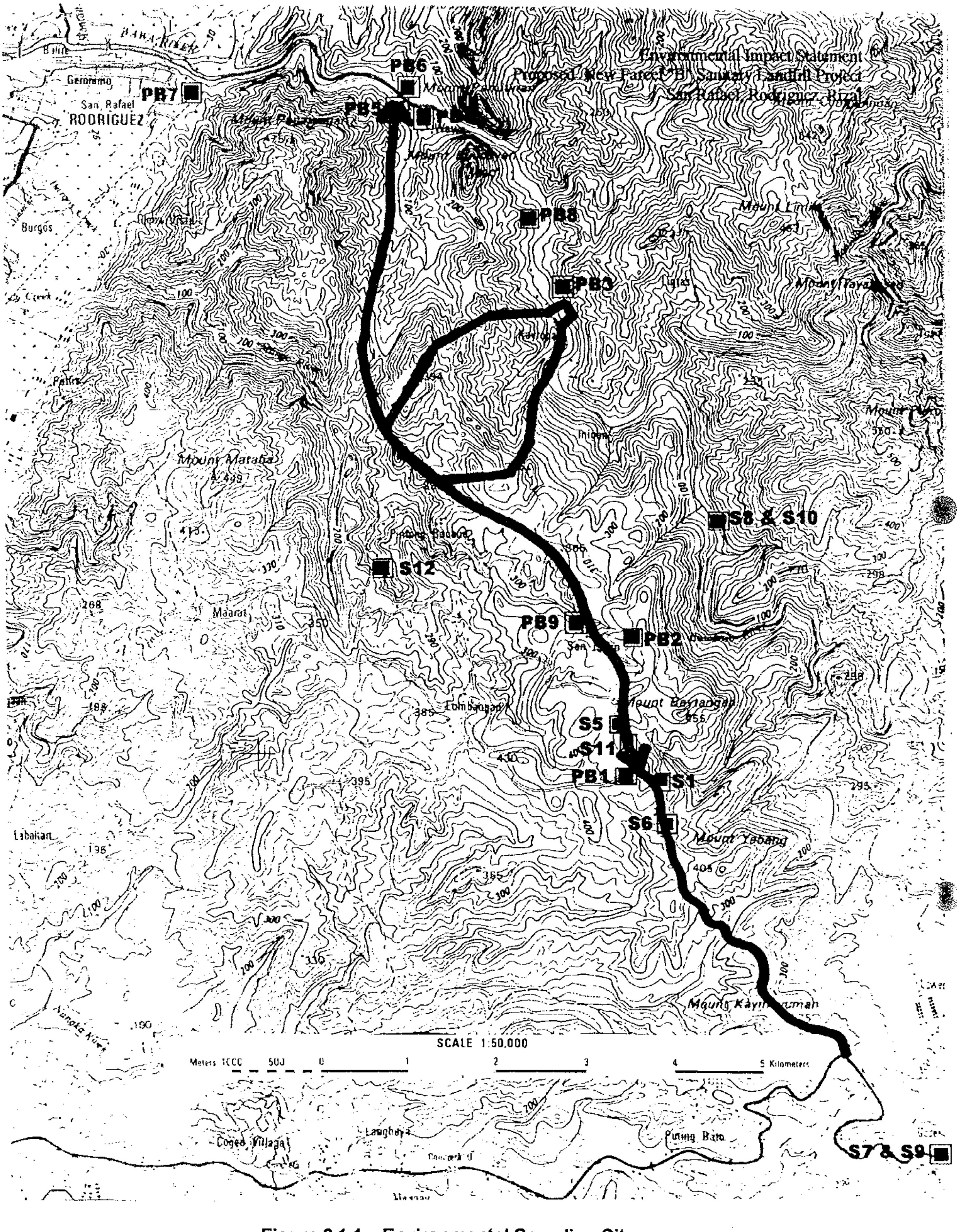


Figure 2.1.1 Environmental Sampling Sites

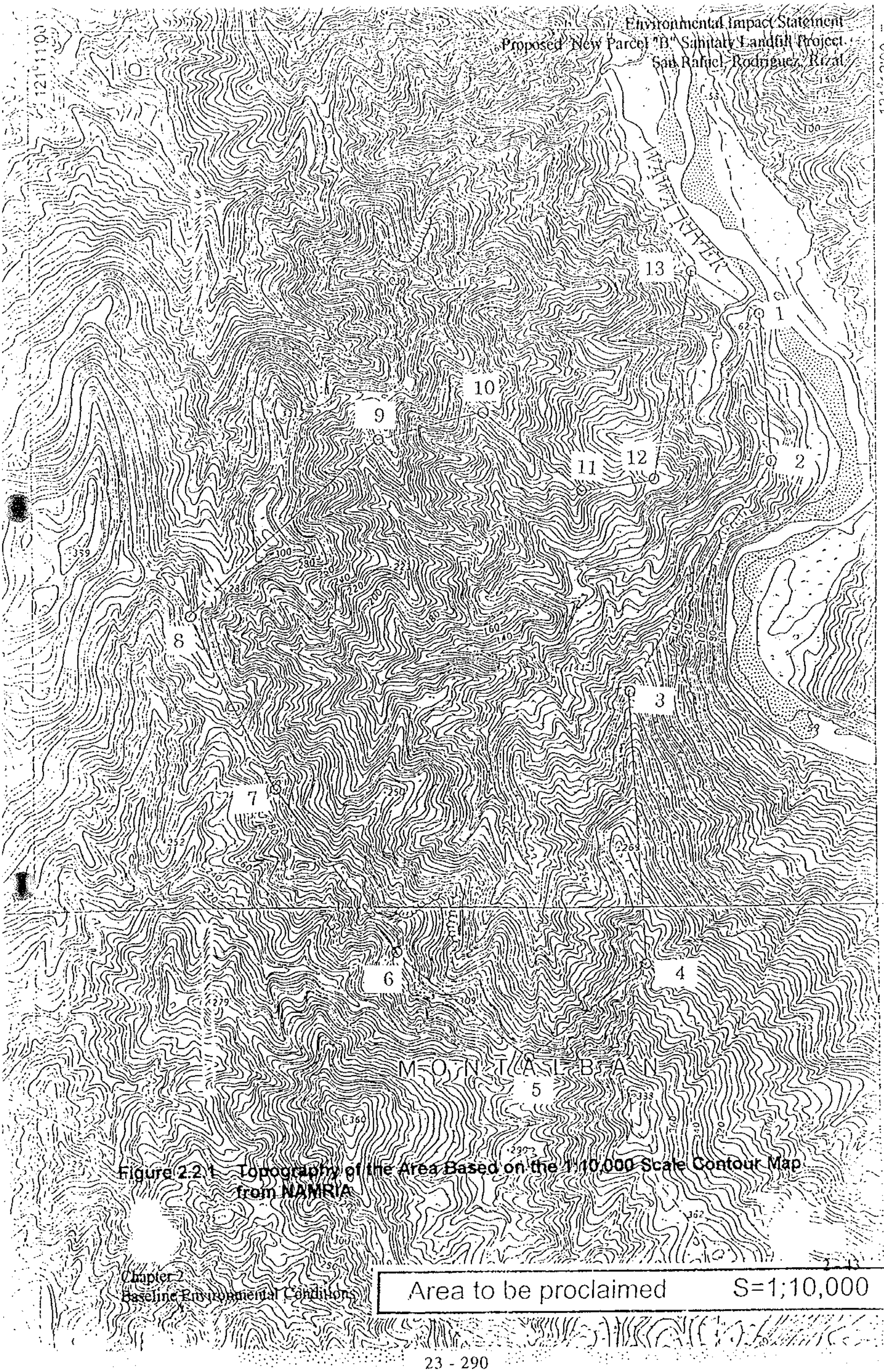


Figure 2.2.1 Topography of the Area Based on the 1:10,000 Scale Contour Map from NAMRIA

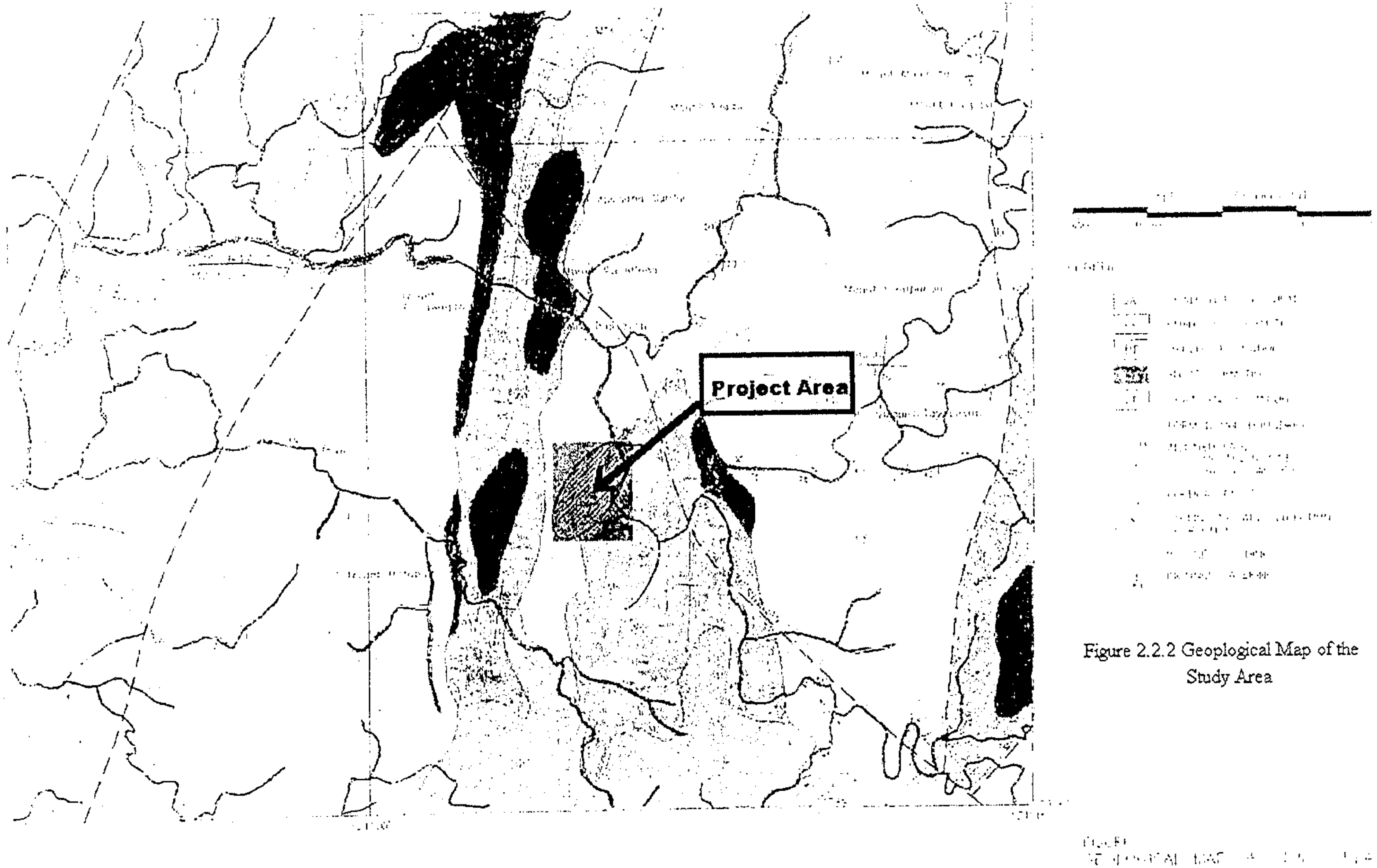


Figure 2.2.2 Geoplogical Map of the Study Area

Table 2.2.1 Locations of Boreholes and/or Test Pits as Defined by their Coordinates

TEST LOCATIONS	BOREHOLES / TEST PITS		COORDINATES		REMARKS
	NO.	Depth (m)	Northing	Easting	
A	BHA1	4.09	14 deg 92' 24.3"	121 deg 11' 43.2"	Supplementary
	BH-A2	4.30	14 deg 42' 23.8"	121 deg 11' 44"	-do-
	BH-A3	7.10	14 deg 42' 23"	121 deg 11' 45"	Reference Borehole for Group A (Samples for Laboratory Tests)
	TP-A1	1.00	14 deg 42' 25.6"	121 deg 11' 39.5"	For Lab Tests
	TP-A2	1.00	14 deg 42' 27.5"	121 deg 11' 38.8"	-do-
	TP-A3	1.00	14 deg 42' 28"	121 deg 11' 36.1"	-do-
B	**BH-B1**	8.05	14 deg 42' 21"	121 deg 11' 41"	Reference Borehole for Group B (Samples for Laboratory Tests)
	BH-B2	7.11	14 deg 42' 22"	121 deg 11' 39"	Supplementary
	TP-B1	1.00	14 deg 42' 22.5"	121 deg 11' 40.9"	For Lab Tests
	TP-B2	1.00	14 deg 42' 20"	121 deg 11' 38.9"	-do-
	TP-B3	1.00	14 deg 42' 20.7"	121 deg 11' 38.7	-do-
C	**BH-C**	**15.00**	14 deg 42' 17"	121 deg 11' 35"	Reference Borehole for Group C (Samples for Laboratory Tests)
	TP-C1	1.00	14 deg 42' 17.9"	121 deg 11' 39"	For Lab Tests
	TP-C2	1.00	14 deg 42' 15.5"	121 deg 11' 38.3"	-do-
	TP-C3	1.00	14 deg 42' 18.2"	121 deg 11' 36.9"	-do-
D	**BH-D1**	**10.09**	14 deg 42' 14.4"	121 deg 11' 36.7"	Reference Borehole for Group D
	BH-D2	7.09	14 deg 42' 15"	121 deg 11' 35.4"	Supplementary
	TP-D1	1.00	14 deg 42' 14.8"	121 deg 11' 35.1"	For Lab Tests
	TP-D2	1.00	14 deg 42' 16.1"	121 deg 11' 36.4"	-do-
	TP-D3	1.00	14 deg 42' 14"	121 deg 11' 35.9"	-do-
E	**BH-E1**	**8.65**	14 deg 42'09"	121 deg 11' 33"	Reference Borehole for Group E (Samples for Laboratory Tests)
	BH-E2	7.10	14 deg 42' 06"	121 deg 11' 35.6"	Supplementary
	TP-E1	1.00	14 deg 42' 7.2"	121 deg 11' 37.8"	For Lab Tests
	TP-E2	1.00	14 deg 42' 6.7"	121 deg 11' 33.1"	-do-
	TP-E3	1.00	14 deg 42' 5.9"	121 deg 11' 34.1"	-do-
F	BH-F1	7.25	14 deg 42' 08"	121 deg 11' 33"	Supplementary
	BH-F2	7.40	14 deg 42' 8.4"	121 deg 11' 35"	Reference Borehole for Group F (Samples for Laboratory Tests)
	TP-F1	1.00	14 deg 42' 07"	121 deg 11' 34.8"	For Lab Tests
	TP-F2	1.00	14 deg 42' 7.4"	121 deg 11' 33.9"	-do-
	TP-F3	1.00	14 deg 42' 7.9"	121 deg 11' 34.5"	-do-

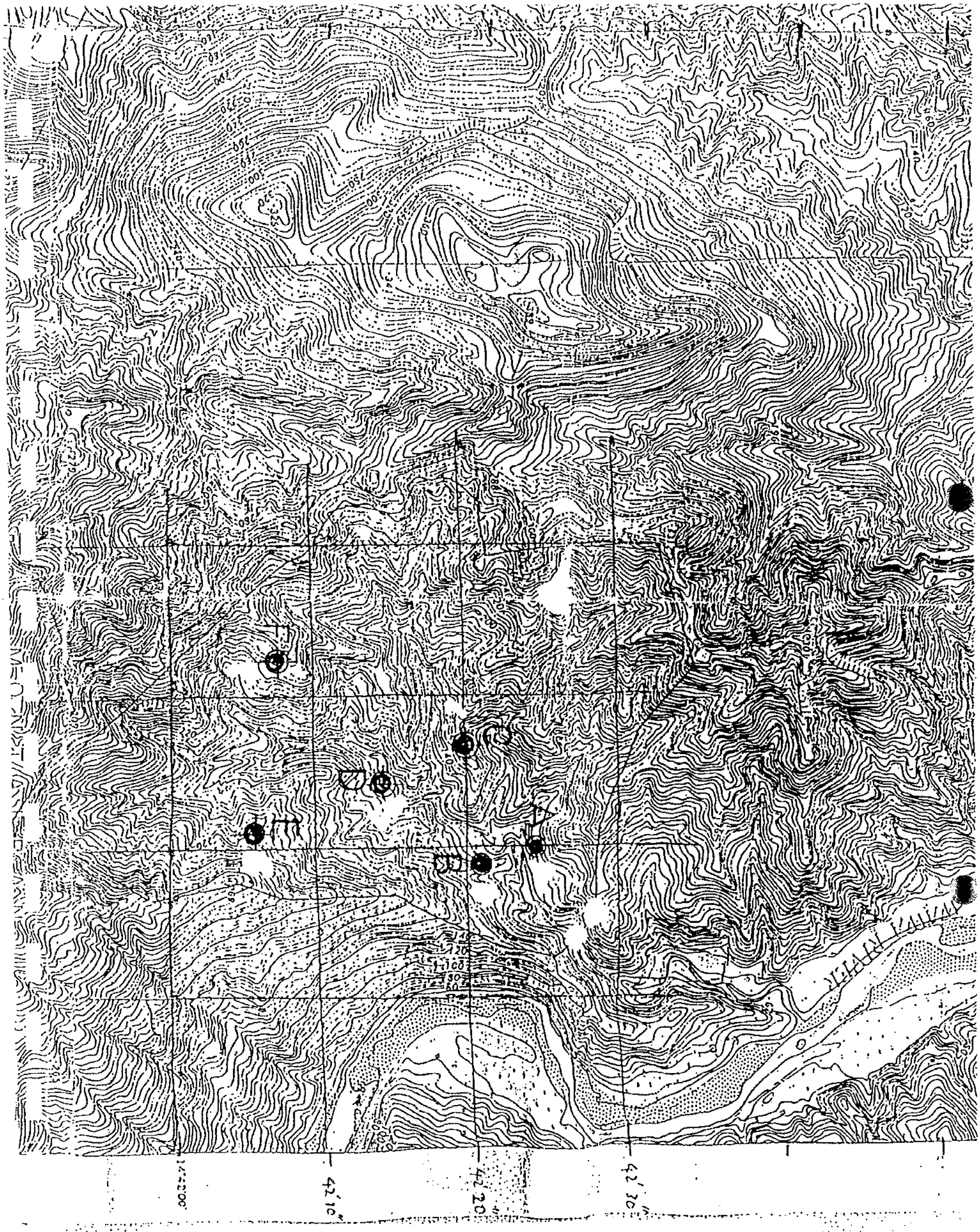
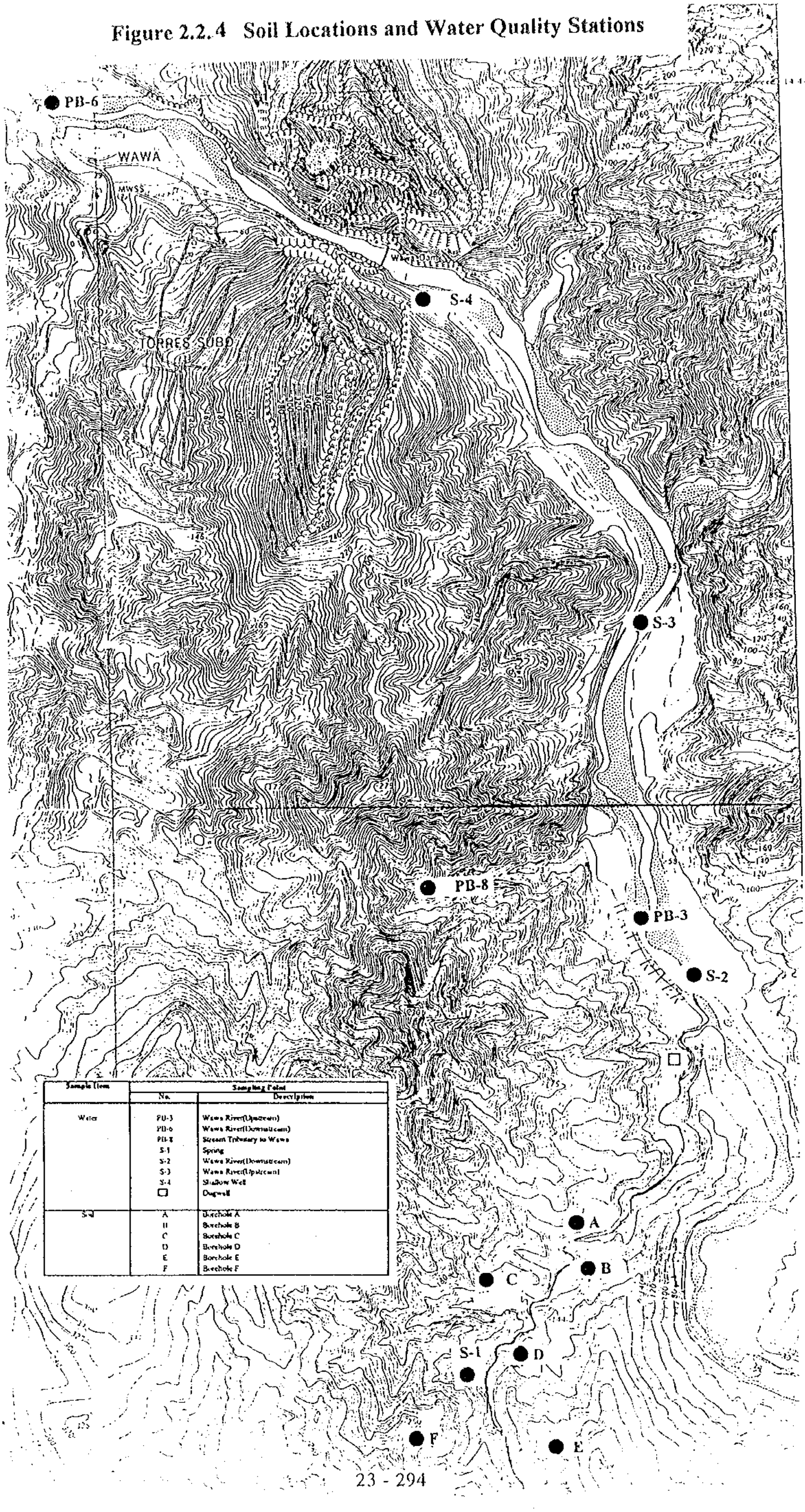


Figure 2.2. 3 Locations of Boreholes and/or Test Pits

Figure 2.2.4 Soil Locations and Water Quality Stations



Sample Item	Sampling Point	
	No.	Description
Water	PB-3	Wawa River(Upstream)
	PB-6	Wawa River(Downstream)
	PB-8	Stream Tributary to Wawa
	S-1	Spring
	S-2	Wawa River(Downstream)
	S-3	Wawa River(Upstream)
	S-4	Shallow Well
	□	Dugwell
Soil	A	Borehole A
	B	Borehole B
	C	Borehole C
	D	Borehole D
	E	Borehole E
	F	Borehole F

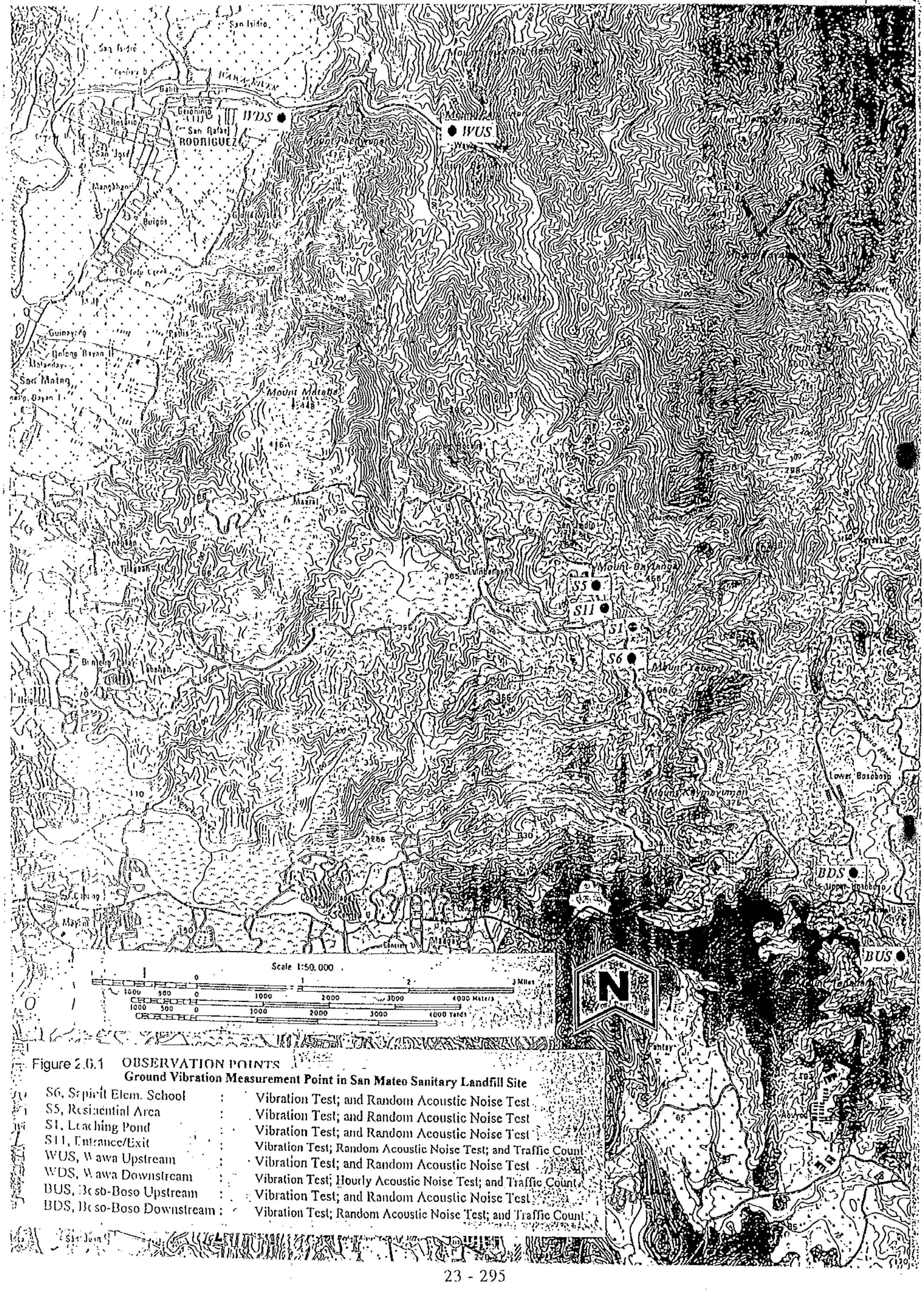


Figure 2.6.1 OBSERVATION POINTS
Ground Vibration Measurement Point in San Mateo Sanitary Landfill Site

S6, Sapiell Elem. School	:	Vibration Test; and Random Acoustic Noise Test
S5, Residential Area	:	Vibration Test; and Random Acoustic Noise Test
S1, Leaching Pond	:	Vibration Test; and Random Acoustic Noise Test
S11, Entrance/Exit	:	Vibration Test; Random Acoustic Noise Test; and Traffic Count
WUS, Wawa Upstream	:	Vibration Test; and Random Acoustic Noise Test
WDS, Wawa Downstream	:	Vibration Test; Hourly Acoustic Noise Test; and Traffic Count
BUS, Boso-Boso Upstream	:	Vibration Test; and Random Acoustic Noise Test
BDS, Boso-Boso Downstream	:	Vibration Test; Random Acoustic Noise Test; and Traffic Count

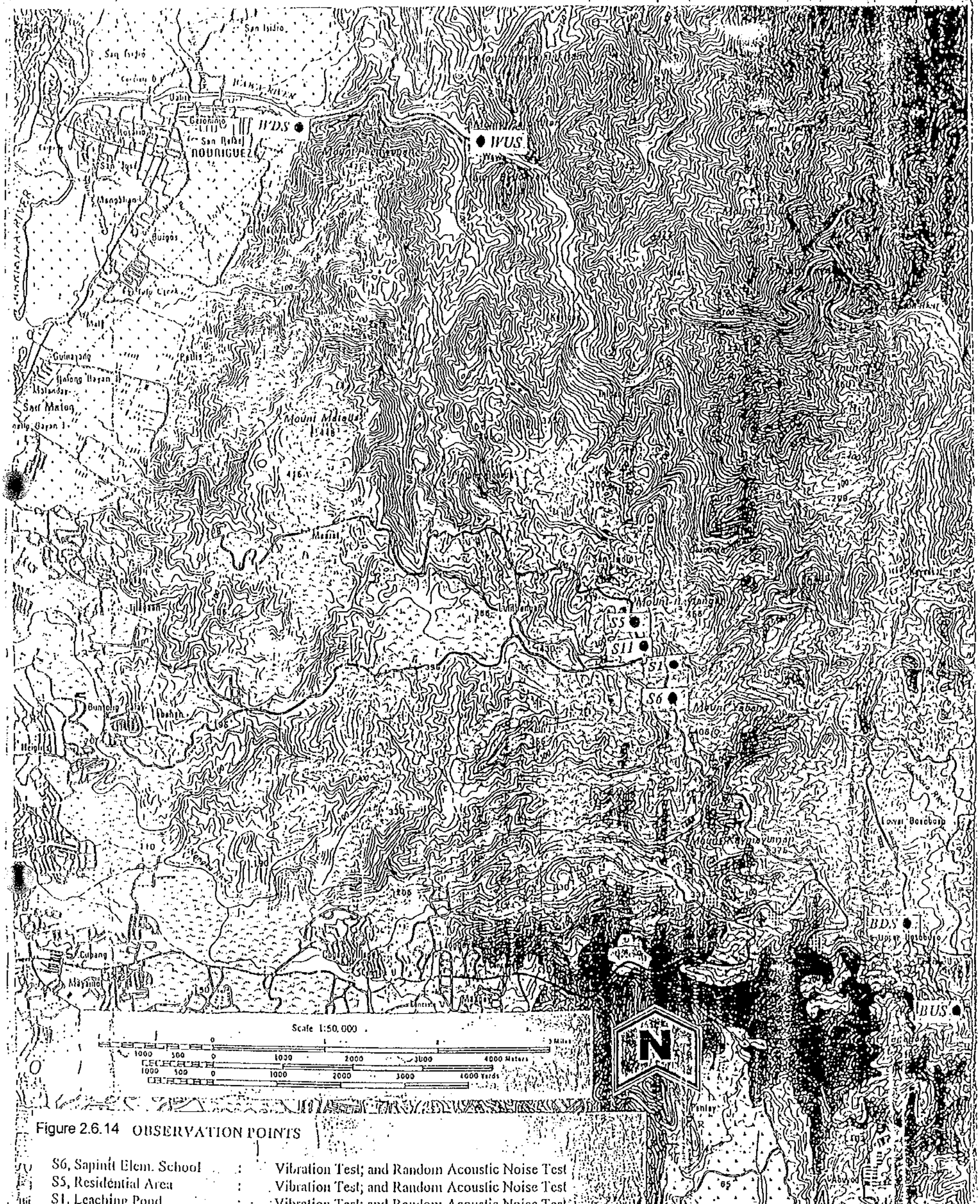


Figure 2.6.14 OBSERVATION POINTS

S6, Sapinit Elem. School	:	Vibration Test; and Random Acoustic Noise Test
S5, Residential Area	:	Vibration Test; and Random Acoustic Noise Test
S1, Leaching Pond	:	Vibration Test; and Random Acoustic Noise Test
S11, Entrance/Exit	:	Vibration Test; Random Acoustic Noise Test; and Traffic Count
WUS, Wawa Upstream	:	Vibration Test; and Random Acoustic Noise Test
WDS, Wawa Downstream	:	Vibration Test; Hourly Acoustic Noise Test; and Traffic Count
BUS, Boso-Boso Upstream	:	Vibration Test; and Random Acoustic Noise Test
BDS, Boso-Boso Downstream	:	Vibration Test; Random Acoustic Noise Test; and Traffic Count

CHAPTER 3

ENVIRONMENTAL IMPACT ASSESSMENT

Chapter 3 ENVIRONMENTAL IMPACT ASSESSMENT

3.1 General

A systematic identification, prediction, and evaluation of the project's potential impacts to the environment is presented in this chapter. Analyses were made on the potential impacts during construction and operation phases. The construction phase is expected to last for about two to three years while the expected life service is about six years. Though the abandonment phase is not comprehensively discussed in this study, the abandonment cum rehabilitation plan will be studied through the detailed feasibility study and master plan for MEFCON concept. This will be undertaken by MMDA through the assistance from JICA experts in the near future.

3.2 Impact Identification

This chapter presents the environmental impact of the project under two scenarios - scenario with the project and scenario without the project. Under the "with the project" scenario, project's impacts to the environment were identified by recognizing that the construction phase would mainly be site development and construction of the various infrastructures on relatively rolling to undulating terrain. The operation phase would involve the occupation of those facilities/structures and operationalization of the various activities inherent to a landfill project. The "without the project" scenario is established by assuming that the proposed project will not be implemented and no other similar activities will be undertaken in the project area.

The analysis cum assessment of the identified impacts considered the effects of the unmitigated impacts. The necessary measures to reduce or eliminate the impacts are partially incorporated in this chapter while the detailed discussions are presented in Chapter 4.0.

Identification of the potential environmental impacts was done comprehensively by evaluating the project's features and operations against the known list of potential impacts identified by various sources for this type of project. These sources include the environmental assessment guidelines prepared by international financing institutions such as the Asian Development Bank Environmental Guidelines for Selected Infrastructure Project - Landfill Project (ADB, 1993) and the World Bank (WB, 1991). Other information sources were also consulted (Canter, 1977; Rau and Wooten, 1980; Carpenter and Maragos, 1989).

Results of the impact analysis are presented in the form of a scaling checklist, which indicates the nature of likely impacts and their predicted significance.

3.3 Impact Prediction and Evaluation without the Project Scenario

Comparing the future conditions without the project against those conditions where the project is implemented is essential for weighing the project's benefits against its impacts. Hence, the future environmental conditions without the project are presented in this section.

3.3.1 Impact on the Physico-Chemical Environment

(1) Meteorology/Atmosphere

Considering the available data, no sudden changes in the microclimate could be expected in the project area for the next five years. Significant changes in the environment, changes in temperature, wind direction and speed, rainfall, relative humidity, etc. are also not expected.

Air quality within the project site is not expected to change without the project if the present land use will be maintained. Noise levels are also expected to be the same if the traffic volume and frequency remain the same.

(2) Terrain

Without the proposed project, the rolling to undulating landscape will remain the same for the next five years. There will be no changes in the topographic, physiographic, or geologic features of the area. The physical and chemical characteristics of the soil in the area are likely to remain the same.

(3) The Water

Groundwater conditions of the project area will remain the same if the present land use will be maintained. Groundwater recharge will still continue with the direct infiltration of precipitation into the permeable sections of the area. The present groundwater flow will be the same if the project site continues to receive its annual average rainfall. Likewise, surface water bodies found in the area such as Wawa River will remain to be polluted by the upstream operation of industries and continued discharge of domestic wastewater.

(4) Atmosphere

Air quality within the project site is not expected to change without the project if the present land use will be maintained. Noise levels are also expected to be the same if the traffic volume and frequency remain the same.

3.3.2 Impact on the Biological Environment

(1) Vegetation

Future environmental conditions are likely to remain the same without the proposed development in the project site. Without the proposed sanitary landfill project, vegetation cover in the study area will not change. The standing crop biomass of grasses within the vicinity of the proposed project area will remain the same due to soil characteristics and topography.

(2) Fish and Wildlife

The proposed project site will continue to have no fish and wildlife population due to past and present land use. No significant bodies of water have been identified in the proposed project site. As such, no fishes and wildlife are expected in the area.

3.3.3 Impact on the Socio-Economic Environment

Without the project, people living near the project site will continue to practice kaingin and marginal farming. Within the next five year span, the project area may experience gradual increase in its population due to the continuing congestion in the nearby Metro Manila area. The possible influx of this people could also be attributed to the attraction or influence of the development of growth centers near the project site such as Metro Manila.

3.4 Impact Prediction and Evaluation "With the Project Scenario"

3.4.1 Construction Phase Impacts

Potential impacts during the construction phase are associated with the activities for site preparation, site development, road network, utilities, and building erection. All impacts are short-term in nature, i.e., it will only persist during this phase. **Table 3.4.1** shows the scaling checklist for unmitigated impacts during construction phase.

(1) Impact on the Physico-Chemical Environment

(a) Obstruction to Natural Drainage

It is possible that the construction activities may obstruct the natural drainage pattern in the area. In the project site, there are existing small creeks that will be affected by the project construction. In times of heavy rains, the prevention of flooding in the lower portion of the project area is desirable. Engineered structures shall be provided to allow the natural flow of water. In addition, the overall construction planning shall implement the activities in such a way that creeks and canals will not be blocked with sediments from the construction sites.

Table 3.4.1 Scaling Checklist for Unmitigated Construction Phase Impacts

Impact Area	Impacts	Nature	Magnitude
Physico-Chemical Environment			
Hydrology/Sediments	Obstruction to Natural drainage Increase in soil erosion/erosion of silt runoff	Negative Negative	Significant Significant
Groundwater quality	Water Pollution	Negative	No effect
Surface water	Water Pollution due to sanitary waste disposal	Negative	Minimal
Air quality	Generation of air pollutants	Negative	Minimal
Noise and vibration	Increase in noise and vibration levels	Negative	Minimal
Traffic	Increase in traffic congestion	Negative	Minimal
Geology/Seismology	Induced seismicity	Negative	No effect
Topography/ Physiography	Alteration of natural terrain	Negative	Minimal
Natural resource use	Loss or conversion of agricultural/forest land	Negative/ positive	Significant
Biological Environment			
Flora and fauna	Loss of Vegetation Fish and wildlife disturbance	Negative Negative	Significant Minimal
Socio-economic Environment			
Population size	In crease in population due to influx of outside labor and their households	Negative	Significant
Displacement of communities	Resettlement of 75 families to be displaced by the project	Negative	Significant
Dependency burden	Increase capability to support dependents	Positive	Significant
Education	Greater capability to support dependents	Positive	Significant
Sex ratio	Imbalance of sex ratio due to male preference as construction workers	Negative	Minimal
Housing characteristics	Increase capability to improve housing and utilities	Positive	Significant
Social services	Increase use of roads	Negative/ positive	Minimal
Health and safety	Greater capability to afford food and medical care Exposure to air- and waterborne diseases	Positive Negative	Significant Significant
Employment and Income	Reduction of unemployment and increase in income	Positive	Significant
Women's welfare	Employment in services catering to workers	Positive	Minimal
Farm production	Reduction of farm production	Negative	Minimal
Displacement of communities	Resettlement of families to be displaced by the project	Negative	Significant

(b) Potential Soil Erosion Problem Due to Civil Works

Any horizontal construction activities especially for site development will definitely cause some soil erosion. Without any mitigating measures, the amount of eroded soil will be significant during rainy periods. This is so because of the large area to be exposed during earth movement or excavation of the project area. Run-off water will transport soil particles that will result in the siltation of the nearby Wawa River. Options for structural erosion prevention and sediment control practices are discussed in the Chapter for Mitigation Measures.

(c) Water Quality

During construction stage, about 500-700 skilled and unskilled workers are to be hired. At a generation rate of 50 L/cap/day, with the assumption that the hiring will be 100% (700 workers) during the heyday of the construction period, the estimated domestic wastewater generation per day is about 35 cubic meters.

Water quality of the surrounding water bodies may be further impaired due to the direct discharge of sanitary wastewater. Likewise, when effluent from septic system is discharged directly into the soil subsurface, it could migrate towards Wawa River or the existing shallow wells which are sources of potable drinking water in the area. Without any mitigating measures, the direct discharge of this wastewater may cause short-term impact on water quality. Deterioration of Wawa River may also be experienced through siltation as discussed in Section 3.4.1 (1) (b).

(d) Generation of Air Pollution

Expected air emission sources are trucks hauling the construction materials and the equipment used for the construction activities. However, magnitudes of these emissions are relatively small and could easily be dispersed by the air since the site is quite wide. Hence, the expected impact would be minimal. A moderate dust generation is expected during the dry seasons due to ground preparation and earthwork activities

1) Emission Inventory

The daily and annual emissions inventory were undertaken using generally accepted procedures and methodology developed by US Environmental Protection Agency and adopted by the DENR-EMB. These are studies conducted by Cowhead, et. al. (1974) and Jutze, et. al. (1974) by USEPA. Other sources of secondary data are those published DENR-Environment and Natural resource Accounting Project (ENRAP).

2) Sources of Fugitive Dust or Total Suspended Particulates (TSP)

During construction phase, one area of concern is the generation of fugitive dust. The generation is caused by two physical phenomena:

- pulverization and abrasion of surface materials by application of mechanical forces through implements like wheels and blades, and
- wind erosion of an exposed surface by wind speed greater than 19 kilometers per hour.

The principal pollutant of interest in this study is total suspended solid (TSP) (particle size <=30μm) which is the basis of existing air quality standard for dust.

Table 3.4.2 presents the number of vehicles needed for daily operation and maintenance of the landfill. These vehicles are:

- 3 units of 2x2 service pick-up
- 2 unit 2-ton truck for hauling
- 4 unit power shovel
- 11 units crawler type bulldozers
- 4 units compactor
- 2 units water tank trucks
- 3 units front loader
- 10 units of 11-ton dump truck

For landfill operation, fugitive dust generation is associated with soil excavating, loading and unloading of soil, and spreading and compaction. Due to the high moisture content of solid waste and its sheer particle size, minimal dust is expected to be produced during spreading, crushing, and compaction of waste. Furthermore, water spreading immediately after waste spreading will substantially suppress generation of dust.

Dust emissions changes day to day, depending on the type and intensity of the activity as well as prevailing meteorological conditions. Furthermore, other activities like hauling of materials to and from the landfill site, causing traffic over temporary roads, may cause fugitive dust emission. But the existence of well-paved road leading to the landfill site will diminish dust generation from the estimated 1,200 trucks that will deliver haul solid waste on a daily basis.

The emission estimation procedure adopted in this study was adopted from the USEPA AP-42 guidelines for heavy construction activities. It was noted that the landfill soil cover work is very similar to heavy construction activities based on the following observations:

- similar unit operations in landfill soil cover work includes soil excavation. soil loading and unloading, compacting, and earthmoving,

- similar equipment used such as front loader for loading/unloading, dump truck for haulage, crawler type tractor for spreading and compaction, and power shovel for excavation

Limited studies have been conducted to correlate dust emissions with construction activities. Field measurements conducted by the U.S. Environmental Protection Agency revealed that 2.69 mg/ha/mo of TSP is emitted for medium construction activity level, moderate silt content of soil, and semi-arid climate. This estimate, however, tends to overestimate fugitive dust emissions since it assumes that the activities occur for an entire month on the same area. Furthermore, the biggest drawback of using a single emission factor is that it does not provide information on which particular landfill activity has the greatest potential impact, and consequently will unable to guide the development of an effective dust control program.

3) Estimating the Fugitive Dust

In estimating the fugitive dust emissions, the following assumptions and construction practices were made

- soil silt content = 6.4%
- soil moisture content = 30%
- operation period = 6 years
- number of days with rainfall >0.254 mm = 149 days annually or 41%
- exposed area = 50% of 130 has
- number of bulldozer operating days for soil removal = 4 bulldozers/day for 22 days/mo
- number of truck loading of soil per truck per day = 5 loadings per day for 10 trucks
- number of soil loading days per month = 22 days/mo.
- soil density = 1,990 kg/m3
- average compactor speed = 2.5 kph

USEPA AP-42 provides the following emission factors equations:

a) Soil Removal

$$TSP(1) = \frac{2.6\,(s)^{1.2}}{(M)^{0.3}}$$ in kg/hr of bulldozer operations

where: s = soil silt content, assumed at 6.4%
M = soil moisture content, assumed at 30%

TSP(1) = 209 kg TSP/day for 3 dozers

b) Loading/Unloading of Excavated Materials

$$TSP(2) = k(1.7)\,(s/12)\,(S/48)\,(W/2.7)^{0.7}\,(w/4)^{0.5}\,(365\text{-}p/365)\ \text{kg/VKT}$$

where: k = particle size multiplier, dimensionless (0.8-1.0)
s = silt content of road (assumed at 6.4%)
S = mean vehicle speed (assumed at 10 kph)
W = mean vehicle weight, tons (16.75 tons net weight + 10 tons payload)
w = mean number of wheels (6 wheels)
p = number of days with at least 0.254 mm or precipitation (149 days/yr)

TSP (2) = 0.33 kg/VKT (vehicle kilometer travel)

For 50 hauling per day travelling a length of 1.27 kilometers, representing the hypotenuse of 65 hectares of square area. Loading and unloading of soil is expected to generate 42 kg TSP/day. The result of the modeling is shown in **Attachment B**.

c) Compacting

Fugitive dust emission factor due to compaction activities has been estimated to be similar to bulldozer debris removal operation,

$$TSP(3) = \frac{2.6\,(s)^{1.2}}{(M)^{0.3}}$$ in kg/hr of bulldozer operations

silt content, assumed at 12%
M = soil moisture content, assumed at 30%

TSP (3) = TSP (1)
=278 kgTSP/day for 4 dozers

(e) Noise Generation and Vibration

Operation of the various construction equipment will be the major source of noise generation during construction. The expected sound levels in dB(A) at various distances from these and other construction equipment are shown in **Table 3.4.4.**

Table 3.4.3. Summary of Emission Factors and TSP Emision Estimate for Each Landfill Soil Cover Work Activity

Activity	Estimated Emission Factor	Estimated Total Emission
Soil Removal	8.69 kg/hr	209 kg/day
Loading and Unloading of Excavated Material	0.33 kg/VKT	42 kg/day
Compacting	8.69kg/hr	278 kg/day

The DENR standards for noise in general areas are shown in **Table 3.4.5**. From this table, it can be seen that noise levels from most of the equipment attenuate to typical ambient levels at a distance of 240 meters and should pose no problem to nearby communities.

It is therefore expected that these noise levels will not become nuisances to the public since there is a reasonable distance between the present residential areas and the proposed construction sites.

Vibration due to the heavy equipment to be used during site preparation is expected to be insignificant. Likewise, vibration from the arriving delivery trucks is expected to be negligible.

(f) Traffic

Vehicular traffic at Marcos Highway, Cogeo Road and the access road leading to the project site will slightly increase due to the hauling of construction materials. However, the average daily trips will not be significant since the construction schedules will be spread over a long period of time.

Construction workers will add up to the existing number of commuters in the area. However, this will only occur during the early phase of construction. The workers will create temporary residence in the construction site that would minimize average daily trips.

(g) Geology/Seismology

There will be no massive load on the ground from any component of the proposed sanitary landfill project. Induced seismicity from huge structure is therefore not expected in this project.

Table 3.4.4 Expected Noise Levels from Construction Equipment, DBA

SOURCE	Distance from source (m)				
	15	30	60	120	240
Front Loader	75	69	63	57	51
Backhoe	85	79	73	67	61
Grader	88	83	78	72	66
Truck	91	85	79	73	67
Concrete Mixer	82	76	70	64	58
Crane	83	77	71	65	59
Generator	78	72	66	60	54
Compressor	81	75	69	63	57
Pump	76	70	64	58	52
Pile Driver	101	95	89	83	77
Jackhammer	88	82	76	70	64

Table 3.4.5. DENR Standards for Noise in General Areas

Maximum Allowable Noise Level, dB(A)			
Area	Daytime	Morning/ Early Eve.	Nighttime
Schools, Hospitals	*50*	45	40
Residential	55	50	45
Commercial	65	60	55
Light Industrial	70	65	60
Heavy Industrial	75	70	65

(h) Natural Resource Use

The proposed project site will cover a substantial area of land which is presently used for marginal farming (kaingin farming). Once implemented, the project area is about to be transformed into an engineered sanitary landfill. The conversion is necessary to accommodate the proposed sanitary landfill project. It is very important therefore for the proponent of the proposed SLF project to secure the necessary permits from government agencies and other local groups existing in the area such as the:

- Office of the President or Congress for the exclusion of the project area from NIPAS
- Clearance and endorsement from LGUs
- Endorsement from NGO, PO, Homeowners Association, etc.

(2) Impact on the Biological Environment

(a) Vegetation

With the proposed sanitary landfill project, the existing number of species of grasses, weeds and non-dipterocarp trees are likely to remain the same. As there will be resurfacing of all exposed areas, additional plants are likely to be introduced within the project site. The planned reforestation of the buffer areas surrounding the project site will surely increase the aesthetic components of the project. The impact therefore of the temporary loss of vegetation and disturbance on juvenile birds and wildlife in the area will be minimized.

Most of the identified plant species in the primary impact zone are considered economically important. However, the density of the affected species is considerably small as these are found only in patches within the project area. No significant negative impact are expected in terms of vegetation cover as only small section of the project site are covered with low density plant population. Most of these plant are grasses, weeds and non-dipterocarp trees found within the project area and considered secondary growth vegetation.

(b) Fish and Wildlife

As there are no fishes around the project area, no significant impact is expected in this population. Although it is likely that the project site will be aesthetically and environmentally enhanced, no significant population of wildlife is expected to thrive in this condition.

(3) Impacts on the Socio-Economic Environment

(a) Population Size

The proposed project will employ 700 workers during the construction phase. If these are brought in from outside or in-migrants are attracted by work opportunities, the population size of Rodriguez will expand. The increase will be mainly felt in Barangay San Rafael where the proposed project will be located. If about 70% of the required workers will be obtained from outside (equivalent to 700 x 0.7 =490), the expansion of the population size of Rodriguez during the construction phase will be 15.95% **(Table 3.4.6)**. Their temporary residence in the construction site may have short-term impact although there are many cases wherein workers stay permanently in the site. They may be encouraged to do so if work during the operation phase will be made available to them.

Table3.4.6 Projected Number of Persons Who Will be Added to the Existing Population of Rodriguez as a Result of the Proposed SLF Project

Item	Construction Phase
1995 population	12,285
No of required workers	490
Total	12,775
Percentage increase of 1995 population	3.99
No of in-migrants if workers will bring in their families	1960
Percentage increase of 1995 population	15.95

The population expansion will be greater if the outside workers will bring in their respective households into the site. There will be three additional migrants for every worker because an average household has about four members. Thus, the 490 workers whom the project will employ during the construction phase means that 1960 in-migrants will settle in Rodriguez. They will increase the municipality's population by 15.95% overnight. Such number of in-migrants will readily overwhelm the host barangay.

If the workers from outside will not take residence in or near the construction site, and they commute from their present residence, they would merely add to the day-time population, but not to the night-time population of the area. In any case, the increase in population will automatically increase the population density in the impact area. The increase in population will translate to higher demand for resources and service in the project area. The short-term impact during the construction phase will become long term if outsiders are still employed during the operation phase.

Other sources of population increase are illegal settlers or professional squatters that may anticipate the operation of the proposed SLF. However, this concern is not discussed as they will be considered during the operation phase of the project.

(b) Resettlement of Affected Families

The resettlement of the 75 households from the project site will alter population size and composition in the host barangay if they are relocated outside of it. But if the relocation site will be within the same barangay, there will be no demographic alteration of the barangay. This means that they will retain their membership in the same political constituency and belongingness in the same social system.

The impact of resettlement of the affected population will depend on the housing characteristics and distribution in the resettlement site. If the project management will construct the houses, uniform houses roofed with GI sheets and walled with concrete will replace the houses of diverse construction and materials. Houses lined up along the road in geometric pattern will also replace the haphazard distribution of houses dictated by farm lot location, route of trails and water availability. The housing utilities will also improve if the resettlement site is fitted with running water, toilets and electricity. This will result in an increase in the number of users of safe drinking water, greatly improved access to water source, and better sanitation due to more widespread use of toilet facilities. The most significant impact is the ownership of home lot among resettlers because these resettlers presently do not own their home lot.

(c) Dependency

If the workers are all taken from Barangay San Rafael, the salaries and wages that will be paid to the 700 persons who will be employed during the construction phase will increase the capability of the economically active adults to support their dependents. The project, therefore is expected to improve dependency ratio at least in the short term.

(d) Education

The increased capability of economically active adults will enable them to support longer years of schooling. In the long run, salaries and wages paid off by the proposed project will have an impact on the educational attainment of the population. If outside workers are brought in, this impact will not redound in the direct impact area.

(e) Sex Ratio

The workers who will be brought in, particularly during the construction phase, will alter the sex ratio in the direct impact area. There will be a preponderance of males over females. All male construction crew will change sex ratio of the host barangay. Drastic wide imbalance in the sex ratio can create conflicts between the outside workers and the local residents.

(f) Housing Characteristics and Utilities

The demand for housing and associated facilities (such as toilets and water supply) would intensify once the outside workers reside in the site during the construction phase. This will mean an increase in the number of housing structures near the site. The existing sanitation level may deteriorate. Furthermore, the occupants of these new structures may compete for such resources as water and land. This problem will be avoided or minimized if the workers are recruited from the site.

(g) Social Services

If the resettlement site is provided with facilities (roads, drainage, health center and a basketball court), it will certainly upgrade the access of the resettled population to these services. But it will not alter the accessibility of social services to the population who are not affected by resettlement. The construction of a road which will link the proposed SLF to the national highway may make other social services more accessible.

The outside workers and their household members will increase the number of users of the existing social services both within and outside the barangay. The increase of population without a corresponding provision of additional housing and community services will certainly lower the existing health and sanitation levels. The problems that will be generated from employing outsiders will have long-term negative impact if these outsiders decide to stay in the area even after the completion of the construction phase.

(h) Health

The provision of running water and toilets to the resettled population is a big boost to the health status of the population. This should decrease the incidence of waterborne and insect-borne diseases. The incidence of diarrhea and other water borne diseases will be minimized. Likewise, the provision of running water and toilets will reduced the incidence of cholera.

The project may have both positive and negative impact on the health status of the barangay population in general. The positive impact will be realized by the increase of income and greater accessibility to health services. Higher income will enable the population to afford better food and medical care. This will partly solve the high level of malnutrition in the project area. The negative effect of the project, on the other hand will be the exposure the nearby residents to more health risks caused by pollution and possible breeding of flies and insect vectors. The existence of SLF may reduce the sanitation level in the host community.

(i) Employment and Income

The project can ease the unemployment in the barangay by employing local residents during the construction phase. If the former assumption will be applied, that is, 30% of 700 required manpower will be directly hired from San Rafael, the project will significantly reduce the unemployment problem in the host barangay at least during the construction phase of the project.

project will significantly reduce the unemployment problem in the host barangay at least during the construction phase of the project.

Table 3.4.7 Balance Between the Manpower Requirement of the Proposed Project and the Available Manpower in Barangay San Rafael

	Construction Phase
Total unemployed labor force	491
Total manpower requirement	210
Balance	281
Expected total wages paid per day at P180 minimum wage	P 37,800.00

Employment in the project is particularly needed by the households who lost their farmland or whose farming operation is reduced by the project. If local residents will be employed, a transfer of funds, in the form of salaries and wages from the project to the local economy will occur. During the construction phase, if the project is expected to employ 210 workers from the residents of the host barangay and at the minimum wage of P180.00 pesos per day, the project is expected to pay its workers P37,800.00 every working day (**Table 3.4.7**).

An average family in Rizal spends 50% of the income on food (NSO, 1994). This means that about half of the total amount paid in the form of salaries and wages to local labor will redound to food-producers such as the fishers, farmers and small-scale food industry operators. The salaries and wages paid will subsequently create a second wave of positive economic impact in the barangay. The other half of the amount will go to an assortment of expenses such as housing, transport, clothing and education which may or may not be spent within the barangay.

If the workers will be recruited from outside the barangay, they will be remitting much of their money back to their families. This means less funds will go into the local economy. Transfer of funds to the barangay will be confined to the expenditures of these outside workers within the project site.

(j) Women's Welfare

During the construction stage, the women are in the advantage side in terms of employment generation. These opportunities will come from service-related employment which may include food and snacks catering. Although the magnitude of this positive impact is limited, their experience or kind of small business enterprise could proliferate especially in the service-oriented sector.

(k) Farming

The project will convert a large portion of cultivated area and this will reduce the food production capacity of the local population. This will mean loss of a food source in Sitio Inigan. **Table 3.4.8** shows the projected loss in farmland production in the affected area (in pesos).

Table 3.4.8 Projected Lost Farmland Production in Sitio Inigan, Rodriguez, Rizal Due to Landfill Site Development

Item	Data
No of households in Sitio Inigan	75 households
Average farm size in hectares	1.4 hectares
Total farm area hectares	49 hectares
Total production	
Upland rice at 40 cavans per hectare and one cropping season per year	1,960 cavans
Corn at 30 cavans per hectare and one cropping season per year	1,470 cavans
Value of Production	
Rice at P 500 per cavan	980,000 pesos
Corn at 300 per cavan	441,000 pesos
Total annual value of production	1,421,000 pesos

The sitio has 75 households cultivating an average of 1.4 hectares of farm. The farm is planted to both temporary (upland rice and corn) and permanent crops (coffee and fruit trees). The temporary crops are cultivated in small patches with once a year cropping. If the entire farmland is planted to rice for one cropping season (wet season) and corn for another cropping season (dry season), the entire farm production is projected to be P 1, 421, 000.00 per year. This is assuming that upland rice yields 40 cavans per hectare and 30 cavans per hectare for corn. Such amount represent the farm production which will be lost every year due to land fill development and operation.

At the same time, there will be an increased demand for food both by the workers during the construction and operation phase. In both instances the remaining food producers will benefit from the increase in demand. The persons who will be transferred from farm to wage employment will cease to produce food and will become mere consumers. Their consumption will serve as a conduit to transfer funds from the project to the local producers.

(l) Recreation and Aesthetics

The area is presently used for hiking and the limestone hills nearby are used for rock climbing. Wawa river, in spite of its polluted state, is still used for bathing and attracts visitors who swim and have picnic on its banks. The landfill may reduce the aesthetic value of the area and its attractiveness to visitors.

3.4.2 Operation Phase Impacts

Potential impacts during the operation phase will start with the commencement of the operation of proposed SLF. The discussion points out the possibility of occurrence of various unmitigated impacts. The mitigating measures are partly presented for each adverse impacts. Detailed discussion is presented in Chapter 4. A scaling checklist for the unmitigated operation phase impacts are presented in **Table 3.4.9.**

(1) Impacts on the Physico-Chemical Environment

(a) Hydrology/Sediment

During the operation of the proposed SLF, the recharge potential of the whole Marikina watershed area may be slightly affected by the proposed SLF project. This is so because the effective bottom surface of the proposed SLF will be made impermeable by using clay and other synthetic materials as liners. However, it is assumed that any reduction in the recharge potential of the watershed area is insignificant because the project area is just a small fraction of the whole watershed area.

In terms of sediment transport to the existing surface water such as Wawa river, it is expected that siltation due to sediment runoff is negligible. This is because of the relatively stabilized liners of the SLF that covers the area. During rainy season, it is expected that very minimal sediment runoff will be experienced. The possible cause is the continuous soil covering of the compacted garbage.

(b) Groundwater Quality

The possible impairment of groundwater quality in the area is the direct infiltration or contact of leachate generated by the SLF to the groundwater aquifer in the area.. Leachate is a liquid contaminated from contact with decomposting wastes containing bacteria and other materials that drain out of dumpsites and landfills. Based on DENR and JICA studies, its chemical and biological characteristics are shown in the above **Table 3.4.10.**

Without proper collection and treatment of leachate, it is possible that it can leach-out to the surrounding groundwater aquifer over the periods of operation and abandonment of the proposed SLF. As part of the pollution prevention measures of the proposed project, it will install efficient leachate collection and treatment systems, which is capable of improving the leachate quality. The treatment efficiency is designed to attain the DENR Effluent Standard. The details of which are presented in Chapter 4. Another measure that will prevent groundwater contamination is the application of clay and synthetic liners. The use of this liners will ensure that the bottom surface of the SLF is impervious to leachate infiltration.

Table 3.4.10. Physico-chemical and biological characteristics of leachates from dumpsites and landfills.

Parameters	**Concentration**
Color	> 3,000 PCU
pH	8.2
BOD5	15,000 mg/l
COD	1,200 mg/l
TSS	136 mg/l
T-Hg	< 0.01 ug/l
Cd	< 0.003 mg/l
As	< 0.001 mg/l
Cr+6	< 0.01 mg/l
Pb	< 0.02 mg/l
PCB	< 0.001 mg/l
Phenols	0.036 mg/l
Oil and grease	3.5 g/l
Total coliform bacteria	> 1,600 MPN/100 ml

Table 3.4.9. Scaling checklist for the Unmitigated Operation Phase Impacts

Impact Area	Impacts	Nature	Magnitude
Physico-Chemical Environment			
Hydrology/Sediments	Disruption or impairment of surface hydrology Disruption of groundwater hydrology	Negative Negative	Significant Minimal
Groundwater quality	Water Pollution due to leachate infiltration	Negative	significant
Surface water	Water Pollution due to leakage or discharge of untreated leachate	Negative	Significant
Air quality	Generation of air pollutants such as methane, obnoxious/foul odor and gas pollutants	Negative	Moderate
Noise and vibration	Increase in noise and vibration levels due to hauling trucks and use of heavy equipment	Negative	Minimal
Traffic	Increase in traffic congestion due to hauling trucks	Negative	Minimal
Geology/Seismology	Induced seismicity	Negative	No effect
Topography/ Physiography	Alteration of natural terrain	Negative	No effect
Biological Environment			
Flora and fauna	Tree planting and reforestation within the project and buffer zone area Fish and wildlife disturbance	positive Negative	Significant Minimal
Socio-economic Environment			
Population size	Increase in population due to influx of outside labor and their households Increase in population due to influx of scavengers and/or squatters in the area	Negative Negative	Significant Significant
Dependency burden	Increase capability to support dependents	Positive	Significant
Education	Greater capability to support dependents	Positive	Significant
Sex ratio	Imbalance of sex ratio due to male preference as construction workers	Negative	Minimal
Housing characteristics	Increase capability to improve housing and utilities	Positive	Significant
Social services	Increase use of access roads	Positive	Significant
Health and safety	Greater capability to afford food and medical care Exposure to air- and waterborne diseases Occurrence of traffic-related accidents	Positive Negative Negative	Significant Significant Minimal
Employment and Income	Reduction of unemployment and increase in income	Positive	Significant
Women's welfare	Employment in services catering to workers Employment in junk shops and recycling centers	Positive Positive	Significant Significant
Farm production	Farm to market transport of agricultural produce	Positive	Significant

(c) Air Quality

1) Sources of Air Pollution and Landfill Gas Composition

One of the most common problems of any SLF project is the foul odor generation that could impair the surrounding air quality. During the operation stage, it is expected that this problem is likely to be experienced by the SLF workers and the nearby communities. The key to odor generation prevention hinges on the regular soil covering of the disposed garbage. If this is practiced, the foul odor generation could be minimized.

The buffer zone around the SLF which is to be planted with trees and other vegetation will help attenuate the odor problem. Similarly, the use of gas mask by the workers will relieve them from the irritating effect of this foul odor.

Another source of air pollution is the generation of gases from landfill operation. It is reported by Tchobanoglous, et al. (1993) that landfill gas is composed of the following gases (dry volume basis) (**Table 3.4.11**):

Table 3.4.11. Composition of landfill gas.

Gas	Percent (dry volume basis)
Methane	40-60%
Carbon Dioxide	40-60%
Nitrogen	2-5%
Carbon Monoxide	0-0.2%
Ammonia	0.1-1.0%
Sulfides, disulfides, mercaptans	0-0.2%
Hydrogen	0-0.2%
Oxygen	0.1-1.0%
Trace constituents	0.01-0.6%

Methane gas and carbon dioxide dominates the gas composition. Methane is a highly combustible volatile organic gas. It poses fire hazards in any SLF area. Once fire is set up due to unscrupulous throwing of lighted cigarette butts or direct flaring, air pollution will become worst due to the burning of garbage that could result to more TSP, Carbon Dioxide, NOx, and other air pollutants generation. It is therefore imperative to recognize that the SLF area is fire hazard and source/s of fire incidence should be completely controlled and prevented.

2) Emission Inventory

As described in section 3.4.1 (d), the daily and annual emissions inventory were undertaken using generally accepted procedures and methodology developed by US Environmental Protection Agency and adopted by the DENR-EMB. These are studies conducted by Cowhead, et. al. (1974) and Jutze, et. al. (1974) by USEPA. Other sources of secondary data are those published DENR-Environment and Natural resource Accounting Project (ENRAP).

4) Methane Gas Inventory

Methane and CO2 gases are produced by the microorganisms anaerobic activity in landfills. The gas generation process can be classified into four phases. The first phase takes place under aerobic condition and the principal gas produced is CO2, nitrogen (N2) content is also high during this phase. As the 02 is depleted, the second phase starts under anaerobic condition and large amount of CO2 and H2 are produced. In the third phase, CO2 production declines and CH4 production starts. Also during the third phase, N2 content sharply declines. The last phase see the steady production of CH4, CO2, and N2.

Uncontrolled CH4 emission rate was estimated in this study using the USEPA Landfill Air Emissions Estimation Model, a first-order kinetic model of methane production.

$$Q_{CH4} = Lo\ R\ (e^{-kc} - e^{-kt})$$

Where:

Q_{CH4} = methane generation rate at time t, m3/year
Lo = methane generation potential, m3 CH4/Mg refuse
e = base log, unitless
k = methane generation constant, yr-1
c = time since landfill closure, yrs (c = 0 for active landfills); and
t = time since the initial refuse placement, years

This model was applied at a scenario five years after the landfill closure, Lo of 150 m3/ton, and k value of 0.02/year. The assumed Lo is 20% higher that the EPA recommended factor while the methane generation rate is assumed at 0.2/year. Due to the importance of these factors, the study team recommends that the actual establishment of their numerical value for the type of refuse that will disposed at the proposed landfill.

The above model yielded a methane generation rate after five years of closure of 240 m3 CH4/year or about 6 m3 annually. At standard temperature and pressure, this CH4 generation translates to 114 kg CH4/day.

4) PM10, NOx, VOCs and CO Inventory

Another source of emissions is the 1,200 trucks that will haul solid waste to the landfill on a daily basis. To estimate PM10, nitrogen oxides (NOx), volatile organic compounds (VOCs), and carbon monoxide (CO), the DENR-Environment and Natural Resources Accounting Project (ENRAP) emission factors were used for diesel trucks:

- NOx = 12.50 g/km
- VOC = 3.70 g/km
- CO = 12.40 g/km
- PM10 = 1.448 g/km

On a per kilometer basis a total of 15 kg of NOx, 4 kg of VOCs, 18 kg of CO, and 2 kg of PM10 will be emitted.

5) Results of Air Quality Modeling

Using the computed emission rate parameters for TSP, CH4 from landfill and NOx, VOCs, CO, and PM10 emissions from 1,200 trucks, the study team the USEPA SCREEN3 Model to estimate maximum pollutant concentration, distance to concentration and meteorological condition conditions that produces the maximum concentration. Essentially, SCREEN3 defines the worst case scenario which will allow the proponent and study team to design appropriate control interventions. Some features of the SCREEN3 are as follows:

- For area source modeling, it allows a search through the range of wind directions based on orientation of the landfill. In this case, the irregular shape of the landfill was simplified to a square shape having length of 1,140 kilometers.

- examine a full range of meteorological conditions, including all stability classes and wind speeds to find maximum impacts

The study team utilized the SCREEN3 View , a proprietary windows interface to the USEPA Fortan SCREEN3 Model.

In modeling fugitive dust emission from soil cover work, the following source inputs were used:

a) emission rate = 0.00028 g/s/m2 (total fugitive dust emissions is estimated at 529 kg/day over an area of 65 hectares)

b) source release height = 1 m
c) larger side of the rectangular area = 1140 m
d) smaller side of the rectangular area = 570 m
receptor height = 0 (simplified as flat terrain)

While CH4 emission modeling, the following source inputs were used:

a) emission rate = 0.00003044 g/s/m2 (114 kg CH4/day over the total area of 130 hectares)
b) source release height = 1 m
c) larger side of the rectangular area = 1140 m
d) smaller side of the rectangular area = 570 m
e) receptor height = 0 (simplified as flat terrain

Attachment B presents the modeling results for this study. The TSP modeling revealed that the maximum ground concentration during soil cover work is 4,114 ug/NCM at a distance of 639 meters from the center of the landfill. While the CH4 modeling indicated that the maximum CH4 concentration five years after the its closure will occur also at a distance of 639 meters from the center with a predicted concentration of 447 ug/NCM. Applying this to the simplified square shape of landfill having dimension of 1,140 m, this is about 70 meters beyond the landfill perimeter. This condition will occur under the Stability Class F, with a wind speed of 1 m/s at a height of 10 meters above ground, and a mixing height of 1,000 meters.

Emissions from trucks is estimated to have its greatest impact within 100 meters from the road centerline. Predicted NOx, VOCs, CO, and PM10 ambient concentrations will increase, on worst condition, by as much as 14.62 ug/NCM, 4.316 ug/NCM, 14.48 ug/NCM, and 1.687 ug/NCM, respectively.

d) Noise and Vibration

The proposed SLF project during its operation phase is neither expected to impact the sonic environment nor produce strong vibrations that would result in adverse consequences. The only possible sources of noise are the hauling trucks for the transport of garbage and those heavy equipment which is used in the compaction and land filling of the SLF. Planted trees along the buffer zone and along side the access road are expected to attenuate the noise into tolerable level.

(e) Microclimate

The microclimate may change in terms of air temperature increases. Since the project area will be operated in phases, possible change in microclimate is not expected to happen. The prevailing ambient temperature is therefore expected to remain the same during the entire period of operation.

(f) Geology/Seismology

Induced seismicity cause by the proposed SLF is not expected since the weight of the garbage even after the landfill service life is too low to cause seismic activity. Except for natural earthquake, there is no other potential sources of induced seismicity.

(g)Natural Resource Use

The operation of the SLF will not damage any economically valuable natural resources. The implementation of the MEFCON Concept, in which the proposed landfill project is one of the major components will instead enhance the natural and economic value of the proposed project area. The project is envisioned to be an environment- friendly landfill.

(h) Aesthetic Effects

At first thought, the introduction of any garbage disposal site to any community is not aesthetically desirable. This is especially true because of the Philippine experience in garbage disposal which include dumping in open dumping sites and road sides and throwing garbage in esteros and canals, etc. However, in advanced countries like Japan, delicately planned and properly managed sanitary landfill is aesthetically pleasing. If the MEFCON Concept is to be realized, the proposed SLF will become the first aesthetically pleasing garbage disposal site in the country.

(2) Impacts on the Biological Environment

(a) Loss in Vegetation

Most of the identified plant species in the primary impact zone are considered economically important. However the density of the affected species is considerably small as these are found only in patches within the project area. The planned reforestation of the buffer zone for the SLF coupled with the implementation of the MEFCON project would even enhance the natural beauty of this portion of the Marikina Watershed. Cutting of trees will be done only during the construction stage to give way to the SLF development. This will be replaced however during the operation stage until abandonment cum rehabilitation stage, when hundreds of trees will be planted to regain the former beauty of the project site and its surrounding environment.

(b) Fish and Wildlife Disturbance

During operation phase, there will be no effect on wildlife species. Before construction stage, the area is already devod of wildlife species due to the kaingin practice of some member of the locality.

There will be no loss of a potential aquatic habitat expected for the project. As there are very limited number of fish thriving in Wawa River, no significant impact is expected.

(3) Impacts on the Socio-economic Environment

(a) Population size

The landfill project will require 102 types of position during the operation phase. These positions are presented in Chapter 4.

The population size of Barangay San Rafael will expand due to the influx of workers are brought in from outside or in-migrants attracted by work opportunities. If 70% of the required workers will be obtained from outside, expansion of the population size of the barangay will be only 0.58% (**Table 3.4.13**).

The population expansion will be greater if the outside workers will bring in their respective households into the site. There will be three additional migrants for every worker because an average household has about four members. Thus, the 71 workers whom the project will employ means that 284 in-migrants can settle in Barangay San Rafael. The number will readily increase its population size by 2.3 percent.

If the workers from outside will not take residence in or near the construction site, and they commute from their present residence, they would merely add to the day-time, but not to the night-time, population of the area. In any case, the increase in population will automatically increase the population density in the impact area.

If 30% of of the 31 persons who will be employed during the operation phase will increase the capability of the economically active adults to support their dependents

The increased capability of the economically active adults will enable them to support longer years of schooling. In the long run, the salaries and wages paid off by the proposed project will have an impact on the educational attainment of the population. If outside workers are brought in, this impact will not redound in the direct impact area. Furthermore, the workers who will be brought in, particularly during the construction phase, will alter the sex ratio in the direct impact area. More males will be added. This situation can create conflicts between the outside workers and local labor.

Table 3.4.13 Projected Number of Persons Who Will be Added to the Existing Population of Barangay San Rafael, Rodriguez As A Result of the Landfill Site Development

Item	Operation Phase
1995 population	12,285
No of required workers	71
Total	12,356
Percentage increase of 1995 population	0.58
No of in migrants if workers will bring in their families	284
Percentage increase of 1995 population	2.3

(b) Dependency

The 31 workers from barangay San Rafael will increase the capability of the economically active adults to support their dependents. However, the project will not greatly affect the existing dependency ratio at least in the short term.

(c) Health and Safety

With the improvement in lifestyle that can be catalyzed by the project, the health and safety of the residents may subsequently improve. As a consequence of development and economic capability of the residents, improvement on the basic utilities such as sanitized pipe drinking water, water-sealed septic tank and other basic health and sanitation facilities are expected to be effected in the project area. However, this scenario hinges on the overall management of the proposed SLF. Experience with San Mateo SLF dictates the other way around. In general, properly managed SLF should improve the health and safety of the host community.

(d) Employment Income and Revenues

The project can employ local residents during the operation phase. It can provide enough work to significantly reduce the unemployment rate in San Rafael, Rodriguez.

Similar with earlier discussion, employment in the project is particularly needed by the households who lost their farmland or whose farming operation is reduced by the project. If local residents will be employed, a transfer of funds, in the form of salaries and wages, from the project to the local economy will occur.

(e) Impact on Traffic

For the new SLF, the traffic forecast are as follows:

- Average Daily Traffic = 1,000 to 2,000 vehicles. This design traffic volume are taken from the maximum traffic volume in the year 2010; and
- Passenger vehicles share 20% of all the traffic volume.

With this traffic volume forecast, it is already anticipated that traffic volume on Marcos Highway and Cogeo Road up to the access road leading to the proposed new SLF would be heavily congested. To alleviate this foreseen traffic problem, it is recommended that the new SLF could be accessed in two directions; (1) via the Marcos highway and Cogeo Road and (2) via the town of Rodriguez and Wawa Village. In this case, it is expected that the impact on traffic would be minimized.

3.5 Environmental Risk Assessment

3.5.1 General

This section deals with the Environmental Risk Assessment (ERA) of the proposed SLF project. It is basically an examination of what can go wrong and whether plausible risk scenarios are considered to be unacceptable.

Risk is defined as the probability or chance of occurrence of an event. The event which is considered negative or undesirable is the focus of the ERA. A risk is often expressed as a statistic on the probability of an accident or death due to specific situations or conditions. A hazard on the other hand is defined as an inherent physical or chemical characteristics that has the potential for causing harm, while a hazard evaluation study is an organized effort to identify and analyze the significance of hazardous situations associated with a process or activity (AIChE, 1992).

In this ERA, the hazard evaluation study is focused on the hazardous situations associated with the operation of the proposed SLF.

3.5.2 Hazard Identification and Evaluation

The hazard evaluation used for this study is the "what-if Analysis" (WIA) technique. Other methods which are usually applied to already constructed systems were not considered. The WIA technique is selected since it does not require detailed information of the facility design and has broad flexibility for identifying and evaluating hazards.

(1) Seismic Hazards Evaluation

Suitable geological setting for an SLF project is the one that prevents the leachate from escaping. In other words, impervious, tight (water proof) rocks is highly desirable. However, finding this kind of geological setting does not guarantee a 100% leakage free environment for leachate. During periods of high intensity earthquake, the formerly tight rocks may result in bedrock fractures that would aid the leachate contact with the underlying groundwater aquifer. Fractured bedrock is highly undesirable beneath a landfill because the wastes cannot be located if they escape. The presence of Marikina Fault, which is about 10 km away from the project site, pose seismic hazard to the proposed SLF. Under extreme condition, this could lead to the eventual fracture of the bedrock setting of the site and breakage of the bottom liner of the SLF. To infer the possibility of this event, the study team has undertaken computerized seismic risk evaluation. The succeeding section presents the method of risk analysis and the results of the evaluation.

(a) Seismic Risk Evaluation Method

The probabilistic approach of assessing the seismic risk at the project site was used in this study. U.S.E.P.A. requires that landfills located in seismic impact zones should be designed to resist the Maximum Horizontal Acceleration (MHA) for the area. A seismic impact zone is defined as an area that has 10% or more probability of exceeding MHA of 0.10g in 250 years.

(b) Seismic Data

The sets of seismic data used in this study were taken from PHILVOCS Earthquake Catalogue. These seismic data gives earthquake events which occurred during the period 1900 to 1998 for magnitudes greater than the Richter Scale 4.5. These data which include the date of occurrence, location of epicenter, magnitude of earthquake and focal depth for some events were utilized in the subject seismic risk study.

For convenience of processing and reserving it for future use, the obtained data were compiled as data base for the project. A worksheet on the hypocentral distance of the earthquake source to the site, attenuation of earthquake and statistical analyses are given in **Attachment C.**

(c) Seismic Risk Analysis

The details of the methods involved in the seismic risk analysis are given below:

1) Attenuation Mode

The maximum ground acceleration arriving at a point from an earthquake source depends on the magnitude and hypocentral distance from the origin. Various attenuation models have been proposed and they are usually given under specific geological conditions and focal length. The method proposed by McGuire will be adopted in this study. From McGuire (1974):

$$A_{g(max)} = \frac{472 \times 10^{0.278}}{(R+25)^{1.3}}$$

where:
$A_{g(max)}$ = maximum ground acceleration (cm/sec^2)
R = hypocentral distance (km)
M = earthquake magnitude (Richter)

From the McGuire (1974) attenuation equation, maximum ground acceleration (Ag) for the subject site can be estimated from the recorded earthquake data. The results of Ag in terms of a ratio to the gravity acceleration (981 cm/sec2) are included in the computer analysis.

The focal depth of the earthquake sources, are not taken into account in the calculation of the hypocentral distance. The actual distance for the transmission of waves from earthquake sources to the site should be greater than the calculated hypocentral distance and therefore such an assumption would be on the safe side.

2) Determination of Extremes

The accuracy of the prediction of an event having a certain percentage of probability of not being exceeded in a defined period of time will much depend on the characteristic of the available data, such as size representative of the data. For this project, it is proposed that the structure be designed to withstand a seismic event having a 80 percent probability of not being exceeded in 50 years.

This corresponds to a seismic event of a return period of about 250 years. The prediction of an event of 250 years return period can be done by assuming the available data to form a representative sample of a large population.

The Gumbel Theory will be adopted in this study. In this method, the probability that an event x is equal to or greater than any event x1, x2........., xn is :

$$P(x) = f(x_1 \leq x, x_2 \leq x, \ldots\ldots, x_n \leq x)$$

The return period TR(x) and the reduced variable y for an event x are defined as:

$$TR(x) = \frac{1}{1-P(x)} \qquad P(x) = \frac{1}{TR(x)}$$

For an observed event, the return period TR(x) can be estimated from the total number of observation N and the rank of the observed event m:

$$TR(x) = \frac{N+1}{m}$$

Any event j of a return period k can be determined from the equation below in which X and □ are the mean and standard deviation of the observed sample.

$$Xj = X + \square\,(0.78Y_k - 0.45)$$

where:

$$Y_k = -\ln(\ln(TR(x)/(TR(x)-1)))$$

in which X and Y are the mean and standard deviation of the observed sample.

Factors affecting the prediction of an extreme seismic event from the available data are as follows:

(a) Zone of Influence

Larger zone of influence will envelope larger area and include more data. This will increase the sample size. Because of attenuation, earthquake occurring at a greater hypocentral distance will give smaller ground acceleration for the same magnitude and therefore the inclusion of distant earthquake sources will lower down the sample mean and standard deviation.

(b) Magnitude of Earthquake

The data has been sorted into three groups, with magnitude greater than 4.5, magnitude greater than 7 and in between 4.5 and 7. Computation of the sample mean and standard deviation for these groups of data and their combination have been performed.

Sensitivity study of the above factors has been carried out and the results are presented in **Table 3.5.2**. The results indicate that the predicted value of a seismic event of 250 years return period is comparatively higher for a 150 km zone of influence to a 300 km zone of influence.

(c) Recommended MHA for the Site

A high value of ground acceleration with Ag = 0.303g was obtained for just considering data of magnitude greater than or equal to 7 and 150 km zone of influence. The sample size is very small (11) and is not representative to the population of earthquake events. It appears that the most reliable result will be

Table 3.5.2
Results of Seismic Risk Analyses

	Influence Zone of 150 km				**Influence Zone of 300 km**			
	No. of Data	Mean A_g	Std. Dev. σ	A_g for Tr of 250 years	No. of Data	Mean A_g	Std. Dev. σ	A_g for Tr of 250 years
M≥7	11	0.106	0.051	0.303	16	0.084	0.053	0.289
7≥M≥4.5	81	0.023	0.011	0.067	210	0.017	0.010	0.057
M≥4.5	90	0.032	0.034	0.163	222	0.021	0.024	0.115

for magnitudes greater than or equal to 4.5 of sample size 90 with an estimated peak ground acceleration of 0.163g. The graphical presentation of the result is given in **Figure 3.5.1**.

Based from the results of the probabilistic study, it is recommended that two levels of earthquake be considered in design. For the deformable landfill structure, a MHA of 0.163g may be used in design. This is consideration of the typically limited lifespan of said structures. It is, however, recommended that more critical appurtenant structures to the landfill be checked for a lower probability MHA of 0.303g as obtained in the analyses.

(d) Liquefaction Potential

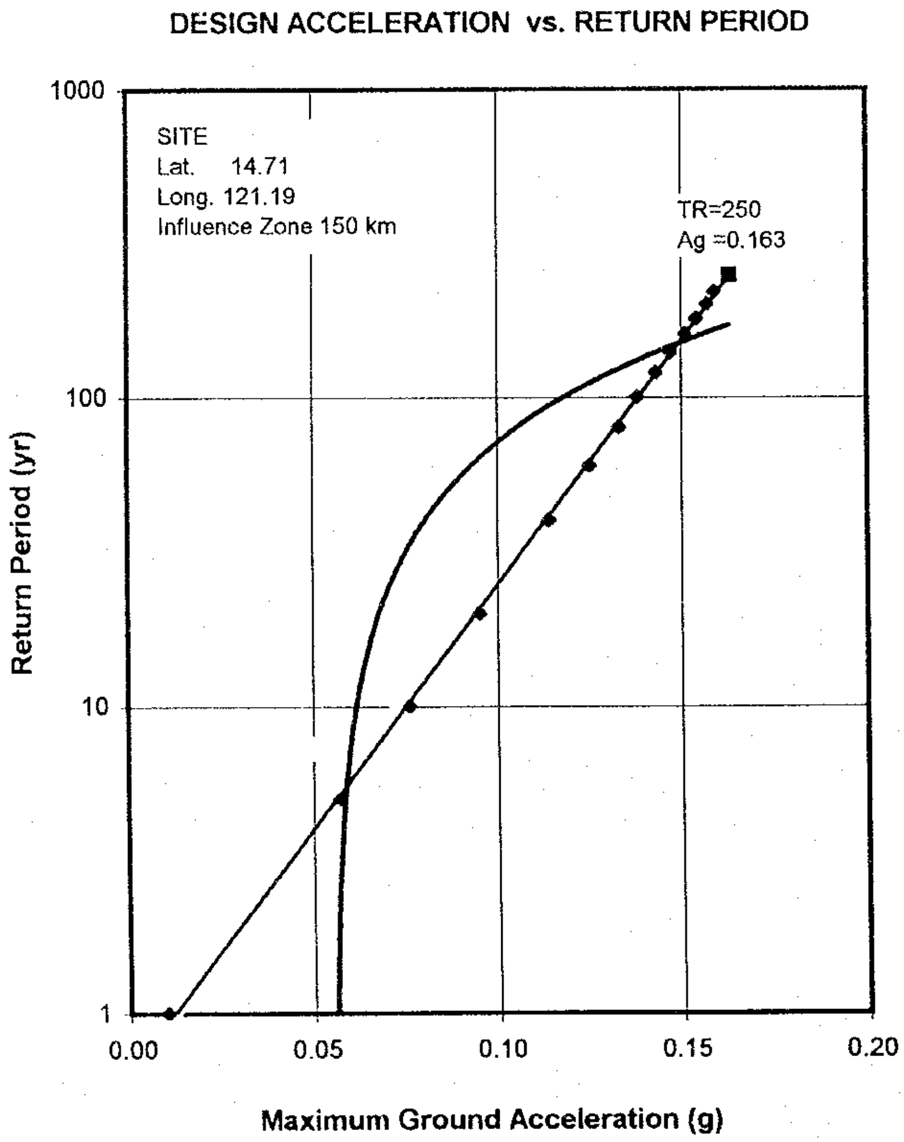


Figure 3.5.1. Plot of Design Acceleration vs Return Period

Liquefaction refers to the significant loss of strength of loose, saturated deposits of sand or silt due to the increase in pore pressure pore as a result of dynamic loading. This is usually an earthquake-induced phenomenon commonly manifested in the form of localized sand boils and more critically by aerial settlement for areas near bodies of water where soil mass can laterally displace.

The nature of the subsurface soils as revealed by the conducted soil investigation indicates that potentially liquefiable deposits are not present in the proposed site of the landfill. The subsoils are generally dense to very dense in consistency and considerable lateral and vertical confinement exists in the area. The additional weight of fill as required in the construction of the landfill base will likewise provide additional confinement and stability to the subsoils.

(e) Natural Slopes

Most of the slopes in the immediate vicinity of the project appears to be stable. Evidence of previous slides are not present in the area. This can be attributed to the stability offered by the relatively thick vegetation and good soil and rock condition in the area.

(2) Fire Hazard Evaluation

All sanitary landfill is a potential generator of methane gas. Methane gas is a highly combustible gas, which is a by-product of the continuous decomposition of garbage in SLF area. In this study, methane generation was estimated at about 240 m3 CH4/year. Since the estimation is just preliminary in the absence of CH4 emission standards, it is assumed that this CH4 generation rate is sufficient enough to start accidental fire in the SLF area.

(3) Leachate Pollution/Leakage Hazard Evaluation

SLF has four critical elements namely; a bottom liner, a leachate collection system, a cover and the natural hydrogeologic setting. The natural setting can be selected to minimize the possibility of wastes escaping to groundwater beneath a landfill. The three other elements must be engineered. Each of these elements is critical to a successful SLF operation.

The bottom line on the other hand can be one or more layers of clay or synthetic flexible membrane (or a combination of these). The bottom liner effectively creates a bathtub (similar to a holding tank) in the ground. If the bottom liner fails, wastes will migrate directly into the environment.

3.5.3 Safety and Emergency Facility

The levels of safety associated with SLF operation hinges on the control measures to be instituted in the project. For the proposed SLF, the following safety control on site will be implemented.

(1) Traffic Safety Control

(a) Traffic control
(b) Installation of traffic signs
(c) Selection of operating vehicles and machinery meeting with site conditions

(2) Safety Control for Landfill Work
(a) Counter measures for landfill gas leakage
(b) Countermeasures for oxygen deficiency in pipes and manholes

(3) Safety Workers
(a) Measures for prevention of accidents
(b) Conduct safety drills and health education program
(c) Medical check-ups of workers

(4) Data Management for Landfill work
(a) Collection, filing and storage of data on landfill work and lanfill work

3.5.4 Risk Management

Risk management usually refers to the examination of the economic and social implications of each level of protection. In this ERA, it refers to the social preferences, political issues, and technological feasibility.

The important issue for management is the propose layout plan and land use zoning of the areas around the propose SLF. Technical prevention of hazards is also important.

3.5.5 Risk Acceptability

In general, the risk associated with the use of properly sited and competently designed SLF is acceptable worldwide since the design and construction would be guided by International Standards. Improvements on landfill technology during the past years have also contributed significantly on the safety of waste disposal.