Stormwater Pollution Prevention Plan

For

Layon Municipal Sanitary Landfill

Layon, Inarajan
Guam 96915

SWPPP Contacts:

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ACRONYMS

AED	Automatic External Defibrillator
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CDL	Commercial Drivers License
CFR	Code of Federal Regulations
COD	Chemical Oxygen Demand
CPR	Cardio-Pulmonary Resuscitation
DPW	Department of Public Works
EPA	United States Environmental Protection Agency
ESCP	Erosion and Sediment Control Plan
GEPA	Guam Environmental Protection Agency
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEM	Heavy Equipment Maintenance
HHW	Household Hazardous Waste
LMSL	Layon Municipal Sanitary Landfill
MOLO	Manager of Landfill Operations
MS4	Municipal Separate Storm Sewer System
MSGP	Multi-Sector General Permit
MSW	Municipal Solid Waste
MSWLF	Municipal Solid Waste Landfill Facility
NEPA	National Environmental Policy Act
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollutant Discharge Elimination System
PMP	Preventative Maintenance Program
QAPP	Quality Assurance Project Plan
SWPPP	Storm Water Pollution Prevention Plan
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids

SECTION 1: FACILITY DESCRIPTION AND CONTACT INFORMATION

1.1 Introduction

This Stormwater Pollution Prevention Plan (SWPPP) was created to help obtain coverage under the 2008 Multi-Sector General Permit (MSGP), which authorizes stormwater discharges from industrial facilities where discharges enter surface waters of the United States, or a municipal separated storm sewer system (MS4) leading to surface waters of the United States subject to the conditions set forth in the MSGP. Subpart L of the MSGP covers stormwater discharges associated with activity from Landfills, Land Application Sites, and Open Dumps, as identified in Appendix D of the MSGP. (See Attachment A)

This SWPP is presented in a reader-friendly, plain language format following the outline of the MSGP. This SWPPP uses the term “OPERATOR” to identify those who have operational control of a “Facility or Activity”, as defined in Appendix A of the MSGP, and who must comply with the conditions of the MSGP. This SWPPP format should allow any qualifying OPERATOR to easily locate and understand applicable requirements.

The Layon Municipal Sanitary Landfill (LMSL) is a new facility constructed on previously undeveloped land. The LMSL will operate under Municipal Solid Waste Landfill Facility Permit No. 09-015, as issued by the Guam Environmental Protection Agency (See Attachment B). The Government of Guam, Department of Public Works has entered into a contract for facility operations with Herzog Environmental, Inc., a qualified OPERATOR. It is required that the OPERATOR amend, update and maintain this SWPPP, as needed, to reflect the OPERATOR’S activities at the facility in compliance with the MSGP and any other permits, as may be required.

1.2 Facility Information

Facility Information

Name of Facility: Layon Municipal Sanitary Landfill

Street: Landfill Access Road

City: Layon, Inarajan State: Guam ZIP Code: 96915

County or Similar Subdivision: None

Permit Tracking Number: N/A

Latitude/Longitude :

Latitude:	Longitude:
13 º 18 ' 14" N	144 º 43 ' 40" W

Method for determining latitude/longitude (check one):

☐ USGS topographic map (specify scale: N/A_______) ☐ EPA Web site ☒ GPS

☐ Other (please specify): N/A

Is the facility located in Indian Country? ☐ Yes ☒ No

If yes, name of Reservation, or if not part of a Reservation, indicate "not applicable." N/A______

Is this facility considered a Federal Facility? ☐ Yes ☒ No

Estimated area of industrial activity at site exposed to stormwater: 28 Acres (134 Acres-Future)

Discharge Information

Does this facility discharge stormwater into an MS4? ☐ Yes ☒ No

If yes, name of MS4 operator: N/A__

Name(s) of water(s) that receive stormwater from your facility Tinaga River, Fensol River & Fintasa River

Are any of your discharges directly into any segment of an "impaired" water? ☐ Yes ☒ No

If Yes, identify name of the impaired water (and segment, if applicable): N/A

Identify the pollutant(s) causing the impairment: N/A

For pollutants identified, which do you have reason to believe will be present in your discharge? N/A

For pollutants identified, which have a completed TMDL? N/A

Do you discharge into a receiving water designated as a Tier 2 (or Tier 2.5) water? ☐ Yes ☒ No

Are any of your stormwater discharges subject to effluent guidelines? ☒ Yes ☐ No

If Yes, which guidelines apply? 40 CFR Part 445 Subpart B

Primary SIC Code or 2-letter Activity Code: LF - Landfills, Land Application Sites and Open Dumps

Identify your applicable sector and subsector: Sector L: Landfills, Landfill Application Sites and Open Dumps

1.3 Contact Information/Responsible Parties

Facility Operator (s):

Name: Herzog Environmental, Inc.
Address: PO Box 170291
City, State, Zip Code: Inarajan, Guam 96917
Contact: Norm Kivett
Telephone Number: (671) 727-6846
Email address: nkivett@herzogcompanies.com

Facility Owner (s):
Name: Guam Department of Public Works (DPW)
Address: 542 North Marine Corps Drive
City, State, Zip Code: Upper Tumon, Guam 96913
Telephone Number: (671) 646-3131/3232 ,
Email address: joanne.brown@dpw.guam.gov
Fax number: (671) 649-6178

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Email address: marcg@tg-engr.com
Fax number: (671) 647-0886

1.4 Stormwater Pollution Prevention Team

Table 1 – Operator's Staff Names & Responsibilities

Staff Names	Individual Responsibilities
Landfill Site Manager	Oversight of all activities for Compliance, Inspections and Monitoring in accordance with MSGP and this SWPPP
Landfill Engineers & Inspectors	Assist with coordinating plan implementation and maintain SWPPP requirements, coordinate employee training, perform inspections, keep records, and submit reports
Operations Supervisor	Coordinate landfill operations in accordance with MSGP and this SWPPP
Maintenance Staff, including Maintenance Supervisor	Maintenance of BMP's in accordance with MSGP and this SWPPP

<u>Note: Landfill Operator shall submit a complete list of personnel with corresponding responsibilities to EPA prior to start of landfill operations and update this table accordingly.</u>

1.5 Activities at the Facility

The Layon Municipal Sanitary Landfill (LMSL) will be the disposal site for non-hazardous municipal solid waste (MSW). MSW will be received from residential, commercial and industrial sources. The total disposal area for the LMSL is approximately 128 acres and the initial landfill operation will be comprised of Cells 1 & 2, with an approximate area of 22 acres.

The LMSL will also receive for disposal certain non-hazardous wastes managed under special operating procedures. These special wastes include wastewater treatment sludge, treated medical waste, asbestos materials, petroleum contaminated soils, and industrial process wastes.

The LMSL will receive waste from throughout Guam, primarily by transfer trucks delivering waste from transfer stations located at various locations around the island of Guam. The landfill site will also receive wastes from public and commercial collection vehicles. In the event public transfer stations are unable to serve the needs of the residential self-haulers, the landfill may also accept refuse from the public.

Transfer trucks will pass through a weigh station en route to Cells 1 & 2. Waste will be deposited in the cells, compacted and covered daily with soil and/or Alternative Daily Cover.

At the Entrance Area Facilities, daily operations will include storage, maintenance, fueling and washing of vehicles and equipment. Also included will be parking of staff vehicles, operation and maintenance of the Administration and Maintenance buildings and operation and maintenance of the water storage tank, pump/generator building and sewer lift station.

A requirement of the GEPA MSWLF Permit is to keep records of the types of wastes disposed of in each cell of the landfill. Part 8.L.8.1 of the MSGP requires that those records, or a copy thereof, also be kept with this SWPPP.

1.6 General Location Map

The Layon Municipal Sanitary Landfill Site is located on Lot B-3REM-2, which contains approximately 317 acres, and is located outside the periphery of the village of Inarajan, near the former NASA tracking station. It is approximately 3.5 miles to the nearest village residential area (Malojloj) in the higher badlands areas on the west side of the Dandan Parcel, southwest of the former NASA tracking station.

See Attachment C, Location Map and Vicinity Map for this facility.

1.7 Site Map

This SWPPP contains site maps, showing the entire site, in Attachment D identifying:

- the size of the property in acres;
- the location and extent of significant structures and impervious surfaces;
- directions of stormwater flow;
- locations of all existing structural control measures;
- locations of all receiving waters in the immediate vicinity of your facility, indicating if any of the waters are impaired and, if so, whether the waters have TMDLs established for them;
- locations of all stormwater conveyances including ditches, pipes, and swales;
- locations of potential pollutant sources identified under MSGP, Part 5.1.3.2;
- locations of all stormwater monitoring points;
- locations of stormwater inlets and outfalls, with a unique identification code for each outfall (e.g., Outfall No. 1, No. 2, etc), indicating if you are treating one or more outfalls as “substantially identical” under MSGP, Parts 4.2.3, 5.1.5.2, and 6.1.1, and an approximate outline of the areas draining to each outfall;
- locations of the following activities where such activities are exposed to precipitation:

    - fueling stations;
    - vehicle and equipment maintenance and/or cleaning areas;
    - loading/unloading areas;
    - locations used for the treatment, storage, or disposal of wastes;
    - liquid storage tanks;
    - processing and storage areas;
    - immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility;
    - transfer areas for substances in bulk;
    - machinery;
- locations of non-stormwater discharges, including
    - Wash Rack washwater
    - Groundwater Subdrain at active Cells
- locations and sources of run-on to the site from adjacent property that contains significant quantities of pollutants.

The following are elements required to be shown on the site maps by the MSGP, but are omitted for the reasons indicated:

- Locations of impaired receiving waters in the immediate vicinity of the facility, and, whether the waters have TMDLs established for them. **No impaired receiving water in vicinity**;
- Locations where significant spills or leaks identified under MSGP, Part 5.1.3.3 have occurred; **New site, none have occurred;**
- Municipal separate storm sewer systems (MS4's), where stormwater discharges to them. **No MS4's in vicinity**;

Disposal Site

The total landfill disposal area for the landfill is approximately 128 acres and the initial landfill operation will comprise of Cells 1 and 2 with an area of approximately 22 acres. It will include the leachate sump and riser, and leachate storage tank to serve Cells 1 & 2 (refer to Attachment D, Exhibit 1 for the landfill overall site plan and Exhibit 4 for Cells 1 & 2 plan). Horizontal gas collectors will be placed above the protective cover soil with pipe risers up the side slopes for future connection to gas headers.

Perimeter Road

Approximately 2,800 linear feet of the permanent perimeter road and drainage ditches/channels on the southwest and southeast sides of Cells 1 & 2 was constructed as part of the construction of the initial cells. Drainage ditches/channels along the sides of the perimeter road were constructed to direct storm runoff from the roadway and the future runoff from the landfill cells that are not in contact with landfill trash. Crushed stone riprap and concrete lining are used to prevent erosion of the ditches.

Operations Road

Approximately 3,160 linear feet of Operations Road was constructed and completed simultaneously with the mass grading for Cells 1 & 2. This road will be the primary access for the operation of Cells 1 & 2. Access into the cells will be via temporary access ramps from the Operations Road to the cells to be built by the landfill operator.

Landfill Entrance Area Facilities

The landfill Entrance Area Facilities occupies approximately 12 acres of land and consists of the administration and scale house building, maintenance shop and fueling facility, water storage tank, generator and pump building, paved roads, security fencing, truck scale and truck/equipment wash rack station. (Refer to Attachment D, Exhibit 3 for the Entrance Area Facilities.)

SECTION 2: POTENTIAL POLLUTANT SOURCES

2.1 Industrial Activity and Associated Pollutants

Table 2 - Industrial Activity and Associated Pollutants

Industrial Activity	Associated Pollutants
Cover vegetation management	Fertilizers
Weed and pest management	Herbicides and pesticides
Outdoor chemical storage	Various chemicals stored
Maintenance of Oil/Water Separator	Oil and grease
Waste transportation	Total suspended solids (TSS), total dissolved solids (TDS), turbidity, floatable debris, windborne debris, spilled trash/waste
Leachate collection, transport	Iron, TSS, biochemical oxygen demand (BOD), ammonia, alpha terpineol, benzoic acid, p-Cresol, phenol, zinc, pH
Landfill operations	BOD, TSS, TDS, turbidity
Exposed soil from excavating cells/trenches	TSS, TDS, turbidity
Exposed stock piles of cover materials	TSS, TDS, turbidity
Inactive cells with final cover but not finally stabilized	TSS, TDS, turbidity
Daily or intermediate cover placed on cells or trenches	TSS, TDS, turbidity
Haul roads used by vehicles (including vehicle tracking of sediments)	TSS, TDS, turbidity
Vehicle/equipment maintenance: fueling activities	Diesel fuel, gasoline, oil
Vehicle/equipment maintenance: parts cleaning Vehicle/equipment maintenance: waste disposal of oily rags, oil and gas filters, batteries, coolants, degreasers	Solvents, oil, heavy metals, acid/alkaline liquids Oil, heavy metals, solvents, acid
Vehicle/equipment maintenance: fluid replacement including hydraulic fluid, oil, transmission fluid, radiator fluids, and grease	Oil and grease, arsenic, lead, cadmium, chromium, chemical oxygen demand (COD), and benzene

The Potential Pollutant Sources and Best Management Practices (BMPs) are shown in Tables 3 & 4.

Table 3 - Potential Pollutants Sources of Total Suspended Solids (TSS) and Best Management Practices (BMPs) for Erosion Control		
Potential Pollutant Sources	**Best Management Practices (BMPs)**	**Location(s)**
Erosion from: • Exposed Soil from excavating cells /trenches. • Exposed stockpiles of cover materials. • Inactive cells with final cover but not yet finally stabilized. • Daily or intermediate cover placed on cells or trenches. • Erosion from haul roads (including vehicle tracking of sediments) • Run-on containing eroded material	• Stabilize soils with seeding, mulching, and geotextiles. • Leave vegetative filler strips along streams. • Implement structural controls such as dikes, swales, silt fences, filter berms, sedimentation traps and ponds, outlet protections, pipe slope drains, check dams and terraces to convey runoff. • Divert storm runoff around or away from erosion susceptible areas to prevent sedimentation from entering water bodies. • Frequently inspect all stabilized and structural erosion control areas and perform all necessary maintenance and repairs. • Stabilize all haul roads and entrances to landfill with gravel or stone. • Construct vegetated swales along roads. • Clean wheels and body of trucks or other equipment as necessary to minimize sediment tracking.	• Cell Areas • Unpaved Roads • Soil Stockpile

Table 4 - Potential Pollutants Sources (Other Than TSS) and Best Management Practices (BMPs)

Potential Pollutant Sources	**Best Management Practices (BMPs)**	**Location(s)**
Application of fertilizers, pesticides, and herbicides	• Observe all Federal and Local regulations when using these products. • Use these products during calm weather to prevent or reduce overspray or runoff. • Strictly follow recommended application rates and methods (i.e., do not apply in excess of vegetative requirements. • Have materials such as absorbent pads easily accessible to clean up spills.	Cells Area, Maintenance Facilities Area
Exposure of chemical material storage areas to precipitation (including pesticides, fertilizers and herbicides)	• Provide barriers such as dikes, berms, or curbs to contain spills. • Provide cover for outside storage areas. • Have materials such as absorbent pads easily accessible to clean up spills.	Maintenance Facilities Area
Exposure at open face	• Minimize the area of exposed open face as much as practicable. • Divert flows around open face using structural measures such as dikes, berms, swales, and pipe slope drains. • Frequently inspect erosion and sedimentation controls	Cells Area
Waste tracking onsite and haul roads, solids transport on wheels and exterior trucks or other equipment (common with incinerator ash)	• Clean wheels and exterior of trucks or other equipment as necessary to minimize waste tracking (but contain any wash waters (process wastewaters)	Cells Area and Operations & Access Roads
Uncontrolled leachate flows and failure or leaks from leachate collection and transport systems	• Frequently inspect leachate collection system and landfill for leachate leaks • Maintain landfill cover and vegetation • Maintain leachate collection system	Cells Area, Operations & Access Roads and Maintenance Facility Area

Spilled Trash/Waste, Windborne Debris, and Floatable Debris	• All spilled trash/waste, windborne debris and floatable debris will be collected on a daily basis and dispose into metal dumpsters. Dumpster will have a secure watertight lid and shall be placed away from stormwater conveyances and drains. • Dumpsters will be inspected weekly and immediately after storm events. The dumpster will be emptied daily. • No waste materials will be buried in the facility except in the landfill cells. • All personnel will be instructed during training sessions, regarding the correct disposal of trash and debris. Notices that state these practices shall be posted in the facility and the Maintenance Supervisor shall ensure these practices are being followed.	Maintenance Facilities Area, Parking Area, Operations and Access Roads, Drainages, Ponds, and Buffer Zone around Landfill Site.

The following are descriptions of locations of Potential Sources of Stormwater Contamination:

2.1.1 Cell Areas

There are a total of 11 cells comprising the LMSL as shown in Attachment D, Exhibit 1. However, initial landfill operations will consist of Cells 1 and 2 which includes the subdrain system, cell liner system, leachate collection system and the gas management system.

Stormwater from Cells 1 and 2 will be collected on a rain cap and directed to a sump within the cells. In the sump, a pump system discharges the water to Pond 3A. After refuse and daily cover soil is placed in Cells 1 and 2 to an elevation above the perimeter road, runoff from the south and west slopes of Cells 1 and 2 will sheet flow to the perimeter road ditch/channel and be directed to Pond 3A.

Groundwater subdrainage from beneath Cells 1 & 2 is collected and transported to a holding tank. MSWLF Permit No 09-015 requires that subdrain water be sampled and tested only if leachate is found to be present in the secondary leachate collection and recovery system. However, US EPA requires that prior to discharge from the holding tank, the subdrain water be sampled and visually inspected for contaminants in accordance with Section 5.1.2.

2.1.2 Maintenance Facilities

There are 4 main maintenance facilities at the Landfill Entrance Area and these are as follows:

2.1.2.1 Maintenance Shop

The shop contains a two roofed bays for maintenance and repairs of landfill operating equipment, plus parts storage areas, lubricant storage and dispensing equipment. Any spillage from the equipment and lubricant storage area can be a potential pollution source to the stormwater runoff.

2.1.2.2 Equipment Wash Rack Area

The Equipment Wash Rack Area receives equipment wash-out water which may contain sediment, debris, oil, etc. The wash rack is not to be used to clean vehicles which have been in contact with sanitary waste, unless they have been cleaned prior in the active landfill cell. Detergents and toxic cleaning solvents, such as chlorinated solvents and other toxic chemicals shall not be used at the Wash Rack.

2.1.2.3 Oil Water Separator

The Oil Water Separator is located northeast of the equipment wash rack. Oily water generated from the equipment wash rack will be collected into a dedicated drain system and piped to the oil water separator. The clean water is discharged to a bio-swale at the north perimeter of the Entrance Area. Periodic maintenance of the oil water separator will be required.

2.1.2.4 Fueling Area

The fueling area includes a diesel fuel storage tank and dispenser. Any spillage from the tank or during the fuel filling operation could contribute to the stormwater pollution. Mobile fueling operations will also take place within the Cell 1 and 2 disposal area.

2.1.3 Unpaved Roads

The only unpaved road for the operations of cells 1 & 2 would be the temporary road(s) to be used for hauling stockpiled material for the landfill solid waste daily cover. Hauling will track dirt or mud and/or sediment and debris from the stockpile site and would become a potential pollution source to the stormwater runoff discharge.

2.1.4 Soil Stockpiles

Excess excavated material from the construction of Cells 1 & 2, the Operations Road, and ponds 2 and 3A is stockpiled in a designated area for use as daily or intermediate soil cover at the active cells. There is a possibility that stockpiled materials will get eroded and discharged to the surrounding area.

2.1.5 Parking Areas

Equipment, machinery, and trucks can track sediment and debris from the landfill site to the parking areas at the entrance area. Such sediment and debris could potentially be washed offsite and into the adjacent watershed.

2.1.6 Entrance Area Facility – Run-on

Topographic contours at the northwest corner of the Entrance Area Facility cause sheet-flow drainage from off-site to enter the perimeter drainage swale. This run-on can potentially contain suspended solids due to erosion from adjacent native soils. The run-on will mix with surface drainage from the Entrance Area and be discharge via swale to the south of the Entrance Area Facility.

2.2 Spills and Leaks

In the event of a spill or leak of petroleum products or hazardous materials, immediate and specific actions will be implemented in accordance with the LMSL Spill Prevention Control and Countermeasure Plan (SPCC), a copy of which shall be kept with this SWPPP.

Table 5 provides a list of areas of site where potential spills/leaks could occur.

Table 5 – Areas Where Potential Spills/Leaks Could Occur

Location	**Outfalls (See Attachment D)**
Active Cells 1 & 2	Outfall #1 (via Pond 3A)
Leachate Collection and Storage Systems	Outfall #1 (via Pond 3A)
Paved & Unpaved Roads in Cell Area	Outfall #1 & #2 (via Ponds 3A & 2)
Cover Soil Stockpiles	Outfall #2 (via Pond 2)
Maintenance Shop	Outfall #3 (via Bio-swale)
Maintenance Shop Parking Areas	Outfall #3 (via Bio-swale)
Fueling Area	Outfall #3 (via Bio-swale)
Admin Bldg Parking Areas & Scales	Outfall #4 (via Bio-swale)
Equipment Wash Rack Area	Outfall #4 (via Oil-Water Separator/Bio-swale)
Water Tank/Gen Bldg/Driveway	Outfall #5

Note: For Outfall Locations, See Site Maps, Attachment D.

Description of Past Spills/Leaks: As this is a new facility, there are no instances of past spills/leaks.

For documenting instances of spills, leaks or other releases, it is recommended that the OPERATOR utilize the ADDITIONAL MSGP DOCUMENTATION TEMPLATE available in Microsoft Word format at:

http://www.epa.gov/npdes/pubs/msgp2008_recordkeepingtemplate.doc

2.3 Non-Stormwater Discharges Documentation

This is a new permit for the new landfill. Therefore, there are no documented non-stormwater discharges. However, upon commencement of operations, the following documentation shall be provided for any non-stormwater discharges which occur:

- Date of evaluation:
- Description of the evaluation criteria used:
- List of the outfalls or onsite drainage points that were directly observed during the evaluation:
- Different types of non-stormwater discharge(s) and source locations:
- Action(s) taken, such as a list of control measures used to eliminate unauthorized discharge(s), if any were identified. Describe actions taken to eliminate unauthorized non-stormwater discharges and the corresponding outfall/drainage point affected.

In accordance with Part 8.L.5.3 of the MSGP, discharge tests must also be conducted for the presence of leachate and vehicle washwater.

2.4 Salt Storage

There are no salt storage piles at this facility.

2.5 Sampling Data Summary

This is a new landfill facility. There are no previous stormwater discharge samples taken for this site.

SECTION 3: STORMWATER CONTROL MEASURES

The stormwater control design for this facility is based on the Guam 25-year (4% exceedance frequency), 24-hour design storm event.

Landfill Cell Areas

Two detention/sedimentation ponds, Pond 2 and Pond 3A, were designed as a component of the Storm Water Pollution and Prevention Plan for the operations of Cells 1 & 2. Pond 2 is currently oversized, in that it was designed to accommodate the drainage from future cells as the landfill operation progresses to adjacent cells. Future ponds will be constructed as part of the development of other cells. Four detention/sediment ponds (Ponds 1, 2, 3A+3B, and 4) will be constructed for the ultimate development of the landfill (refer to Attachment D, Exhibit 1.) Pond 2 has a future tributary area of 41.2 acres (current tributary approximately 20 acres), a storage capacity of 19.3 acre-feet, a peak inflow of 381 CFS, and a peak outflow of 63 CFS (assuming water level below top of riser structure). Pond 3A a tributary area of 33 acres, a storage capacity of 18 acre-feet, a peak inflow of 400 CFS and a peak outflow of 63 CFS (assumed similar to Pond 2 – same outlet structure). To accommodate heavy storms, above the 25-year design storm, the ponds are provided with overflow structures which are intended to safely convey high flows out of the ponds (refer to calculations in Attachment F.)

The operation of the Cells 1 & 2 will require a rain cap to limit stormwater from coming in contact with deposited trash to reduce production of leachate. Stormwater on the rain cap will be pumped to Pond 3A. When the cells reach a height above the drainage ditches on the perimeter road stormwater from the rain cap will drain directly into the roadside ditches and be conveyed into the ponds.

Landfill Entrance Area

Existing stormwater runoff flows from the southwest to the northeast side of the entrance area. The entrance area will maintain the existing general drainage pattern and will sheet flow on paved, graveled, and grassed areas into dry swales (also referred to as “bio-swales”) along the north and eastern perimeter of the entrance area and discharge offsite following the natural drainage flow of the area. A “dry swale” is a GEPA approved bio-infiltration system designed to filter the “first flush” of a storm event to remove contaminants before the runoff discharges into the surrounding areas. Discharges from dry swales are provided with rip-rap to prevent scour and erosion.

3.1 Minimize Exposure - Structural Control Measures

Through implementing daily cover; locating HHW handling activities under cover, or indoors; and performing HEM within the Maintenance building, the OPERATOR will significantly reduced the exposure of stormwater to industrial activities at the Landfill. The OPERATOR shall minimize the exposure of landfill materials, processing, and material storage areas (including loading and unloading, storage, disposal, cleaning, maintenance, and fueling operations) to rain, and runoff by either locating these industrial materials and activities inside, or protecting them with storm-resistant coverings. There are soil stockpiles at the Landfill; if a stockpile is inactive for more than seven (7) days it shall receive temporary stabilization. During the rainy season, this time frame should be reduced to two (2) days. The Landfill Cells area is designed so that stormwater runoff from industrial activity flows into a series of ditches that direct runoff to detention/sedimentation ponds. In the Landfill Entrance Area, stormwater run off is directed to ditches or culverts that convey water to bio-swales prior to discharge to surrounding areas. Maintain these facilities to minimize discharge of contaminated stormwater.

In minimizing exposure, the OPERATOR shall pay particular attention to the following:

- use grading, berming, or curbing to prevent runoff of contaminated flows and to divert run-on away from these areas;
- locate materials, equipment, and activities so that leaks are contained in existing containment and diversion systems (confine the storage of leaky or leak-prone vehicles and equipment awaiting maintenance to protected areas);
- clean up spills and leaks promptly using dry methods (e.g., absorbents) to prevent the discharge of pollutants;
- use drip pans and absorbents under or around leaky vehicles and equipment, or store indoors where feasible;
- use spill/overflow protection equipment;
- drain fluids from equipment and vehicles prior to disposal;
- perform all cleaning operations indoors, under cover, or in bermed areas that prevent runoff and run-on and also that capture any overspray; and
- ensure that all washwater drains to a proper collection/treatment system.

In addition to the above, specific structural controls and practices are described below:

Detention/Sedimentation Ponds

Ponds 2 and 3A were constructed as the primary structural drainage control measures for the operations of Cells 1 & 2. The overflows from Ponds 2 & 3A are discharged to Fintasa River basin.

The following is a list of general practices for detention/sedimentation pond maintenance and operation:

- Examine pond banks for seepage and structural soundness. Stabilize and repair, when necessary.

- Check the pond embankments for signs of burrowing rodents. Eliminate such rodents immediately and repair any damage.

- Check inlet and outlet pipes, channels, structures and spillways for any damage or obstructions. Repair damage and remove obstructions, as needed.

- Check inlet and outlet areas for erosion and stabilize, if required.

- Remove sediment prior to each wet season, and when storage zone is one-third full. Sediment shall not be allowed above the lowest row of inlet holes of the overflow structure.

- Inspect ponds before and after each rainfall event. During extended rainfall events, inspect at least daily.

- Remove floatable debris frequently, at least weekly. Floatable debris can block outlet orifices. Excessive accumulation can pose a risk to overflow structure screens during periods of high water.

- Implement control of vectors (mosquitoes) if the ponds retain standing water more than fourteen (14) continuous days.

Drainage Channels and Roadside Ditches

Drainage channels are concrete lined and roadside ditches are either lined with loose riprap or grouted riprap. Clean channels and ditches when debris or sedimentation affects performance.

Excavation and embankment slopes

Excavation and embankment are constructed with flat slopes, 3:1 or flatter. All slopes including areas disturbed during construction were heavily seeded to promote a healthy growth of grass ground cover. Maintaining flat slopes with heavy vegetation will minimize erosion.

3.2 Good Housekeeping

Good housekeeping involves maintaining a clean and orderly work environment. Extra attention paid to surfaces draining to storm drains or ditches can significantly reduce pollutant wash off. An orderly work environment will also reduce the chance for inadvertent spills, allow for the early detection of problems, and to ensure unimpeded access to the landfill site. The following practices are examples of good housekeeping measures:

- All material that is a potential pollutant shall be kept in a covered, contained area. Containers shall be well sealed, and labeled with substance name, date, and hazards.

- All empty cleaner, oil, or chemical containers shall be promptly and properly disposed.

- Drip pans or pads shall be used when working on equipment or with equipment fluid and cleaners.

- A designated individual shall keep a running inventory of all chemical substances and Material Safety Data Sheets (MSDS) in a fixed location onsite.

- Any trash or debris that is present shall be picked up immediately and properly disposed.

- Containers, tanks or equipment shall be monitored weekly for leaks and overflow; observed leaks shall be contained. Any defective items shall be repaired or replaced immediately.

- Vehicles shall be monitored daily (when in use, or otherwise weekly) for leaks; any observed leaks shall be repaired and cleaned up immediately.

- Trench drains in the HEM building shall be periodically emptied and cleaned to prevent overflows.

- At the vehicle/equipment wash rack, do not use detergents or toxic cleaning solvents, such as chlorinated solvents and other toxic chemicals.

3.3 Maintenance

The OPERATOR shall regularly inspect, test, clean and maintain the LMSL stormwater devices and equipment to ensure that it is in working order and to help prevent conditions that could cause breakdowns or failures resulting in discharges of pollutants. All maintenance of equipment and vehicles occurs within the HEM building.

All erosion and sediment control measures and other protective measures identified in the SWPPP shall be maintained in effective operating condition by the OPERATOR. If required site inspections identify BMPs that are not operating effectively, maintenance shall be performed by the OPERATOR as soon as possible and before the next storm event, whenever practicable, to maintain the continued effectiveness of stormwater controls.

If existing BMPs need to be modified, or if additional BMPs are necessary for any reason, implementation shall be completed by the OPERATOR before the next storm event whenever practicable. If implementation before the next storm event is impracticable, the situation shall be documented by the OPERATOR in the SWPPP and alternative BMPs will be implemented as soon as possible.

Sediment control structures will be monitored to ensure continuous structural integrity. Sediment from sediment traps, or detention ponds will be removed by the OPERATOR when design sediment capacity has been reduced by 33 percent. Collected sediments will be removed and placed in appropriate disposal areas.

Any areas that become damaged shall be regraded, as necessary, during the permit term. Silt fences will be repaired or replaced if damaged, clogged, or disintegrated. Any ditches that fill with sediment will be cleaned and regraded.

As part of the preventative maintenance program the OPERATOR shall maintain the following: all elements of the leachate collection and transport system to prevent commingling of leachate with stormwater, and the integrity and effectiveness of any intermediate or final cover (including repairing the cover as necessary) to minimize the effects of settling, sinking, and erosion.

Stormwater management maintenance activities include the following Preventive Maintenance BMPs:

1. Cleaning of accumulated debris from sump pump areas, conveyance structures and outfalls.
2. Clearing of debris from stormwater drainage system.
3. Maintenance and inspection of secondary containment structures and associated drain valves and perform repair immediately, as needed.
4. Where feasible, store potential stormwater pollutant materials inside the maintenance building or under a cover containment.
5. Major maintenance and repair of equipment will be performed regularly at offsite maintenance facilities approved for such activities.
6. On-site equipment maintenance will be limited to re-fueling and minor servicing activities except when further repairs are required due to vehicle breakdown.
7. Equipment will be inspected for leaks regularly (daily when in use, otherwise weekly.)
8. Minimize use of toxic cleaning solvents, such as chlorinated solvents and other toxic chemicals.
9. Empty drip pans immediately after a spill or leak are collected in an uncovered area.
10. Regular inspection and maintenance of rainfall protection coverings for waste storage bins and receptacles.
11. An overall inspection of the site will be performed to identify new problem areas and to repair any existing drainage features.
12. Regularly empty and clean floor trench drains in the Maintenance Building so that overflows will not occur.

Preventive maintenance is also required to ensure the erosion and sediment controls are functioning properly. It includes inspection and maintenance of the surface water conveyance systems and erosion control facilities. It is also important to inspect all disturbed areas for evidence of erosion. If any maintenance or sediment removal is needed, the observer shall note the location and how much sediment removal is needed.

Nonstructural control measures must also be diligently maintained (e.g., spill response supplies available, personnel appropriately trained, etc.)

To document maintenance of control measures and industrial equipment and systems maintenance, it is recommended that the OPERATOR utilize the ADDITIONAL MSGP DOCUMENTATION TEMPLATE available in Microsoft Word format at:

http://www.epa.gov/npdes/pubs/msgp2008_recordkeepingtemplate.doc

3.4 Spill Prevention and Response

The LMSL has an SPCC plan which dictates appropriate measures and actions to be taken to prevent and respond to spill. In concert with that plan, the OPERATOR shall implement spill prevention measures which, at a minimum, are as follows:

- Routinely label all containers that could be susceptible to spillage or leakage to encourage proper handling and facilitate rapid response if spills or leaks occur.
- Install barriers between material storage and traffic areas.
- Provide secondary containment for containers of potentially pollutant materials.
- Adopt procedures for the orderly storage and handling of potentially pollutant materials.
- Adopt and practice procedures for expeditiously stopping, containing, and cleaning up leaks, spill, and other releases, and
- Prepare a list of contact persons, including facility personnel, emergency responders, Guam EPA, other regulatory agencies, etc. to notify immediately in case of a leak or spill warranting such action.

In the event of a spill or release of petroleum products or hazardous materials, the following guidelines shall be followed:

1. Identification: The person observing the spill or release must immediately notify his supervisor, who in turn must notify the Landfill Site Manager or his duly authorized representative.
2. Immediate Response: The following steps are to be taken when an employee discovers a large or uncontrolled release within the facility; Move away from the area of the release; Stop all operations; Remove any injured persons from the immediate area of danger and render first aid treatment; Notify the Landfill Site Manager or his duly authorized representative and all government agencies concerned, including the Guam Environmental Protection Agency (GEPA).

   Do not expose personnel to the risk of injury or loss of life. If the Landfill Site Manager's decision is to remediate, the following actions must be strictly followed; Don the appropriate personal protective equipment; Eliminate all possible sources of ignition/detonation; Remove or isolate ignitable and incompatible materials from the area of release or spill; Locate and stop the source of the spill or release.
3. Clean-Up Operations and Equipment: Appropriate personal protective equipment such as boots, gloves, coveralls, respirators, etc., shall be maintained on-site and utilized during containment and clean-up activities.

   Absorbent materials such as blanketing, pads, or booms shall be maintained on site and may be used to form dikes around releases within the facility. Absorbent materials used for diking must be replaced as they become saturated or reinforced with fresh materials if immediate removal is not possible. For large releases, a portable pump and/or recovery vacuum truck may be used to remove standing product form within diked areas.

Oil recovery and clean-up operations should be implemented as soon as possible once the source of the release has been secured and containment activities are completed. Recovery operations must not be postponed unless authorized by the Landfill Site Manager or his duly authorized representative.

4. Secondary Containment: The Fuel Storage Tank will have a secondary tank containing the same amount as the tank, plus a concrete containment berm, which acts as tertiary containment. The Equipment Wash Rack is itself a concrete berm that contains all wash water and directs it to the Oil Water Separator. The Oil Water Separator is a separate unit and requires periodic inspections and removal of oily water to prevent spills.

5. The OPERATOR shall modify the SWPPP as required within seven (7) calendar days of knowledge of a release in order to: provide a description of the release, the circumstances leading to the release, and the date of the release. The modification shall identify measures to prevent the reoccurrence of such releases and to respond to such releases.

3.5 Erosion and Sediment Controls

Structural erosion and sediment controls are inherent in the design and construction of the facility. For example, earthen channels are paved or lined with grass or rip-rap. Road surfaces are paved or graveled. Detention/sediment ponds are provided to contain sediment. Pond outlets are controlled to prevent erosion from scouring by incorporating orifices and weirs. In addition, vegetative planting and hydroseeding are employed on native soil and cut/embankment slopes. All of the foregoing provide flow velocity dissipation, aiding in retaining sediment within the facility.

Erosion and sediment control BMPs are intended to limit soil erosion in areas that have a high potential for significant erosion. Such areas include stockpiles in which daily cover is to be removed, as well as sloped areas.

<u>Stockpiling Guidelines</u>

- The initial stockpile material for the daily soil cover will come from the excavation from the mass grading of Cells 1 & 2 and Ponds 2 and 3A. The ground surfaces prior to stockpiling were graded in the direction that allows runoff to drain in the direction of existing site drainage. Silt fences were also installed to prevent sediment from leaving the site. The stockpile slopes were 3H:1V or flatter and hydroseeded to minimize erosion.

- Removal of soil from the stockpile will begin once the landfill is opened for operation. The removal of material shall be performed uniformly in such a manner to maintain a minimum 5% slope at the top and the resulting side slopes are maintained at 3H:1V or flatter. No depressions shall be created in which stormwater can collect.

- During wet weather, soil removal from the stockpile shall not be performed. When heavy rainfall is anticipated, the working areas of the stockpile shall be graded and compacted to minimize erosion. Berms shall be employed to retard runoff. Silt fencing shall be checked for integrity to contain sediments.

- If the working area of the stockpile is to remain untouched for seven (7) days, it shall be graded and compacted. During the rainy season, this time frame should be reduced to two (2) days.

- Install silt fence around the perimeter of the stockpile, to prevent the migration of sediments.

- Stockpiling of new soil cover shall conform to the abovementioned stockpiling guidelines.

Areas at the perimeter of the facility which may potentially produce stormwater run-on which contains eroded soil materials shall be managed to prevent erosion in accordance with the Slope Area BMP Guidelines provided below.

Slope Area BMP Guidelines

The following slope area BMP guidelines shall be implemented, including for all future construction of additional landfill cells.

- Diversion Measures – Earth dike, swale, sandbag barriers, etc. can be used to collect stormwater runoff and convey it to a suitable discharge location, i.e. sheet flowing off-site or, if sediment laden, to sedimentation ponds. Diversion measures shall be applied above unprotected slopes.

- Slope Stabilization Measures – Hydroseeding, geotextiles, swales, slope drains, soil binders, etc. can be used to stabilize slopes.

- Vegetative Buffer Strips – preserve existing vegetation at the base of a slope if possible. Alternatively, silt fence can be constructed at the toe of slope to retain sediment runoff.

In addition, provide temporary stabilization (e.g., temporary seeding, mulching, and placing geotextiles on inactive portions of stockpiles) for the following:

- Materials stockpiled for daily, intermediate and final cover

- Inactive areas of the landfill

- Landfill areas that have received final cover but where vegetation has yet to establish itself

3.6 Management of Runoff

Guam receives over 100 inches of precipitation each year, and often incurs very heavy rain. Management of stormwater runoff is essential to prevent pollution from exiting the facility. Inherent in the design and operation of the facility are several stormwater controls:

Landfill Cells Area:

- Lined ditches and channels collect and divert runoff
- Detention/Sedimentation ponds attenuate storm flows, infiltrate water, and remove sediment
- Rain caps or daily cover diverts runoff from contacting sanitary waste
- Impoundment within cells collect and store runoff to be later disposed properly

Cover Material Stockpile Area:

- Grading/compacting appropriately reduces erosion
- Silt fences contain eroded materials
- Diversion ditches control runolff from active areas
- Hydroseeding/mulching reduces runoff

Entrance Area Facilities:

- Lined ditches collect and divert runoff
- Grassed/landscaped areas reduce runoff
- Bio-swales infiltrate water and retain sediments
- Flat grading reduces erosion
- Gravel areas promote infiltration
- Hydroseeding/mulching reduces runoff

In addition to these measures, the OPERATOR shall implement additional BMPs to divert, infiltrate, reuse, contain, or otherwise reduce stormwater runoff. He is encouraged to consult the following resources:

- The Guam Erosion and Sediment Control Manual
- CNMI and Guam Stormwater Management Manual
- Industrial Stormwater Fact Sheet Series, (www.epa.gov/npdes/stormwater/msgp)
- National Menu of Stormwater BMP's , (www.epa.gov/npdes/stormwater/menuofbmps)
- National Management Measures to Control Nonpoint Source Pollution from Urban Areas, (www.epa.gov/owow/nps/urbanmm/index.html)

3.7 Salt Storage Piles or Piles Containing Salt

There will be no salt storage piles or piles containing salt at this facility

3.8 MSGP Sector-Specific Non-Numeric Effluent Limits

Sector-specific non-numeric effluent limits for preventive maintenance are covered in Section 3.3. Erosion and sediment controls are covered in Section 3.5. The unauthorized discharge test certificate is not applicable as this is a new facility, as discussed in Section 2.3.

3.9 Employee Training

All employees who work in areas where industrial materials or activities are exposed to stormwater, or who are responsible for implementing activities necessary to meet the conditions of the MSGP shall be trained to properly perform the duties in a safe and effective manner. All such employees shall be trained prior to their first day of work at the LMSL and training shall be refreshed at least annually. All such employees will be required to read, understand and implement the requirements and goals of the SWPPP. All training shall be documented in accordance with the requirements of the MSGP. Employee training will include the following:

- Requirements for performing inspections, monitoring, sampling, assessments, documentation and reporting
- Good housekeeping and maintenance requirements
- Erosion and sediment control concepts, practices, and implementation
- Proper storage, washing and inspection procedures.
- Spill prevention and response procedures
- Proper waste material handling
- Disposal and control of waste
- Equipment fueling

In addition, employees shall be trained for safety and operations, including:

- Waste screening
- Hazards communication
- Hazardous material identification and handling (HAZWOPER)
- Accident prevention
- Eye protection
- Respirator fit
- Fire prevention and Fire Extinguisher use
- First Aid and CPR
- Landfill cell active face operations and safety
- Fork lift

A detailed Training Plan and Schedule shall be developed and implemented by the Landfill OPERATOR prior to start of operations at the LMSL. The OPERATOR'S training plan shall become a part of this SWPPP.

To document training, it is recommended that the OPERATOR utilize the ADDITIONAL MSGP DOCUMENTATION TEMPLATE available in Microsoft Word format at:

http://www.epa.gov/npdes/pubs/msgp2008_recordkeepingtemplate.doc

3.10 Non-Stormwater Discharges

The following non-stormwater discharges are not authorized by this permit: leachate, gas collection condensate, drained free liquids, contaminated ground water, laboratory wastewater, and contact washwater from washing vehicles and equipment within Cells that have come in direct contact with waste at the landfill facility. Such non-stormwater discharges must be prevented or eliminated.

An elaborate leachate collection, storage, transmission and discharge system is installed at the LMSL. The leachate system prevents the migration of leachate offsite, except for disposal to the sanitary sewer system. The system, in conjunction with implementation of daily, temporary, and final cover, minimizes the amount of contaminated stormwater, landfill wastewater, and leachate production. The leachate system prevents the occurrence of non-stormwater discharges of leachate from the LMSL.

All vehicles and equipment which have come in direct contact with waste at the landfill shall be cleaned within the active cell(s) prior to exiting the cell(s). Failure to do so allows precipitation or washwater to become contaminated outside the area protected by the leachate collection system and eventually flow offsite.

The following are the non-stormwater discharges authorized under this permit:

- Discharges from fire fighting activities;
- Fire hydrant flushing;
- Potable water, including water line flushing;
- Uncontaminated condensate from air conditioners, coolers, and other compressors and from the outside storage of refrigerated gases or liquids;
- Irrigation drainage;
- Landscape watering provided all pesticides, herbicides, and fertilizer have been applied in accordance with the approved labeling;
- Pavement run-off where no detergents are used and no spills or leaks of toxic or hazardous materials have occurred;
- Routine external building wash down that does not use detergents;
- Uncontaminated ground water or spring water;

- Foundation or footing drains where flows are not contaminated with process materials;
- Incidental windblown mist from air conditioning units that collects on rooftops or adjacent portions of this facility, but not intentional discharges from the air conditioning units (e.g. "piped" cooling system blowdown or drains); and,
- Washwater from cleaning of vehicles and equipment at the wash rack provided the have not come in direct contact with waste, or have been cleaned of such waste prior to using the wash rack, and that no detergents or toxic cleansers are used.

3.10.1 Wash Rack

Washwater drains from the wash rack to a concrete sediment basin. A turned-down elbow at the outlet aids in retaining floating debris in the basin. Flow from the basin is passed through an oil/water separator before being discharged to a bio-swale, leading to discharge off-site. Cleaning and maintenance of these systems will reduce potential for pollutant discharges. It is estimated that the flow of water from the wash rack will be approximately 20 gallons per week, depending on the usage of the wash rack. The OPERATOR shall report the estimated use (flow) in the Annual Report prepared per Section 5.13 and update annually, as needed.

3.10.2 Groundwater Subdrain

Groundwater from beneath the liners of active Cells is collected and conveyed to the Subdrain Tank. Prior to any discharge of the groundwater from the tank, it is to be visually inspected per Section 5.1.2. It is estimated that the flow of groundwater may be approximately 100 gallons per week. The OPERATOR shall record the volume of water in the tank prior to each discharge and shall report the volume of each release in the Annual Report prepared per Section 5.1.3.

Groundwater that exhibits any of the characteristics under Section 5.1.2 is no longer an allowed non-stormwater discharge under this MSGP SWPPP and shall be properly managed pursuant to the RCRA permit, MSWLF Permit No. 09-015 issued by Guam EPA. Under the RCRA permit Section IV.D Subdrain Monitoring, subdrain liquid may be collected and discharged into the leachate collection system for treatment and disposal. U.S. EPA shall be notified of any such occurrence.

Groundwater determined to be contaminated pursuant to the RCRA permit, MSWLF Permit No. 09-015 issued by Guam EPA, is no longer an allowed non-stormwater discharge under this MSGP SWPPP, and shall be managed pursuant to the RCRA permit. U.S. EPA shall be notified of any such occurrence.

3.11 Waste, Garbage and Floatable Debris

Maintenance staff will ensure that all waste, garbage and floatable debris are not discharged to receiving waters by keeping exposed areas free of such materials or by intercepting them before they are discharged. Removal of such materials on exposed areas including the access road, operations road, the parking lot, and all exposed areas in the Entrance Area Facility, will be frequent to avoid accumulation.

All waste materials will be handled as follows:

- All waste materials will be collected and disposed of into metal dumpster;
- Dumpsters will have a secure watertight lid and will be placed away from stormwater conveyances and drains. Only trash will be deposited in the dumpsters;
- The dumpster will be inspected weekly and immediately after storm events. The dumpster will be emptied weekly or more frequently as necessary;
- All maintenance staff will be instructed during training sessions on how to dispose trash correctly. Notices on the correct disposal procedures will be posted in the Maintenance Facility area;
- The Maintenance Supervisor shall ensure that all above procedures are being implemented properly.

If windblown waste or debris tends to exit the active cell(s) provide portable or permanent screens/fencing to prevent material from being blown off-site. Collect and dispose of such windblown debris frequently.

Within the detention/sedimentation ponds, remove floatable debris weekly. Floatable debris can block outlet orifices. Excessive accumulation can pose a risk to overflow structure screens during periods of high water.

3.12 Dust Generation and Vehicle Tracking of Industrial Materials

Generation of dust and off-site tracking of raw, final, or waste materials must be minimized. The following procedures are the general guidelines for the control of dirt and dust on the facility:

<u>Dirt</u>

- Vehicles or equipment with heavy dirt or mud on tires will be cleaned before entering roads or highways.
- Dirt or mud tracks on landfill roads will be washed by water truck and/or swept with mechanical equipment.
- Maintenance Staff will insure on-site roadways are clear of excessive dirt or mud before the end of each workday.

<u>Dust</u>

- Equipment transporting material that will cause dust shall have the material covered.
- Roads that will generate dust when traveled on shall be watered down with a water truck or swept to remove any tracked or dropped sediments.
- All equipment that generate dust shall be monitored to insure that if it exceeds acceptable amounts of dust, proper corrective measures will be taken to reduce the generation of dust (replace equipment, watering, filters, etc.).

- All equipment shall have guard and dust control attachments in working order.

- Daily site observations by Maintenance Staff will be conducted to insure all dust control measures are implemented.

- Dust mask or respirator shall be provided to employees when dust generated poses a hazard.

Waste/Debris

- Waste or debris found outside of active cells shall be collected and placed in appropriate disposal facilities.

Vehicles and equipment operated in contact with landfill waste shall be cleaned of contaminants in the active cell(s) prior to exiting the cell(s), including moving to the Entrance Area Facilities for maintenance.

SECTION 4: SCHEDULES AND PROCEDURES FOR MONITORING

4.1 Benchmark Monitoring

Sector-specific benchmark monitoring of storm water for total suspended solids (100 mg/L) and total iron (1.0 mg/L) will be performed at each Sampling Point in accordance with MSGP. The Sampling Point locations are identified in Attachment D. All samples will be grab samples. See 4.8 below.

Sampling has been performed at the site to determine the Baseline Concentrations for total iron in surface waters. Baseline Concentration for dissolved iron in surface waters has been as high as 3.0 mg/L. Therefore, benchmark monitoring shall consider 3.0 mg/L as the natural background concentration in evaluating the effectiveness of the BMP's related to total iron. 3.0 mg/L is also the maximum numerical limit for fresh water in Table IV of Guam Water Quality Standards (2000).

Benchmark Monitoring will be performed quarterly and shall start in the first full quarter following the date of discharge authorization. Benchmark monitoring data will be used primarily to determine the overall effectiveness of the control measures and to assist in determining if additional corrective actions maybe necessary to comply with the effluent limitations.

After collections of 4 quarterly samples and if the average of the 4 monitoring values for any parameter does not exceed the benchmark, then the monitoring requirements for that parameter for the permit term has been fulfilled. However, if the average of the 4 monitoring values for any parameter exceeds the benchmark, then the selection, design, installation and implementation of the control measures shall be reviewed to determine if modifications are necessary to meet the effluent limits of the permit, and follow additional requirements as outlined in MSGP 6.2.1.2 BENCHMARK MONITORING SCHEDULE. See also MSGP 6.3 FOLLOW-UP ACTIONS IF DISCHARGE EXCEEDS NUMERIC LIMIT.

4.2 Effluent Limitations Guidelines Monitoring

Beginning in the first full quarter following the date of discharge authorization, monitor effluent once per year at each Sampling Point. The Sampling Points are identified as numbered "Outfalls" and the locations are shown in Attachment D. All samples will be grab samples. See 4.8 below. Effluent limitations guidelines require that the following parameters (Table 6) meet the corresponding numeric effluent limits:

Table 6 – Sector L Effluent Limits		
Industrial Activity	**Parameter**	**Effluent Limit**
Discharges From Non-Hazardous Waste Landfills Subject to Effluent Limitations in 40 CFR Part 445 Subpart B	Biochemical Oxygen Demand (BOD)	140 mg/L, Daily Maximum / 37 mg/L, Monthly Average Maximum
	Total Suspended Solids (TSS)	88 mg/L, Daily Maximum / 27 mg/L, Monthly Average Maximum
	Ammonia	10 mg/L, Daily Maximum / 4.9 mg/L, Monthly Average Maximum
	Alpha Terpineol	0.033 mg/L, Daily Maximum / 0.016 mg/L, Monthly Average Maximum
	Benzoic Acid	0.12 mg/L, Daily Maximum / 0.071 mg/L, Monthly Average Maximum
	p-Cresol	0.025 mg/L, Daily Maximum / 0.014 mg/L, Monthly Average Maximum
	Phenol	0.026 mg/L, Maximum / 0.015 mg/L, Monthly Average Maximum
	Total Zinc	0.20 mg/L, Daily Maximum / 0.11 mg/L, Monthly Average Maximum
	pH	Within the range of 6-9 standard pH units (s.u)

Follow-up monitoring must be conducted within 30 calendar days (or during the next qualifying runoff event, should none occur within 30 days) to implement corrective actions in response to an exceedance of a numeric effluent limit contained in this permit. Monitoring must be performed for any pollutant(s) that exceeds the effluent limit. See MSGP 6.3 ‘FOLLOW-UP ACTIONS IF DISCHARGE EXCEEDS NUMERIC LIMIT’.

4.3 State and Tribal Specific Monitoring

In accordance with MSGP, Section 9.9.4, there are no state and tribal monitoring requirements at this site.

4.4 Impaired Waters Monitoring

According to the GEPA 2010 Integrated Report, Table 23, the rivers/streams in the vicinity of this facility are not identified as impaired waters or waters with TMDL’s. Therefore, no impaired waters monitoring is necessary for this facility

4.5 Additional Monitoring Required by EPA

There is no additional monitoring required by EPA for this facility.

4.6 Inactive and Unstaffed Site Exception

The inactive and unstaffed site exception is not applicable to this facility.

4.7 Substantially Identical Outfall Exception

The substantially identical outfall exception will not be used at this facility.

4.8 Additional Requirements

Collect and analyze storm water samples and document monitoring activities consistent with the procedures described in MSGP, Part 6 and Appendix B, Subsections 10 – 12, and Part 8 L. Reporting and recordkeeping shall be in accordance with MSGP, Part 7. Note that all monitoring must be conducted in accordance with the relevant sampling and analysis requirements of 40 CFR Part 136. The Landfill Site Manager, or his designee, shall be responsible for ensuring compliance with these requirements.

Prior to initiating operations at the LMSL, the OPERATOR shall prepare and submit for EPA review, a monitoring plan including procedures to be followed for collecting samples, staff who will be involved, logistics for taking and handling samples, laboratory to be used, etc. Once approved, this monitoring plan shall be made a part of this SWPPP.

SECTION 5: INSPECTIONS

5.1 Inspection Requirements

There are three types of inspections to be performed on this facility, as required by the MSGP, as follows:

5.1.1 Routine Facility Inspections

The routine facility inspections shall be conducted on the active portion of the facility at least once every seven (7) days by a qualified Landfill Inspector. The areas to be inspected are as follows:

- Areas of the landfill that have not yet been finally stabilized
- Areas used for storage of material and wastes that are exposed to precipitation
- Stabilization and structural control measures
- Leachate collection and transport systems
- Landfill facility entrances and exits
- All areas exposed to precipitation will be visually inspected for evidence of or the potential for pollutants entering the storm drain system.
- All structural (berms and dikes) and non-structural BMPs for erosion and sediment control shall be inspected to ensure they are operating correctly
- Complete the BMP checklist during the inspection and maintain the records for at least five years.

For inactive or stabilized portions of the facility, conduct inspections at least once every month.

At a minimum, the documentation for each routine facility inspection must include:

- The inspection date and time;
- The name(s) and signature of the inspector(s);
- Weather information and a description of any discharges occurring at the time of the inspection;
- Any previously identified discharges of pollutants from the site;
- Any control measures needing maintenance or repairs;
- Any failed control measures that need replacement;
- Any incident of noncompliance observed; and
- Any additional control measures needed to comply with the permit requirements.

Any corrective action required as a result of a routine facility inspection must be performed consistent with Part 3 of the MSGP.

At least once each calendar year, a routine facility inspection must be conducted during a period when a stormwater discharge is occurring. Routine inspection reports shall be kept with the SWPPP, but are not required to be submitted to EPA unless specifically requested by EPA.

5.1.2 Quarterly Visual Assessment of Stormwater Discharges

Once each quarter for the entire permit term, a stormwater sample from each Sample Point shall be collected and a visual assessment of each of these samples shall be conducted by a qualified Landfill Inspector. The samples shall be collected in such a manner that the samples are representative of the stormwater discharge.

The visual assessment must be made:

- Of a sample in a clean, clear glass, or plastic container and examined in a well-lit area.
- On samples collected within the first 30 minutes of an actual discharge from a storm event. If it is not possible to collect the sample within the first 30 minutes of discharge, the sample shall be collected as soon as practicable after the first 30 minutes and document why it was not possible to take samples within the first 30 minutes.
- For storm events, on discharges that occur at least 72 hours (3 days) from the previous discharge. The 72-hour (3-day) storm interval does not apply if you document that less than a 72-hour (3-day) interval is representative for local storm events during the sampling period.

The sample shall be visually inspected for the following water quality characteristics:

- Color
- Odor
- Clarity
- Floating solids
- Settled solids
- Suspended solids
- Foam
- Oil sheen
- Other obvious indicators of stormwater pollution

At a minimum, the visual assessment documentation must include the following;

- Sample location(s)
- Sample collection date and time, and visual assessment date and time for each sample
- Personnel collecting the sample and performing visual assessment, and their signatures
- Nature of the discharge (i.e., runoff, outfall, etc)
- Results of observations of the stormwater discharge
- Possible source of any observed stormwater contamination
- If applicable, why it was possible to take samples within the first 30 minutes

Quarterly visual inspection reports shall be kept with the SWPPP, but are not required to be submitted to EPA unless specifically requested by EPA.

Additional visual inspection requirements:

- Groundwater subdrainage from beneath Cells 1 & 2: Prior to any discharge from the subdrain holding tank, subdrain water shall be sampled and visually inspected in accordance with this Section. Subdrain water shall not be discharged if the inspection indicates contamination. If contamination is present, as indicated by any of the water quality characteristics indicated above, or is determined to be contaminated by leachate pursuant to MSWLF Permit No. 09-015, provide notification to GEPA and EPA and properly dispose of contaminated subdrain water in compliance with MSWLF Permit No. 09-015.

The following are exceptions to quarterly Visual Assessments:

- Adverse Weather Conditions: When adverse weather conditions prevent the collection of samples during the quarter, substitute samples shall be taken during the next qualifying storm event. Documentation of the rationale for no visual assessment for the quarter must be included in the SWPPP records as described in Part 5.4 of the MSGP. Adverse conditions are those that are dangerous or create inaccessibility for personnel, such as flooding, high winds, electrical storms, or situations that otherwise make sampling impractical.

5.1.3 Comprehensive Site Inspections;

Annual comprehensive site inspections shall be conducted while covered under this permit. Annual, as defined herein, means once during each of the following inspection periods beginning with the period that discharge is authorized under this permit:

- Year 1: September 30, 2010 – September 29, 2011
- Year 2: September 30, 2011 – September 29, 2012
- Year 3: September 30, 2012 – September 29, 2013

A comprehensive site inspection is waived if authorization to discharge is obtained less than 3 months before the end of that inspection period. Should permit coverage be administratively continued after the expiration of the MSGP, annual comprehensive site inspections must continue until the facility is no longer covered.

Comprehensive site inspections shall be conducted by a qualified Landfill Inspector and must cover all areas of the facility affected by the requirements in the MSGP, including the areas identified in this SWPPP as potential pollutant sources where industrial materials or activities are exposed to stormwater and any areas where control measures are used to comply with the effluent limits, and areas where spill and leaks have occurred in prior years. The inspections must also include a review of monitoring data collected in accordance with Section 4 of this

SWPPP, as well as consideration of the results of past year's visual and analytical monitoring when planning and conducting inspections.

The inspectors shall examine the following:

- Industrial materials, residue or trash that may have or could come into contact with stormwater
- Leaks or spills form industrial equipment, drums, tanks and other containers
- Offsite tracking of industrial or waste materials, or sediments where vehicles enter or exit the facility
- Tracking or blowing of raw, final, or waste materials from areas of no exposure to exposed areas
- Control measures needing replacement, maintenance, or repair
- Stormwater control measures to ensure they are functioning properly

The annual comprehensive site inspection may also be used as one of the routine inspections, as long as all components of both types of inspections are included.

At a minimum, the documentation of the comprehensive site inspection shall include the following:

- The date of the inspection
- The name(s) and title(s) of the personnel making the inspection
- Findings from the examination of areas of the facility identified above
- All observations relating to the implementation of the control measures including:
  - previously unidentified discharges from the site
  - previously unidentified pollutants in existing discharges
  - evidence of, or the potential for, pollutants entering the drainage system
  - evidence of pollutants discharging to receiving waters at all facility outfall(s), and the condition of and around the outfall, including flow dissipation measures to prevent scouring
  - additional control measures needed to address any conditions requiring corrective action identified during the inspection
  - groundwater discharge monitoring results associated with the active Cell subdrain system
- Any required revisions to the SWPPP resulting from the inspection
- Any incidents of noncompliance observed or a certification stating that the facility is in compliance with the MSGP
- A statement, signed and certified, in accordance with Appendix B, Subsection 11 of the MSGP

Any corrective action required as a result of the comprehensive site inspection must be performed consistent with Part 3 of the MSGP.

Maintain records of comprehensive site inspection with the SWPPP. Submit the documentation in an annual report.

5.2 Inspection Procedures, Records and Reporting

Procedures, Records and Reporting must be performed in accordance with the MSGP. The OPERATOR'S attention is directed to Part 7 of the MSGP for Reporting and Recordkeeping. It is recommended that the OPERATOR utilize the ADDITIONAL MSGP DOCUMENTATION TEMPLATE available in Microsoft Word format at:

http://www.epa.gov/npdes/pubs/msgp2008_recordkeepingtemplate.doc

SECTION 6: DOCUMENTATION TO SUPPORT ELIGIBILITY CONSIDERATIONS UNDER OTHER FEDERAL LAWS

6.1 Documentation Regarding Endangered Species

Based on the Final Selection Report (which includes the Final EIS) by Duenas and Associates, dated March 14, 2005, there are no species that are federally listed as endangered or threatened within the project boundaries, nor are there designated critical habitat areas.

6.2 Documentation Regarding Historic Properties

According to documentation cited in GEPA MSWLF Permit No. 09-015, no formal archaeological sites were identified during government sponsored surveys of the site. Therefore, the stormwater discharges and allowable non-stormwater discharges do not have the potential effect on historic properties.

6.3 Documentation Regarding NEPA Review

In response to the Consent Decree, Civil Case No. 02- 0002, the Guam Department of Public Works (DPW) and the Guam Environmental Protection Agency (GEPA) initiated a site selection study and Environmental Impact Statement ("EIS") for the selection of a site for a new Municipal Sanitary Landfill Facility that meets local and federal solid waste disposal regulations. (Environmental Impact Statement (EIS) prepared by Duenas & Associates, dated March 14, 2005, is available for reference). After careful consideration of the three candidate sites, Layon (also known as Dandan), Inarajan was chosen as the least damaging alternative site. The Guam DPW then initiated the design of the proposed landfill including access road and utilities infrastructure.

The site selection EIS was prepared in accordance with the National Environmental Policy Act and Guam EPA and was completed under the terms of the Consent Decree.

SECTION 7: SWPPP CERTIFICATION

7.1 Preparer's Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name: TG Engineers, PC
125 Tun Jesus Crisostomo St., Ste. 206
Tamuning, Guam 96913-3551
By: Marc Gagarin, PE

Title: Chief Engineer

Signature: [signature]

Date: 5-27-11

7.2 Operator's Certification

I certify that the operation of the LMSL will conform to the requirements set forth in this SWPPP and the MSGP. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name: Herzog Environmental, Inc.
PO Box 170291
Inarajan, Guam 96917
By: Norm Kivett

Title: Project Manager

Signature: Norm Kivett

Date: 5-28-11

SECTION 8: SWPPP MODIFICATIONS

This SWPPP is a "living" document and is required to be modified and updated, as necessary, in response to operational modifications and/or corrective actions. Modifications to the SWPPP in response to corrective action required by Part 3.1 of the MSGP require the certification statement in Section 7 of this SWPPP to be re-signed. All modifications must be documented.

In order to document modifications to this SWPPP, it is recommended that the OPERATOR utilize the ADDITIONAL MSGP DOCUMENTATION TEMPLATE available in Microsoft Word format at:

http://www.epa.gov/npdes/pubs/msgp2008_recordkeepingtemplate.doc

SWPPP ATTACHMENTS

The following documents are attached to the SWPPP:

Attachment A – EPA 2008 MSGP

Attachment B – GEPA MSWLF Permit No. 09-015

Attachment C – Location Map and Vicinity Map

Attachment D – Site Plans

Attachment E – Additional MSGP Documentation Template

Attachment F – LMSL Design, Storm Drainage Calculations

Attachment A - EPA 2008 MSGP

Incorporated by reference and available in electronic format at:
http://www.epa.gov/npdes/pubs/msgp2008_finalpermit.pdf

In addition, a printed copy shall be produced and kept with this SWPPP.

Attachment B - GEPA MSWLF Permit No. 09-015

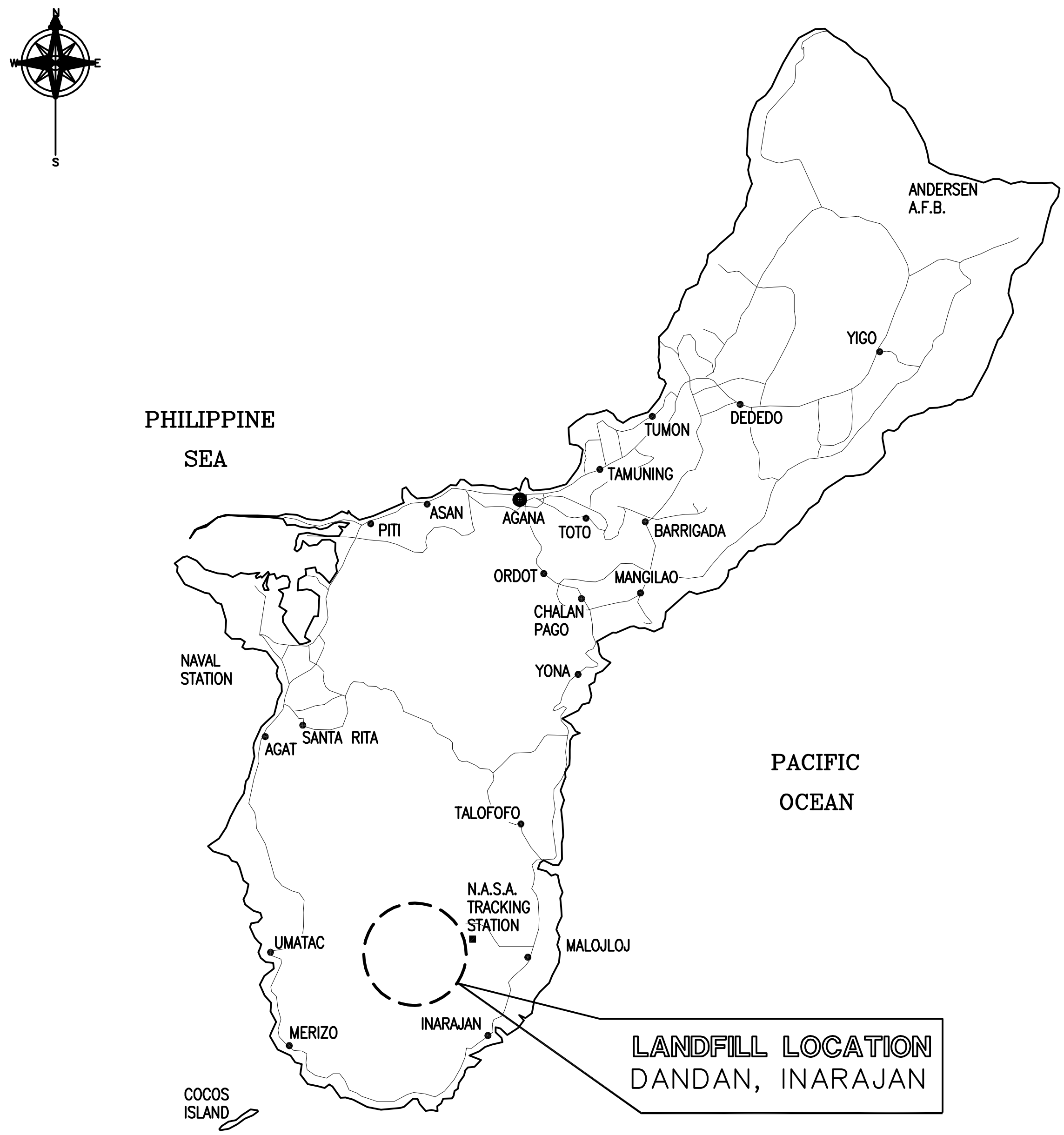
Incorporated by reference and available at:

http://www.guamsolidwastereceiver.org/pdf/1._Layon_Landfill_Solid_Waste_Facility_Permit_No_09_015_and_FO_020.pdf

Attachment C - Location Map and Vicinity Map

Exhibit 1 – Location Map

Exhibit 2 – Vicinity Map



ISLAND of GUAM

LOCATION MAP

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Cell: (671)688-0889

EXHIBIT 1

GUAM LAYON MUNICIPAL SANITARY LANDFILL

OPERATION SWPPP

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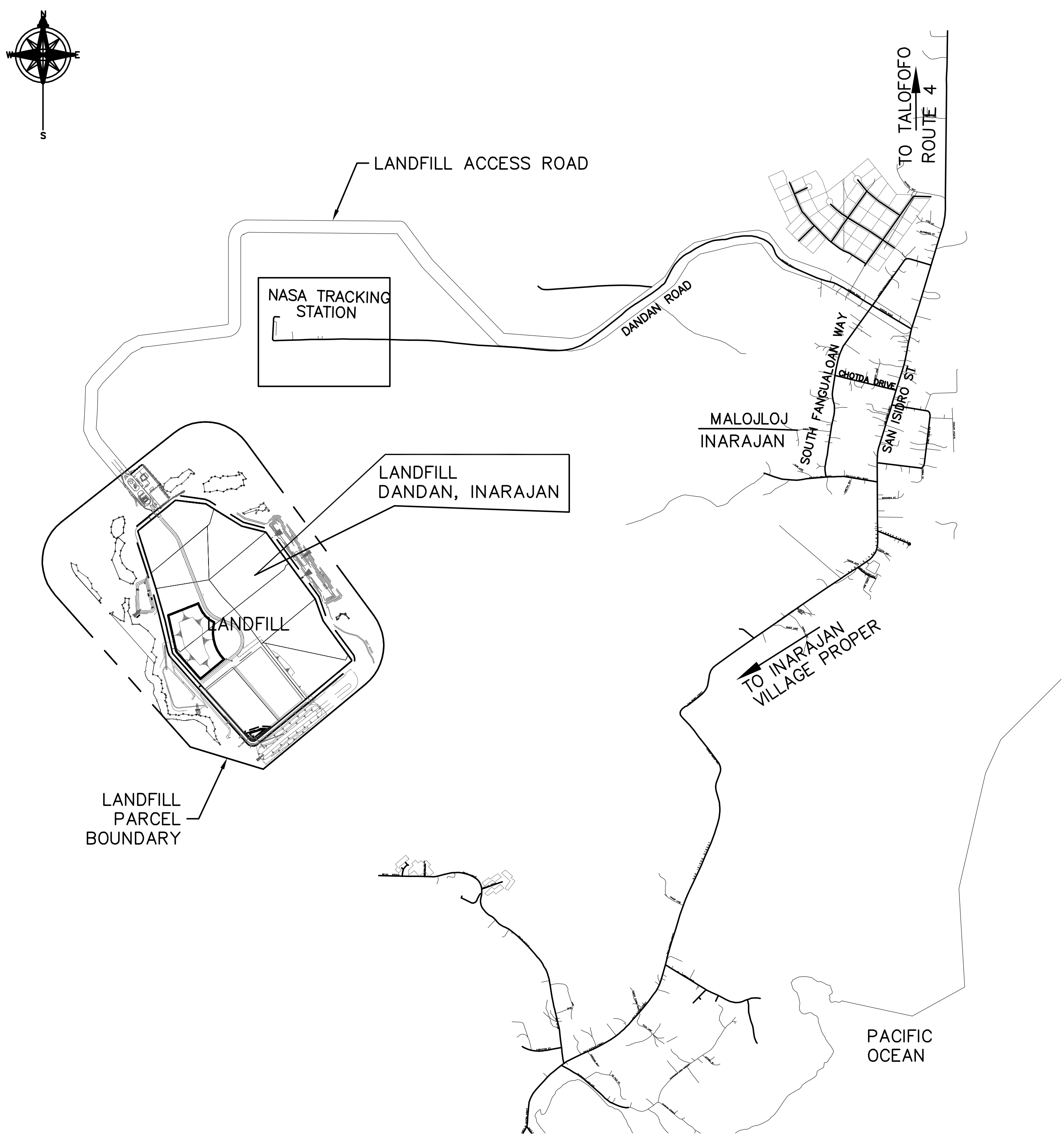

VICINITY MAP

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EXHIBIT 2

GUAM LAYON MUNICIPAL SANITARY LANDFILL

OPERATION SWPPP

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Attachment D – Site Plans

Exhibit 1 – Landfill and Surrounding Area Site Plan

Exhibit 2 – Landfill Area Contour and Drainage Map

Exhibit 3 – Entrance Area Facility Contour and Drainage Map

Exhibit 4 – Landfill Cell Area Contour and Drainage Map

LEGEND

- AC PAVEMENT
- GRADED AREA, SEEDED EXCEPT CELL AREAS
- UNDISTURBED AREA, NATURAL TERRAIN & VEGETATION
- STRUCTURES
- WETLAND
- MONITORING WELL ACCESS ROAD

NOTES:

1. EACH "OUTFALL" SHOWN HEREON IS A SAMPLING POINT
2. FOR MORE DETAIL, SEE ENLARGED EXHIBITS

LANDFILL AND SURROUNDING AREA SITE PLAN

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EXHIBIT 1

GUAM LAYON MUNICIPAL SANITARY LANDFILL

OPERATION SWPPP

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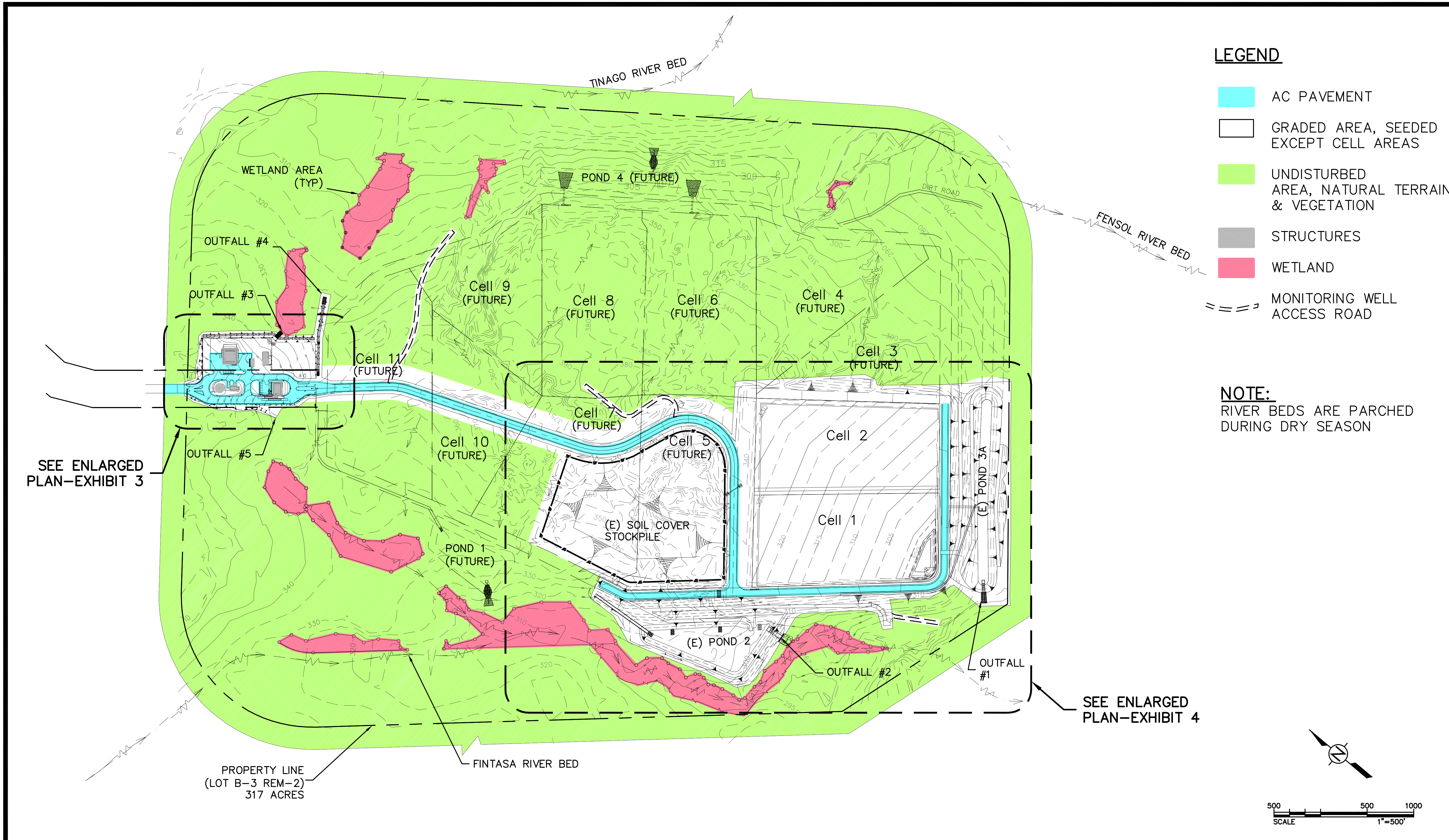

LANDFILL AREA CONTOUR AND DRAINAGE MAP

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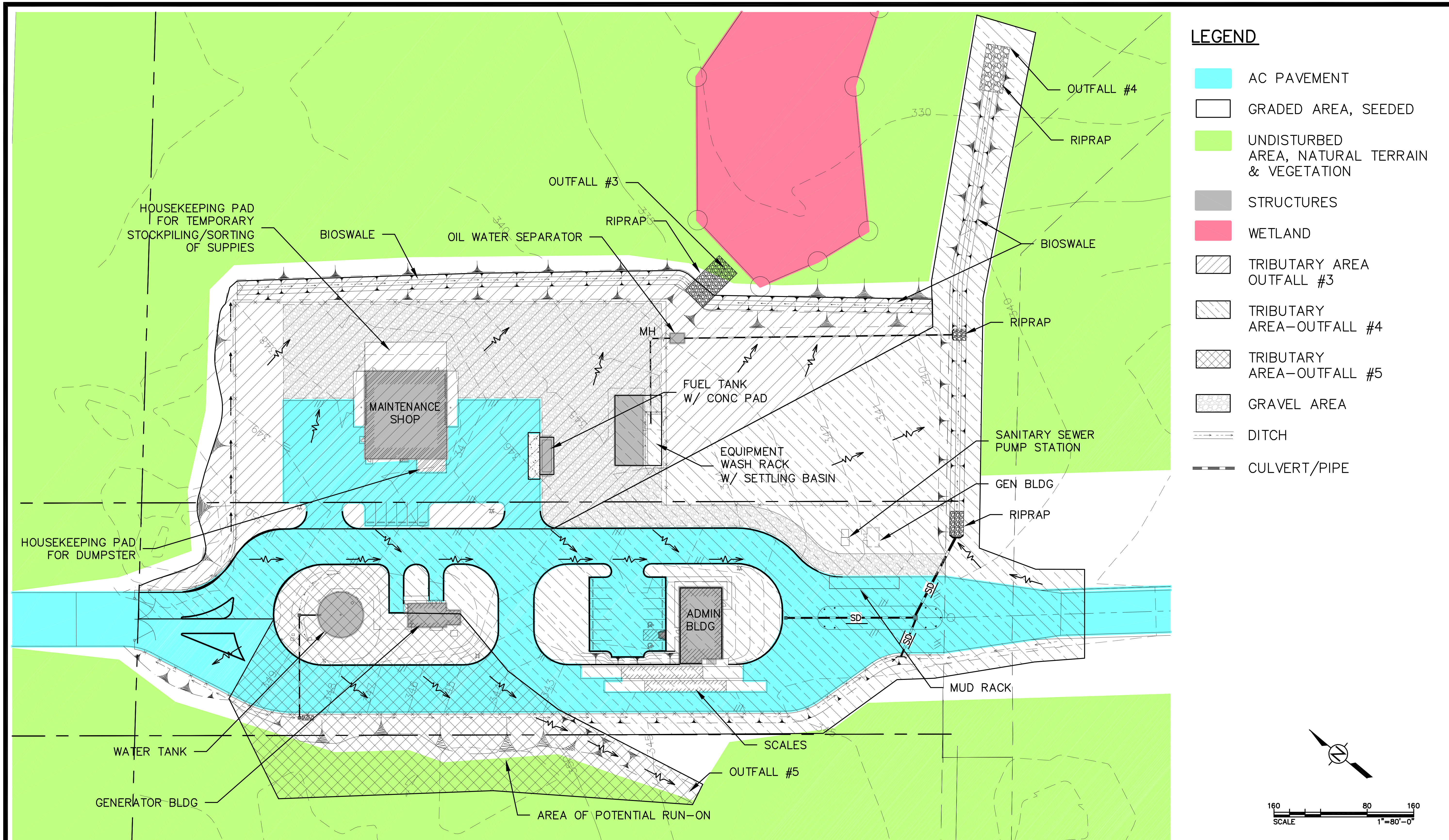
EXHIBIT 2

GUAM LAYON MUNICIPAL SANITARY LANDFILL

OPERATION SWPPP



ENTRANCE AREA FACILITY CONTOUR AND DRAINAGE MAP

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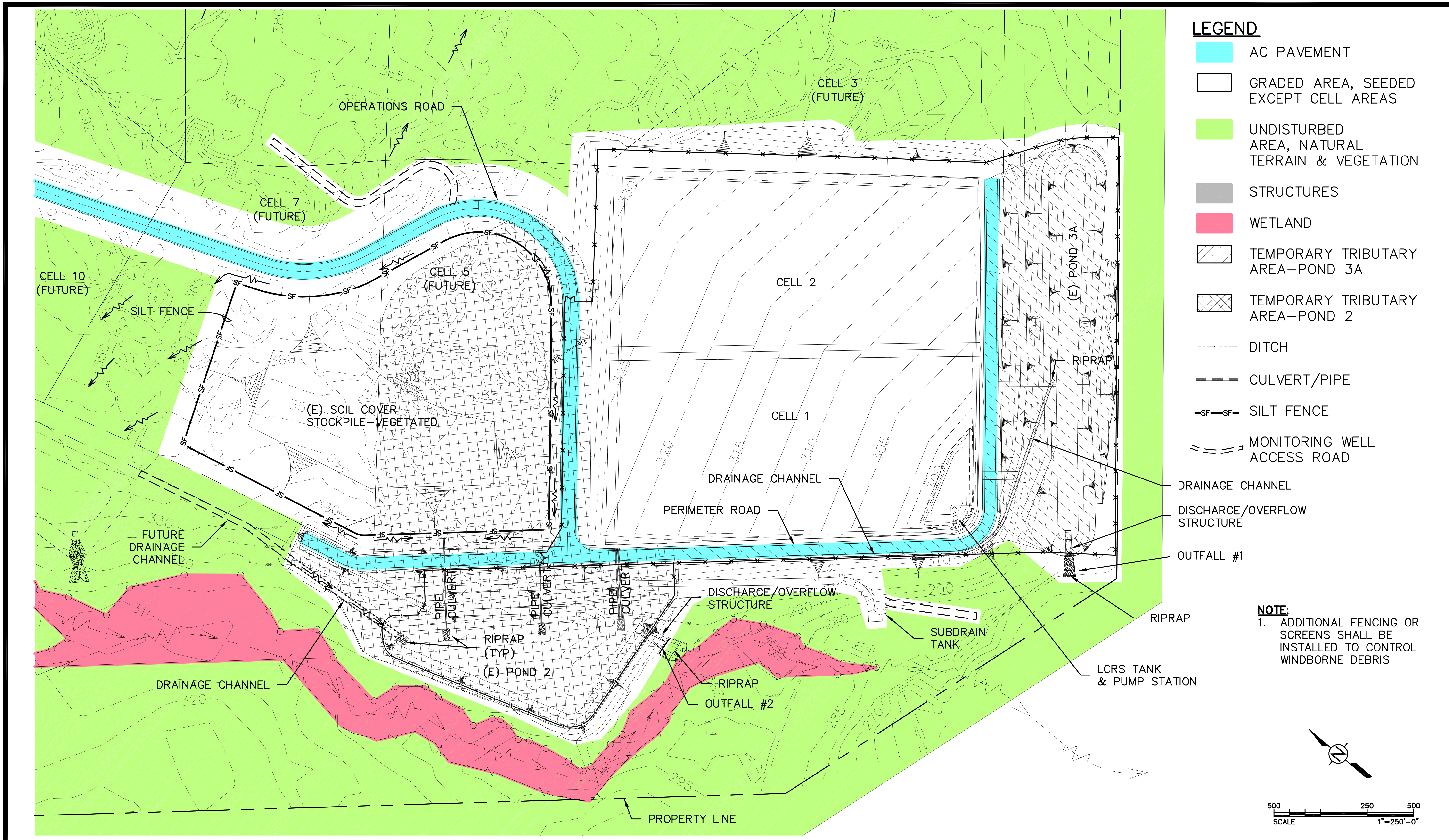
EXHIBIT 3

GUAM LAYON MUNICIPAL SANITARY LANDFILL

OPERATION SWPPP



LANDFILL CELL AREA CONTOUR AND DRAINAGE MAP

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EXHIBIT 4

GUAM LAYON MUNICIPAL SANITARY LANDFILL

OPERATION SWPPP

Attachment E – Additional MSGP Documentation Template

Incorporated by reference and available in electronic format at:
http://www.epa.gov/npdes/pubs/msgp2008_recordkeepingtemplate.doc

Attachment F – LMSL Design, Storm Drainage Calculations

Part 1 – Technical Memo, "Updated Hydrology/Hydraulics Calculations for Revised Pond 2 Design", May 5, 2010

Part 2 – Design Memorandum, "Surface Water Drainage System Calculations, Layon Landfill, Guam", November, 2008

Part 3 – Design Technical Memorandum, "Guam Municipal Solid Waste Landfill Project – Design Criteria; Hydrology and Hydraulic Analysis", July 29, 2005

Technical Memo

Updated Hydrology/Hydraulics Calculations for Revised Pond 2 Design.

Layon Landfill Entrance Area Project - Pond 2 Design Analysis

In Accordance with Civil Case No. 02-00022
Consent Decree Filed February 11, 2004
In U.S. District Court, Territory of Guam

PREPARED BY
TG ENGINEERS, PC
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May 5, 2010

6/3/10

THIS WORK WAS PREPARED BY ME OR DONE UNDER MY DIRECT SUPERVISION

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Project Understanding

The Layon Municipal Landfill Entrance Area project, which is currently under construction, includes a requirement to build what is currently known as 'Pond 2 improvements' which generally consists of a detention pond, discharge culverts and input culverts from the Cells, both current and future.

It should be noted that much of the information contained herein was submitted and approved by the either Guam Division of Solid Waste Management and/or Guam Environmental Protection Agency. Reference is made to a design memorandum prepared by A-Mehr Inc. and titled *Surface Water Drainage System Calculations, Layon Landfill, Guam* dated November 8, 2008 and accompanying technical memorandum prepared by Winzler & Kelly dated July 29, 2005. Both of these documents were submitted as Appendix B, Book 1, 40% Plans, Specifications, & Estimates as part of the overall permitting process. It is not the intent of this report to overhaul the watershed and/or subsequent hydrograph(s) data but to confirm their general validity as it applies to the ***current*** topographic information and design concepts contained herein.

Review of the design basis is as follows:

- 25-year, 24 hour storm
- Review hydrograph and routing calculations of the full site development as established by A-Mehr Inc. / Winzler & Kelly Design Memorandum dated November 2008.

It should be understood that the previous comprehensive design was completed using limited (i.e. less precise) topographic information. The previous discharge results were then applied to each pond (a total of four) surrounding the entire 127 acre landfill site. The subsequent A-Mehr Inc. design memorandum notes that their own exhibits, which are in contrast to the Winzler & Kelly exhibits, reflect a revised numbering of the four ponds which was adopted after an apparent decision to '***start at the south end***' construction sequence. In order to review the drainage watershed, a new 'final grading watershed' exhibit was developed herein (see Appendix) which used current topographic information and design details and assumed that the final waste grades shall remain as shown in the Winzler and Kelly Figure 2 exhibit. The results of this reconciliation show the current design result will slightly modify the watershed permeters and corresponding areas. It should also be noted that sub watershed area A1 includes a culvert at Perimeter Road STA 15+00 in the Winzler & Kelly Figure 2 exhibit while current construction drawing L0.3 calls for a culvert at STA 17+50. This minor difference results in sub watershed area A1 3.5 acres instead of 6.3 acres listed in Table 3 Final Grading Condition Runoff Analysis Results. In addition A10 is changed from 19.3 acres to 17.6 acres and A11 is changed from 20.2 acres to 17.7 acres.

Storm-water Routing

Figure 1 was developed by TG Engineers to review the areas of the final site development. The figure indicates that the areas generally conform to what was established by Winzler & Kelly. However, the pond 2 area itself was added to the calculation and labeled A11.1 given its proximity to A11 and connection via the drainage culverts located along the Perimeter Road at 19+40.

A-Mehr Inc established the peak design inflows to the subareas tributary to each of the Ponds as shown in the Table 1 shown below and is partially replicated herein.

Table 1 – Pond 2 & Pond 3A Inflows at Full Development
(November 2008 Submittal)

Pond	Sub-watershed Area	Acres	Peak Flow (cfs)	Pond Total Flow (cfs) 1/	Comments
Pond 2	A10	19.3	164		
	A11	20.3	205		
	Pond 2 total	**45.9**		334	Acreage sum = 45.9. Note A1 area is not included
Pond 3A	A1	6.3	70		Assumes 100% of A1 goes to Pond 2
	A2	7.2	89		
	A3	14.4	159		
	A4 (30%)	6.6	102 (50)		A4 = 16.6 acres; 30% = 5.0 acres. Adjust Peak Flow.
	Pond 3A total	**33.0**	80	400	Acreage sum =/ 33.0 as shown. Area totals = 28.2 acres

1/: Pond totals may not equal sum of area peak flows due to different lag time in area peak flows reaching basin

Table 2 – Pond 2 & Pond 3A Inflows at Full Development
(April 2010 Submittal)

Pond	Sub-watershed Area	Acres	Peak Flow (cfs)	Pond Total Flow (cfs) 1/	Comments
Pond 2	A10	17.6	168		
	A11	17.7	170		
	A11.1	3.8	57		Pond 2 itself
	A1 (60%)	3.5	22		60% A1 = 2.1 ac; culvert shifted 250' N of previous location
	Pond 2 total	**41.2**		**381**	Acreage decrease of 4.7 from above
Pond 3A	A1 (40%)	1.4	28		Based on updated alignment of Perimeter Road and topographic information there is no contribution from A1
	A2	7.2	89		
	A3	14.4	159		
	A4 (30%)	5.0	50		A4 Peak Flow = 164 cfs at 100% per WK. Assume 30% Peak Flow
	Pond 3A total	**28.0**		**338**	Acreage decrease of 0.2 acres from WK Table 1 above due to change in topographic information.

1/: Pond inflow totals may not equal sum of area peak flows due to different lag time in area peak flows reaching basin

Fig.1

In order to reconcile the 'Pond Total Flows' due to changes in the sub watershed areas due to updated toppgraphic and surveyed information, a ratio calculation is performed as follows:

- Using the W&K Table 1, Pond 2 Peak Flow totals **439 cfs** (164+205+70) /45.2 acres or 9.6 cfs /acre. Due to updated topographic information, Pond 2 has moved northward to avoid encroachment into the Fintasa River. Thus the 'Total Flow' is now computed as 9.6 cfs / acre times 41.2 acres which results in a flow of **396 cfs** which is a decrease.

- Using the W&K Table 1, Pond 3A Peak Flow totals **326 cfs** (0+89+159+50) / 28.2 acres or 10.6 cfs / acre. The 'Total Flow' is now computed as 10.6 cfs / acre times 28.0 acres which results in a flow of **297 cfs** which is a decrease.

Stormwater Ponds

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The primary design objective of Pond 2 is to provide detention time for sediment to settle out on the basin floor before stormwater is discharged to the Fintasa River. In addition provide retention such that peak discharges to the adjacent streambeds do not exceed existing peak flows from the undeveloped site. The key variables are pond storage and rate of discharge.

Pond 2 is designed for a maximum depth of 10 feet, with an emergency spill at elevation 8 feet above the pond bottom. Note that in the A-Mehr Inc. report, the cumulative storage by depth for Pond 2 is shown as 26.1 acre-feet. The pond discharge characteristic spreadsheet, located in the appendix, shows the cumulative volume storage by increment totals 1,181,613 cubic feet or 27.1 acre-feet, an increase of one acre-foot.

Discharge Structure(s)

Pond 2 will discharge the design flow through three 48-inch HDPE pipes. The pipes are sized to pass the peak inflow to the pond when the headwater depth is between six and eight feet above the pond bottom and just prior to the spillway allowing an additional two feet before the pond is crested. Pond discharges at low water depths are controlled by a low concrete wall around the pipe inlets with embedded orifices openings (6-inch diameter) that allow water to be discharged while retaining flow to allow sediment fallout.

The Hydraulic Culvert Program HY-8 (v 8.7.1) developed by the Federal Highway Administration Program was used with the results posted below in the appendix. This was in slight contrast to what the previous designer used which included a nomograph from the former Bureau of Roads dated May 1964. Because the fundamental equations remained the same, the results were generally the same. The HY-8 program calculated a culvert discharge of 440 cubic feet per second for an eight foot deep pond elevation (303 GGN), a 478 cubic feet per second for an nine foot deep pond elevation (304 GGN), which is just less than the 511 cubic feet per second for ten foot deep pond elevation (305 GGN) as predicted by Equation 6.

Discharge Structure Components

The discharge structure can be broken down into three components as follows:

1. Riser Structure
   - Consists of three rows of 6-inch orifices in the concrete box set at centerline of 1.5, 3.0, 4.5 feet above the pond bottom.
2. Discharge Pipes
   - consists of three 48-inch HDPE pipes
3. Spillway
   - Consists of a concrete trapezoidal structure with a base 8 feet wide and 2 feet high slopes at 3.75:1 relationship to a top width of 23 feet.

Riser Structure

The orifice equation is as follows:
$Q_o = C A (2gH)^{1/2}$
Q = flow in cubic feet per second
A = pipe area square feet - 6 inch diameter = Pi R^2 = 3.1416 $(0.25)^2$ = 0.196 square feet
H = head or water depth above orifice centerline (ft)

$Q_o = 0.932 H^{½}$ cubic feet per second **Orifice - Equation 1**

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As the water depth in the pond rises, each row of orifices, starting with the lowest, will become submerged and allow flow through the pipes. The three water levels above the pond bottom are defined as 1.6, 3.1 and 4.5 feet which are highlighted in the table below. As the water level rises to 6 feet, the flow from all the orifices contributes 48 cubic feet per second. As the water level rises to 8 feet, the flow contribution rises to from all the orifices contributes 63 cubic feet per second.

As the water in the pond rises, the 48-inch pipes as noted above begin to fill. As it reaches the top of the riser, it flows over the riser walls on all four sides which are described by the weir equation below (Sturm, 2001).

The weir equation is as follows:

$$Q_w = 2/3\, C_w\, L\, (2g)^{1/2}\, H_w^{1.5}$$

Q_w = flow in cubic feet per second
$C_w = 0.602 + 0.075\,(H_w / y)$: H_w = head above weir, y = weir height above pond bottom,
L = length of weir

For Pond 2, the head above the weir will operate between 6.1 feet and 8 feet above the pond bottom or in a range of 1.9 feet. The riser, designed as a rectangle at 18 feet by 23 feet, produces a weir length of (2(18+23)) = 82 feet. Therefore:

- Y = 6 feet
- H_w </= 1.9 feet
- C_w = </= 0.602 + 0.075 (1.9/6) = 0.626
- L = 2(18+23)) = 82 feet

Weir flow is calculated as follows:

$$Q_w = (2/3)\,(0.626)\,(82)\,(64.4)^{1/2}\, H_w^{1.5}$$

$Q_w = 275\, H_w^{1.5}$ **Weir - Equation 2**

At a pond water level of 8 feet, which corresponds to the spillway depth, the discharge into the riser would be as follows:

$Q_w = 275\,(2)^{1.5} = 778$ cubic feet per second for the riser.

<u>Discharge Pipes</u>

The design calls for three 48-inch diameter pipes for discharge into the Fintasa River. As a check, a Manning's Equation calculation was developed for various slopes to determine various velocities.

$Q = 1.486 / n\, A\, R^{2/3}\, S^{1/2}$ **Manning's – Equation 3**

Where:

Q = Flow Rate, (ft^3/s)
v = Velocity, (ft/s)
A = Flow Area, (ft^2)

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n = Manning's Roughness Coefficient
R = Hydraulic Radius, (ft)
S = Channel Slope, (ft/ft)

Assuming a roughness value of 0.012 for the HDPE pipe, the peak flow capacity for three different slopes is as follows:

S = 0.005	Q = 118 cubic feet per second x3 = 354	V = 9.6 feet per second
S = 0.010	Q = 167 cubic feet per second x3 = 501	V = 13.5 feet per second
S = 0.020	Q = 236 cubic feet per second x3 = 708	V = 19.1 feet per second

Based on these results, it appears that the three pipes will have sufficient capacity to discharge the riser structure. In addition, the PCSWMM 2009 computer program was used to view how the 3-48-inch pipes would flow given a time series SCS Type III Storm of 20-inches in depth. The 71 feet of pipe (3 barrels) was modeled with two slopes of 0.25 ft/ft and 0.005 ft/ft which is designed to create an hydraulic jump and decrease velocities. The resulting hydraulic grade line shows open flow for 613 CFS in the steep reach and pressure flow for 330 CFS with a velocity of 8.8 ft/s. This change in grade will slow down the water and minimize scour.

It should be noted that A-Mehr Inc. used the HY-5 nomograph from which the following calculations were based and are presented herein for consistency. Given the riser structure, the pipes will act as a culvert with inlet control; hence the head at the inlet is determined by the following equations:

Un-submerged Culvert

$HW_u/D = K\ (HW_u/D = K\ (Q/AD^{½})^{M}$

Where:

HW_u = headwater depth above pipe invert, feet
D = culvert diameter, feet
A = cross-section area of culvert, square feet
Q = discharge flow, cubic feet per second
M = coefficient for square edge pipe with headwall = 2
K = coefficient for square edge pipe with headwall = 2

For a 48 inch diameter pipe, the equation can be rewritten as follows:

$HW_u = 0.00062\ Q^2$ **Un-submerged Culvert - Equation 4**

This equation is applicable for values of $Q/AD^{½}$ up to a depth of 3.5 or for flow less than $Q = 3.5\ AD^{1/2}$ - 3.5 (3.1416)(4) $(4)^{½}$ = 88 cubic feet per second.

Submerged Culvert

$HW_s/D = C\ (KuQ/AD^{½})\ 2 + Y - 0.5S$

Where:

HW_s = headwater depth above pipe invert, feet
D = culvert diameter, feet
A = cross-section area of culvert flowing full, square feet
Q = discharge flow, cubic feet per second

S = slope of culvert = assumed value of 0.04
Y = coefficient = 0.667
C = coefficient = 0.0398
K_u = coefficient for square edge pipe with headwall = 1

For a 48 inch diameter pipe, the equation can be rewritten as follows:

$HW_u = 0.000252\ Q^2 + 2.68$ **Submerged Culvert - Equation 5**

This equation is applicable for values of $Q/AD^{½}$ up to a depth of 4.0 or for flow less than $Q = 4.0\ AD^{1/2}$ = 3.5 (3.1416)(4) $(4)^{½}$ = 100 cubic feet per second.

At higher flows, the value of HW_t = calculated using equation 3 will exceed the water level elevation in the pond. Therefore the pipe discharge is calculated using the pond water elevation as HWs in the following equation derived from solving Equation 3 for Q.

$Q = 63\ (HW_s - 2.68)\ 0.5$ **Transition Depth Culvert - Equation 6**

Equation 5 is used to calculate the maximum pipe discharge when the pond reaches the crest or a depth of 10 feet.

Q = 63 (10 – 2.68) 0.5 = 170.4 for each pipe (x3) = 511 cubic feet per second at elevation 305.

Spillway

The spillway is a concrete trapezoidal structure with an 8 foot wide base and 2 feet high slopes at a 3.75:1 grade, to a top width of 23 feet. The spillway is treated as a simple weir with a width of 8 feet.

The weir equation is as follows:

$$Q_w = 2/3\ C_w\ L\ (2g)^{½}\ H_w^{1.5}$$

Q_w = flow in cubic feet per second
$C_w = 0.602 + 0.075\ (H_w / y)$: H_w = head above weir, y = weir height above pond bottom,
L = length of weir

Because the depth is only two feet, the (H_w / y) item is negligible and the equation is evaluated as follows:

$$Q_w = (2/3)\ (0.626)\ (8)\ (64.4)^{1/2}\ H_w^{1.5}$$

$Q_w = 26.8\ H_w^{1.5}$ **Weir Spillway - Equation 7**

The maximum flow across the spillway occurs when the pond reaches the crest or 305 GGN with H_w at 2 feet. Equation 7 results in 75.8 cubic feet per second.

Pond Discharge Characteristics

Flow enters the pond from four sources. A trapezoidal channel from the north, twin 48-inch culverts from the south, a 36-inch culvert from the center and whatever falls into the pond itself during a rain event. The pond bottom is thought to be level and free of debris. Flow begins to discharge into each row of orifices when the water exceeds the orifice centerline at 1.5, 3.0 and 4.5 feet of depth. The flow is computed for each row using Equation 1. The previous calculations assumed that each row of orifices ceases when the elevation of the headwater in the riser reaches the elevation of the water in the pond, which is to assume some sort of equilibrium due to pressure. This results in a peak flow of about 54 CFS. If this is not assumed due to momentum and continuity, water would continue to flow through the orifices with a resulting peak flow up to the crest of 74 CFS.

Flow across the riser begins with the water depth in the pond exceeds 6 feet in depth. Flow is computed in Equation 2. Discharge from the spillway is computed using Equation 6 when water depth in the pond exceeds 8 feet. For each increment of pond depth and flow, the required headwater depth of the discharge through the culvert pipes is computed using Equations 3, 4, and 5. Detailed results are contained in the computational spreadsheet in the column heading Total Discharge.

What is commonly referred to as the Storage Indication Quantity is located on the right side of the computational spreadsheet. These columns reflect the current pond geometry which is totals about 1,181,613 cubic feet or 27.13 acre feet.

The discharge characteristics results show that the size of the riser footprint, which in this analsyis is 82 feet results in a large outlet capacity.

- Orifices Flows — Flow Depths 0 - 08 feet — Peak Q 54 cfs – Orifice Equation
- Riser Box — Flow Depths 6 - 08 feet — Peak Q 440 cfs – (HY-8 Program)
- Spillway — Flow Depths 8 - 10 feet — Peak Q 75 cfs – Weir Equation

Pond Discharge Hydrographs

In order to analyze or design a detention basin, a computation spreadsheet was constructed to model the detention basin and outlet structure. The model adequately reflects the performance of the system composed of the basin and the three outlet structure devices. The basic problem reduces to the solution of a differential equation.

$$\frac{ds}{dt} = I(t) - O(t)$$

Where ds/dt = the rate of change of storage with respect to time
I(t) = the inflow as a function of time
O(t) = the outflow as a function of time.

The inflow hydrograph was determined using the TR-55 Program which generally defines discrete points for a 24 hour period using data dereived from the Guam Stormwater Management Manual. The outflow hydrograph is dependent on the inflow hydrograph and on the geometry of the basin and outflow device. An iterative approach was used that discrete data that incorporates the geometry of the pond and outlet structure. The data is known as *Stage-Storage-Discharge (SSD).*

Stage-Storage-Discharge Data

Stage-storage data gives the relationship between the water surface elevation and the total volume of storage in the reservoir. This information is based on the topography of the basin and provided in a computational spreadsheet. The minimum elevation is 295 and the maximum elevation is 305 or the crest.

The storage indication method was used to compute the outflow hydrograph. The basic reservoir routing equation is derived from the continuity equation as follows: (Ponce, 1989 3/)

$$I_1 + I_2 + \frac{2S_1}{\Delta t} - O_1 = \frac{2S_2}{\Delta t} + O_2$$

1/ S 1 and S 2 are storage volumes in cubic feet on Pond 2 at times T 1 and T 2 respectively

2/ I 1 and I 2 are the incoming flow rates in cubic feet per second at time T 1 and T 2

3/ T 1 and T 2 is the time interval in seconds between times one and two which in this case is 360 seconds.

The right hand side of the equation is the storage indication quantity which is computed from the pond's discharge characteristics and storage volume data for increments of pond depth. A computation spreadsheet was used to compute the outflow hydrographs. The storage indication quantity was computed for each 0.1 foot increment. Then using a time step of 360 seconds or 0.1 hours, the spreadsheet related the storage indication quantity to the storage and outflow. By determining the variation in the storage indication quantity over time, the variation of the other two parameters of depth and flow are established.

The results from the SSD spreadsheet show that the peak storage occurs at a depth of 7.59 feet above the pond bottom elevation which is 0.4 feet below the spillway. The peak storage volume is 19.29 acre-feet which occurs around 12.5 hours into the 25-year storm event.

Discharge Into the Fintasa

The Hydraulic Culvert Program HY-8 (v 8.7.1) also includes an energy dissipation report. The scour hole geometry presented in the report represents the local scour at the outlet of structures based on soil and flow data and culvert geometry. Chapter V of FHWA publication HEC 14, Hydraulic Design of Energy Dissipators for Culverts and Channels, dated July 2006 presents the general concept and equations used by the program to compute the scour hole geometry for cohesive and cohesion-less materials.

For Cohesive soils, the program requires the following parameters:

- Time to Peak -- Enter the value obtained in the 'HYDROLOGY' option of HY-8
- Saturated Shear Strength -- Obtained from the geotechnical report prepared by A-Mehr Inc.
- Plasticity Index -- Obtained from the geotechnical report prepared by A-Mehr Inc.

Note on Time to Peak

The time of scour is estimated based upon knowledge of peak flow duration. Lacking this knowledge, it is recommended that a time of 30 minutes be used in Equation 5.1. The tests indicate that approximately 2/3 to 3/4 of the maximum scour depth occurs in the first 30 minutes of the flow duration.

The results indicate a potential scour hole dimension of 50 feet. We recommend additional rip rap be placed beyond the grouted rip rap which is currently set at 30 feet from the end of the culvert. An additional 28 feet could be placed in bowl like contours of perhaps a foot deep to allow the flow to reduce in velocity as it enters the Fintasa River.

Appendix

1. <u>References</u>
   a. Appendix B: Design Memorandum - Surface Water Drainage System Calculations
      i. A-Mehr Inc and submitted as Appendix B in November 2008
      ii. Winzler & Kelly Technical Memorandum – July 29, 2005

2. <u>Hydrograph Runoff Program</u> (WinTR 55 (version 1.00.09) – US Department of Agriculture)
   a. WinTR-55 Data Results.. 9 pages

3. <u>Hydraulic Culvert Program</u> (HY-8 (version 8.7.1) - Federal Highway Administration)
   a. HY-8 Culvert Analysis Report.. 8 pages
   b. HY-8 Energy Dissipation Report.. 1 page

4. <u>Hydraulic Culvert Program</u> (PCSWMM 2009 (version 5.0.017) – US EPA/Computation Hydraulic Institute)
   a. Project Summary Report.. 2 pages

5. <u>Stage-Storage-Discharge Routing - Spreadsheet</u>
   a. Prepared by TG Engineers.. 3 pages

6. <u>Pond Discharge Characteristics - Spreadsheet</u>
   a. Prepared by TG Engineers.. 3 pages

7. <u>Final Grading Watershed – Pond 2 Exhibit</u>
   a. Prepared by TG Engineers (current topographic information)...................1 page

8. <u>Storage Indication Routing Discussion</u> – (see spreadsheets 6 and 7 above)

   a. It was deemed necessary to review and calculate the outflow from the detention basin based on a known inflow hydrograph. Inflow hydrograph data was reviewed and calculated from the synthetic hydrograph method TR55. The outflow characteristics of the basin are determined by the geometry of the basin, the hydraulic characteristics of the outlet structure, and by the nature of the inflow hydrograph.

   b. The method for simulating the basin outflow is by Storage Indication Routing or Modified Puls routing.

c. Storage Indication routing uses an iterative step method to solve the differential equation.

$$\frac{ds}{dt} = I(t) - O(t)$$

d. The differential equation placed into discrete pieces over the x-t time plane and the inflow and outflow functions are approximated over a small time increment using average values as follows.

$$I(t) = \frac{I_2 + I_1}{2} \qquad ds = S_2 - S_1$$

$$O(t) = \frac{O_2 + O_1}{2} \qquad \Delta t = t_2 - t_1$$

e. These equations are rearranged (i.e substitute approximations) into the differential equation to obtain the follow relationships.

$$\frac{S_2 - S_1}{t_2 - t_1} = \frac{I_2 + I_1}{2} - \frac{O_2 + O_1}{2}$$

f. In general we know I(t) for all time and we have the initial conditions of the pond which include the starting storage (S_1) and outflow (O_1). Rearranging the equation and putting the known's on one side and the unknowns on the other gives:

$$I_1 + I_2 + \frac{2S_1}{\Delta t} - O_1 = \frac{2S_2}{\Delta t} + O_2$$

g. The right side is known as the storage indication quantity (SIQ). There are two unknowns for each calculation time step. One more independent relationship for storage and outflow is needed to solve the equation. That relationship comes from the Stage-storage-discharge (SSD) data previously discussed.

h. The process of routing is as follows:

i. Determine the inflow hydrograph TR55 Tabular

ii. Determine a routing time step which for this project is set at 360 seconds. Δt.

iii. Develop *Stage-Storage-Discharge (SSD)* data for the pond-outlet system

iv. Compute a static lookup table using the SSD data and develop a column of ($2S/\Delta t$) + O values. The storage indication values are now related to values of outflow and storage for a particular routing time step, Δt

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v. Establish the initial conditions for storage and outflow for the pond. (S_1=0.0 and O_1=0.0 for a dry pond.)

vi. Apply the discrete form of the differential equation to generate the solution one time step in the future. Repeat until the entire outflow hydrograph is obtained. By determining the variation of the storage indication quantity over time we can establish the variation of the other two parameters over time as well.

vii. Now route the inflow hydrograph through the pond using the SSD and the storage indication quantities above. Compute the storage indication quantity (SIQ) based on initial conditions at time=0.0 and the inflows at t=0.0 and t=360 seconds. Note that the SIQ is identically equal to the left side of the equation below

$$I_1 + I_2 + \frac{2S_1}{\Delta t} - O_1 = \frac{2S_2}{\Delta t} + O_2 = \text{SIQ}$$

viii. After determining the SIQ, interpolate values for outflow and storage from the SSD table above to obtain O(2) and S(2). Once the outflow and storage are determined, use these values as the next initial conditions and repeat this step process until the outflow returns to zero or until the peak of the hydrograph is reached.

ix. The maximum stage in the basin occurs at the maximum outflow and by interpolating in the SSD table the maximum water surface in the basin is determined.

Hydrograph Runoff Program

WinTR55 (version 1.00.09) - USDA

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RSchneider

Layon Landfill - Pond 2
Pond 2 contributions
County, Pacific Basin

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period ANALYSIS: (cfs) (hr)
SUBAREAS	
A10	168.08 12.39
A11	170.17 12.40
A1	22.88 12.30
A11.1	56.57 12.12
REACHES	
Trap Chan	168.08 12.39
Down	168.02 12.43
36 pipe	190.98 12.38
Down	190.98 12.38
OUTLET	381.19

WinTR-55 Current Data Description

--- Identification Data ---

User:	RSchneider	Date:	4/22/2010
Project:	Layon Landfill - Pond 2	Units:	English
SubTitle:	Pond 2 contributions	Areal Units:	Acres
State:	Pacific Basin		
County:			

Filename: C:\Documents and Settings\Robert Schneider\Application Data\WinTR-55\WINTR55 Landfill Po:

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
A10	North end of basin	Trap Chan	17.8	72	.616
A11	Middle part of basin	36 pipe	17.75	72	.598
A1	South part of basin	36 pipe	2.1	71	.434
A11.1	Basin - Pond 2	Outlet	3.8	71	.138

Total area: 41.45 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
4.5	8.0	10.0	20.0	27.0	32.0	3.5

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type III
Dimensionless Unit Hydrograph: <standard>

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Layon Landfill - Pond 2
Pond 2 contributions
County, Pacific Basin

Watershed Peak Table

Sub-Area or Reach Identifier	ANALYSIS: (cfs)	Peak Flow by Rainfall Return Period
SUBAREAS		
A10	168.08	
A11	170.17	
A1	22.88	
A11.1	56.57	
REACHES		
Trap Chan	168.08	
Down	168.02	
36 pipe	190.98	
Down	190.98	
OUTLET	381.19	

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Layon Landfill - Pond 2
Pond 2 contributions
County, Pacific Basin

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period ANALYSIS: (cfs) (hr)
SUBAREAS	
A10	168.08 12.39
A11	170.17 12.40
A1	22.88 12.30
A11.1	56.57 12.12
REACHES	
Trap Chan	168.08 12.39
Down	168.02 12.43
36 pipe	190.98 12.38
Down	190.98 12.38
OUTLET	381.19

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Layon Landfill - Pond 2
Pond 2 contributions
County, Pacific Basin

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
A10	17.80	0.616	72	Trap Chan	North end of basin
A11	17.75	0.598	72	36 pipe	Middle part of basin
A1	2.10	0.434	71	36 pipe	South part of basin
A11.1	3.80	0.138	71	Outlet	Basin - Pond 2

Total Area: 41.45 (ac)

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Layon Landfill - Pond 2
Pond 2 contributions
County, Pacific Basin

Reach Summary Table

Reach Identifier	Receiving Reach Identifier	Reach Length (ft)	Routing Method
Trap Chan	Outlet	600	CHANNEL
36 pipe	Outlet	150	CHANNEL

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Pond 2 contributions
County, Pacific Basin

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
A10							
SHEET	100	0.0100	0.150				0.182
SHALLOW	1200	0.0100	0.050				0.207
SHALLOW	900	0.0100	0.050				0.155
CHANNEL	1300	0.0050					
CHANNEL	1300					5.000	0.072
				Time of Concentration			.616
							========
A11							
SHEET	100	0.0300	0.150				0.117
SHALLOW	800	0.0100	0.050				0.138
SHALLOW	2800	0.0200	0.050				0.341
CHANNEL	400	0.0050					
CHANNEL	150					25.000	0.002
				Time of Concentration			.598
							========
A1							
SHEET	100	0.0200	0.150				0.138
SHALLOW	1200	0.0050	0.050				0.292
CHANNEL	700	0.0010					
CHANNEL	150					10.000	0.004
				Time of Concentration			.434
							========
A11.1							
SHEET	100	0.0200	0.150				0.138
				Time of Concentration			.138
							========

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Layon Landfill - Pond 2
Pond 2 contributions
County, Pacific Basin

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
A10	Paved; open ditches (w/right-of-way)	C	1	92
	Meadow -cont. grass (non grazed)	C	16.8	71
	Total Area / Weighted Curve Number		17.8	72
			====	==
A11	Paved; open ditches (w/right-of-way)	C	.75	92
	Meadow -cont. grass (non grazed)	C	17	71
	Total Area / Weighted Curve Number		17.75	72
			=====	==
A1	Meadow -cont. grass (non grazed)	C	2.1	71
	Total Area / Weighted Curve Number		2.1	71
			===	==
A11.1	Meadow -cont. grass (non grazed)	C	3.8	71
	Total Area / Weighted Curve Number		3.8	71
			===	==

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Layon Landfill - Pond 2
Pond 2 contributions
County, Pacific Basin

Reach Channel Rating Details

Reach Identifier	Reach Length (ft)	Reach Manning's n	Friction Slope (ft/ft)	Bottom Width (ft)	Side Slope
Trap Chan	600	0.013	0.1	12	1 :1
36 pipe	150	0.012	0.1	3	1 :1

Reach Identifier	Stage (ft)	Flow (cfs)	End Area (sq ft)	Top Width (ft)	Friction Slope (ft/ft)
Trap Chan	0.0	0.000	0	12	0.1
	0.5	135.779	6.3	13	
	1.0	430.445	13	14	
	2.0	1376.353	28	16	
	5.0	6743.411	85	22	
	10.0	24661.695	220	32	
	20.0	102555.463	640	52	
36 pipe	0.0	0.000	0	3	0.1
	0.5	36.983	1.8	4	
	1.0	121.872	4	5	
	2.0	431.119	10	7	
	5.0	2755.672	40	13	
	10.0	13158.078	130	23	
	20.0	70375.685	460	43	

Hydraulic Culvert Program

HY-8 (version 8.7.1) - FHWA

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Table 1 - Summary of Culvert Flows at Crossing: Pond 2 - Outlet Culverts

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
296.78	60.00	60.00	0.00	1
297.88	132.00	132.00	0.00	1
298.80	204.00	204.00	0.00	1
299.79	276.00	276.00	0.00	1
301.00	348.00	348.00	0.00	1
302.53	420.00	420.00	0.00	1
303.27	492.00	450.24	41.67	6
303.49	564.00	458.99	104.75	5
303.68	636.00	466.12	169.74	5
303.84	708.00	472.35	235.17	4
304.00	780.00	478.00	301.82	4
303.00	439.46	439.46	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
60.00	[illegible]	[illegible]	1.704	0.000	1-S2n	0.7[illegible]	1.2[illegible]	0.[illegible]	1.0[illegible]	[illegible]	2.[illegible]
132.00	132.00	297.[illegible]	2.[illegible]	2.[illegible]	1-S2n	1.1[illegible]	1.[illegible]	1.4[illegible]	1.841	10.[illegible]	2.[illegible]
204.00	204.00	[illegible]	3.[illegible]	3.601	1-S2n	1.4[illegible]	2.4[illegible]	1.[illegible]	2.113	11.[illegible]	3.4[illegible]
276.00	276.00	[illegible]	4.7[illegible]	4.7[illegible]	5-S2n	1.7[illegible]	2.[illegible]	2.218	2.816	12.[illegible]	3.7[illegible]
348.00	348.00	301.00	[illegible]	[illegible]	5-S2n	2.014	3.2[illegible]	2.[illegible]	2.872	13.724	4.074
[illegible]	420.00	302.[illegible]	7.531	7.531	5-S2n	2.257	3.4[illegible]	2.[illegible]	3.1[illegible]	14.707	4.324
492.00	[illegible]	303.27	[illegible]	[illegible]	5-S2n	2.3[illegible]	3.[illegible]	2.[illegible]	3.494	15.[illegible]	4.544
[illegible]	[illegible]	303.49	[illegible]	[illegible]	5-S2n	2.3[illegible]	3.[illegible]	3.002	3.771	16.1[illegible]	4.741
[illegible]	[illegible].12	303.[illegible]	[illegible]	[illegible]	5-S2n	2.414	3.[illegible]	3.[illegible]	4.0[illegible]	16.[illegible]	4.9[illegible]
708.00	472.25	303.84	8.844	8.844	5-S2n	2.4[illegible]	3.671	3.0[illegible]	4.279	16.41[illegible]	5.0[illegible]
780.00	478.00	304.00	8.9[illegible]	7.444	4-FFf	2.4[illegible]	3.[illegible]	2.4[illegible]	4.514	18.707	5.231

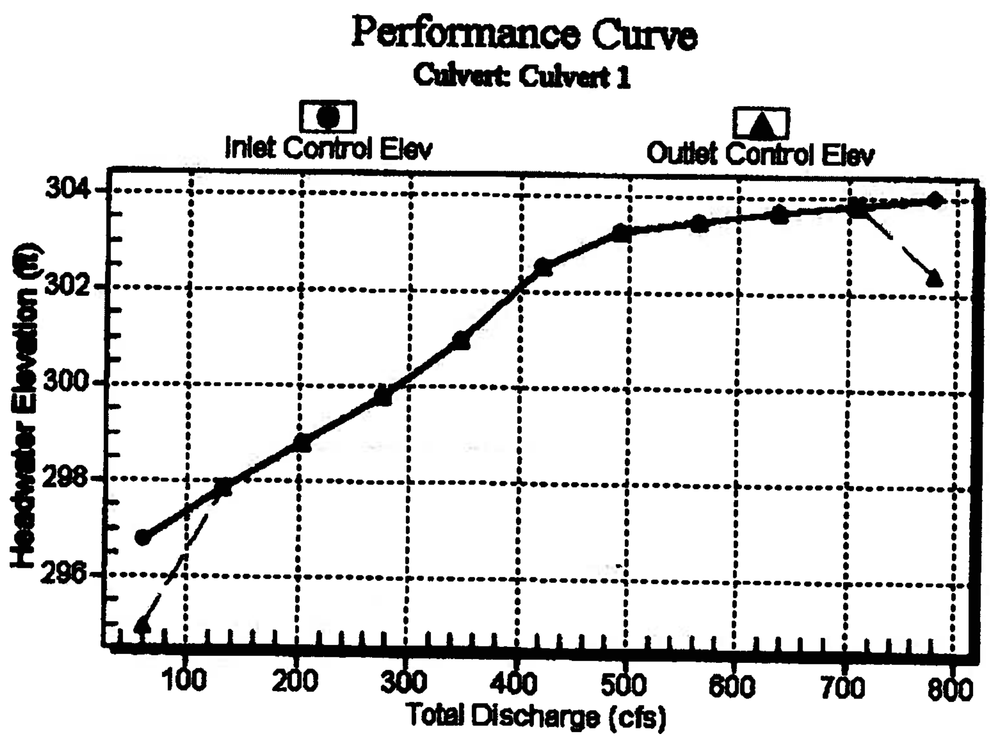
****

Inlet Elevation (invert): 295.00 ft, Outlet Elevation (invert): 294.20 ft

Culvert Length: 37.01 ft, Culvert Slope: 0.0216

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1

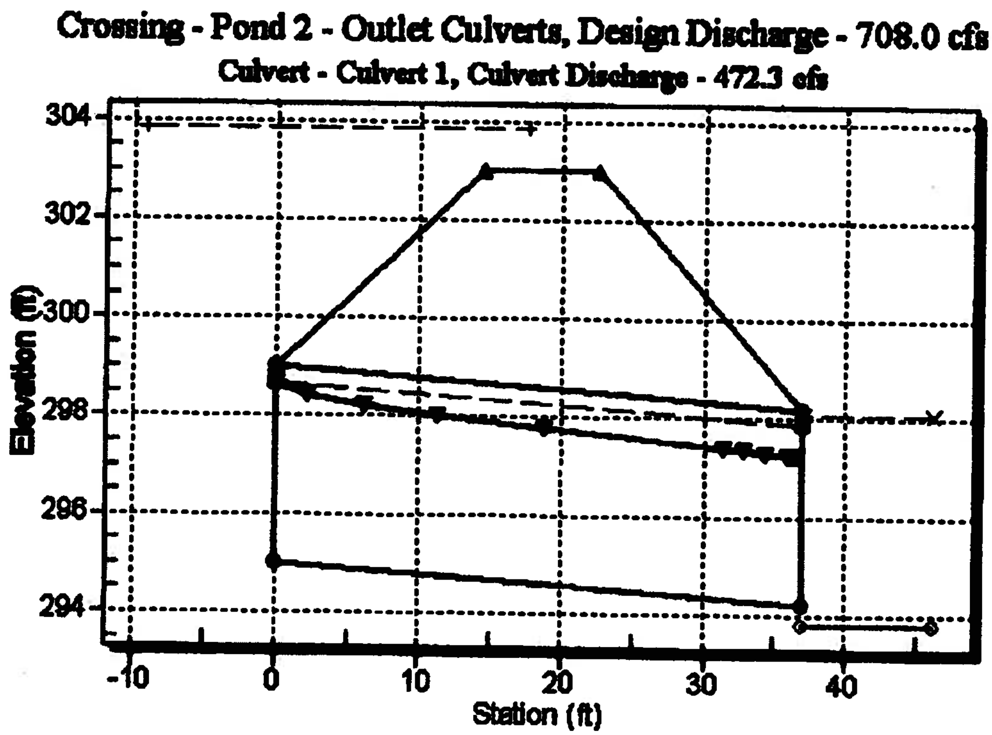


Table 3 - Downstream Channel Rating Curve (Crossing: Pond 2 - Outlet Culverts)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
60.00	294.83	1.03	2.23	0.19	0.40
132.00	295.44	1.64	2.95	0.31	0.43
204.00	295.91	2.11	3.42	0.40	0.44
276.00	296.32	2.52	3.78	0.47	0.45
348.00	296.67	2.87	4.07	0.54	0.46
420.00	297.00	3.20	4.32	0.60	0.47
492.00	297.29	3.49	4.54	0.65	0.47
564.00	297.57	3.77	4.74	0.71	0.48
636.00	297.83	4.03	4.92	0.75	0.48
708.00	298.08	4.28	5.08	0.80	0.49
780.00	298.31	4.51	5.23	0.85	0.49

Tailwater Channel Data - Pond 2 - Outlet Culverts

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 24.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0030

Channel Manning's n: 0.0350

Channel Invert Elevation: 293.80 ft

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	Pond 2 - Outlet Culverts	
Culvert	Culvert 1	
Flow	708.00	cfs
Culvert Data		
Culvert Width	4.0	ft
Culvert Height	4.0	ft
Outlet Depth	3.04	ft
Outlet Velocity	16.42	ft/s
Froude Number	1.56	
Tailwater Depth	4.28	ft
Tailwater Velocity	5.08	ft/s
Tailwater Slope (SO)	0.0216	
Scour Data		
Time to Peak		
Note:	If Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	3000.000	psf
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	16.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	5.026	psf
Modified Shear Number	91.666	
Scour Hole Dimensions		
Length (LS)	50.482	ft
Width (WS)	[illegible]	ft
Depth (DS)	[illegible]	ft
Volume (VS)	2352.643	ft^3
DS at 0.4(LS)	20.193	ft
Tailwater Depth (TW)	4.279	ft
Velocity with TW and WS	2.541	ft/s

Hydraulic Culvert Program

PCSWMM (version 5.0.017) – USEPA/Computation Hydraulic Institute

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PCSWMM Model Run
Version 5.0.017
Computational Hydraulic Incorporated.

Project: Lavon Landfill Pond 2 Outfall
May 2010

Purpose of run was to determine the velocity of 3-48 pipes flowing at capacity. Results indicated outlet velocity will be about 9 fps. Outlet section shall be a rip rap lined trapezoidal channel.

Flow units	CFS
Infiltration method	Horton
Flow routing method	Kinematic wave
Link offsets defined by	Depth
Allow ponding	No
Skip steady periods	No
Inertial dampening Partial	
Define supercritical flow by	Both
Force main equation	H-W
Variable time step	On
Adjustment factor (%)	75
Conduit lengthening (s)	0
Minimum surface area	0
Starting date (ft³)	May-5-2010 12:00:00 AM
Ending date	May-6-2010 12:00:00 AM
Duration of simulation (hours)	24
Antecedent dry days (days)	0
Rain interval (h:mm)	0:15
Report time step (h:mm:ss)	00:15:00
Wet time step (h:mm:ss)	00:05:00
Dry time step (h:mm:ss)	01:00:00
Routing time step (s)	30
Minimum time step used (s)	30
Average time step used (s)	30
Minimum conduit slope	0
Ignore rainfall/runoff	No

Model inventory

Raingages	1
Subcatchments	0
Aquifers	0
Snowpacks	0
RDII hydrographs	1
Junction nodes	2
Outfall nodes	1
Flow divider nodes	0
Storage unit nodes	0
Conduit links	2
Time Series	1
Time Patterns	0

Inflows

Time series inflows	1
Dry weather inflows	0
Groundwater inflows	0
RDII inflows	0

Node attribute ranges

Max. ground elev. (ft)	295
Min. ground elev. (ft)	280.1
Max. invert elev. (ft)	295
Min. invert elev. (ft)	280
Max. max. depth (ft)	0
Min. max. depth (ft)	0

Conduit attribute ranges

Max. roughness	0.012
Min. roughness	0.012
Max. length (ft)	51
Min. length (ft)	20
Total length (ft)	71
Max. slope (ft/ft)	0.2922
Min. slope (ft/ft)	0.005

Pipe inventory

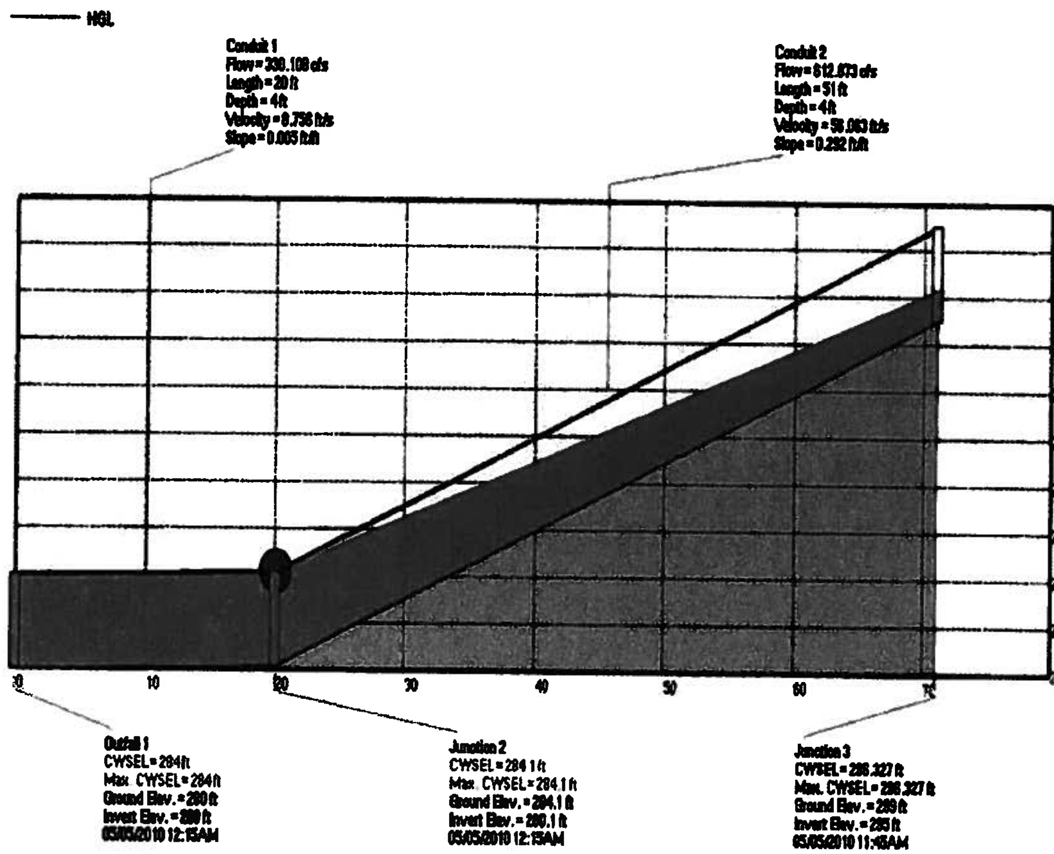
Max. pipe diameter (ft)	4
Min. pipe diameter (ft)	4
Total 48" pipe length (ft)	71
Total pipe length (ft)	71

Flow routing continuity

External inflow (10^6 gal)	388.397
External outflow (10^6 gal)	213.393
Internal outflow (10^6 gal)	174.970
Evaporation loss (10^6 gal)	n/a
Initial stored volume (10^6 gal)	0.000
Final stored volume (10^6 gal)	0.010
Continuity error (%)	0.006

Results

Max. subcatchment total runoff (10^6 gal)	n/a
Max. subcatchment peak runoff (cfs)	n/a
Max. subcatchment runoff coefficient	n/a
Max. subcatchment total precip (in)	n/a
Min. subcatchment total precip (in)	n/a
Total subcatchment runoff coefficient	n/a
Max. node depth (ft)	4
Num. nodes surcharged	1
Max. node surcharge duration (hours)	24.01
Max. node height above crown (ft)	0
Min. node depth below rim (ft)	0
Num. nodes flooded	1
Max. node flooding duration (hours)	24.01
Max. node flood volume (10^6 gal)	174.987
Max. node ponded volume (acre-in)	0
Max. storage volume (1000 ft³)	n/a
Max. storage percent full (%)	n/a
Max. outfall flow frequency (%)	100
Max. outfall peak flow (cfs)	330.11
Max. outfall total volume (10^6 gal)	213.377
Total outfall volume (10^6 gal)	213.377
Max. link peak flow (cfs)	619.03
Max. link peak velocity (ft/s)	8.76
Min. link peak velocity (ft/s)	0
Num. conduits surcharged	1
Max. Conduit surcharge duration (hours)	24.01
Max. Conduit capacity limited duration (hours)	24.01



HGL
Conduit 1
Flow = 330.108 cfs
Length = 20 ft
Depth = 4 ft
Velocity = 8.756 ft/s
Slope = 0.005 ft/ft
Conduit 2
Flow = 612.873 cfs
Length = 51 ft
Depth = 4 ft
Velocity = 56.083 ft/s
Slope = 0.292 ft/ft
10
20
30
40
50
60
70
Outfall 1
CWSEL = 284 ft
Max. CWSEL = 284 ft
Ground Elev. = 280 ft
Invert Elev. = 280 ft
05/05/2010 12:15AM
Junction 2
CWSEL = 284.1 ft
Max. CWSEL = 284.1 ft
Ground Elev. = 284.1 ft
Invert Elev. = 280.1 ft
05/05/2010 12:15AM
Junction 3
CWSEL = 298.327 ft
Max. CWSEL = 298.327 ft
Ground Elev. = 299 ft
Invert Elev. = 295 ft
05/05/2010 11:45AM

Stage-Storage-Discharge Routing

TG Engineers, PC
125 Tun Jesus Crisostomo Street #206
Tamuning GU 96913

Layon Landfill - Pond 2

Stage - Storage - Discharge Routing

			Left Side Equation 4/							
Time	Inflow - 1	Inflow - 2	$I_1 + I_2$	$2S_1/\Delta T$	$(-)O_1$	SIQ	Storage - S		Depth	Cumulative Flow
(hrs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cf)	(ac-ft)	(cfs)	(cfs)
						519.6	93,520	2.15	1.00	
9.0	15.5	15.5	15.5	519.6	0	535.1	96,710	2.22	1.02	-
9.1	16.4	16.4	31.8	537.3	0	569.1	102,547	2.35	1.08	-
9.2	17.3	17.3	33.6	569.7	0	603.3	108,596	2.49	1.14	-
9.3	18.2	18.2	35.4	603.3	0	638.7	114,966	2.64	1.21	-
9.4	19.1	19.1	37.3	638.7	0	676.0	121,680	2.79	1.28	-
9.5	20.1	20.1	39.2	676.0	0	715.2	128,730	2.96	1.35	-
9.6	20.9	20.9	41.0	715.2	0	756.2	136,116	3.12	1.42	-
9.7	21.8	21.8	42.7	756.2	0	798.9	143,802	3.30	1.50	-
9.8	22.8	22.8	44.6	798.9	0	843.5	151,422	3.48	1.58	-
9.9	23.9	23.9	46.7	841.2	3.6	884.3	158,531	3.64	1.65	3.6
10.0	24.9	24.9	48.8	880.7	4.5	925.0	166,504	3.82	1.73	8.1
10.1	26.1	26.1	51.0	925.0	5.2	970.8	174,736	4.01	1.81	13.3
10.2	27.4	27.4	53.5	970.8	5.9	1018.4	183,308	4.21	1.89	19.2
10.3	28.7	28.7	56.1	1,018.4	6.6	1067.9	192,231	4.41	1.98	25.8
10.4	30.2	30.2	58.9	1,068.0	6.8	1120.1	201,396	4.62	2.07	32.6
10.5	31.7	31.7	61.9	1,118.9	7.7	1173.1	211,014	4.84	2.17	40.3
10.6	33.3	33.3	65.0	1,172.3	8.7	1228.6	221,228	5.08	2.26	49.0
10.7	34.9	34.9	68.1	1,229.0	9.3	1287.9	231,912	5.32	2.37	58.3
10.8	36.6	36.6	71.4	1,288.4	9.8	1350.0	243,085	5.58	2.48	68.1
10.9	38.3	38.3	74.9	1,350.5	9.9	1415.5	254,727	5.85	2.59	78.0
11.0	40.3	40.3	78.6	1,415.2	10.3	1483.5	266,875	6.13	2.70	88.3
11.1	42.0	42.0	82.3	1,482.6	10.8	1554.1	279,584	6.42	2.82	99.1
11.2	44.6	44.6	86.6	1,553.1	11.4	1628.3	292,973	6.73	2.95	110.5
11.3	47.5	47.5	92.1	1,627.6	14.2	1705.5	306,904	7.05	3.08	124.7
11.4	51.1	51.1	98.6	1,705.0	16.9	1786.7	321,629	7.38	3.22	141.6
11.5	56.2	56.2	107.3	1,786.8	18.6	1875.5	337,573	7.75	3.37	160.2
11.6	62.7	62.7	118.9	1,875.4	20.3	1974.0	355,265	8.16	3.53	180.5
11.7	70.6	70.6	133.3	1,973.7	22.0	2085.0	375,299	8.62	3.71	202.5
11.8	90.5	90.5	161.1	2,085.0	23.8	2222.3	399,986	9.18	3.93	226.3
11.9	132.1	132.1	222.6	2,222.1	25.2	2419.5	435,327	9.99	4.25	251.5
12.0	204.8	204.8	336.9	2,418.5	34.1	2721.3	489,803	11.24	4.73	285.6
12.1	278.4	278.4	483.2	2,721.1	42.2	3162.1	569,103	13.06	5.41	327.8
12.2	312.3	312.3	590.7	3,161.7	70.7	3681.7	662,558	15.21	6.18	398.5
12.3	342.6	342.6	654.9	3,680.9	243.6	4092.2	736,583	16.91	6.78	642.1
12.4	370.3	370.3	712.9	4,092.1	420.5	4384.5	789,393	18.12	7.20	1,062.6
12.5	363.3	363.3	783.6	4,385.5	548.4	4570.7	822,833	18.89	7.46	1,611.0
12.6	323.7	323.7	687.0	4,571.3	600.3	4658.0	840,089	19.29	7.59	2,211.3
12.7	275.3	275.3	599.0	4,667.2	599.9	4666.3	838,121	19.24	7.58	2,811.2
12.8	227.9	227.9	503.2	4,656.2	563.8	4595.6	827,025	18.99	7.49	3,375.0
12.9	185.2	185.2	413.0	4,594.6	331.4	4676.2	766,236	17.59	7.02	3,706.4
13.0	160.8	160.8	346.0	4,256.9	331.4	4271.4	767,015	17.61	7.02	4,037.8
13.1	128.5	128.5	289.3	4,261.2	323.1	4227.4	761,176	17.47	6.98	4,360.9

			Left Side Equation 4/							
Time	Inflow - 1	Inflow -2	$I_1 + I_2$	$2S_1/\Delta T$	$(-)O_1$	SIQ	Storage - S		Depth	Cumulative Flow
(hrs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cf)	(ac-ft)	(cfs)	(cfs)
13.2	106.0	106.0	234.5	4,228.8	290	4173.2	751,317	17.25	6.90	4,650.9
13.3	91.2	91.2	197.2	4,174.0	0	4371.1		-	1.00	4,650.9
13.4	81.0	81.0	172.2	-	0			-	1.00	4,650.9
13.5	74.3	74.3	155.4	-	0			-	1.00	4,650.9
13.6	66.9	66.9	141.3	-	0			-	1.00	4,650.9
13.7	62.1	62.1	129.0	-	0			-	1.00	4,650.9
13.8	58.5	58.5	120.5	-	0			-	1.00	4,650.9
13.9	54.9	54.9	113.3	-	0			-	1.00	4,650.9
14.0	52.1	52.1	107.0	-	0			-	1.00	4,650.9
14.1	50.0	50.0	102.1	-	0			-	1.00	4,650.9
14.2	47.8	47.8	97.7	-	0			-	1.00	4,650.9
14.3	45.6	45.6	93.4	-	0			-	1.00	4,650.9
14.4	44.3	44.3	89.9	-	0			-	1.00	4,650.9
14.5	42.5	42.5	86.8	-	0			-	1.00	4,650.9
14.6	41.2	41.2	83.7	-	0			-	1.00	4,650.9
14.7	40.0	40.0	81.2	-	0			-	1.00	4,650.9
14.8	39.3	39.3	79.3	-	0			-	1.00	4,650.9
14.9	37.0	37.0	76.4	-	0			-	1.00	4,650.9
15.0	36.0	36.0	73.1	-	0			-	1.00	4,650.9
15.1	35.1	35.1	71.2	-	0			-	1.00	4,650.9
15.2	34.2	34.2	69.3	-	0			-	1.00	4,650.9
15.3	33.0	33.0	67.2	-	0			-	1.00	4,650.9
15.4	32.1	32.1	65.2	-	0			-	1.00	4,650.9
15.5	31.2	31.2	63.3	-	0			-	1.00	4,650.9
15.6	30.3	30.3	61.5	-	0			-	1.00	4,650.9
15.7	29.4	29.4	59.8	-	0			-	1.00	4,650.9
15.8	28.3	28.3	57.8	-	0			-	1.00	4,650.9
15.9	27.6	27.6	55.9	-	0			-	1.00	4,650.9
16.0	26.5	26.5	54.1	-	0			-	1.00	4,650.9
16.1	25.5	25.5	52.0	-	0			-	1.00	4,650.9
16.2	24.8	24.8	50.3	-	0			-	1.00	4,650.9
16.3	23.8	23.8	48.6	-	0			-	1.00	4,650.9
16.4	23.3	23.3	47.1	-	0			-	1.00	4,650.9
16.5	22.5	22.5	45.7	-	0			-	1.00	4,650.9
16.6	21.9	21.9	44.3	-	0			-	1.00	4,650.9
16.7	21.5	21.5	43.3	-	0			-	1.00	4,650.9
16.8	21.0	21.0	42.4	-	0			-	1.00	4,650.9
16.9	20.5	20.5	41.5	-	0			-	1.00	4,650.9
17.0	20.1	20.1	40.6	-	0			-	1.00	4,650.9
17.1	19.6	19.6	39.6	-	0			-	1.00	4,650.9
17.2	19.2	19.2	38.8	-	0			-	1.00	4,650.9
17.3	18.7	18.7	37.9	-	0			-	1.00	4,650.9
17.4	18.3	18.3	37.0	-	0			-	1.00	4,650.9

Layon Landfill - Pond 2

Stage - Storage - Discharge Routing

			Left Side Equation 4/							
Time	Inflow 1	Inflow 2	I_1+I_2	$2S_1/\Delta T$	$(-)O_1$	ΣQ	Storage S		Depth	Cumulative Flow
(hrs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cf)	(ac-ft)	(cfs)	(cfs)
17.5	17.9	17.9	36.1	-	0			-	1.00	4,650.9
17.6	17.4	17.4	35.3		0	–		-	1.00	4,650.9
17.7	16.9	16.9	34.3		0			-	1.00	4,650.9
17.8	16.5	16.5	33.5		0			-	1.00	4,650.9
17.9	16.1	16.1	32.6		0			-	1.00	4,650.9
18.0	15.8	15.8	31.9		0			-	1.00	4,650.9

1/ S 1 and S 2 are storage volumes in cubic feet on Pond 2 at times T 1 and T 2 respectively

2/ I 1 and I 2 are the incoming flow rates in cubic feet per second at time T 1 and T 2

3/ T 1 and T 2 is the time interval in seconds between times one and two which in this case is 360 seconds.

4/ Reservoir Routing Equation Approximation : $I1 + I2 + (2S\,1/\Delta T + O1) = 2S_2/\Delta T + O_2$

5/ Initial time chosen to approximate 1.00 foot depth in pond which turned out to be 9-hours

Pond Discharge Characteristics

TG Engineers, PC
125 Tun Jesus Crisostomo Street #206
Tamuning GU 96913

Water Elevation From Pond Bottom (ft)	Orifice Equation: CA = 0.1178	Coeff.- 2g	Head (ft)	Orifice Row # 1: Q/ EA Pipe (cfs)	Orifice Row # 1: Q/Row 1 (10) (cfs)	Orifice Row # 2: Q/ EA Pipe (cfs)	Orifice Row # 2: Q/Row 2 (10) (cfs)	Orifice Row # 3: Q/ EA Pipe (cfs)	Orifice Row # 3: Q/Row 3(18) (cfs)	Cum - Q (cfs)
0										
0.1										
0.2										
0.3										
0.4										
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.7	0.118	64.4	0.20	0.42	4.22					4.22
1.8	0.118	64.4	0.30	0.52	5.17					5.17
1.9	0.118	64.4	0.40	0.60	5.97					5.97
2.0	0.118	64.4	0.50	0.67	6.68					6.68
2.1	0.118	64.4	0.60	0.73	7.32					7.32
2.2	0.118	64.4	0.70	0.79	7.90					7.90
2.3	0.118	64.4	0.80	0.84	8.45					8.45
2.4	0.118	64.4	0.90	0.90	8.96					8.96
2.5	0.118	64.4	1.00	0.94	9.45					9.45
2.6	0.118	64.4	1.10	0.99	9.91					9.91
2.7	0.118	64.4	1.20	1.03	10.35					10.35
2.8	0.118	64.4	1.30	1.08	10.77					10.77
2.9	0.118	64.4	1.40	1.12	11.18					11.18
3.0	0.118	64.4	1.50	1.16	11.57					11.57
3.2	0.118	64.4	1.70	1.23	12.32	0.42	4.22			16.54
3.3	0.118	64.4	1.80	1.27	12.67	0.52	5.17			17.85
3.4	0.118	64.4	1.90	1.30	13.02	0.60	5.97			18.99
3.5	0.118	64.4	2.00	1.34	13.36	0.67	6.68			20.04
3.6	0.118	64.4	2.10	1.37	13.69	0.73	7.32			21.00
3.7	0.118	64.4	2.20	1.40	14.01	0.79	7.90			21.91
3.8	0.118	64.4	2.30	1.43	14.32	0.84	8.45			22.77

Water Elevation From Pond Bottom (ft)	Riser Box - Weir Equation: Q (cfs)	Coeff.	L = ft (28x18)	Coeff. 2g ^ 0.5	Depth - H (ft)	Coeff.	Q Entering Riser (cfs)	Q Entering Each Pipe (cfs)	Spillway - Weir Equation: Q (cfs)	Coeff.	L - length	2g	Weir H - 2'	Coeff.	Total Discharge - (cfs)
0		0.6666	82	8.025		1.5				0.6667	8	64.4	2	0.5	
0.1							-	-							-
0.2							-	-							-
0.3							-	-							-
0.4							-	-							-
0.5							-	-							-
0.6							-	-							-
0.7							-	-							-
0.8							-	-							-
0.9							-	-							-
1.0							-	-							-
1.1							-	-							-
1.2							-	-							-
1.3							-	-							-
1.4							-	-							-
1.5							-	-							-
1.7							4.2	1.4							4.2
1.8							5.2	1.7							5.2
1.9							6.0	2.0							6.0
2.0							6.7	2.2							6.7
2.1							7.3	2.4							7.3
2.2							7.9	2.6							7.9
2.3							8.4	2.8							8.4
2.4							9.0	3.0							9.0
2.5							9.4	3.1							9.4
2.6							9.9	3.3							9.9
2.7							10.3	3.4							10.3
2.8							10.8	3.6							10.8
2.9							11.2	3.7							11.2
3.0							11.6	3.9							11.6
3.2							16.5	5.5							16.5
3.3							17.8	5.9							17.8
3.4							19.0	6.3							19.0
3.5							20.0	6.7							20.0
3.6							21.0	7.0							21.0
3.7							21.9	7.3							21.9
3.8							22.8	7.6							22.8

Water Elevation From Pond Bottom (ft)	Pond Geometry: Area (sf)	Average Area (sf)	Volume (cf)	Pond Volume Storage (cf)	Storage Indication Quantity (SIQ): $2S_2 / \Delta T + O_2$: (Δt = 180 seconds)
0	92,490			-	0.0
0.1	92,944	92,717	9,272	9,272	51.5
0.2	93,398	93,171	9,317	18,589	103.3
0.3	93,853	93,626	9,363	27,951	155.3
0.4	94,307	94,080	9,408	37,359	207.6
0.5	94,761	94,534	9,453	46,813	260.1
0.6	95,218	94,990	9,499	56,312	312.8
0.7	95,675	95,447	9,545	65,856	365.9
0.8	96,132	95,904	9,590	75,447	419.1
0.9	96,589	96,361	9,636	85,083	472.7
1.0	97,046	96,818	9,682	94,765	526.5
1.1	97,506	97,276	9,728	104,492	580.5
1.2	97,966	97,736	9,774	114,266	634.8
1.3	98,425	98,196	9,820	124,085	689.4
1.4	98,885	98,655	9,866	133,951	744.2
1.5	99,345	99,115	9,912	143,862	799.2
1.7	100,270	100,039	10,004	163,824	914.4
1.8	100,733	100,502	10,050	173,874	971.1
1.9	101,195	100,964	10,096	183,970	1028.0
2.0	101,658	101,427	10,143	194,113	1085.1
2.1	102,172	101,915	10,192	204,305	1142.3
2.2	102,686	102,429	10,243	214,547	1199.8
2.3	103,200	102,943	10,294	224,842	1257.6
2.4	103,714	103,457	10,346	235,187	1315.6
2.5	104,228	103,971	10,397	245,585	1373.6
2.6	104,705	104,467	10,447	256,031	1432.3
2.7	105,183	104,944	10,494	266,526	1491.0
2.8	105,660	105,422	10,542	277,068	1550.0
2.9	106,138	105,899	10,590	287,658	1609.3
3.0	106,615	106,376	10,638	298,295	1668.8
3.2	107,595	107,350	10,735	319,716	1792.7
3.3	108,085	107,840	10,784	330,500	1854.0
3.4	108,575	108,330	10,833	341,333	1915.3
3.5	109,065	108,820	10,882	352,215	1976.8
3.6	109,549	109,307	10,931	363,146	2038.5
3.7	110,034	109,792	10,979	374,125	2100.4
3.8	110,518	110,276	11,028	385,153	2162.5

Water Elevation From Pond Bottom (ft)	Orifice Equation: CA = 0.1178	Coeff.- 2g	Head (ft)	Orifice Row # 1: Q/ EA Pipe (cfs)	Orifice Row # 1: Q/Row 1 (10) (cfs)	Orifice Row # 2: Q/ EA Pipe (cfs)	Orifice Row # 2: Q/Row 2 (10) (cfs)	Orifice Row # 3: Q/ EA Pipe (cfs)	Orifice Row # 3: Q/Row 3(10) (cfs)	Cum - Q (cfs)	Riser Box - Weir Equation: Q (cfs)	Coeff.	L = ft (22x18)	Coeff. 2g ^ 0.5	Depth - H (ft)	Coeff.	Q Entering Riser (cfs)	Q Entering Each Pipe (cfs)	Spillway - Weir Equation: Q (cfs)	Coeff.	L - length	2g	Weir H - 2'	Coeff.	Total Discharge - (cfs)	Pond Geometry: Area (sf)	Average Area (sf)	Volume (cf)	Pond Volume Storage (cf)	Storage Indication Quantity (SIQ): $2S_2 / \Delta T + O_1$: (Δt = 180 seconds)
3.9	0.118	64.4	2.40	1.46	14.63	0.90	8.96			23.59							23.6	7.9							23.6	111,003	110,760	11,076	396,229	2224.9
4.0	0.118	64.4	2.50	1.49	14.93	0.94	9.45			24.38							24.4	8.1							24.4	111,487	111,245	11,124	407,353	2287.5
4.1	0.118	64.4	2.60	1.52	15.23	0.99	9.91			25.14							25.1	8.4							25.1	111,983	111,735	11,174	418,527	2350.3
4.2	0.118	64.4	2.70	1.55	15.52	1.03	10.35			25.87							25.9	8.6							25.9	112,479	112,231	11,223	429,750	2413.4
4.3	0.118	64.4	2.80	1.58	15.81	1.08	10.77			26.57							26.6	8.9							26.6	112,976	112,728	11,273	441,023	2476.7
4.4	0.118	64.4	2.90	1.61	16.08	1.12	11.18			27.26							27.3	9.1							27.3	113,472	113,224	11,322	452,345	2540.3
4.5	0.118	64.4	3.00	1.64	16.36	1.16	11.57			27.93							27.9	9.3							27.9	113,968	113,720	11,372	463,717	2604.1
[illegible]																														
4.7	0.118	64.4	3.20	1.69	16.90	1.23	12.32	0.42	4.22	33.44							33.4	11.1							33.4	114,950	114,704	11,470	486,609	2736.8
4.8	0.118	64.4	3.30	1.72	17.16	1.27	12.67	0.52	5.17	35.00							35.0	11.7							35.0	115,440	115,195	11,520	498,128	2802.4
4.9	0.118	64.4	3.40	1.74	17.42	1.30	13.02	0.60	5.97	36.41							36.4	12.1							36.4	115,931	115,686	11,569	509,697	2868.1
5.0	0.118	64.4	3.50	1.77	17.67	1.34	13.36	0.67	6.68	37.71							37.7	12.6							37.7	116,422	116,177	11,618	521,315	2933.9
5.1	0.118	64.4	3.60	1.79	17.92	1.37	13.69	0.73	7.32	38.93							38.9	13.0							38.9	116,932	116,677	11,668	532,982	2999.9
5.2	0.118	64.4	3.70	1.82	18.17	1.40	14.01	0.79	7.90	40.08							40.1	13.4							40.1	117,443	117,188	11,719	544,701	3066.2
5.3	0.118	64.4	3.80	1.84	18.41	1.43	14.32	0.84	8.45	41.19							41.2	13.7							41.2	117,953	117,698	11,770	556,471	3132.7
5.4	0.118	64.4	3.90	1.87	18.65	1.46	14.63	0.90	8.96	42.25							42.2	14.1							42.2	118,464	118,208	11,821	568,292	3199.4
5.5	0.118	64.4	4.00	1.89	18.89	1.49	14.93	0.94	9.45	43.27							43.3	14.4							43.3	118,974	118,719	11,872	580,164	3266.4
5.6	0.118	64.4	4.10	1.91	19.13	1.52	15.23	0.99	9.91	44.26							44.3	14.8							44.3	119,474	119,224	11,922	592,086	3333.6
5.7	0.118	64.4	4.20	1.94	19.36	1.55	15.52	1.03	10.35	45.22							45.2	15.1							45.2	119,973	119,723	11,972	604,058	3401.1
5.8	0.118	64.4	4.30	1.96	19.59	1.58	15.81	1.08	10.77	46.16							46.2	15.4							46.2	120,473	120,223	12,022	616,081	3468.8
5.9	0.118	64.4	4.40	1.98	19.81	1.61	16.08	1.12	11.18	47.07							47.1	15.7							47.1	120,972	120,723	12,072	628,153	3536.8
6.0	0.118	64.4	4.50	2.00	20.04	1.64	16.36	1.16	11.57	47.96					0.00		48.0	16.0							48.0	121,472	121,222	12,122	640,275	3605.0
[illegible]																														
6.2	0.118	64.4	4.70	2.05	20.48	1.69	16.90	1.23	12.32	49.69	24	0.6666	82	8.025	0.20	1.5	74.0	24.7							74.0	122,477	122,226	12,223	664,670	3766.6
6.3	0.118	64.4	4.80	2.07	20.69	1.72	17.16	1.27	12.67	50.52	45	0.6666	82	8.025	0.30	1.5	95.3	31.8							95.3	122,979	122,728	12,273	676,943	3858.0
6.4	0.118	64.4	4.90	2.09	20.91	1.74	17.42	1.30	13.02	51.34	69	0.6666	82	8.025	0.40	1.5	120.3	40.1							120.3	123,482	123,230	12,323	689,266	3949.6
6.5	0.118	64.4	5.00	2.11	21.12	1.77	17.67	1.34	13.36	52.15	97	0.6666	82	8.025	0.50	1.5	148.7	49.6							148.7	123,984	123,733	12,373	701,639	4046.7
6.6	0.118	64.4	5.10	2.13	21.33	1.79	17.92	1.37	13.69	52.94	127	0.6666	82	8.025	0.60	1.5	180.1	60.0							180.1	124,496	124,240	12,424	714,063	4147.1
6.7	0.118	64.4	5.20	2.15	21.54	1.82	18.17	1.40	14.01	53.72	161	0.6666	82	8.025	0.70	1.5	214.3	71.4							214.3	125,008	124,752	12,475	726,538	4250.6
6.8	0.118	64.4	5.30	2.17	21.74	1.84	18.41	1.43	14.32	54.48	196	0.6666	82	8.025	0.80	1.5	250.9	83.6							250.9	125,521	125,265	12,526	739,065	4356.9
6.9	0.118	64.4	5.40	2.19	21.95	1.87	18.65	1.46	14.63	55.23	235	0.6666	82	8.025	0.90	1.5	290.0	96.7							290.0	126,033	125,777	12,578	751,642	4465.8
[illegible]																														
7.1	0.118	64.4	5.60	2.24	22.35	1.91	19.13	1.52	15.23	56.71	318	0.6666	82	8.025	1.10	1.5	374.9	125.0							374.9	127,055	126,800	12,680	776,951	4691.3
7.2	0.118	64.4	5.70	2.26	22.55	1.94	19.36	1.55	15.52	57.43	363	0.6666	82	8.025	1.20	1.5	420.5	140.2							420.5	127,564	127,309	12,731	789,682	4807.6
7.3	0.118	64.4	5.80	2.27	22.75	1.96	19.59	1.58	15.81	58.14	410	0.6666	82	8.025	1.30	1.5	468.1	156.0							468.1	128,074	127,819	12,782	802,464	4926.3
7.4	0.118	64.4	5.90	2.29	22.94	1.98	19.81	1.61	16.08	58.84	459	0.6666	82	8.025	1.40	1.5	517.6	172.5							517.6	128,583	128,329	12,833	815,297	5047.1
7.5	0.118	64.4	6.00	2.31	23.14	2.00	20.04	1.64	16.36	59.53	509	0.6666	82	8.025	1.50	1.5	569.0	189.7							569.0	129,093	128,838	12,884	828,181	5170.0
7.6	0.118	64.4	6.10	2.33	23.33	2.03	20.26	1.66	16.63	60.22	562	0.6666	82	8.025	1.60	1.5	622.2	207.4							622.2	130,460	129,776	12,978	841,158	5295.3
7.7	0.118	64.4	6.20	2.35	23.52	2.05	20.48	1.69	16.90	60.89	616	0.6666	82	8.025	1.70	1.5	677.2	225.7							677.2	131,826	131,143	13,114	854,273	5423.1

Layon Landfill - Pond 2

Pond Discharge Characteristics

Water Elevation From Pond Bottom (ft)	Orifice Equation: CA = 0.1178	Coeff.- 2g	Head (ft)	Orifice Row # 1: Q/ EA Pipe (cfs)	Orifice Row # 1: Q/Row 1 (10) (cfs)	Orifice Row # 2: Q/ EA Pipe (cfs)	Orifice Row # 2: Q/Row 2 (10) (cfs)	Orifice Row # 3: Q/ EA Pipe (cfs)	Orifice Row # 3: Q/Row 3(10) (cfs)	Cum - Q (cfs)	Riser Box - Weir Equation: Q (cfs)	Coeff.	L = ft (23x18)	Coeff. 2g ^ 0.5	Depth - H (ft)	Coeff.
7.8	0.118	64.4	6.30	2.37	23.71	2.07	20.69	1.72	17.16	61.56	672	0.6666	82	8.025	1.80	1.5
7.9	0.118	64.4	6.40	2.39	23.90	2.09	20.91	1.74	17.42	62.22	730	0.6666	82	8.025	1.90	1.5
8.0	0.118	64.4	6.50	2.41	24.08	2.11	21.12	1.77	17.67	62.87	789	0.6666	82	8.025	2.00	1.5
8.2	0.118	64.4	6.70	2.44	24.45	2.15	21.54	1.82	18.17	64.16	912	0.6666	82	8.025	2.20	1.5
8.3	0.118	64.4	6.80	2.46	24.63	2.17	21.74	1.84	18.41	64.79	976	0.6666	82	8.025	2.30	1.5
8.4	0.118	64.4	6.90	2.48	24.81	2.19	21.95	1.87	18.65	65.41	1042	0.6666	82	8.025	2.40	1.5
8.6	0.118	64.4	7.10	2.52	25.17	2.24	22.35	1.91	19.13	66.63	1177	0.6666	82	8.025	2.60	1.5
8.7	0.118	64.4	7.20	2.53	25.34	2.26	22.55	1.94	19.36	67.25	1247	0.6666	82	8.025	2.70	1.5
8.8	0.118	64.4	7.30	2.55	25.52	2.27	22.75	1.96	19.59	67.85	1318	0.6666	82	8.025	2.80	1.5
8.9	0.118	64.4	7.40	2.57	25.69	2.29	22.94	1.98	19.81	68.45	1391	0.6666	82	8.025	2.90	1.5
9.1	0.118	64.4	7.60	2.60	26.04	2.33	23.33	2.03	20.26	69.63	1540	0.6666	82	8.025	3.10	1.5
9.2	0.118	64.4	7.70	2.62	26.21	2.35	23.52	2.05	20.48	70.21	1616	0.6666	82	8.025	3.20	1.5
9.3	0.118	64.4	7.80	2.64	26.38	2.37	23.71	2.07	20.69	70.78	1694	0.6666	82	8.025	3.30	1.5
9.4	0.118	64.4	7.90	2.65	26.55	2.39	23.90	2.09	20.91	71.35	1773	0.6666	82	8.025	3.40	1.5
9.6	0.118	64.4	8.10	2.69	26.88	2.43	24.27	2.13	21.33	72.48	1985	0.6666	82	8.025	3.60	1.5
9.7	0.118	64.4	8.20	2.70	27.05	2.44	24.45	2.15	21.54	73.03	2017	0.6666	82	8.025	3.70	1.5
9.8	0.118	64.4	8.30	2.72	27.21	2.46	24.63	2.17	21.74	73.59	2101	0.6666	82	8.025	3.80	1.5
9.9	0.118	64.4	8.40	2.74	27.38	2.48	24.81	2.19	21.95	74.14	2186	0.6666	82	8.025	3.90	1.5
10.0	0.118	64.4	8.50	2.75	27.54	2.50	24.99	2.22	22.15	74.68	2273	0.6666	82	8.025	4.00	1.5

Water Elevation From Pond Bottom (ft)	Q Entering Riser (cfs)	Q Entering Each Pipe (cfs)	Spillway - Weir Equation: Q (cfs)	Coeff.	L - length	2g	Weir H - 2'	Coeff.	Total Discharge - (cfs)	Pond Geometry: Area (sf)	Average Area (sf)	Volume (cf)	Pond Volume Storage (cf)	Storage Indication Quantity (SIQ): $2S_2/\Delta T + O_2$: (Δt = 360 seconds)
7.8	733.8	244.6							733.8	133,193	132,510	13,251	867,524	5553.4
7.9	792.1	264.0							792.1	134,559	133,876	13,388	880,911	5686.1
8.0	852.1	284.0							852.1	135,926	135,243	13,524	894,435	5821.1
8.2	976.6	325.5	2.4	0.66666	8	64.4		0.626	916.8	137,710	137,264	13,726	921,799	6037.9
8.3	1,041.2	347.1	4.4	0.66666	8	64.4		0.626	918.8	138,603	138,157	13,816	935,615	6116.7
8.4	1,107.3	369.1	6.8	0.66666	8	64.4		0.626	921.2	139,495	139,049	13,905	949,520	6198.3
8.6	1,243.8	414.6	12.5	0.66666	8	64.4		0.626	926.9	140,938	140,663	14,066	977,580	6357.9
8.7	1,314.2	438.1	15.7	0.66666	8	64.4		0.626	930.1	141,490	141,214	14,121	991,701	6439.6
8.8	1,385.9	462.0	19.2	0.66666	8	64.4		0.626	933.6	142,041	141,766	14,177	1,005,878	6521.8
8.9	1,459.0	486.3	22.9	0.66666	8	64.4		0.626	937.3	142,593	142,317	14,232	1,020,110	6604.6
9.1	1,609.2	536.4	30.9	0.66666	8	64.4		0.626	945.8	144,044	143,594	14,359	1,048,756	6771.8
9.2	1,686.3	562.1	35.2	0.66666	8	64.4		0.626	949.6	144,943	144,493	14,449	1,063,205	6856.3
9.3	1,764.6	588.2	39.7	0.66666	8	64.4		0.626	954.1	145,843	145,393	14,539	1,077,745	6941.6
9.4	1,844.1	614.7	44.4	0.66666	8	64.4		0.626	958.8	146,742	146,293	14,629	1,092,374	7027.6
9.6	2,007.1	669.0	54.2	0.66666	8	64.4		0.626	968.7	148,201	147,921	14,792	1,121,885	7201.3
9.7	2,090.4	696.8	59.4	0.66666	8	64.4		0.626	973.8	148,760	148,480	14,848	1,136,733	7289.0
9.8	2,174.9	725.0	64.7	0.66666	8	64.4		0.626	979.1	149,318	149,039	14,904	1,151,637	7377.1
9.9	2,260.5	753.5	70.2	0.66666	8	64.4		0.626	984.6	149,877	149,598	14,960	1,166,597	7465.7
10.0	2,347.3	782.4	75.8	0.66666	8	64.4		0.626	990.2	150,436	150,157	15,016	1,181,613	7554.7

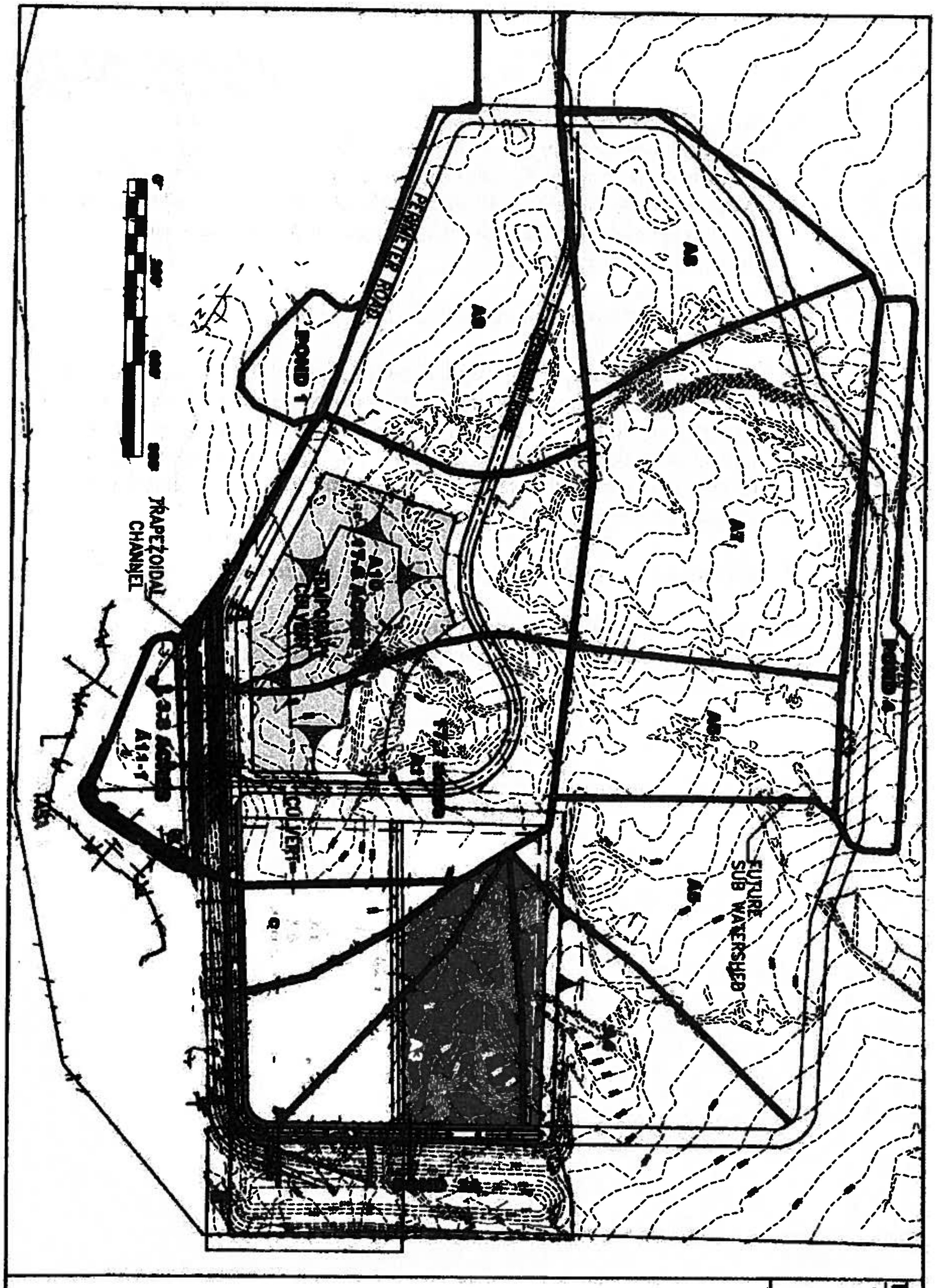
1/ Orifice Equation : [$Q = CA(2gH)^{0.5}$] ft3/sec; A = 6" Pipe Area = 0.1963 ft2 ; C = 0.6 ; H = head water depth above orifice centerline

2/ Weir: [Q = 2/3 Cw L 2g 0.5 Hw 1.5 ft 3 / sec]; L = length; Y = height above pond; Hw = head above weir

3/ Spillway: $Q = 2/3\ C_w\ L\ (2g)^{0.5}\ H_w^{1.5}$

Final Grading Watershed

TG Engineers, PC
125 Tun Jesus Crisostomo Street #206
Tamuning GU 96913



TG ENGINEERS, PC
CIVIL ENGINEERING, PLANNING & CONSTRUCTION MANAGEMENT

FINAL GRADING WATERSHEDS POND 2

A-Mehr Inc.

Professional Engineers and Scientists Specializing in Landfills

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DESIGN MEMORANDUM

Surface Water Drainage System Calculations
Layon Landfill, Guam

PREPARED FOR

TG ENGINEERS, PC
Sunny Plaza, Suite 303
125 Tun Jesus Criostomo St.
Tamuning, Guam 96913

November 2008

LAYON LANDFILL
SURFACE WATER DRAINAGE CALCULATIONS
November 2008

Contents

1. Scope

- Design / evaluate perimeter drainage channels
- Design / evaluate sedimentation pond discharge structures
- Check distribution of stormwater discharge against existing distribution of runoff to the Fintasa, Fensol and Tinago rivers.

2. Design Basis

- 25-year, 24 hour storm (per Guam solid waste regulations)
- Existing hydrograph and full site development hydrograph as established by Winzler & Kelly Technical Memorandum, July 29, 2005 (Appendix B, Book 1, 40% Plans, Specifications & Estimates, Layon Municipal Sanitary Landfill, Layon, Inarajan, Guam, August 1, 2005 by TG Engineers, PC.

3. Stormwater Routing

Figure 1 presents the stormwater routing established by Winzler & Kelly (W&K) for the site at full development. We have modified the drawing to reflect the revised numbering of the four ponds, based on the new South End Start construction sequence, and to show clearly the distribution of sub-watersheds to each of the four ponds.[1]

W&K established the peak design inflows to the subareas tributary to each of the four ponds as shown in Table 1. Current master planning and surface water management designs are generally consistent with the runoff patterns shown in the 2005 study, and therefore will be used for the present analyses.

[1] Ponds designated 1, 2, 3 and 4 in 2005-06 submittals are currently designated as Ponds 4, 1, 2, and 3, respectively. All references in this analysis are to the ponds as currently identified.

Table 1 – Pond Inflows at Full Development

Pond	Area	Acres	Peak Flow (cfs)	Pond Total Flow (cfs)**
Pond 1	A-9	26.0	273	273
Pond 2	A-10	19.3	164	
	A-11	20.3	205	
	Pond 2 Total	45.9		334**
Pond 3A	A-1	6.3	70	
	A-2	7.2	89	
	A-3	14.4	159	
	A-4 (30%)	6.6	102	
	Pond 3A Total	33.0	80	400**
Pond 3B	A-4 (60%)	10.0	169	
	A-5	11.5	188	
	Pond 3B Total	21.5		357**
Pond 4	A-6	11.6	117	
	A-7	33.0	280	
	A-8	19.5	210	
	Pond 4 Total	64.1		578**

**Note: Pond totals may not equal sum of area peak flows due to different lag times in area peak flows reaching basin.

4. Perimeter Drainage Channels

Shallow rip-rap lined drainage swales will be constructed on the inside of the perimeter road to carry minor flows, and on the outside edge adjacent to the sedimentation basins and in road segments where no significant run-on to the road is expected. Elsewhere, concrete trapezoidal channels will be constructed on the outside edge of the perimeter road to convey runoff to the ponds.

Based on preliminary computations, the perimeter concrete trapezoidal channels were designed with a uniform bottom width of 6.0 feet. Channel depth was varied according to the peak flow and slope gradient of each segment. Flow calculations based on Manning's Equation were performed using FlowMaster computer software (Haestad Methods, Inc.). The design channel depth was established using the computed water depth at the peak flow, plus a freeboard of 0.5 foot. The resulting depths range from 1.5 to 3.0 feet in depth. Table 3 presents the results of the analysis, and Attachment 1 contains the Flowmaster output sheets.

Table 2
Perimeter Channel Design Conditions

Perimeter Road Station	Areas Drained	Discharge Location	Slope Gradient	Peak Flow (cfs)
8+00 to 15+00	A-2	Pond 3A	0.0222	89
25+00 to 33+00	A-10	Pond 2	0.0047	164
38+00 to 47+00	A-9	Pond 1	0.0063	273
50+00 to 66+00	A-8	Pond 4	0.0120	210
73+50 to 88+50	A-5	Pond 3B	0.0230	188

Table 3
Channel Design Analysis

Perimeter Road Station	Peak Flow (cfs)	Channel Width (ft)	Peak Flow Depth (ft)	Channel Depth (ft)	Freeboard (ft)
8+00 to 15+00	89	6	0.9	1.5	0.6
25+00 to 33+00	164	6	2.1	3.0	0.9
38+00 to 47+00	273	6	2.5	3.0	0.5
50+00 to 66+00	210	6	1.8	2.5	0.7
73+50 to 88+50	188	6	1.4	2.0	0.6

5. Stormwater Ponds

The primary design objectives for the stormwater ponds are to:

- Provide detention time for sediment to settle out on the basin floor before stormwater is discharged to the adjacent natural streambeds; and
- Provide retention such that peak discharges to the adjacent streambeds do not exceed existing peak flows from the undeveloped site.

The key design variables needed to meet these objectives are pond storage capacity, and the rate of discharge from the pond to the adjacent stream. These features are addressed below.

Storage Capacity

Ponds 1, 2 and 3 are designed for a maximum depth of 10 feet, with an emergency spillway at an elevation 8 feet above the pond bottom. Pond 3 will be constructed in two stages, with Pond 3A constructed during Phase 1 of site development (Cell 1 and Cell 2), with Pond 3B constructed during Phase 2. Ponds 3A and 3B are of equal size, each comprising 50% of the total capacity and flow of Pond 3. Pond 4 will have a depth of 15 feet with the spillway set at 12 feet above the bottom. Table 4 presents the storage capacity of each pond as a function of depth.

Table 4
Cumulative Pond Storage by Depth (Acre-feet)

Depth (ft)	Pond 1	Pond 2	Pond 3 (3A + 3B)	Pond 4
1	0.5	2.2	2.9	1.4
2	1.4	4.4	5.9	3.0
3	2.4	6.8	9.1	4.9
4	3.5	9.2	12.4	7.1
5	4.6	11.8	16.0	9.6
6	5.8	14.5	19.6	12.6
7	7.0	17.2	23.5	15.9
8	8.4	20.1	27.5	19.3
9	9.9	23.1	31.7	22.9
10	11.5	26.1	36.0	26.7
11	--	--	--	30.7
12	--	--	--	34.9
13	--	--	--	35.0
14	--	--	--	39.6
15	--	--	--	44.5

The remainder of this design memorandum addresses only Ponds 1, 2 and 3. Pond 4, which will not be constructed for at least 15 years after the initial landfill construction, will be analyzed by the Engineer responsible for its design at that time.

Discharge Structures

The ponds will discharge the design flow through reinforced concrete pipes, with flows in excess of the design to be handled by a concrete spillway. The discharge pipes are sized to pass the peak inflow to the basin with a headwater depth of 8 feet, corresponding to the spillway elevation, Pond discharges at low water depths are controlled by a low concrete wall around the pipe inlets, with imbedded orifice openings that allow water to be discharged while retaining flow to allow sediment to settle.

The number and size of discharge pipes for each pond is established using the Federal Highway Administration design guide for culverts, HDS-5, "Hydraulic Design of Highway Culverts". Chart 1B of the publication (Figure 3) is a nomograph relating culvert diameter, discharge and headwater for circular concrete pipes. For the Ponds 1, 2 and 3 design with a headwater depth of 8 feet, the maximum flow for pipes 3.5 ft. (42") to .0 ft. (72") is established as follows:

Diameter (inches)	Diameter (ft)	Maximum Flow (cfs)
42	3.5	110
48	4.0	145
54	4.5	190
60	5.0	200
66	5.5	240
72	6.0	280

Based on these capacities, the optimum configuration of pipes for each pond is established as follows:

Pond	Design Flow (cfs)	Configurations	Total Flow (cfs)
Pond 1	273	2 @ 48" 1 @ 60"	290 280
Pond 2	404	3 @ 48" 2 @ 60"	435 400
Pond 3A, 3B	292	2 @ 48" 2 @ 54"	290 380

For convenience of material supply and construction, we conclude a design based on 48"RCP pipes is most appropriate. Ponds 1, 3A and 3B will have two pipes, and Pond 2 will have 3 pipes to manage the peak flow.

The FHWA culvert design nomograph can be used to generate the following table of discharges from the 48" pipes as a function of pond headwater depth:

Headwater Depth H (ft)	H/D	1 Pipe Q (cfs)	2 Pipes Q (cfs)	3 Pipes ((cfs)
1	0.25	10	20	30
2	0.5	22	44	66
3	0.75	45	90	135
4	1.0	70	140	210
5	1.25	95	190	285
6	1.5	110	220	330
7	1.75	130	260	390
8	2.0	145	290	435

Figure 4 illustrates a typical discharge structure for the ponds. The discharges for ponds 1, 2 and 3 will be identical, consisting of:

- A concrete riser structure, 6 feet tall with three rows of inlet orifices consisting of 6-inch PVC pipe sections set into three of the four walls;;
- A 48-inch concrete discharge pipe draining water entering the riser structure; and
- A trapezoidal concrete spillway with a 6-feet bottom width set 2 feet below the pond crest,

The following sections develop the discharge volumes and relationships for each of these elements, then combine the results to produce a composite table of discharge volumes as a function of water depth in the pond.

Riser Structure

The three rows of orifices in the structure are set with centerlines at 1.5, 3 and 4.5 feet above the basin bottom. The bottom and top rows consist of 10 orifices, each made of a 6-inch long piece of 6" PVC pipe (Schedule 40, inside diameter 6.0 inches) embedded in the concrete wall.

Flow through each orifice can be reasonably approximated using the conventional orifice equation

$$Q_o = CA(2gH)^{0.5}$$

Where $C = 0.6$
$A = \text{Area} = \pi D^2/4 = \pi(0.5)^2/4 = 0.1963\ ft^2$
$g = 32.2\ ft/sec^2$
$H =$ head – water depth above orifice centerline, in feet

Combining, the flow through each orifice is:

$$Q_o = 0.932\ H^{0.5}\ ft^3/sec \qquad \text{Equation (1)}$$

As water depth in the pond rises and the 48-inch discharge pipe begins to fill, the lower rows of orifices will be submerged. At that point the head value H in the Equation (1) becomes the difference in water level between the pond and the riser inside. Water level inside the riser is determined by the head required to discharge the flow entering the riser through the discharge pipe.

When the water level in the pond reaches the top of the riser, it flows over the riser walls on all four sides. This flow is described by the weir flow equation (Sturm, 2001):

$$Q_w = 2/3\ C_w L(2g)^{0.5} H_w^{1.5}$$

Where $C_w = 0.602 + 0.075\ (H_w/y)$; H_w = hydraulic head above weir
y = weir height above pond bottom
L = length of weir

For the riser as designed, $y = 6$ ft
$H_w <= 4$ ft, typical maximum 2 ft (spillway)
$C_w <= 0.602 + 0.025 = 0.627$
$L = 2\ (18 + 16) = 68$ ft. (Ponds 1, 3A and 3B)
$L = 2\ (26 + 16+ = 84$ ft. (Pond 2)

Then:

$$Q_w = 0.667(0.627)(68)(64.4)^{0.5}H_w^{1.5}$$

$Q_w = 228\ H_w^{1.5}$ **ft³/sec** (Ponds 1, 3A, 3B) **Equation (2A)**

$Q_w = 282\ H_w^{1.5}$ **ft³/sec** (Pond 2) **Equation (2B)**

At a pond water level of 8 feet, corresponding to the elevation of the pond crest, the discharge into the riser would be:

$Q_w = 228 \times 2^{1.5} = 645$ cfs (Ponds 1, 3A, 3B)
$Q_w = 282 \times 2^{1.5} = 798$ cfs (Pond 2)

This result indicates the riser has sufficient capacity to discharge the maximum capacity of the culvert pipes without overtopping the pond crest.

Discharge Pipe

Each 48-inch reinforced concrete pipe has an inside diameter of 48.0 inches. At the specified installed slope of 2.0%, it has a full-flow capacity of 287 cfs. The pipe acts as a culvert with inlet control, hence the head at the inlet (water elevation within the riser is determined by the following equations (Federal Highway Administration, 2001)[2].

For an unsubmerged culvert:

$HW_u/D = K\ [\ Q/AD^{0.5}]^M$;

HW_u = headwater depth above pipe invert, ft.
D = culvert pipe diameter, ft.
A = culvert cross-section area, ft^2
Q = discharge flow, ft^3/sec
For a square-edged circular concrete pipe with headwall, $M = 2$
$K = 0.0098$

For $D = 4.0$ ft., $A = \pi(4^2/4) = 4\pi$
$D^{0.5} = 4^{.5} = 2$
$AD^{0.5} = 8\pi = 25.13$

[2] Federal Highway Administration, 2005. HDS-5, Hydraulic Design of Highway Culverts. Publication No. FHWA-NHI-01-020, Revised May 2005

$HW_u = 4(0.0098)(Q/25.13)^2 = \{4(0.098)/631.6\}\ Q^2$

$HW_u = 6.20 \times 10^{-4}\ Q^2$ **Equation (3)**

Equation (3) is applicable up to a value of $Q/AD^{0.5}$ of 3.5, or for flows equal to or less than:

$Q = 3.5\ AD^{0.5} = 3.5(\pi 4^2/4)(4^{.5}) = 28\pi = 88$ cfs

At which value $HW_u = 6.20 \times 10^{-4}\ Q^2 = 4.8$ ft.

For a <u>submerged culvert:</u>

$HW_s/D = C\ \{K_u Q/AD^{0.5}\}^2 + Y - 0.5\ S^2$;

S = slope of culvert barrel = 0.04
Y = 0.67
C = 0.0398
$K_u = 1.0$

$HW_s = D(CQ^2/A^2D) + D(Y - 0.5\ S^2)$

$HW_s = CQ^2/A^2 + D(Y - 0.5\ S^2)$;

$A^2 = (4\pi)^2 = 157.9\ ft^2$
$S^2 = 0.0016$

$HW_s = 0.0398/157.9\ Q^2 + D(0.67 - 0.0008)$

$HW_s = 0.000252\ Q^2 + 2.68$ **Equation (4)**

Equation (4) is applicable for values of $Q/AD^{0.5}$ equal to or greater than 4.0, or for flows equal to or greater than

$Q = 4.0\ AD^{0.5} = 4(\pi 4^2/4)(4^{.5}) = 32\pi = 100$ cfs

At which value $HW_s = 0.000252\ Q^2 + 0.67(4) = 5.2$ ft

For flows in the transition zone between $Q/AD^{0.5}$ of 3.5 to 4.0, (i.e. from 88 to 100 cfs), HW may be linearly interpolated. Therefore:

$HW_T = 4.8 + (5.2 - 4.8)\ (Q\text{-}88)/(100\text{-}88)$

$HW_T = 4.8 + 0.033\ (Q\text{-}88)$ for $88 < Q < 100$ **Equation (5)**

At higher flows, the value of HW_t calculated using Equation (4) will exceed the water level elevation in the pond. For this case, the pipe discharge is calculated using the pond water level as HW_S in the following equation, derived from solving Equation (4) for Q:

$Q = 63.0\ (HW_S - 2.68)^{0.5}$ **Equation (6)**

Equation (6) can be used to calculate the maximum pipe discharge when water elevation in the pond reaches the pond crest, or a depth of 10 feet:

$Q = 63.0\ (10 - 2.68)^{0.5}$

$Q^2 = 63.0\ (7.32)^{0.5}$

$Q = 170.4$ cfs (for each pipe)

Spillway

The spillway is a concrete trapezoidal structure with a base 8 feet wide and 2-feet high slopes at a 2:1 grade, to a top width of 16 ft. As a conservative estimate of its capacity, the spillway may be treated as a simple weir with a width of 8 feet. As applied to the riser top,

$Q_w = 2/3\ C_w L (2g)^{0.5} H_w^{1.5}$

Where $C_w = 0.602 + 0.075\ (H_w/y)$

In this case the term (H_w/y) is negligible and the equation is evaluated as

$Q_S = 2/3\ (0.602)(6)(64.4)^{0.5} H_w^{1.5}$

$\mathbf{Q_S = 25.7\ H_w^{1.5}}$ **Equation (7)**

The maximum flow across the spillway occurs when the pond level reaches the pond crest, or at $H_w = 2$ feet. For this condition Equation 6 produces a value of 54 cfs.

Composite Pond Discharge Characteristic

A spreadsheet was used to compute a table of discharge rates as a function of water depth in the pond. The following criteria were applied:

1. One foot of sediment was assumed in the bottom of the pond, with no sediment inside the riser.

2. Flow begins in each row of orifices when the water depth exceeds the orifice centerline, i.e. at 1.5, 3.0 and 4.5 feet of depth. Flow is computed using Equation

(1). Flow in each row of orifices ceases when the elevation of headwater in the riser reaches the elevation of the water in the pond.

3. Flow across the riser top begins when the water depth in the pond exceeds 6 feet. Flow is computed using Equation (2)

4. Discharge from the spillway is computed using Equation (6) when water depth in the pond exceeds 8 feet.

5. For each increment of pond depth and flow, the required headwater depth for discharge through the culvert pipes is computed using Equations (3), (4) and (5).

Figure 5 presents a graphic representation of the discharge characteristics for Ponds 1, 2 and 3. Detailed results are contained in the computational spreadsheet in Attachment 2.

Pond Discharge Hydrographs

The modified Puls method, also known as the storage indication method, was used to compute the outflow hydrograph for Ponds 1, 2 and 3. The basic equation for this method, derived from the continuity equation, is:

$$\frac{2S_2}{\Delta t} + O_2 = (I_1 + I_2) + \left(\frac{2S_1}{\Delta t} + O_1\right) \qquad \text{(Ponce, 1989)}^3$$

Where: S_1 and S_2 are storage volumes in the pond at times 1 and 2, respectively (cubic feet);
I_1 and I_2 are the incoming flow rates at times 1 and 2 (cfs); and
Δt is the time interval between times 1 and 2 (seconds).

The left-hand side of the equation, the "storage indication quantity" , is computed from the pond's discharge characteristic and storage volume data for increments of pond depth, and a relationship established between the storage indication quantity and discharge volume. Attachment 2 contains the computational spreadsheets used to compute outflow hydrographs from the inflow hydrographs developed by Winzler & Kelly. Figures, 6, 7 and 8 are the resulting hydrographs.

Peak flow and total volume discharges from the ponds are computed as follows:

[3] Ponce,Victor Miguel, Engineering Hydrology, Principles and Practice, Prentice Hall, 1989

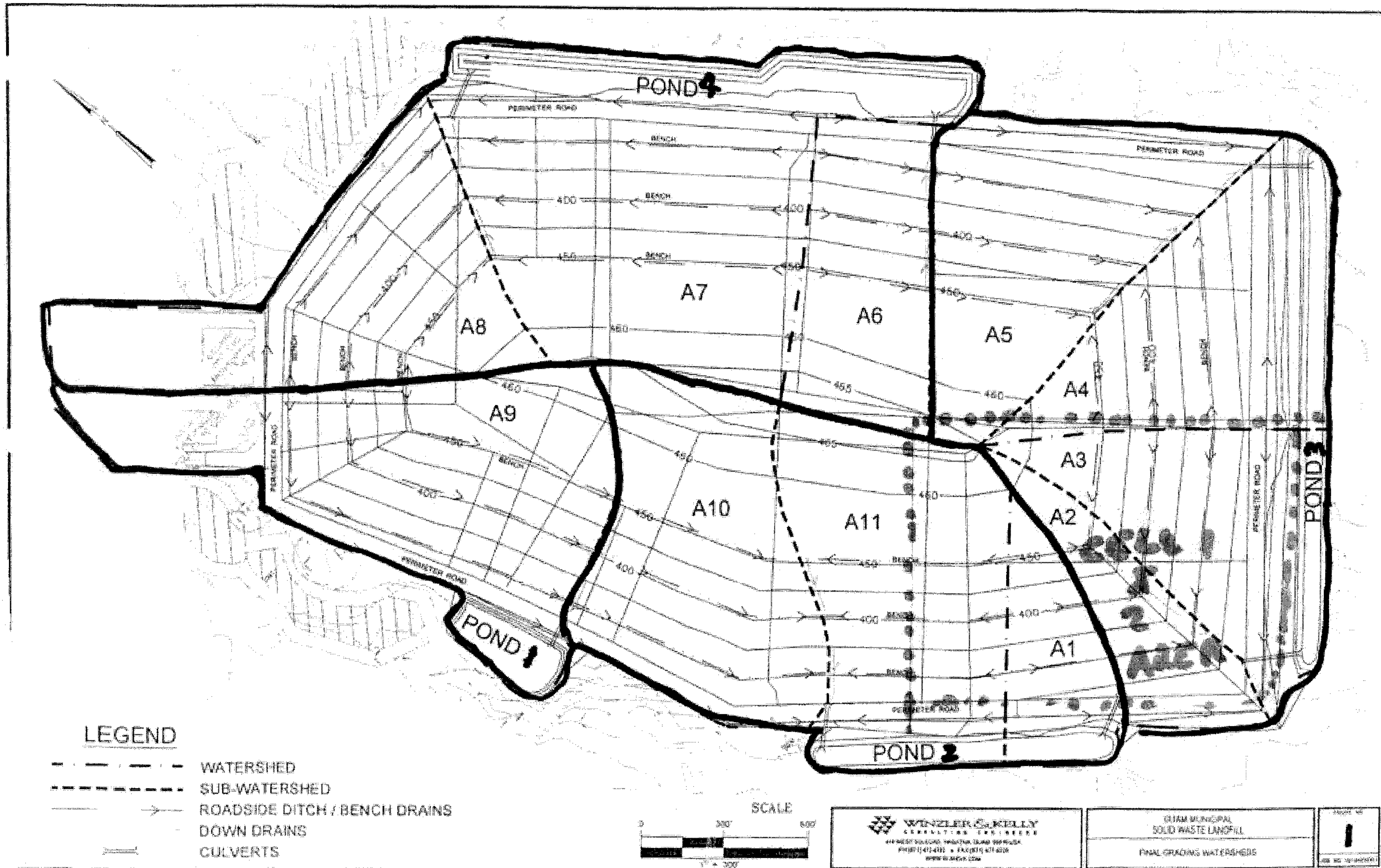
Pond	Peak Flow (cfs	Maximum Water Elevation (ft)	Total Volume (acre-feet)
1	256	6.9	28.4
2	306	6.8	48.2
3A	289	7.9	39.5
Total	851	---	116.1

It is notable that all of the ponds reach a maximum water elevation below the overflow spillway, leaving additional capacity for storms in excess of the 25-year design storm.

All three of the Phase I ponds discharge to the Fintasa River Basin. Winzler and Kelly established the existing discharges from the landfill site to the Fintasa Basin during the design storm as:

Peak flow	830 cfs
Total Volume	103.5 acre-feet

The computed peak and total volumes from the three ponds are sufficiently close to the existing quantities that no significant impact on downstream uses will occur during the design storm.


POND 4
POND 3
POND 2
POND 1
PERIMETER ROAD
BENCH
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
LEGEND
WATERSHED
SUB-WATERSHED
ROADSIDE DITCH / BENCH DRAINS
DOWN DRAINS
CULVERTS
SCALE
0
300'
600'
1" = 300'
WINZLER & KELLY
CONSULTING ENGINEERS
GUAM MUNICIPAL
SOLID WASTE LANDFILL
FINAL GRADING WATERSHEDS
1

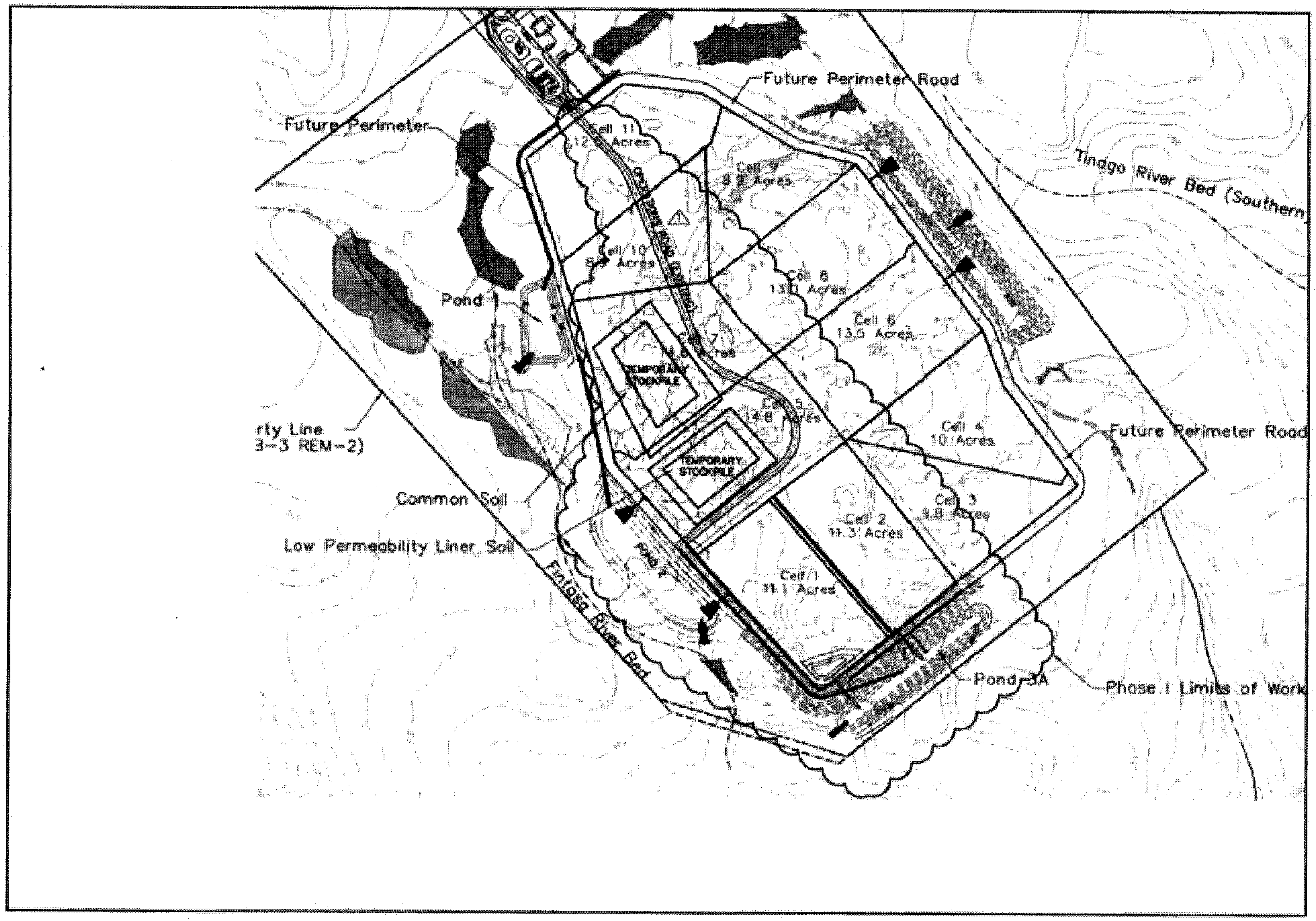
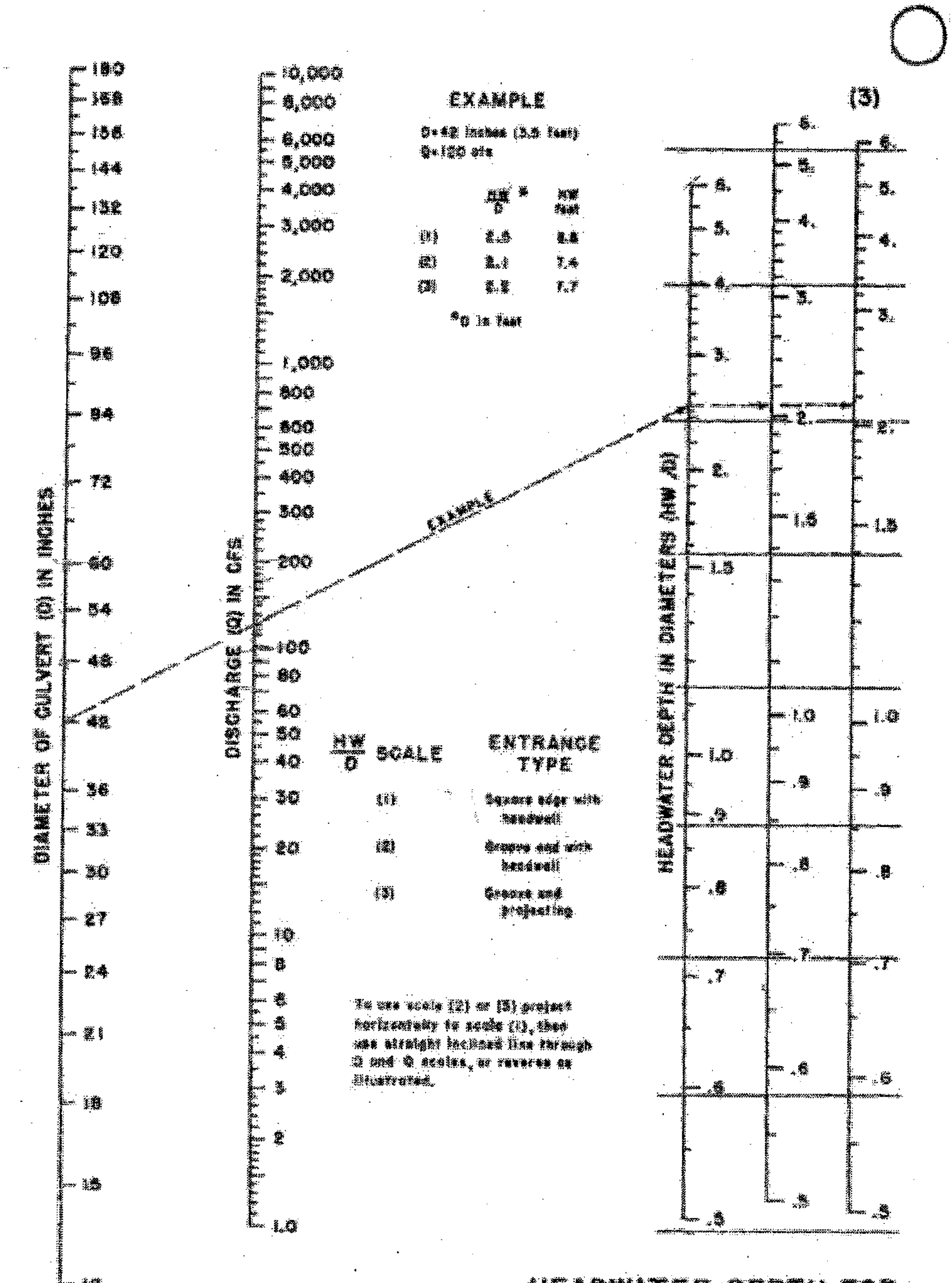


FIGURE 2 - PHASE 1 DRAINAGE PLAN

FIG. 3

CHART 1B



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3 REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

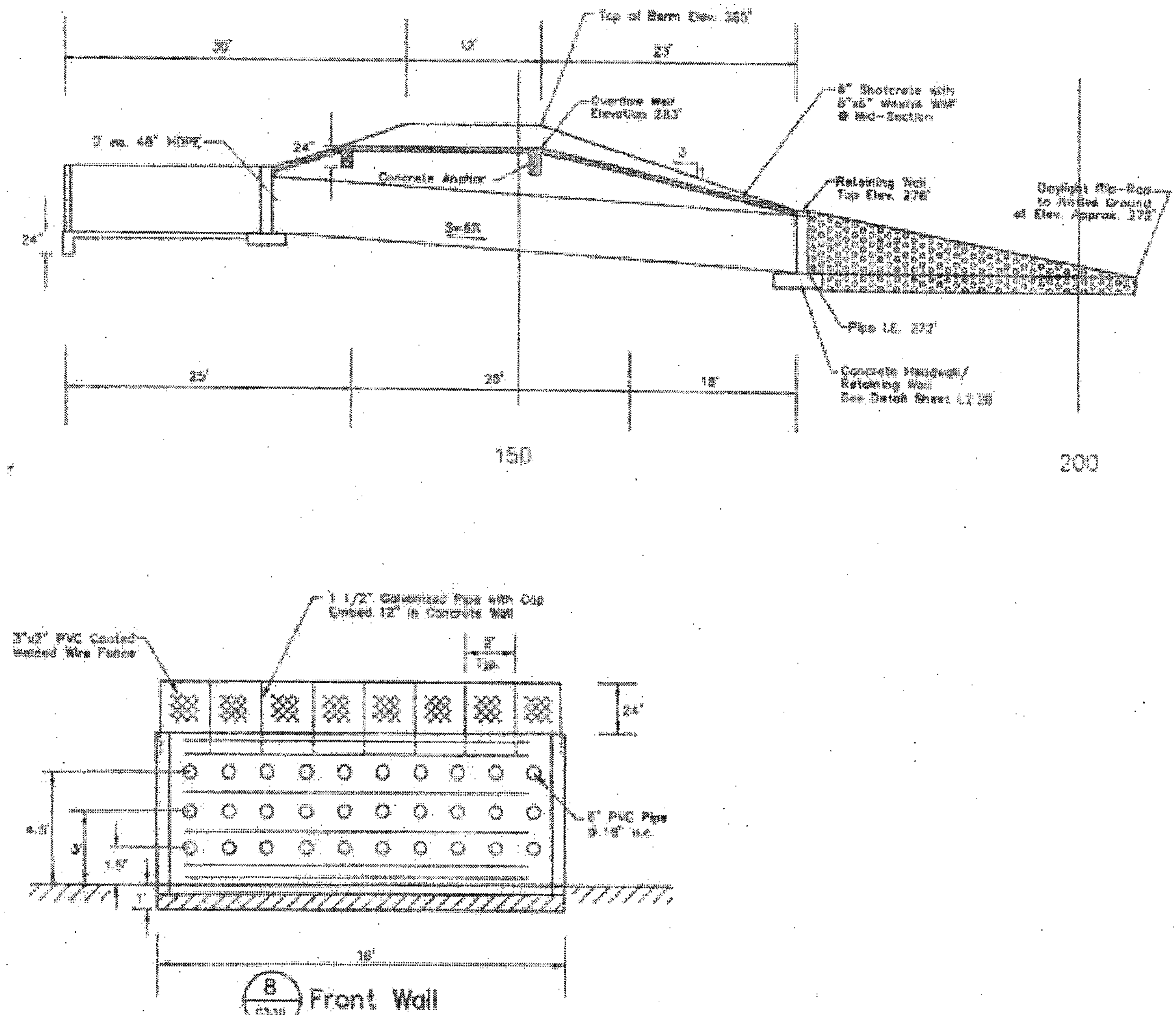


FIGURE 4
POND 3A DISCHARGE STRUCTURE

Figure 5
Pond Discharge Characteristics

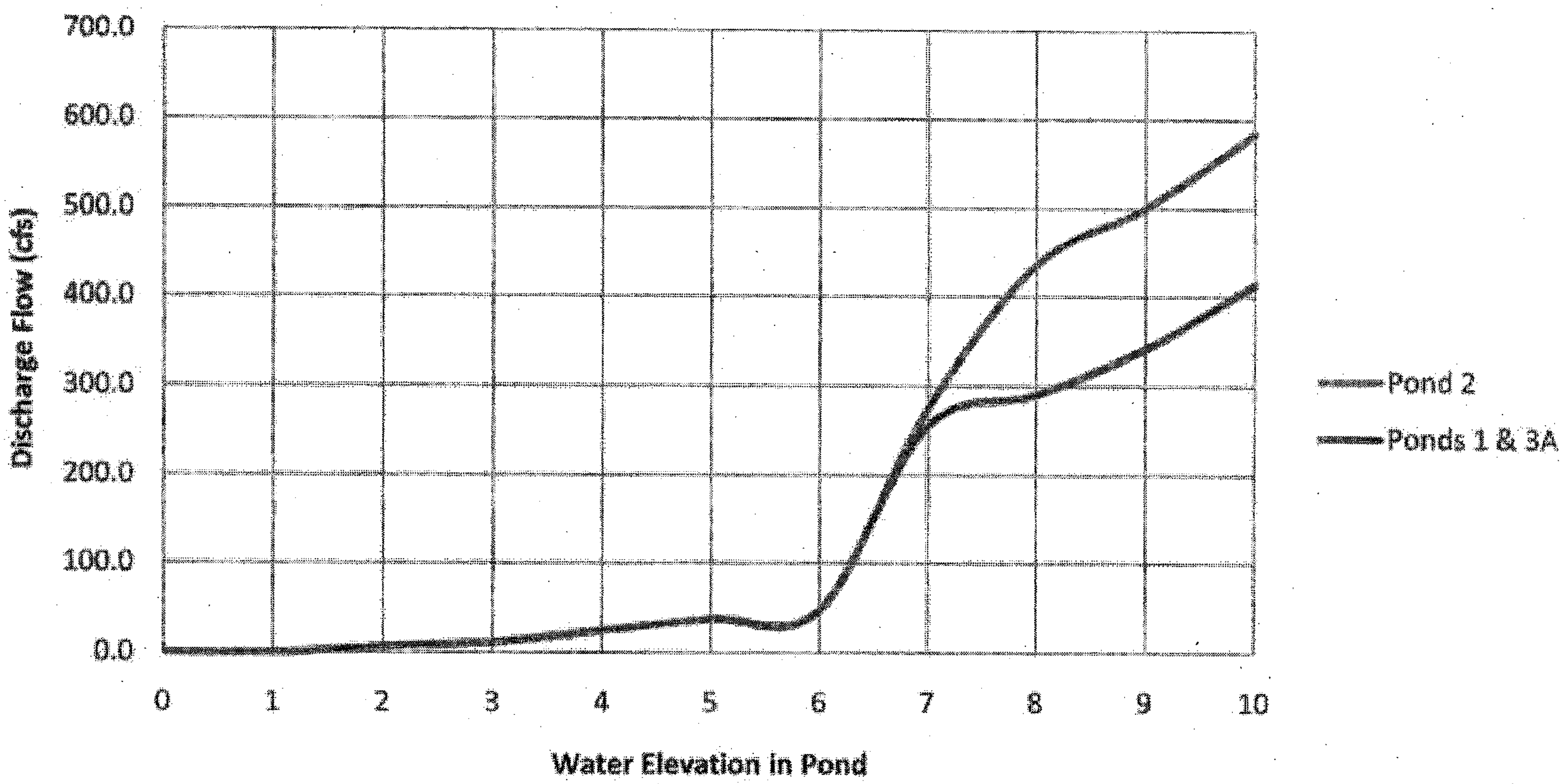


Figure 6
Pond 1 Inflow & Outflow Hydrograph

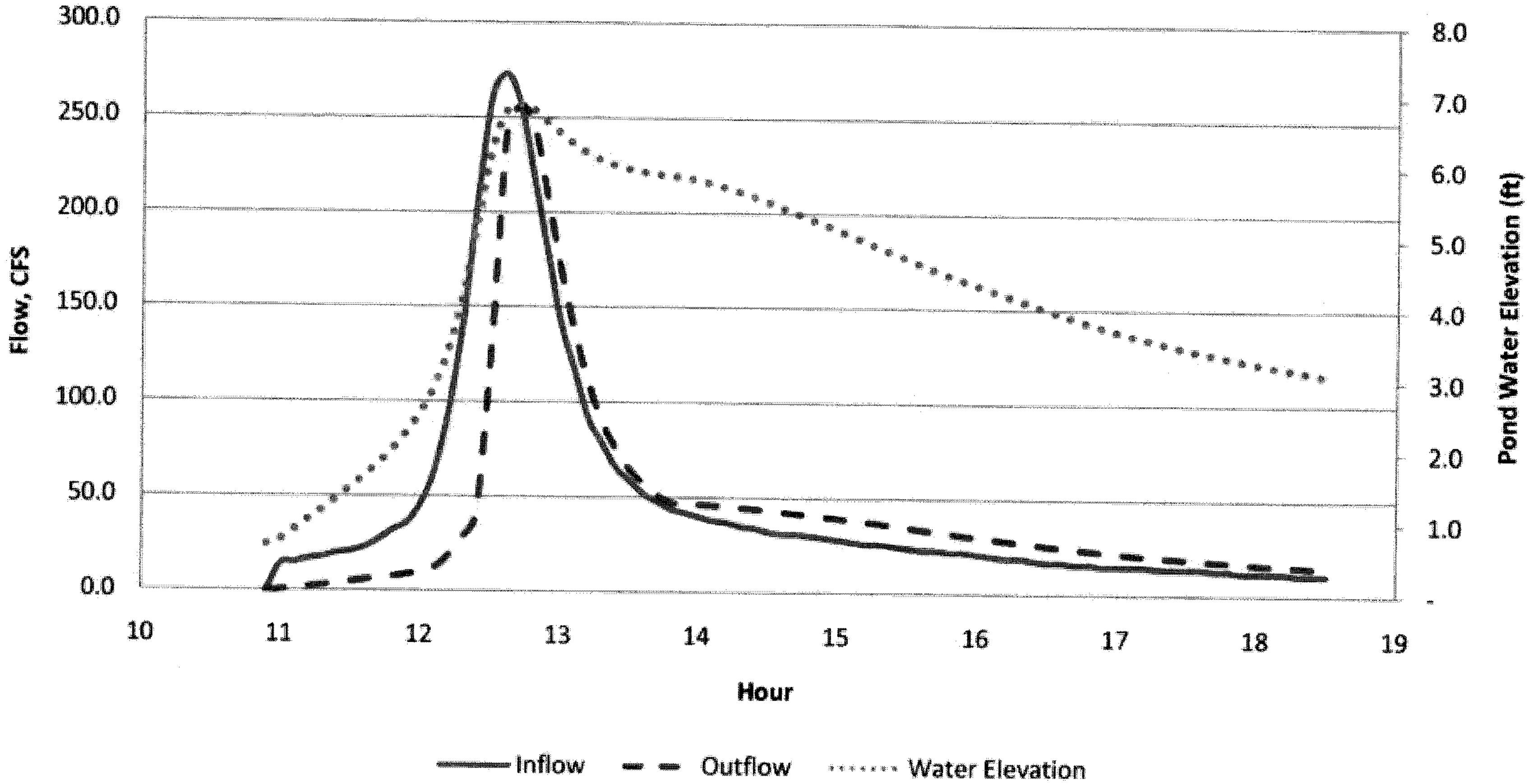


Figure 7
Pond 2 Inflow & Outflow Hydrograph

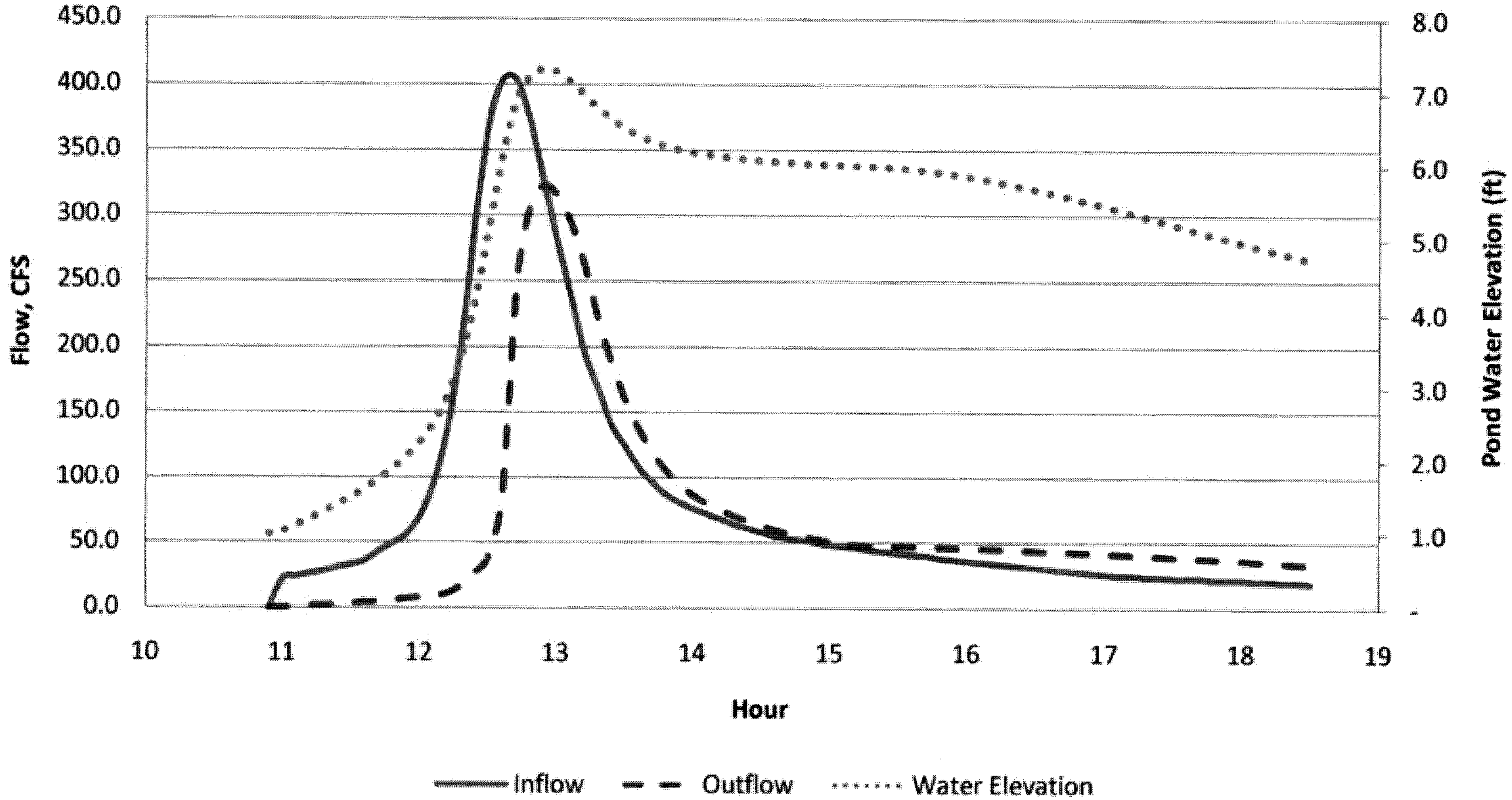
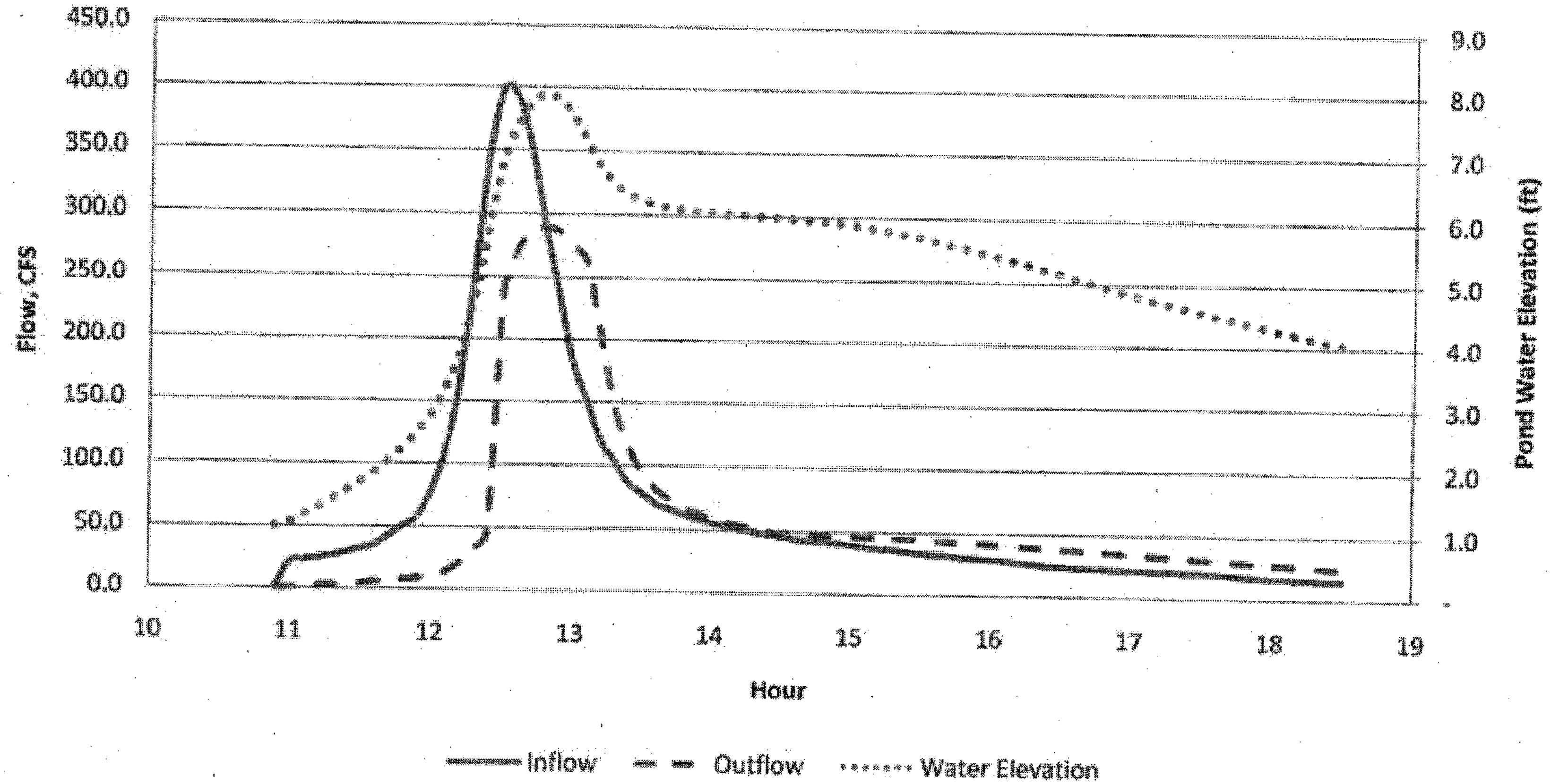


Figure 8
Pond 3A Inflow & Outflow Hydrograph



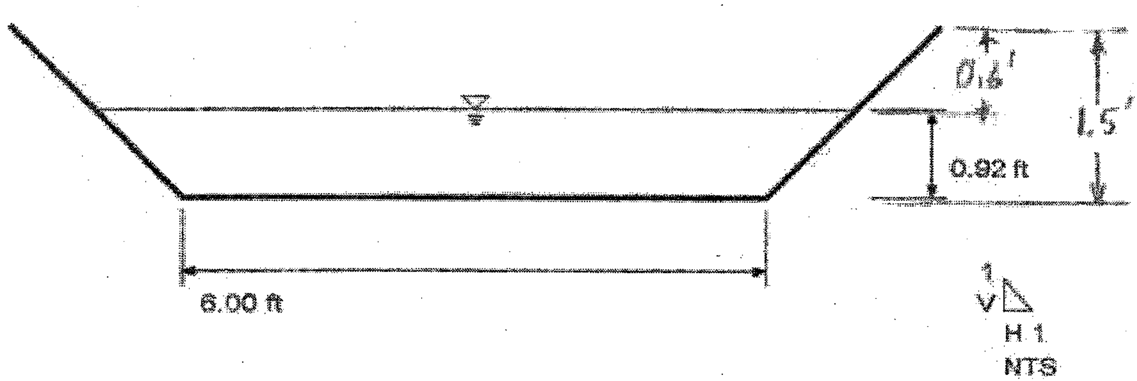
ATTACHMENT 1

CHANNEL DESIGN COMPUTATION SHEETS

Station 8+00 to 15+00
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\docume~1\owner\my documents\technical references\haestad\fmw\guam 200.fm2
Worksheet	Perimeter Channel
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

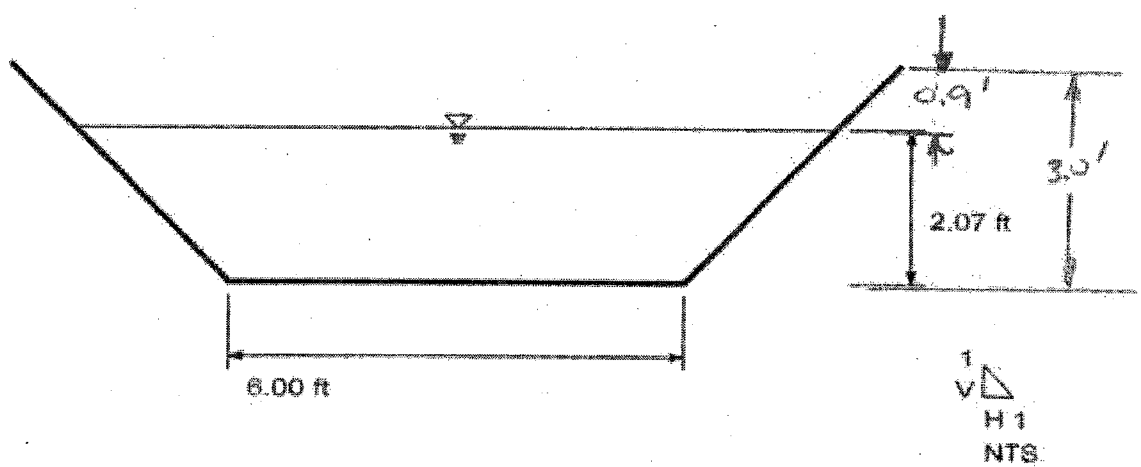
Section Data		
Mannings Coefficient	0.013	
Channel Slope	0.022200	ft/ft
Depth	0.92	ft
Left Side Slope	1.000000	H : V
Right Side Slope	1.000000	H : V
Bottom Width	6.00	ft
Discharge	89.00	cfs



Station 25+00 to 33+00
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\docume~1\owner\my documents\technical references\haestad\fmw\guam 200.fm2
Worksheet	Perimeter Channel
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

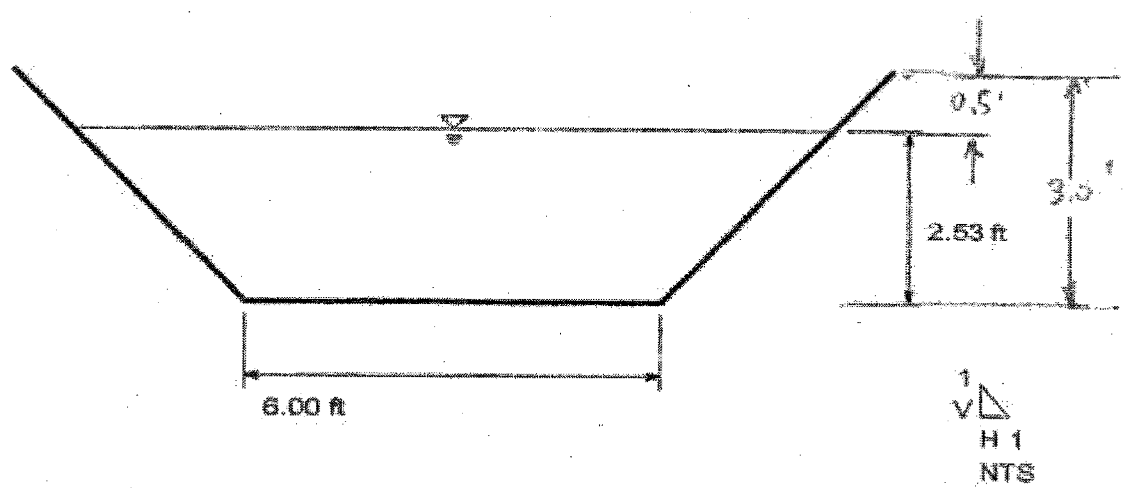
Section Data		
Mannings Coefficient	0.013	
Channel Slope	0.004700	ft/ft
Depth	2.07	ft
Left Side Slope	1.000000	H : V
Right Side Slope	1.000000	H : V
Bottom Width	6.00	ft
Discharge	164.00	cfs



Station 38+00 to 47+00
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\docume~1\owner\my documents\technical references\haestad\fmw\guam 200.fm2
Worksheet	Perimeter Channel
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

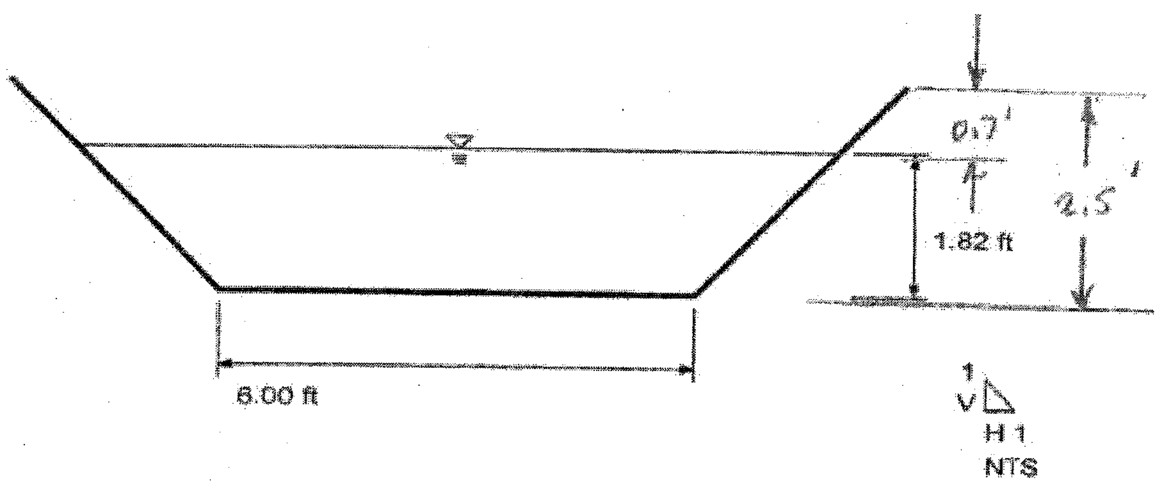
Section Data		
Mannings Coefficient	0.013	
Channel Slope	0.006300	ft/ft
Depth	2.53	ft
Left Side Slope	1.000000	H : V
Right Side Slope	1.000000	H : V
Bottom Width	6.00	ft
Discharge	273.00	cfs



Station 50+00 to 66+00
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\docume~1\owner\my documents\technical references\haestad\fmw\guam 200.fm2
Worksheet	Perimeter Channel
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.013	
Channel Slope	0.012000	ft/ft
Depth	1.82	ft
Left Side Slope	1.000000	H : V
Right Side Slope	1.000000	H : V
Bottom Width	6.00	ft
Discharge	210.00	cfs



Station 73+50 to 88+50
Cross Section for Trapezoidal Channel

Project Description	
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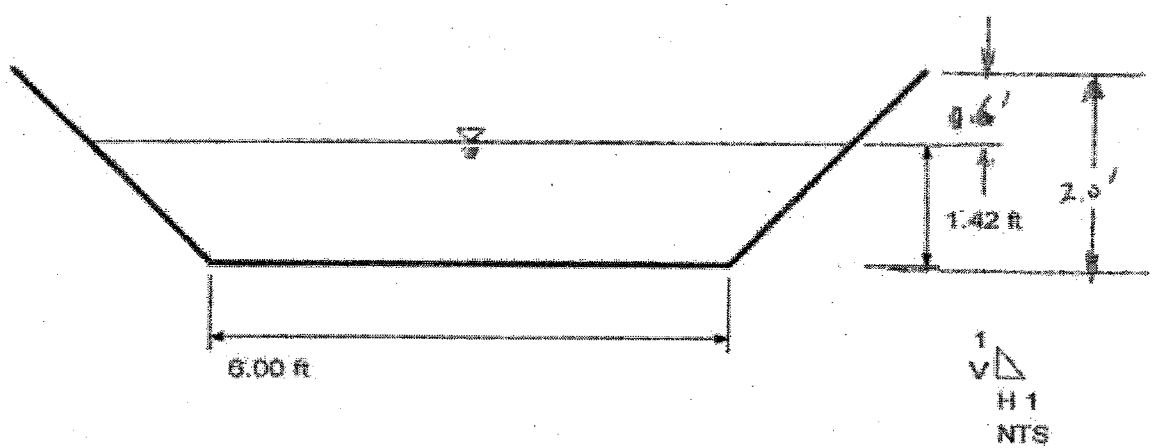
Worksheet	Perimeter Channel
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.013	
Channel Slope	0.023000	ft/ft
Depth	1.42	ft
Left Side Slope	1.000000	H : V
Right Side Slope	1.000000	H : V
Bottom Width	6.00	ft
Discharge	188.00	cfs



ATTACHMENT 2

POND DISCHARGE AND HYDROGRAPHS COMPUTATION SPREADSHEETS

COMPUTATIONS OF POND DISCHARGE CHARACTERISTIC - PONDS 1 & 3A

Depth of Sediment in Pond Bottom: 1 feet

Number of Pipes: 2
Maximum Flow, Each Pipe: 170 s
Spillway Length: 5 ft
Riser Perimeter: 16 ft

Water Elevation of Pond Bottom (ft)	Orifice (6" PVC Pipe) $Q_o = 0.932 H^{0.5}$ ft³/sec — Orifice Row 1: Head	Orifice Row 1: Q, Each	Orifice Row 1: Total of 10	Orifice Row 2: Head	Orifice Row 2: Q, Each	Orifice Row 2: Total of 10	Orifice Row 3: Head	Orifice Row 3: Q, Each	Orifice Row 3: Total of 10	Riser Weir $Q_w = 3.35 L H_w^{1.5}$: Riser Weir	Total Entering Riser	Total Entering Each Pipe	Spillway $Q_s = 3.22 L H_s^{1.5}$	Total Discharge CFS	Headwater Depth in Riser (ft): Selected Value	Trial Flow	Unsubmerged $HW_u = 6.30 \times 10^{-4} Q^2$	Transition HW_t (Q-86)	Submerged $HW_s = 0.00252 Q^2 + 2.08$
0											0.0			0.0		0.0			
0.1											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
0.2											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
0.3											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
0.4											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
0.5											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
0.6											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
0.7											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
0.8											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
0.9											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
1.0											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
1.1											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
1.2											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
1.3											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
1.4											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
1.5											0.0	0.0	0.0	0.0	0.00	0.0	0.000		
1.6	0.1	0.298	2.98								3.0	1.5	0.0	3.0	0.00	1.5	0.001		
1.7	0.2	0.417	4.17								4.2	2.1	0.0	4.2	0.00	2.1	0.003		
1.8	0.3	0.510	5.10								5.1	2.6	0.0	5.1	0.00	2.6	0.004		
1.9	0.4	0.589	5.89								5.9	2.9	0.0	5.9	0.01	2.9	0.005		
2.0	0.5	0.659	6.59								6.6	3.3	0.0	6.6	0.01	3.3	0.007		
2.1	0.6	0.722	7.22								7.2	3.6	0.0	7.2	0.01	3.6	0.008		
2.2	0.7	0.780	7.80								7.8	3.9	0.0	7.8	0.01	3.9	0.009		
2.3	0.8	0.834	8.34								8.3	4.2	0.0	8.3	0.01	4.2	0.011		
2.4	0.9	0.884	8.84								8.8	4.4	0.0	8.8	0.01	4.4	0.012		
2.5	1.0	0.932	9.32								9.3	4.7	0.0	9.3	0.01	4.7	0.013		
2.6	1.1	0.977	9.77								9.8	4.9	0.0	9.8	0.01	4.9	0.015		
2.7	1.2	1.021	10.21								10.2	5.1	0.0	10.2	0.02	5.1	0.016		
2.8	1.3	1.063	10.63								10.6	5.3	0.0	10.6	0.02	5.3	0.018		
2.9	1.4	1.103	11.03								11.0	5.5	0.0	11.0	0.02	5.5	0.019		
3.0	1.5	1.141	11.41								11.4	5.7	0.0	11.4	0.02	5.7	0.020		
3.1	1.6	1.179	11.79	0.1	0.298	2.98					14.7	7.4	0.0	14.7	0.03	7.4	0.034		
3.2	1.7	1.215	12.15	0.2	0.417	4.17					16.3	8.2	0.0	16.3	0.04	8.2	0.041		
3.3	1.8	1.250	12.50	0.3	0.510	5.10					17.6	8.8	0.0	17.6	0.05	8.8	0.049		
3.4	1.9	1.285	12.85	0.4	0.589	5.89					18.7	9.4	0.0	18.7	0.05	9.4	0.054		
3.5	2.0	1.318	13.18	0.5	0.659	6.59					19.8	9.9	0.0	19.8	0.06	9.9	0.061		
3.6	2.1	1.351	13.51	0.6	0.722	7.22					20.7	10.4	0.0	20.7	0.07	10.4	0.067		
3.7	2.2	1.382	13.82	0.7	0.780	7.80					21.6	10.8	0.0	21.6	0.07	10.8	0.072		
3.8	2.3	1.413	14.13	0.8	0.834	8.34					22.5	11.2	0.0	22.5	0.08	11.2	0.079		
3.9	2.4	1.444	14.44	0.9	0.884	8.84					23.3	11.6	0.0	23.3	0.08	11.6	0.084		
4.0	2.5	1.474	14.74	1.0	0.932	9.32					24.1	12.0	0.0	24.1	0.09	12.0	0.090		
4.1	2.6	1.503	15.03	1.1	0.977	9.77					24.8	12.4	0.0	24.8	0.10	12.4	0.095		
4.2	2.7	1.531	15.31	1.2	1.021	10.21					25.5	12.8	0.0	25.5	0.10	12.8	0.101		
4.3	2.8	1.560	15.60	1.3	1.063	10.63					26.2	13.1	0.0	26.2	0.11	13.1	0.107		
4.4	2.9	1.587	15.87	1.4	1.103	11.03					26.9	13.4	0.0	26.9	0.11	13.4	0.113		
4.5	3.0	1.614	16.14	1.5	1.141	11.41					27.6	13.8	0.0	27.6	0.12	13.8	0.118		
4.6	3.1	1.641	16.41	1.6	1.179	11.79	0.1	0.298	2.98		31.1	15.6	0.0	31.1	0.15	15.6	0.150		
4.7	3.2	1.667	16.67	1.7	1.215	12.15	0.2	0.417	4.17		33.0	16.5	0.0	33.0	0.17	16.5	0.169		
4.8	3.3	1.693	16.93	1.8	1.250	12.50	0.3	0.510	5.10		34.5	17.3	0.0	34.5	0.18	17.3	0.184		
4.9	3.4	1.719	17.19	1.9	1.285	12.85	0.4	0.589	5.89		35.9	18.0	0.0	35.9	0.20	18.0	0.200		
5.0	3.5	1.744	17.44	2.0	1.318	13.18	0.5	0.659	6.59		37.2	18.6	0.0	37.2	0.21	18.6	0.215		
5.1	3.6	1.768	17.68	2.1	1.351	13.51	0.6	0.722	7.22		38.4	19.2	0.0	38.4	0.23	19.2	0.229		
5.2	3.7	1.793	17.93	2.2	1.382	13.82	0.7	0.780	7.80		39.5	19.8	0.0	39.5	0.24	19.8	0.242		
5.3	3.8	1.817	18.17	2.3	1.413	14.13	0.8	0.834	8.34		40.6	20.3	0.0	40.6	0.26	20.3	0.256		
5.4	3.9	1.841	18.41	2.4	1.444	14.44	0.9	0.884	8.84		41.7	20.8	0.0	41.7	0.27	20.8	0.269		

COMPUTATIONS OF POND DISCHARGE CHARACTERISTIC - PONDS 1 & 3A

Depth of Sediment in Pond Bottom ___1 feet

Number of Pipes 2
Maximum Flow, Each Pipe 170.4
Spillway Length [illegible] ft
Riser Perimeter [illegible] ft

Water Elevation of Pond Bottom (ft)	Orifice (8" PVC Pipes) $Q_o = 0.592 H^{0.5}$ ft³/sec — Orifice Row 1: Head	Orifice Row 1: Q. Each	Orifice Row 1: Total of 10	Orifice Row 2: Head	Orifice Row 2: Q. Each	Orifice Row 2: Total of 10	Orifice Row 3: Head	Orifice Row 3: Q. Each	Orifice Row 3: Total of 10	Riser Weir $Q_w = 3.33 L H_w^{1.5}$: Riser Weir	Total Entering Riser	Total Entering Each Pipe	Spillway $Q_s = 2.333 H_s^{1.5}$	Total Discharge CFS	Selected Value	Total Pipe	HW[illegible]
5.5	4.0	1.864	18.64	2.5	1.474	14.74	1.0	0.932	9.32		42.7	21.3	0.0	42.7	0.28	21.3	
5.6	4.1	1.887	18.87	2.6	1.503	15.03	1.1	0.977	9.77		43.7	21.8	0.0	43.7	0.30	21.8	
5.7	4.2	1.910	19.10	2.7	1.531	15.31	1.2	1.021	10.21		44.6	22.3	0.0	44.6	0.31	22.3	
5.8	4.3	1.933	19.33	2.8	1.560	15.60	1.3	1.063	10.63		45.5	22.8	0.0	45.5	0.32	22.8	
5.9	4.4	1.955	19.55	2.9	1.587	15.87	1.4	1.103	11.03		46.4	23.2	0.0	46.4	0.34	23.2	
6.0	4.5	1.977	19.77	3.0	1.614	16.14	1.5	1.141	11.41		47.3	23.7	0.0	47.3	0.35	23.7	
6.1	4.6	1.999	19.99	3.1	1.641	16.41	1.6	1.179	11.79	7.2	55.4	27.7	0.0	55.4	0.48	27.7	
6.2	4.7	2.021	20.21	3.2	1.667	16.67	1.7	1.215	12.15	20.4	69.4	34.7	0.0	69.4	0.75	34.7	
6.3	4.8	2.042	20.42	3.3	1.693	16.93	1.8	1.250	12.50	37.4	87.3	43.6	0.0	87.3	1.18	43.6	
6.4	5.2	2.128	21.28	3.4	1.719	17.19	1.9	1.285	12.85	57.6	109.0	54.5	0.0	109.0	1.84	54.5	
6.5	4.7	2.082	20.82	3.5	1.744	17.44	2.0	1.318	13.18	80.5	131.3	65.6	0.0	131.3	2.57	65.6	
6.6	3.9	1.847	18.47	3.6	1.766	17.66	2.1	1.351	13.51	105.9	155.6	77.8	0.0	155.6	3.75	77.8	
6.7	3.0	1.601	16.01	3.0	1.601	16.01	2.7	1.382	13.82	133.4	178.3	89.1	0.0	178.3	4.85	89.1	
6.8	1.9	1.300	13.00	1.9	1.300	13.00	1.9	1.300	13.00	163.0	202.0	101.0	0.0	202.0	5.25	101.0	
6.9	1.6	1.196	11.96	1.6	1.196	11.96	1.6	1.196	11.96	194.6	230.4	115.2	0.0	230.4	6.03	115.2	
7.0	1.0	0.930	9.30	1.0	0.930	9.30	1.0	0.930	9.30	227.6	255.4	127.7	0.0	255.4	6.79	127.7	
7.1	0.3	0.517	5.17	0.3	0.517	5.17	0.3	0.517	5.17	262.6	264.8	132.4	0.0	264.8	7.55	132.4	
7.2	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	298.5	267.9	133.9	0.0	267.9	8.33	133.9	
7.3	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	337.7	270.6	135.3	0.0	270.6	9.47	135.3	
7.4	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	377.4	273.7	136.9	0.0	273.7	10.00	170.4	
7.5	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	410.5	276.6	138.3	0.0	276.6	10.00	170.4	
7.6	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	461.0	279.5	139.7	0.0	279.5	10.00	170.4	
7.7	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	504.9	282.3	141.2	0.0	282.3	10.00	170.4	
7.8	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	550.1	285.1	142.5	0.0	285.1	10.00	170.4	
7.9	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	596.6	287.5	143.8	0.0	287.5	10.00	170.4	
8.0	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	644.3	290.6	145.3	0.0	290.6	10.00	170.4	
8.1	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	693.2	293.3	146.7	0.8	294.2	10.00	170.4	
8.2	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	743.3	296.0	148.0	2.3	298.3	10.00	170.4	
8.3	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	794.6	298.7	149.4	4.2	302.9	10.00	170.4	
8.4	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	847.6	301.3	150.7	6.5	307.9	10.00	170.4	
8.5	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	900.5	304.0	152.0	9.1	313.1	10.00	170.4	
8.6	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	955.0	306.6	153.3	12.0	318.6	10.00	170.4	
8.7	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1010.6	309.1	154.6	15.1	324.2	10.00	170.4	
8.8	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1067.3	311.7	155.9	18.4	330.1	10.00	170.4	
8.9	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1125.0	314.3	157.1	22.0	336.2	10.00	170.4	
9.0	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1183.7	316.8	158.4	25.8	342.6	10.00	170.4	
9.1	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1243.4	319.3	159.6	29.7	349.0	10.00	170.4	
9.2	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1304.0	321.7	160.9	33.9	355.6	10.00	170.4	
9.3	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1365.5	324.2	162.1	38.2	362.4	10.00	170.4	
9.4	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1428.1	326.6	163.3	42.7	369.3	10.00	170.4	
9.5	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1491.6	329.1	164.5	47.3	376.4	10.00	170.4	
9.6	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1556.0	331.5	165.7	52.1	383.6	10.00	170.4	
9.7	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1621.3	333.8	166.9	57.1	390.9	10.00	170.4	
9.8	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1687.4	336.2	168.1	62.2	398.4	10.00	170.4	
9.9	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1754.5	338.6	169.3	67.5	406.0	10.00	170.4	
10.0	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1822.4	340.9	170.4	72.9	413.8	10.00	170.4	

COMPUTATIONS OF POND DISCHARGE CHARACTERISTIC - POND 2

Depth of Sediment in Pond Bottom ____1 foot

Number of Pipes 3 (Pond 2)
Maximum Flow, Each Pipe 170 ± cfs @ 10 ft. Hw
Spillway Length 0 ft
Riser Perimeter 58 ft

Water Elevation of Pond Bottom (ft)	Orifice (8" PVC Pipes) $Q_o = 0.933 H^{0.5}$ (cfs) Orifice Row 1 Head	Orifice Row 1 Q, Each	Orifice Row 1 Total of 10	Orifice Row 2 Head	Orifice Row 2 Q, Each	Orifice Row 2 Total of 10	Orifice Row 3 Head	Orifice Row 3 Q, Each	Orifice Row 3 Total of 10	Riser Weir $Q_w = 3.33 L H_w^{1.5}$ Riser Weir	Total Entering Riser	Total Entering Each Pipe	Spillway $Q_s = 3.21 L H_s^{1.5}$	Total Discharge CFS	Headwater Depth in Riser (ft) Selected Value	Trial Flow	Unsubmerged HW_r = [illegible]	Transition HW_r = [illegible]	Submerged HW_r = [illegible] + 2.88
0											0.0	0.0		0.0		0.0			
0.1											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
0.2											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
0.3											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
0.4											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
0.5											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
0.6											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
0.7											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
0.8											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
0.9											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
1.0											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
1.1											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
1.2											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
1.3											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
1.4											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
1.5											0.0	0.0	0.0	0.0	0.00	0.0	0.00		
1.6	0.1	0.295	2.95								3.0	1.0	0.0	3.0	0.00	1.0	0.00		
1.7	0.2	0.417	4.17								4.2	1.4	0.0	4.2	0.00	1.4	0.00		
1.8	0.3	0.510	5.10								5.1	1.7	0.0	5.1	0.00	1.7	0.00		
1.9	0.4	0.589	5.89								5.9	2.0	0.0	5.9	0.00	2.0	0.00		
2.0	0.5	0.659	6.59								6.6	2.2	0.0	6.6	0.00	2.2	0.00		
2.1	0.6	0.722	7.22								7.2	2.4	0.0	7.2	0.00	2.4	0.00		
2.2	0.7	0.780	7.80								7.8	2.6	0.0	7.8	0.00	2.6	0.00		
2.3	0.8	0.834	8.34								8.3	2.8	0.0	8.3	0.00	2.8	0.00		
2.4	0.9	0.884	8.84								8.8	2.9	0.0	8.8	0.01	2.9	0.01		
2.5	1.0	0.932	9.32								9.3	3.1	0.0	9.3	0.01	3.1	0.01		
2.6	1.1	0.977	9.77								9.8	3.3	0.0	9.8	0.01	3.3	0.01		
2.7	1.2	1.021	10.21								10.2	3.4	0.0	10.2	0.01	3.4	0.01		
2.8	1.3	1.063	10.63								10.6	3.5	0.0	10.6	0.01	3.5	0.01		
2.9	1.4	1.103	11.03								11.0	3.7	0.0	11.0	0.01	3.7	0.01		
3.0	1.5	1.141	11.41								11.4	3.8	0.0	11.4	0.01	3.8	0.01		
3.1	1.6	1.179	11.79	0.1	0.295	2.95					14.7	4.9	0.0	14.7	0.01	4.9	0.01		
3.2	1.7	1.215	12.15	0.2	0.417	4.17					16.3	5.4	0.0	16.3	0.02	5.4	0.02		
3.3	1.8	1.250	12.50	0.3	0.510	5.10					17.6	5.9	0.0	17.6	0.02	5.9	0.02		
3.4	1.9	1.285	12.85	0.4	0.589	5.89					18.7	6.2	0.0	18.7	0.02	6.2	0.02		
3.5	2.0	1.318	13.18	0.5	0.659	6.59					19.8	6.6	0.0	19.8	0.03	6.6	0.03		
3.6	2.1	1.351	13.51	0.6	0.722	7.22					20.7	6.9	0.0	20.7	0.03	6.9	0.03		
3.7	2.2	1.382	13.82	0.7	0.780	7.80					21.6	7.2	0.0	21.6	0.03	7.2	0.03		
3.8	2.3	1.413	14.13	0.8	0.834	8.34					22.5	7.5	0.0	22.5	0.03	7.5	0.03		
3.9	2.4	1.444	14.44	0.9	0.884	8.84					23.3	7.8	0.0	23.3	0.04	7.8	0.04		
4.0	2.5	1.474	14.74	1.0	0.932	9.32					24.1	8.0	0.0	24.1	0.04	8.0	0.04		
4.1	2.6	1.503	15.03	1.1	0.977	9.77					24.8	8.3	0.0	24.8	0.04	8.3	0.04		
4.2	2.7	1.531	15.31	1.2	1.021	10.21					25.5	8.5	0.0	25.5	0.04	8.5	0.04		
4.3	2.8	1.559	15.59	1.3	1.063	10.63					26.2	8.7	0.0	26.2	0.05	8.7	0.05		
4.4	2.9	1.587	15.87	1.4	1.103	11.03					26.9	9.0	0.0	26.9	0.05	9.0	0.05		
4.5	3.0	1.614	16.14	1.5	1.141	11.41					27.6	9.2	0.0	27.6	0.06	9.2	0.06		
4.6	3.1	1.641	16.41	1.6	1.179	11.79	0.1	0.295	2.95		31.1	10.4	0.0	31.1	0.07	10.4	0.07		
4.7	3.2	1.667	16.67	1.7	1.215	12.15	0.2	0.417	4.17		33.0	11.0	0.0	33.0	0.07	11.0	0.07		
4.8	3.3	1.693	16.93	1.8	1.250	12.50	0.3	0.510	5.10		34.5	11.5	0.0	34.5	0.09	11.5	0.09		
4.9	3.4	1.718	17.18	1.9	1.285	12.85	0.4	0.589	5.89		35.9	12.0	0.0	35.9	0.09	12.0	0.09		
5.0	3.5	1.744	17.44	2.0	1.318	13.18	0.5	0.659	6.59		37.2	12.4	0.0	37.2	0.10	12.4	0.10		
5.1	3.6	1.768	17.68	2.1	1.351	13.51	0.6	0.722	7.22		38.4	12.8	0.0	38.4	0.10	12.8	0.10		
5.2	3.7	1.793	17.93	2.2	1.382	13.82	0.7	0.780	7.80		39.6	13.2	0.0	39.6	0.11	13.2	0.11		
5.3	3.8	1.817	18.17	2.3	1.413	14.13	0.8	0.834	8.34		40.6	13.5	0.0	40.6	0.11	13.5	0.11		
5.4	3.9	1.841	18.41	2.4	1.444	14.44	0.9	0.884	8.84		41.7	13.9	0.0	41.7	0.12	13.9	0.12		
5.5	4.0	1.864	18.64	2.5	1.474	14.74	1.0	0.932	9.32		42.7	14.2	0.0	42.7	0.13	14.2	0.13		

COMPUTATIONS OF POND DISCHARGE CHARACTERISTIC - POND 2

Depth of Sediment in Pond Bottom ______1 foot

Number of Pipes 3 (Pond 2)
Maximum Flow, Each Pipe 170.4 cfs @ 10 ft. Hw
Riser Perimeter 66 ft
Spillway Length 8 ft

Water Elevation of Pond Bottom (ft)	Orifice (8" PVC Pipes) $Q_o = 0.592 H^{0.5}$ ft³/sec — Orifice Row 1: Head	Q, Each	Total of 10	Orifice Row 2: Head	Q, Each	Total of 10	Orifice Row 3: Head	Q, Each	Total of 10	Riser Weir $Q_w = 3.35 L H_w^{1.5}$ — Riser Weir	Total Entering Riser	Total Entering Each Pipe	Spillway $Q_s = 3.33 L H_w^{1.5}$	Total Discharge CFS	Headwater Depth in Riser (ft): Selected Value	Trial Flow	Unsubmerged $HW_i = 6.20x10^{-4} Q^{2}$	Transition $HW_t = 4.8 + 0.023 (Q-88)$	Submerged $HW_s = 0.0002520 Q^2 + 2.86$
5.6	4.1	1.887	18.87	2.6	1.502	15.02	1.1	0.977	9.77		43.7	14.6	0.0	43.7	0.13	14.6	0.13		
5.7	4.2	1.910	19.10	2.7	1.531	15.31	1.2	1.021	10.21		44.8	14.9	0.0	44.8	0.14	14.9	0.14		
5.8	4.3	1.933	19.33	2.8	1.560	15.60	1.3	1.063	10.63		45.6	15.2	0.0	45.6	0.14	15.2	0.14		
5.9	4.4	1.955	19.55	2.9	1.587	15.87	1.4	1.103	11.03		46.4	15.5	0.0	46.4	0.15	15.5	0.15		
6.0	4.5	1.977	19.77	3.0	1.614	16.14	1.5	1.141	11.41		47.3	15.8	0.0	47.3	0.15	15.8	0.15		
6.1	4.6	1.999	19.99	3.1	1.641	16.41	1.6	1.178	11.78	7	55.4	18.5	0.0	55.4	0.21	18.5	0.21		
6.2	4.7	2.021	20.21	3.2	1.667	16.67	1.7	1.215	12.15	20	69.4	23.1	0.0	69.4	0.33	23.1	0.33		
6.3	4.8	2.042	20.42	3.3	1.693	16.93	1.8	1.250	12.50	37	87.2	29.1	0.0	87.2	0.52	29.1	0.52		
6.4	4.9	2.063	20.63	3.4	1.719	17.19	1.9	1.285	12.85	58	108.3	36.1	0.0	108.3	0.81	36.1	0.81		
6.5	5.0	2.084	20.84	3.5	1.744	17.44	2.0	1.318	13.18	81	132.0	44.0	0.0	132.0	1.20	44.0	1.20		
6.6	5.1	2.105	21.05	3.6	1.768	17.68	2.1	1.351	13.51	106	158.7	52.9	0.0	158.7	1.74	52.9	1.74		
6.7	5.0	2.077	20.77	3.7	1.793	17.93	2.2	1.382	13.82	133	188.8	62.0	0.0	188.8	2.38	62.0	2.38		
6.8	4.4	1.952	19.52	3.8	1.817	18.17	2.3	1.413	14.13	163	214.8	71.6	0.0	214.8	3.10	71.8	3.18	4.26	
6.9	3.7	1.797	17.97	3.7	1.797	17.97	2.4	1.444	14.44	194	244.9	81.6	0.0	244.9	4.13	81.6	4.13	4.56	
7.0	2.8	1.579	15.79	2.8	1.579	15.79	2.5	1.474	14.74	226	274.1	91.4	0.0	274.1	4.81	91.4	5.18	4.91	
7.1	2.2	1.379	13.79	2.2	1.379	13.79	2.2	1.379	13.79	260	304.2	101.4	0.0	304.2	6.27	101.4	6.37	6.24	6.27
7.2	1.9	1.294	12.94	1.9	1.294	12.94	1.9	1.294	12.94	295	338.3	112.8	0.0	338.3	5.88	112.8	7.08	5.62	5.60
7.3	1.4	1.108	11.08	1.4	1.108	11.08	1.4	1.108	11.08	330	370.9	123.6	0.0	370.9	6.53	123.6	9.45	5.98	6.53
7.4	0.8	0.867	8.67	0.8	0.867	8.67	0.8	0.867	8.67	377	403.4	134.5	0.0	403.4	7.06	134.5	11.21	6.33	7.26
7.5	0.3	0.477	4.77	0.3	0.477	4.77	0.3	0.477	4.77	418	414.9	138.3	0.0	414.9	7.93	144.3	12.90	6.66	7.83
7.6	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	461	419.2	139.7	0.0	419.2	8.85	153.7	14.64	6.97	8.53
7.7	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	505	423.5	141.2	0.0	423.5	9.82	166.3	17.36	7.43	8.92
7.8	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	550	427.7	142.6	0.0	427.7	10.00	170.4	18.00	7.42	10.00
7.9	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	597	431.8	143.9	0.0	431.8	10.00	170.4	18.00	7.52	10.00
8.0	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	644	435.9	145.3	0.0	436.9	10.00	170.4	18.00	7.52	10.00
8.1	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	693	440.0	146.7	0.3	440.3	10.00	170.4	18.00	7.43	10.00
8.2	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	743	444.0	148.0	2.4	446.4	10.00	170.4	18.00	7.52	10.00
8.3	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	795	448.1	149.4	4.2	452.3	10.00	170.4	18.00	7.82	10.00
8.4	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	847	452.0	150.7	6.9	458.9	10.00	170.4	18.00	7.82	10.00
8.5	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	900	456.0	152.0	9.1	465.1	10.00	170.4	18.00		10.00
8.6	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	955	459.9	153.3	11.9	471.8	10.00	170.4	18.00		10.00
8.7	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1011	463.7	154.6	15.1	478.8	10.00	170.4	18.00		10.00
8.8	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1067	467.5	155.9	18.4	486.0	10.00	170.4	18.00		10.00
8.9	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1125	471.4	157.1	22.0	493.4	10.00	170.4	18.00		10.00
9.0	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1184	475.1	158.4	25.8	500.9	10.00	170.4	18.00		10.00
9.1	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1243	478.9	159.6	29.7	508.6	10.00	170.4	18.00		10.00
9.2	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1304	482.6	160.9	33.9	516.5	10.00	170.4	18.00		10.00
9.3	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1365	486.3	162.1	38.2	524.5	10.00	170.4	18.00		10.00
9.4	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1428	489.9	163.3	42.7	532.6	10.00	170.4	18.00		10.00
9.5	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1492	493.6	164.5	47.3	540.9	10.00	170.4	18.00		10.00
9.6	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1556	497.2	165.7	52.1	549.3	10.00	170.4	18.00		10.00
9.7	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1621	500.8	166.9	57.1	557.9	10.00	170.4	18.00		10.00
9.8	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1687	504.3	168.1	62.2	566.5	10.00	170.4	18.00		10.00
9.9	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1754	507.8	169.3	67.5	575.3	10.00	170.4	18.00		10.00
10.0	0.0	0.000	0.00	0.0	0.000	0.00	0.0	0.000	0.00	1822	511.3	170.4	72.9	584.2	10.00	170.4	18.00		10.00

POND 1
OUTFLOW HYDROGRAPH COMPUTATIONS

Time (hrs)	Pond 3A+3B Total Inflow (cfs)	Pond 3A I Flow (cfs)	I1+I2 cfs	2S/T+O cfs	Discharge O cfs	2S/T-O cfs	Storage S cf	Storage S acre-ft	Depth ft	Discharge cfs	Cumulative Discharge acre-feet
10.9	0	0.0	0	124.7	-	124.7	22,445	0.515	0.65	0	
11.0	14	14.0	14	139	0.4	137.9	24,893	0.571	0.72	0.4	0.0
11.1	15	15.0	29	167	1.2	164.5	29,823	0.685	0.86	1.2	0.0
11.2	17	17.0	32	196	2.1	192.4	34,994	0.803	1.00	2.1	0.0
11.3	18	18.0	35	227	2.9	221.5	40,394	0.927	1.15	2.9	0.1
11.4	20	20.0	38	259	3.9	251.7	46,008	1.056	1.30	3.9	0.1
11.5	21	21.0	41	293	4.8	283.1	51,824	1.190	1.46	4.8	0.1
11.6	23	23.0	44	327	5.8	315.5	57,831	1.328	1.62	5.8	0.2
11.7	27	27.0	50	365	6.8	351.9	64,561	1.482	1.80	6.8	0.2
11.8	32	32.0	59	411	7.7	395.4	72,568	1.666	2.00	7.7	0.3
11.9	36	36.0	68	463	8.8	445.9	81,845	1.879	2.24	8.8	0.4
12.0	46	46.0	82	528	10.0	507.9	93,225	2.140	2.52	10.0	0.4
12.1	64	64.0	110	618	12.4	593.2	108,994	2.502	2.90	12.4	0.6
12.2	96	96.0	160	753	18.8	715.6	132,190	3.035	3.44	18.8	0.7
12.3	144	144.0	240	956	28.3	899.1	166,833	3.832	4.19	28.3	0.9
12.4	210	210.0	354	1,253	40.8	1171.5	218,214	5.010	5.23	40.8	1.3
12.5	263	263.0	473	1,645	128.3	1387.8	272,913	6.265	6.24	128.3	2.3
12.6	273	273.0	536	1,924	241.8	1440.3	302,775	6.951	6.76	241.8	4.3
12.7	257	257.0	530	1,970	256.7	1457.0	308,461	7.081	6.85	256.7	6.5
12.8	219	219.0	476	1,933	245.5	1442.0	303,756	6.973	6.77	245.5	8.5
12.9	180	180.0	399	1,841	208.1	1424.8	293,924	6.748	6.60	208.1	10.2
13.0	142	142.0	322	1,747	169.9	1407.1	283,844	6.516	6.43	169.9	11.6
13.1	117	117.0	259	1,666	137.1	1391.9	275,215	6.318	6.28	137.1	12.7
13.2	92	92.0	209	1,601	110.6	1379.6	268,248	6.158	6.16	110.6	13.7
13.3	79	79.0	171	1,551	90.2	1370.2	262,877	6.035	6.06	90.2	14.4
13.4	66	66.0	145	1,515	75.8	1363.5	259,098	5.948	5.99	75.8	15.0
13.5	59	59.0	125	1,489	65.0	1358.9	256,237	5.882	5.94	65.0	15.6
13.6	52	52.0	111	1,470	57.3	1355.0	254,205	5.836	5.90	57.3	16.0
13.7	48	48.0	100	1,455	51.4	1352.2	252,647	5.800	5.88	51.4	16.5
13.8	44	44.0	92	1,444	47.3	1349.6	251,447	5.772	5.85	47.3	16.9
13.9	42	42.0	86	1,436	47.0	1341.6	249,951	5.738	5.83	47.0	17.2
14.0	40	40.0	82	1,424	46.6	1330.4	247,862	5.690	5.79	46.6	17.6
14.1	38	38.0	78	1,408	46.1	1316.3	245,220	5.629	5.74	46.1	18.0
14.2	37	37.0	75	1,391	45.5	1300.3	242,237	5.561	5.68	45.5	18.4
14.3	35	35.0	72	1,372	44.8	1282.6	238,935	5.485	5.62	44.8	18.8
14.4	34	34.0	69	1,352	44.1	1263.3	235,337	5.403	5.55	44.1	19.1
14.5	32	32.0	66	1,329	43.4	1242.5	231,463	5.314	5.48	43.4	19.5
14.6	31	31.0	63	1,306	42.6	1220.4	227,332	5.219	5.40	42.6	19.8
14.7	31	31.0	62	1,282	41.8	1198.8	223,309	5.126	5.33	41.8	20.2
14.8	30	30.0	61	1,260	41.0	1177.8	219,386	5.036	5.25	41.0	20.5
14.9	29	29.0	59	1,237	40.2	1156.3	215,383	4.945	5.18	40.2	20.8
15.0	28	28.0	57	1,213	39.4	1134.5	211,306	4.851	5.10	39.4	21.2
15.1	27	27.0	55	1,189	38.6	1112.3	207,159	4.756	5.01	38.6	21.5
15.2	26	26.0	53	1,165	37.8	1089.7	202,947	4.659	4.93	37.8	21.8
15.3	26	26.0	52	1,142	36.9	1067.9	198,863	4.565	4.85	36.9	22.1
15.4	25	25.0	51	1,119	35.8	1047.2	194,949	4.475	4.77	35.8	22.4
15.5	24	24.0	49	1,096	34.8	1026.6	191,054	4.386	4.69	34.8	22.7
15.6	23	23.0	47	1,074	33.7	1006.1	187,178	4.297	4.62	33.7	23.0
15.7	23	23.0	46	1,052	32.7	986.6	183,490	4.212	4.54	32.7	23.2
15.8	22	22.0	45	1,032	31.8	968.0	179,972	4.132	4.47	31.8	23.5
15.9	22	22.0	44	1,012	30.9	950.3	176,609	4.054	4.40	30.9	23.8
16.0	21	21.0	43	993	30.0	933.2	173,387	3.980	4.33	30.0	24.0
16.1	20	20.0	41	974	29.1	916.0	170,120	3.905	4.26	29.1	24.3
16.2	19	19.0	39	955	28.2	898.5	166,813	3.829	4.19	28.2	24.5
16.3	19	19.0	38	936	27.4	881.7	163,641	3.757	4.13	27.4	24.7
16.4	18	18.0	37	919	26.6	865.6	160,592	3.687	4.06	26.6	24.9
16.5	17	17.0	35	901	25.7	849.2	157,482	3.615	3.99	25.7	25.1
16.6	17	17.0	34	883	24.9	833.4	154,499	3.547	3.93	24.9	25.3

POND 1
OUTFLOW HYDROGRAPH COMPUTATIONS

Time	Pond 3A+3B Total Inflow	Pond 3A I Flow	I1+I2	2S/T+O	Discharge O	2S/T-O	Storage S		Depth	Discharge	Cumulative Discharge
(hrs)	(cfs)	(cfs)	cfs	cfs	cfs	cfs	cf	acre-ft	ft.	cfs	acre-feet
16.7	16	16.0	33	866	24.1	818.1	151,602	3.480	3.87	24.1	25.5
16.8	16	16.0	32	850	23.4	803.4	148,815	3.416	3.81	23.4	25.7
16.9	15	15.0	31	834	22.6	789.2	146,119	3.354	3.75	22.6	25.9
17.0	15	15.0	30	819	21.9	775.4	143,507	3.294	3.69	21.9	26.1
17.1	15	15.0	30	805	21.2	762.9	141,148	3.240	3.64	21.2	26.3
17.2	15	15.0	30	793	20.7	751.6	139,002	3.191	3.59	20.7	26.5
17.3	14	14.0	29	781	20.1	740.4	136,893	3.143	3.54	20.1	26.6
17.4	14	14.0	28	768	19.5	729.5	134,812	3.095	3.49	19.5	26.8
17.5	14	14.0	28	757	19.0	719.5	132,928	3.052	3.45	19.0	26.9
17.6	14	14.0	28	748	18.5	710.5	131,223	3.012	2.41	18.5	27.1
17.7	13	13.0	27	738	18.0	701.5	129,507	2.973	3.37	18.0	27.2
17.8	13	13.0	26	727	17.6	692.4	127,783	2.933	3.34	17.6	27.4
17.9	12	12.0	25	717	17.1	683.2	126,050	2.894	3.30	17.1	27.5
18.0	12	12.0	24	707	16.6	674.0	124,310	2.854	3.26	16.6	27.7
18.1	12	12.0	24	698	16.2	665.7	122,735	2.818	3.22	16.2	27.8
18.2	12	12.0	24	690	15.8	658.2	121,309	2.785	3.19	15.8	27.9
18.3	11	11.0	23	681	15.4	650.5	119,847	2.751	3.15	15.4	28.1
18.4	11	11.0	22	672	14.9	642.6	118,351	2.717	3.12	14.9	28.2
18.5	11	11.0	22	665	14.6	635.4	116,998	2.686	3.09	14.6	28.3

POND 2
OUTFLOW HYDROGRAPH COMPUTATIONS

Time (hrs)	Total Inflow (cfs)	Pond 2 Flow (cfs)	I1+I2 cfs	2S/T+O cfs	Discharge O cfs	2S/T-O cfs	Storage S cf	Storage S acre-ft	Depth ft	Cumulative Flow acre-ft feet	2S/T+O Interval Discharge O Interval 2S/T+O	Discharge cfs	Cumulative Discharge acre-feet
10.9	0	0.0	0	520.7	-	520.7	95,751	2.192	1.00	-			
11.0	22	22.0	22	543	0.3	542.2	97,645	2.242	1.04	0.18	542.7	0.3	0.0
11.1	24	24.0	46	588	0.8	586.6	105,730	2.427	1.13	0.38	588.2	0.8	0.0
11.2	26	26.0	50	637	1.4	633.6	114,335	2.625	1.22	0.60	636.6	1.4	0.0
11.3	28	28.0	54	688	2.0	683.8	123,445	2.834	1.31	0.83	687.8	2.0	0.0
11.4	31	31.0	59	743	2.7	737.5	133,227	3.058	1.41	1.08	742.8	2.7	0.1
11.5	33	33.0	64	801	3.4	794.3	143,663	3.298	1.52	1.35	801.5	3.4	0.1
11.6	36	36.0	69	864	4.1	855.5	154,738	3.552	1.63	1.65	863.9	4.1	0.1
11.7	43	43.0	79	935	5.0	924.6	167,327	3.841	1.76	2.01	934.5	5.0	0.2
11.8	49	49.0	92	1,017	5.9	1004.8	181,926	4.176	1.90	2.43	1016.6	5.9	0.2
11.9	56	56.0	105	1,110	6.9	1095.9	198,513	4.557	2.07	2.88	1109.8	6.9	0.3
12.0	70	70.0	126	1,222	7.9	1206.2	218,534	5.017	2.27	3.46	1221.9	7.9	0.3
12.1	96	96.0	166	1,372	9.1	1354.0	245,329	5.633	2.53	4.25	1372.2	9.1	0.4
12.2	138	138.0	234	1,588	10.9	1566.3	283,871	6.517	2.90	5.39	1588.0	10.9	0.5
12.3	206	206.0	344	1,910	16.9	1876.5	340,782	7.823	3.44	7.09	1910.3	16.9	0.6
12.4	296	296.0	502	2,378	26.6	2325.1	423,306	9.718	4.20	9.54	2378.3	26.6	0.9
12.5	371	371.0	667	2,992	38.8	2914.5	531,547	12.204	5.17	12.40	2992.1	38.8	1.2
12.6	404	404.0	775	3,689	84.0	3521.4	648,976	14.898	6.17	15.94	3689.5	84.0	1.9
12.7	404	404.0	808	4,329	245.8	3837.8	735,046	16.874	6.88	19.28	4329.4	245.8	3.9
12.8	372	372.0	776	4,614	306.7	4000.4	775,776	17.798	7.23	22.36	4613.8	306.7	6.4
12.9	326	326.0	698	4,698	322.7	4053.0	787,826	18.085	7.33	25.06	4698.4	322.7	9.1
13.0	280	280.0	606	4,659	315.2	4028.5	781,878	17.949	7.28	27.36	4659.0	315.2	11.7
13.1	238	238.0	518	4,547	294.0	3958.6	765,457	17.572	7.14	29.33	4546.5	294.0	14.1
13.2	195	195.0	433	4,392	261.5	3868.5	743,457	17.066	6.96	30.94	4391.8	261.5	16.3
13.3	168	168.0	363	4,232	221.1	3789.4	721,888	16.573	6.78	32.33	4231.5	221.1	18.1
13.4	140	140.0	308	4,097	187.2	3723.1	705,842	16.159	6.63	33.49	4097.4	187.2	19.7
13.5	124	124.0	264	3,987	159.3	3668.5	686,007	15.817	6.51	34.51	3987.2	159.3	21.0
13.6	108	108.0	232	3,900	137.4	3625.8	677,367	15.550	6.41	35.40	3900.5	137.4	22.1
13.7	97	97.0	205	3,830	119.8	3590.3	667,981	15.335	6.33	36.21	3830.6	119.8	23.1
13.8	87	87.0	184	3,775	105.7	3565.9	660,516	15.163	6.27	36.93	3775.3	105.7	24.0
13.9	81	81.0	168	3,731	94.7	3542.3	654,673	15.029	6.22	37.60	3731.8	94.7	24.8
14.0	76	76.0	157	3,699	86.5	3526.3	650,305	14.929	6.19	38.22	3699.3	86.5	25.5
14.1	72	72.0	148	3,674	80.2	3513.9	646,985	14.852	6.16	38.82	3674.3	80.2	26.2
14.2	68	68.0	140	3,654	75.0	3503.8	644,283	14.790	6.14	39.38	3653.9	75.0	26.8
14.3	64	64.0	132	3,636	70.5	3494.9	641,761	14.733	6.11	39.92	3635.8	70.5	27.4
14.4	61	61.0	125	3,620	66.4	3487.0	639,617	14.684	6.09	40.41	3619.9	66.4	27.9
14.5	58	58.0	119	3,606	62.9	3480.1	637,750	14.641	6.08	40.88	3606.0	62.9	28.4
14.6	55	55.0	113	3,593	59.7	3473.8	636,020	14.601	6.06	41.35	3593.1	59.7	28.9
14.7	53	53.0	108	3,582	56.8	3468.1	634,492	14.566	6.05	41.79	3581.8	56.8	29.4
14.8	52	52.0	105	3,573	54.6	3463.5	633,333	14.539	6.04	42.21	3573.1	54.6	29.8
14.9	50	50.0	102	3,565	52.8	3460.3	632,357	14.517	6.03	42.63	3565.9	52.8	30.3
15.0	48	48.0	98	3,558	50.9	3456.5	631,336	14.493	6.02	43.02	3558.3	50.9	30.7
15.1	47	47.0	95	3,552	49.2	3453.2	630,429	14.473	6.02	43.41	3552.3	49.2	31.1
15.2	46	46.0	93	3,546	47.8	3450.6	629,710	14.456	6.01	43.79	3546.2	47.8	31.5
15.3	44	44.0	90	3,540	47.3	3446.0	628,794	14.435	6.00	44.16	3540.6	47.3	31.9
15.4	43	43.0	87	3,533	47.2	3438.7	627,457	14.404	5.99	44.52	3533.0	47.2	32.3
15.5	42	42.0	85	3,524	47.0	3429.7	625,809	14.367	5.98	44.86	3523.7	47.0	32.7
15.6	41	41.0	83	3,513	46.8	3419.0	623,854	14.322	5.96	45.20	3512.7	46.8	33.1
15.7	40	40.0	81	3,500	46.6	3406.7	621,606	14.270	5.94	45.53	3500.0	46.6	33.4
15.8	38	38.0	78	3,485	46.4	3391.9	618,895	14.208	5.92	45.84	3484.7	46.4	33.8
15.9	37	37.0	75	3,467	46.1	3374.6	615,738	14.135	5.89	46.15	3466.9	46.1	34.2
16.0	36	36.0	73	3,448	45.8	3356.0	612,324	14.057	5.86	46.45	3447.6	45.8	34.6
16.1	35	35.0	71	3,427	45.5	3335.9	608,660	13.973	5.83	46.74	3427.0	45.5	35.0
16.2	34	34.0	69	3,405	45.2	3314.6	604,754	13.883	5.80	47.02	3404.9	45.2	35.3
16.3	33	33.0	67	3,382	44.8	3291.9	600,615	13.788	5.76	47.29	3381.6	44.8	35.7
16.4	32	32.0	65	3,357	44.4	3268.1	596,249	13.688	5.73	47.55	3356.9	44.4	36.1
16.5	31	31.0	63	3,331	44.0	3243.0	591,663	13.582	5.69	47.81	3331.1	44.0	36.4
16.6	30	30.0	61	3,304	43.6	3216.7	586,866	13.472	5.64	48.06	3304.0	43.6	36.8
16.7	29	29.0	59	3,276	43.2	3189.4	581,860	13.358	5.60	48.30	3275.7	43.2	37.2
16.8	28	28.0	57	3,246	42.7	3160.9	576,655	13.238	5.56	48.53	3246.4	42.7	37.5
16.9	27	27.0	55	3,216	42.3	3131.4	571,256	13.114	5.51	48.75	3215.9	42.3	37.9
17.0	26	26.0	53	3,184	41.8	3100.8	565,670	12.986	5.46	48.97	3184.4	41.8	38.2
17.1	25	25.0	51	3,152	41.3	3069.3	559,900	12.854	5.41	49.17	3151.8	41.3	38.5
17.2	25	25.0	50	3,119	40.8	3037.7	554,135	12.721	5.36	49.38	3119.3	40.8	38.9
17.3	24	24.0	49	3,087	40.3	3006.2	548,365	12.589	5.31	49.58	3086.7	40.3	39.2
17.4	24	24.0	48	3,054	39.8	2974.7	542,599	12.456	5.26	49.78	3054.3	39.8	39.5
17.5	23	23.0	47	3,022	39.3	2943.1	536,828	12.324	5.21	49.97	3021.7	39.3	39.9
17.6	23	23.0	46	2,989	38.8	2911.6	531,068	12.192	5.16	50.16	2989.1	38.8	40.2
17.7	23	23.0	46	2,958	38.3	2881.1	525,481	12.063	5.11	50.35	2957.6	38.3	40.5
17.8	22	22.0	45	2,926	37.8	2850.5	519,889	11.935	5.06	50.53	2926.1	37.8	40.8
17.9	22	22.0	44	2,894	37.3	2819.9	514,293	11.807	5.01	50.71	2894.5	37.3	41.1
18.0	22	22.0	44	2,864	36.7	2790.5	508,892	11.683	4.97	50.89	2863.9	36.7	41.4
18.1	21	21.0	43	2,833	36.1	2761.5	503,573	11.560	4.92	51.07	2833.5	36.1	41.7

POND 2
OUTFLOW HYDROGRAPH COMPUTATIONS

Time (hrs)	Total Inflow (cfs)	Pond 2 I Flow (cfs)	I1+I2 cfs	2S/T+O cfs	Discharge O cfs	2S/T-O cfs	Storage S cf	Storage S acre-ft	Depth ft	Cumulative Flow acre-ft feet	2S/T+O Interval Discharge O Interval	Discharge cfs	Cumulative Discharge acre-feet
18.2	21	21.0	42	2,809	35.4	2732.4	498,521	11.486	4.87	51.24	2803.5	35.4	42.0
18.3	20	20.5	41	2,733	34.8	2763.8	492,852	11.317	4.83	51.40	2773.4	34.8	42.5
18.4	20	20.0	40	2,744	34.2	2676.4	487,728	11.197	4.78	51.57	2743.8	34.2	42.8
18.5	19	19.0	39	2,714	33.6	2647.2	482,540	11.078	4.75	51.73	2714.4	33.6	42.9

POND 3A
OUTFLOW HYDROGRAPH COMPUTATIONS

Time (hrs)	Pond 3A+3B Total Inflow (cfs)	Pond 3A I Flow (cfs)	I1+I2 cfs	2S/T+O cfs	Discharge O cfs	2S/T-O cfs	Storage S cf	Storage S acre-ft	Depth ft	Cumulative Inflow acre-ft feet	Discharge cfs	Cumulative Discharge acre-feet
10.9	0	0.0	0	347.1	-	347.1	62,478	1.434	1.00			
11.0	31.0	21.2	21.295	368	0.4	367.6	66,235	1.520	1.06	0.18	0.4	0.0
11.1	34.0	23.3	44.525	412	1.1	409.8	73,973	1.698	1.18	0.37	1.1	0.0
11.2	36.0	24.7	47.95	458	2.0	453.9	82,046	1.884	1.30	0.57	2.0	0.0
11.3	39.0	26.7	51.375	505	2.8	499.6	90,439	2.076	1.43	0.79	2.8	0.1
11.4	43.0	29.5	56.17	556	3.7	548.4	99,383	2.282	1.57	1.04	3.7	0.1
11.5	48.0	32.9	62.355	611	4.7	601.5	109,100	2.505	1.71	1.31	4.7	0.1
11.6	52.0	35.6	68.5	670	5.7	658.8	119,568	2.745	1.87	1.60	5.7	0.2
11.7	63.0	43.2	78.775	737	6.8	723.7	131,497	3.019	2.04	1.96	6.8	0.2
11.8	74.0	50.7	93.845	818	7.8	802.0	145,762	3.346	2.25	2.38	7.8	0.3
11.9	85.0	58.2	108.915	911	8.9	893.0	162,355	3.727	2.49	2.86	8.9	0.4
12.0	115.0	78.8	137	1,030	10.4	1009.2	183,531	4.213	2.80	3.51	10.4	0.4
12.1	163.0	111.7	190.43	1,200	14.1	1171.5	213,398	4.899	3.22	4.43	14.1	0.6
12.2	246.0	168.5	280.169	1,452	21.7	1408.2	257,306	5.909	3.82	5.83	21.7	0.7
12.3	376.0	257.6	426.07	1,834	33.2	1767.5	324,196	7.443	4.70	7.95	33.2	1.0
12.4	514.0	352.1	609.66	2,378	46.3	2284.9	419,620	9.633	5.88	10.86	46.3	1.4
12.5	584.0	400.0	752.13	3,037	237.1	2562.8	503,962	11.570	6.87	14.17	237.1	3.4
12.6	569.0	389.8	789.805	3,353	272.8	2807.1	554,368	12.727	7.43	17.39	272.8	5.6
12.7	508.0	348.0	737.745	3,545	285.8	2973.3	586,627	13.467	7.77	20.27	285.8	8.0
12.8	420.0	287.7	635.68	3,609	290.1	3028.7	597,390	13.714	7.88	22.64	290.1	10.4
12.9	342.0	234.3	521.97	3,551	286.2	2978.3	587,613	13.490	7.78	24.58	286.2	12.7
13.0	265.0	181.5	415.795	3,394	275.6	2843.0	561,343	12.887	7.50	26.08	275.6	15.0
13.1	220.0	150.7	332.225	3,175	260.7	2653.7	524,607	12.043	7.10	27.33	260.7	17.2
13.2	175.0	119.9	270.575	2,924	202.3	2519.7	489,965	11.248	6.71	28.32	202.3	18.8
13.3	151.0	103.4	223.31	2,743	146.3	2450.5	467,429	10.731	6.45	29.17	146.3	20.1
13.4	127.0	87.0	190.43	2,641	114.7	2411.6	454,729	10.439	6.30	29.89	114.7	21.0
13.5	115.0	78.8	165.77	2,577	95.0	2387.3	445,816	10.257	6.21	30.54	95.0	21.8
13.6	103.0	70.6	149.38	2,537	82.4	2371.7	441,751	10.141	6.15	31.13	82.4	22.5
13.7	97.0	66.4	137	2,509	73.8	2361.1	438,284	10.062	6.11	31.67	73.8	23.1
13.8	91.0	62.3	128.78	2,490	68.0	2353.9	435,938	10.008	6.08	32.19	68.0	23.6
13.9	86.0	58.9	121.245	2,475	63.4	2348.3	434,106	9.966	6.06	32.68	63.4	24.2
14.0	82.0	56.2	115.06	2,463	59.6	2343.8	432,640	9.932	6.04	33.14	59.6	24.7
14.1	79.0	54.1	110.285	2,454	56.9	2340.2	431,493	9.905	6.03	33.58	56.9	25.1
14.2	75.0	51.4	105.49	2,446	54.3	2337.0	430,446	9.882	6.01	34.01	54.3	25.6
14.3	72.0	49.3	100.695	2,438	51.9	2334.0	429,453	9.859	6.00	34.42	51.9	26.0
14.4	69.0	47.3	96.585	2,431	49.7	2331.2	428,564	9.838	5.99	34.81	49.7	26.4
14.5	67.0	45.9	93.16	2,424	47.8	2328.9	427,798	9.821	5.98	35.19	47.8	26.8
14.6	64.0	43.8	89.735	2,419	47.2	2324.2	426,853	9.799	5.97	35.55	47.2	27.2
14.7	62.0	42.5	86.31	2,410	47.0	2316.4	425,418	9.766	5.95	35.90	47.0	27.6
14.8	61.0	41.8	84.255	2,401	46.8	2307.6	423,686	9.726	5.93	36.25	46.8	28.0
14.9	60.0	41.1	82.885	2,390	46.6	2296.7	421,789	9.683	5.91	36.59	46.6	28.4
15.0	58.0	39.7	80.83	2,378	46.3	2284.9	419,616	9.633	5.88	36.92	46.3	28.7
15.1	56.0	38.4	78.09	2,363	46.0	2271.0	417,056	9.574	5.85	37.23	46.0	29.1
15.2	54.0	37.0	75.35	2,346	45.6	2255.1	414,129	9.507	5.82	37.54	45.6	29.5
15.3	53.0	36.3	73.295	2,328	45.2	2237.9	410,968	9.435	5.78	37.84	45.2	29.9
15.4	51.0	34.9	71.24	2,309	44.8	2219.6	407,589	9.357	5.74	38.13	44.8	30.2
15.5	49.0	33.6	68.5	2,288	44.3	2199.4	403,877	9.272	5.69	38.41	44.3	30.6
15.6	48.0	32.9	66.445	2,266	43.8	2178.2	399,963	9.182	5.65	38.68	43.8	31.0
15.7	47.0	32.2	65.075	2,243	43.3	2156.6	395,991	9.091	5.60	38.94	43.3	31.3
15.8	45.0	30.8	63.02	2,220	42.8	2134.0	391,830	8.995	5.55	39.20	42.8	31.7
15.9	44.0	30.1	60.965	2,195	42.3	2110.5	387,493	8.896	5.49	39.45	42.3	32.0
16.0	43.0	29.5	59.595	2,170	41.7	2086.7	383,107	8.795	5.44	39.69	41.7	32.4
16.1	42.0	28.8	58.225	2,145	41.1	2062.6	378,675	8.693	5.38	39.93	41.1	32.7
16.2	40.0	27.4	56.17	2,119	40.6	2037.7	374,079	8.588	5.33	40.15	40.6	33.1
16.3	39.0	26.7	54.115	2,092	40.0	2011.8	369,325	8.479	5.27	40.38	40.0	33.4
16.4	37.0	25.3	52.06	2,064	39.3	1985.2	364,421	8.366	5.21	40.58	39.3	33.7
16.5	36.0	24.7	50.005	2,035	38.7	1957.8	359,373	8.250	5.14	40.79	38.7	34.0
16.6	35.0	24.0	48.635	2,006	38.1	1930.3	354,309	8.134	5.08	40.99	38.1	34.3
16.7	34.0	23.3	47.265	1,978	37.4	1902.7	349,229	8.017	5.01	41.18	37.4	34.7
16.8	34.0	23.3	46.58	1,949	36.7	1876.0	344,280	7.904	4.95	41.37	36.7	35.0
16.9	33.0	22.6	45.895	1,922	35.8	1850.3	339,495	7.794	4.89	41.56	35.8	35.3
17.0	32.0	21.9	44.525	1,895	35.0	1824.7	334,757	7.685	4.83	41.74	35.0	35.5
17.1	32.0	21.9	43.84	1,869	34.2	1800.1	330,185	7.580	4.77	41.92	34.2	35.8
17.2	31.0	21.2	43.155	1,843	33.5	1776.3	325,767	7.479	4.72	42.10	33.5	36.1
17.3	31.0	21.2	42.47	1,819	32.7	1753.3	321,494	7.380	4.66	42.27	32.7	36.4
17.4	30.0	20.6	41.785	1,795	32.0	1731.1	317,359	7.286	4.61	42.44	32.0	36.6

POND 3A
OUTFLOW HYDROGRAPH COMPUTATIONS

Time	Pond 3A+3B Total Inflow	Pond 3A I Flow	I1+I2	2S/T+O	Discharge O	2S/T-O	Storage S		Depth	Cumulative Inflow	Discharge	Cumulative Discharge
(hrs)	(cfs)	(cfs)	cfs	cfs	cfs	cfs	cf	acre-ft	ft	acre-ft feet	cfs	acre-feet
17.5	30.0	20.6	41.1	1,772	31.3	1709.5	313,351	7.194	4.56	42.61	31.3	36.8
17.6	29.0	19.9	40.415	1,750	30.7	1688.6	309,465	7.104	4.50	42.78	30.7	37.2
17.7	28.0	19.2	39.045	1,728	30.0	1667.6	305,572	7.015	4.45	42.93	30.0	37.4
17.8	26.0	17.8	36.99	1,705	29.3	1646.0	301,554	6.923	4.40	43.08	29.3	37.6
17.9	25.0	17.1	34.935	1,681	28.6	1623.7	297,419	6.828	4.35	43.22	28.6	37.9
18.0	24.0	16.4	33.565	1,657	27.9	1601.5	293,292	6.733	4.29	43.36	27.9	38.1
18.1	24.0	16.4	32.88	1,634	27.2	1580.0	289,294	6.641	4.24	43.49	27.2	38.3
18.2	23.0	15.8	32.195	1,612	26.5	1559.1	285,415	6.552	4.19	43.62	26.5	38.6
18.3	23.0	15.8	31.51	1,591	25.9	1538.8	281,650	6.466	4.14	43.76	25.9	38.8
18.4	22	15.1	30.825	1,570	25.3	1519.1	277,991	6.382	4.09	43.88	25.3	39.0
18.5	22	15.1	30.14	1,549	24.7	1500.0	274,432	6.300	4.04	44.00	24.7	39.2

DESIGN TECHNICAL MEMORANDUM
Guam Municipal Solid Waste Landfill
Project - Design Criteria; Hydrology & Hydraulic Analysis

WINZLER & KELLY
CONSULTING ENGINEERS

Reviewed by: Neal Carnam
Date: 7/29/05

PREPARED FOR: TOR GUDMUNDSEN

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REVIEWED BY: Neal Carnam, Winzler & Kelly

DATE: July 29, 2005

JOB #: 10-16405001

This technical memorandum summarizes the design criteria and assumptions used in developing the existing and developed conditions hydrology analysis. The hydrology results and preliminary sizing of hydraulic structures are summarized.

Hydrology Model:

- Haestads Quick TR 55 to develop runoff hydrographs (results are similar to SCS Unit Hydrograph)
- Haestad's POND 2 for routing hydrographs through detention basins
- SCS Type III rainfall distribution
- CN curve number for runoff loss rate analysis
- Hydrologic Soil Group C
- Use Figure 6 Wetlands and Surficial Cover –Dandan for existing conditions CN values
- Assume Grassland/Savana for developed conditions CN values (71); Access area to site assume a CN of 90
- Antecedent Soil Moisture Condition II
- Lag (L) = (l^0.8* (S+1)^0.7)/1900*Y^0.5 where: l = hydraulic length; S = maximum retention; Y = slope in percent.
- Time of Concentration (Tc) = 5/3L
- Tc values not associated with Lag calculations used velocities from *A Guide to Hydrologic Analysis Using SCS Methods* by Richard H. McCuen (Figure 8 – Velocities for upland method of estimating Tc).
- Design Storm: 25-year, 24-hour - use 20-inches in 24 hours from: *CNMI and Guam Stormwater Management Criteria, Phase I Final Report,* July 30, 2004

Existing Conditions Analysis

There are three major drainages:

- Fensol River in the north east (WS FE)

- Fintasa River in the south (WS FI)
- Tinago River in the north west (WS T)

The project site is subdivided into watersheds that flow to these three major watersheds. Refer to Figure 1. The peak 25-year flow and volume hydrograph from each subbasin will serve as the existing conditions for sizing detention facilities. The peak calculated flow exiting the project site from the detention basins should not be exceeded for the developed conditions.

WS FE

- Area = 69.1 ac (0.108 sq mi)
- CN = 79
- Lag: l = 1650 feet; S = 1000/CN-10 = 2.66; Y = 75/1650 = 4.5%: **L = 0.23 HRS (Tc = 0.38 HRS)**

WS FI

- Area = 74.1 ac (0.116 sq mi)
- CN = 81

Lag: l = 2600 feet; S = 1000/CN-10 = 2.35; Y = 100/2600 = 3.8%: **L = 0.34 HRS (Tc = 0.57 HRS)**

WS T

- Area = 49.4 ac (0.077 sq mi)
- CN = 79

Lag: l = 1460 feet; S = 1000/CN-10 = 2.66; Y = 65/1460 = 4.5%: **L = 0.21 HRS (Tc = 0.35 HRS)**

Table 1 summarizes the peak flows and hydrograph volumes from the watersheds.

Table 1 EXISTING CONDITIONS RUNOFF ANALYSIS RESULTS					
Watershed	**AREA (Ac)**	**CN**	**LAG (Tc)(hrs)**	**Peak Q (cfs)**	**Volume (Ac-Ft)**
Fensol River WS	69.1	79	0.23 (0.38)	830	94.8
Fintasa River WS	74.1	81	0.34 (0.57)	830	103.5
Tinago River WS	49.4	79	0.21 (0.35)	594	67.9

Final Grading Conditions Analysis

The final graded site has a perimeter road around the site with 4 detention/sedimentation ponds located at the perimeter limits of the project site. Refer to Figure 2. We have made preliminary assumptions as to the grading of the site based on the information supplied by A-MEHR, INC. Assumptions include the following:

- A roadside ditch will extend the length of the road on the outside edge draining to culverts that drain to the individual ponds.
- The perimeter road will have low swales that will allow concentrated flows from the graded site to cross the road at these locations to the roadside ditch.
- Benches will be constructed at 50 foot elevation intervals starting at contour 450 at the top of slope. These will be routed to down drains that flow to the roadside ditch and culverts.

The final graded site has been divided into 11 sub-watersheds that flow to one of the 4 ponds that flow to one of the major watersheds:

- Pond 1 flows to the Tinago River
- Ponds 2 and 3 flow to the Fintasa River
- Pond 4 flows to the Fensol River

Refer to Table 2 for the sub-watershed routings.

Table 2 SUB-WATERSHED ROUTINGS

Drainage	Sub-watersheds
Tinago River WS	A6+A7+A8
Fintasa River WS	A1+A9+A10+A11
Fensol River WS	A2+A3+A4+A5
Pond 1	A6+A7+A8
Pond 2	A9
Pond 3	A1+A10+A11
Pond 4	A2+A3+A4+A5

The sub-watersheds under final grading conditions are assumed to be revegetated (except for a small portion of areas 8 and 9 where the entrance area is located), resulting in a lower CN curve number than the existing sub-watersheds. The time of concentrations for these watersheds were calculated by estimating the length of the various channel reaches and slopes (overland flow on cap top, bench drains and down-drains) and assigning velocities to each. Velocities were obtained from Figure 8 in *A Guide to Hydrologic Analysis Using SCS Methods* referenced above. They were converted to lag by the referenced formula of Tc = 5/3L. This method was used rather than the Lag formula due to the extreme variance in slopes for various reaches.

When combining sub-watersheds, the overall composite peak flow and hydrograph is determined by adding the flow values of each sub-watershed based on their individual Tc to create a composite hydrograph. That is, the combination picks the highest overall peak and the time to peak. When two or more sub-watersheds are added together the resultant peak for the composite may not equal the sum of the individual values. This is apparent in Table 3.

Table 3 summarizes the peak flows and hydrograph volumes from the sub-watersheds.

Table 3 FINAL GRADING CONDITIONS RUNOFF ANALYSIS RESULTS					
Watershed	AREA (Ac)	CN	LAG (Tc)(hrs)	Peak Q (cfs)	Volume (Ac-Ft)
A1	6.3	71	0.22 (0.36)	70	8.0
A2	7.2	71	0.20 (0.33)	89	9.1
A3	14.4	71	0.26 (0.44)	159	18.3
A4	16.6	71	0.27 (0.45)	169	21.1
A5	18.5	71	0.35 (0.58)	188	23.5
A6	11.6	71	0.29 (0.49)	117	14.6
A7	33.0	71	0.51 (0.85)	280	41.8
A8	19.5	77	0.37 (0.61)	210	26.4
A9	26.0	74	0.36 (0.60)	273	34.1
A10	19.3	71	0.40 (0.67)	164	25.6
A11	20.2	71	0.37 (0.61)	205	25.3
POND 1 (A6+A7+A8) TINAGO RIVER	58.4	73	na	578	82.8
POND 2 (A9)	26.0	74	0.36 (0.60)	273	34.1
POND 3 (A1+A10+A11)	45.8	71	na	404	57.8
POND 2+Pond 3 (A9+A1+A10+A11) FINTASA RIVER	71.8	72	na	677	91.9
POND 4 (A2+A3+A4+A5) FENSOL RIVER	56.7	71	na	584	71.9

Table 4 summarizes the peak flows and hydrograph volumes flowing to the three main watersheds under existing and final grading conditions.

Table 4 Watershed Comparisons under Existing and Final Grading Conditions						
	Existing Conditions		Final Grading Conditions		Peak Flow Change	Volume Change
Watershed	Peak Flow (cfs)	Volume (Ac-Ft)	Peak Flow (cfs)	Volume (Ac-Ft)	Peak Flow (cfs)	Volume (Ac-Ft)
Fensol River	830	94.8	584	71.9	-246	-22.9
Fintasa River	830	103.5	677	91.9	-153	-11.6
Tinago River	594	67.9	578	82.8	-16	14.6

Pond Routing

This analysis reviews routing only through Pond 1 which discharges to the Tinago River. The peak inflow and hydrograph volume from Table 4 above are:

- 578 cfs
- 82.5 ac-ft

Pond 1 ranges from approximately elevation 310 at the invert to elevation 320 at the top. The approximate pond area and volume are:

- Elevation 310; area = 104,234 square feet
- Elevation 320; area = 186,467 square feet
- Volume: 1,453,505 cubic feet (33.3 acre feet)

We want to size the pond outlet structure to allow maximum storage within Pond 1 as the inflow hydrograph is routed through it. A suggested outlet structure could consist of the following. Refer to Figure 3:

- 42-inch RCP with inlet set at elevation 310.5. This would allow a weir 0.5 feet above the pond invert for sediment storage.
- 36-inch standpipe with the invert set at elevation 316

This structure would allow result in the following storage and outflow:

- 33.25 acre feet
- Maximum elevation of 319.98
- peak outflow of 197 cfs

Sedimentation Analysis

From the *EROSION & SEDIMENT CONTROL HANDBOOK* BY Goldman, Jackson and Bursztynsky the settling formula for an ideal sediment basin is:

WL = Q/Vs where:

- WL = sediment basin area
- Q = peak inflow
- Vs = settling velocity (assumed to be 9.6×10^{-4} for a medium size silt particle of 0.02 mm)

From the routing analysis above, the existing area (WL) for Pond 1 is 186,467 square feet. The 25-year, 2-year and 1-year storm discharging to Pond 1 and the Tinago River watershed were analyzed. The resulting peak flows (Q) for each event are:

- Q25 = 578 cfs
- Q2 = 139 cfs
- Q1 = 38 cfs

Using the formula above to calculate the necessary area to allow settling results in the following:

- 25-year pond area = 602,083 square feet > 186,467 square feet. Pond 1 will not work properly for the 25-year event
- 2-year pond area = 144,791 square feet < 186,467 square feet. Pond 1 should work for a 2-year event
- 1-year pond area = 39,583 square feet < 186, 467 square feet. Pond 1 will easily work for a 1-year event.

It is recommended that intermittent berms be placed across Pond 1 to serve as individual trapping basins under low flow conditions. These could be K-rails that are easily removable to allow for ease in sediment removal.

Hydraulic Analysis

The perimeter roadside ditch will be located on the outside edge of the perimeter road. The allowable width is estimated to be 15 feet. This roadside ditch will be constructed of concrete with a bottom width of 8 feet to allow mechanical equipment cleaning. Side slopes of 1:1 are used to minimize the top width. The ditch slope is assumed to be approximately 1%. Area A7 has the largest area and runoff with a peak flow of 280 cfs. Assuming no backwater conditions and a mannings "n" of 0.015 for concrete, the peak flow would flow under supercritical conditions at a depth of 2.1 feet and a velocity of 13.1 feet per second. Critical depth is 2.95 feet. It is recommended that the channel have approximately 1 foot of freeboard so the typical maximum ditch section would be:

- Bottom Width = 8 feet
- Side slopes = 1:1
- Depth = 4 feet

Conclusions

Hydrology Analysis
The hydrology analysis indicates that the runoff peak flows and hydrograph volumes are reduced under final grading conditions to the Fensol River watershed and the Fintasa River watershed. While peak flows to the Tinago River watershed are lower under final grading conditions, there is a minor increase in runoff volume of 14.6 acre-feet.

These lower flow conditions are expected as under final grading conditions, the runoff curve numbers CN are lower than under existing conditions due to revegetation of the site. In addition, the contributing watersheds to both the Fensol River and Fintasa River under final grading conditions are less than under existing conditions (56. 7 acres vs. 69.1 acres for the Fensol watershed and 71.8 acres vs. 74.1 acres for the Fintasa watershed). Although the CN number is lower for the Tinago River under final grading conditions, the contributing watershed area is larger (58.4 acres vs. 49.4 acres). Thus though the peak flow is lower, the larger watershed will contribute a higher volume during a 24-hour storm event

Routing Analysis
A preliminary analysis of available storage in Pond 1 that drains to the Tinago River indicates that it can contain approximately 33.3 acre-feet. Routing the watershed that contributes to Pond 1 and the Tinago River watershed (areas A6+A7+A8) results in the following:

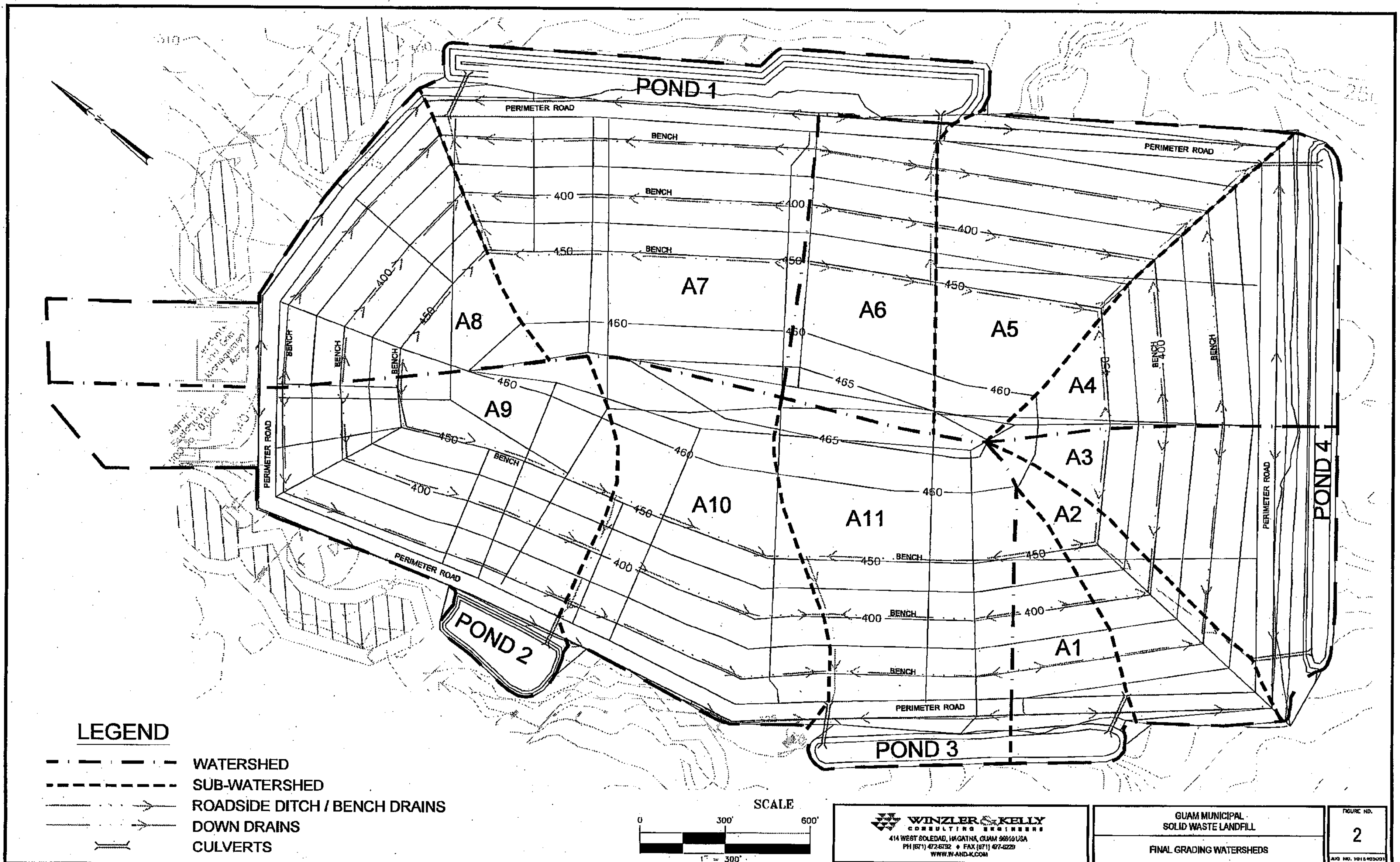
- Inflow = 578 cfs; 82.8 ac-ft
- Outflow = 197 cfs; storage of 33.3 ac-ft

Sedimentation Analysis
Pond 1 is capable of effectively serving as a sediment control structure for particle sizes approximating 0.02 mm (medium size silt) for storms up to a 2-year, 24-hour event.

Hydraulic Analysis
The typical maximum perimeter roadside ditch configuration is:

- Concrete ditch with a bottom width of 8 feet, 1:1 side slopes and a depth of 4 feet.
- This ditch will normally flow under supercritical conditions. The 4 feet depth allows approximately 1 foot of freeboard above critical depth.

The detailed hydrology calculations are included as Attachment A. The Hydraulic calculation for the perimeter roadside ditch is included in Attachment B.


POND 1
POND 2
POND 3
POND 4
PERIMETER ROAD
BENCH
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
400
450
460
465
LEGEND
WATERSHED
SUB-WATERSHED
ROADSIDE DITCH / BENCH DRAINS
DOWN DRAINS
CULVERTS
SCALE
0
300'
600'
1" = 300'
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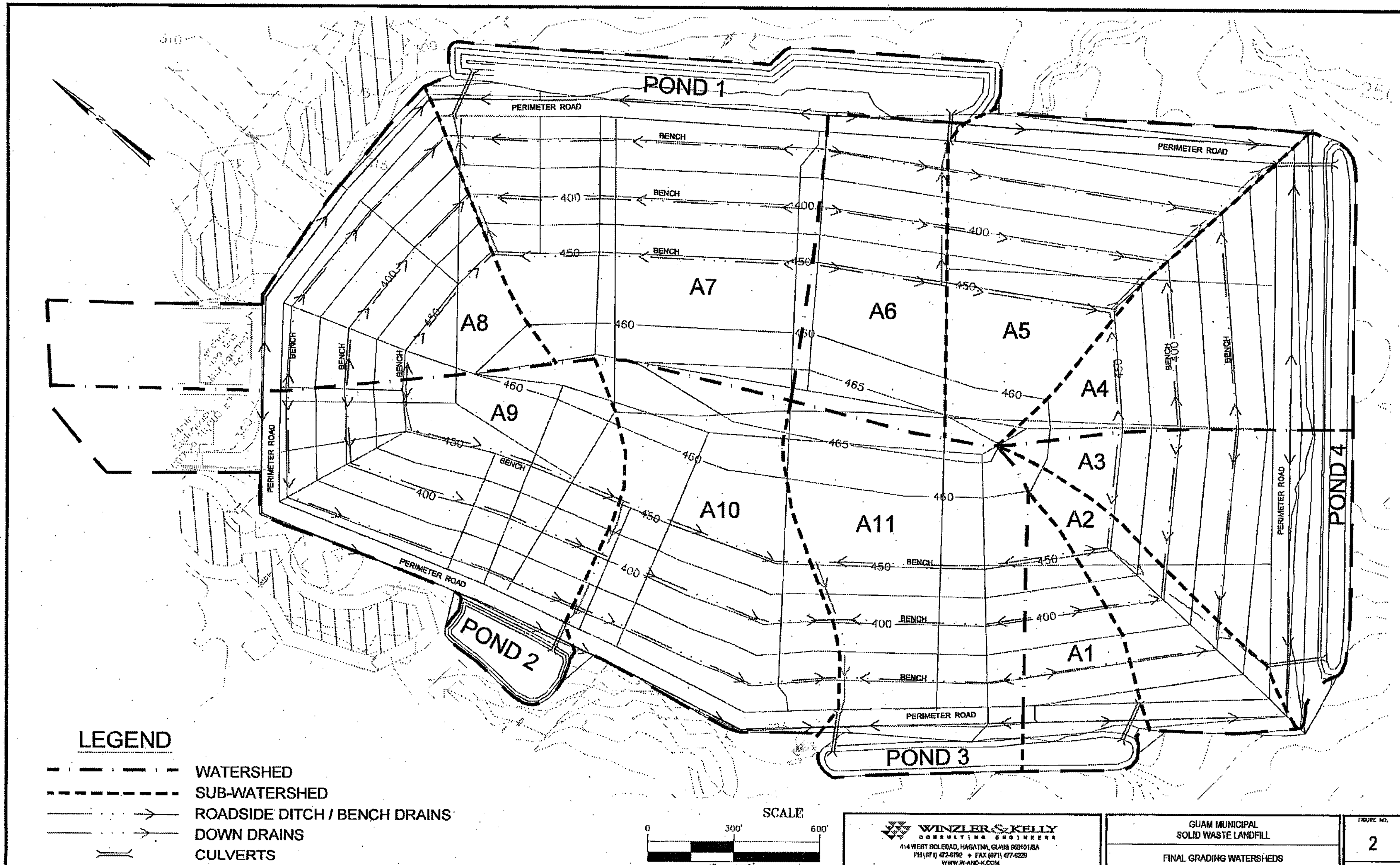
GUAM MUNICIPAL
SOLID WASTE LANDFILL
FINAL GRADING WATERSHEDS
FIGURE NO.
2



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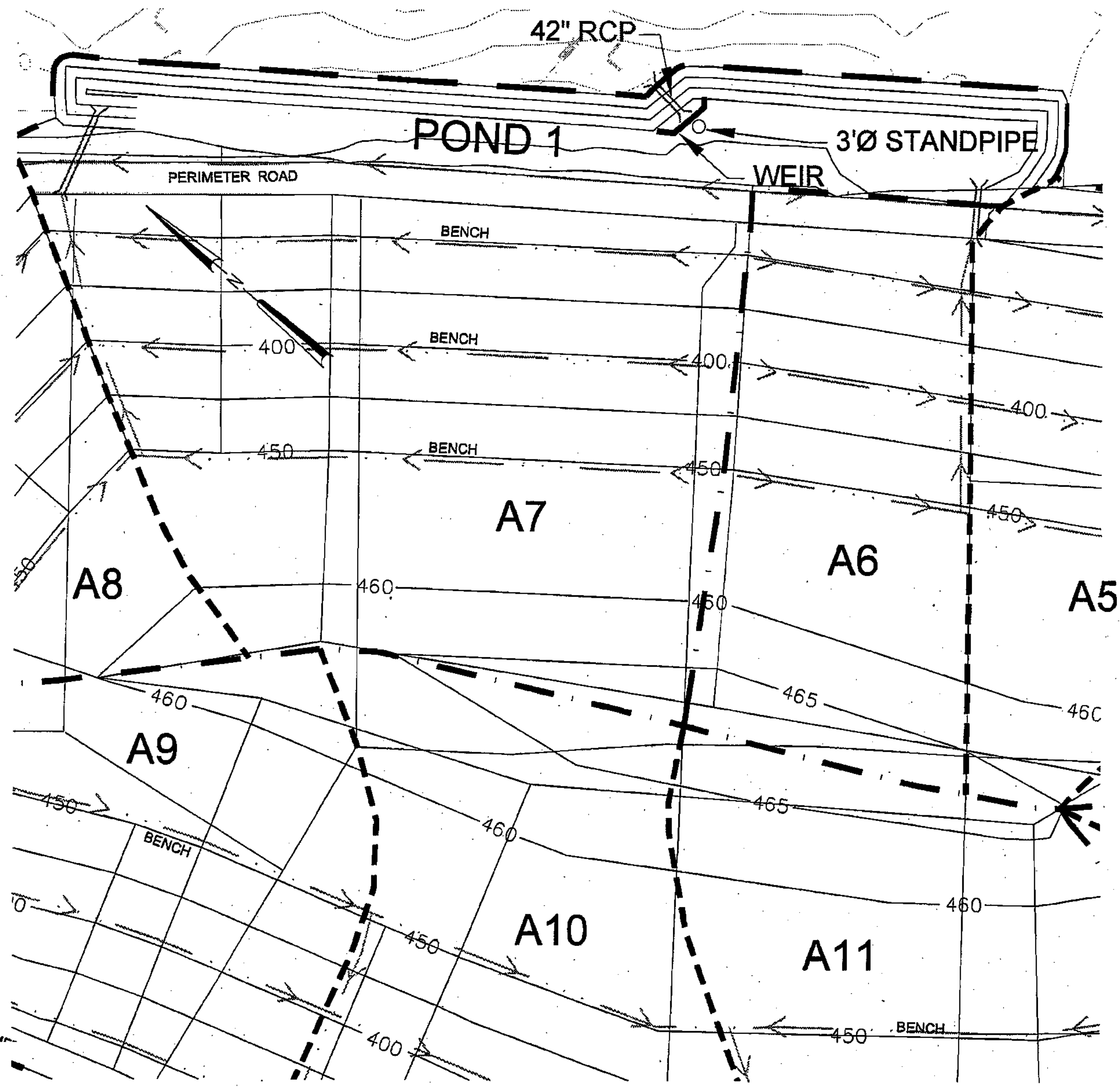
GUAM MUNICIPAL SOLID WASTE LANDFILL

FINAL GRADING WATERSHEDS

FIGURE NO. 2



LEGEND

- WATERSHED
- SUB-WATERSHED
- ROADSIDE DITCH / BENCH DRAINS
- DOWN DRAINS
- CULVERTS

SCALE

0 300' 600'

1" = 300'

WINZLER & KELLY CONSULTING ENGINEERS 414 WEST SOLEDAD, HAGATNA, GUAM 96910 USA PH (671) 472-6792 ♦ FAX (671) 477-6229 WWW.W-AND-K.COM	GUAM MUNICIPAL SOLID WASTE LANDFILL	FIGURE NO. 3
	OUTFLOW STRUCTURE	JOB NO. 1016405001

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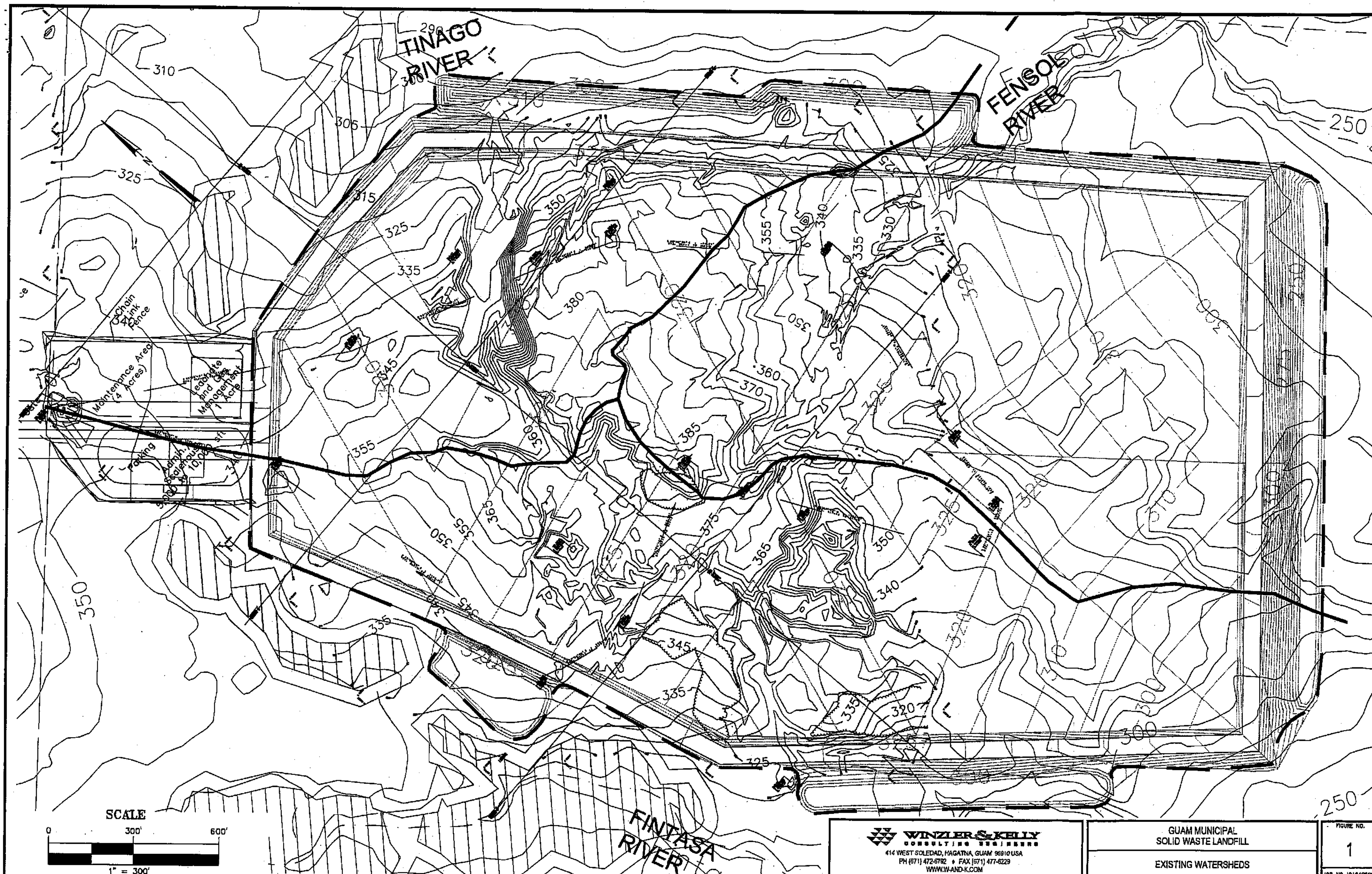

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EXISTING WATERSHEDS

FIGURE NO.
1

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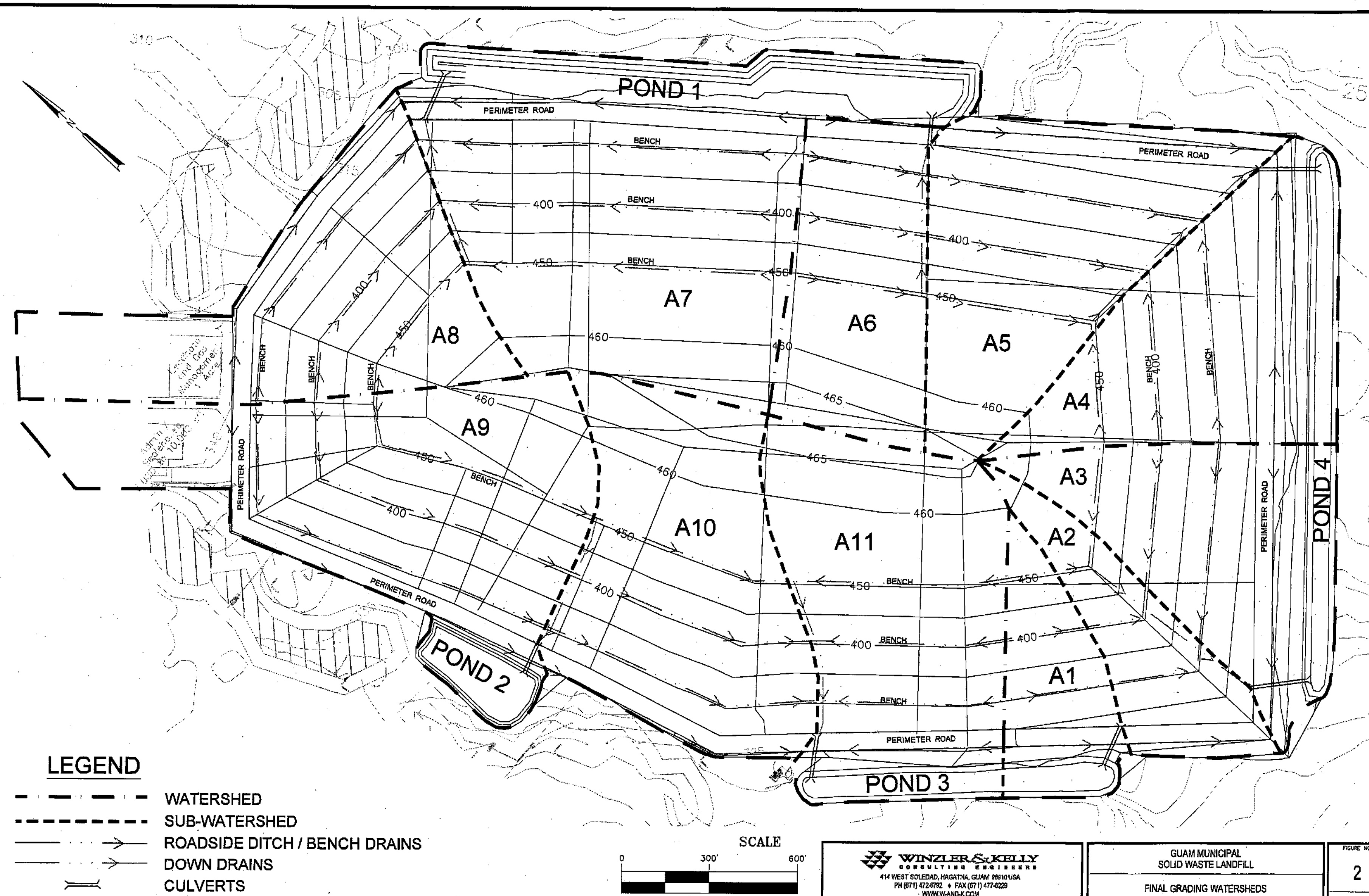

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FINAL GRADING WATERSHEDS

FIGURE NO. 2

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