COMPREHENSIVE STUDY REPORT

Tinian Landfill
Tinian, CNMI

March 2005

U.S. Army Engineer District, Honolulu
Programs and Project Management Division
Environmental Branch

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U.S. Army Corps of Engineers

Pacific Ocean Division

Honolulu Engineer District

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OF
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Prepared for:

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FIGURES

TABLES

ACM	asbestos-containing material
AIR 21	Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (Public Law No. 106-181)
APC	Area of Particular Concern
C/D	construction/demolition
CD/D/DC	construction debris/demolition/disaster cleanup
CFR	U.S. Code of Federal Regulations
CNMI	Commonwealth of the Northern Mariana Islands
COMNAVMAR	Commander, Naval Forces Marianas
CPA	Commonwealth Ports Authority
CRM	CNMI Coastal Resources Management
CY	cubic yard(s)
d	day
DEQ	CNMI Division of Environmental Quality
DFW	CNMI Division of Fish and Wildlife
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
fam.	Family
ft	foot, feet
FTE	Full-Time Equivalent
HPO	CNMI Historic Preservation Office
hr	hour
ITC	Integrated Tool Carrier
kw	kilowatt
kwh	kilowatt hour
MPLA	Marianas Public Lands Authority
MSWL	municipal solid waste landfill
NPIAS	National Plan of Integrated Airport Systems
OEDPC	Overall Economic Development Plan Commission
RCRA	Resource Conservation and Recovery Act of 1976
sp.	species

SWMF	solid waste management facility
SY	square yard(s)
U.S.	United States
USDA	U.S. Department of Agriculture
USDC	U.S Department of Commerce
USDOT	U.S. Department of Transportation
WHA	Wildlife Hazard Assessment
WHMP	Wildlife Hazard Management Plan
y	year

A comprehensive study was performed to determine applicable relevant and appropriate requirements for the permanent closure of an existing landfill on Tinian Island, Commonwealth of the Northern Mariana Islands (CNMI), and to evaluate sites to construct a new replacement landfill or other form(s) of solid waste management for the Municipality of Tinian. Objectives of the comprehensive study were to identify the steps to be taken to close the existing on-island open dump and identify new landfill, transfer station, and septage facility sites toward the design and construction of said actions. It accounted for an on-island residential population growth of 5 percent per annum and a per person waste disposal rate of approximately 4 pounds per day which is consistent with the rate on Saipan.

Closure of the existing open dump on Tinian Island is warranted as there are no environmental protection features associated with that facility when compared to a regulatory compliant municipal solid waste landfill. Closure alternatives include waiting until a new municipal solid waste landfill is constructed and operational, immediate partial closure by keeping only a portion of the dump open as construction of a new landfill ensues, or temporary or permanent shipment of solid waste to an off-island permitted municipal solid waste landfill. Final closure would entail institutional controls (e.g., fencing and signage) to restrict unauthorized access, and installing a soil cap, an impermeable cover, or a combination thereof.

A transfer station is a facility where customers deliver small loads of solid waste to for eventual bulk hauling to an on-island or off-island municipal solid waste landfill. Closure of the existing open dump will create a need for a transfer station in conjunction with a municipal solid waste landfill as it is being constructed and once in operation. Transfer station design criteria include, but are not limited to, the types and volume of waste to be received, location and hours of operation, site features, and community acceptance. A recycling center can be operated in tandem with and at a transfer station to decrease the solid waste volume to be hauled, however, the small population on Tinian may not support an economically viable recycling program.

Septage is the solid, semi-solid, or liquid material that collects in septic tanks, cesspools, or portable sanitation devices. These receptacles must be periodically pumped out and subsequently treated or disposed. Existing practice is for pumped septage to be discharged at an area adjacent to the existing open solid waste dump. Health concerns associated with raw sewage warrant consideration of a septage disposal facility until such time a wastewater treatment plant can be constructed on Tinian Island. One alternative is to site collocate a septage dewatering facility and municipal solid waste landfill. Liquids from the dewatering process in sand drying beds can be treated with landfill leachate, and dewatered biosolids can be placed in the landfill. Collocation affords operational and maintenance efficiency.

A new, regulatory compliant municipal solid waste landfill would consist of an impermeable liner, leachate collection and treatment system, and environmental monitoring. Other facets of the landfill may include separate and distinct areas based on waste type, e.g., construction/demolition/disaster cleanup debris, wood waste, asbestos-containing material, and dewatered septage. Siting constraints must be taken into account given Tinian Island's limited land area and distance limitations imposed by the CNMI Division of Environmental Quality, U.S. Environmental Protection Agency, and Federal

Aviation Administration. Other siting criteria include areal geology, underlying aquifer significance, threatened or endangered species, conservation areas, and critical habitats.

Several solid waste processing technologies have been suggested for consideration on Tinian in lieu of a municipal solid waste landfill. These include incineration, biodegradation, solid waste composting, and proprietary technologies such as hydrometallurgical extraction (Hydromex), ethanol generation, gas or oil production, etc. In general, there are several disadvantages to these various technologies with respect to solid waste management on Tinian Island. They include, but are not limited to, fiscal and time constraints, unproven and unsubstantiated track record, and mechanical, electrical, or operating complexity. While seemingly viable processes, these alternative technologies would tend to increase the cost of solid waste management given the current and anticipated volume of solid waste generated on Tinian. Some have the possibility of revenue generation, however, it would not approach system capital and operating costs. Additionally, these add-on alternatives would still require a landfill disposal site for processing residues and materials the system is unable to process.

Factors the Municipality of Tinian should consider before an alternative technology to landfilling is selected include obtaining details of the biological, mechanical, and chemical processes employed by the technology as well as third-party reviews of these processes; cost-efficiency and financial risk associated with the technology given the current and projected volume of solid waste generated on Tinian; timely receipt of spare parts as well as maintenance and repair by trained personnel; application of the technology to treatment or disposal of different waste streams (e.g., asbestos-containing material, construction/demolition/disaster debris, green waste); process-generated waste and its disposition; and land and public utilities requirements.

Construction and operation of solid waste management facilities on Tinian must comply with local regulatory requirements enforced by the Division of Environmental Quality, Coastal Resources Management Office, Department of Land and Natural Resources, Historic Preservation Office, et al. These requirements include, but are not limited, to solid waste management regulations, major siting permit preparation, and natural and cultural resources consultation.

Landfill siting must also comply with Federal Aviation Administration distance requirements (i.e., 6 statute miles from a public-use airport) or application of a variance thereto, and wildlife assessment, and protection. Additionally federally licensed or permitted activities and the provisions for federal financial assistance for activities affecting land or water uses of the coastal zone must be consistent with the local Coastal Resources Management program.

1.1 INTRODUCTION

This comprehensive study report was prepared by the U.S. Army Corps of Engineers in accordance with sections 4.5 and 5.5 of *Scope of Work, Comprehensive Study of Tinian Landfill* dated 5 February 2004 (Task Order Number 0068, U.S. Army Engineer District, Honolulu Contract Number DACA83-00-D-0012).

1.2 PURPOSE

The purpose of the comprehensive study is to determine applicable relevant and appropriate requirements for the permanent closure of an existing landfill on Tinian Island, Commonwealth of the Northern Mariana Islands (CNMI), and to evaluate sites to construct a new replacement landfill or other form(s) of solid waste management for the Municipality of Tinian. Study objectives address the following topics:

- Existing open dump closure
- Transfer station siting and conceptual design
- Landfill siting and conceptual design
- Septage disposal facility siting and conceptual design
- Alternative solid waste processing technologies

2.1 LOCATION

Tinian is the second largest of the Northern Mariana Islands, an archipelago located in the Western Pacific Ocean approximately 3,730 miles (6,000 kilometers) southwest of Hawaii. At latitude 15 degrees 5 minutes north and longitude 145 degrees 45 minutes east, Tinian lies about 6 miles (10 kilometers) south-southwest of Saipan and about 124 miles (200 kilometers) north-northeast of Guam (see Figures 1 and 2).

2.2 PHYSIOGRAPHY

Approximately 39 square miles (101 kilometers) in size, Tinian is dominated by flat terraces and plateaus separated by steeply sloping areas and escarpments. The greatest relief is formed by two relatively prominent blocks in the north-central and southeastern areas of the island. Land surface elevation is near sea level at wetland depressions in southeastern and northwestern Tinian. The coast of the island largely consists of steep cliffs, most ranging from 20 to 100 feet (6 to 30 meters) high, separated by several small beaches and coves (Gingerich and Yeatts 2000; USDA 1989).

The island of Tinian is about 12 miles (19 kilometers) long and as much as 6 miles (10 kilometers) wide. The surface landforms can be divided into five major physiographic areas, i.e., northern lowland, north-central highland, central plateau, median valley, and southeastern ridge. The southeastern ridge is the southernmost and highest part of the island and consists of a north and south ridge, separated by a gap near its midpoint. Steep slopes and cliffs ascend as much as 500 feet (152 meters) from the southeast boundary of the ridge. The highest point on Tinian is Mount Kastiyu on the south ridge at 614 feet (187 meters). To the northwest, the median (i.e., Makpo, also Marpo) valley, a low, broad depression that separates the southeastern ridge from the central plateau, reaches an altitude of about 150 feet (46 meters). The land surface intersects groundwater at a depression in the valley, forming the Makpo marsh. The north and west flanks of the median valley steeply slope to the central plateau (Gingerich and Yeatts 2000; USDA 1989) (see Figure 3).

The central plateau extends northward and comprises all of central and some of the northern part of Tinian. The central plateau is broad and gently sloping with principal relief along its boundaries with the median valley and northern lowland. The north-central highland rises within the northern part of the central plateau, midway between the east and west coasts. The highest point of the north-central highland at 545 feet (166 meters) is exceeded in height only on the southeastern ridge. The northern lowland generally is flat and about 100 feet (30 meters) in altitude except at Hagoi Lake where the elevation is near sea level (Gingerich and Yeatts 2000).

2.3 GEOLOGY

Volcanic rock forms the foundation of Tinian predominantly below sea level, and coralline limestone dominates the lithology above sea level comprising 98 percent of the surface exposures. The composition and natural porosity of coralline limestone usually cause high permeability, whereas the texture and poor sorting of the volcanic material usually cause low permeability. Faults transect the island throughout complicating the structure and permeability of the rock units (Gingerich and Yeatts 2000; USDA 1994).

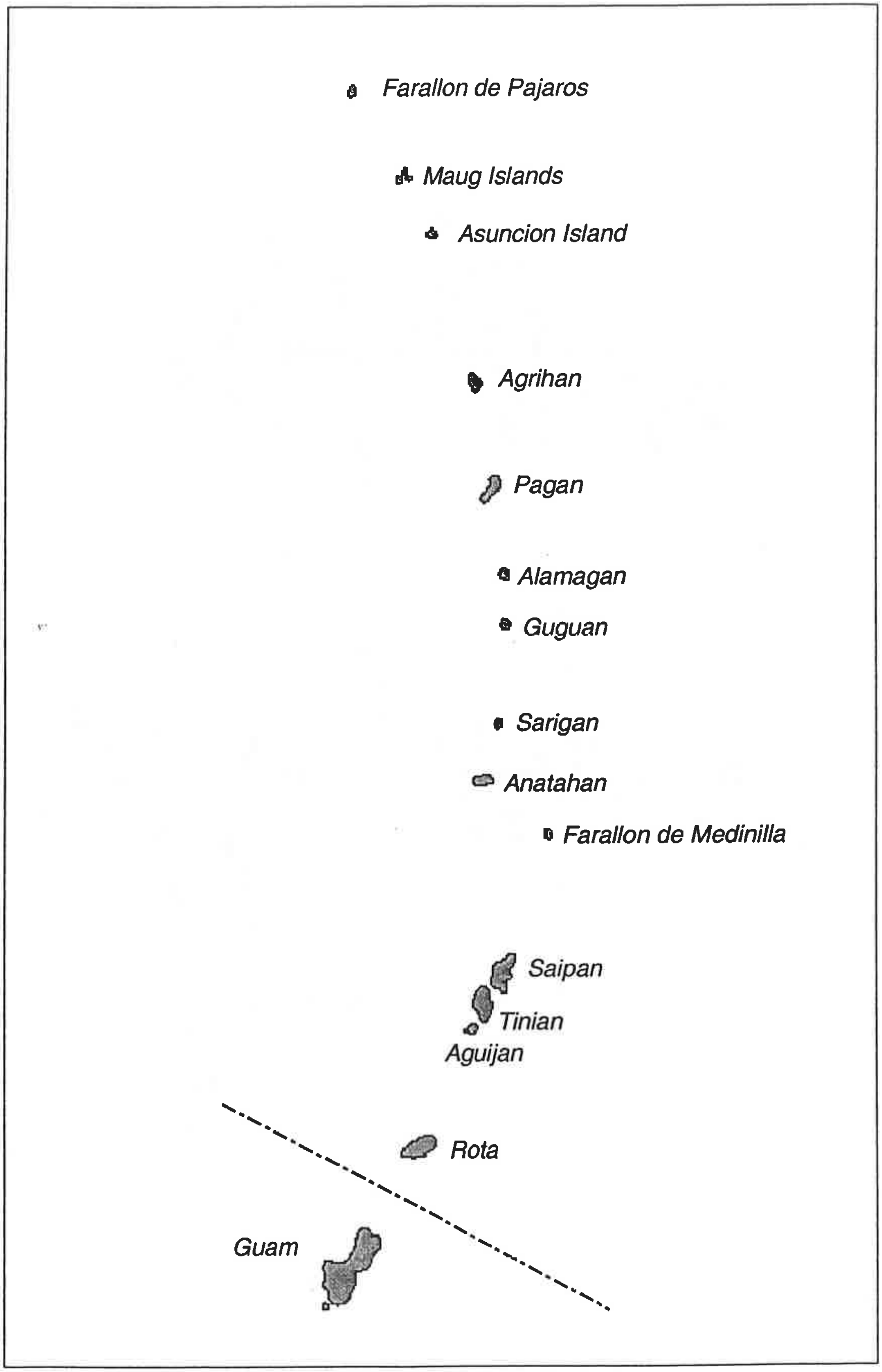


Figure 1: Commonwealth of the Northern Mariana Islands

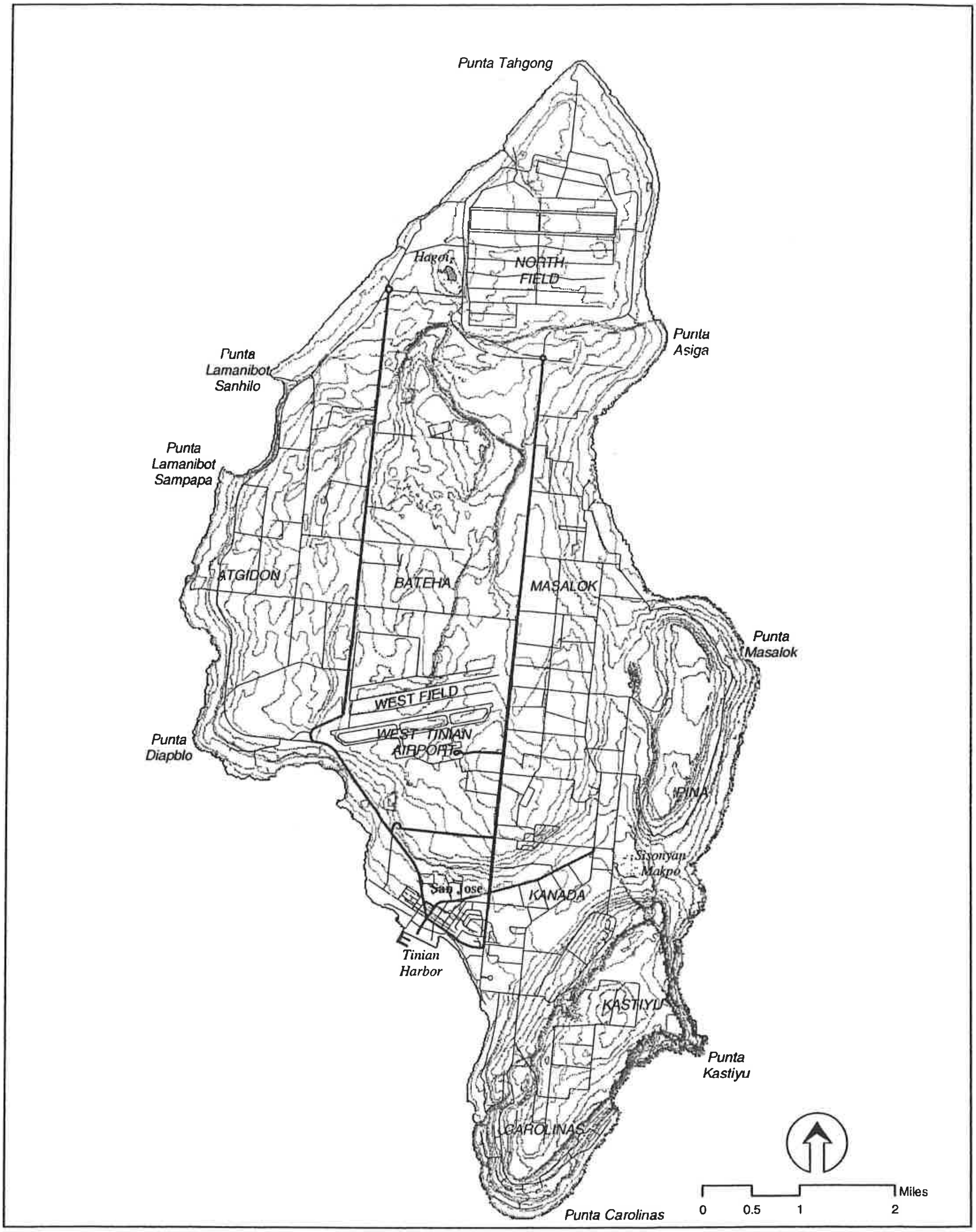


Figure 2: Tinian Island

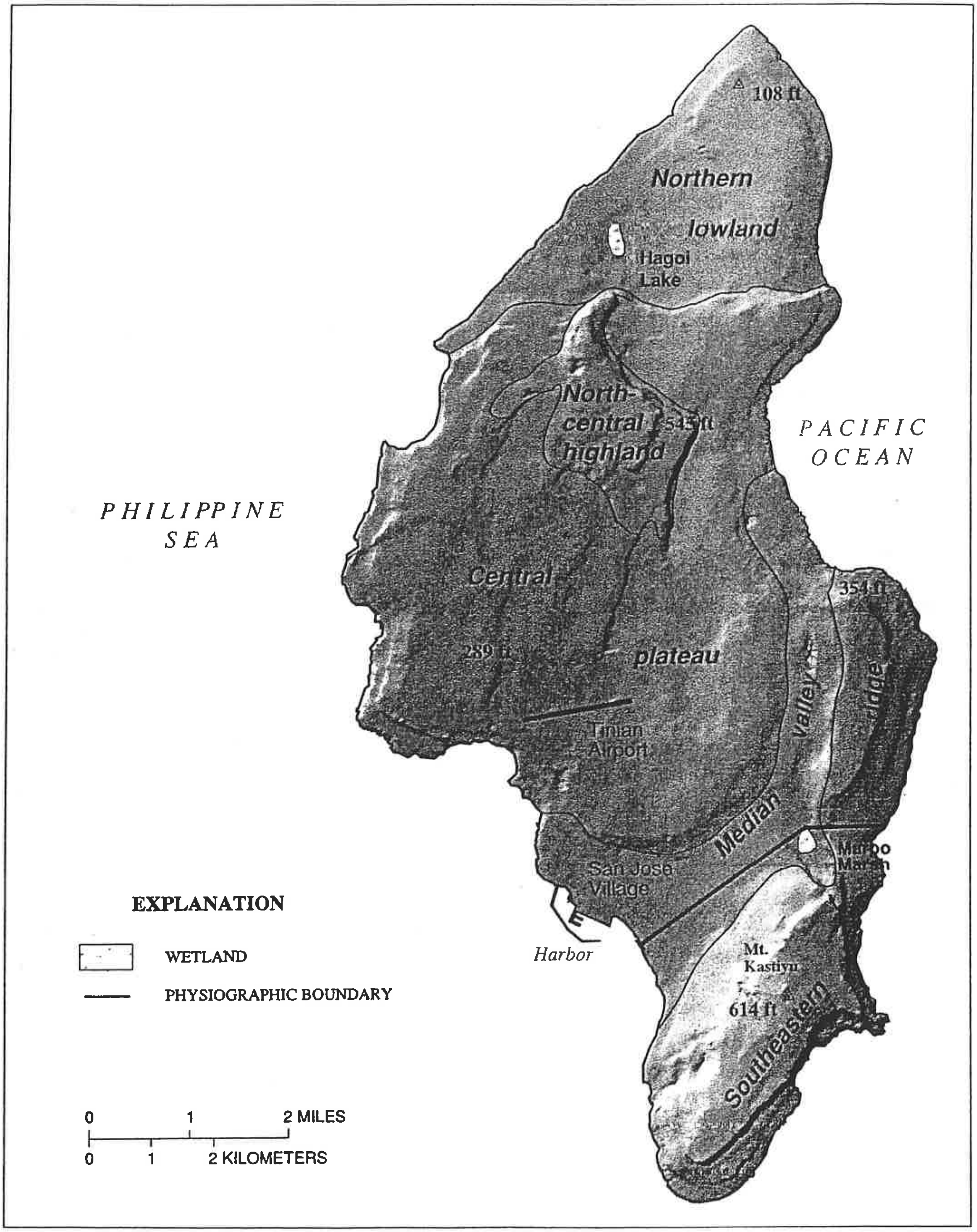


Figure 3: Tinian Island Physiography (from Gingerich and Yeatts 2000)

Four major geologic units make up the island (see Figure 4). Tinian Pyroclastic Rocks are the oldest exposed rocks of late Eocene age, and underlie all other exposed rock units (Doan and others 1960 in Gingerich and Yeatts 2000). This unit is exposed in the north-central highland and southeastern ridge and forms about 2 percent of the surface of the island. The thickness of the unit is unknown because the position of the base is undetermined. Tinian Pyroclastic Rocks consist of fine to coarse-grained consolidated ash and angular fragments of volcanic origin. Outcrops usually are high weathered and altered to clay (Gingerich and Yeatts 2000).

Tagpochau Limestone is of early Miocene age (Doan and others 1960 in Gingerich and Yeatts 2000). It is exposed on about 15 percent of the surface on Tinian, principally in the north-central highland and the south part of the southeaster ridge. The unit thickens from zero to at least 600 feet (183 meters) in all directions away from the surface exposures of Tinian Pyroclastic Rocks in the north-central highland and southeastern ridge. Tagpochau Limestone is composed of fine to coarse-grained, partially recrystallized broken limestone fragments, and about 5 percent reworked volcanic fragments and clays. Surface exposures are highly weathered (Gingerich and Yeatts 2000).

Mariana Limestone is of Pliocene to Pleistocene age and is the most extensive unit areally and volumetrically above sea level. It comprises about 80 percent of the surface area, forming nearly all of the northern lowlands, the central plateau, and the median valley. Mariana Limestone thickens from zero to at least 450 feet (137 meters) in all directions away from the surface exposures of Tinian Pyroclastic Rocks and Tagpochau Limestone. It is composed of fine to coarse-grained fragmented limestone, commonly coralliferous, with some fossil and algal remains, and lesser amounts of clay particles (Doan and others 1960 in Gingerich and Yeatts 2000). Small voids and caverns are common in surface exposures. Mariana Limestone differs from Tagpochau Limestone in its higher coral content and lesser incidence of recrystallization (Gingerich and Yeatts 2000).

Beach deposits, alluvium, and colluvium are of Pleistocene to Holocene age. These deposits cover less than 1 percent of the surface of Tinian, and may be as much as 15 feet (5 meters) thick. The deposits are composed of poorly consolidated sediments, mostly calcareous sand and gravel thrown onto beaches by wave action, but also clays and silts deposited inland beside Hagoi Lake and Makpo marsh, and loose soil and rock material deposited at the base of slopes, especially in the north-central highlands (Gingerich and Yeatts 2000).

High permeability favors the limestone units due to its porosity and high susceptibility to solution weathering. Pyroclastic rocks tend to exhibit low permeability due to poor sorting and high susceptibility of some volcanic minerals to chemical weathering and alteration to clay (Gingerich and Yeatts 2000).

Normal faults transect the island throughout, displacing rock units relative to one another by generally less than 100 feet (30 meters). The regional strike of the faults is oriented north-south, approximately parallel to the trend axis of the Mariana Arc. Faults in limestone rock exposed at the surface commonly show weathered gaps along the fault ranging from inches to feet in width, thus faults in limestone may represent narrow zones of relatively higher permeability than surrounding rock. Tinian Pyroclastic Rocks and Tagpochau Limestone are dissected by faults concealed by Mariana Limestone (Gingerich and Yeatts 2000).

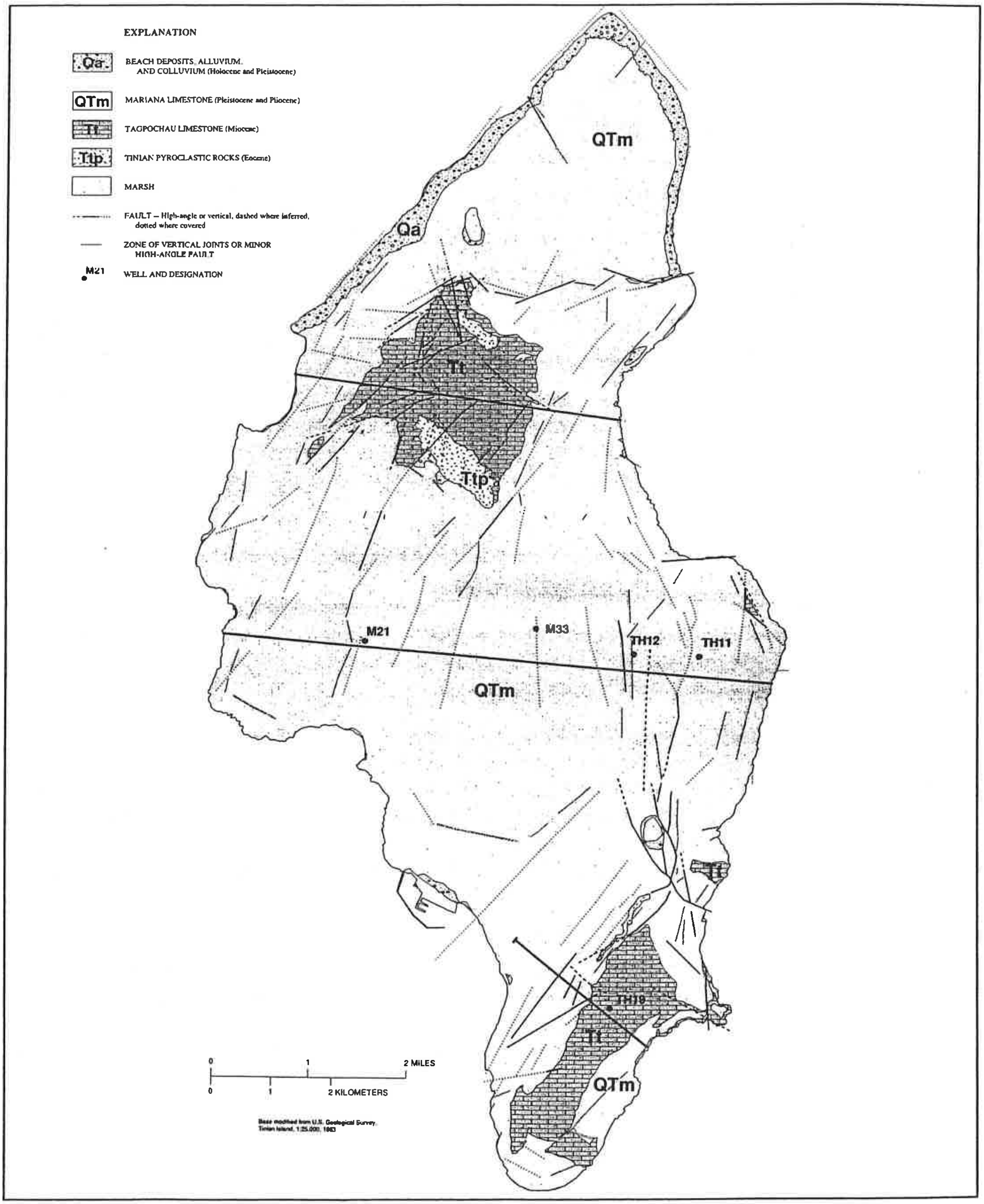


Figure 4: Tinian Island Geology (from Gingerich and Yeatts 2000)

2.4 HYDROLOGY

There are no perennial rivers or streams on Tinian and most non-torrential precipitation immediately evaporates or percolates into the substrata. Surface water nonetheless can be found at various locations on the island. The two largest surface water bodies are Hagoi Lake in the Puntan Tahgong Watershed along the northwestern edge of North Field, and Sisoyan Makpo (i.e., Makpo marsh) in the Makpo Watershed in the east-central portion of the median (Makpo) valley. Hagoi Lake, a fresh to brackish water body and the largest permanent wetland on Tinian, is located at the north end of the island. The area of open water may extend to 0.5 mile (0.8 kilometer) in length during the wet season, and decrease to a marsh with little open water during the dry season. Makpo marsh in the median valley is a wetland with a small area of shallow open water (Gingerich and Yeatts 2000; USDA 1994).

Tinian is underlain by a Ghyben-Herzberg lens of fresh water from which island inhabitants obtains their potable water. The water table reaches its highest points in the volcanic rocks that are above sea level. Groundwater flows from the north-central highlands and the southeastern ridge, where the water-table elevation is highest, towards the coast. Over most of the island, the water table is relatively flat and water levels are less than 2 feet above mean sea level. The freshwater lens beneath the median (Makpo) valley is thickest about 40 feet (12 meters)—in the interior of the island, thins slightly near the municipal well and Makpo marsh, and thins even more toward the coasts (Gingerich and Yeatts 2000; USDA 1994).

On Tinian, the shape of the water table can be used to infer directions and rates of groundwater flow as well as the movement of contaminants dissolved therein. Groundwater will flow from areas of higher water level to areas of lower water level, in directions roughly perpendicular to the water-table contours. It appears to move radially from the north-central highland and the southeastern ridge, and flows generally seaward. Drawdown from well pumping, however, diverts some of the seaward groundwater flow to wells (Gingerich and Yeatts 2000) (see Figure 5).

The Sisoyan Makpo wetland complex provides all the agricultural and domestic water supply for Tinian. Two hand-dug wells installed for sugar mill operations during the Japanese era still remain in the wetland with the larger well used as the main source of agricultural water. The domestic well is located approximately one-quarter of a mile north of the agricultural well and draws water from the same depression through a Maui-type well. Water quality and supply fluctuate during wet and dry seasons, and are highly susceptible to overdraft pumping and non-point-source contamination (USDA 1994).

2.5 BIOTA

Vegetation covering the island of Tinian consists of secondary introduced species dominated by hedge acacia or *tangantangan* (*Leucaena leucocephala*) mixed with Formosan koa or *sosugi* (*Acacia confusa*) and Siris tree or *trongkon-kalskas* (*Albizia lebbeck*). *Tangantangan* growth is extremely dense, forming large thickets in some areas particularly at the northern end of the island (USDA 1994).

Native limestone forest patches are restricted to benched or terraced areas isolated from disturbance by steep escarpments in the Kastiyu and Pina plateaus on the southeastern side of Tinian. These native forests are unique complexes of species composed of large and small trees, shrubs and understory species including *umumu* (*Pisonia grandis*), *pahong* (screw pine) and *kafu* (*Pandanus* sp.), *lemai* and *dukduk* (seedless and seeded breadfruit, respectively) (*Artocarpus* sp.), and *paipai* (*Guamia mariannae*).

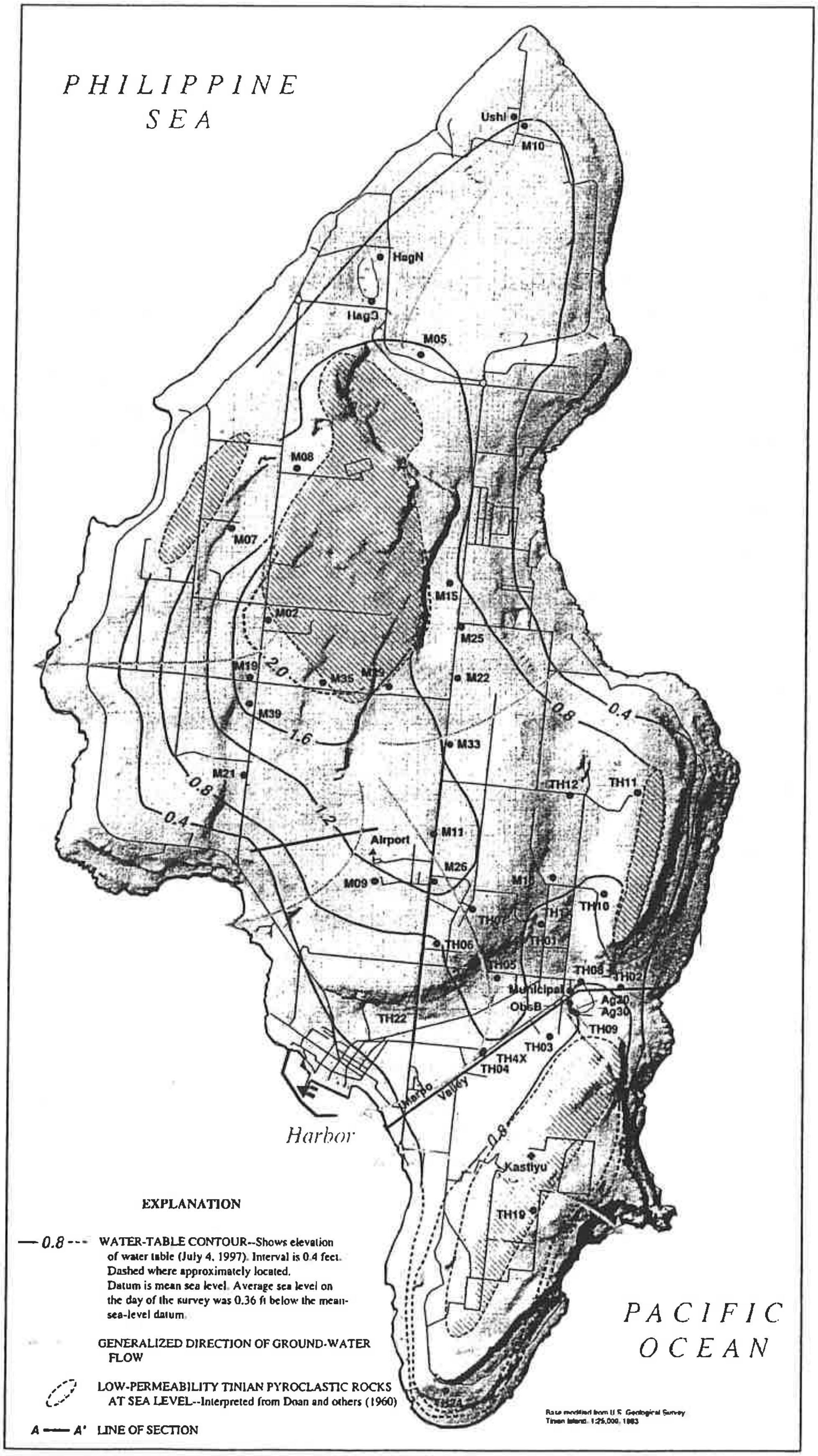


Figure 5: Tinian Island Hydrology

Coastal forest and beach strand vegetation consist of exotic, native, and rare endemic species including spurge (Euphorbiaceae fam.) (Raulerson and Rinehart 1991; USDA 1994; Wagner et al. 1990). None of the plant species on Tinian are listed as threatened or endangered by the CNMI or U.S. governments (USDA 1994).

Tinian's wildlife resources are limited by the degradation of forest habitat due to sugar cane cultivation, World War II activities, and a relatively long history of cattle grazing. Avifauna include the recently de-listed Tinian monarch or *chichirikan Tinian* (*Monarcha takatsukasae*), rufous fantail or *chichirika* (*Rhipidura ruffifrons*), and bridled white-eye or *nosa* (*Zosterops conspicillatas saypani*). The federally and locally listed Marianas common moorhen or *pulattat* (*Gallinula chloropus guami*) is consistently found at Hagoi Lake. Native forest birds include the Mariana fruit dove or *totot* (*Ptilinopus roseicapilla*), white-throated ground dove (*Gallicolumba xanthonura*), Micronesian starling or *sali* (*Aplonis opaca*), collared kingfisher or *sihek* (*Halcyon chloris*), cardinal honeyeater or *egigi* (*Myzomela cardinalis saffordi*), and yellow bittern or *kakkak* (*Ixobrychus sinensis*). The introduced Eurasian tree sparrow or *ga'ga'pale'* (*Passer montanus*) and Philippine turtle dove (*Streptopelia bitorguata*) are well established on Tinian (USDA 1994).

Low numbers of the Mariana fruit bat or *fanihi* (*Pteropus mariannus*) may be seen on Tinian. A gecko (*Perochirus ateles*) is on the CNMI endangered species list and a skink (*Emoia slevini*) is listed as a species of concern by the U.S. Fish and Wildlife Service. The coconut crab (*Birgus latro*) is traditionally hunted on Tinian and its numbers have declined somewhat in recent years. The green sea turtle (*Chelonia mydas*), a federally listed species, reportedly nests on several of Tinian's beaches (USDA 1994).

Hagoi Lake received protection from disturbance because it is a wetland, but it has not been designated as a conservation area (USDA 1994). Land near the Makpo wetland and along the cliff line to the south to Suicide Cliff had been proposed for designation as a conservation area under a long-term lease but said lands were returned to the public domain in May 2004. To date, the only officially designated conservation area on Tinian is the marine environment along the island's west coast from Lasarino to Puntan Diablo (Deputy Commissioner, Tinian 2004).

2.6 POPULATION AND LAND USE

Tinian and the Mariana Islands in general have undergone significant change since the first western contact by Ferdinand Magellan in 1521. During the pre-contact period, Tinian sustained an estimated population of 10,000 inhabitants. The island experienced minimal western influence until 1698 when the Spanish administration began relocating the native population from the Northern Marianas Island to Guam. By 1742, there were no permanent inhabitants on Tinian which the Spanish managed as a game preserve using a transient population to regularly harvest feral cattle and pigs for exportation to Guam. At the end of the Spanish era in 1898, there were a total of 95 people on Tinian most of whom were Carolinian. During German administration from 1898 until the outbreak of World War I in 1914, Tinian continued to be used primarily for cattle grazing, and the human population remained at no more than a hundred individuals (Stewart no date 1; Bowers 1950 and Farrell 1989 in USDA 1994).

Nanyo Kohatsu Kabushiki Kaisha, a Japanese government-affiliated company, leased the entire island of Tinian in 1926 for sugar cane cultivation, this following the commencement of Japan's administration of the Mariana Islands in 1919 as mandated by the League of Nations. By 1935, over 14,000 Japanese resided on Tinian (Boehm 1995; Stewart no date 2; USDA 1994).

The invasion of Tinian by U.S. armed forces in July 1944 drastically changed the island's population and land use. By early 1945, as many as 150,000 U.S. military personnel were based on Tinian. Nearly 40 water wells were drilled with 30 wells withdrawing an estimated 2.3 million gallons per day. By September 1945, approximately 371 acres (150 hectares) adjacent to Tinian Harbor and inland along Makpo Valley were used for agricultural purposes to help support the food needs of on-island military personnel (USDA 1994).

Tinian's resident population grew from 364 in 1949 to 800 in 1960, 866 in 1980, 2,118 in 1990, and 2,631 in 1995. Results of the 2000 census of population and housing within Tinian Municipality reveal an on-island resident population of 3,540. Total households number 790 and the average size per household is 3.62 individuals. The average family size is 4.34 individuals and the average family household size is 4.69 individuals (OEDPC 1997; USDA 1994; USDC 2003).

The population of Tinian resides in a rural setting located in the median valley and parts of the adjacent central plateau and southeastern ridge, occupying about 25 percent of the island (Baldwin 1995 in Gingerich and Yeatts 2000). Most public and residential land use activities take place in this area. Public land accounts for about 60 percent of the rural area and land use includes an airport, a harbor, schools, a cemetery, agricultural cooperatives, Makpo marsh, parks and beaches, and unused grassland and secondary forest. Residential and commercial land covers about 40 percent of the rural area and land use includes a casino resort, small businesses, farming, grazing, and housing. The single village of San Jose is located on a southwestern exposure beside a deepwater harbor (Gingerich and Yeatts 2000).

About 75 percent of the island is grassland and secondary forest supporting minor land use activities. About 40 percent of the grassland is reserved exclusively for military use (i.e., Exclusive Military Use Area) in the northern part of the island, except for a U.S. Information Agency radio station operating in the southwestern part of this area. Military activities usually consist of occasional military exercises. About 60 percent of the remaining grassland and secondary forest, mostly on the central plateau and southeastern ridge, is used for scattered grazing of cattle and horses (Gingerich and Yeatts 2000) (see Figure 6).

Prime farmlands as defined by the U.S. Department of Agriculture are soils best suited to producing food, seed, forge, fiber, and oilseed crops. These soils produce the highest yields with minimal energy input and economic resources, and results in the least damage to the environment. Less than four percent of the soils in the CNMI are classed as prime farmland. The three soil types that meet the criteria for this classification are Dandan-Saipan clay, 0 to 5 percent slopes; Kagman clay, 0 to 5 percent slopes; and Saipan clay, 0 to 5 percent slopes. Of the 3,355 acres (1,358 hectares) of prime farmland in the CNMI, about 1,547 acres (626 hectares) are located on Tinian primarily on the Carolinas plateau and in the central and western parts of the northern plateau (USDA 1994).

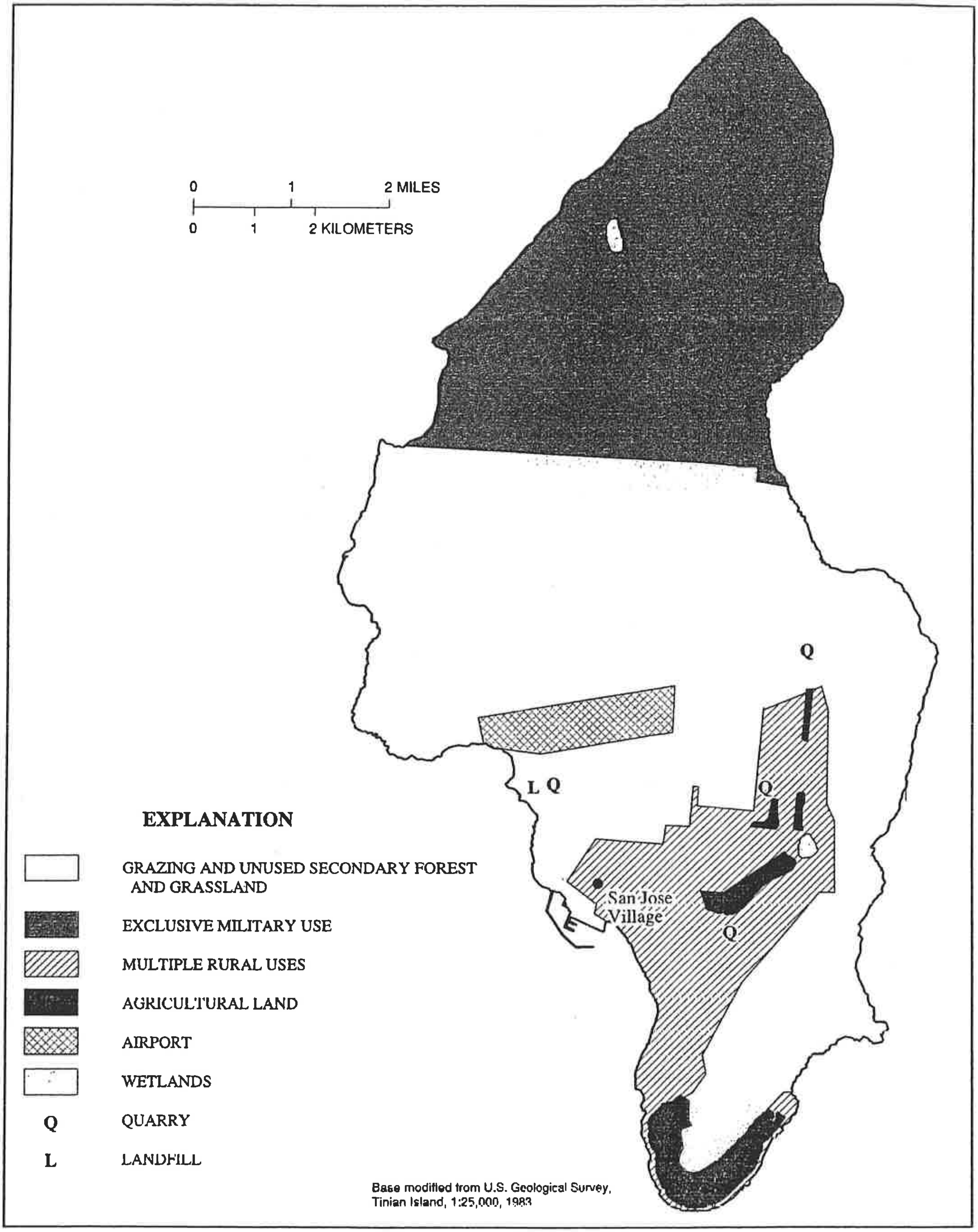


Figure 6: Tinian Island Land Use (from Gingerich and Yeatts 2000)

With substantial new farm land available for leaseback in the Exclusive Military Use Area and emergence of its casino industry, Tinian Municipality plans to revitalize its agriculture industry. The municipality's first priority is to provide commercial farmers with an adequate and efficient water irrigation system extending directly to each individual farm—the majority of which are located in Makpo Valley—to reduce the cost of starting or expanding existing farms, increase crop productivity, and increase farm profitability (OEDPC 1997).

Over 7,500 acres (3,035 hectares) in the Exclusive Military Use Area is available for cattle grazing. A Tinian Rancher's Water Reserve Project seeks to open an existing well centrally located in the northeast section of the island and construct a 50,000-gallon storage tank to provide water to areal ranchers and relieve them of the need to transport as much as 6,000 gallons daily from Makpo Valley (OEDPC 1997).

All solid waste, including toxic materials and sewage from holding tanks, is dumped at an open dump located at the west end of the island. Tinian presently has no sewer facility and all residences and businesses use septic and seepage tanks, leaching fields, or holding tanks to dispose of sewage.

3.1. GENERAL

Solid waste generation is a function of numerous factors, including permanent resident population; transient (e.g., tourist) population; types and quantity of agriculture, commercial businesses, and industrial facilities; location; climate; and fuel use. Even with recycling, the quantity of waste often tends to grow along with an expanding population. The quantity and types of wastes that are expected in the future will in turn affect decisions about solid waste management, e.g., what type of waste disposal facilities to construct, their size, their location, their distribution around the island to serve various communities, etc.

3.2 WASTE VOLUME ESTIMATES

A reasonably accurate estimate of future waste generation can generally be developed using historical waste tonnage records combined with population projections based on census data. However, waste records were not available for Tinian, as waste is not weighed before it is placed in the extant dump. Therefore, the current waste disposal rate for Saipan (i.e., 4.06 pounds per person per day) was used as a reasonable proxy for actual waste records from Tinian (Hiney pers. comm.). This number is not dissimilar to the historical rate of waste generation (i.e., without considering the effects of recycling) in the United States (Freudemich 2004). Because Tinian has relatively few commercial and industrial waste generators, it is not surprising that it would generate waste as if it were comprised merely of residences.

Table 1 lists the projected resident, transient, and visitor population, waste generation in tons per year, and cumulative waste generation in 5-year increments over the initial 30-year planning period (i.e., 2005 to 2035). These projections assume that the current per capita waste generation rate of 4.06 pounds per person per day will remain constant, and that the resident, transient, and visitor populations on Tinian will grow an average of 5 percent each year.

Census data for the year 2000 show Tinian's population as 3,540 "permanent" residents. The estimated 2005 baseline population of 4,518 in Table 1 represents a 5 percent per annum growth rate since 2000.

The construction and operation of existing and future tourist facilities such as casinos and hotels will increase the "transient" population consisting of non-resident workers. This transient population is not measured by the census, and other available data do not quantify the number of non-resident workers on Tinian at any particular point in time. However, Department of Labor and Immigration records report 2,557 work permits were issued to non-resident hotel workers in the CNMI in 2002 (CNMI Department of Commerce 2004). Assuming one-third of that work force were employed and living on Tinian at the time, and that number grew by 5 percent each year, the island would realize a transient population of about 1,000 by 2005.

There were reportedly about 60,000 visitors to Tinian in 2004 (Hofschneider pers. comm.). It is assumed herein that the visitor count is 63,000 in 2005 (i.e., 5 percent growth from 2004), and the average visitor stay is 3 days.

3.3 OTHER CONSIDERATIONS

The solid waste projections discussed herein assume that even if commercial, industrial, and tourist businesses expand on Tinian, the additional waste they generate will be accounted for by the growing resident and transient (tourist) population already included in the estimate. It is believed that agriculture activities will expand on Tinian. However, there is no regulatory requirement for agricultural wastes to be disposed in a landfill designed for solid waste. Plant wastes can generally be disposed on-site (i.e., on farmland) unless the wastes cause water pollution, odors, or other nuisances. The same holds true for manure from grazing animals. Without a regulatory requirement for agricultural wastes to be disposed in a landfill, it will probably be economically advantageous for farms or other agri-business to dispose their agricultural wastes on-site. Thus, agricultural wastes will probably not significantly affect the solid waste projections of this study.

Predicting the distant future is by no means an exact science. Therefore, the landfill and transfer station considered in this document should be planned and constructed with sufficient capacity to handle waste stream growth, or with the ability to be expanded economically.

Table 1: Population and Waste Generation Projections, Tinian, CNMI

Year	Years After Landfill Opens	Growth Rate (%)[1]	Forecast Resident Population	Forecast Transient Population[2]	Forecast Visitor Population[3]	Waste Generated (Tons/Year)[4]	Tons in Previous 5-Year Period	Cumulative Waste Generated (Tons)
1980			*866*			*642*		
1990		*9.35*	*2,118*			*1,569*		
2000		*5.27*	*3,540*	*884*		*2,623*		
2005	0	5.00	4,518	1,000	63,000	4,472		
2010	5	5.00	5,766	1,276	80,406	5,708	25,450	25,450
2015	10	5.00	7,359	1,629	102,620	7,285	32,482	57,932
2020	15	5.00	9,393	2,079	130,972	9,298	41,456	99,388
2025	20	5.00	11,988	2,653	167,158	11,866	52,909	152,297
2030	25	5.00	15,300	3,386	213,340	15,145	67,527	219,825
2035	30	5.00	19,527	4,322	272,282	19,329	86,184	306,008

Actual statistics are italicized
[1] Assumes a 5 percent annual resident, transient, and visitor population growth rate
[2] Non-resident workers
[3] Average per person stay of 3 days
[4] Constant waste generation rate of 4.06 pounds per person per day (equal to Saipan's 2003 rate)

3.4 EFFECTS OF RECYCLING ON TINIAN

Recycling on Tinian is currently limited by a number of factors. First, the island has a small population, and the quantity of recyclables generated is extremely small by global standards. Second, there are no local industries that would use large quantities of recyclables such as cardboard, newspaper, or

aluminum cans as a raw material. Thus, there is unlikely to be a local buyer that would make it economically attractive to remove these recyclables from the waste stream. Third, because of high shipping costs, it is difficult to profitably export recyclables to remote markets overseas. Lastly, the market value of recyclables fluctuates dramatically, making it a challenging and risky business even in large cities located near markets. Because these factors are not expected to drastically improve the economics of recycling on Tinian in the next 30 years, recycling on the island is not expected to grow significantly.
Currently Saipan has an effective recycling program and bales recyclables for export. Saipan's program includes significant effort to maintain a high quality recyclable product. As such the island continues to be able to export the recyclables to market. Assuming residents of Tinian are interested in having and paying the cost for a recycling program, a cooperative program working in conjunction with Saipan would be the most likely to succeed.

One area of recycling that would increase landfill life and could reduce overall cost would be the development of a composting green waste program. This can reduce the total volume of waste requiring disposal by 10 to 20 percent. In rural areas, as would be the case for Tinian, both home (residential) and centralized programs would be feasible. As described below in section 3.5.3, a wood waste/woody debris staging area could be included in the landfill operation. This would include both a location for unloading green waste including any woody debris free from contamination, and a mulch and compost storage area.

In Tinian's case, landfilling is surmised to be the only available disposal method. That is, the amount of solid waste that would be disposed in an on-island landfill is equal to the amount generated minus the amount recycled. Because recycling is not expected to grow significantly faster than waste generation, it should not appreciably decrease the amount of waste placed in the landfill. However, the waste generation numbers in Table 1 are conservative in that they assume only a small amount of recycling. In essence, Table 1 may over estimate the amount of waste to be disposed in a landfill as additional recycling would decrease the quantities shown.

4.1 GENERAL

The current site being used for disposal of municipal solid waste on Tinian is located less than one mile north of San Jose and west of 8th Avenue. It is also located less than 3,000 feet southwest of the West Tinian Airport runway (see Figure 7).

The existing dump was not designed as a municipal solid waste landfill and has no environmental protection or features associated with a modern landfill. The disposal site is being operated as an open burning dump. There is a concrete platform located along the west edge of 8th Avenue where municipal solid waste is dumped into an open area several feet below the platform. When the waste reaches a level that makes unloading difficult, a bulldozer is used to push the waste away from the unloading area. It appears waste has been spread in a half circle away from 8th Avenue and no consistent effort has been made to provide soil cover over the waste. Additionally, it was reported that waste pile burning has occurred on a regular basis. There are no fences to limit access or control litter.

Municipal solid waste provides food and harborage for rodents, birds and flies, which are capable of transmitting these disease organisms to humans and animals. There is also the potential for environmental degradation of the soil, surface and groundwater, air, and vegetation. Two other significant human risks associated with the open dump are its proximity to West Tinian Airport and injury associated with the lack of physical barriers and uncontrolled access. Having the dump located very near the airport runways presents a bird hazard for aircraft and its occupants. The concrete platform lacks a barricade to prevent individuals from falling or vehicles from rolling off. An uncontrolled open dump is also an attractive nuisance where individuals can sustain injury while scavenging.

4.2 CLOSURE ALTERNATIVES

The existing Tinian dump is needed to remain in service until an alternative disposal system is available. Alternatives for closure of the existing site are presented below and include grading and capping, and relocation of the waste. Grading and capping follows the U.S. Environmental Protection Agency (EPA) standards for a municipal solid waste landfill and present an alternative closure using a soil only cap. Conceptual construction details are described in succeeding sections.

As an option, the community may desire to evaluate the feasibility of relocating solid waste at the existing open dump to a new landfill site on Tinian. Alternatives include mass relocation of the waste and associated other materials existing at the current dump site, and processing or screening of the waste prior to disposal. Both relocation options would result in the need to construct a significantly larger first landfill cell than that described in Section 7.

Entire relocation of old dumps is rarely performed, and is particularly difficult in wet areas. Prior to undertaking relocation, detailed investigations of the existing dump would be appropriate. This would include a detailed subsurface investigation over the entire area to determine the lateral and vertical extent of waste at the site as well as its composition. This work would typically be undertaken in accordance with appropriate health and safety precautions. Both site investigation and waste relocation are often expensive and difficult to estimate because of the unexpected nature of the filling method and waste disposed at the site. This method, however, would preclude post-closure monitoring and maintenance.

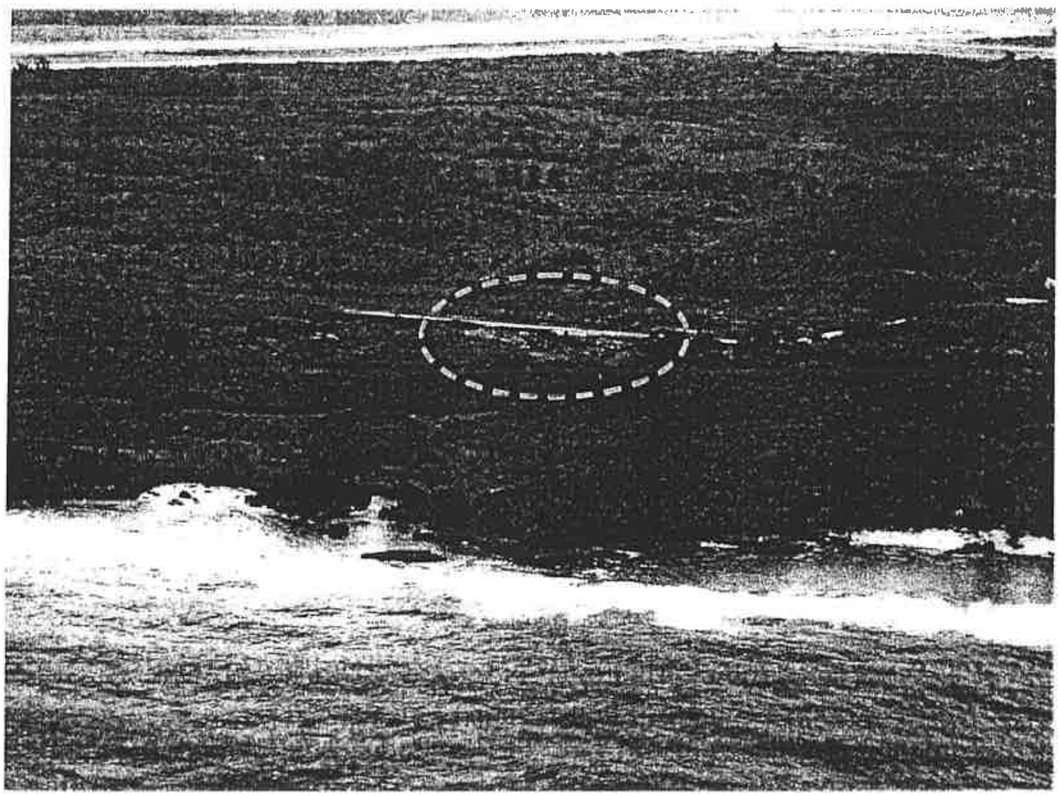


Figure 7: Tinian Island Open Dump

Landfill mining or excavation and processing of solid waste for relocation to a new landfill have been used on occasion. This typically involves excavating and processing the waste using a screening mechanism to separate soil from trash. The soil would be left at the site, stockpiled, or removed for construction/demolition (C/D) disposal. C/D disposal usually costs much less per unit volume than disposal at a municipal solid waste landfill.

4.2.1 Relocation Quantity Estimates

In order to estimate the amount of waste present at the existing site (see Table 2 below), historic population and assumed waste generation rates—as shown previously in Table 1—were adjusted for decomposition and density. The population in 1970 was assumed to be similar to the population in 1980 and actual population counts for 1980, 1990, and 2000 were used. Also, to forecast current waste generation, a 5 percent per year increase from 2000 to 2005 was used. Using these assumptions, a cumulative amount of refuse currently present at the existing dump was estimated. The total was subsequently reduced based on waste decomposition.

Decomposable materials (i.e., organics including food waste, yard wastes, and paper) typically comprise between 40 and 70 percent of the waste stream in areas that do not have separately collected yard wastes and recyclable paper. Additionally, urban areas contain less decomposable waste than rural areas. Because waste composition values were not available for Tinian, a conservative value of 50 percent of the waste disposed was assumed to be decomposable.

The decomposition rate of organic material is a function of available nutrients, water, temperature, oxygen, and mixing. A warm, wet environment with sufficient oxygen decomposes comparatively rapidly (e.g., landfills in Florida have shown nearly complete decomposition of organics in approximately 15 years) while an arid lined landfill lacking oxygen would decompose very slow, taking decades to break down organics. As a conservative assumption, this study assumes a 25-year rate of decomposition for Tinian (i.e., 4 percent a year).

As described above in Section 4.1, it was reported that waste pile burning has occurred on a regular basis. Regular burning of the disposed refuse would greatly reduce the waste volume and tonnage at the existing dump. If open burning has occurred on a regular basis then a significant portion of the organic and other combustible wastes that do not decompose well (e.g., plastics, lumber, synthetics) will have been transformed to ash and particulates. The extent of volume and weight reduction could reduce the total amount of material requiring relocation by over 50 percent.

While the alternative for waste relocation has been evaluated, it would constitute a significant additional cost above site closure. In addition, to excavating, loading, and hauling the existing waste, it would require a significant enlargement of the proposed first new landfill cell on the order of 50 to 100 percent to accommodate refuse from the existing dump. For the purpose of this study, normal dump closure has been assumed using federal Resource Conservation and Recovery Act (RCRA) Subtitle D closure requirements.

Table 2: Estimated Waste Volume at the Existing Tinian Open Dump

Year	Population	Waste Generated (Tons)	Cumulative Waste Disposed	Organics (50%)	Decomposition (%)	Decomposition (Tons)	Waste Remaining (Tons)
1970	866	640	---	---	---	---	---
1980	866	640	6,400	3,200	100	3,200	3,200
1990	2,118	1,570	11,100	5,550	60	3,300	7,800
2000	3,540	2,600	21,000	10,500	20	2,100	19,000
2005	4,518	3,700	16,000	8,000	0	0	16,000
Cumulative Waste Remaining at Dump (Tons)							45,000
Cumulative Waste Remaining at Dump (CY)							150,000

1. Decomposable (organic) portion of the waste estimated to be 50 percent of the total waste deposited.
2. Decomposition of organics estimated to be 4 percent per year.
3. Conversion from cubic yards to tons assumes waste density of 600 pounds per cubic yard.
4. Assumes no reduction of volume or tonnage due to open burning of waste.
5. CY = cubic yards.

4.3 PROPOSED APPROACH

Normal open dump closure activities include planning, permitting, design and construction, post-closure monitoring, and maintenance. During the planning phase, potential or proposed land uses are studied and evaluated; in the case of the Tinian open dump, conversion of the site into a golf course is already being considered. This typically includes analysis of settlement, collection and disposal of methane gas generated in the waste mass, maintenance of an impermeable cover between the waste and the turf, irrigation and drainage, slopes, and the ability to monitor the site.

One alternative is for the existing dump to remain open until a new landfill can be constructed, or if interim or permanent off-island disposal can be arranged. The latter two scenarios would require the construction and operation of a solid waste transfer station which is addressed below in section 5.

Partial closure could be started immediately by the Municipality of Tinian as a means of preparing the open dump for final closure. Steps would include identifying the recommended shape and size of the area to be closed. Since waste has been spread in a fairly thin layer around the area, it may be possible using existing earthmoving equipment at the site to create a mound of waste and soil and reduce the area requiring capping during final closure.

4.4 FINAL CLOSURE

When the existing dump is able to stop accepting solid waste, the first step should be to restrict access with fencing and posted signs site to minimize continued dumping. Typically, it is difficult to halt unauthorized dumping at a site that is in the process of being closed. Signs should direct customers to new facilities and include the threat of prosecution for illegal dumping.

Actual closure construction would include delineating the area to cap, identifying an acceptable on-site or on-island source of capping soil within a reasonable haul distance, installing the final cover, and establishing a vegetative cover. Among other requirements, RCRA Subtitle D regulations specify that the final cover restrict the infiltration of rain water into the waste unit and be maintained for a period of 30 years. The site must also be graded to divert surface water from entering the capped area.

Specific cover systems are defined in RCRA Subtitle D regulations and would ordinarily include a membrane (e.g., 60-mil high-density polyethylene [HDPE]) or a 2-foot-thick layer of impermeable clay soil. Because of the site's remote nature, the Municipality of Tinian may choose to apply for a waiver from the standard membrane/impermeable soil capping system. A possible alternate cover would be to use several feet of native soil instead of a membrane cap. Using an evapotranspiration cover with 7 to 10 feet of soil cover would effectively limit leachate generation and allow for landfill gas to escape without needing a separate gas collection system. This alternate would facilitate long-term maintenance and care of the site. By comparison, a membrane cap would require routine maintenance to prevent or repair damage to the HDPE sheeting.

Based on the apparent condition of the waste, the lack of soil cover, frequent fires, rural nature of the waste generated, and tropical climate, it is probable that most of the waste readily decomposes. Also, in the process of reducing the area requiring cover, a significant amount of soil in the area would be mixed with the waste. These factors combined with the small volume of total waste generated lend credence to consideration of alternate closure systems.

Selecting the type of cap to be installed should also consider the proposed end-use of the site. If the area is developed as a recreational site with regular human access to the capped waste, then a conventional approach (e.g., membrane cap with gas collection system) would be appropriate.

4.5 OPEN DUMP CLOSURE COST

Approximate costs for closure of the existing open dump on Tinian Island are presented in Tables 3 to 5. They represent three alternatives, i.e., closure in place, excavating the waste and hauling it to a new on-island landfill, and excavating then processing the waste prior to hauling it to a new landfill. Flow charts that follow summarize the overall closure process along with approximate time frames during which each step could be completed. Though its accuracy is approximately plus or minus 25 percent, the cost margin may increase or decrease based on final design parameters.

Table 3: Open Dump Closure Cost Estimate – Capping

ITEM	Quantity	Unit	Unit Price	Price (rounded)	Category Subtotal
Site Work					
Landfill Site Access Road (from 8th Ave.)	3,000	SY	$15	$45,000	
Site Clearing	6	Acre	$10,000	$60,000	
Entrance Gate, Signs and Chain Link	500	LF	$18	$9,000	
Perimeter Site Fencing (5-strand barbwire)	1,000	LF	$6	$6,000	
Ditches & Culverts	1,500	LF	$3.00	$4,500	
Storm Detention Pond	1	LS	$5,000	$5,000	
Excavate Area for Filling (350 feet X 350 feet)	7,000	CY	$2.00	$14,000	
Move Existing Waste to Area for Capping	40,000	CY	$2.00	$80,000	
Seed Cap with Local Grasses	2.50	Acre	$5,000	$12,500	
Install Monitoring Wells	3	Each	$10,000	$30,000	
Mobilization				$32,000	$298,000
Capping System – Liner					
Install 2 feet Soil for Liner (Grade/Compact)	7,000	CY	$2	$14,000	
Liner/Geotextile Anchor Trench	1,500	LF	$4	$6,000	
Geotextile Cushion (16-ounce)	11,500	SY	$2	$23,000	
High Density Polyethylene Liner (60-mil)	11,500	SY	$6	$69,000	
Strip Drains (every 100 feet)	1,000	LF	$7	$7,000	
Cover Soil 2.5 feet over Liner	8,500	CY	$8	$68,000	$187,000
CONSTRUCTION SUBTOTAL					**$485,000**
Agency Notification, Consultation	1	%		$5,000	
Geotech, Survey, Other Studies	7	%		$34,000	
Engineering Design	8	%		$39,000	
Permits	1	%		$5,000	
SERVICES SUBTOTAL					**$83,000**
Contingency	20	%			**$114,000**
CAPPING TOTAL					**$682,000**
Alternate Capping System – Soil Cover					
Install 10-foot Soil Cover (Grade/Compact)	36,000	CY	$4	$144,000	
Post-Closure Maintenance (Annual)					
Repair Soil Cover (Grade/Compact)	1,500	CY	$2.00	$3,000	
Geotextile Cushion (16-ounce)	2,000	SY	$2.00	$4,000	
High Density Polyethylene Liner (60-mil)	2,000	SY	$6.00	$12,000	
Strip Drains (Every 100 feet)	125	LF	$8.00	$1,000	
Seed Cap with Local Grasses	0.50	Acres	$5,000	$2,500	
Mobilization & Contracting	1	LS	$5,500	$5,500	
Environmental Monitoring & Reporting	1	LS	$25,000	$25,000	
ANNUAL MAINTENANCE TOTAL					**$53,000**

CY = cubic yards
LF = linear feet
SY = square yards

Table 4: Open Dump Closure Cost Estimate – Excavate and Dispose

ITEM	Quantity	Unit	Unit Price	Price (rounded)	Category Subtotal
Site Work					
Temporary Access Road (from 8th Ave.)	800	SY	$10	$8,000	
Entrance Gate, Signs and Chain Link	500	LF	$18	$9,000	
Load & Haul Existing Waste to New Landfill	150,000	CY	$5	$750,000	
Cost of Landfill Space	150,000	CY	$10	$1,500,000	
Grade and Contour Existing Dump Site	6	Acre	$10,000	$60,000	
Seed Cap with Local Grasses	6	Acre	$5,000	$30,000	
CONSTRUCTION SUBTOTAL					**$2,357,000**
Agency Notification, Consultation	1	%		$24,000	
Geotech, Survey, Other Studies	7	%		$165,000	
Engineering Design	8	%		$189,000	
Permits	1	%		$24,000	
SERVICES SUBTOTAL					**$402,000**
Contingency	20	%			**$552,000**
EXCAVATE/DISPOSE TOTAL					**$3,311,000**

CY = cubic yards
LF = linear feet
SY = square yards

Table 5: Open Dump Closure Cost Estimate – Excavate, Process, and Dispose

ITEM	Quantity	Unit	Unit Price	Price (rounded)	Category Subtotal
Site Work					
Temporary Access Road (from 8th Ave.)	800	SY	$10	$8,000	
Entrance Gate, Signs and Chain Link	500	LF	$18	$9,000	
Site Clearing	6	Acre	$10,000	$60,000	
Move Existing Waste to Processing Area	150,000	CY	$2	$300,000	
Screening Existing Waste	150,000	CY	$3	$450,000	
Hauling Waste to New Landfill	60,000	CY	$5	$300,000	
Cost of Landfill Space	60,000	CY	$10	$600,000	
Grade and Contour Existing Dump Site	6	Acre	$10,000	$60,000	
Seed Cap with Local Grasses	6	Acre	$5,000	$30,000	$1,817,000
CONSTRUCTION SUBTOTAL					**$1,817,000**
Agency Notification, Consultation	1	%		$18,000	
Geotech, Survey, Other Studies	7	%		$127,000	
Engineering Design	8	%		$145,000	
Permits	1	%		$18,000	
SERVICES SUBTOTAL					**$308,000**
Contingency	20	%			**$425,000**
EXCAVATE/PROCESS/DISPOSE TOTAL					**$2,550,000**

CY = cubic yards
LF = linear feet
SY = square yards

OPEN DUMP CLOSURE PROCESS – CAPPING

Agency Notification/Consultation

Approximate Duration: 3-6 Months
Approximate Cost: $6,000

Studies
Geotechnical, Topography, etc.

Approximate Duration: 6-12 Months
Approximate Cost: $41,000

Design
(Preliminary & Final Design, Cost Estimates, etc.)

Approximate Duration:3-6 Months
Approximate Cost: $47,000

Permits/Reviews
Building, Earth Moving, etc.

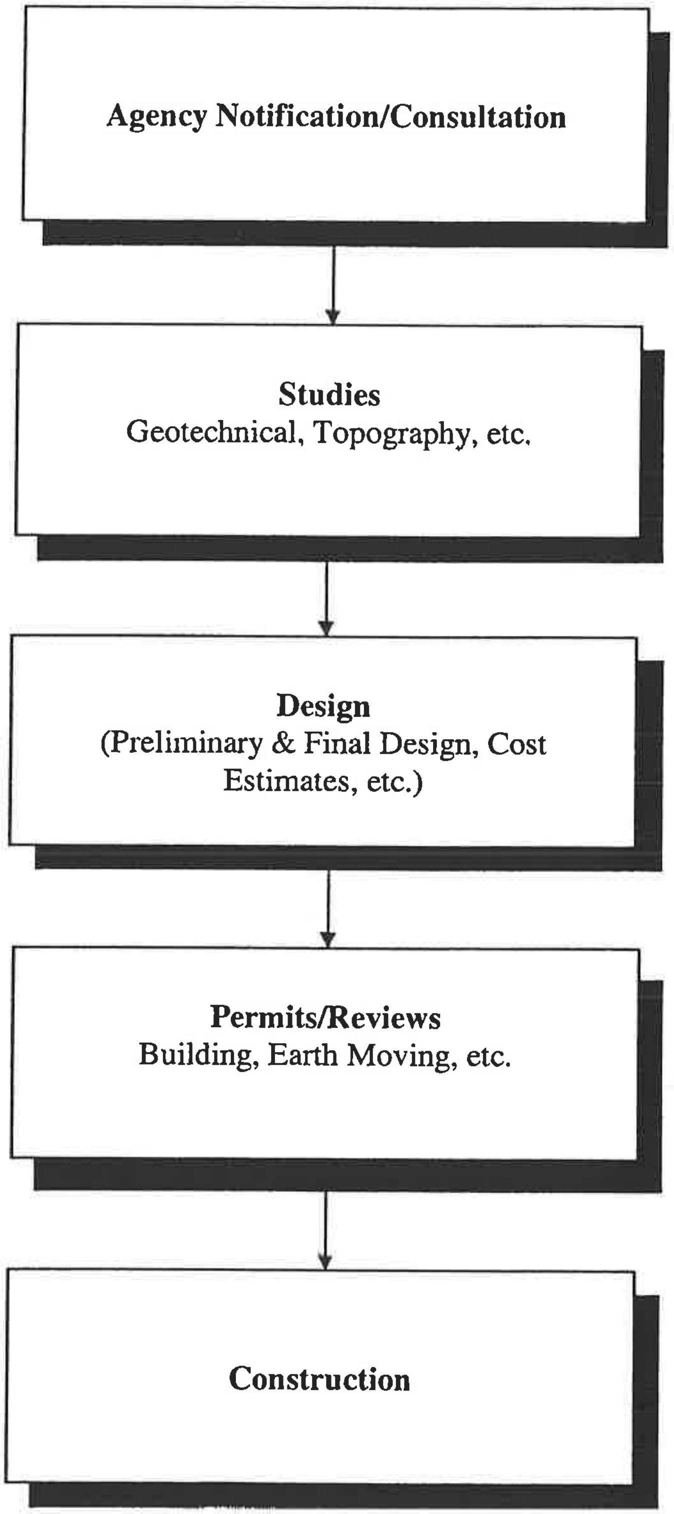
Approximate Duration: 3-6 Months
Approximate Cost: $6,000

Construction

Approximate Duration: 3-6 Months
Approximate Cost: $582,000

Note 1: Approximate costs include a 20 percent contingency factor.
Note 2: Construction cost includes a liner.

OPEN DUMP CLOSURE PROCESS – EXCAVATION AND DISPOSAL



Approximate Duration: 3-6 Months
Approximate Cost: $29,000

Approximate Duration: 6-12 Months
Approximate Cost: $198,000

Approximate Duration:3-6 Months
Approximate Cost: $227,000

Approximate Duration: 3-6 Months
Approximate Cost: $29,000

Approximate Duration: 6-12 Months
Approximate Cost: $2,828,000

Note 1: Approximate costs include a 20 percent contingency factor.

OPEN DUMP CLOSURE PROCESS – EXCAVATION, PROCESSING, AND DISPOSAL

Agency Notification/Consultation

Approximate Duration: 3-6 Months
Approximate Cost: $22,000

↓

Studies
Geotechnical, Topography, etc.

Approximate Duration: 6-12 Months
Approximate Cost: $152,000

↓

Design
(Preliminary & Final Design, Cost Estimates, etc.)

Approximate Duration:3-6 Months
Approximate Cost: $174,000

↓

Permits/Reviews
Building, Earth Moving, etc.

Approximate Duration: 3-6 Months
Approximate Cost: $22,000

↓

Construction

Approximate Duration: 6-12 Months
Approximate Cost: $2,180,000

Note 1: Approximate costs include a 20 percent contingency factor.

5.1 GENERAL

A transfer station is a facility where customers deliver many relatively small loads of solid waste. The waste is then consolidated into a few large loads that are more economical to transport to a remote disposal facility such as a landfill or incinerator. Waste can be brought in by citizens in cars, pickup trucks, and trailers; by businesses in various types of trucks; or by commercial garbage haulers in compaction ("packer") trucks and roll-off boxes (i.e., dumpsters).

Some Tinian residents self-haul their waste to the dump. In 2004, Tinian's only commercial garbage hauler picked up waste from individual households and businesses using two licensed hauling vehicles. Each vehicle has a small compaction unit and waste container that are hauled on a special pickup truck to the existing on-island dump where the waste is deposited. This planning study contemplates the likelihood that in the future, the percentage of the solid waste stream collected by one or more commercial garbage haulers will increase while the percentage of waste self-hauled by residents will decrease.

5.2 TRANSFER STATION DEVELOPMENT SCENARIOS

Whether the Tinian dump is closed for environmental reasons or to allow development of the site or neighboring properties, this closure will create the need for a transfer station that allows waste to be transported economically to the new, replacement landfill. As discussed below, there are three main scenarios for developing a transfer station on Tinian:

5.2.1 The Conventional Approach

1. Site, design, build, and open a new landfill.
2. At the same time site, design, build, and operate a new transfer station to send waste to the new landfill.
3. Subsequently design and construct closure of the existing dump.

5.2.2 Early Dump Closure, Interim Waste Export

1. Design and build a facility for short-term export of waste to an off-island landfill such as Marpi, Saipan. Include a temporary site for holding waste during shipping interruptions (e.g., a small lined area or a protected site at the transfer station).
2. At the same time site, design, build, and operate a new transfer station to send waste to the new landfill.
3. Subsequently site, design, build, and operate a new landfill on Tinian.
4. Design and construct closure of the existing dump the same time as step number 3.

5.2.3 Permanent Waste Export

1. Design and build a facility for short-term export of waste to an off-island landfill such as Marpi, Saipan. Include a temporary holding site for waste during shipping interruptions (e.g., a small lined area or a protected site at the transfer station).
2. At the same time, design and construct closure of the existing dump.
3. Subsequently site, design, build, and operate a new transfer station to permanently export waste to an off island landfill.

Any scenario that involves exporting waste from Tinian to a landfill located off-island such as Marpi, Saipan requires the approval of both island's municipal governments. Environmental concerns can be mitigated using conventional technology, but political expediency, project timing, and economics will be the primary factors that affect the feasibility of exporting waste from one island to another.

5.3 TRANSFER STATION SITING CRITERIA

In planning a transfer station, the factors or criteria typically considered include the following:

- Types of waste (municipal solid waste, demolition debris, land-clearing waste, agricultural wastes, sewage sludge, appliances, etc.)
- Quantity of waste to be received hourly, daily, weekly, and yearly
- Quantity and types of recyclable materials
- Size of population to be served
- Types of generators (residences, businesses, industries, farms, etc.)
- Convenience and distance to competing disposal facilities such as landfills
- Business hours (days of the week and hours when the station is open to receive waste)
- Types and quantity of vehicles delivering waste
- Type of waste compaction equipment to be used
- Type of vehicle used to haul waste to disposal facility

In siting a transfer station based on the factors listed above, the following criteria are typically considered:

- Convenience and distance to the various waste generators
- Distance to the final disposal facility where the waste will be transported
- Environmental features of the proposed site (e.g., proximity to sensitive areas, ground and surface water resources, residential neighborhoods, hospitals, schools, etc.)
- Size and topography (especially slope) of the proposed site
- Community acceptance
- Quality of access roads

In the case of Tinian, siting a new transfer station is greatly dependent on where the new landfill is eventually sited. Potential locations for the new landfill are limited by the presence of drinking water aquifers that underlie much of the island. All other things being equal, an ideal location for the transfer station would make it convenient for the majority of waste generators to take their waste (or have it hauled) to either the landfill or the transfer station, thus minimizing the travel distance. Of course, in the real world, other factors besides driving distance must be considered. Because most of the population lives in or near San Jose, locating a transfer station there should maximize its convenience and minimize the amount of illegal dumping that could result if the station were located too far away from the population center.

5.4 TRANSFER STATION SIZING

Waste generation projections for Tinian as shown in Table 1 above assume that the resident and transient (tourists and non-resident workers) populations each grow at an annual rate of 5 percent. It is projected that about 3,700 tons of waste will be generated on Tinian in 2005. If a transfer station is open 6 days a week and 52 weeks a year, then it would receive an average of 12 tons per day. In larger cities, more garbage is received on weekdays (arriving in garbage trucks), while fewer tons are received on weekends (more cars and pickup trucks, but no garbage trucks). However, because Tinian has only one commercial garbage hauler, it is anticipated that daily tonnage will not vary greatly between weekdays and weekend days.

5.5 DESIGN CONSIDERATIONS

The proposed transfer station should be:

- Designed for efficient waste unloading and consolidation into transfer vehicles
- Simple and economical to operate
- Safe for customers and workers
- Environmentally sensitive to minimize adverse impacts such as odor, noise, pests (e.g., insects, rodents, and birds), and water pollution
- Constructed of durable materials suitable for the climate
- Architecturally pleasing and similar to other local industrial or municipal buildings
- Cost-effective to construct
- Landscaped appropriately for visual screening of waste operations

5.6 CONCEPTUAL DESIGN

Figure 8 presents a flow chart for a generic transfer station showing functional areas and potential traffic circulation. This generic station concept was developed to meet the expected waste flow, operational characteristics, and level of service appropriate for a small island community such as Tinian. Once a specific piece of land has been selected as the transfer station site, a detailed layout can be created. This would involve modifying the generic layout in Figure 8 to fit the site's topography (slopes and contours), size, shape, and natural features (e.g., streams, public roads, steep slopes, etc.). The proposed transfer station's major functional features include the items described below.

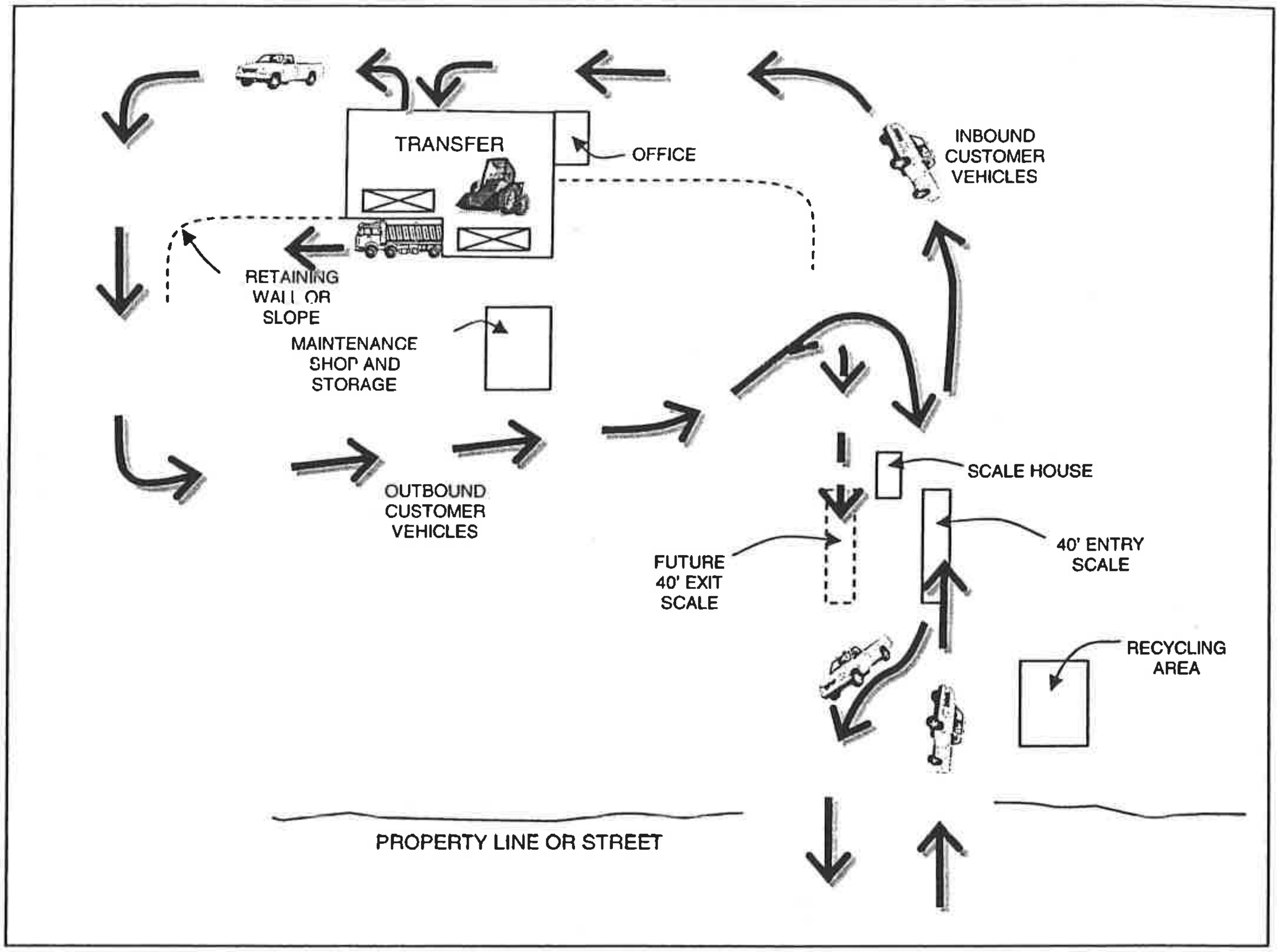


Figure 8: Transfer Station Site Layout

5.6.1 Scale and Scale House

At transfer stations serving a relatively high number of vehicles (e.g., 200 or more a day), it is common practice to weigh vehicles in both the inbound and outbound direction (i.e., before and after unloading) to determine how much waste was unloaded. At present, cars, pickup trucks, some commercial vehicles, and local garbage hauler trucks visit the Tinian dump though no daily vehicle count data was available for use in this study. However, the volume and type of vehicles is not expected to increase dramatically in the next 5 years or so. Therefore, it would be economical for the transfer station to have a single 40-foot scale that would accommodate all the types of vehicles presently seen at the dump. When traffic volumes are light, it is possible to weigh vehicles in both directions without significant delays using a single scale. In the distant future, when vehicle volumes increase significantly, a second scale can be added. In the meantime, the decision may be made to charge a uniform flat rate for passenger cars, and another rate for small pickup trucks. Only large pickups and commercial trucks would be weighed and charged by the ton for their waste. This procedure accelerates the processing of vehicles and minimizes waiting times at the scale.

A scale house provides an air-conditioned facility for the scale attendant to sit, weigh vehicles, answer customer's questions, and collect payments. It would have drawers, shelves and countertops; a safe for cash receipts; a scale computer and associated electronics; and limited storage space. A sink, microwave oven, small refrigerator, and restroom allow the scale attendant to remain on duty continuously without having to leave the scale house during business hours.

5.6.2 Recyclables Drop-off Area

Before reaching the scale, customers may access a small, paved parking area to the right that has containers (e.g., 2- to 4-cubic-yard dumpsters) to deposit the more popular recyclables such as aluminum, clean cardboard, or newspaper. Because of their low economic value and high weight, it is probably not economical to recycle glass bottles. Additional dumpsters can be added in the future as it becomes more economical to recycle other materials.

5.6.3 Transfer Building

The transfer building (Figure 9) would be a pre-engineered metal building with concrete floors and walls on three sides. Vehicles would back in through the fourth side to unload. The building could have three 12-foot-wide unloading stalls for cars and pickup trucks, as well as two 15-foot-wide stalls for larger commercial vehicles and garbage trucks. The roof structure must be high enough to allow commercial vehicles to raise their beds and unload without striking the roof joists. Exhaust fans can be installed to remove dust and odors, and circulate air in the building. Skylights and/or translucent wall panels can reduce the use of electric lights.

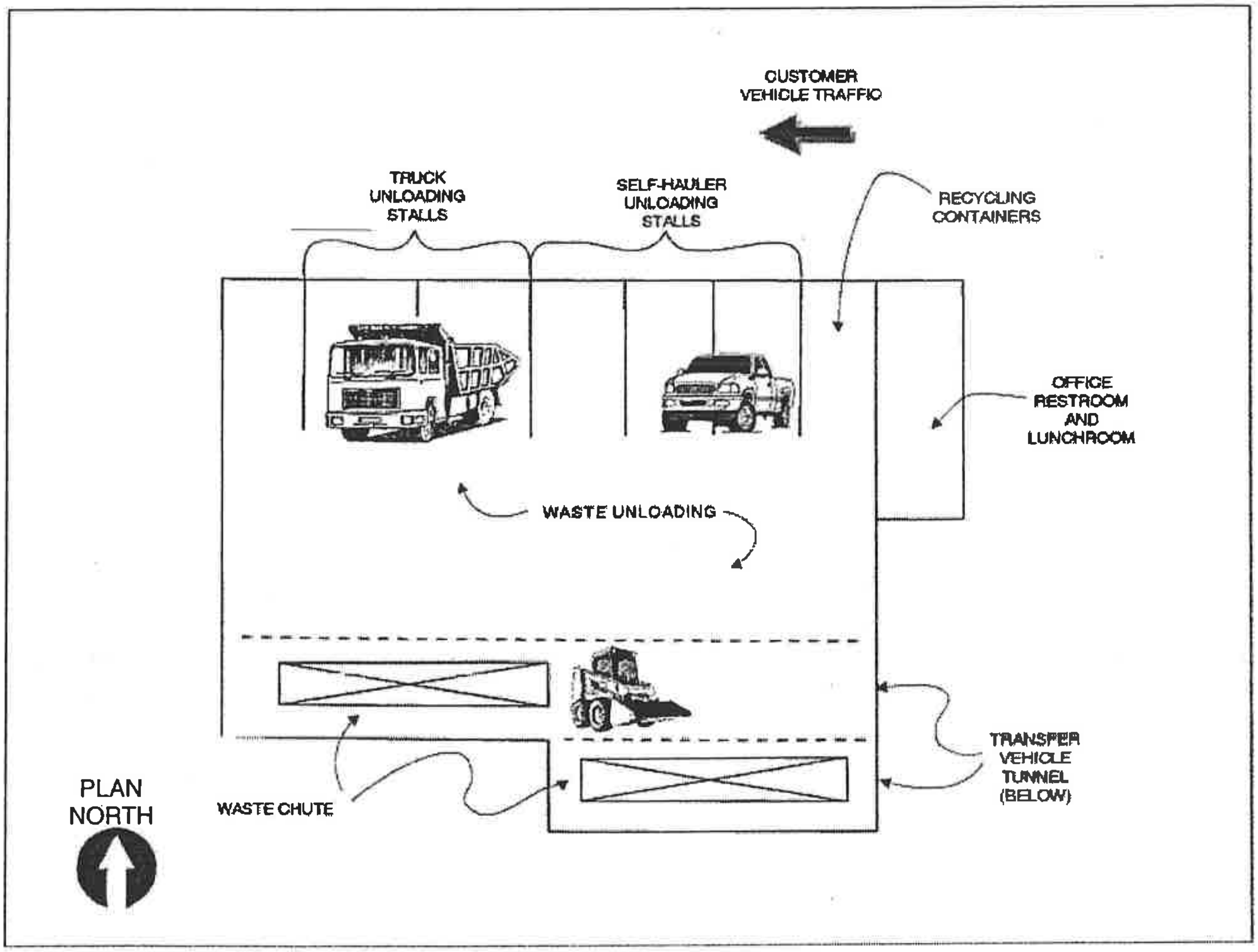


Figure 9: Transfer Station Concept Floor Plan

5.6.4 Roadways

Roads to, through, and from the transfer station can be constructed of asphalt concrete. It is desirable for traffic circulation on the site to flow in a counter-clockwise direction. This allows drivers to back up their vehicles using their driver-side (left-hand) rear view mirror; experience shows that it is safer and easier for most drivers to back up to their left. Parking can be provided for at least three transfer vehicles in the paved vehicle yard adjacent to the transfer building. To the extent possible, large vehicles such as transfer trailers operate on separate roadways from cars and pickup trucks to minimize accidents.

5.7 TRANSFER STATION OPERATIONS

The following is a brief overview of how the transfer station would operate:

- The station would be open to receive waste 8 hours a day, 6 days a week.
- Vehicles would weigh in at the scale house and then proceed to the transfer building to unload their waste.
- Vehicles would weigh out and pay at the scale house.
- A station equipment operator would assist customers in backing into the building and unloading their refuse. That individual would use a wheeled loader to push the refuse into a transfer vehicle below. At night the top of the transfer vehicle would be covered with a tarp to exclude insects, rodents, and birds.
- When the transfer vehicle is full, the equipment operator (or mechanic or operations manager) would drive the transfer vehicle to the landfill. Depending on waste quantities, this might occur once every 2 to 3 days.

5.8 POTENTIAL SITES

Locating a transfer station in or near San Jose would make it convenient for the majority of the island's population. A desirable site would have many of the following attributes:

- Size of approximately 4 acres (adequate operational space, room for some future expansion, and buffering from neighbors)
- Located in or within 2 miles of San Jose
- Publicly owned (to prevent the cost of the property from escalating once the transfer station is announced)
- Moderate slope to reduce the amount of grading to achieve the upper level (tipping floor) and lower level (transfer vehicle parking)
- Suitable zoning
- Sufficient distance from residences, schools, and sensitive businesses to minimize negative impacts such as noise and odor
- Sufficient distance from environmentally sensitive areas
- Downwind of the population center
- No planned development on the particular parcel

- Sufficient distance from areas of significant, non-agricultural planned development

The Municipality of Tinian should take the lead in identifying potential transfer station sites for preliminary comparison. When private parties begin inquiring about property, it sometimes causes the price to rise. It is also not uncommon for the price of property to rise as soon as a government agency announces that it is interested in building a facility in the area. Therefore, some preference should be given to sites that are already owned by the municipality, thus precluding an increase in the cost of acquiring a site. Potential areas of interest include the area west of 8th Avenue and the borrow site north of San Jose.

Once a number of sites are identified and some basic information about each is obtained, they can be compared on the basis of how well each site satisfies the criteria listed above. The sites may then be sorted into qualitative categories such as *Highly Desirable*, *Worth Considering*, or *Undesirable*.

5.9 IMPACT OF RECYCLING

It is widely accepted that it is desirable to recycle and reuse materials that would otherwise be discarded and use up valuable landfill space. Recycling is frequently a goal of municipal governments. Types of materials that are typically recycled in large urban areas include tin-coated steel cans; aluminum beverage cans; newspapers; corrugated cardboard; and clear, brown, and green glass. Depending on local conditions, mixed waste paper, No. 1 and No. 2 plastic containers, white goods (appliances), non-ferrous metals, and other items may be recycled.

While recycling is popular and desirable from an environmental standpoint, it truly works only if it makes good economic sense. For example, because Tinian has a small population, it does not generate large amounts of old newspaper. Newspaper needs to be stored under a roof to protect it from rain. While adequate quantities are being accumulated, it poses a fire hazard and potential harborage for rodents. To gather a marketable quantity, newspaper collected on Tinian would probably need to be consolidated with recycled newspaper on Saipan and other islands. This inter-island transport would be expensive relative to its market value. Finally, this recycled newspaper would have a long cross-ocean journey to a paper mill or other recycling market. The cost of gathering and shipping old newspaper would be high. On the other hand, the value per ton of old newspaper is relatively low (compared to say, aluminum). Thus, as many places have found, it may be necessary to make up the difference between market value and cost of collecting the recyclable material. The public may have to subsidize recycling of newspaper (and other commodities) through household garbage fees, taxes, or other government-imposed funding mechanisms. Presently, a few materials such as aluminum have a relatively high market value and are worth transporting over long distances.

Recycling could potentially remove a significant amount (possibly 10 to 20 percent) of the waste stream that would otherwise go to a landfill. However, it would require at least two of the following conditions to be true: 1) Tinian's citizens would need to have a strong recycling ethic; 2) markets for recyclables would have to be strong and prices high while transportation costs were relatively low; and/or 3) the public is willing to subsidize the difference between what it costs to recycle and what the materials are worth. Otherwise, recycling will do little to reduce the amount of waste going to the landfill.

It should be noted that the recyclables market is global; in 2004, high demand by China and other Asian markets increased the price of recycled materials. As with other commodities, prices for recyclables are subject to large fluctuations, consequently this variability should be considered when planning for recycling. In light of this economic uncertainty, the proposed recycling facilities at the Tinian transfer station are modest, but could be expanded subject to citizen and government approval.

5.10 EFFECTS OF WASTE EXPORT ON TRANSFER STATION PLANNING

In the *Early Dump Closure, Interim Waste Export* scenario described in section 5.2.2 above, a temporary waste export facility would be required to temporarily ship waste to an off-island landfill while a new on-island landfill is being built. In the *Permanent Waste Export* scenario (section 5.2.3), solid waste would continue to be exported permanently if siting a new landfill or other treatment or disposal alternative on Tinian is unsuccessful. This may occur if environmental considerations such as designation of a sole-source aquifer underlying a desired site prevented a new landfill from being constructed, community opposition, or economic infeasibility. To export waste, it must be put in closed containers for transport by ferry or barge. This would require consideration of additional factors such as:

- Type and frequency of inter-island vessels (e.g., ferry, barge, chartered craft, etc.)
- Type and weight of container suitable for transport by each type of vessel
- Type of equipment used to load waste into containers (hydraulic rams to compress the waste)
- Trade-off between compacted and uncompacted waste (compacted waste has a higher density and needs fewer containers, but there are significant capital and operations/maintenance costs associated with compaction equipment)
- Reliability, availability of spare parts, and mechanics trained to repair and maintain this type of equipment
- Number of empty containers needed to ensure adequate storage under a variety of transportation scenarios
- Labor considerations, including interactions between various unions for loading and unloading waste-filled containers on/off vessels and driving the containers to/from the landfill and transfer station

5.11 TRANSFER STATION CAPITAL COST

5.11.1 Site Conditions

The construction cost of a transfer station is very much dependent on site conditions such as topography (affects how much soil must be moved to create the different levels of the station, as well as roadways); availability of utilities (electricity and water availability at the property line), and soils (suitable for heavy construction and septic tank systems). With only a conceptual layout and without such site-specific information, it is difficult to develop precise construction costs. The following cost estimate is based on these assumptions:

- A CNMI government or municipal agency would make the particular site available at no cost as site acquisition costs are highly variable
- Site soils are suitable for concrete slab-on-grade construction (i.e., does not require piles, removal of expansive or peaty soils, or blasting)

- No environmental mitigation or special construction to avoid wetlands or streams, or other sensitive natural areas
- No environmental mitigation or special construction to avoid impacting sensitive neighboring facilities such as hospitals or schools
- The transfer station (transfer building, scale house, employee facility, recycling area, etc.) is as described above

5.11.2 Alternate (Smaller) Transfer Station

If a landfill is located less than about 10 to 15 miles from the transfer station, it could be beneficial to send garbage trucks directly to the landfill rather than to the transfer station. The following are among the reasons for having a transfer station for the sole use of cars and pickup trucks:

- This arrangement avoids double-handling the majority of the garbage, otherwise the garbage truck would unload onto the transfer station floor; the waste would be reloaded into a transfer vehicle, and then unloaded again at the landfill.
- It is safer for the public to drive on transfer station roads and to unload their waste in the transfer building if there are no garbage trucks nearby.
- Garbage trucks do not have to wait in line for other customers to unload in the transfer building; this savings in time compensates partly for the longer drive to the landfill (instead of the transfer station)
- The transfer building could be less expensive to build: It would not need to be as high since cars and pickup trucks need less vertical clearance than do garbage trucks. The building could be built without unloading stalls for garbage trucks, thus decreasing the length of the building; because garbage trucks must pull forward as they unload their waste on a floor, they require more building depth than a car or pickup truck. Thus, the building's depth could be decreased somewhat if garbage trucks hauled directly to the landfill. The overall savings could amount to about 20 percent or more of the cost of the transfer building.
- Fewer transfer trailers would need to be purchased, since the amount of waste being hauled from the transfer station would decrease by 50 percent or more.

The tourist population would likely reside at the Tinian Dynasty Hotel & Casino, other existing hotels, and visitor facilities to be built in the future. It will be more cost-effective to haul solid waste generated at these lodging facilities (potentially a large percentage of the total waste stream) directly to the landfill rather than to a transfer station. Otherwise, the required transfer station will be considerably larger than one sized to handle just the waste generated by permanent residents and consequently more costly to construct and operate.

Therefore, it will be worthwhile to consider whether diverting garbage trucks directly to the landfill would result in significant savings when sites have been chosen for both the transfer station and the landfill.

5.11.3 Construction Cost Estimate

Table 6 shows approximate construction costs for the transfer station described above while the flow chart that follows summarizes the overall construction process along with approximate time frames during which each step could be completed. Costs are preliminary based on a conceptual non-site-specific layout, as well as the assumptions listed in section 5.11.1. Though its accuracy is approximately plus or minus 25 percent, the cost margin may increase or decrease based on final design parameters.

5.12 TRANSFER STATION OPERATING COST

5.12.1 Staffing

Assume that the station is open 8 hours a day, 6 days a week, and 52 weeks a year. A full-time scale attendant would answer customers' questions, supervise the semi-automatic operation of the scale(s), and collect payment. The attendant will need basic computer skills and the ability to deal with the public. A full-time equipment operator would direct traffic at the transfer building and assist customers with unloading their garbage. That individual would operate a small, rubber-tired loader or backhoe to push garbage into the transfer vehicles. The equipment operator would move the full transfer vehicle into the storage yard and replace it with an empty vehicle, and would also pick up litter and keep the transfer building tidy. A full-time site operations manager would maintain records, supervise operations, and assist the equipment operator when necessary. A mechanic and general maintenance person may be required approximately half-time. The mechanic, equipment operator, or operations manager would drive loaded transfer vehicles to the landfill several times a day to dispose the collected garbage.

5.12.2 Operating Cost Estimate

Table 7 shows approximate annual operating costs for the transfer station described above. These are preliminary costs based on a conceptual, non-site-specific facility, and staffing levels described above. These assumptions may change significantly depending on the actual distance to the landfill, as well as potential equipment sharing with the landfill. Furthermore, some operations planned for the transfer station may potentially be accomplished more economically at the landfill. The operating cost accuracy is approximately plus or minus 25 percent. Budget adjustments will probably be required each year to account for general inflation and escalation in labor, fuel, and other materials rates.

Table 6: Transfer Station Construction Cost Estimate

ITEM	Quantity	Unit	Unit Price	Price (rounded)	Category Subtotal
Site Work					
On-site roadways (1,000 feet, 24 feet wide)	2,700	SY	$30	$81,000	
Paved Recycling Area 40 feet x 30 feet	130	SY	$30	$3,900	
Site Clearing	4	Acre	$5,000	$20,000	
Site Grading (2 feet deep)	12,900	CY	$3	$38,700	
Miscellaneous Backfill	1	LS	$10,000	$10,000	
Site Perimeter Chain Link Fence & Gates	2,000	LF	$12	$24,000	
Storm water System & Infiltration	1	LS	$25,000	$25,000	
Wastewater Piping & Septic System	1	LS	$30,000	$30,000	
Water Service, Fire Mains & Hydrants	600	LF	$60	$36,000	
Electrical Service	1	LS	$12,000	$12,000	
Site Lighting	1	LS	$15,000	$15,000	
Misc: curbs, striping, signs, etc.	1	LS	$10,000	$10,000	$306,000
Transfer Building					
Transfer Building (pre-engineered metal shell)	5,800	SF	$35	$203,000	
Concrete Slab (12 inch thick)	215	CY	$300	$64,500	
Concrete Retaining Wall/Trailer Tunnel	5,120	SF	$50	$256,000	
Plumbing & Ventilation	1	LS	$4,000	$4,000	
Fire Sprinklers	5,800	SF	$2	$11,600	$539,000
Office, restroom, lunchroom	384	SF	$80	$31,000	
Furnishings, computer equipment	1	LS	$4,000	$4,000	$35,000
Scale House w/ restroom/kitchenette	160	SF	$100	$16,000	
40-ft truck scale, computer equipment	1	LS	$41,000	$41,000	$57,000
Construction					$937,000
Contractor Mobilization, Overhead, Profit	12	%			$112,000
CONSTRUCTION SUBTOTAL					**$1,049,000**
Geotech, Survey, Other Studies	7	%		$73,000	
Engineering Design	8	%		$84,000	
Notifications, Permits, Assessments	8	%		$84,000	
SERVICES SUBTOTAL					**$241,000**
Contingency	20	%			**$258,000**
TRANSFER STATION TOTAL					**$1,548,000**
Equipment					
Backhoe or loader, 2 CY bucket	1	LS	$50,000	$50,000	
Road tractor	1	LS	$90,000	$90,000	
Transfer trailer, 40-foot self-unloading	4	Each	$50,000	$200,000	
Pickup truck	1	LS	$30,000	$30,000	
Misc. tools, welding equipment, etc.	1	LS	$12,000	$12,000	
EQUIPMENT TOTAL					**$382,000**

CY = cubic yards
LF = linear feet
LS = lump sum
SF = square feet

TRANSFER STATION CONSTRUCTION PROCESS

Site Selection	Approximate Duration: 6-12 Months Approximate Cost: $20,000 (May need to be repeated if studies determine a site is unacceptable)
Studies Geotechnical, Topography, Biology, Archaeology, Hydrology, Meteorology, etc. (Concurrent with Site Selection, Notifications/Permits/Reviews as necessary)	Approximate Duration: 6-18 Months Approximate Cost: $88,000 (May need to be repeated if multiple sites are to be evaluated)
Design (Preliminary & Final Design, Cost Estimates, etc.)	Approximate Duration: 6-10 Months Approximate Cost: $101,000
Notifications/Permits/Reviews Major Siting, Building, Historic Preservation, Earth Moving, etc.	Approximate Duration: 6-18 Months Approximate Cost: $101,000
Construction	Approximate Duration: 8-12 Months Approximate Cost: $1,259,000

Note 1: Approximate costs include a 20 percent contingency factor.
Note 2: Equipment costs are not included.

Table 7: Transfer Station Annual Operating Cost Estimate

ITEM	Quantity	Unit	Annual Salary	Benefits 37%	Price (rounded)
Labor					
Scale Attendant	1	FTE	$18,000	$6,660	$25,000
Equipment Operator/Laborer	1	FTE	$21,000	$7,770	$29,000
Mechanic	0.5	FTE	$25,000	$9,250	$17,000
Supervisor	1	FTE	$35,000	$12,950	$48,000
Miscellaneous			Unit Price		
Fuel: 200 10-mile trips to landfill;10 mpg; $3/gal	200	Gal	$3		$600
Loader fuel: 0.5 gal/day, 6 days/week, 50 weeks/year	150	Gal	$3		$500
Electricity: 3 kw, 9 hr/d, 300 d/yr @ 12 cents/kwh	8,100	kwh	$0.12		$1,000
Water	1	LS	$500		$500
Supplies, miscellaneous	1	LS	$1,000		$1,000
Misc. repairs & maintenance for vehicles & site	1	LS	$1,000		$2,000
OPERATING COST TOTAL					**$125,000**
Contingency	10%				**$12,500**

d = day
FTE = Full-Time Equivalent
Gal = gallons
hr = hour
kw = kilowatt
kwh = kilowatt hours
LS = lump sum
mpg = miles per gallon
yr = year

6.1 GENERAL

As noted earlier, Tinian Island has no wastewater treatment facility. As a result most households and businesses use septic systems for wastewater disposal. Septage is the solid, semi-solid, or liquid material that collects in septic tanks, cesspools, or portable sanitation devices that receive domestic sewage, and which must be periodically pumped out. Pumped septage from these septic systems is currently transported to and discharged at an area located directly north of the existing on-island open dump.

Septic systems usually include a tank for solids collection and decomposition. Solids that are not decomposed remain in the septic tank. If they are not removed by periodic pumping, solids continue to accumulate until they overflow into the drain field. Measuring the sludge and scum layer thickness in the tank is the most common method to determine when the tank needs to be pumped.

Most health departments recommend annual septic tank inspections (measuring the sludge and scum layer thickness) and pumping of septage from the tank every 3 to 5 years. The actual pumping schedule depends on tank size, amount of solids entering the tank, and user habits. Based on existing conditions on Tinian, it is estimated that septage pumping is less frequent than recommended or on the order of every 4 to 10 years. Additionally, based on the economy and rural nature of the area, the actual amount of septage generated is likely to be less than published averages described below.

6.2 SEPTAGE FACILITY DEVELOPMENT SCENARIO

Septage disposal is an unsafe practice and potential health hazard for both humans and other species at the site receiving the waste. It contains various types of pathogenic bacteria, viruses, and parasites that can infect both humans and animals. These wastes can provide food and harborage for vector such as rodents and flies. There is also the potential for heavy metals and pathogens to contaminate soil, surface and ground water, air, and vegetation.

The plan for a new municipal solid waste landfill is to collocate a septage dewatering facility on the same parcel as the landfill. Liquids from the dewatering facility would be combined and treated in the same manner as landfill leachate. Solids from the dewatering facility would be disposed in the new landfill. Since the population is relatively low and the area is rural in nature, it is likely that a septage disposal facility would be needed for several years.

Assuming the population grows as projected (refer to Table 1), the town of San Jose will eventually need a wastewater collection and treatment system. This would significantly reduce the amount of septage generated. Depending on the process, a wastewater treatment facility may also be able to accept septage for treatment. If not, the septage dewatering facility collocated at the new landfill would need to remain in service.

Sludge from the treatment plant could either be disposed in the landfill or through land application. Typically, treated sludge from a new wastewater treatment plant would constitute significantly less volume than the anticipated septage volumes from the planned dewatering facility.

6.3 SEPTAGE FACILITY SITING CRITERIA

Siting and planning a new septage disposal facility on Tinian would be driven primarily by operational access and locational convenience concomitant with existing regulatory requirements. Typically septage treatment areas are located near or adjacent to a disposal site. Septage is first dried through evaporation or mechanical means and the solids disposed in a landfill. In some areas, dried screened septage is able to be disposed in agricultural areas in fields that are used for crops not intended for human consumption. If climatological conditions do not allow for evaporation, then alternative means to prepare septage for disposal are employed including mechanical drying, construction of a covered structure to include lined sand filter beds, and stabilization.

Planning for Tinian would include evaluation of current and projected septage quantities, climatic conditions and periods that evaporation would be possible, options used on other Northern Mariana Islands, and possible direct disposal in a new lined landfill and construction of the landfill to allow it to be classified as a bioreactor.

The location of a new septage facility should preferably be adjacent to the new landfill site. This would provide operation and maintenance efficiency since both activities are typically malodorous. The operations of the septage treatment facility are similar to those at the landfill, and can share some of the same equipment. Monitoring and operational requirements become more manageable particularly for small municipalities and low population jurisdictions when both landfill and septage facilities are collocated. The septage facility would ordinarily be located close to the leachate wet well to allow combined treatment of septage decant and landfill leachate. If sand beds are chosen as the preferred treatment method, it will be necessary to replace sand as it is collected with the decanted solid portion of the septage. The soil stockpiles and earthmoving equipment at the landfill can provide for this operation. Solids are then placed in the landfill and decant treated with the leachate.

If a new landfill is not constructed on Tinian and solid waste is instead transported off the island, then a stand-alone septage treatment facility should be considered. The septage treatment facility is not required to meet the same siting standards as a landfill and may be located nearer to the population center. Considerations for siting would be similar to a transfer station and include access, land area and topography, geologic conditions, proximity to sensitive neighbors, and ability to properly dispose the solids and liquids as generated.

A stand-alone septage treatment facility would include a new access road, site fencing, treatment equipment, sand beds, and a decant treatment component similar to, but smaller than, leachate treatment ponds. Additionally, an Integrated Tool Carrier (ITC) or tractor, and the equivalent of at least one full-time employee to manage the site and handle the solids would be necessary for facility operation. Most likely solids would be land applied on Tinian and not exported with solid waste.

With an estimated 2005 resident population of approximately 4,500 and a per capita generation rate of 55 gallons per year, this amounts to 250,000 gallons of total wet septage. This equates to about 1,250 wet cubic yards (CY), or if dewatered 50 percent, 600 CY of dewatered septage to dispose in a landfill. In subsequent years, the dewatered septage would amount to 800 CY in 2010, 1,000 CY in 2015, 1,300 CY in 2020, and 1,600 CY in 2025.

By comparison, it is estimated that in 2005 over 12,000 CY of solid waste would be placed in the landfill as compared to 600 CY of dewatered septage assuming an average in-place solid waste density of 600 pounds per CY. In 2025—with an estimated on-island resident population of about 12,000—over 32,000 CY of solid waste would be disposed as compared to 1,600 CY of septage sludge. Therefore, total septage solids would comprise less than five percent of the waste volume in the landfill even if the septage facility is the only means of disposal for wastewater solids. This, however, does not include the volume of daily and interim cover soil used at the landfill.

6.3.1 Septage Dewatering

There are several options for septage disposal in rural/remote areas. Most require the construction of facilities for treatment and reduction of the delivered septage volume. Septage is highly variable and organic with significant levels of grease, grit, hair, and debris. Liquids pumped from septic tanks and cesspools have an offensive odor and appearance, a tendency to foam on agitation, and a resistance to settling and dewatering.

However, as described above, volume reduction is not a concern for Tinian. The current population of Tinian indicates relatively small amounts of septage would be generated into the near future. For planning septage disposal, a low-tech, low-maintenance approach utilizing either land application or a parallel series of lined sand drying beds for dewatering and subsequent solids disposal in a lined municipal solid waste landfill is recommended.

If land application is the chosen alternative, then a site or area other than the new landfill should be considered. Liquids from septage that infiltrate into the ground include a number of compounds that are common in landfill leachate. The risk is associated with groundwater monitoring wells located around the new landfill. If there was a rise above background water quality, it would indicate that leachate from the landfill was entering the groundwater; when in fact, it would only be the result of a nearby septage land application site.

6.3.2 Sand Drying Beds

Sand bed drying is one of the simplest systems that can be used for dewatering and conditioning septage. They are typically rectangular and set parallel to each other. While one bed is being discharged to, the others are resting or have a layer of septage that is dewatering. Typical drying times range from 2 days to 4 weeks with 7 to 14 days being typical. After drying, the resultant cake can be collected and placed in the landfill. The predominate function of sand bed dewatering is drainage, most of which usually occurs within about 7 to 10 days. Depending on weather conditions, evaporation also contributes significantly to dewatering. Advantages of this system are:

- Simple construction
- Minimal operator training and attention required
- Low capital and operation cost

System disadvantages are:

- Relatively large land area requirement
- Potential problems with operation during wet weather seasons unless the beds are covered

Since septage is resistant to dewatering, it may be necessary to have available soil, lime, or other conditioning chemicals to assist in the dewatering process prior to landfilling during wet periods. Another alternative would be to provide waterproof covers over a portion of the sand drying beds for wet weather operations. Once placed in the landfill, the septage would be covered with at least 6 inches of soil cover to limit odor generation.

6.4 SEPTAGE FACILITY CAPITAL COST

A capital cost estimate to construct a septage facility at a municipal solid waste landfill is included as Table 8. It provides for a three-cell sand bed with each cell 25 feet wide by 125 feet long. Concrete walls would surround the beds and separate the cells. The entire area would either be lined with the same material as the landfill or include a concrete base with integral membrane liner. Each cell would include a septage vehicle unloading basin, access ramp, and decant collection system. An optional pole building has been estimated to provide for covering the sand beds during wet weather.

Table 9 presents a cost estimate to construct a detached (i.e., stand-alone) septage facility that is not sited at a municipal solid waste landfill. Unlike that located at a landfill, a detached septage facility must have a concrete base with membrane liner.

Flow charts that follow summarize the overall construction process along with approximate time frames during which each step could be completed. Costs are preliminary based on a conceptual non-site-specific layout, as well as the assumptions listed in section 5.11.1. Though its accuracy is approximately plus or minus 25 percent, the cost margin may increase or decrease based on final design parameters.

6.5 SEPTAGE FACILITY OPERATING COST

The annual operating cost for a septage facility collocated at a municipal solid waste landfill would include only one part-time individual, an ITC or tractor, and some fuel and maintenance. Supervision, earthwork, and other costs would be considered incidental and associated with landfill operations (see section 7.7. Operation of a stand-alone septage facility would be slightly more per annum to account for facility administration, and obtaining sand and bulking agents from an off-site source. Estimated annual operating costs for both scenarios are presented in Tables 10 and 11.

Table 8: Septage Facility Construction Cost Estimate – At Municipal Solid Waste Landfill

ITEM	Quantity	Units	Unit Price	Price (rounded	Category Subtotal
Site Work					
Site Preparation & Clearing	15,000	SF	$3	$45,000	
Excavate For Septage Facility	3,500	CY	$3	$10,500	
Trench Ex. & Backfill (Header System)	100	LF	$40	$4,000	
Concrete Curbs & Separators	250	CY	$300	$75,000	
Concrete Ramps	60	CY	$300	$18,000	
Access Road Around Facility	625	SY	$8	$5,000	$158,000
Liner System					
Subbase Preparation (Grade & Compact)	1,500	SY	$1	$1,500	
Liner/Geotextile Anchor Trench	500	LF	$4	$2,000	
Geotextile Cushion (16-ounce)	2,000	SY	$2	$4,000	
High Density Polyethylene Liner (60-mil)	2,000	SY	$6	$12,000	
Liner Penetration Seal	1	Each	$2,000	$2,000	
Geosynthetic Clay Liner w/Membrane	2,000	SY	$8	$16,000	
Geotextile Separation Layer (8-ounce)	1,000	SY	$1	$1,000	
Drain Net in Decant Trench	500	SY	$2	$1,000	
Decant Collection Pipe (6-inch HDPE)	625	LF	$8	$5,000	
Aggregate - Drain Layer (In Place)	1,500	CY	$8	$12,000	
Sand - Above Drain Layer	1,625	CY	$8	$13,000	
Cleanouts for Decant lines	10	Each	$400	$4,000	$74,000
Construction					$232,000
Contractor Mobilization, Overhead, Profit	12	%			$28,000
CONSTRUCTION SUBTOTAL					**$260,000**
Geotech, Survey, Other Studies				$0	
Engineering Design	8	%		$21,000	
Notifications, Permits, Assessments				$0	
SERVICES SUBTOTAL					**$21,000**
Contingency	20	%			**$56,000**
SEPTAGE FACILITY TOTAL					**$337,000**
Alternate – Concrete Slab & Liner					
Subbase Preparation (Grade & Compact)	1,000	SY	$1	$1,000	
Concrete Slab Below	350	CY	$300	$105,000	
Add for Membrane Concrete Seal	1,500	SY	$4	$6,000	
Decant Collection Pipe (6-inch HDPE)	625	LF	$8	$5,000	
Cleanouts for Decant lines	8	Each	$500	$4,000	
Sand - Above Drain Layer	875	CY	$8	$7,000	
Credit for less excavation	875	CY	($4)	($3,500)	$123,500
Optional Wet Weather Cover System					
Pole Building over Septage Facility	9,500	SF	$30.00	$285,000	$285,000

CY = cubic yards
HDPE = high-density polyethylene
LF = linear feet
SF = square feet
SY = square yards

Table 9: Septage Facility Construction Cost Estimate – Detached

ITEM	Quantity	Unit	Unit Price	Price (rounded)	Category Subtotal
Site Work					
Site Preparation & Clearing	15,000	SF	$3	$45,000	
Excavate For Septage Facility	2,500	CY	$3	$7,500	
Subbase Preparation (Grade & Compact)	1,000	SY	$1	$1,000	
Concrete Slab Below	400	CY	$300	$120,000	
Add for Membrane Concrete Seal	1,300	SY	$5	$6,500	
Decant Collection Pipe (6-inch HDPE)	625	LF	$8	$5,000	
Cleanouts for Decant lines	8	Each	$500	$4,000	
Sand - Above Drain Layer	875	CY	$8	$7,000	
Trench Ex. & Backfill (Header System)	100	LF	$40	$4,000	
Concrete Curbs & Separators	250	CY	$300	$75,000	
Concrete Ramps	60	CY	$300	$18,000	
Access Road and Road Around Facility	3,400	SY	$15	$51,000	$344,000
Construction					$344,000
Contractor Mobilization, Overhead, Profit	12	%			$41,000
CONSTRUCTION SUBTOTAL					**$385,000**
Geotech, Survey, Other Studies	15	%		$58,000	
Engineering Design	8	%		$31,000	
Notifications, Permits, Assessments	15	%		$58,000	
SERVICES SUBTOTAL					**$147,000**
Contingency	20	%			**$106,000**
SEPTAGE FACILITY TOTAL					**$638,000**
Equipment (Capital Cost -One Time Expense)					
Integrated Tool Carrier	1	LS	$120,000	$120,000	
Misc. tools, equipment, etc.	1	LS	$5,000	$5,000	$125,000
EQUIPMENT TOTAL					**$125,000**
Optional Wet Weather Cover System					
Pole Building over Septage Facility	9,500	SF	$30.00	$285,000	

CY = cubic yards
LF = linear feet
LS = lump sum
SF = square feet
SY = square yards

SEPTAGE FACILITY CONSTRUCTION PROCESS – AT SOLID WASTE LANDFILL

Site Selection

Approximate Duration: 6-12 Months
Approximate Cost: $20,000

↕

Studies
Geotechnical, Topography, Biology, Archaeology, Hydrology, Meteorology, etc.
(Concurrent with Site Selection, Notifications/Permits/Reviews as necessary)

Approximate Duration: 6-18 Months
Approximate Cost: $0
(Can be addressed by landfill studies)

↓

Design
(Preliminary & Final Design, Cost Estimates, etc.)

Approximate Duration: 3-6 Months
Approximate Cost: $25,000

↓

Notifications/Permits/Reviews
Major Siting, Building, Historic Preservation, Earth Moving, etc.

Approximate Duration:6-18 Months
Approximate Cost: $0
(Can be addressed by landfill notifications, permits, and reviews)

↓

Construction

Approximate Duration: 8-12 Months
Approximate Cost: $312,000

Note 1: Approximate costs include a 20 percent contingency factor.

SEPTAGE FACILITY CONSTRUCTION PROCESS – DETACHED

Site Selection

Approximate Duration: 3-6 Months
Approximate Cost: $20,000
(May need to be repeated if studies determine a site is unacceptable)

↕

Studies
Geotechnical, Topography, Biology, Archaeology, Hydrology, Meteorology, etc.
(Concurrent with Site Selection, Notifications/Permits/Reviews as necessary)

Approximate Duration: 6-18 Months
Approximate Cost: $69,500
(May need to be repeated if multiple sites are to be evaluated)

↓

Design
(Preliminary & Final Design, Cost Estimates, etc.)

Approximate Duration: 3-6 Months
Approximate Cost: $37,000

↓

Notifications/Permits/Reviews
Major Siting, Building, Historic Preservation, Earth Moving, etc.

Approximate Duration: 6-18 Months
Approximate Cost: $69,500

↓

Construction

Approximate Duration: 8-12 Months
Approximate Cost: $462,000

Note 1: Approximate costs include a 20 percent contingency factor.
Note 2: Equipment costs are not included.

Table 10: Septage Facility Annual Operating Cost Estimate – At Municipal Solid Waste Landfill

ITEM	Quantity	Unit	Annual Salary	Benefits 37%	Price (rounded)
Labor					
Equipment Operator/Laborer	0.5	FTE	$21,000	$7,770	$14,000
Supervisor	0.5	FTE	$35,000	$12,950	$24,000
Miscellaneous			Unit Price		
Fuel: 2 days/week, 4 hours/day; 10 gal/hr; $3/gal	4,000	Gal	$3		$12,000
OPERATIONAL COST TOTAL AT LANDFILL					**$50,000**
Contingency	10%				$5,000
FTE = Full-Time Equivalent Gal = gallons					

Table 11: Septage Facility Annual Operating Cost Estimate – Detached

ITEM	Quantity	Unit	Annual Salary	Benefits 37%	Price (rounded)
Labor					
Equipment Operator/Laborer	0.5	FTE	$21,000	$7,770	$14,000
Supervisor	0.5	FTE	$35,000	$12,950	$24,000
Miscellaneous			Unit Price		
Fuel: 2 days/week, 4 hours/day; 10 gal/hr; $3/gal	4,000	Gal	$3		$12,000
Sand for Beds	500	CY	$8		$4,000
Bulking Agent	100	CY	$10		$1,000
OPERATIONAL COST TOTAL AT LANDFILL					**$55,000**
Contingency	10%				$5,500
CY = cubic yards FTE = Full-Time Equivalent Gal = gallons					

7.1 GENERAL

The current solid waste disposal practice on Tinian Island is described in section 4 above. This section describes the siting process, and features and design standards associated with a new RCRA Subtitle D municipal solid waste landfill. Also described in this section are construction and expansion phasing of municipal solid waste landfill (MSWL) site operations, and environmental monitoring.

A new RCRA Subtitle D landfill would be significantly different from the existing open dump and would include the installation of a new liner, leachate collection and treatment system, and environmental monitoring. Presumably, only commercial haulers (various types of trucks; or by commercial garbage haulers in compaction ["packer"] trucks and roll-off boxes) would have access into the landfill. Customers (i.e., residents in cars, pickup trucks, and trailers) would unload to roll-off containers at a conveniently located transfer station that would be then hauled by the landfill operator to the active face.

7.2 NEW LANDFILL SITING

RCRA Subtitle D is codified as Part 258 (Criteria for Municipal Solid Waste Landfills) to Title 40 of the Code of Federal Regulations (CFR). Subpart B of 40 CFR Part 258 specifies federal landfill siting requirements. Often the government jurisdiction responsible for permitting adds a second layer of local siting considerations. These are secondary to the federal restrictions but are often significant factors in determining the actual location of a new landfill. A discussion of each of these items is included in the Locational Analysis and Site Certification Document.

In siting a new landfill, the following criteria are typically considered:

- Environmental features of the proposed site (e.g., proximity to sensitive areas, ground and surface water resources, etc.)
- Size and topography (especially slope) of the proposed site
- Community acceptance

In the case of Tinian, potential locations for the new landfill are limited by the Exclusive Military Use Area and the presence of drinking water aquifers that underlie much of the island. According to Municipality of Tinian representatives, the Navy prefers the landfill not be sited north of a latitudinal line from Puntan Lamanibot Sampapa to Unai Dangkolo (approximately 15 degrees 2 minutes 10 seconds to 15 degrees 1 minute 59 seconds north latitude) which is to be set aside for military training. There is also a tacit agreement between the CNMI government and U.S. Navy not to construct any permanent facilities within a 2,000-foot buffer from the boundary line into the leaseback area. Similarly, Municipality of Tinian representatives have requested that the landfill not be sited east of Broadway nor south of a subjectively designated line running from the existing open dump at the west end of the island to about Unai Masalok at the east end (approximately 14 degrees 59 minutes 54 seconds to 15 degrees 1 minute 3 seconds north latitude).

Additionally, 40 CFR § 258.10 states that owners or operators of a new MSWL within a 5-mile radius of any airport runway end used by turbojet or piston-type aircraft must notify the affected airport and the

Federal Aviation Administration of the proposed action. Additionally, a municipal solid waste landfill located within 10,000 feet of an airport runway end used by turbojet aircraft must demonstrate that the landfill is designed and operated so as not to pose a bird hazard to aircraft (see section 8.2.5 below).

Other environmental considerations to landfill siting include designation of the underlying groundwater lens as a sole-source aquifer, protected threatened or endangered species, conservation areas, critical habitats, and cultural sites. For example, a wildlife mitigation area has been established at the north end of the leaseback area to the Exclusive Military Use Area abutting the military exclusion area. Additionally, historical water tanks are known to exist at the northwestern end of the leaseback area.

This 936-acre wildlife mitigation area was set aside in September 1999 as a conservation area for the protection of endangered and threatened wildlife, particularly the Tinian Monarch (*M. takatsukasae*). According to the agreement establishing the conservation area, the land's status as a conservation area shall remain in full force and effect for the maximum period of time allowed by the Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the Unites States of America (US Public Law 94-241 [90 Stat. 263]). While the Tinian Monarch was removed from the federal list of threatened and endangered species recently, its delisting does not change the status of the mitigation site as a conservation area.

The north and south demarcation lines, the 2,000-foot and 10,000-foot buffer zones, and wildlife mitigation area are shown in Figure 10. As is shown, provision of these various locational constraints results in a relatively small area suitable for siting a new MSWL, cultural and biological features notwithstanding. Note that while the 2,000-foot buffer zone is shown as extending completely from the eastern to the western coastlines, discussions in September 2004 between Marianas Public Lands Authority (MPLA) and Commander, Naval Forces Marianas (COMNAVMAR) indicate this requirement could be relaxed for areas west of 8th Avenue (Deputy Commissioner, Tinian 2004). Figure 11 contains an oblique aerial photograph of a general area that may be suitable for an MSWL.

Even under the most favorable conditions, successful siting of a new landfill is a long, complex process involving negotiations among the many stakeholders. The siting effort typically consumes a myriad of resources including time, money, patience, and political goodwill. If the United States Department of Defense chooses not to grant the preferred site in the leaseback area available as a landfill site, or the negotiations proceed too slowly for the Municipality of Tinian, then alternative sites must be considered.

The primary focus of this contingency is to expand the search area to identify other potential landfill sites other than the preferred site within the leaseback area using the siting criteria described above. The search could be expanded by looking east and south of the suggested community acceptance limit shown in Figure 10, which was initially and somewhat arbitrarily defined by Municipality of Tinian representatives and based on an interpretation of what the community would find acceptable. Nonetheless, preference should continue to exclude sites within the 10,000-foot airport buffer zone as well as the Makpo aquifer watershed, and the expanded search area could include the mid-eastern and southern portions of the island (refer to Figure 10). If a sufficient number of worthy sites are not readily identified within the expanded search area, it may even be worthwhile to consider sites within the Exclusive Military Use Area.

The preferred landfill site in the leaseback area was chosen because it scores high with respect to various landfill siting criteria. It is likely that alternative sites identified in this expanded search area will not score as high as the preferred site. However, this is to be expected as real-world conditions and the need for timely action often require compromise.

7.3 LANDFILL FEATURES

In planning and sizing a landfill, the following are among the factors or criteria taken into consideration:

- Location of a site large enough to allow for the projected life of the landfill and buffers
- The site meets RCRA Subtitle D siting requirements
- Impacts to neighboring properties and nearby receptors
- Existing and forecasted daily, weekend, and annual waste quantities (tons or cubic yards)
- Current and forecasted population to be served
- Types of waste (e.g., municipal solid waste, demolition debris, asbestos, tires, wood waste, land-clearing waste, agricultural wastes, sewage sludge, appliances, etc.)
- Types of generators (residences, businesses, industries, farms, etc.)
- Types and quantity of vehicles delivering waste
- Quantity and types of recyclable materials if recycling is to be considered
- Business hours, i.e., days of the week and hours of operation the station is open to receive waste
- Access roads and distance from the largest location of waste generation

The proposed new site should include provision for a number of features associated with an MSWL.

7.3.1 Entrance Facilities

Current landfill standards include access control to prevent unauthorized entry and dumping. Entrance facilities and perimeter fencing are usually adequate to control unauthorized entry. At small landfills, entry facilities often are not attended; instead only authorized personnel (haulers and operators) are provided with a means of access. Therefore, a gatehouse, and inbound and outbound scales may not be needed for the initial development of an MSWL on Tinian. If the projected population growth does occur (see Table 1), then provisions for a gatehouse, and inbound and outbound scales at the entrance is warranted.

7.3.2 Office, Equipment Operator/Equipment Maintenance/Shop Building

An equipment maintenance and small office structure is recommended at the outset of operation and would provide a location for performing maintenance and repair on earthmoving equipment. As with entrance facilities, offices for a landfill manager of operations, a secretary/gate house attendant, and operations staff would be required when incoming waste volume justifies full-time landfill operation. A locker room and personal hygiene facilities could be added for staff when waste flow expands to require the need for full-time equipment operators.

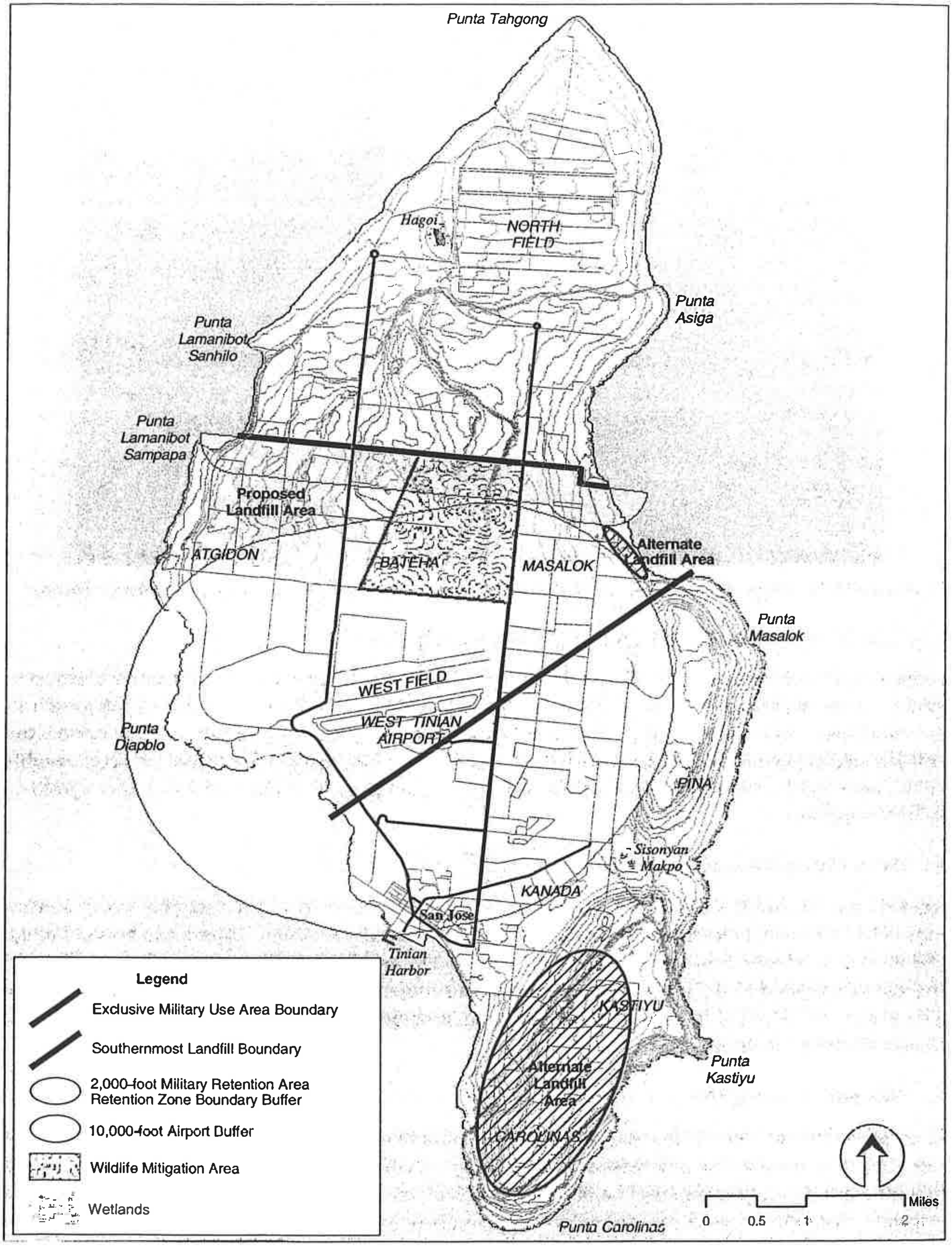


Figure 10: Proposed and Alternate Municipal Solid Waste Landfill Areas

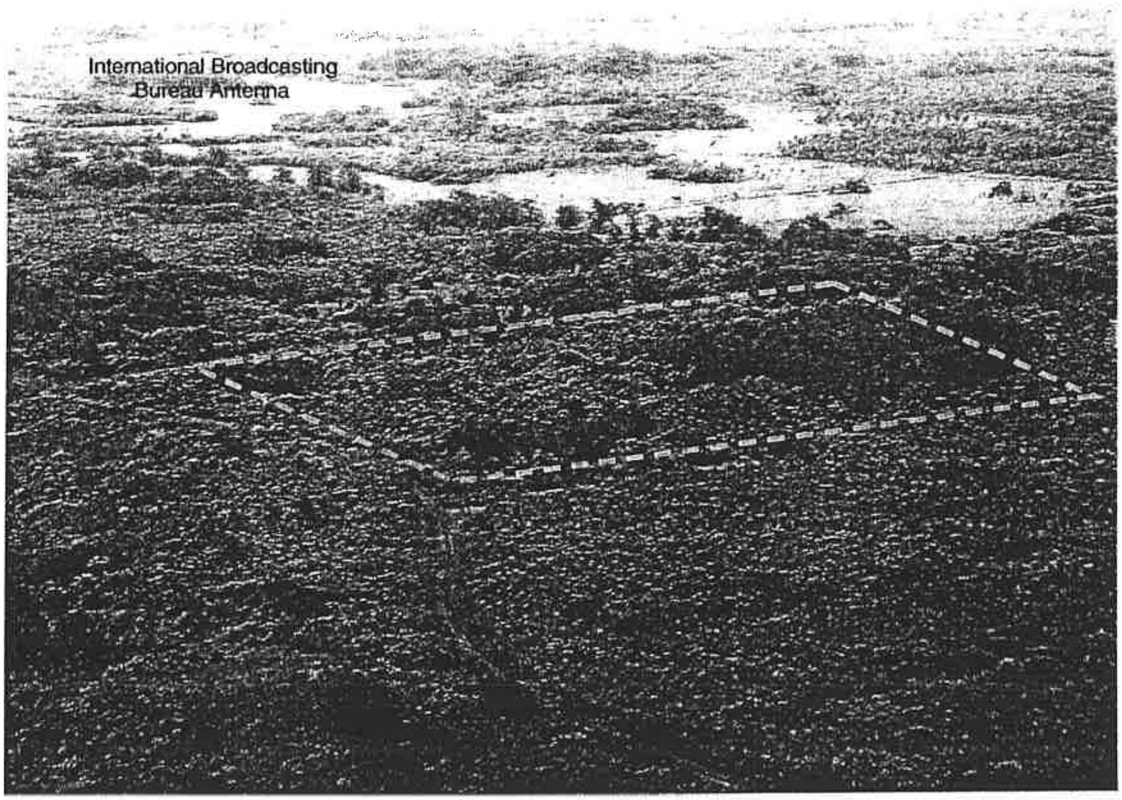


Figure 11: Municipal Solid Waste Landfill Proposed Location, Tinian Island (view facing NNE from Atgidon)

7.3.3 Construction/Demolition/Disaster Clean-up Disposal Area

An area at the landfill site should be established for construction, demolition, and disaster cleanup waste disposal. Large quantities of these wastes are inorganic in nature and do not need to be disposed in the lined municipal solid waste landfill. Typically, these wastes can be buried in an excavated trench, backfilled, and capped after completion of fill. However, any wastes that are organic (decomposable) or have the potential to cause groundwater contamination should be diverted to the municipal solid waste landfill for disposal.

7.3.4 Wood Waste/Woody Debris Staging Area

A graded area outside the landfill operational area should be considered for staging wood wastes and woody debris from land clearing and other natural clean vegetative wastes. These can be stockpiled and stored until a wood waste tub grinder can be barged to Tinian. The wood waste can be ground and used at the site or provided to the public as ground cover or mulch. Ground/processed wood waste or mulch can be used at the MSWL site for slope stabilization, erosion control, as a bulking agent for septage, or sold as landscaping material.

7.3.5 Asbestos Disposal Area

Like construction and demolition wastes, asbestos is inorganic and not a risk to groundwater or humans as long as it is handled and disposed appropriately. Asbestos-containing material (ACM) disposal regulations specify that the material be double bagged and promptly covered after disposal. Additionally the specific location of ACM burial sites must be posted with signs, and its location surveyed and recorded to avoid accidental excavation.

7.3.6 Septage Disposal Area

Currently the Municipality of Tinian has no wastewater treatment facility. As a result most households use septic systems that require periodic septage pumping. Pumped septage is currently unloaded and discharged at the north end of the existing open dump. Direct dumping of septage creates several problems including offensive odor, and spreading of pathogens and diseases associated with vectors around the dump site.

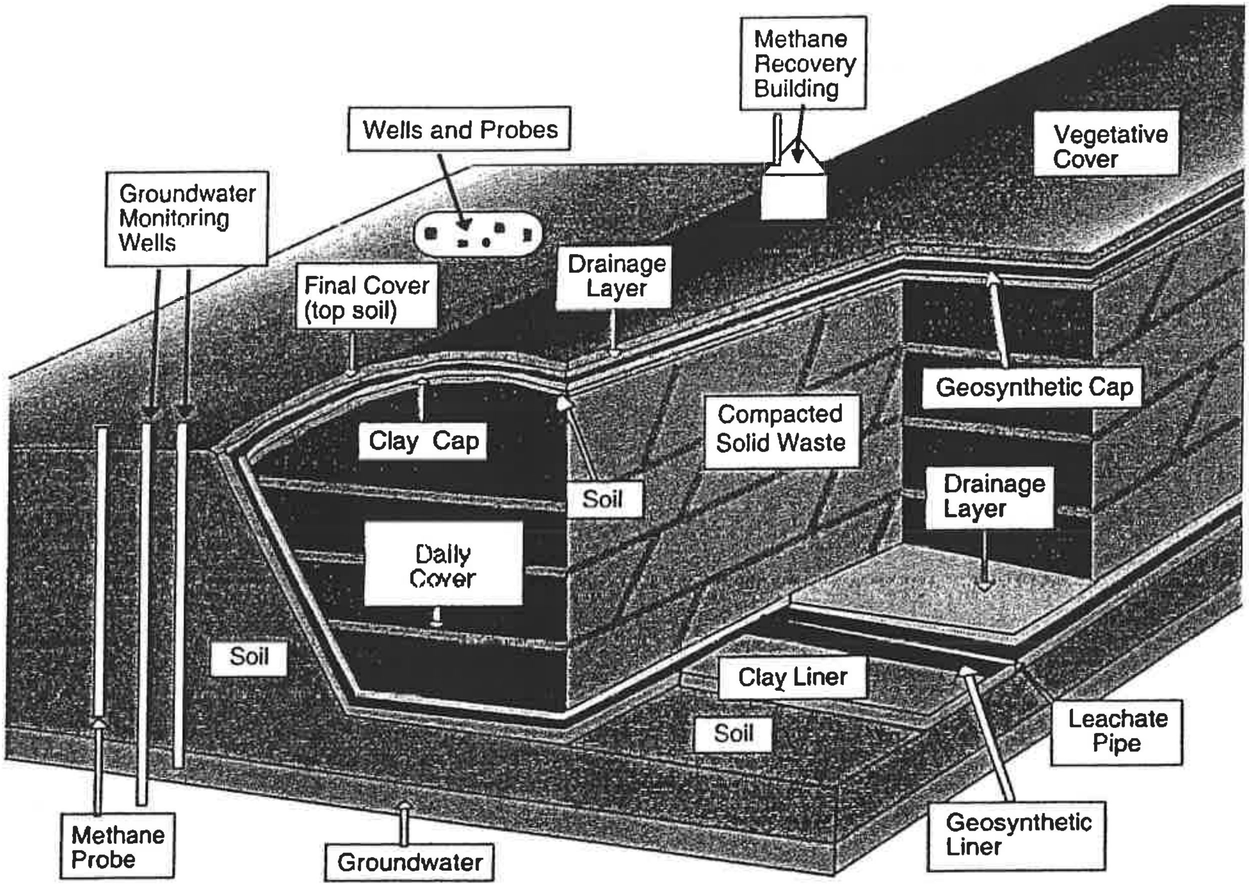
A new MSWL on Tinian Island should be equipped to provide for the disposal of septage until an alternate disposal option is available to include a treatment facility for septage dewatering and/or bulking. There area several options for septage disposal in rural or remote areas. Most require construction of treatment facilities to achieve volumetric reduction of septage received at the site.

A treatment facility at an MSWL can be planned and sized to accommodate the current and near-future quantity of septage generated on Tinian. Assuming the population increases by five percent a year as shown in Table 1 above, then a wastewater treatment plant should probably be constructed to serve the island. If constructed, a wastewater treatment plant would reduce the amount of on-island septage generated, and could also be designed to provide for treatment of septage as well as wastewater. The landfill could continue to receive biosolids from the treatment plant, and the septage facility could still be used for homes and businesses still on septic systems. The septage treatment facility likely would not need to be expanded under this latter scenario.

As discussed in section 6.3 above, septage volume reduction on Tinian is not a significant concern at this time. The current population of Tinian indicates only small amounts of septage would be generated over the near future. For planning septage disposal, a low-tech approach could be employed using a parallel series of lined sand drying beds for septage dewatering and biosolids disposal at the MSWL. To accommodate the wet season, sand beds could be covered or used as a blending area to add a bulking material to solidify the liquid for disposal in the landfill. Bulking agents could include daily cover soil, ground vegetative mulch, or other available moisture absorbing material.

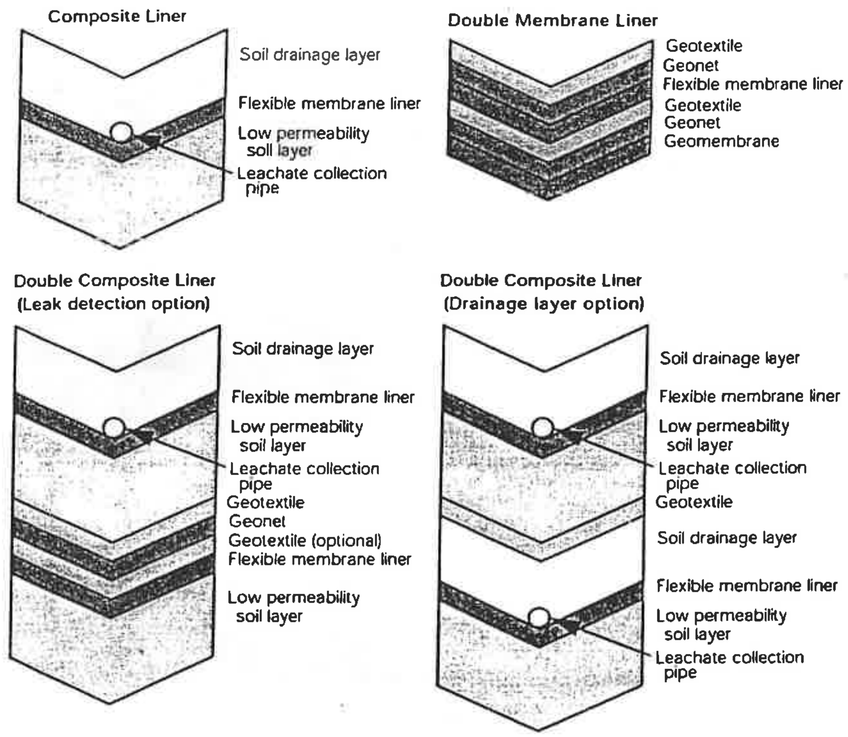
7.4 MUNICIPAL SOLID WASTE LANDFILL CONCEPTUAL PLAN

Figures 12 to 15 depict a typical MSWL and associated features.



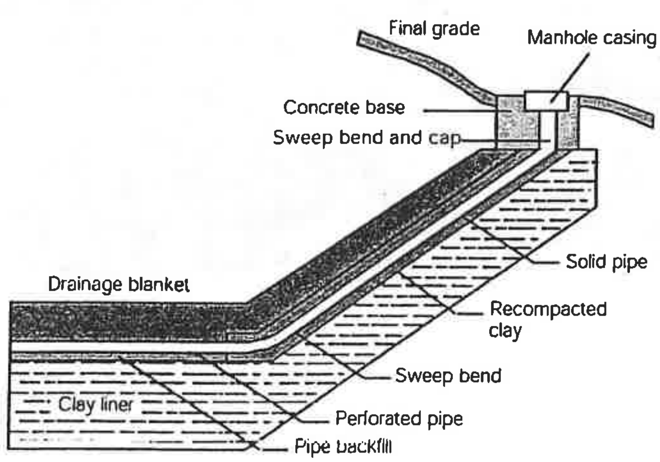
Source: P. O'Leary and P. Walsh, University of Wisconsin-Madison Solid and Hazardous Waste Education Center, reprinted from *Waste Age* 1991-1992

Figure 12: Typical Municipal Solid Waste Landfill Schematic (from O'Leary and Walsh 1995)



Source: P. O'Leary. University of Wisconsin–Madison Solid and Hazardous Waste Education Center, 1994

Figure 13: Landfill Liner System Examples (from O'Leary and Walsh 1995)



Source: P. Kmet, 1994

Figure 14: Typical Leachate Collection System (from O'Leary and Walsh 1995)

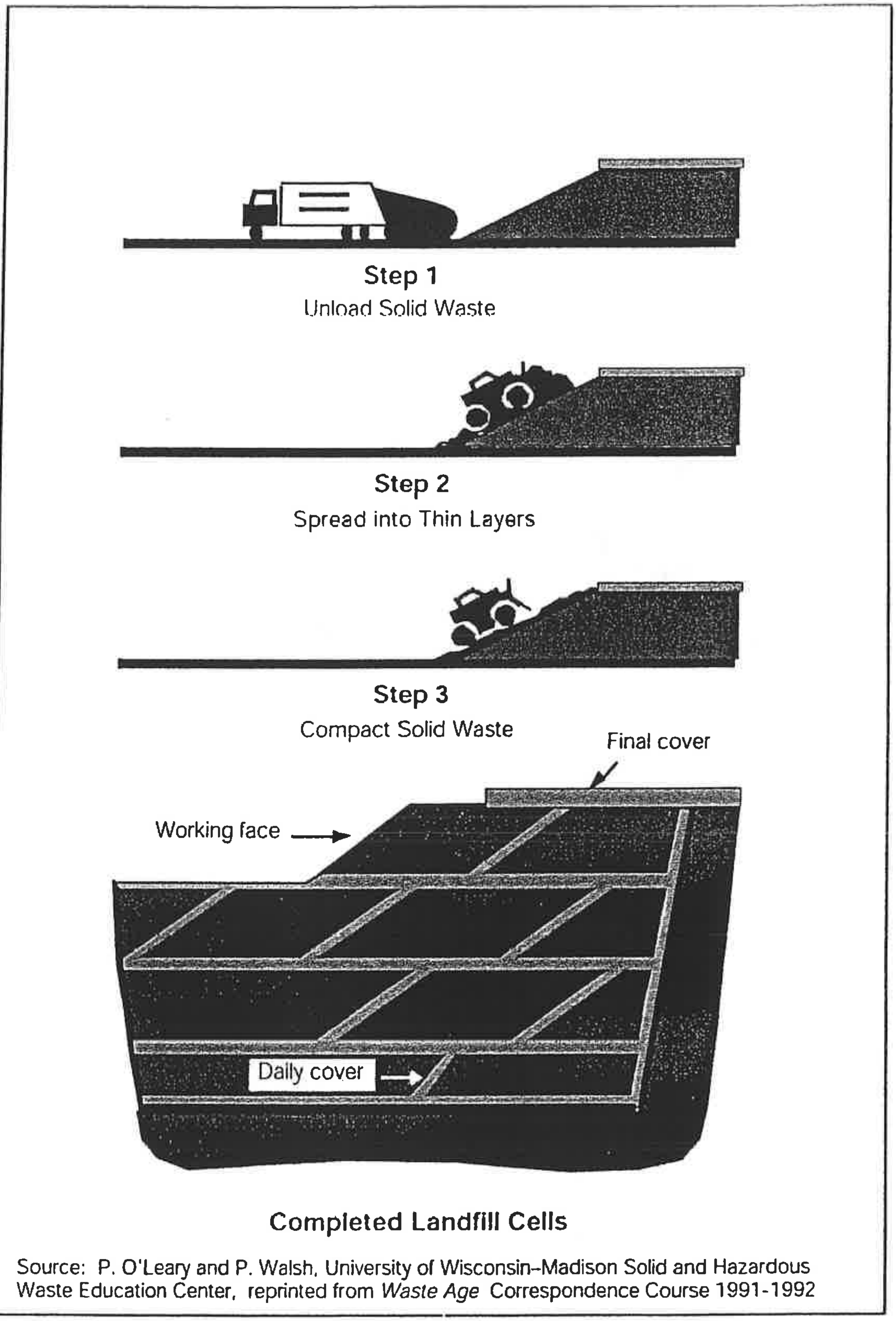


Figure 15: Solid Waste Placement and Compaction Example (from O'Leary and Walsh 1995)

Figures 16 to 24 present a conceptual layout and typical features of an MSWL that could be constructed and operated on Tinian. It includes the items described below.

- An entry scale and gate house. Office and maintenance building may be larger than currently necessary and could be added in the future. For now a temporary office and entry facility would suffice, with construction of permanent facilities in a subsequent phase.
- Access roads with litter and site fences around the site boundary and at the perimeter of the landfill.
- A perimeter storm collection and diversion system directed to a single detention pond. The storm water detention pond could easily be expanded if needed and portion of the pond could be lined and used for water storage to keep the leachate treatment system moist during the dry season.
- Two elongate, lined cells with leachate collected at a single low point and a single pump station. The landfill design and layout can be configured to allow expansion with additional cells continuing in the same pattern in the future if needed. Therefore, more cells can be added toward the wood waste storage area, mulch/compost storage, and topsoil soil stock pile.
- A septage treatment facility that may consist of three parallel beds with septage drainage decanted back to the leachate pump station.
- A construction debris/demolition/disaster cleanup (CD/D/DC) waste disposal area can be located along the entry side to allow for a separate access if needed in the future associated with a disaster (e.g., typhoon). The size could also be expanded away from the landfill if additional CD/D/DC space is needed in the future.
- A gas flare and blower would likely be needed from about the year 2020 to 2025 and could either be located near the septage treatment facility and leachate pump station (recommended) or by the office. Power would need to be available for these features.

7.5 LANDFILL CONSTRUCTION AND EXPANSION PHASING

Construction of an MSWL would be performed in phases as described below.

- Phase 1 would include the site fencing, excavation grading and lining of cell 1, construction of a leachate pump station, a leachate/septage decant treatment system, site roads and ditches, storm water detention pond and outfall, and environmental monitoring features.
- Phase 2 would include the expansion of the offices and maintenance structures, the first phase of the entrance gatehouse and a scale.
- Phase 3 would be for construction of the second cell and initial installation of the landfill gas collection system.

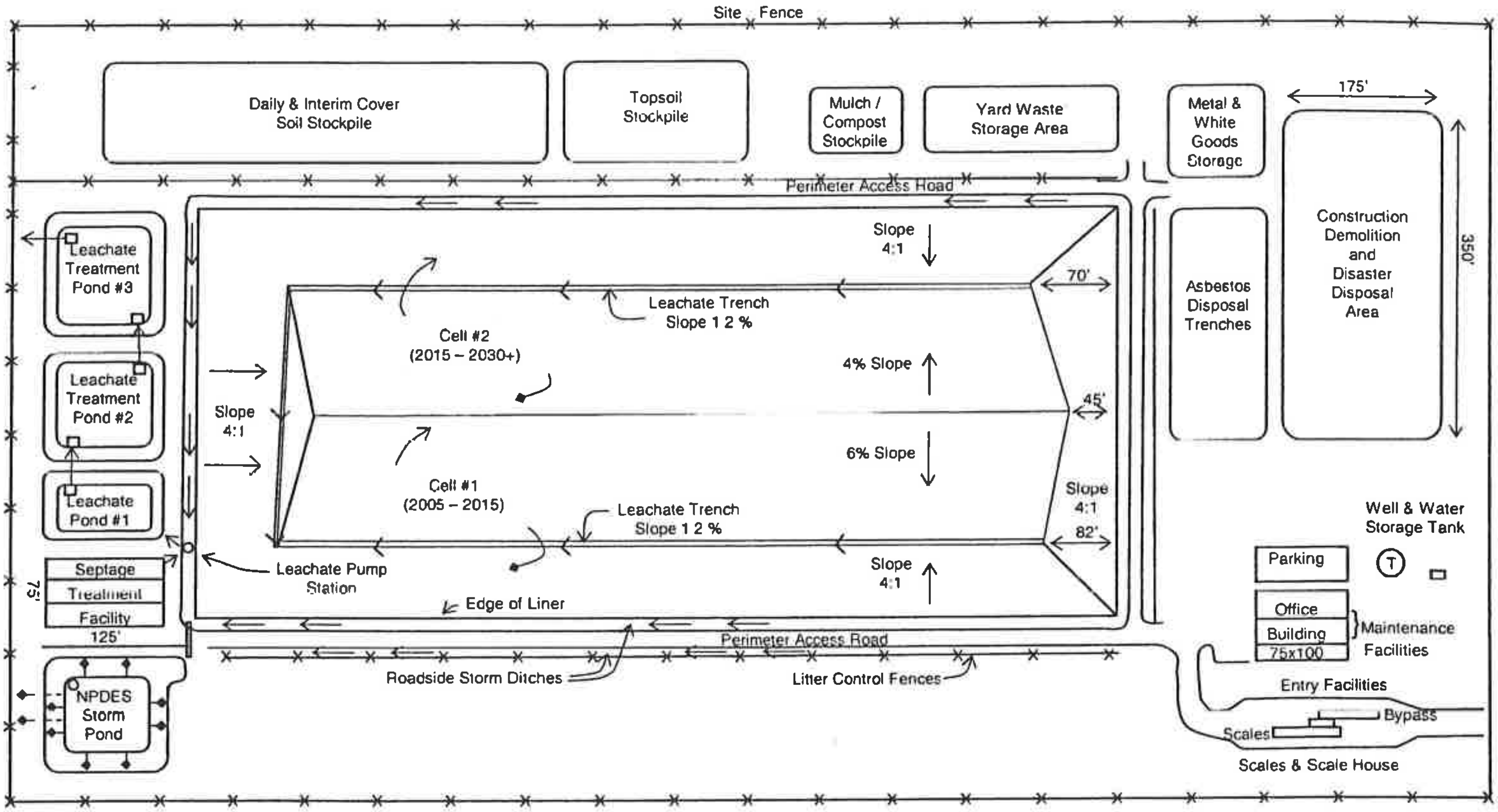


Figure 16: Tinian Municipal Solid Waste Landfill Conceptual Plan

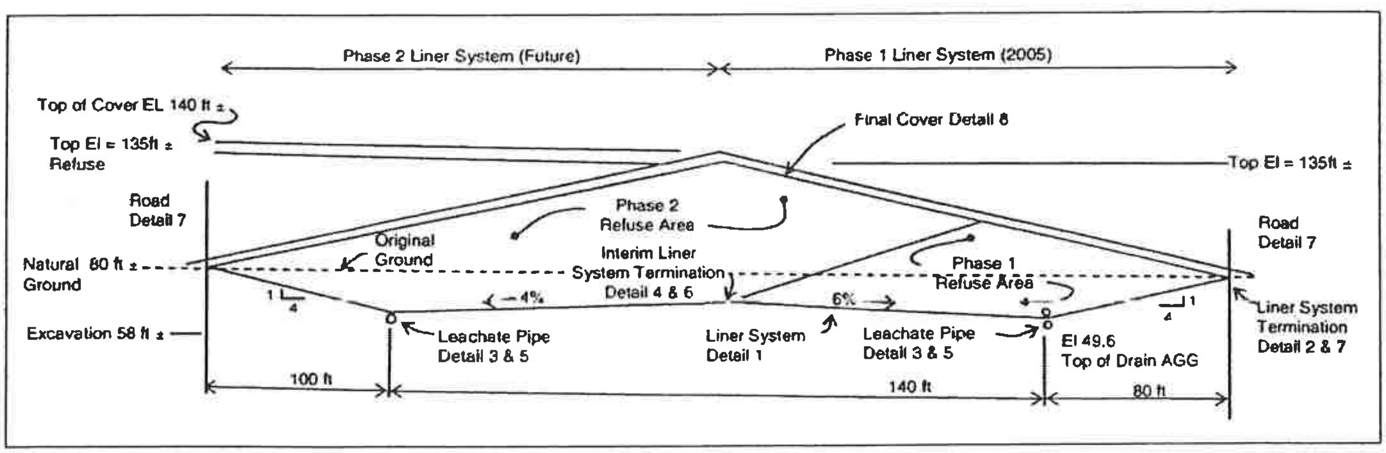


Figure 17: Tinian Municipal Solid Waste Landfill, Section View

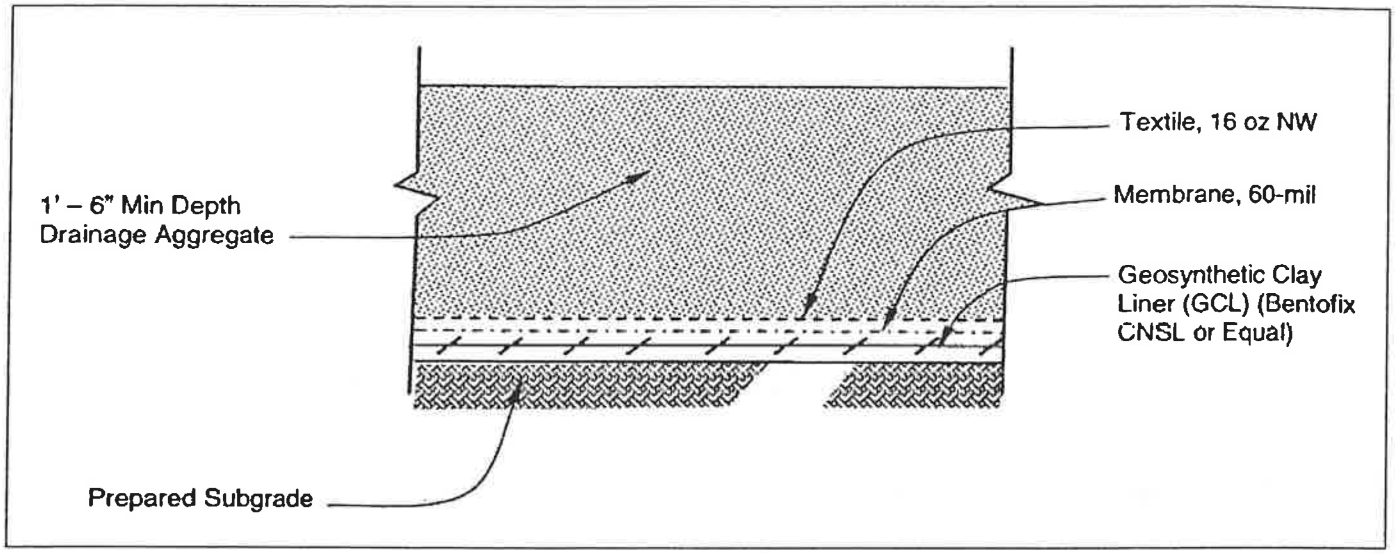


Figure 18: Detail 1 – Landfill Liner System

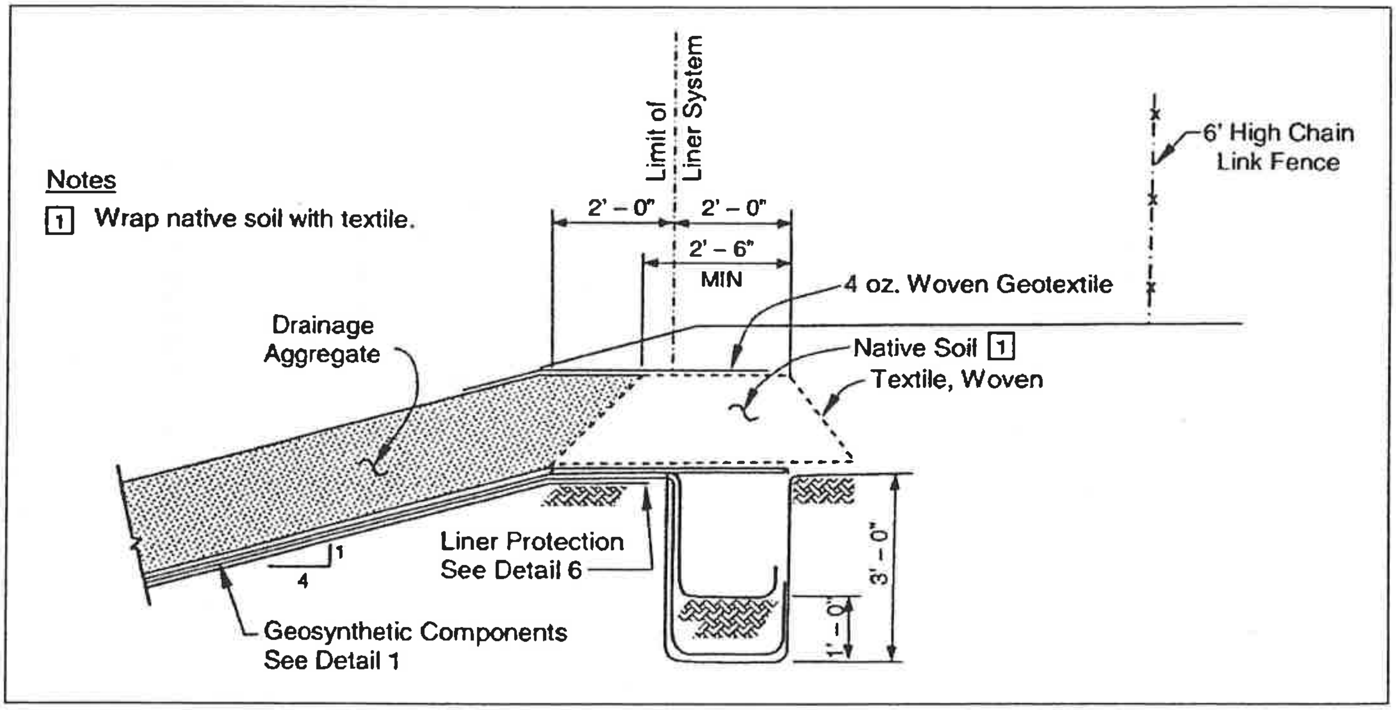


Figure 19: Detail 2 – Landfill Liner System Termination (South and East Sides)

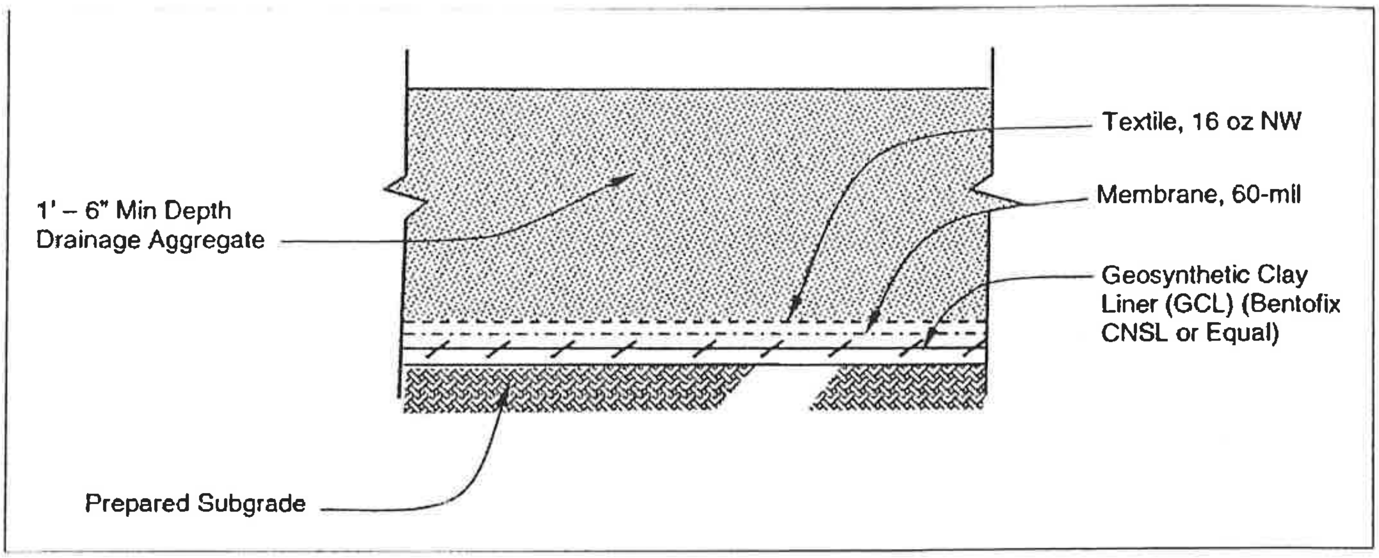


Figure 20: Detail 3 – Leachate Collection Trench

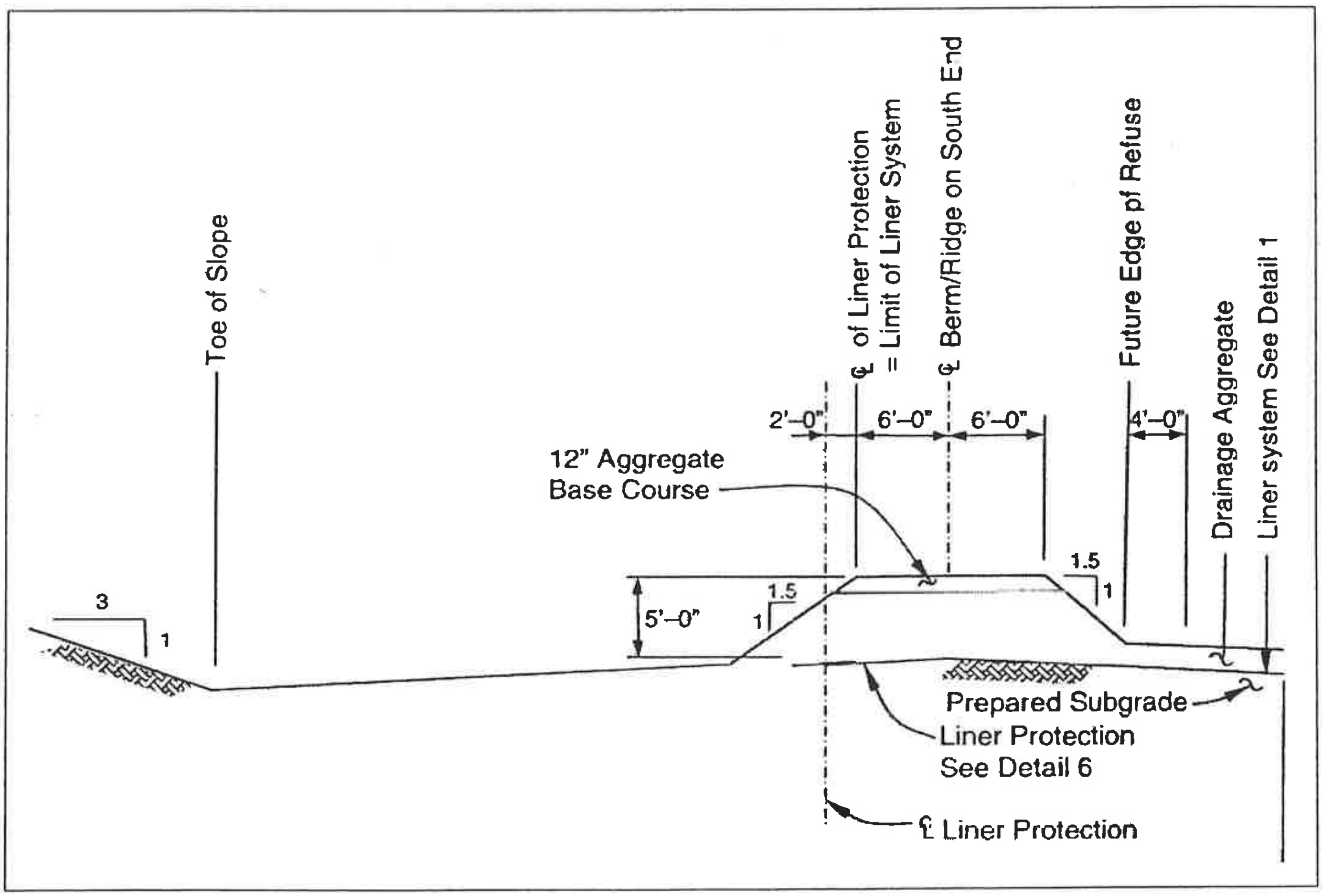


Figure 21: Detail 4 – Interim Liner System Termination (North Side)

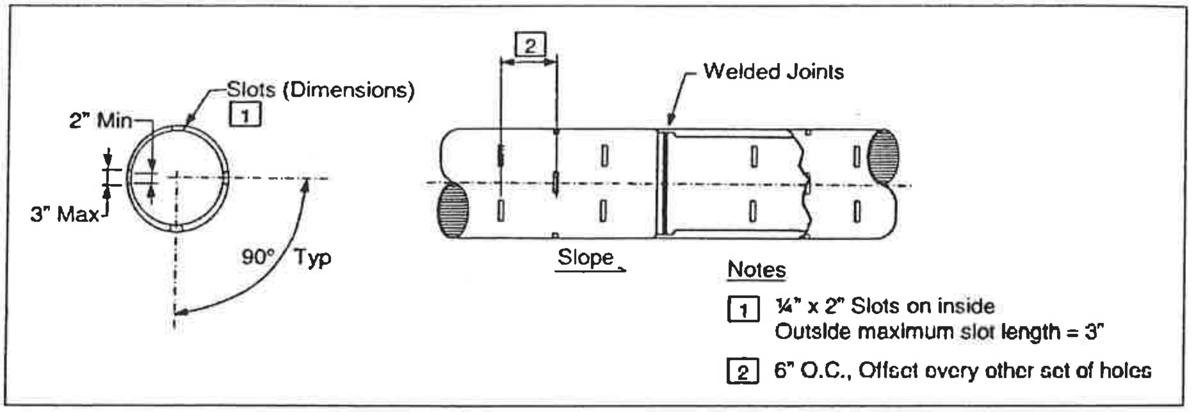


Figure 22: Detail 5 – Slotted Pipe

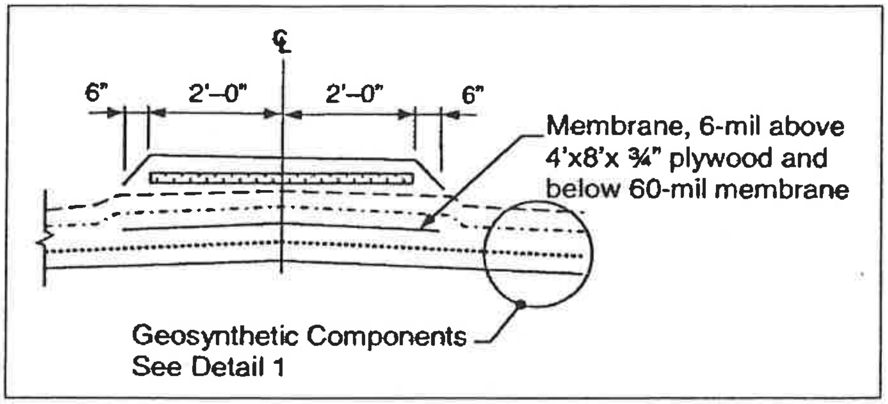


Figure 23: Detail 6 –Liner Protection

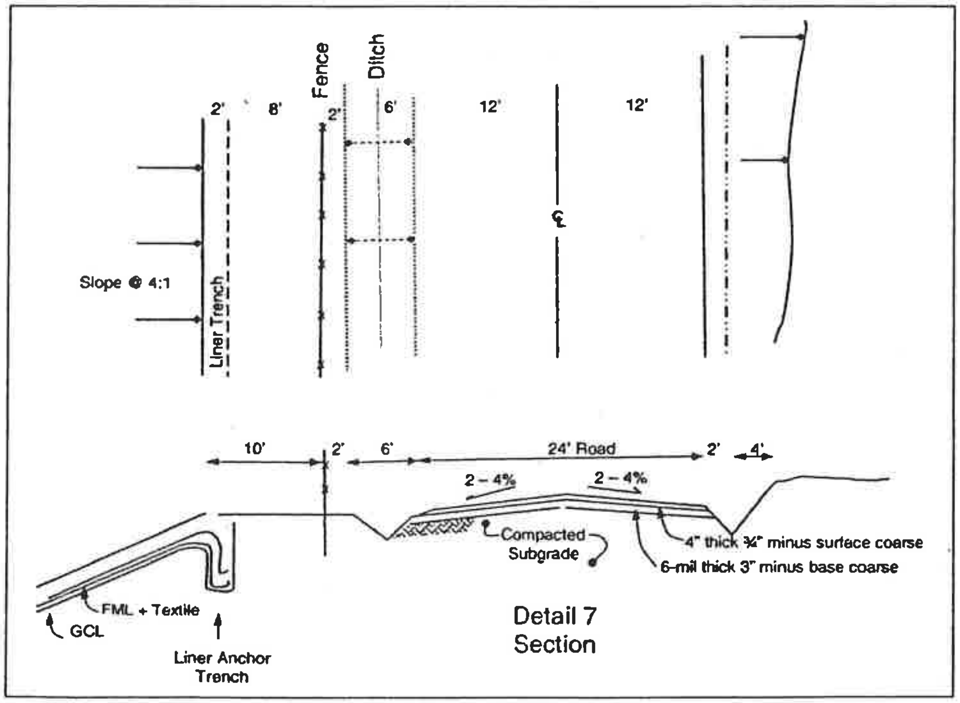


Figure 24: Detail 7 – Road, Section View

7.6 LANDFILL CAPITAL COST

The cost of landfill construction was estimated assuming the site would be located south of Puntan Lamanibot Sampapa as shown in Figures 10 and 11. Located west of 8th Avenue, the topography slopes gradually to the west towards the coast. The overall site would be laid out on a parcel approximately 1,600 feet long (east-west) by 850 feet wide (north-south) covering approximately 31 acres. The landfill would be located in the center portion of the site with a minimum 200-foot buffer around the actual landfill area. The landfill is estimated would be 1,000 feet long (east-west) by 440 feet wide (north-south) and would cover just over 10 acres. The landfill would be divided into two equal size cells 220 feet wide by 1,000 feet long.

The east side of the site would include entrance facilities, a CD/D/DC area, and ACM disposal trenches. The north side along the landfill would include a wood waste storage and processing area, a mulch/compost storage area, and construction stockpiles for topsoil, and daily cover. The west side of site would include storm water ponds, a septage treatment facility, a leachate pump station, and leachate treatment ponds.

As with the transfer station, construction cost of a landfill is dependent on site conditions such as topography, subsurface geology and soils, and site drainage. With only a conceptual layout and without such site-specific information, it is difficult to develop precise construction costs. The cost estimate presented in Table 12 and attendant flow chart are based on the same assumptions detailed in the transfer station section with the following additions:

- Site soils are suitable for excavation and use in the landfill as daily cover
- No environmental mitigation or special construction to avoid wetlands or endangered species, or other sensitive natural areas is required

A cost estimate to construct an additional landfill cell is presented in Table 13.

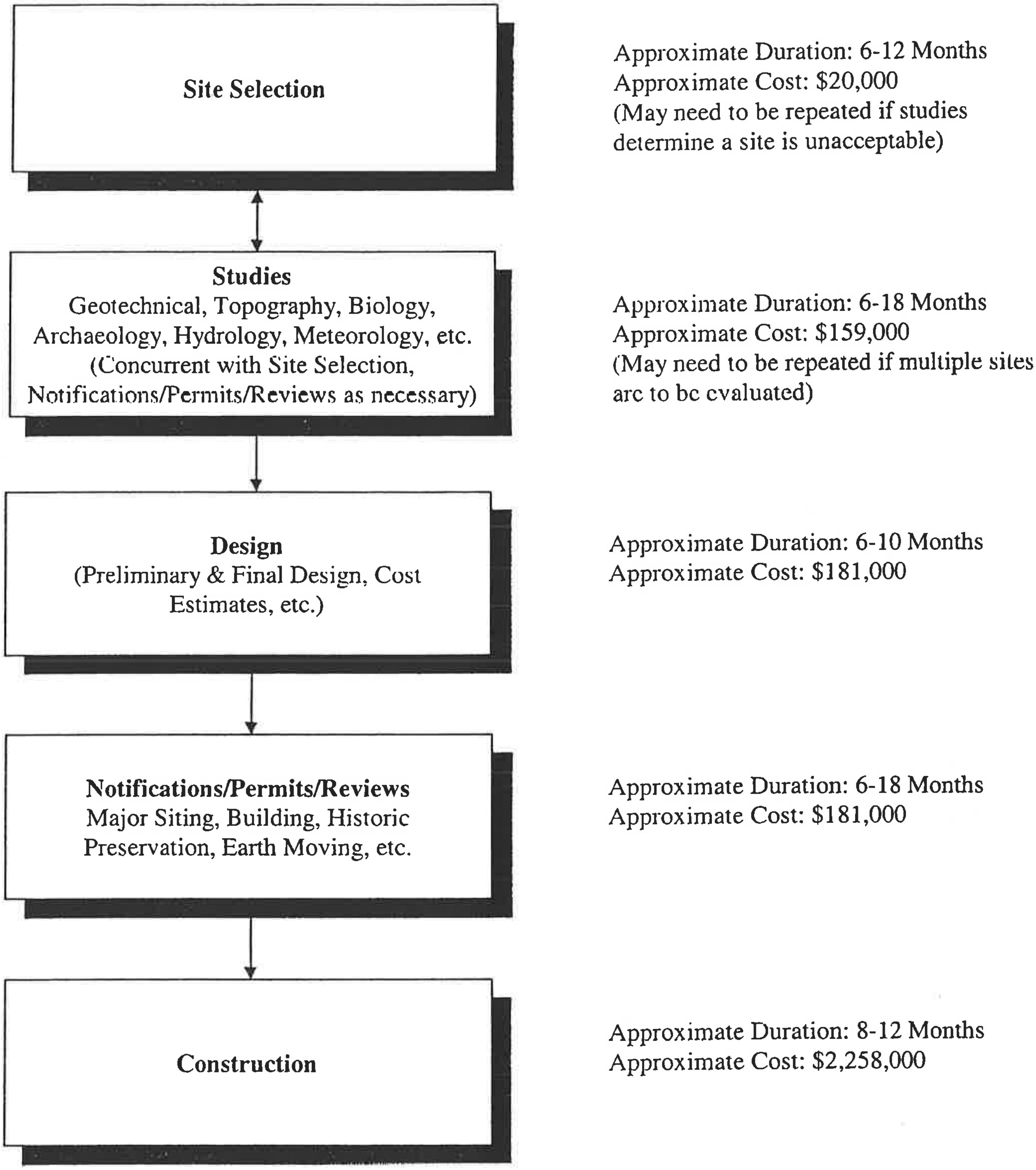
Table 12: Landfill Construction Cost Estimate

ITEM	Quantity	Unit	Unit Price	Price (rounded)	Category Subtotal
Site Work					
Landfill Site Access Road (from 8th Ave.)	2,667	SY	$15	$40,000	
Site Clearing	31	Acre	$5,000	$155,000	
Perimeter Site Fencing (5-strand barbwire)	5,000	LF	$6	$30,000	
Entrance Roads to Office & Landfill	1,800	SY	$15	$27,000	
On-Site Service Road Construction	4,500	SY	$10	$45,000	
Temporary Access Roads	2,500	SY	$10	$25,000	
Ditches & Culverts	4,000	LF	$3	$12,000	
Storm Detention Pond	1	LS	$25,000	$25,000	
Entrance Facility	5,000	LF	$24	$120,000	
Temporary Office	500	SF	$100	$50,000	$529,000
Environmental Controls					
Monitoring Wells	4	Each	$35,000.00	$140,000	$140,000
Landfill Cell No. 1					
Landfill Fencing and Gates (Chain Link)	3,000	LF	$12	$36,000	
Phase 1 Excavation & Stockpile	137,000	CY	$2	$274,000	$310,000

ITEM	Quantity	Unit	Unit Price	Price (rounded)	Category Subtotal
Liner System					
Subbase Preparation (Grade & Compact)	29,000	SY	$1	$29,000	
Liner/Geotextile Anchor Trench	1,500	LF	$4	$6,000	
Geotextile Cushion (16-ounce)	28,000	SY	$2	$56,000	
High Density Polyethylene Liner (60-mil)	28,000	SY	$6	$168,000	
Geosynthetic Clay Liner w/membrane	28,000	SY	$8	$224,000	
Particle Board at Liner Connection	200	Each	$15	$3,000	
Geotextile Separation Layer (8-ounce)	2,000	SY	$1	$2,000	
Drain Net in Leachate Trench	1,000	SY	$2	$2,000	
Leachate Collection Pipe (8-inch HDPE)	1,000	LF	$8	$8,000	
Aggregate - Drain Layer (In Place)	14,000	CY	$8	$112,000	$610,000
Leachate Pump Station					
Trench Ex. & Backfill (Header System)	80	LF	$40	$3,200	
Liner Penetration Seal	1	EA	$2,000	$2,000	
Leachate Pump Station	1	EA	$40,000	$40,000	
Valve/Meter Vault	1	EA	$22,000	$22,000	
Leachate Force Main	100	LF	$33	$3,300	
Extend Electrical & PS Controls	1	LS	$20,000	$20,000	$91,000
Construction					$1,680,000
Contractor Mobilization, Overhead, Profit	12	%			$202,000
CONSTRUCTION SUBTOTAL					**$1,882,000**
Geotech, Survey, Other Studies	7	%		$132,000	
Engineering Design	8	%		$151,000	
Notifications, Permits, Assessments	8	%		$151,000	
SERVICES SUBTOTAL					**$434,000**
Contingency	20	%			**$463,000**
LANDFILL TOTAL					**$2,779,000**
Equipment					
Integrated Tool Carrier (Septage Operation)	1	LS	$120,000	$120,000	
Compactor (Steel Wheel)	1	LS	$250,000	$250,000	
Dozer (Tracked w/ Overdrive)	1	LS	$200,000	$200,000	
Scraper (Excavating & Soil Cover)	1	LS	$250,000	$250,000	
Site & Maintenance Vehicles (2 pick-ups)	2	Each	$30,000	$60,000	
Misc. tools, equipment, etc.	1	LS	$20,000	$20,000	$900,000
EQUIPMENT COST					**$1,600,500**

CY = cubic yards
HDPE = high density polyethylene
LF = linear feet
LS = lump sum
oz = ounces
SY = square yards

LANDFILL CONSTRUCTION PROCESS



Note 1: Approximate costs include a 20 percent contingency factor.
Note 2: Equipment costs are not included.

Table 13: Additional Landfill Cells Construction Cost Estimate

ITEM	Quantity	Unit	Unit Price	Price (rounded)	Category Subtotal
Site Work					
Landfill Fencing and Gates (Chain Link)	1,500	LF	$12	$18,000	
Phase 2 Excavation & Stockpile	137,000	CY	$2	$274,000	
Ditches & Culverts	1,500	LF	$3	$4,500	$297,000
Environmental Controls					
Monitoring Wells	2	Each	$35,000	$70,000	$70,000
Liner System					
Subbase Preparation (Grade & Compact)	29,000	SY	$1	$29,000	
Liner/Geotextile Anchor Trench	1,500	LF	$4	$6,000	
Geotextile Cushion (16-ounce)	28,000	SY	$2	$56,000	
High Density Polyethylene Liner (60-mil)	28,000	SY	$6	$168,000	
Geosynthetic Clay Liner w/membrane	28,000	SY	$8	$224,000	
Geotextile Separation Layer (8-ounce)	2,000	SY	$1	$2,000	
Drain Net in Leachate Trench	1,000	SY	$2	$2,000	
Leachate Collection Pipe (8-inch HDPE)	1,500	LF	$8	$12,000	
Aggregate - Drain Layer (In Place)	14,000	CY	$8	$112,000	$611,000
Construction					$978,000
Contractor Mobilization, Overhead, Profit	12	%			$117,000
CONSTRUCTION SUBTOTAL					**$1,095,000**
Agency Notification, Consultation	1	%		$11,000	
Geotech, Survey, Other Studies	7	%		$77,000	
Engineering Design	8	%		$88,000	
Permits, Reviews	1	%		$11,000	
SERVICES SUBTOTAL					**$187,000**
Contingency	20	%			**$256,000**
ADDITIONAL LANDFILL CELL TOTAL					**$1,538,000**

CY = cubic yards
HDPE = high density polyethylene
LF = linear feet
oz = ounces
SY = square yards

ADDITIONAL LANDFILL CELL CONSTRUCTION PROCESS

Agency Notification/Consultation

Approximate Duration: 3-6 Months
Approximate Cost: $13,000

↓

Studies
Geotechnical, Topography, etc.

Approximate Duration: 6-12 Months
Approximate Cost: $92,000

↓

Design
(Preliminary & Final Design, Cost Estimates, etc.)

Approximate Duration:3-6 Months
Approximate Cost: $106,000

↓

Permits/Reviews
Building, Earth Moving, etc.

Approximate Duration: 3-6 Months
Approximate Cost: $13,000

↓

Construction

Approximate Duration: 6-12 Months
Approximate Cost: $1,314,000

Note 1: Approximate costs include a 20 percent contingency factor.

7.7 LANDFILL OPERATING COST

7.7.1 Staffing

The Tinian landfill operation would be very small compared to most new and existing facilities meeting RCRA Subtitle D regulations. It is estimated that initially only 17 tons of waste would be generated on a daily basis; this amount would not justify having the landfill open every day. The operational requirements of Subtitle D require waste be compacted and covered daily. Covering the emplaced solid waste on a daily basis would result in the landfill being filled with more cover material than waste. Therefore, initially the landfill should only be open 3 to 4 days a week or 2 to 3 weekdays and 1 weekend day. This could be accomplished by coordinating with trash haulers and the transfer station to limit deliveries to specific days.

Work days are assumed in this study to be 4 days at 10 hours each to allow full-time operations. The mechanic could be shared with transfer station operations to provide a single Full-Time Equivalent (FTE). The following table assumes that two equipment operators would be available to spread and compact the waste, deliver and spread the daily cover, and assist with operation of the septage facility. A site attendant would also be needed to record deliveries, perform site activities including, maintenance, litter control, monitor and maintain the leachate treatment and pumping systems, and respond to customer inquiries. It is assumed one of the equipment operators would be the site superintendent until the waste volume increases to a level justifying a full-time manager.

7.7.2 Operating Cost Estimate

The following table presents an approximate annual estimate to operate the landfill described above. These are preliminary costs based on a conceptual, non-site-specific facility, and staffing levels described above. These assumptions may change depending on actual site operations and site conditions. Budget adjustments will be required each year to account for actual expenses encountered, general inflation, and escalation in the cost of labor, fuel, and other materials.

Table 14: Landfill Annual Operating Cost Estimate

ITEM	Quantity	Unit	Annual Salary	Benefits 37%	Price (rounded)
Labor					
Site Attendant	1	FTE	$18,000	$6,660	$25,000
Equipment Operator/Laborer	1	FTE	$21,000	$7,770	$29,000
Supervisor	1	FTE	$35,000	$12,950	$48,000
Mechanic	0.5	FTE	$25,000	$9,250	$17,000
Miscellaneous			Unit Price		
Fuel: 4 days/week, 4 hours/day; 10 gal/hr; $3/gal	8,000	Gal	$3		$24,000
Groundwater Monitoring (semi-annually)	2	Each	$6,000		$12,000
OPERATIONAL COST TOTAL					**$155,000**
Contingency	10	%			$15,500
FTE = Full-Time Equivalent Gal = gallons					

7.8 LANDFILL CLOSURE COST

A municipal solid waste landfill must be closed in accordance with a DEQ-approved closure plan. The goal of closure and post-closure care is to minimize the need for site maintenance, and to ensure the long-term protection of human health and the environment.

7.8.1 Financial Assurance for Closure and Post-Closure Care

Federal standards require that landfill owners and operators, including municipalities that operate landfills, have financial assurances in place to cover the costs of closure and post-closure. Financial assurance is also required when corrective action is necessary to clean up releases of hazardous constituents to groundwater. Several mechanisms are allowed, including trust funds, surety bonds, letters of credit, insurance, a state/tribal approved mechanism, state/tribal assumption of responsibility, and use of multiple mechanisms.

Closure and post-closure cost estimates used to determine the amount of coverage required must be based on the cost of closing the landfill at a point in the landfill's active life when the extent and manner of its operation would make closure and post-closure care the most expensive. Furthermore, estimates must reflect the cost that a third party would incur in conducting closure and post-closure activities. The estimates must be updated yearly to account for inflation and whenever changes to the closure and post-closure plans occur, or when facility modifications increase the closure/post-closure cost. The MSWL owner or operator must increase the level of financial assurance provided whenever the cost estimates increase. Critical technical issues that must be faced by the designer include the following:

- The degree and rate of post-closure settlement and stresses imposed on soil liner components
- The long-term durability and survivability of the cover system
- The long-term waste decomposition and management of landfill leachate and gases
- The environmental performance of the combined bottom liner and final cover system

7.8.2 Landfill Closure

The primary objectives of MSWL closure are to establish low-maintenance cover systems and to design a final cover that minimizes rainfall infiltration at the site. Installation of a final cover must be completed within 6 months of the last volume of solid waste received. Procedures for placing a cover over the landfill are usually defined during site design. If no cover design is available, specifications must be prepared.

7.8.3 Post-Closure

Post-closure care of an MSWL commences upon completion of the closure process. The post-closure care period can be 30 years, but some jurisdictions can choose to shorten or lengthen the interval. During this period the MSWL owner or operator is responsible for providing for the general upkeep of the landfill, maintaining all of the landfill's environmental protection features, operating monitoring equipment, remediating groundwater should it become contaminated, and controlling landfill gas migration or emissions.

After closure, the landfill site may appear inactive, but biological activity in the landfill cells will continue resulting in settlement as the waste consolidates. Settlement will cause depressions in the cover and stresses on the cover requiring repair. A few years after closure, the settlement rate should slow, necessitating less repair work of this type.

Settlement may affect MSWL access roads, which must be maintained so equipment can reach monitoring points at the site without damaging the cover. Access roads may also experience settlement and erosion problems. Additionally, drainage patterns on the landfill may be diverted as settlement occurs.

Leachate will continue to be generated after the landfill is closed. The quantity should diminish if a good cover was placed over the landfill. The chemical composition will also change as the landfill becomes more biologically stable with pollutant concentrations slowly diminishing. Leachate collection and treatment generally will be necessary throughout the entire post-closure care period. Pumps and other leachate collection equipment must be operated and serviced. Every few years, leachate lines must be cleaned. On-site leachate treatment facilities must be maintained and operated. Where leachate is transported off-site, arrangements for trucking and treatment must be continued.

Groundwater beneath the landfill must be monitored during the post-closure care period. If contamination is detected, RCRA Subtitle D specifies a procedure for more intensive monitoring and corrective action.

The operation of landfill gas control and monitoring systems will need to continue for many years after a landfill is closed. Failure to operate and maintain the system may result in damage to the vegetative cover of the landfill and off-site migration of landfill gases. RCRA Subtitle D requirements specify that gas monitoring probes around the landfill be tested on a quarterly basis each year. Where landfill gas migration is detected near occupied structures, more frequent monitoring is recommended. If regulatory standards for migration are exceeded, improved migration control and landfill gas recovery facilities maybe necessary. An MSWL may need to be retrofitted for gas control if a system is not already in place.

Table 15 presents an estimated cost for municipal solid waste landfill closure and post-closure care. Note that, as stated above, closure and post-closure costs to be incurred by the Municipality of Tinian will be dictated by an approved closure plan, with said costs reviewed and updated annually to account for inflation and site changes.

Table 15: Landfill Closure and Post-Closure Cost Estimate

ITEM	Quantity	Unit	Unit Price	Price (rounded)	Category Subtotal
Site Work					
Install 2 feet Soil for Liner (Grade/Compact)	36,000	CY	$2	$72,000	
Geotextile Cushion (16-ounce)	54,000	SY	$2	$108,000	
High Density Polyethylene Liner (60-mil)	54,000	SY	$6	$324,000	
Strip Drains (every 100 feet)	4,000	LF	$7	$28,000	
Cover Soil 2.5 feet over Liner	45,000	CY	$8	$360,000	
Seed Cap with Local Grasses	11	Acres	$5,000	$55,000	$947,000
Construction					$947,000
Contractor Mobilization, Overhead, Profit	12	%			$114,000
CONSTRUCTION SUBTOTAL					**$1,061,000**

ITEM	Quantity	Unit	Unit Price	Price (rounded)	Category Subtotal
Agency Notification, Consultation	1	%		$11,000	
Geotech, Survey, Other Studies	7	%		$74,000	
Engineering Design	8	%		$85,000	
Permits, Reviews	2	%		$21,000	
SERVICES SUBTOTAL					**$191,000**
Contingency	20	%			**$250,000**
CLOSURE TOTAL					**$1,502,000**
Post-Closure Maintenance (Annual)					
Repair Soil Cover (Grade/Compact)	1,500	CY	$2	$3,000	
Geotextile Cushion (16-ounce)	2,000	SY	$2	$4,000	
High Density Polyethylene Liner (60-mil)	2,000	SY	$6	$12,000	
Strip Drains (Every 100 feet)	125	LF	$8	$1,000	
Seed Cap with Local Grasses	0.50	Acres	$5,000	$2,500	
Mobilization & Contracting	1	LS	$5,500	$5,500	
Environmental Monitoring & Reporting	1	LS	$25,000	$25,000	$53,000
ANNUAL MAINTENANCE TOTAL					**$53,000**
CY= cubic yards					
LF = linear feet					
SY = square yards					

7.3.9 Other Municipal Solid Waste Processing Technologies

A number of solid waste processing technologies have been suggested for consideration on Tinian. These include incineration, bioreactors, solid waste composting, and proprietary technologies such as Hydromex, ethanol generation, gas or oil production, etc. While a detailed analysis of these technologies is beyond the scope of this study, the following is a brief, general description of each technology: Estimated costs are provided when known or available in the public domain.

- **Incineration.** Waste can be burned in an incinerator consisting of several refractory-lined chambers. The waste rests on a grate that is periodically agitated to promote better burning. Depending on the quantity of waste to be burned, there are several different styles of incinerators. For Tinian's anticipated waste stream, a modular, controlled-air incinerator would be appropriate.

  The gases that result from the combustion process require treatment through air pollution control (APC) equipment to remove particulate matter, acid gases, dioxins, and other dangerous compounds. The APC equipment can cost as much or more than the incinerator. Monitoring air emissions and maintaining APC equipment is expensive. Incinerators are often required to repeat their air emissions tests each year until sufficient operating data is obtained. The annual cost of testing can easily exceed $25,000.

  The resulting ash (partially burned and non-combustible material such as glass and metal) requires disposal in a landfill. Ash is tested by leaching with an acid solution to determine its potential for leaching heavy metals. Depending on local regulations, the test results can determine whether the ash must be disposed in a hazardous waste landfill; in a special ash landfill; or in a regular solid waste landfill. It should be noted that a landfill will still be necessary to receive objects that are either unburnable by nature or are too large to fit into the incinerator (e.g., old appliances, auto bodies, tree stumps, concrete from demolition, etc.)

By recovering heat from the combustion gases, it is possible to generate steam to drive a steam turbine that turns an electrical generator. Because the quantity of waste on Tinian is relatively small, it is unlikely that the sale of electricity will pay back the additional cost of the steam boiler, steam turbine, and electrical generator in a timely manner.

In general, the public does not favor incineration. Additional steps are necessary to obtain environmental permits and public support for an incinerator project. A health risk assessment based on computer modeling of local weather conditions and anticipated air emissions will probably be required. The cost of just the health risk assessment and air emissions modeling can easily exceed $100,000..

Siting, permitting, design, construction, and initial air emissions testing of an incinerator for Tinian could easily cost $2-3 million. Annual operating costs including ash disposal and air emissions testing could exceed $100,000. In summary, incineration on Tinian is likely to result in higher waste disposal capital and operating costs than a landfill. Furthermore, the permitting process and the actual operation of an incineration facility will be much more complicated than a normal solid waste landfill, which will still be required.

- **Biodegradation.** Waste is decomposed in a tank or in a landfill using bacteria. Decomposition produces contaminated liquids (leachate) and odorous, noxious or potentially explosive gases (e.g., methane) that require treatment.
- **Solid Waste Composting.** Inorganic materials (e.g., metals, glass and plastic) are removed using various types of mechanical and magnetic equipment. The remaining organic material is reduced to a suitable size through shredding and other mechanical means, then decomposed by bacteria in an aerated environment. The material may be composted in piles, windrows, or enclosed vessels. Aeration is supplied by using blowers to force air up or vacuums to suck air down through the piles, or by frequent turning and agitation using paddles or earth-moving equipment. The compost must pass a variety of tests to show that it is safe for agricultural and landscaping uses, otherwise the product will have little economic value.
- **Hydrometallurgical Extraction**. Commonly referred to as "Hydromex," this technology sorts, grinds, and shreds solid waste that can be mixed with polymers to produce building materials. The technology, however, cannot process wet waste. There are as many as four such facilities presently operating in the Philippines and U.S.
- **Ethanol/Methanol Generation**. The organic portion of solid waste is fermented in tanks to produce various forms of alcohol. The process essentially requires a small chemical plant with sophisticated equipment and controls, and a highly trained staff. Consistently producing a high quality product and finding stable long-term markets for the alcohol are major challenges.
- **Gas Production**. Through various combinations of chemical, biological, and heating processes, a combustible gas is driven off from the waste. After moisture and contaminants are removed, the gas can be burned in boilers or other heating equipment. The process essentially requires a small chemical plant or refinery, with sophisticated equipment and controls, and a highly trained staff. Consistently producing a high quality product and finding stable long-term markets for the produced are major challenges. It may be difficult to persuade equipment manufacturers to modify and certify their equipment to run on this gas. If the gas is not utilized by local industries,

it will not be economical to transport the gas off-island for sale elsewhere. Power plant capitalization cost in conjunction with methane gas production facility can be on the order of $600,000 to $1 million per megawatt.

- **Oil Production**. Through various combinations of chemical, biological, and heating processes, combustible oil is distilled from solid waste. After moisture and contaminants are removed, the oil can be burned in boilers or other heating equipment. As with gas production, the process would require a small chemical plant or refinery with specialized equipment and a highly trained staff. The technology is also challenged by the production of a consistently high quality product, long-term market demand, and manufacturer willingness to modify and certify their equipment to run on the oil. Off-island transportation of the oil may be costly if not consumed locally.

In general, the aforementioned solid waste processing technologies and others have the following disadvantages with respect to Tinian:

- A municipal solid waste landfill will still be required as alternative solid waste management technologies are incapable of treating all waste streams and will likely generate process byproducts requiring additional treatment or disposal.
- While a landfill may be smaller when designed for use in conjunction with an ancillary processing technology, the total cost for all the components will most likely be greater than for just the landfill alone. Thus, the use of an alternative technology will increase overall project capital and operating costs.
- Few solid waste processing technologies produce a saleable product for which there is wide acceptance and a proven, stable, long-term market. Experience has shown that: 1) the product quality is low, its output is variable, and market prices are low or fluctuate greatly; or 2) it is difficult to persuade industrial and commercial facilities to use non-standard gas and oil products in their heating equipment.
- Except for incineration under certain conditions, none of the alternative technologies has a proven track record of being financially self supporting (i.e., revenues exceed capital and operating costs).
- Complex mechanical, electrical, and control equipment is required. Spare parts will be difficult to obtain. It is unlikely that knowledgeable service technicians will be readily available to repair or bring equipment back on line.
- Since many innovative solid waste processing technologies are proprietary, it is difficult to obtain detailed technical and financial data from an objective, unbiased third party to substantiate the manufacturer and vendor claims.
- Performing a detailed analysis of the array of solid waste processing technologies at this time—while essential to informed and intelligent decision making—is likely to be time consuming and detract from the urgent and unavoidable task of permitting and constructing a new landfill that meets current environmental regulations, and to permanently close the extant open dump.

If the Municipality of Tinian is contemplating the use of one or more solid waste processing technologies ancillary to an MSWL, it should obtain answers to at least the following concerns and questions. Only when satisfactory responses have been obtained should the Municipality seriously consider a solid waste processing technology for on-island application: The following criteria should be considered in the decision-making process to employ ancillary waste processing technology to an MSWL:

- Details of the biological, mechanical, and chemical processes employed by the technology.
- Byproducts (waste products), emissions (air, water, noise, etc.), and saleable products (if any).
- Track record of reliability at multiple facilities for at least a continuous 5-year period.
- Track record of reliability at a facility where the technology was operated by someone other than the technology's developers/vendors.
- Independent, third-party reviews of the technology's performance at specific sites.
- Is the technology appropriate for the low volume of waste generated on Tinian?
- Is the technology relatively simple to use, operator-friendly, does not require extensive operator training, and would not be considered "high tech" compared to landfilling?
- Is there a local company that would operate the technology, and can document its applicable experience and trained personnel?
- If a saleable product is generated, who will buy it? How will it be marketed and exported or used locally? What will happen to product that cannot be sold?
- Because other components of the solid waste system (i.e., landfill, septage facility, and transfer station) would still be required, how much smaller (less expensive) could they be made as a result of using the alternative technology?
- How would the process handle debris from construction, demolition, or disaster clean-up?
- How would the process handle asbestos and vegetative/wood waste?
- Describe the treatment, control and/or disposal of leachate, air and water emissions, noise, and non-saleable byproducts.
- Describe other required equipment and facilities.
- Describe the labor requirements and types of education and training necessary.
- How much land area is required?
- Does the process require holding tanks or ponds, chemical addition, or nutrient feeders?
- What are the power requirements?
- Tinian is a rural and isolated location relative to the availability of spare parts and having repairs performed. How sensitive is the process to power outages, lack of spare parts, equipment shutdowns, and other challenges associated with the location?
- Who will carry the financial risk if the technology fails to perform as advertised? What sorts of performance guarantees are provided?

- Any project, or proposed project, that may cause underground injection of hazardous wastes, of fluids used for extraction of minerals, oil and energy, and of certain other fluids with potential to contaminate ground water
- Any other proposed project which by consensus of the CRM Agency Officials, has the potential for causing a direct and significant impact on coastal resources including any project having a peak demand of 500 kilowatts per day and/or 3,500 gallons of water per day as established by CUC demand rates for particular types of projects
- Proposed projects that modify areas that are particularly susceptible to erosion and sediment loss; areas that provide important water quality benefits and/or are necessary to maintain riparian and aquatic biota and/or necessary to maintain the natural integrity of water bodies and natural drainage systems

Additionally, an environmental assessment is required for all CRM major sitings. Six CNMI agencies partner with CRM to review each major siting permit application and attendant environment assessment. The agencies are Commonwealth Utilities Corporation, Department of Commerce, Department of Land and Natural Resources, Department of Public Works, Historic Preservation Office, and DEQ. As a minimum, each permit application and assessment must include the following items:

- Project summary, justification and size
- Description of the existing site environment including vegetation, wildlife, land uses, and historic and cultural resources, soil, geology, topography, weather, air quality
- Description of socio-economic characteristics of the project including income and employment, education, infrastructure, law enforcement, fire protection, hospital, and medical facilities
- Discussion of alternatives to the proposed project size and design, and how the preferred alternative was selected
- Description of the direct, indirect and cumulative environmental and socio-economic effects, both positive and negative, that may result from the project, i.e., air and water quality, noise and dust levels, sedimentation and erosion, plant and wildlife habitat and populations, infrastructure capacity (short and long term)
- Description of how impacts have been avoided or minimized and how any unavoidable impacts will be mitigated
- Evaluation of alternative management measures to control non-point source pollution and a description of management measures selected for incorporation in the proposed project

An Area of Particular Concern (APC) is a geographically delineated area with special management requirements enforced by CRM. The five APCs are:

- Shoreline (area between the mean high water mark and 150 feet inland)
- Lagoon and Reef (area extending seaward from the mean high water mark to the outer slope of the reef)
- Wetlands and Mangrove (areas which are permanently or periodically covered with water and where species of wetland or mangrove vegetation can be found)

- Port and Industrial (land and water areas surrounding the commercial ports of Saipan, Tinian, an Rota)
- Coastal Hazards (areas identified as a coastal flood hazard zone)

For the purpose of siting an on-island municipal solid waste landfill, transfer station, and septage facility, the Municipality of Tinian should avoid APCs or if unavoidable, ensure that the proposed SWMFs that may be situated within an APC comply with CRM's coastal permit requirements.

Section 1500 of the CRM rules and regulations (Title 15, Chapter 10) defines consistency requirements when federal activities and development projects directly affect the coastal zone or when federally licensed or permitted activities and the provisions for federal financial assistance for activities affect land or water uses of the coastal zone. These activities and projects must be conducted or supported in a manner which is, to the maximum extent practicable, consistent with the CRM program. Furthermore, any federal agency proposing to undertake any development project in the coastal zone shall insure that the project is, to the maximum extent practicable, consistent with the CRM program. A federal development project includes any federal activity involving the planning, construction, modification, or removal of public works, facilities, or other structures, and the acquisition, utilization or disposal of land or water resources. Federal activities include those federal agency actions, which are either development projects or licenses, permits, or assistance actions. Examples include federal agency activities requiring a federal permit and federal assistance to entities other than the local government. Although federal lands in the CNMI are excluded from the CRM program jurisdiction, federal activities occurring on federal lands which result in spillover impacts which directly affect the Commonwealth's coastal zone must be consistent, to the maximum extent practicable, with the CRM program.

The following criteria are to be used in making federal consistency determinations:

- The goals and policies set forth in CNMI Public Law 3-47 [2 CMC §§ 1501, et seq.]
- The standards and priorities set forth in CRM rules and regulations (Title 15, Chapter 10)
- Federal air and water quality standards and regulations, to the extent applicable to CNMI
- CNMI air and water quality standards and regulations including, but not limited to, the CNMI Underground Injection Control Regulations and the CNMI Drinking Water Regulations; and any additional policies, regulations, standards priorities and plans that are enforceable and incorporated into any amendment of the CRM program in the future

8.1.3 Division of Fish and Wildlife

The Division of Fish & Wildlife (DFW) is one of several agencies under the CNMI Department of Land and Natural Resources. Through research, monitoring. regulation, enforcement, planning, and management, DFW seeks to ensure the long-term survival and sustainability of CNMI's natural resources. Development proposals (e.g., major siting permit applications and attendant environmental impact assessments) submitted to CRM and/or DEQ are reviewed by DFW to ensure that negative impacts to endangered or threatened species are minimized, mitigated, or avoided. Additionally, DFW would be involved with consultation with the U.S. Fish and Wildlife Service pursuant to the federal Endangered Species Act as warranted.

SWMF siting, construction, and operation on Tinian Island must address protection of species such as the Tinian monarch (*M. takatsukasae*) that was recently de-listed. Native forest birds on Tinian that are recognized by the Division of Fish and Wildlife as species of special concern include the rufous fantail (*R. ruffifrons*), bridled white-eye (*Z. conspicillatas saypani*), Mariana fruit dove (*P. roseicapilla*), white-throated ground dove (*G. xanthonura*), Micronesian starling (*A. opaca*), and collared kingfisher (*H. chloris*). The federally and CNMI listed Marianas common moorhen (*G. chloropus guami*) is consistently found at Hagoi Lake (DFW no date, USDA 1994).

Low numbers of the Mariana fruit bat (*P. mariannus*), which is proposed for listing as a threatened species by the Division of Fish and Wildlife, may be seen on Tinian. The Micronesian gecko (*P. ateles*) is on the CNMI endangered species list and a skink (*E. slevini*) is listed as a species of concern by the U.S. Fish and Wildlife Service. The coconut crab (*B. latro*) is traditionally hunted on Tinian and its numbers have declined somewhat in recent years therefore is listed as a CNMI species of special concern.

8.1.4 Historic Preservation

The Historic Preservation Office (HPO) was established by the CNMI Historic Preservation Act of 1982 (Public Law 3-39) to ensure the identification and protection of significant archaeological, historic, and cultural resources in the Commonwealth; to educate the public concerning matters relating to local history, archaeology, culture, and historic preservation; and to develop historic and cultural properties.

Under Public Law 3-39, HPO is mandated to perform a review of proposed developments pursuant to Section 106 of the federal Historic Preservation Act of 1966. A Section 106 review must be performed for projects that involve a direct, indirect, or an adverse impact on a property that is on or is eligible for inclusion in the National Register of Historic Places. The responsibility of initiating and completing the Section 106 review lies with the proponent of a proposed action. Also stated above, HPO assists CRM with the evaluation of major siting permit applications and environmental assessments oftentimes during which Section 106 review is initiated. HPO's input would ensure that significant prehistoric, historic, and cultural resources at or in proximity of a proposed SWMF are either protected from damage or there is sufficient site data compiled prior to alteration or destruction.

The proponent may also be required to complete an *Application for Historic Preservation Review* to include construction plans and location maps (which would necessarily be annexed to the CRM major siting permit application and environmental assessment). HPO clearance would allow the developer to obtain a DEQ earthmoving permit as warranted.

8.2 U.S. FEDERAL GOVERNMENT

8.2.1 Environmental Protection Agency

Subtitle D of the Resource Conservation and Recovery Act of 1976 (RCRA) uses a combination of design and performance standards for regulating municipal solid waste landfills and solid waste management facilities in general. It also establishes facility design and operating standards, groundwater monitoring corrective action measures, and conditions (including financial requirements) for landfill closure and post-closure care as enforced by the U.S. Environmental Protection Agency.

RCRA creates a framework for federal, state, and local government cooperation in controlling the disposal of municipal solid waste. While the federal landfill rule establishes national minimum standards for protecting human health and the environment, implementation of solid waste programs remains largely the responsibility of local, state, or tribal governments. As stated above, CNMI Solid Waste Management Regulations have adopted RCRA Subtitle D codified as 40 CFR Part 258. Locational restrictions are described in the following sections to Part 258:

- Airport Safety (§ 258.10)
- Floodplains (§ 258.11)
- Wetlands (§ 258.12)
- Fault Areas (§ 258.13)
- Seismic Impact Areas (§ 258.14)
- Unstable Areas (§ 258.15)

8.2.2 Department of Commerce, Office of Coastal Resources Management

CNMI Coastal Resources Management Rules and Regulations are consistent with the federal Coastal Zone Management Act and applicable rules and regulations.

8.2.3 Fish and Wildlife Service

Section 7 of the Endangered Species Act outlines the procedures for interagency cooperation to conserve federally listed species and designated critical habitats. Applicable regulations codified in 50 CFR Part 402 (Joint Regulations on Endangered Species) establishes the procedural requirements to initiate the consultation process. The U.S. Fish and Wildlife Service has a policy with state and local agencies for gathering information during implementation of the consultation process. By law, section 7 consultation is a cooperative effort involving affected parties analyzing effects posed by a proposed action on listed species or critical habitats.

Consequently, the SWMF proponent must complete a biological assessment prior to construction to determine if a proposed project may affect any listed species or designated critical habitat at or in the vicinity of the site. A determined effect to a listed species or critical habitat will require Fish and Wildlife Service consultation.

8.2.4 Advisory Council for Historic Preservation

HPO is mandated to comply with all federal laws and regulations governing the protection and preservation of historic and cultural resources pursuant to 36 CFR Part 800.

8.2.5 Federal Aviation Administration

Information about the risks posed to aircraft by certain wildlife species has increased a great deal in recent years. Improved reporting, studies, documentation, and statistics clearly show that aircraft collisions with birds and other wildlife are a serious economic and public safety problem. Section 503 of the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (Public Law No. 106-181) (AIR 21), enacted in April 2000, addresses this hazard by prohibiting the construction or establishment of a new municipal solid waste landfill within 6 statute miles of certain public-use airports measured from the airport property line to the landfill property line provided the airport meets the following criteria:

- Received a Federal grant(s) under 40 U.S.C. § 47101, et seq.
- Is under the control of a public agency
- Serves some schedule air carrier operations conducted in aircraft with less than 60 seats
- Have total annual enplanements consisting of at least 51 percent of schedule air carrier enplanements conducted in aircraft with less than 60 passenger seats

In its *National Plan of Integrated Airport Systems (NPIAS) (2001-2005)* (USDOT 2002), the Federal Aviation Administration (FAA) lists West Tinian Airport (also known as Tinian International Airport) as a primary commercial service facility thus requiring compliance with AIR 21 (USDOT 2002). However, the FAA district office acknowledges that geographic and physical limitations preclude compliance with the distance requirement, consequently the Municipality of Tinian—through the Commonwealth Ports Authority—must apply for a variance using FAA Form 7460-1 (*Notice of Proposed Construction or Alteration*) to site a municipal solid waste landfill within 6 statute miles of West Tinian Airport.

In recognition of the increased risk of serious aircraft damage or the loss of human life that can result from a wildlife strike caused by a solid waste management unit as the attractant, FAA may require the development of a Wildlife Hazard Assessment (WHA) and a Wildlife Hazard Management Plan (WHMP) for FAA approval and inclusion in an Airport Certification Manual as it pertains to West Tinian Airport. The FAA would use the WHA—prepared in accordance with 14 CFR Part 139—along with aeronautical activity at the airport (e.g., approach and departure patterns) as well as the views of the airport operator and airport users in determining whether a formal WHMP is required. If FAA determines that a WHMP is needed, the airport operator must formulate and implement a plan using the WHA as the basis for the plan. Note that this requirement would be imposed upon the airport operator, i.e., Commonwealth Ports Authority (CPA), and not the solid waste management unit owner or operator.

Wildlife Hazard Management at Airports (December 1999) prepared by FAA and the U.S. Department of Agriculture, Wildlife Services contains a compilation of information to assist CPA or its designate with the development, implementation, and evaluation of a WHMP. The manual includes specific information on the nature of wildlife strikes, legal authority, regulations, wildlife management techniques, WHAs, WHMPs and sources of assistance and information. The manual is downloadable free of charge from FAA's wildlife hazard mitigation web site at http://wildlife-mitigation.tc.faa.gov.

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