3m in PN-W3. The lenses of Very Loose to Loose Sand layer with the thickness of 3.5m were also found in PN-W3.
b) Medium Stiff to Stiff Clay	This layer comprises of yellowish brown mottled grey to brownish grey silt with the presence of fine to medium grained sand and fine gravel and occasionally with some organic decayed material. The thickness of this layer varied from 0.7m in PN-W3 to 4.65m in PN-W2. The pockets or lenses of the Very Loose to Loose Sand with thickness of 1m also occurred in this layer.
c) Very Stiff Clay	This layer only occurred only in PN-W1 and comprises of yellowish brown mottled grey light grey to grey clay with traces of fine sand. The layer thickness is about 3.85m.
d) Very Loose to Loose Sand	This layer comprises of light grey to greenish grey and dark grey silty sand to sand with presence of sub-angular quartz gravels and seashell fragments. The layer thickness varied from 3.15m in PN-W3 to 9.7m in PN-W2.
e) Medium Dense Sand	This layer is found only in PN-W2 and comprises of dark grey, fine to coarse-grained with the presence of fine quarts sand. This layer occurs as lenses in Very Loose to Loose Sand layer.

The water levels below ground that were monitored in the water standpipes throughout the period of the fieldwork, ranged from 1.3m to 2.65m. The engineering properties of the soil layers were obtained from the in-situ analysis and laboratory tests, and are summarised in **Table 7.3.3**.

Table 7.3.3 Pekan Nenasi Landfill Site Soil Engineering Properties

	Unit	Very Soft to Soft Clay	Medium Stiff to Stiff Clay	Very Stiff Clay	Very Loose to Loose Sand	Medium Dense Sand
1. Grading texture						
Gravel	(%)	0–1	0	0	0-8	3
Sand	(%)	1– 60	2-16	1	76-90	97
Silt	(%)	26–69	47-78	34	0-18	0
Clay	(%)	15–30	18-50	65	0-5	0
2. Unit weight	Mg/m^3	1.62-1.88	1.91-2.08			
3. Atterburg limits						
Liquid limit	(%)	42-69	24-39	54		
Plastic limit	(%)	26-43	15-24	28		
Plasticity index		15-29	9-18	26		
4. Natural water content	(%)	27-71	20-30	39	20-41	21
5. Specific gravity		2.61-2.73	2.62-2.73	2.69	2.63-2.72	2.65
6. SPT Values (range)	N	0-3	4-13	15-16	3-10	14
7. Unconfined Compressive Strength	kPa	19-110	179-243			
8. Consolidation properties						
Pre-consolidation pressure	Pc(kPa)	60-175	110-214			
Compression Index		0.27-0.77	0.17-0.18			

The coefficient of permeability (k) obtained from in-situ analysis and laboratory testing are summarised in **Table 7.3.4**.

Table 7.3.4 Pekan Nenasi Landfill Site Coefficient of Permeability

Borehole	Depth (m)	Soil layer	Coefficient of Permeability, k (m/sec)			Drainage Character-istics
			Field	Laboratory		
				Permeability test	Consolidation test	
PN-W1						
(UD1)	3.00-3.70	Silty sand	NA	$1.36x10^{-7}$	$3.34x10^{-9}$	Poor to Practically impervious
(UD2)	9.00-9.80	Silt	NA	$1.27x10^{-9}$	$1.5x10^{-9}$	Practically impervious
(UD3)	11.00-11.80	Silt		$1.78x10^{-9}$	$1.5x10^{-9}$	
(UD4)	13.00-13.80	Silt	NA	$5.95x10^{-9}$	$2.5x10^{-9}$	
(UD5)	16.00-16.80	Silt	NA	$1.35x10^{-9}$	$1.7x10^{-9}$	
(UD6)	19.00-19.80	Silt	NA	NA	$9.5x10^{-10}$	
(UD7)	22.00-22.80	Silt	NA	$1.5x10^{-10}$	$1.6x10^{-9}$	
(UD8)	25.00-25.80	Silt	NA	$2.1x10^{-10}$	$3x10^{-10}$	
(PT1)	25.50-26.00	Silt	$1.5x10^{-4}$	NA	NA	Good

PN-W2						
(PT1)	6.00-6.50	Sand to silty sand	$1.7x10^{-4}$	NA	NA	Good
(UD1)	12.00-12.80	Silt	NA	$1.28x10^{-10}$	$1.2x10^{-9}$	Practically impervious
(UD2)	14.00-14.80	Silt	NA	$2.36x10^{-10}$	$6x10^{-10}$	
(UD3)	16.00-16.80	Silt	NA	$2.51x10^{-10}$	$8.5x10^{-10}$	
PN-W3 (UD1)	6.00-6.80	Silt	NA	$3.01x10^{-9}$	$3x10^{-9}$	
(UD2)	8.00-8.80	Silt	NA	$2.31x10^{-10}$	$1.4x10^{-9}$	
(UD3)	10.00-10.80	Silt	NA	$1.94x10^{-10}$	$1x10^{-9}$	
(UD4)	13.00-13.80	Sandy clay	NA	NA	$1.2x10^{-9}$	
(PT1)	16.00-16.50	Sand	$1.5x10^{-4}$	NA	NA	Good
(UD5)	19.00-19.80	Silt	NA	$7.55x10^{-10}$	$5x10^{-10}$	Practically impervious

7.4 PEKAN NENASI PILOT PROJECT IMPLEMENTATION

Subsequent to the PP tender and evaluation exercise, the Pekan Nenasi Pilot Project was eventually awarded to the successful contracting company, S.S. Selenggara Padu, and the Design and Build Contract was signed on August 13th, 2003.

Following the commencement of the project, as part of the deliverables, the contractor prepared and submitted the project implementation schedule as shown in **Figure 7.4.1**.

The detailed design was completed and approved by the Study Team within one month from the project commencement date. Samples of the design drawings are shown in **Figure 7.4.2** and **Figure 7.4.3**. The final As-built drawings are provided Volume 4, Chapter 8. The photographs records of the progress of the work and the main facilities are shown in **Plate 7.4.1** and **Plate 7.4.2** respectively.

The brief description and Bill-of-Quantities (BQ) of the Pilot Project is summarised in **Table 7.4.1**.

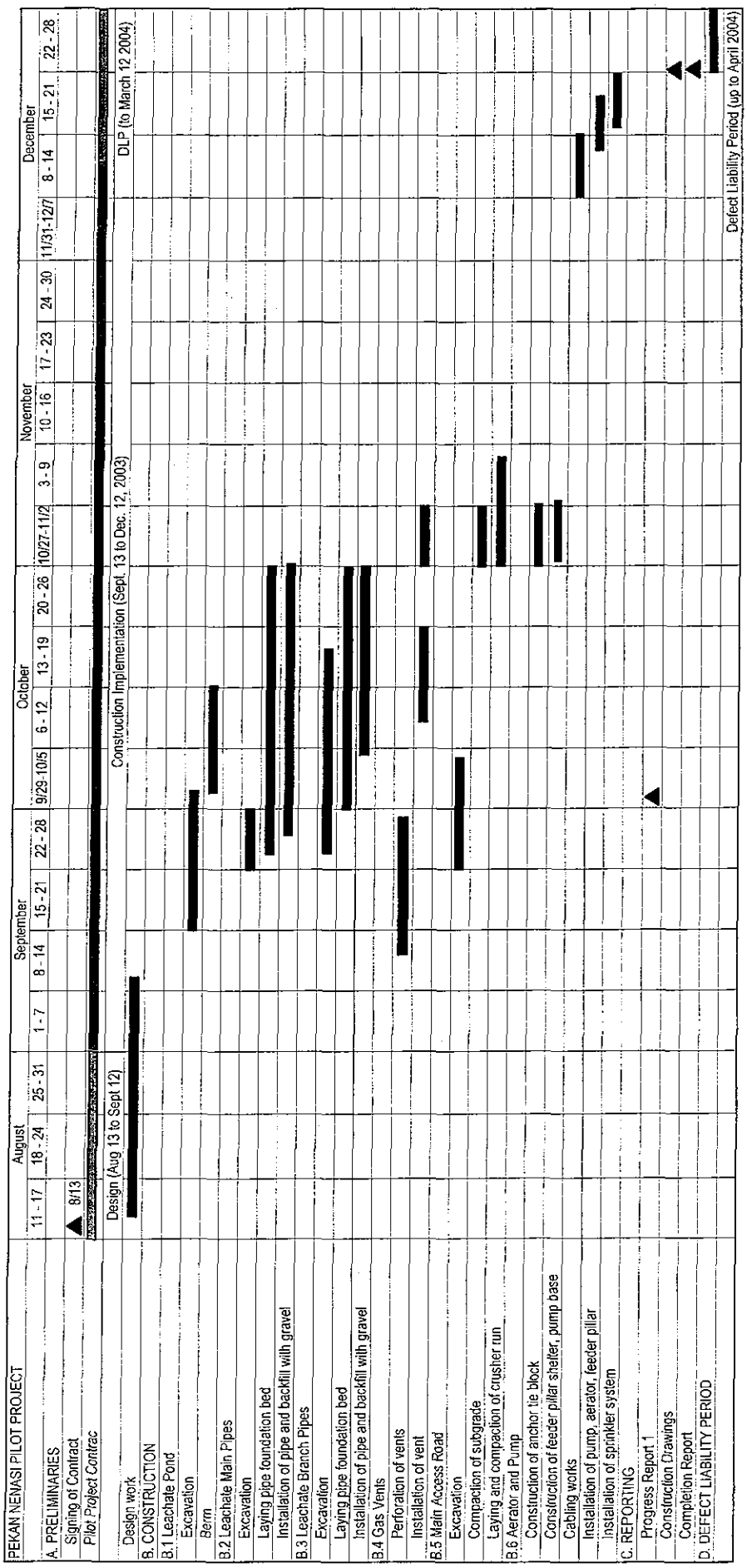
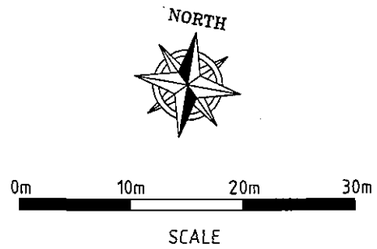
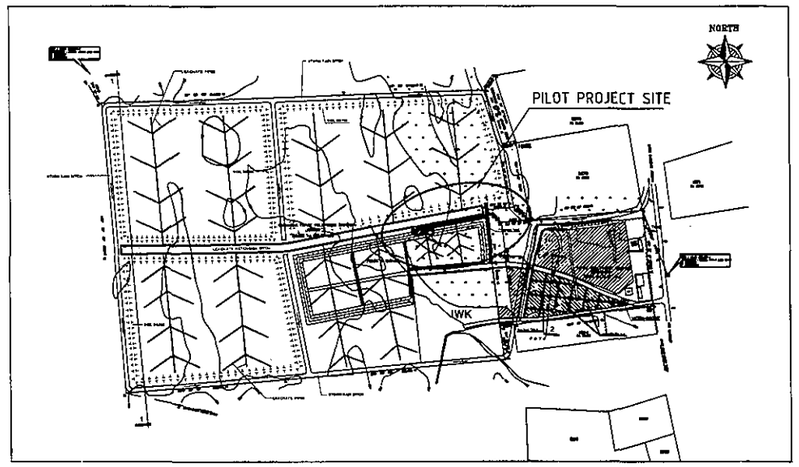


Figure 7.4.1 Project Implementation Schedule for Pekan Nenasi PP

Table 7.4.1 Pekan Nenasi PP Description

No.	Item/Description	Quantity
1	Leachate Collection System	
	Excavation of solid waste *Excavation of the solid waste in the existing operation area in order to install the leachate collection system. The excavated waste was placed in the adjacent active cell.*	500m^3
	Main leachate collection pipe (dia. = 450mm) installed in two lines *Non-perforated spun concrete pipe, Class H, of nominal diameter 450mm laid under the berm and road, with a length of 12m x 2 lines. Perforated spun concrete pipe, Class H of nominal diameter 450mm including placing of gravel around the pipe and preparation of pipe bed with crusher-run of 200mm, over wooden sleeper/wedge of length 30m x 2 lines.*	84m
	Branch leachate collection pipe (dia. = 225mm) installed in 4 lines *Supply and install perforated spun concrete pipe of nominal diameter 225mm with minimum slope of 1:200 and total length of 290m. Pipes laid on compacted crusher run and surrounded by gravel.*	331m
2	Gas venting system	
	Vertical gas venting pipe *Supply and install 4 gas collection pipes, uPVC class D, diameter 160mm with a height of 2.5m. Installation at square pits of brick walls of outer dimensions of 1.65 x 1.65m and clear height of 0.9m. These pits also serve intersection points between the main and branch pipes.*	4 units
3	Leachate pond	
	Excavation for leachate pond *Leachate pond dimensions are 100m length x 10m bottom width x 2m depth and the pond is excavated at the location of the present pond so only part of the required excavation volume of 2,600m^3 is required.*	1,400m^3
	Earth berm along the leachate pond (h = 1.0m, L = 145m) *Supply impermeable clayey soil to form 1m high berm from the existing ground level, with slope of 1:2 and 1m width at the top. Top level of the berm is 3.20m from the ground level.*	145m
	Access road embankment (t = 200mm) between dike and leachate pond *Levelling, subgrade and fill the soil material with average thickness of 200mm crusher run. Access road constructed on existing berm with a minimum width of 3m.*	2,250m^2
	Crusher-run pavement for access road *Supply, level and compact the crusher run with a thickness of 300mm.*	180m^3
	Aerator (7.5 kw) *Supply and installation of low speed surface aerator, vertically mounted geared motor, with electrical accessories and wiring of 300m extensions. Aerator installed at approximately centre point of the pond length.*	1 set
	Re-circulation pump (5 kw) *Supply and installation of suction pump with discharge outlet of diameter 80mm including all accessories and wiring of 300m extensions. Pump is installed near the access road between the waste disposal operations area and the pond. Rubber hoses are connected from the pump to 4 sprinklers installed at the top of each gas vent.*	1 set





KEY PALN

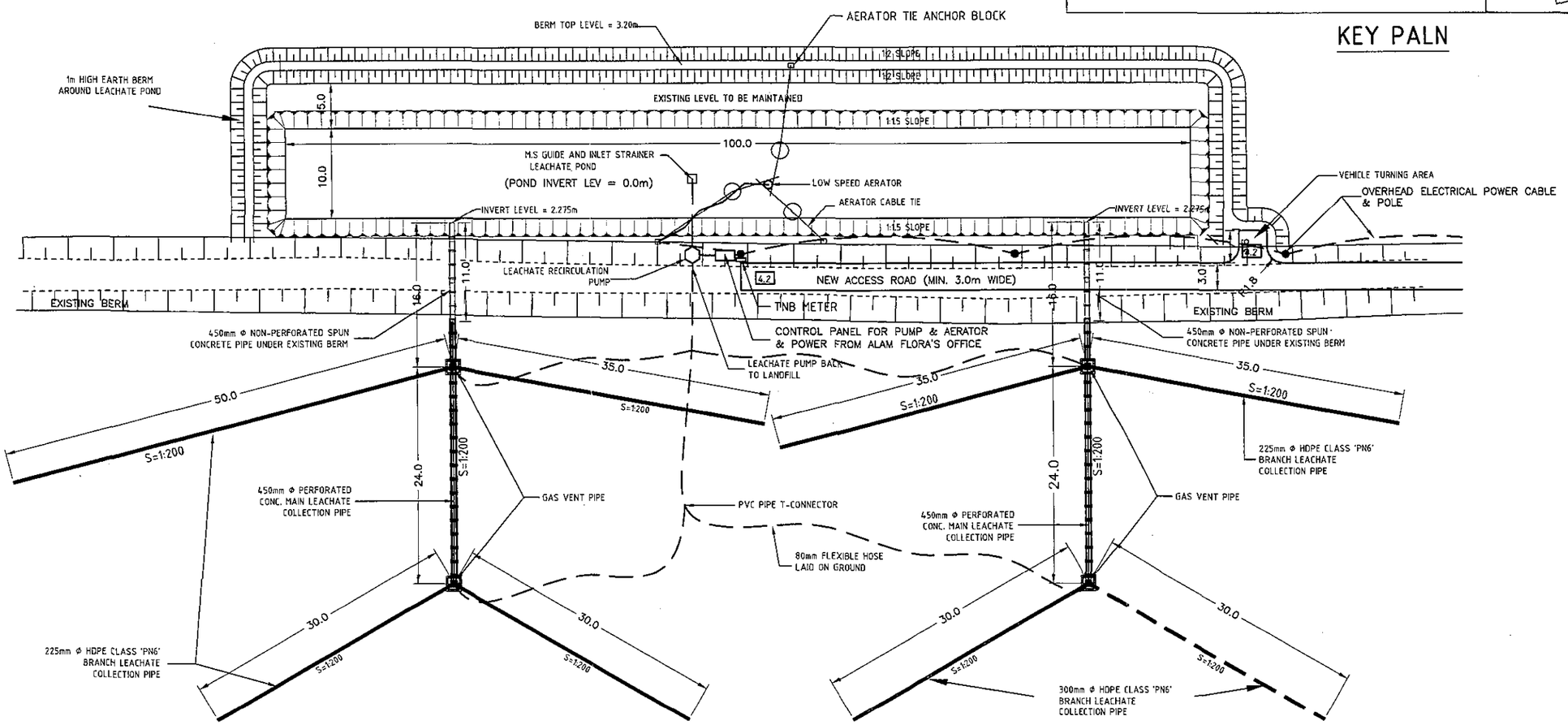
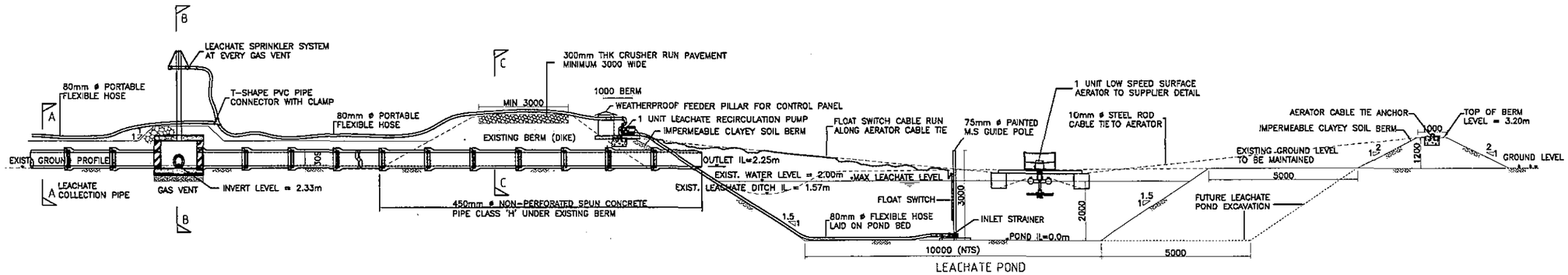
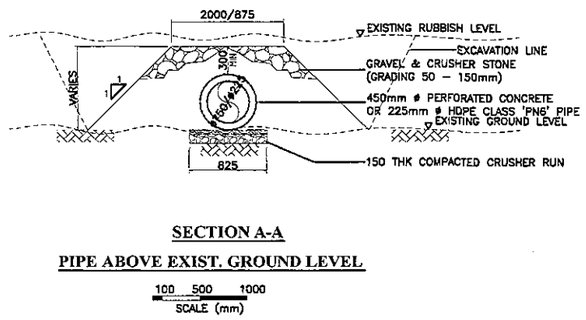


Figure 7.4.2 Layout Plan (Pekan Nenasi Pilot Project)



LEACHATE COLLECTION PIPE LONG-SECTION

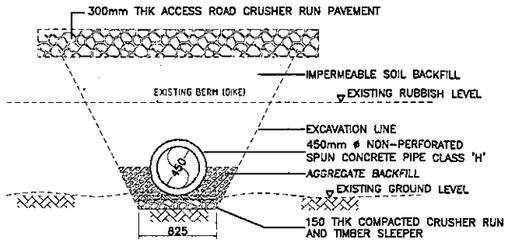
100 250 500
SCALE (mm)



SECTION A-A

PIPE ABOVE EXIST. GROUND LEVEL

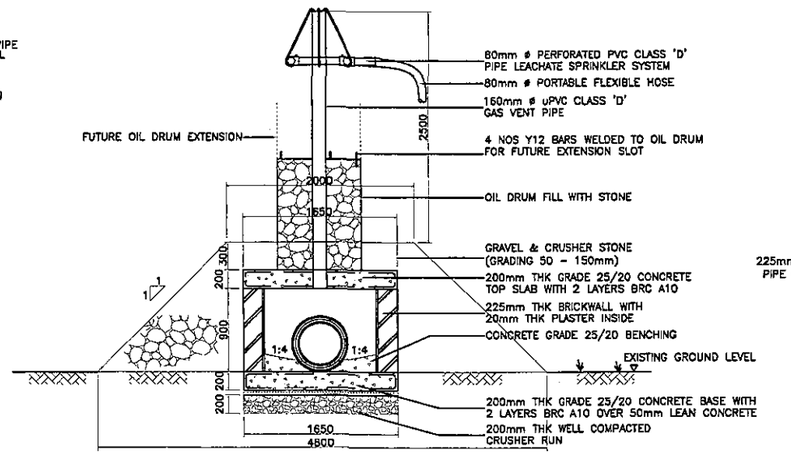
100 500 1000
SCALE (mm)



SECTION C-C

PIPE BELOW ACCESS ROAD & BERM

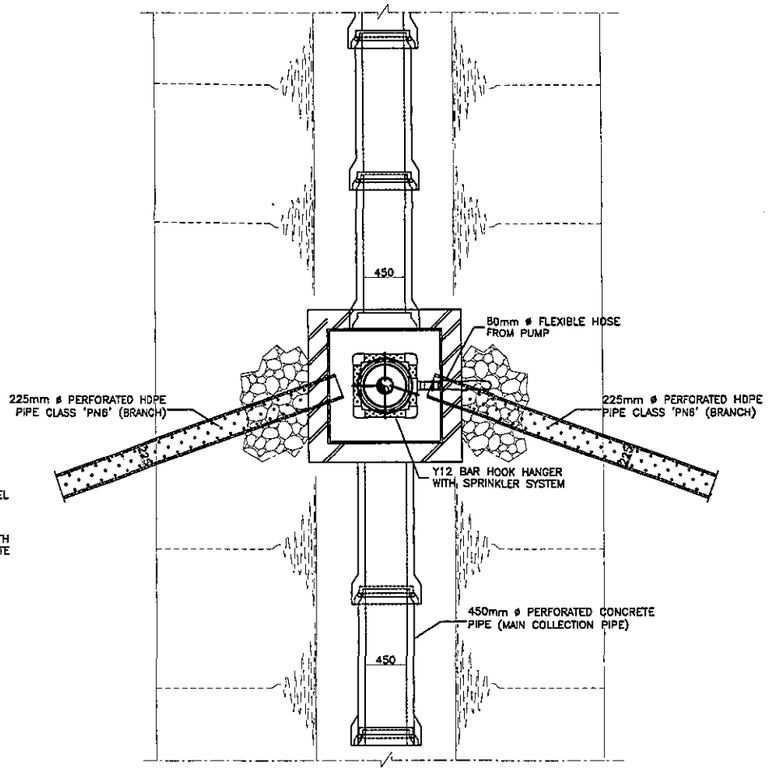
100 500 1000
SCALE (mm)



SECTION B-B

GAS VENT SYSTEM

100 500 1000
SCALE (mm)



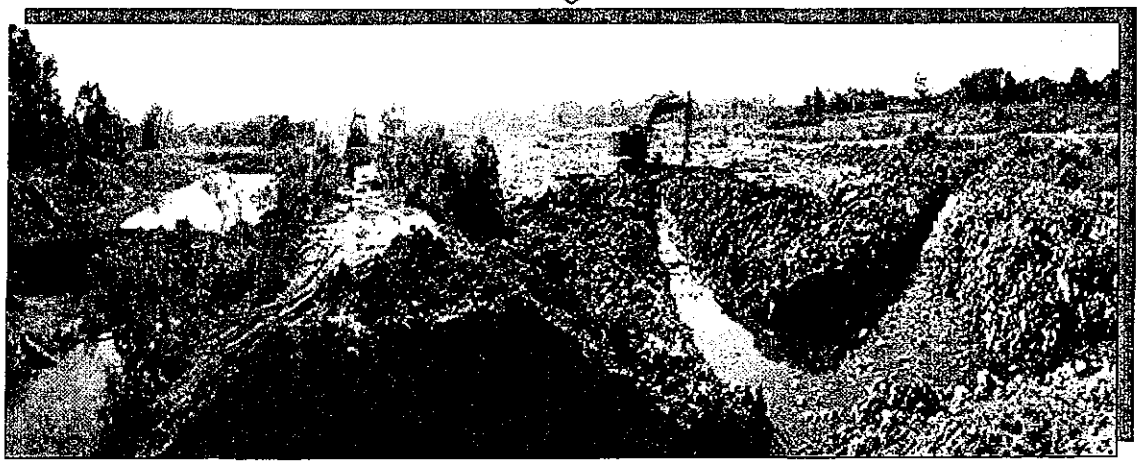
GAS VENT PLAN

100 500 1000
SCALE (mm)

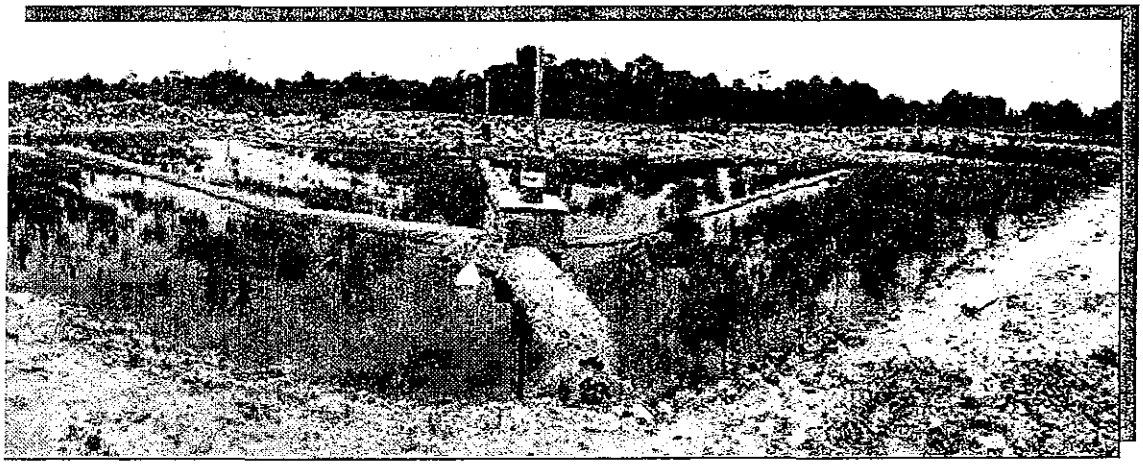
Figure 7.4.3 Typical Sections (Pekan Nenasi Pilot Project)

Plate 7.4.1 Pekan Nenasi Pilot Project 1

Before pilot project (PP)

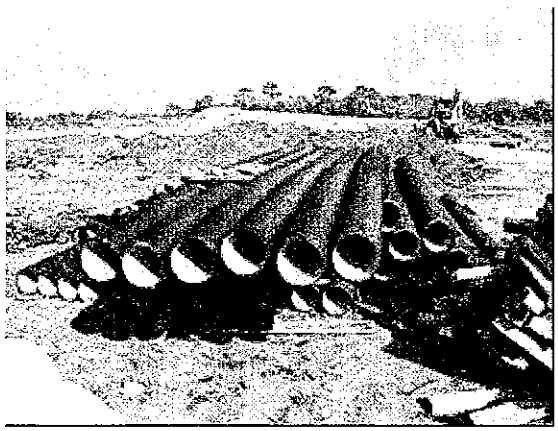


During PP



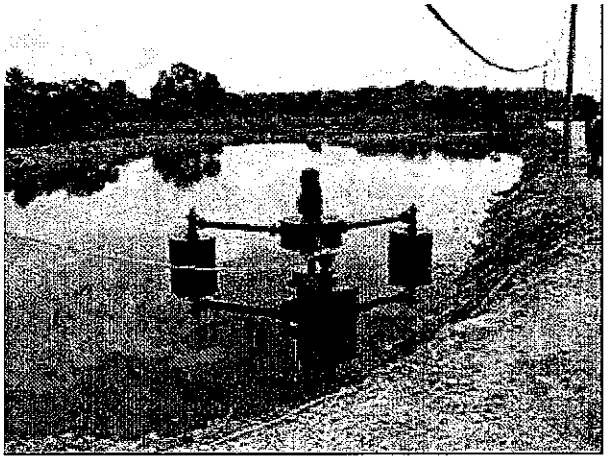
After PP
(Installation of leachate pipe & gas vent)

Plate 7.4.2 Pekan Nenasi Pilot Project 2

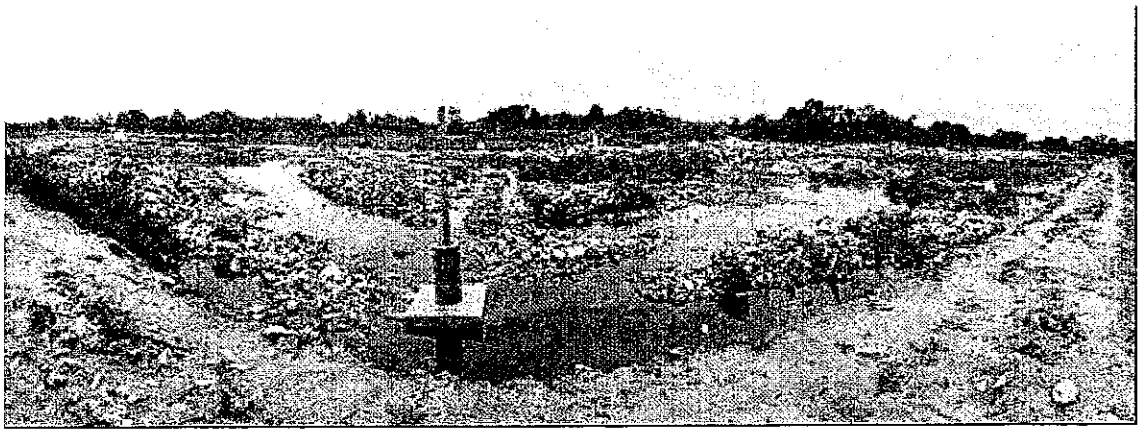


Leachate collection pipe
(Brunch pipe)

Leachate collection pipe
(Main Pipe)



Aerator



Leachate collection & gas venting System Installed by the LA
(After pilot project works)

7.5 ENVIRONMENTAL MONITORING

7.5.1 Monitoring program

(1) Monitoring parameters for water quality and gas composition

Water quality parameters and gas composition parameters, as well as their analytical method are same as those of Ampang Jajar and shown in **Table 5.2.1** in the **Section 5.2** previously.

(2) Sampling Quantity, Schedule and Locations

The following **Table 7.5.1** summarizes the sampling quantity of monitoring for Pekan Nenasi pilot project site.

Table 7.5.1 Sample Number at Pekan Nenasi Pilot Project Site

Sample type	Pekan Nenasi (Number of locations)
Surface water	2
Leachate	1
Groundwater	3
Gas	2

Sampling schedule and specific consideration is same as that applied for Ampang Jajar site.

Figure 7.5.1 shows the location of monitoring for each sample type.

(3) Geological setting and Installation of monitoring well

The site is an active landfill, which is located along the coastal area. The site is relatively flat with the present ground level varies from RL+3.2m to RL+4.2m.

<Geological Background>

Figure 7.5.2 shows a geological map of the site and its surrounding areas. It is reproduced from a geological map of published by Geological Survey Department of Malaysia. As shown in the figure, the site is located in an area of Quaternary Deposits. The Quaternary Deposits are also found prominently along the coastal area. The Quaternary Deposits comprise of beach sand, high and low terrace deposits, laterite, gravel, sand, silt and clay.

<Soil Stratification>

Based on the results of the exploratory drilling, 1 soil profile is prepared. The orientation of the soil profile is indicated in **Figure 7.5.3** whereas the profiles are shown in **Figure 7.5.4**. As can be seen in the soil profile, the subsurface ground conditions at the site can be divided into 2 major geological units:

a) Miscellaneous Fill
b) Quaternary Deposits

<Miscellaneous Fill>

The miscellaneous fill covers the entire area of the landfill site with the thickness varying from 1.85m in PN-W3 to 3m in PN-W1. The fill comprises of yellowish brown mottled grey, brownish gray to dark gray clay or sandy silt and rubbish waste with presence of sand, decayed roots and woods.

Quaternary Deposits
The quaternary deposits consist of the following 4 sub-layers:

a) Very Soft to Soft Clay
b) Medium Stiff to Stiff Clay
c) Very Stiff Clay
d) Very Loose to Loose Sand
e) Medium Dense Sand

<Very Soft to Soft Clay>

The marine clay covers the entire project site. It comprises of greenish gray to gray, dark gray silt with presence of seashell fragments, organic matters and traces of fine sand. The thickness of Marine Clay layer ranges from 3.4m in PN-W2 to 15.3m in PN-W3. The lenses of Very Loose to Loose Sand layer with the thickness of 3.5m are found in Marine Clay in PN-W3.

<Medium Stiff to Stiff Clay>

The Medium Stiff to Stiff Clay comprises of yellowish brown mottled gray to brownish gray silt with presence of fine to medium grained sand and fine gravel and occasionally with some organic decay. The thickness of the Medium Stiff to Stiff Clay layer ranges from 0.7m in PN-W3 to 4.65m in PN-W2. The pockets or lenses of the Very Loose to Loose Sand with thickness of 1m also occur in the Medium Stiff to Stiff Clay layer.

<Very Stiff Clay>

The Very Stiff Clay occurs only in BHPN-W1 and it comprises of yellowish brown mottled gray light gray to gray clay with traces of fine sand. The thickness of Very Stiff Clay is 3.85m.

Very Loose to Loose Sand

The Very Loose to Loose Sand comprises of light gray to greenish gray and dark gray silty sand to sand with presence of sub-angular quartz gravels and seashell fragments. The thickness of Very Loose to Loose Sand varies from 3.15m in PN-W3 to 9.7m in PN-W2.

<Medium Dense Sand>

The Medium dense sand is encountered only in PN-W2. It comprises of dark gray, fine to coarse grained with presence of fine quartz gravels. The Medium Dense Sand occurs as lenses in Very Loose to Loose Sand layer.

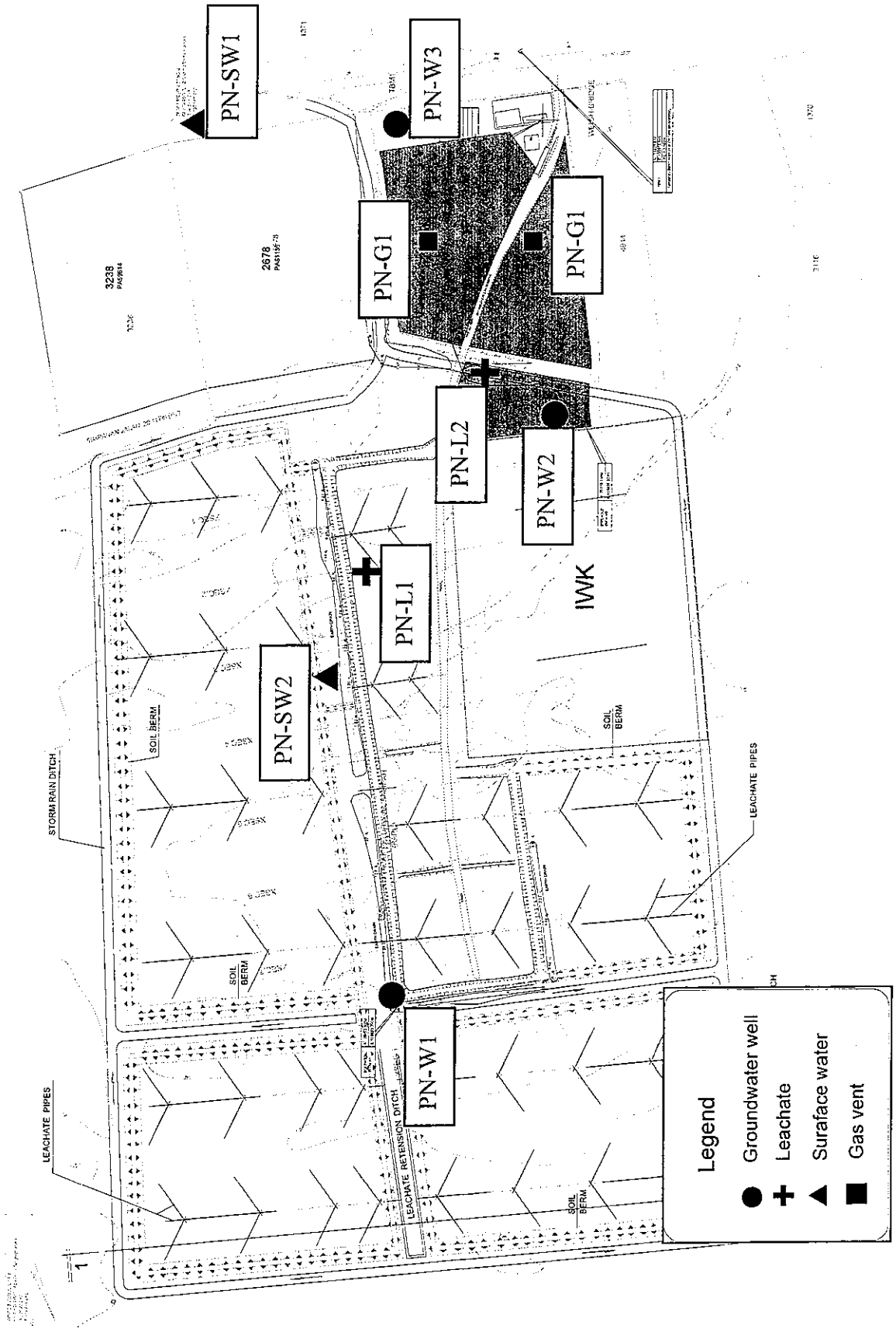


Figure 7.5.1 Sampling Location for Monitoring, Pekan Nenasi

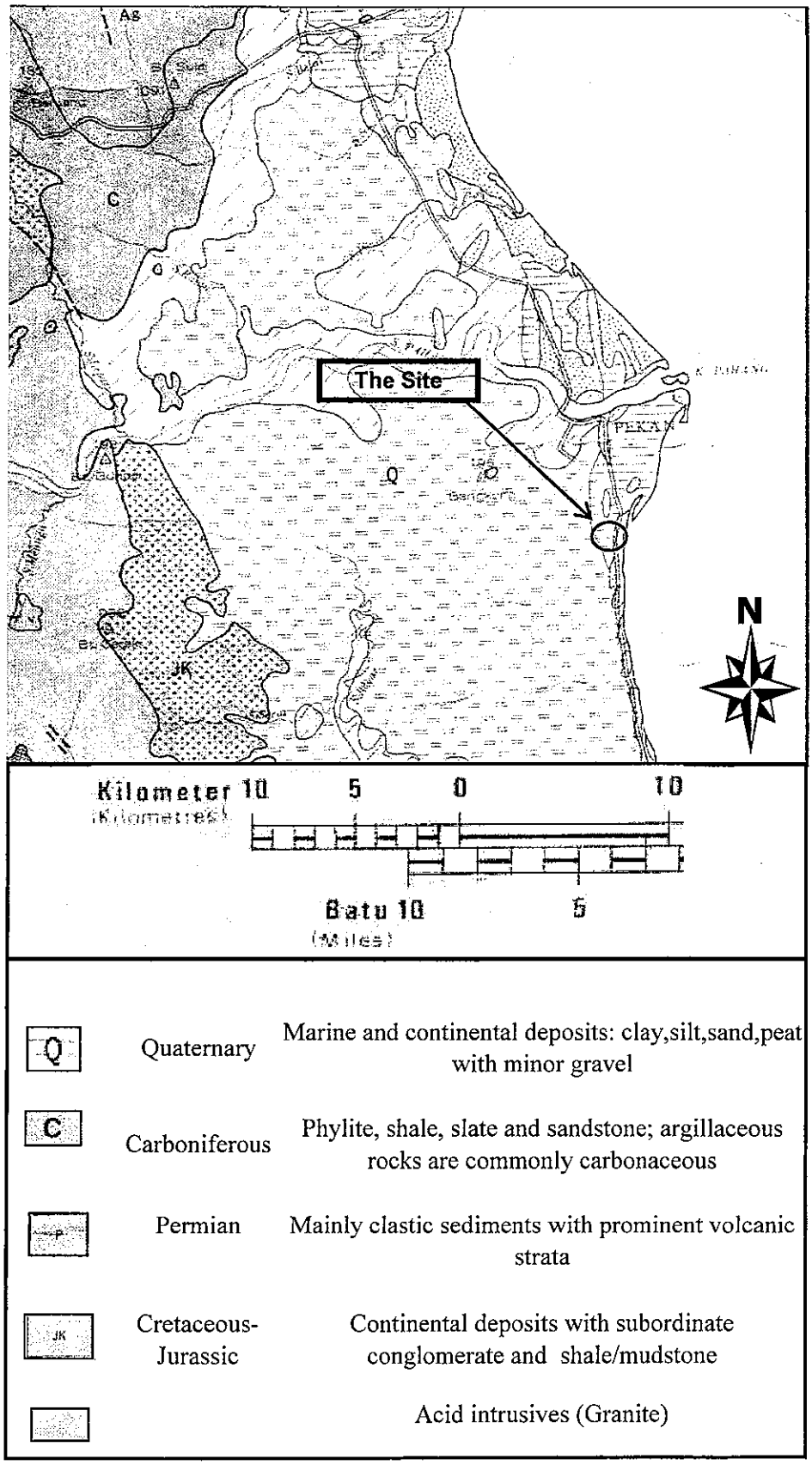


Figure 7.5.2 Map of Geological Setting, Pekan Nenasi (reproduced from geological map published by Geological Survey Malaysia, 1985)

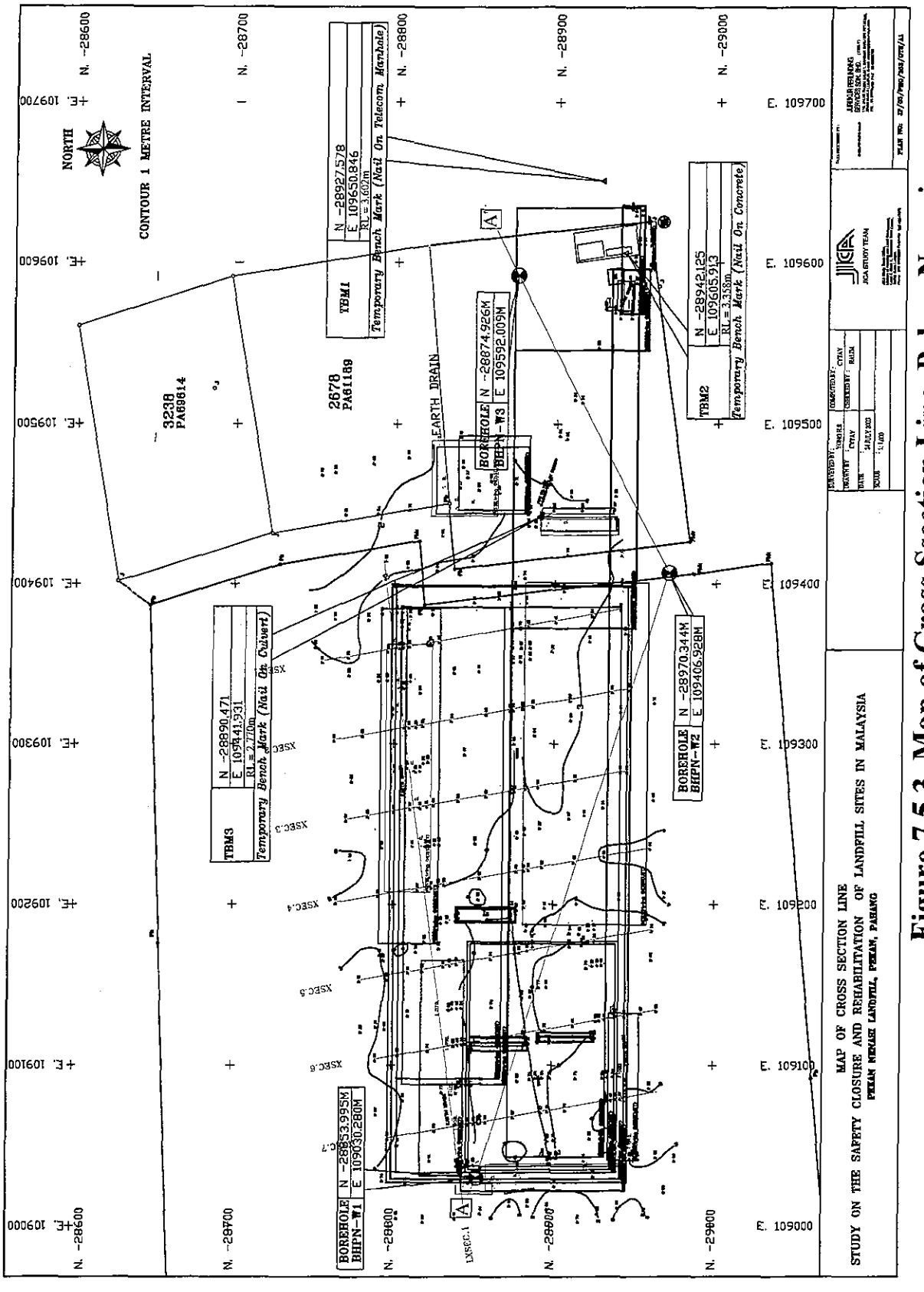


Figure 7.5.3 Map of Cross Ssection Line, Pekan Nenasi

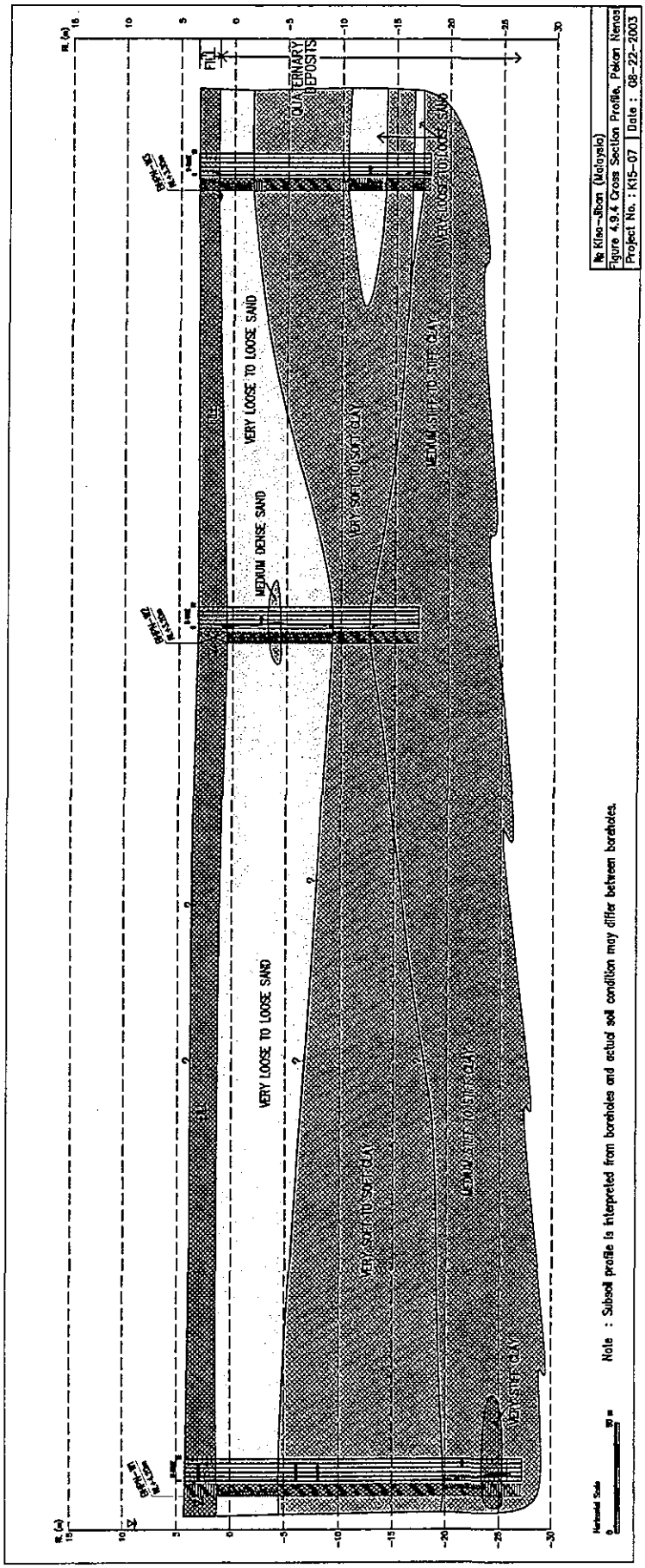


Figure 7.5.4 Cross Section Profile, Pekan Nenasi

7.5.2 Field sampling activity

Field sampling and measurement were carried out prior to the commencement of the works at the site for use as the baseline data. A similar set of sampling was also taken after the works. The sampling schedules are shown in **Table 7.5.2** and **Table 7.5.3.**

Table 7.5.2 Sampling Schedule –Before PP, for Baseline Data

Sampling points	Date	Time	Type of monitoring
PN-W1	10 Oct 2003	11:30	Groundwater monitoring
PN-W3	10 Oct 2003	12:15	
PN-W2	27 Aug 2003	13:00	
PN-G1	27 Aug 2003	13:45	Landfill gas monitoring
PN-G2	27 Aug 2003	14:00	
PN-L1	27 Aug 2003	11:45	Water & leachate monitoring
PN-L2	27 Aug 2003	14:35	
PN-SW1	27 Aug 2003	15:00	
PN-SW2	27 Aug 2003	11:15	

Table 7.5.3 Sampling Schedule – After PP Improvements

Sampling points	Date	Time	Type of monitoring
PN - W1	8 Feb 2004	10:30	Groundwater monitoring
PN – W2	8 Feb 2004	13:00	
PN - W3	8 Feb 2004	12:30	
PN - G1	8 Feb 2004	12:15	Landfill gas monitoring
PN – G2	8 Feb 2004	12:00	
PN - SW 1	8 Feb 2004	13:30	Water & leachate monitoring
PN - SW 2	8 Feb 2004	11:00	
PN - L 1	8 Feb 2004	11:30	
PN - W1	20 May 2004	09:45	Groundwater monitoring
PN – W2	20 May 2004	13:30	
PN - W3	20 May 2004	12:55	
PN - G1	20 May 2004	14:20	Landfill gas monitoring
PN – G2	20 May 2004	14:00	
PN - SW 1	20 May 2004	11:20	Water & leachate monitoring
PN - SW 2	20 May 2004	10:30	
PN - L 1	20 May 2004	11:00	
PN - W1	30 June 2004	13:20	Groundwater monitoring
PN – W2	30 June 2004	12:25	
PN - W3	30 June 2004	10:55	
PN - G1	30 June 2004	11:35	Landfill gas monitoring
PN – G2	30 June 2004	11:45	
PN - SW 1	30 June 2004	12:10	Water & leachate monitoring
PN - SW 2	30 June 2004	09:20	
PN - L 1	30 June 2004	09:40	

The samples were taken in accordance with the parameters and specific preservation methods as explained in **Sections 5.2** and **5.3.**

Plate 7.5.1 shows some of the photographs taken during the sampling exercise in August 2003.

Plate 7.5.1 Sampling Exercise in Pekan Nenasi PP

PN-L1

PN-L2

PN-SW1

PN-SW2

PN-W1

PN-W3

PN-W2

PN-G1

7.5.3 Laboratory analysis

The results of the laboratory analysis for both the sampling exercise are shown in **Table 7.5.4**, **7.5.5** and **7.5.6**.

Table 7.5.4 Summary of Results - Physical Parameters

Samples taken on		*10/10/03*		*27/8/03*			
Test Parameters	Units	W1 11:30hrs	W3 12:15hrs	W2 13:00hrs	L1 11:45hrs	SW1 15:00hrs	SW2 11:15hrs
pH (*in-situ*)	-	6.9	7.0	6.4	7.4	7.3	4.1
Temperature (*in-situ*)	^{0}C	30	30	32	34	29	32
ORP	mV	-45	-132	-113	56	41	353
Conductivity	mS/cm	1.41	3.95	1.16	4.35	0.236	0.348
Turbidity	NTU	18.4	27.6	60.8	56.1	13.8	6.28
DO	mg/l	4.6	4.7	1.31	0.3	1.05	2.81
BOD_5 at 20^{0}C	mg/l	4	21	25	47	5	1
COD	mg/l	28	38	86	653	87	17
Total suspended solid	mg/l	24	15	146	35	6	7
Samples taken on		*08/02/04*					
Test Parameters	Units	W1 10:30hrs	W2 13:00hrs	W3 12:30hrs	L1 11:30hrs	SW1 13:30hrs	SW2 11:00hrs
pH	-	6.8	6.0	7.1	7.8	6.2	6.0
Temperature	°C	28	30	30	28	30	27
ORP	mV	-301	-74	-162	-58	53	-132
Conductivity	mS/cm	4.45	1.26	3.65	1.20	0.082	0.281
Turbidity	NTU	7.89	7.59	7.00	32.3	26.6	18.3
DO	mg/l	1.35	1.62	0.75	2.50	0.85	4.48
BOD_5	mg/l	22	6	12	90	4	1
COD	mg/l	105	79	75	161	38	15
Suspended Solids	mg/l	4	11	1	52	25	8

Samples taken on		*20/05/04*					
Test Parameters	Units	W1 09:45hrs	W2 13:30hrs	W3 12:55hrs	L1 11:00hrs	SW1 11:20hrs	SW2 10:30hrs
pH	-	6.9	6.4	6.4	7.5	7.4	3.7
Temperature	°C	29	31	30	31	30	31
ORP	mV	-217	-118	-173	106	378	279
Conductivity	mS/cm	6.95	1.70	4.06	1.13	3.52	1.09
Turbidity	NTU	46.6	4.50	3.85	56.40	14.7	3.04
DO	mg/l	0.64	1.70	0.96	3.00	1.99	6.16
BOD_5	mg/l	29	31	46	24	5	2
COD	mg/l	96	56	109	159	20	10
Suspended Solids	mg/l	12	4	11	47	10	1
Samples taken on		*30/06/04*					
Test Parameters	Units	W1 13:20hrs	W2 12:25hrs	W3 10:55hrs	L1 09:40hrs	SW1 12:10hrs	SW2 9:20hrs
pH	-	7.0	6.0	6.9	7.2	5.8	3.6
Temperature	°C	30	31	29	30	28	29
ORP	mV	-85	-93	-176	55	-15	364
Conductivity	mS/cm	6.43	1.37	3.26	1.6	0.1	0.52
Turbidity	NTU	41.7	5.67	6.13	125	19.4	5.73
DO	mg/l	1.91	1.13	1.04	2.68	2.49	3.89
BOD_5	mg/l	30	12	15	85	9	1
COD	mg/l	125	74	95	340	66	7
Suspended Solids	mg/l	36	2	9	62	20	2

Table 7.5.5 Summary of Results - Metals and Other Test

Samples taken on		*10/10/03*		*27/8/03*			
Test Parameters	Units	W1 11:30hrs	W3 12:15hrs	W2 13:00hrs	L1 11:45hrs	SW1 15:00hrs	SW2 11:15hrs
Arsenic	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Boron	mg/l	0.3	0.8	<0.2	<0.2	<0.2	<0.2
Cadmium	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hexavalent Chrome	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Trivalent Chrome	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	mg/l	1.54	3.08	17.0	1.55	3.08	0.51
Lead	mg/l	0.08	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	mg/l	0.55	0.42	0.54	0.08	0.08	0.54
Mercury	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/l	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Tin	mg/l	<0.1	<0.1	<0.1	0.2	<0.1	<0.1
Zinc	mg/l	0.08	0.13	0.05	0.07	0.04	0.11
Cyanide	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphide	mg/l	<0.01	0.02	<0.01	0.31	<0.01	<0.01
Chloride ion	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenol	mg/l	0.03	0.1	<0.02	<0.02	<0.02	<0.02
Oil & Grease	mg/l	<1	<1	<1	<1	<1	<1
Total Nitrogen	mg/l	4	18.2	16	218	2	<1
Ammonia Nitrogen	mg/l	4.3	18	16.5	218	1.77	0.40
Nitrate Nitrogen	mg/l	<0.01	<0.01	0.03	<0.01	0.07	0.11
Nitrite Nitrogen	mg/l	<0.01	<0.01	<0.01	0.03	<0.01	<0.01

Samples taken on		*08/02/04*					
Test Parameters	Units	W1 10:30hrs	W2 13:00hrs	W3 12:30hrs	L1 11:30hrs	SW1 13:30hrs	SW2 11:00hrs
Arsenic	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Boron	mg/l	0.6	0.2	0.7	< 0.2	< 0.2	< 0.2
Cadmium	mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hexavalent Chrome	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Trivalent Chrome	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Copper	mg/l	0.02	0.05	0.03	0.09	0.08	0.10
Iron	mg/l	0.13	22.1	0.90	0.32	2.75	0.78
Lead	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Manganese	mg/l	0.18	0.31	0.40	0.20	0.09	0.19
Mercury	mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/l	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01
Tin	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/l	0.05	0.03	0.07	0.07	0.14	0.08
Cyanide	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Sulphide	mg/l	7.39	< 0.01	0.68	< 0.01	< 0.01	< 0.01
Chloride ion	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Phenol	mg/l	0.280	0.060	< 0.001	< 0.001	< 0.001	< 0.001
Oil & Grease	mg/l	ND(<1)	ND(<1)	ND(<1)	ND(<1)	ND(<1)	ND(<1)
Total Nitrogen	mg/l	18	20	14	38	2	2
Ammonium-nitrogen	mg/l	15.0	16.0	12.0	33.0	< 0.01	0.42
Nitrate-nitrogen	mg/l	0.11	0.13	0.19	3.17	0.05	0.39
Nitrite-nitrogen	mg/l	< 0.01	< 0.01	< 0.01	16.1	< 0.01	< 0.01

Samples taken on		*20/05/04*					
Test Parameters	Units	W1 09:45hrs	W2 13:30hrs	W3 12:55hrs	L1 11:00hrs	SW1 11:20hrs	SW2 10:30hrs
Arsenic	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Boron	mg/l	0.8	<0.2	0.6	<0.2	<0.2	<0.2
Cadmium	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hexavalent Chrome	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Trivalent Chrome	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	mg/l	1.91	17.3	5.47	0.84	5.16	0.28
Lead	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	mg/l	0.41	0.59	0.27	0.18	0.59	1.10
Mercury	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tin	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	mg/l	0.03	0.03	0.01	0.03	0.13	0.17
Cyanide	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphide	mg/l	0.76	0.03	0.08	0.03	<0.01	<0.01
Chloride ion	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenol	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Oil & Grease	mg/l	<1	<1	<1	<1	<1	<1
Total Nitrogen	mg/l	36	23	23	20	9	10
Ammonium-nitrogen	mg/l	29.5	15.5	15.1	5.25	0.37	0.08
Nitrate-nitrogen	mg/l	<0.01	0.23	<0.01	<0.01	<0.01	<0.01
Nitrite-nitrogen	mg/l	0.02	<0.01	<0.01	<0.01	<0.01	<0.01

Samples taken on		*30/06/04*					
Test Parameters	Units	W1 13:20hrs	W2 12:25hrs	W3 10:55hrs	L1 09:40hrs	SW1 12:10hrs	SW2 9:20hrs
Arsenic	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Boron	mg/l	1.2	< 0.2	0.8	< 0.2	< 0.2	< 0.2
Cadmium	mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hexavalent Chrome	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Trivalent Chrome	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Copper	mg/l	0.09	0.19	< 0.01	0.27	0.24	< 0.01
Iron	mg/l	0.03	44.8	4.76	1.29	7.02	0.5
Lead	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Manganese	mg/l	0.07	1.07	0.22	0.31	0.13	1.16
Mercury	mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/l	< 0.01	< 0.01	< 0.01	0.03	< 0.01	0.03
Tin	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/l	0.01	0.11	0.02	0.22	0.1	0.17
Cyanide	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Sulphide	mg/l	1.23	< 0.01	0.24	0.18	< 0.01	< 0.01
Chloride ion	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Phenol	mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Oil & Grease	mg/l	< 1	< 1	< 1	< 1	< 1	< 1
Total Nitrogen	mg/l	43	36	19	37	4	1
Ammonium-nitrogen	mg/l	39.4	34.2	17.9	22.6	< 0.01	0.26
Nitrate-nitrogen	mg/l	0.13	0.1	0.08	0.07	0.07	0.08
Nitrite-nitrogen	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Table 7.5.6 Summary of Results - Landfill Gases

Samples taken on		*27/8/03*	
Test Parameters	Units	PN-G1 13:45hrs	PN-G2 14:00hrs
Methane (CH_4)	%	0.2	0.2
Carbon Dioxide (CO_2)	%	<0.03	<0.03
Oxygen (O_2)	%	21.5	21.4
Nitrogen (N_2)	%	78.4	78.5
Hydrogen Sulphide (H_2S)	ppm	Not Detectable	Not Detectable
Carbon Monoxide (CO)	ppm	4.0	2.0
Samples taken on		*08/02/04*	
Test Parameters	Units	PN-G1 12:15hrs	PN-G2 12:00hrs
Methane (CH_4)	%	0.06	0.2
Carbon Dioxide (CO_2)	%	<0.03	2.9
Oxygen (O_2)	%	20.5	17.8
Nitrogen (N_2)	%	79.4	79.2
Hydrogen Sulphide (H_2S)	ppm	Not Detectable	Not Detectable
Carbon Monoxide (CO)	ppm	2.3	2.7
Samples taken on		*20/05/04*	
Test Parameters	Units	PN-G1 14:20hrs	PN-G2 14:00hrs
Methane (CH_4)	%	0.5	0.4
Carbon Dioxide (CO_2)	%	1.4	<0.03
Oxygen (O_2)	%	16.8	18.3
Nitrogen (N_2)	%	81.0	81.3
Hydrogen Sulphide (H_2S)	ppm	Not Detectable	Not Detectable
Carbon Monoxide (CO)	ppm	4.0	1.5

Samples taken on		*30/06/04*	
Test Parameters	Units	PN-G1 11:35hrs	PN-G2 11:45hrs
Methane (CH_4)	%	0.6	0.7
Carbon Dioxide (CO_2)	%	1.1	<0.03
Oxygen (O_2)	%	16.6	17.2
Nitrogen (N_2)	%	81.7	82.0
Hydrogen Sulphide (H_2S)	ppm	Not Detectable	Not Detectable
Carbon Monoxide (CO)	ppm	3.3	4.0

7.5.4 Considerations

(1) Considerations - Baseline

The monitoring data taken in August 2003 represent the baseline data.

1) Groundwater quality

The monitoring wells PN-W1 and PN-W3 were installed to the depth below the soft clay layer of over 5-10m thick. The depth of PN-W2 was set at the sand layer near the surface. The results roughly indicated that the iron and manganese values exceeded the permitted benchmarked limits. Generally, iron and manganese are present in the groundwater from the dissociation of iron and manganese hydroxide in the soil and thus their detection may be insignificant and may not be due to the influence of the landfill contaminant. However, the results also show relatively high levels of ammonia and electric conductivity that are caused by contamination. The contamination may have originated from the landfilled waste and may have also come from the adjacent sewage sludge disposal site. The sampling point PN-W1 that is the furthest from the landfilled area of the site showed the least contamination.

2) Groundwater Flow

The groundwater levels measured during the sampling exercise are shown in **Table 7.5.7**.

Table 7.5.7 Groundwater Levels at Pekan Nenasi PP Site

Monitoring Well	Elevation (MSL m)	Groundwater level from the top of the well (m)	Groundwater level (MSL m)
PN-W1	4.2	2.04	2.16
PN-W2	3.2	1.3	1.9
PN-W3	3.3	1.77	1.53

With the groundwater levels, the contour map for groundwater was generated and shown in **Figure 7.5.5**. The general direction of the groundwater flow can be deduced by considering its flow as perpendicular to the contour line. Thus, from the contour map, the groundwater flow was deduced to flow from the west to the east. The relatively equally spaced contour lines indicate the homogeneous permeability of the aquifer and this may imply that the aquifer crossing the monitoring wells may be interconnected despite their difference in the depths.

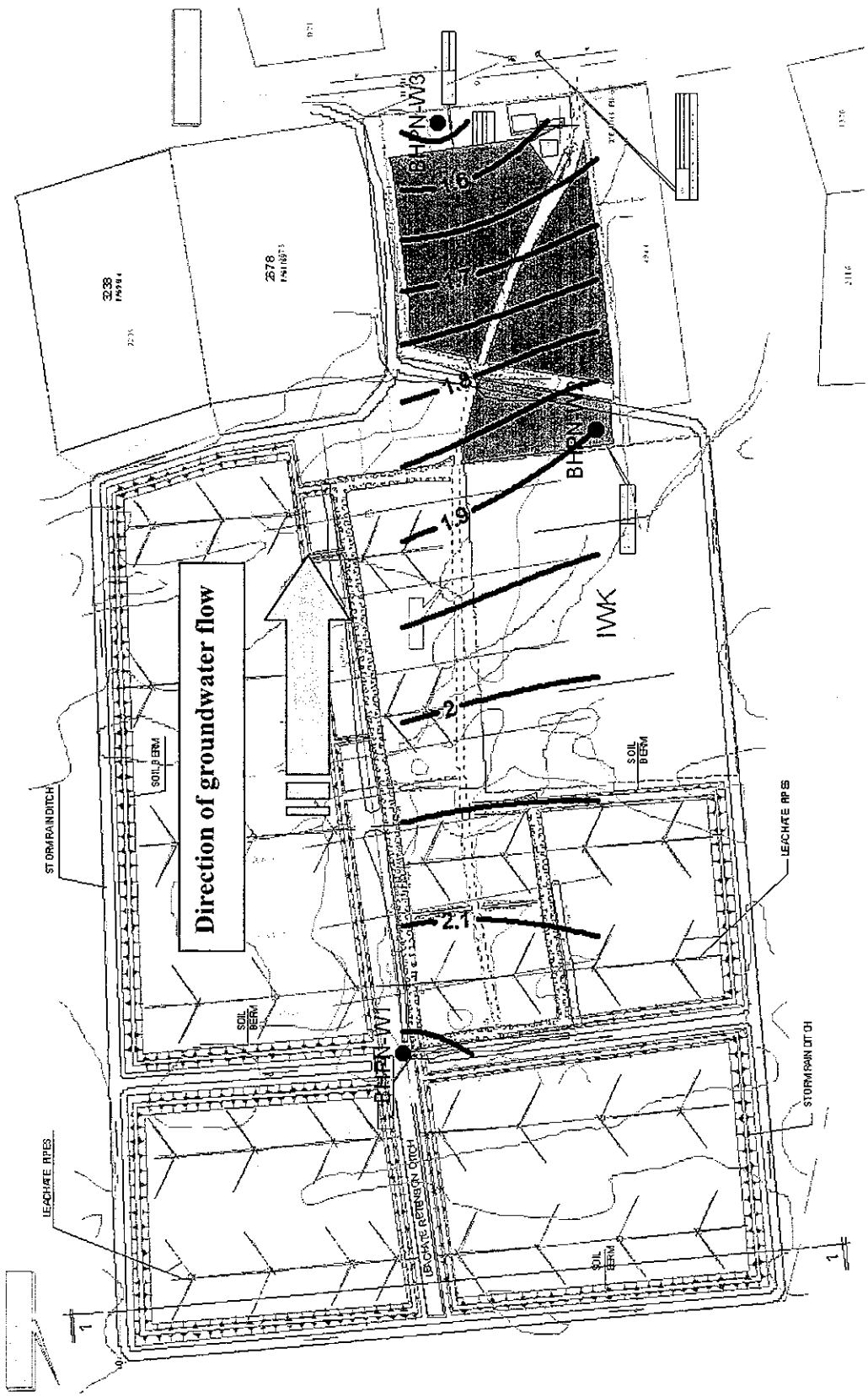


Figure 7.5.5 Groundwater Level Contour Map - Pekan Nenasi PP

3) Leachate and Surface water quality

Similarly, with the Ampang Jajar PP, the Pekan Nenasi Landfill site is situated downstream of water intake points and hence the EQA effluent quality Standard B is applied. The results for the water quality parameters are shown in **Table 7.5.8**.

Table 7.5.8 Leachate and Water Quality

	Standard B	L1	SW1	SW2
BOD_5 at 20° C (mg/l)	50	47	5	1
COD (mg/l)	100	*653*	87	17

From the above table, it shows that the result for COD for PN-L1 exceeded the permitted standard limits. The results for the other monitoring points were within the limits of Standard B. The surface water around the site is within the standard B though they are vulnerable to be contaminated due to stagnation.

The relationship between the quality of leachate, surface water and groundwater can be expressed in their total nitrogen and electric conductivity as shown in **Figure 7.5.6**, similar to the chart that was produced for Ampang Jajar PP.

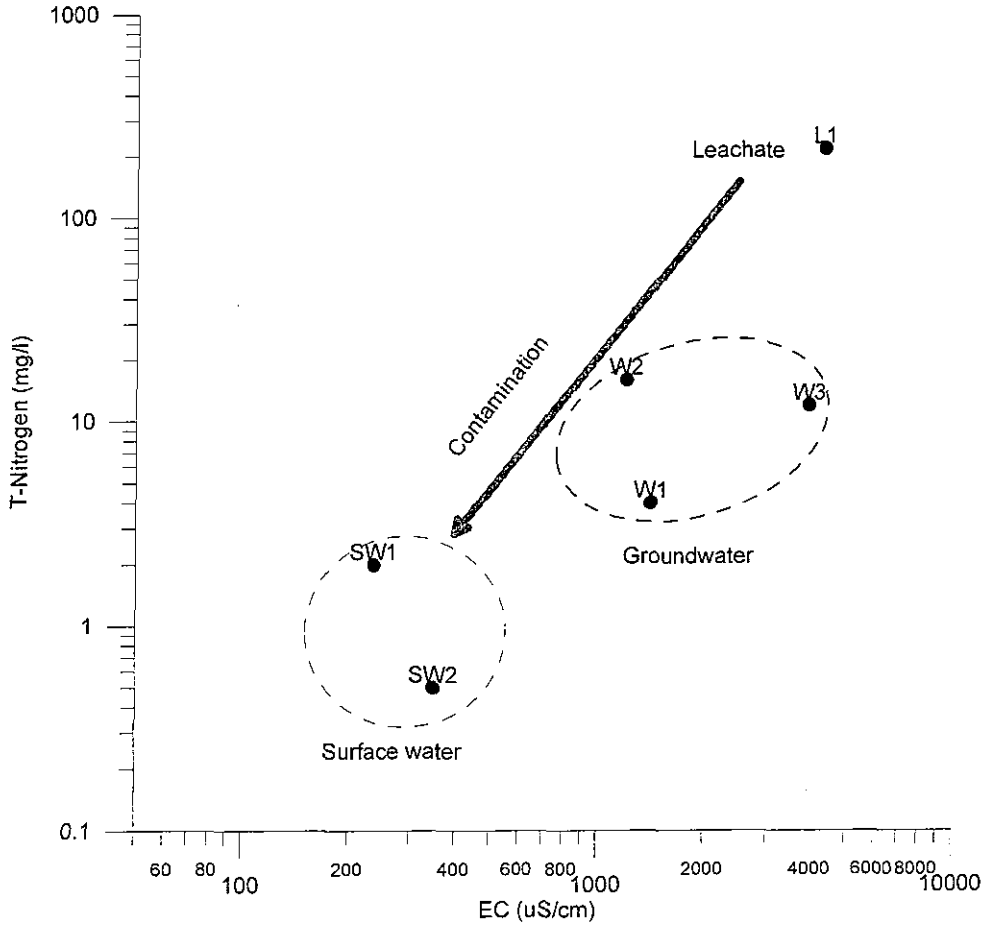


Figure 7.5.6 Water Quality Relationship - Pekan Nenasi PP

From the chart, it can be observed that the 3 sample groups are apart, with leachate as the most contaminated, followed by groundwater and the surface water. Also it is noted that approximate ratio of Total nitrogen and Electric conductivity are the same for the three groups thus implying they may have the same source of contamination.

4) Landfill gas

The Pekan Nenasi site is relatively new and the waste layer at the closed site is fairly thin, thus there is no significant landfill gas detected at the gas vents.

(2) Considerations - after the PP improvements

The evaluation of the PP improvement will be discussed in **Volume 4, Chapter 9**. The brief results of the environmental monitoring will be discussed for three aspects, i.e., environmental impact, safety and stabilization process.

1) Environmental impact

For surface water and leachate, their water quality was compared with the effluent standard B. As noted in **Table 7.4.7**, the BOD_5 and COD in L1 point exceeded the effluent standard B during baseline sampling before PP improvement. **Table 7.5.9** summarised the result of the monitoring for those parameters exceeding the effluent standard B.

Leachate L1 exceeded the BOD_5 and COD in most cases. Surface water SW1 and SW2 were well below the standard. As the site is relatively flat, flow of the surface water is almost negligible, and leachate outflow is minimum. The environmental impact by high BOD5 and COD to the surrounding area is not serious. On the other hand, high Iron and Manganese were observed in the surface water. As the leachate sample showed low concentration for Iron and Manganese, these high values in the surface water may have come from other sources and most likely naturally from the soil.

Table 7.5.9 Result of Landfill Gas Parameters

	Sampling point	BOD_5 (mg/l)	COD (mg/l)	Iron (mg/l)	Manganese (mg/l)
Effluent standard B		50	100	5.0	1.0
Feb/04	L1	***90***	***161***	0.32	0.2
	SW1	4	38	2.75	0.09
	SW2	1	15	0.78	0.19
May/04	L1	24	***159***	0.84	0.18
	SW1	5	20	***5.16***	0.59
	SW2	2	10	0.28	***1.1***
June/04	L1	***85***	***340***	1.29	0.31
	SW1	9	66	***7.02***	0.13
	SW2	1	7	0.5	***1.16***

The groundwater quality of the monitored samples was not suitable for human consumption, mainly due to the high ammonia of over 10mg/l. Also high Iron and Manganese were observed. The flow of the groundwater was determined to flow towards the eastern direction. According to the baseline survey, hydraulic gradient of

the area is approximately 1/1,000 and permeability ranged between 1.5 x 10^{-4} to 1.7 x 10^{-4} m/sec. Assuming effective porosity at 10%, the approximate velocity of groundwater flow should be about 50 m/year. These are preliminary estimates based on currently available limited data. Any use of the groundwater at the eastern direction of the site within approximately 500 m should be strictly supervised to avoid any negative health effect.

2) Safety

Presently the waste layer is relatively thin and the amount of waste is not sufficient enough to generate much landfill gas.

Risk of slope collapse is not concern for the site.

3) Stabilisation process

Since the Pekan Nenasi landfill is still relatively new, it is too early to discuss about the stabilisation process.

7.6 CONTINUOUS OPERATIONS & MAINTENANCE AND MONITORING

7.6.1 *Operation and maintenance of landfill facilities*

All the facilities provided and installed at the landfill site, such as the leachate collection and treatment systems, leachate pond and gas ventilation systems should be operated and maintained properly throughout the entire life of the landfill and including the post closure period.

It is highly recommended that the Local Authority or the operator of the site should carry out the regular inspection and maintenance work at the site, and to ensure that the facilities are in good working conditions. The types of work required are as follows;

a. *Leachate collection and treatment facilities*

The proper operation and maintenance of the leachate collection and treatment facilities is essential for the treatment of the leachate prior to discharging the effluent into the drains. The equipments such as the aerator and the recirculation pump must be maintained and serviced regularly and should be in good working conditions. The control panel should be inspected regularly and maintained.

b. Gas ventilation pipes

The gas ventilation pipes act as the gas vents and also air supply pipes to supply oxygen to the waste layers and accelerate the waste degradation process. The gas ventilation pipes should be maintained over the long term and new ventilation pipes be installed where necessary.

c. Top cover

Since the Pekan Nenasi landfill site is still in operations, top cover is not necessary however, intermediate soil cover should be provided and compacted for the active cells. Nevertheless, for the closed section of the site, i.e. in the eastern front area, the top cover should be inspected regularly and any cracks on the surface should be repaired where necessary.

d. Surface drainage

Surface drains were not included in the PP but however the existing surface drainage system and stream should be inspected and maintained regularly, and cleared of any debris and blockages. Since the area is on a low lying swamp land, it is crucial to ensure that the surface water or floor water does not flow into the landfill cells, and should be diverted to the main discharge drains.

e. Other supporting facilities

Other supporting facilities like the access road, bund walls and power supply pylons and cables should be maintained where necessary for a long period of time.

The typical example of the maintenance items of the landfill facilities, method and scale/frequency are shown in **Table 7.6.1**.

Table 7.6.1 Summary of Maintenance Items

Facilities	Items	Methods	Scale/ Frequency
Top cover & dykes	Cracks, pools and soil erosion on the surface, State of plants	Periodic visual inspections	The entire site, weekly
Surface drainage on the top cover	Clogging by soil/leaves, Damage by sedimentation	Periodical visual inspections	The entire site, weekly (more frequent during the rain season)
Cut-off drainage around the site	Clogging by soil/leaves, Damage by traffic	Periodical visual inspections	The entire site, weekly (more frequent during the rain season)
Gas ventilation pipes	Clogging, damage to pipes, corrosion	Periodical visual inspections	all pipes, weekly
Leachate collection pipes	Clogging, damage to pipes, corrosion	Periodical inspections & comparison of the effluent quantity data	daily
Leachate treatment facility	Quality of treated effluent	Daily inspections (colour of effluent) Periodical effluent analysis	daily monitoring frequency
Monitoring facility	Conditions of the monitoring wells	Periodical inspections	all wells, weekly

7.6.2 Monitoring of environment and landfill stabilisation

In accordance with the Guideline, for the Post Closure Management for Pekan Nenasi, the following monitoring programme has been recommended, as shown in **Table 7.6.2**.

Table 7.6.2 Monitoring Programme

Monitoring media/parameters	Item and parameters	Frequency	Location
Leachate	• pH • BOD • COD • Nitrogen (Ammonia, Nitrate, Nitrite) • ORP • EC • TOC	4 times/year	1 point/ leachate pond
Landfill gas	• Oxygen (O_2) • Nitrogen (N_2) • Methane (CH_4) • Carbon Dioxide (CO_2) • Hydrogen Sulfide • Temperature	2 times/ year	2 points/ site
Land subsidence	Topographic height of the top of the landfill	Once a year	1 point/ landfill block
Groundwater	Groundwater benchmark parameters	Once a year	3 points/ site
Surface water	Effluent standard parameters	Once a year	2 points/ stream

The site specific recommendations are as follows.

(1) Leachate

Leachate should be monitored according to the guideline.

(2) Landfill gas

If the waste thickness is more than 1.5m, landfill gas monitoring will be required. The gas vent pipes should be extended when necessary.

(3) Land subsidence

Since the Pekan Nenasi Landfill is still relatively shallow, the subsidence may not be detectable. Nevertheless, the surface level should be monitored in accordance with the guideline.

(4) Groundwater

All the groundwater samples exhibited deteriorating water quality that is not suitable for human consumption. It is recommended that additional monitoring well be provided at the eastern direction, at about 200-300 m east of well W3.

(5) Surface water

Surface water should be monitored regularly in accordance with the guideline.

CHAPTER 8 AMPANG JAYA CLOSED LANDFILL SITE (SELANGOR)

8.1 LANDFILL OPERATIONS AND SITE CHARACTERISTICS

The brief description of the closed landfill operations and site characteristics are summarised in **Table 8.1.1**.

Table 8.1.1 Ampang Jaya Closed Landfill Operations and Site Characteristics

Operational Characteristics	Location Characteristics
⇒ Started operations in 1992 and closed in 1998 after an accident at the site ⇒ About 400 tonnes/day of waste was disposed at the landfill (about 1.0 million tons in total) ⇒ Waste was by dumped into the valley from the top and filled the western and eastern slopes and the bottom of the western valley	⇒ Located east of MP Ampang Jaya on a hilly area in the basin of Sungai Langat ⇒ The Hulu Langat water intake point is located about 8km downstream of the site

8.2 THE SAFE CLOSURE PLAN

Since the site has been closed and abandoned, it must be closed properly. The SC Plan included the installation of a proper surface drainage system, leachate collection systems and gas ventilations systems in order to close this site properly and keep the slope safe, stop erosion and avoid water contamination.

8.3 PILOT PROJECT IMPLEMENTATION AND SCHEDULE

(1) Topography Survey

The Ampang Jaya closed landfill is situated in a hilly area and a valley. The waste was dumped along the ridge and onto the western slopes and into the valley. In 1998, a landslide occurred and subsequently the landfill operation was stopped and the site closed. For the rescue purposes, a temporary access road was constructed leading down to the valley.

During the site visit, it was observed that the valley was deep and the slopes were steep. Thus it was decided to implement the Pilot Project works at the bottom of the valley and up to the foot of the western slopes. For access purposes, the temporary access road needed to be upgraded as well. The topography survey focused on the valley bed and the entire length of the access road from the top to the bottom. The survey was carried out in August 2003 and produced the final survey plans that included the following:

a) For the Valley Bed

- Locations of the 2 survey control point benchmarks.
- Plane table survey (spot levelling, approx. 10 hectares) and mapping (1:1,000)
- Cross section and longitudinal section levelling and mapping (1:1,000 scale for horizontal direction and 1:100 scale for vertical direction)

- Indication of existing salient features on the site such as buildings, pipelines, etc.

b) For the Access Road

- Plane table survey (spot levelling, approx. 2 hectares, width of 2m and 1,000m distance) and mapping (1;1,000 scale)
- Cross section and longitudinal section levelling and mapping (1:1,000 scale for horizontal direction and 1:100 scale for vertical direction)

(2) Soil Investigations

The soil investigations exercise was carried out from July 21 to July 28, 2003. The fieldwork required the drilling and sampling at 3 locations, and the installation of 2 water-monitoring wells and 1 gas monitoring well. The undisturbed soil samples and selected disturbed Standard Penetration Test (SPT) soil samples were taken to the laboratory for analysis.

The topography of the site featured undulating hill. The north-eastern part of the site is higher and sloping towards the western part. The boreholes AM-W1 and AM-G1 are located on the northern tip of the site on higher grounds. The AM-W2 is located on the valley bed downstream of the Pilot Project area.

The summary of the fieldworks and types of laboratory tests for the Ampang Jaya PP is tabulated in **Table 8.3.1**. The information for soil stratifications are summarised in **Table 8.3.2**.

Table 8.3.1 Soil Investigation Borehole Specifications and Tests Results

Boreholes	AM-W1	AM-W2	AM-W3	Total
1. Geographical coordinates				
North	3°7'59.7"	3°7'41.8"	3°7'58"	-
East	101°48'25.8"	101°48'20.3"	101°48'27.6"	-
Elevation (RL m)	188.0	95.964	191.0	-
2. Fieldwork				
Total drilling (m)	19.72	15.20	14.60	49.52
Standard Penetration Test (no.)	19	13	14	46
3. Laboratory Tests (numbers)				
Moisture content	9	9	0	18
Specific gravity	9	9	0	18
Grain size analysis	9	9	0	18

Table 8.3.2 Soil Stratification at Ampang Jaya Closed Landfill Site

Layer	Description
Miscellaneous fill material	The miscellaneous fill material covered the entire area of the landfill site varying from 5.75m thick in AM-W2 to more than 14.60m thick in AM-G1. The fill material comprises of greyish brown mottled yellowish to yellowish brown sand with presence of decayed woods, construction debris, domestic waste and fine gravel. Yellowish brown to light grey spotted black, weak to strong boulders were also observed in the fill layers in AM-W1 with confirmed thickness ranging form 0.2m to 1.4m.
Colluvial deposits	The Colluvial deposits are debris produced by slope failure and erosion. The colluvial distribution at the site was random and the variation of its components is very large. These layers were found

	underlying the fill layer in AM-W1 and AM-W2 and underlaid by the residual soils of Granite. The colluvial deposits varied from 1.05m thick in AM-W2 to 1.10m thick in AM-W1, and comprised of light grey to dark grey, sandy clay and sand with presence of decayed woods and some fine gravel.
Residual Soils of Granite	This layer is distributed throughout the entire site and consists of light grey to yellowish brown mottled white silty sand and sandy silt with some fine to medium grained sand, fine quartz gravels and completely destroyed feldspar. In terms of SPT N-values, the layer is sub-divided into 3 zones; a) residual soil I (RSI) with N=0 to 30 and 2.8m -4.7m thick, b) residual soil II (RSII) with N= 30 to 50 and 1m thick, and c) residual soil III (RSIII) with N>50 with 2.7m thick.
Granite Bedrock	This layer was encountered at a depth of 13.7m in AM-W2. The layer is yellowish brown to light grey, weak to strong and moderately to slightly weathered. the final layer thickness was not confirmed as the drilling was terminated at this depth.

The water levels below ground that were monitored in the water standpipes throughout the period of the fieldwork, ranged from 1.65m to 16.05m. The engineering properties of the soil layers were obtained from the in-situ and laboratory tests, and are summarised in **Table 8.3.3**.

Table 8.3.3 Ampang Jaya Closed Landfill Site Soil Engineering Properties

	Unit	Misc. Fill	Colluvial Deposits	RS I	RS II	RS III
1. Grading texture						
Gravel	(%)	9-40	16-19	1-24	18	2-20
Sand	(%)	45-65	41-55	50-78	58	57-77
Silt	(%)	3-20	15-16	6-18	22	13-23
Clay	(%)	0-17	10-28	2-14	2	3-11
2. Natural water content	(%)	18-27	29-32	16-21	16	12-14
3. Specific gravity		2.62-2.67	2.65-2.72	2.63-2.71	2.67	2.67-2.76
4. SPT Values (range)	N	2-50	3-5	10-30	30-50	>50
5. Coefficient of Permeability, k	m/sec		$1.6x10^{-4}$			$4.1x10^{-6}$
Drainage characteristics			Good			Poor

8.4 AMPANG JAYA PILOT PROJECT IMPLEMENTATION

Subsequent to the PP tender and evaluation exercise, the Ampang Jaya Pilot Project was eventually awarded to the successful contracting company, JDC (Malaysia) Corporation Sdn. Bhd, and the Design and Build Contract was signed on August 13th, 2003.

Following the commencement of the project, as part of the deliverables, the contractor prepared and submitted the project implementation schedule as shown in **Figure 8.4.1**.

The detailed design was completed and approved by the Study Team within three weeks from the project commencement date. Samples of the design drawings are shown in **Figure 8.4.2** and **Figure 8.4.3**. The final As-built drawings are provided in Volume 4, Chapter 8. The photographic records of the progress of the work and the main facilities are shown in **Plate 8.4.1** and **Plate 8.4.2** respectively.

The and brief description Bill-of-Quantities (BQ) of the Pilot Project is summarised in **Table 8.4.1**.

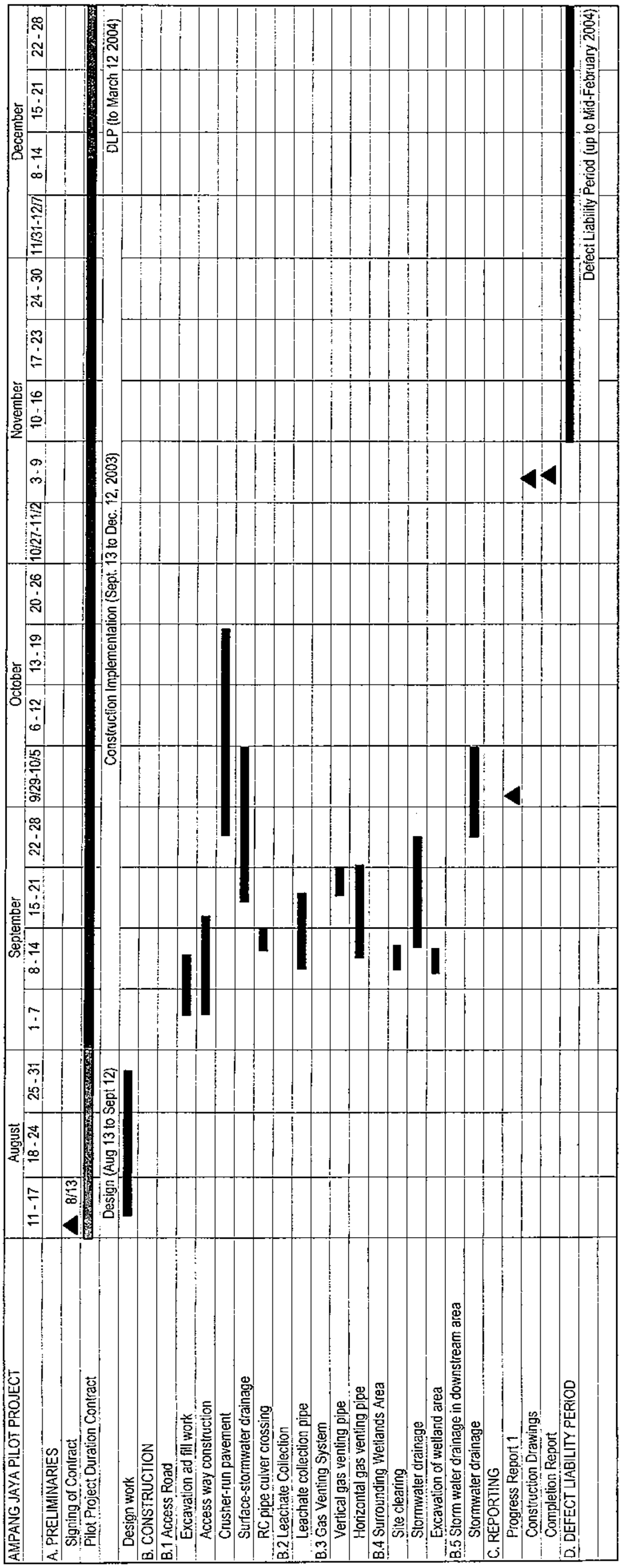
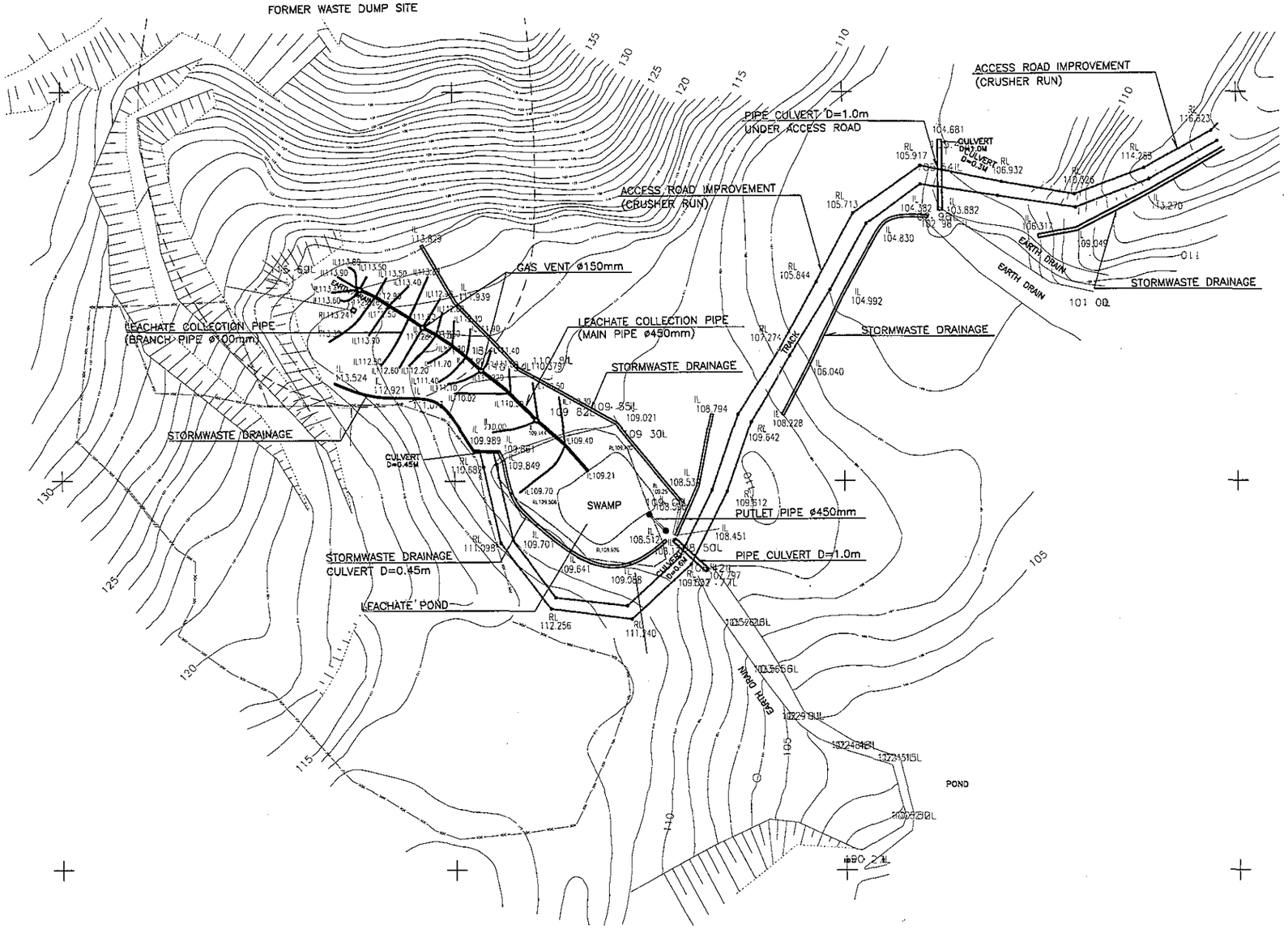
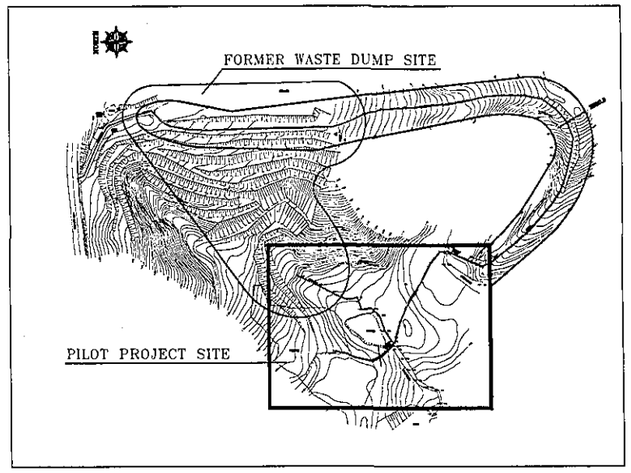


Figure 8.4.1 Project Implementation Schedule for Ampang Jaya Pilot Project

Table 8.4.1 Ampang Jaya PP Description

No.	Item/Description	Quantity
1	Access way through the site Improvement of existing access road which extends to the valley bed, descending from an elevation of 187.980 at the site entrance (Station 1) to an elevation of 105.800 at the pipe culvert crossing. Road section to be improved extends to a length of 1,032m.	
	Excavation and fill work *Cut and fill works to form subgrade.*	4,500m^3
	Access way construction (w = 7.0m) *Level the subgrade.*	7,350m^2
	Crusher-run pavement (t = 200mm) *Supply, level and compact crusher run of thickness 200mm.*	3,675m^2
	Surface storm water plastered drains (width 450 to 600mm) at the higher road elevation section *Install plaster drain along the inner access road edge to a length of approximately 400m.*	400m
	Surface storm water drainage (w = 600 to 900mm) installed at the lower road section as it descends into the valley *Supply and install precast RC drains off size 600 x 600mm and 900 x 900mm to a length of about 500m along the inner edge of the access road.*	500m
	Pipe culvert at crossings (dia. = 1m) *Supply and installation of concrete pipe culvert of diameter 1.05m, spun pipe, Class H below the road to channel the water in the existing earth drain below the road.*	45m
2	Leachate collection	
	Main leachate collection pipes (dia. = 450mm) *Supply and install perforated spun concrete pipe, Class H, of nominal diameter 450mm, including placing of gravel around the pipe, with partial excavation and preparation of pipe bed with crusher run of 200mm and over wooden sleeper/wedge with a length of about 130m. RC pipe is installed in 5 sections with inclinations of 1:26, 1:13, 1:4, 1:8 and 1:4 in ascending order. Elevations are RL 110 at the swamp and increasing to RL 125 at the foot of the waste slope.*	126m
3	Gas venting system and branch leachate pipes	
	Vertical gas venting pipe (dia. = 150mm) *Supply and install vertical gas ventilation perforated pipe, HDPE, of diameter150mm and heights of approximately 1.5m. Pipes are installed at four locations at the upper portions of the pipe at the pits were pipe inclination changes.*	4 units
	Horizontal leachate and gas venting pipe (dia. = 100mm) *Supply and install horizontal gas ventilation perforated HDPE pipe, of diameter 100mm, in trenches of size 500m x 350m, surrounded by gravel of size 25mm. Pipes installed in pairs at 7 points of intersection with the main leachate pipe and at varying lengths, with the total length of 500m. The ends of the pipes bend to the vertical position to serve as gas vents as well.*	500m
4	Surrounding wetland areas	
	Site clearing *Clearing the site, trees and shrubs in order to implement the construction of the storm water drainage and leachate retention pond.*	6,000m^3
	Storm water drainage (w = 600) *Supply and install RC pre-cast drains of 600 x 600mm surrounding the swamp (pond) and channelled to the earth drain in order to limit divert rain water from the pond.*	300m
	Excavation of wetland area *Deepening the swamp area to receive the collected leachate for retention before discharge into the water channel.*	1,500m^3
5	Storm water drainage in the downstream area	
	Storm water drainage (w = 1,000 mm) *Supply and install three RC pipes under the access road to channel storm water from the storm water drainage system and leachate from the retention pond to the earth drain.*	200m





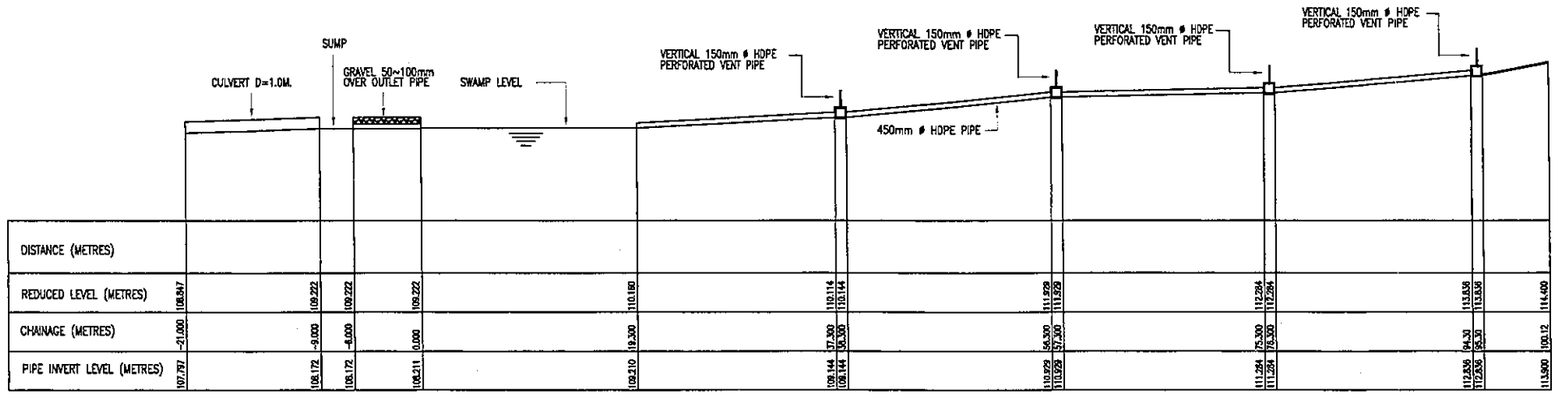
KEY PALN

NORTH

SCALE

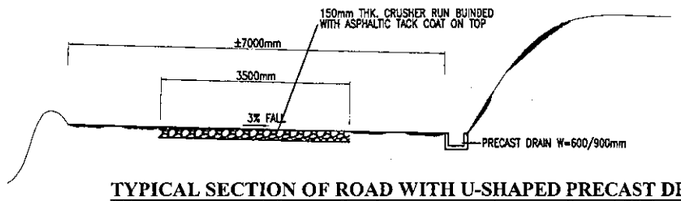
0 20 40 60 80 100m

Figure 8.4.2 Layout Plan (Ampang Jaya Pilot Project)



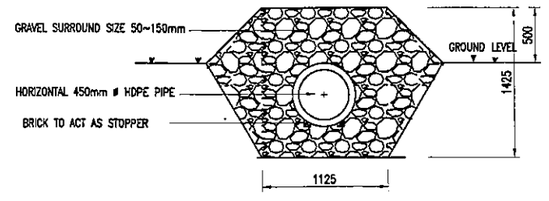
LONGITUDINAL SECTION OF 450mm Ø LEACHATE PIPE

SCALE VERTICAL 1 : 1000, HORIZONTAL 1 : 1000



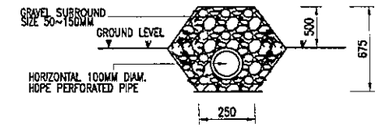
TYPICAL SECTION OF ROAD WITH U-SHAPED PRECAST DRAIN

NOT TO SCALE



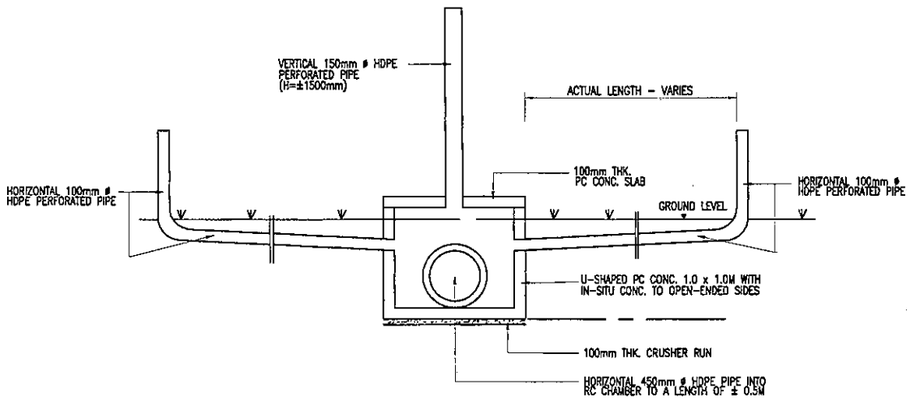
TYPICAL SECTION OF GRAVEL SURROUND FOR 450mm Ø LEACHATE PIPE

NOT TO SCALE



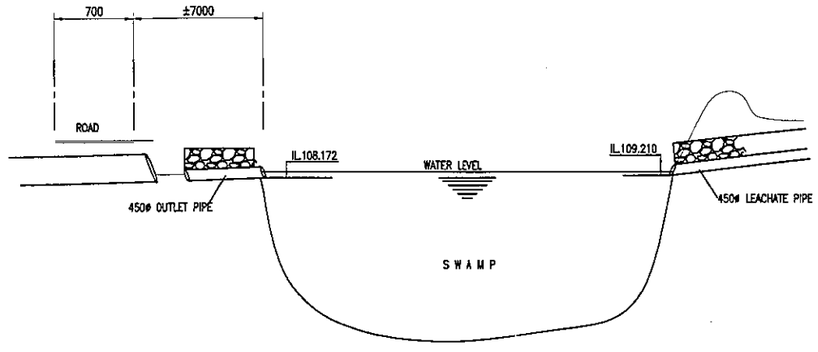
TYPICAL SECTION OF GRAVEL SURROUND FOR 100mm Ø LEACHATE PIPE

NOT TO SCALE



TYPICAL SECTION AT JUNCTION OF HORIZONTAL AND VERTICAL LEACHATE/GAS PIPES

NOT TO SCALE



CROSS SECTION AT SWAMP AREA

NOT TO SCALE

Figure 8.4.3 Typical Sections (Ampang Jaya Pilot Project)

Plate 8.4.1 Ampang Jaya Pilot Project 1

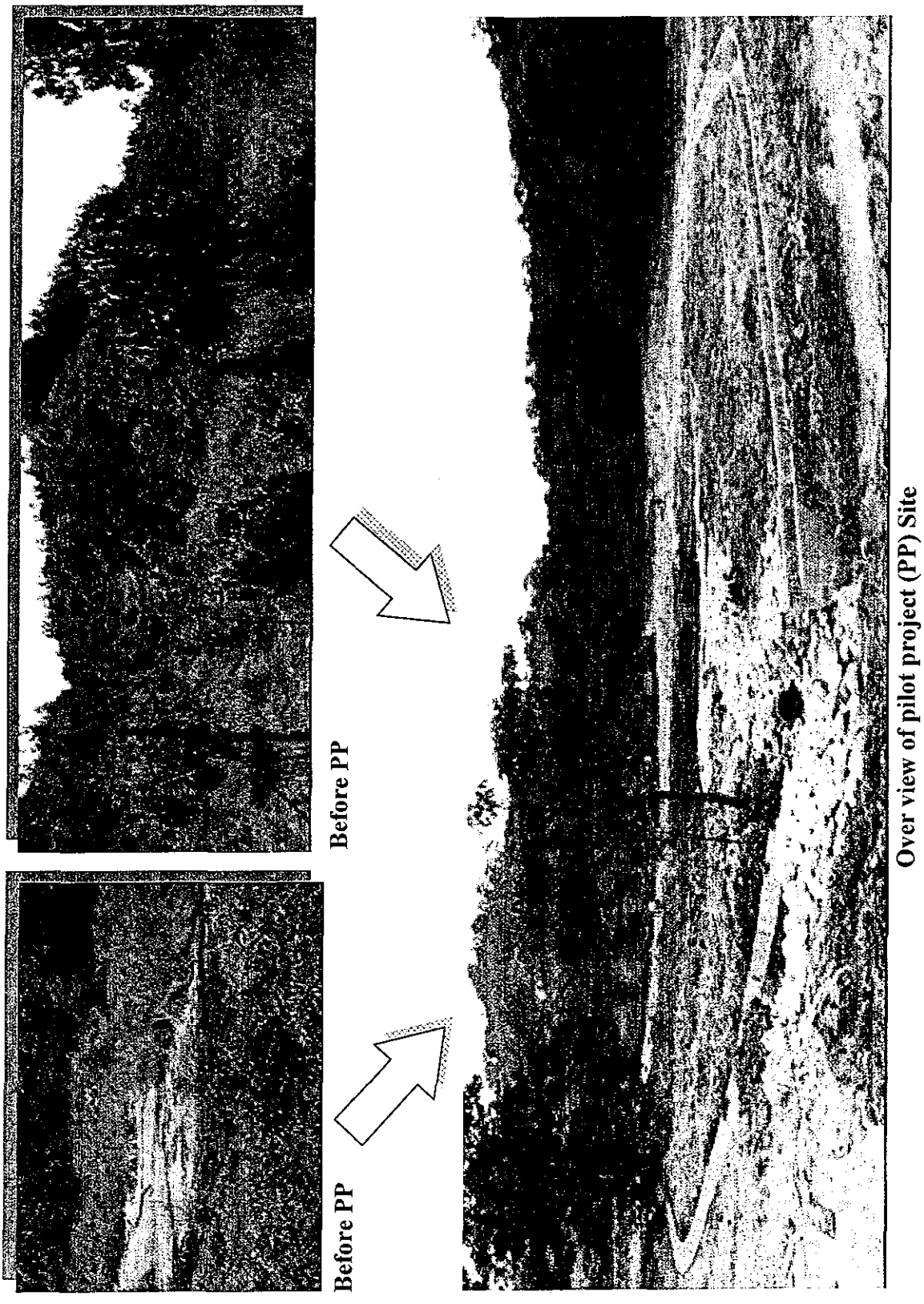
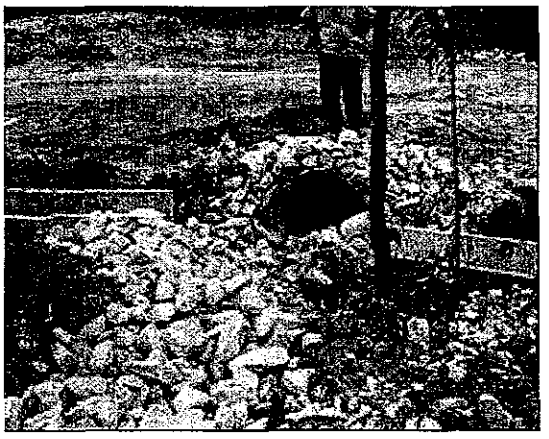
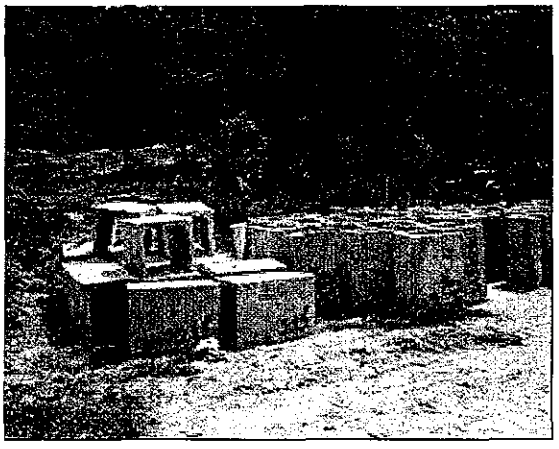


Plate 8.4.2 Ampang Jaya Pilot Project 2

Installation of leachate collection pipe

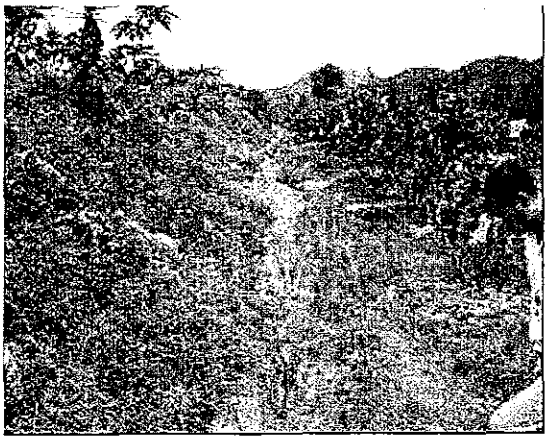


Storm water drainage below access road

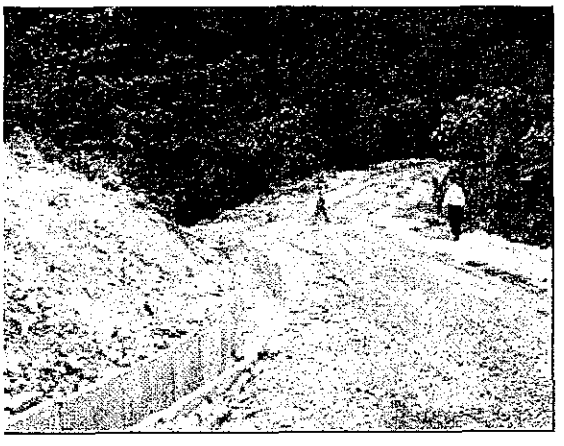


U-shaped drainage

Gas ventilation pipe



Storm water drainage at upper valley



Improvement of access road and drain