Department of Economic Development and Transportation
Resolute Bay Airport Operation and Maintenance Manual
Sewage Treatment Facility

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History and Background

Introduction:
This Operations and Maintenance(O&M) has been prepared according to the *Guidelines for the Preparation of an Operation and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories*, by Diep Duong and Ron Kent (1996). The purpose of the O&M Plan for the sewage lagoon at the Resolute Bay Airport is to provide the sewage treatment facility operators with a consistent methodology by which to run and upkeep the two-cell lagoon. There are several reasons that this O&M Plan is necessary:

- to provide optimum treatment of effluent within the lagoon
- to provide the best wetland treatment through proper annual decanting
- to prevent environmental degradation to the surrounding tundra ecosystem
- to prevent substances deleterious to marine life from entering the ocean environment
- to prevent catastrophic breaching of the berm

General Historical and Geological Context, Vegetation, and Climate:
Resolute Bay Airport is located on the south coast of Cornwallis Island, a part of the Queen Elizabeth Islands, at approximately 74° 43' N Latitude, 94° 58' W Longitude. It is approximately 900 km north of the Arctic Circle. It functions as a center for administration, transportation, research, and communications for the High Arctic. Surficial Geology in the area consists of raised beach deposits of sand and gravel and shattered bedrock from eons of freeze-thaw cycles. The Airport area is on a demarcation between the Allen Bay and Cape Storm Formations. Both of these formations date from the Paleozoic era, consisting bedrock outcrops of dolomite, dolomitic limestone, limestone, as well as deposits of shale and siltstone. Sands, clays, and silts characterize most of the loose granular deposits. The terrain slopes gently towards Allen Bay to the west and Resolute Bay to the south. To the east of the runway the local topography is characterized by steep hills. Resolute Bay is in the zone of continuous permafrost. From most of September through much of July, the ground is typically completely frozen. The depth to permafrost at the airport has been reported to range between approximately 0.3 to 1.4 meters below grade. The average mean annual precipitation is 13 cm. Investigations reveal shallow melt water flow (groundwater flow in the active zone above the permafrost layer) which characterizes the hydrological regime.

Polar desert conditions limit vegetation to ground-hugging dwarf trees, as well as mosses, lichens, and some species of grass. Birds, including the rare ivory gull species, are present seasonally. Arctic fox, weasels, and polar bear visit the Resolute Bay area occasionally, including the airport and landfill areas. Marine species - including walrus, beluga, and seals – represent a significant component of the local environment and of the economy.

Winds most often come from the north-northwest at an annual average speed of 21.5 km/hr. Typical high and low mean temperatures for July and January are presented in the table below:

	High (^{o}C)	Low (^{o}C)
July	6.8	1.4
January	-28.4	-35.7

Location and Description:

The airport consists of two gravel air strips (a main runway and a cross-wind runway), a gravel apron area, a number of occupied and abandoned buildings and a series of bulk fuel storage tanks (known as the North Camp Tank Farm), above and below grade delivery pipelines. In addition to the existing structures, several former buildings have been demolished or destroyed (some by fire) at the airport. A service road leading from the Hamlet (about 5 km south of the airport), runs parallel to the main runway on the west side of the airport and continues north to a solid waste landfill and a former firefighter training area (currently under remediation), and a sewage lagoon (see Fig. 1 below).

The sewage lagoon is situated about 3 km from the actual Resolute Bay airport facilities and approximately 8 km from the Hamlet of Resolute Bay. The lagoon, a two-celled detention facility, was built sometime in the 1970s, it is believed, by Transport Canada. It was built abutting the large landfill, also managed by Transport Canada, who, at the time, oversaw the operations of the entire airport site. The relative location of both facilities can be seen in the figure below (lagoon identified by the blue arrow, and the edge of the airport runway indicated by the red arrow).

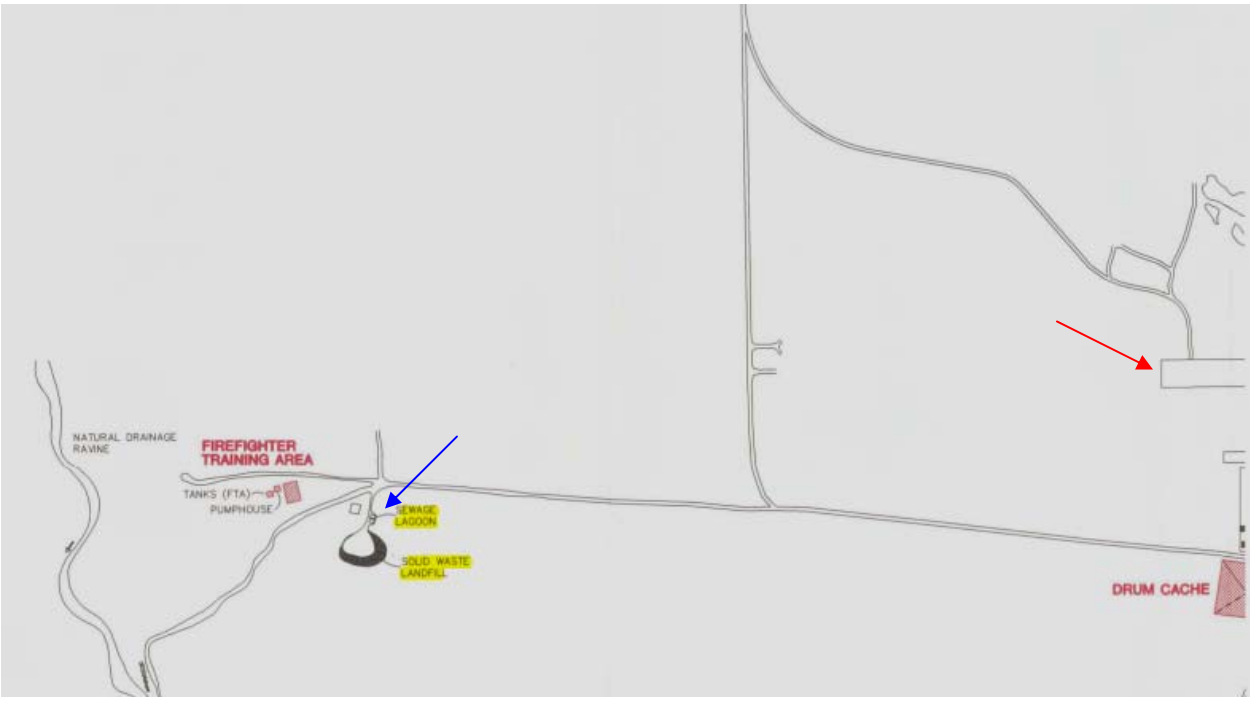

Fig. 1. Dillon Consulting. Resolute Bay Airport Environmental Baseline Study for Transport Canada, March, 1996

The sewage lagoon was designed by the Canadian Government as a standard unlined two-cell detention exfiltration and over-topping pit to service all trucked sewage from all the airport tenant facilities at and around the airport site, including businesses, government agencies, and residences. At the present time, fewer buildings are serviced, and the approximate annual volume of sewage deposited in the lagoon is 3,640 cubic m, far less than the volume that the lagoon was first intended to treat.

The lagoon is located just North-East of the solid waste site (see the enlarged drawing below). Decanting takes place from the lower cell and is designed to be directed to the South-West, through the solid waste site and on to the wetland for further treatment, thence to the ocean outfall.

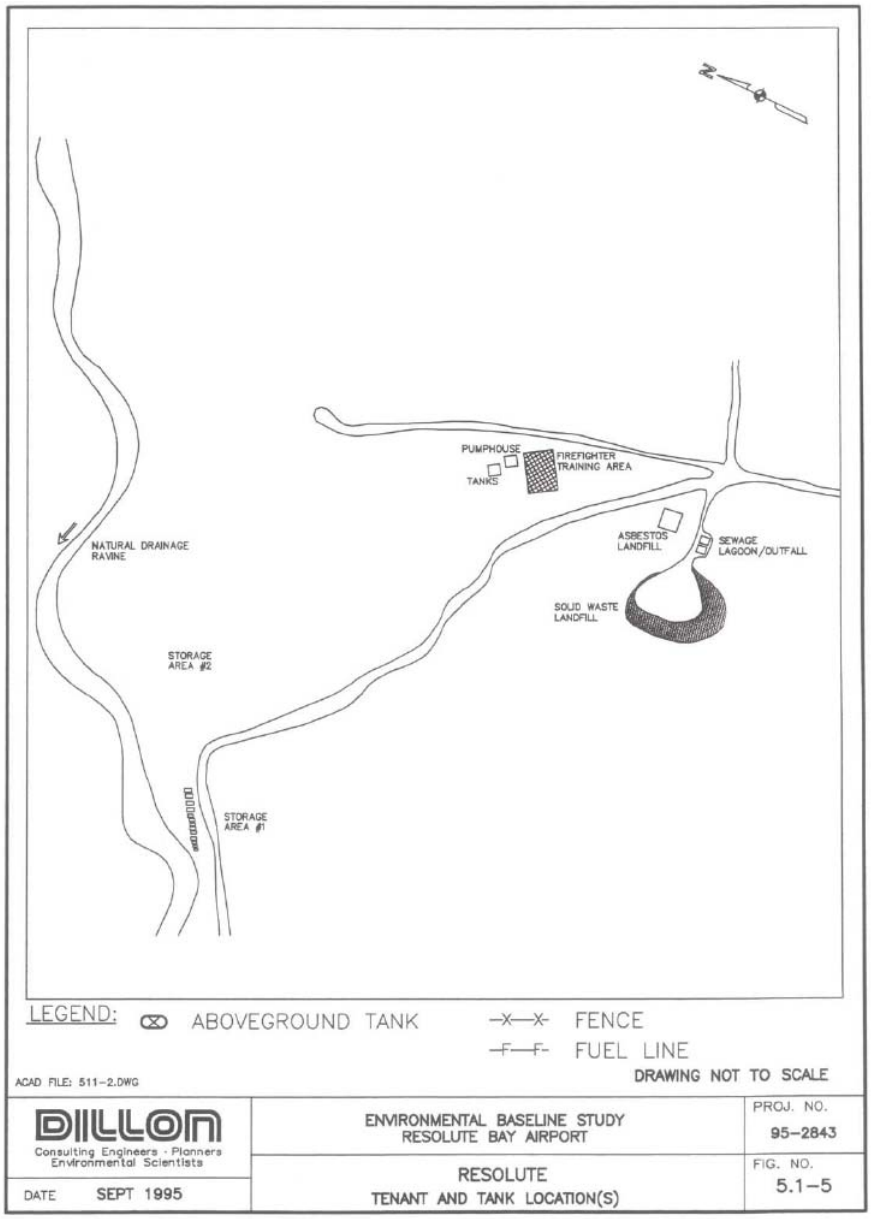

Fig. 2. Dillon Consulting. Resolute Bay Airport Environmental Baseline Study for Transport Canada, March, 1996

From a subsequent Dillon report (1999): "The sewage lagoons are unlined and treatment of the wastewater is accomplished through overland flow to the west and down-gradient of the landfill…Properties for several hundred metres in all other directions from the landfill are currently vacant and have historically been unoccupied."[1] See Fig. 3 below.

[1] Dillon Consulting. Resolute Bay Airport Landfill: Environmental Site Investigation for Transport Canada, April, 1999 p. 3

Sewage lagoon near landfill

Fig. 3.[2]

Background:

The raw sewage is retained in individual heated storage tanks located within each building with running water. Scheduled and regular pump-outs are performed by sewage tanker truck crews from one of the two local contractors. These trucks transport the raw sewage for discharge into the first cell of the sewage lagoon.

Population Growth and Projections:

Since the sewage lagoon and solid waste facilities were first built by Transport Canada, the population at the Airport has actually declined from the 1960s, when the facilities were believed to be first commissioned. A 1996 Dillon environmental study listed the following 19 businesses and government agencies (termed "airport tenant facilities") located on airport grounds at that time:[3]

1. Environment Canada

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[2] Dillon Consulting. Resolute Bay Airport Landfill: Environmental Site Investigation for Transport Canada, April, 1999 (from Appendix B – Site Photographs)

[3] Dillon Consulting. Resolute Bay Airport Landfill: Environmental Site Investigation for Transport Canada, April, 1999 (from the Executive Summary)

2. Kenn Borek Air Ltd.Bradley
3. Airport Garage and Air Terminal Bldg
4. Narwhal Arctic Services (a division of ATCO Frontec)
5. Northwest Territories Power Corporation
6. Air Services Ltd. (First Air)
7. Transport Canada
8. Canadian Regional Airlines Ltd.
9. Cominco Ltd.
10. Energy, Mines & Natural Resources
11. Fisheries & Oceans
12. Imperial Oil
13. Jessco Operations Ltd.
14. MacKenzie A.A.
15. Department of National Defence
16. Northwestel
17. Royal Canadian Mounted Police (RCMP)
18. Tudjaat Cooperative Ltd.
19. Washburn A.l.

In addition, there were a number of residences and some crew bunkhouses. All of these made use of the sewage lagoon.

A current count shows only nine airport tenant facilities (plus the lately-added RCMP station located in the hamlet) that use the sewage lagoon and solid waste site, **a decline of 47% during the past 12 years**.

1. Environment Canada
2. Kenn Borek Air
3. Airport Garage and Air Terminal Bldg
4. Narwhal Arctic Services (a division of ATCO Frontec)
5. Nunavut Power Corp.
6. First Air
7. Nav Canada
8. RCMP (in the Hamlet of Resolute Bay)
9. SRI International
10. Natural Resources Canada (Polar Continental Shelf Project)

In addition, some residences remain at the airport site, though again not as many as previously. This dramatic decline makes it difficult to predict future needs. However, at this time there is no reason to believe the trend will reverse itself. A conservative approach would assume current population would remain unchanged into the foreseeable future, and the lagoon, licensed for a higher volume of sewage, would be sufficient until at least a new sewage treatment facility can be built.

Sewage Generation and Composition:
Water consumption figures are available for the years 2007. The water generation for the first nine of the ten buildings in the list above is:

The monthly water use in 2007[4] was:

Month	Litres	cu m
Jan/07	212,110	212
Feb/07	173,537	174
Mar/07	271,086	271
Apr/07	352,805	353
May/07	258,436	258
Jun/07	230,505	231
Jul/07	312,649	313
Aug/07	349,468	349
Sep/07	263,874	264
Oct/07	215,491	215
Nov/07	210,905	211
Dec/07	199,513	200
Total	**3,050,379**	**3050**
Avg per mo	**254198.3**	**254**

In addition, during the summer and swing seasons, Polar Shelf (the tenth building in the list above, usually operating for approximately half the year only) consumes roughly the same amount (250 m^3) per month[5] while open. A common ratio in estimating sewage generation rates is to assume that for every 10 litres of water delivered, 8 litres is pumped out as sewage. Thus, the quantities of sewage can be summarized in the tables below:

Quantities per month for six month summer and swing seasons:

	Water (m^3)	Sewage (m^3)
First 9 Bldgs	254	203
Polar Shelf	250	200

Quantities per month for six month winter and swing seasons:

	Water (m^3)	Sewage (m^3)
First 9 Bldgs	254	203
Polar Shelf	nil	nil

Quantities for year:

	Water (m^3)	Sewage (m^3)
First 9 Bldgs	3,048	2,440
Polar Shelf	1,500	1,200
Totals	4,548	3,640

Sewage Treatment and Disposal:

A search has revealed no historical records or drawings of the two-cell sewage lagoon as originally designed by Transport Canada. From a 1999 report, a 1992 aerial photograph clearly

[4] Figures supplied by Rick Gaulton of Narwhal Arctic Services in an e-mail
[5] Figure supplied by Aziz Kheraj of 953731 NWT Ltd. Note that this amount was for sewage removed. At an approximate 0.8 to 1 sewage to water use ratio, the sewage rate reported was 200 m^3 per mo.

shows the lagoon.[6] It was designed to treat sewage for at least 19 airport and government buildings (as reported in 1996) and an unknown number of residences and bunkhouses. It is a two-cell detention lagoon that was designed to exfiltrate and overflow naturally when the weather warmed sufficiently. The lagoon is located approximately 1.5 km east of the ocean at an elevation of about 60m above sea level. The ground surface in the area slopes gently to the west toward the ocean. Treatment takes place partly within the lagoon itself, but the area between the lagoon and the ocean outfall was designed as part of the treatment system. Since the lagoon was designed to be both an exfiltrating and over-topping detention pit, freeboard was most likely designed to operate at zero m. Overland flow of decanted effluent is a key component to treatment. Where effluent has traditionally flowed the vegetation is lush, the difference between the wetland treatment areas and non-treatment areas is profound. See figures 4 and 5 below.

Fig. 4. Lush vegetation in wetland treatment area

[6] Dillon Consulting. Resolute Bay Airport Landfill: Environmental Site Investigation for Transport Canada, April, 1999 p. 4

Fig. 5. Showing contrast between wetland treatment area and typical terrain

Capacity and Historic Placement of Sewage Lagoon:

The sewage lagoon was designed by Transport Canada for a larger number of buildings than presently exist. However, a report on the airport facilities status at the time of transfer to the Government of the Northwest Territories made the point: "Transport Canada should address sewage treatment capacity concerns"[7] No changes were subsequently made by TC, who clearly will retain responsibility for any required upgrades or relocation under the National Airports Policy of 1994. An Excerpt from an Environmental Baseline Study that TC commissioned as a direct result of this Policy clarifies the responsibilities of the Federal Government prior to transferring regional or small airports to provincial and territorial governments:[8]

> In July 1994, Transport Canada issued the National Airports Policy (NAP). The NAP is a major initiative of the federal government which requires the transfer of regional/local or small airports (ownership and operation) to territorial, provincial and local governments, airports commissions, private businesses or other interests .
>
> According to Real Property Management policy requirements, as a result of the transfer of airport property, Transport Canada must ascertain the environmental condition of the property , determine whether to undertake remedial action, and **ensure that such remediation is carried out**. As well , Transport Canada must understand the dynamics of airport activities and their impacts (present and future) on the environment. In order to do this for the proposed transfer of Resolute Bay Arctic "A" Airport to the Government of the Northwest Territories, Transport Canada commissioned this Environmental Baseline Study (EBS).
>
> The EBS was prepared in accordance with the requirements set forth by Transport Canada -Western Region Airports Group. The EBS included a detailed environmental audit and site investigation of all Transports Canada facilities, and airport tenant facilities. The study also includes a review and assessment of hydrogeologic investigations prepared by other consultants in preparation for said transfer. These

[7] Dillon Consulting. Resolute Bay Airport Environmental Baseline Study for Transport Canada, March, 1996, Part A page 8
[8] Dillon Consulting. Resolute Bay Airport Environmental Baseline Study for Transport Canada, March, 1996, Preface

previous investigations were conducted in areas on airport property where subsurface contamination are known or suspected to exist. The EBS provides an environmental regulations assessment of the Resolute Bay Airport and associated facilities, including the activities of Transport Canada and the airport tenants. The EBS report provides an assessment of environmental impacts, and an assessment of non-compliance with environment regulations (federal and NWT territorial), guidelines, and codes of practice. The specific objectives of the EBS can be summarized as follows :

- Assess the adequacy, effectiveness, and efficiency of environmental control systems at the airport;
- Assess whether or not the existing operations and facilities are in compliance with current regulations, guidelines, recommended codes of practice and policies;
- Identify existing and potential environmental problems and deficiencies;
- Determine the possible degree of contamination and environmental impacts of the airport area;
- Make recommendations regarding remedial actions and implementation strategies to resolve operational deficiencies; and
- Provide cost estimates for additional investigations and identified remedial actions. [bold text added]

From a table in this Environmental Baseline Report, the authors state that there exists "Insufficient capacity of sewage lagoons. Permeable sewage lagoons. Potential for discharge of untreated effluent….Confirm sewage quantities are not exceeding license allowance."[9]

The location that Transport Canada chose for the lagoon has resulted a situation where the effluent path flows through a section of the solid waste site. From the 1999 Environmental Site Investigation Final Report:

> "Areas of standing water were noted down -gradient and to the west of the landfill. Potential sources of this moisture include the sewage disposal lagoons located up-gradient and to the east of this area as well as the waste materials contained in the land fill itself. The disposal of wastes in a landfill will typically produce a zone with artificially high permeability and localized mounding of the water table, resulting in a discharge of water/leachate to areas down-gradient of the waste. Given the low amount of annual precipitation in Resolute and the lack of an impermeable liner under the waste. this is not likely a significant concern at the site. Abundant algal and plant growth were noted in the area of the standing water, indicating waters discharged to this area have elevated nutrient concentrations. Therefore, the main source of this moisture is believed to be the Hamlet sewage disposal lagoons, rather than leachate from the wastes."[10] [see Fig. 7 below]

From the 1996 Environmental Baseline Study, a hand-written description of the Sewage Lagoon reveals its design intent:[11]

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[9] Dillon Consulting. Resolute Bay Airport Environmental Baseline Study for Transport Canada, March, 1996, Part A page 17

[10] Dillon Consulting. Resolute Bay Airport Landfill: Environmental Site Investigation for Transport Canada, April, 1999, p. 8

[11] Dillon Consulting. Resolute Bay Airport Environmental Baseline Study for Transport Canada, March, 1996

Sewage Lagoon. Constructed of gravel. 2 cells present. No liner present. Overflows in spring to tundra. Sewage from holding tanks at airport trucked here. Level in lagoon is higher than the ground so may be short-circuiting occurring.
DAS

The water license, signed by the Nunavut Water Board on November 24, 2003,

Fig. 7. Showing effluent path through the solid waste site

Planned Future Facilities:

The Department of Economic Development and Transportation is aware that a new sewage lagoon in a new location will be needed in order to better treat the sewage from the airport buildings, and has substantiated the need for funding this new facility in its Capital Plan. Due to the responsibility of the Federal Government (as a legacy of the National Airports Policy), the Department is exploring avenues to receive specific funding through Transport Canada or other appropriate Federal agencies.

Operation and Maintenance of Sewage Disposal Facilities

Site Description:
Sewage trucks deliver raw sewage at the Monitoring Station Number YRB-2 (see Fig. 8 below). The sewage lagoon is a two-cell engineered exfiltration and over-topping pit. The overall dimensions are approximately 18m x 36m x 2m deep with a one meter wide divider between the two cells.[12] Total capacity is approximately 1,275 m^3. The lagoon is located next to the solid waste facilities (refer to Fig. 1) and the sewage had by design flowed through a part of the solid waste itself prior to spreading across the tundra wetland on its 1.5 km sheet flow to the ocean outfall.

Fig. 8. Sewage Truck depositing effluent in the sewage lagoon

Personnel responsible for the O&M of the sewage lagoon:

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Normal O&M Procedures:
Normal Operation and Maintenance consists of berm inspection and repair, solids removal, sludge removal, and annual decanting.

Berm and Site Inspection and Repair:
The lagoon operator will perform an annual visual inspection of the integrity and height of the berms. This inspection should be made at the end of the decanting period, just before freeze-up in the Fall. If the inspection reveals defects or that additional granular material is needed, repairs will be made immediately, compacting the new material so that it will remain in situ and provide a strong and integrated berm.
In addition, a visual inspection of the signage will be undertaken, and repairs or replacement of damaged signage will ensue immediately

[12] Information supplied by Jason Brown, Airport Manager, Resolute/Nanisivik

Solids Removal:
During the annual inspection, any floating solids discovered will be removed.

Sludge Management:
At the end of the decant season, an inspection will be made of the bottom of the cells. If the amount of sludge build-up is more than 400 mm, excess sludge will be removed (by trash pump while the sludge is still semi-liquid) and placed in a lined and bermed area where the winter's below-zero temperatures will aid in de-watering.

Lagoon Decant Method:
Decant is by continuous slow pumping by portable trash pump from the lower cell of the lagoon. This decant should begin as soon as the weather is sufficiently warm to permit vegetation growth. Assuming a two-month decant period, this decant will proceed at a rate of approximately 40 L/minute, or 2,500 litres per day.
Procedure:

Set the trash pump at a level place near the lower cell of the lagoon and run the 3" hose over the landfill until it rests at the landfill toe. This is done in order to avoid effluent leaching through the mound of solid waste from the edge of the second cell berm, as has always been the method in the past.

Times of Annual Decant:
Start time of Decant:

As soon as the weather is sufficiently warm to permit vegetation growth (sometime in mid-July).

End time of Decant:

When the active layer is once again frozen (sometime in mid-September)

Required Equipment for Decant:

A trash pump and a 3" hose that is sufficiently long to reach grade at the foot of the solid waste site in order to avoid effluent leaching through the mound of solid waste.

Sampling of Effluent:
Location of sampling

Sampling of effluent will take place two times during the two-month decant period: once at the end of July, and once at the end of August. Sampling will take place at the established monitoring points which are indicated by markers:

- Monitoring Station Number YRB-2 (at the truck discharge point): GPS coordinates:
- Monitoring Station Number YRB-3 (Final Discharge Point): GPS coordinates:

Effluent Parameters:

Effluent will be analysed for the following parameters:

- Faecal Coliforms
- BOD_5
- Total Suspended Solids
- pH
- Ammonia Nitrogen

Sampling Methodology:

Sampling methodology will follow the procedures outlined in the Plain Language Manual which is attached as an Appendix to this O&M Manual. An example of a completed sample sheet is included therein.

Site Records:

Site records are necessary to assist in the planning of site operations and meeting regulatory requirements. Information that must be included is:

- Annual volumes of any effluent discharged to the environment
- Monthly volumes of sewage collected
- Details of any maintenance undertaken at site
- Details and approximate volumes of sludge removed
- Record sheets

Safety Procedures:

Operators while engaged in lagoon decant, sludge removal, and berm repair will wear appropriate gear and contaminant-proof clothing and protective gloves, and will dispose of these articles after use.