Government of Nunavut

Dam Safety Review

Type of Document
Final

Project Name
Dam Safety Review
Sewage Lagoon and Water Reservoir
Kimmirut, Nunavut

Project Number
OTT-00209248-A0

Prepared By: Surinder K. Aggarwal, M.Sc., P.Eng.

Reviewed By: Ismail M. Taki, M.Eng., P.Eng.

exp Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6
Canada

Date Submitted
September 13, 2013

Government of Nunavut

Department of Community & Government Services
Directorate - P.O. Box 490
Rankin Inlet, Nunavut X0C 0G0

Attention: Ralph Ruediger

Dam Safety Review

Type of Document:
Final

Project Name:
Dam Safety Review, Sewage Lagoon & Water Reservoir
Kimmirut, Nunavut

Project Number:
OTT-00209248-A0

Prepared By:
Exp Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6
Canada
T: 613-688-1899
F: 613-225-7337
www.exp.com

REGISTERED PROFESSIONAL ENGINEER
Sept 13/13
S.K. AGGARWAL
LICENSEE
NWT/NU

Surinder K. Aggarwal, M.Sc., P.Eng.
Professional License # : L1359
Senior Project Manager, Geotechnical Services
Earth and Environment

Ismail M. Taki, M.Eng, P.Eng.
Professional License # : L1812
Manager, Geotechnical Services
Earth and Environment

Date Submitted:
September 13, 2013

Legal Notification

This report was prepared by **exp** Services Inc. for the account of **Government of Nunavut.**

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. **Exp** Services Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this project

Executive Summary

A dam safety review of the sewage lagoon and the water reservoir located in the Hamlet of Kimmirut, Nunavut was undertaken. This work was authorized by Community and Government Services of the Government of Nunavut.

The review comprised of a review of the available documentation, site visit, interviews with Government of Nunavut and Hamlet staff, and preparation of a report documenting the findings and recommendations.

The existing sewage system of the Hamlet comprises of discharging the effluent in a ditch from where it flows downhill to a pond located east of Lake Fundo.

The old sewage disposal facility was upgraded in 2008. The enhanced sewage disposal facility comprises of an upper lagoon, a lower lagoon and wetlands. The upper lagoon has been created by construction of a berm across a valley. The upper lagoon discharges into a gulch. Since the upper lagoon did not have sufficient storage capacity, the lower lagoon was created by construction of another berm across the gulch approximately 400 m south of the north berm. The berms of both the lagoons have been designed with a crest width of 4m and upstream and downstream slopes of 3H:1V. They are 6 m to 9 m in height. The upper lagoon is designed to store the effluent during the summer months whereas the gulch and the bottom lagoon are designed to receive the effluent during the winter months. The effluent from the lower lagoon is discharged to the wetlands located approximately 150 m southeast of the lagoon.

Review of the upper sewage lagoon berm did not reveal any signs of seepage, slope instability or erosion. Review of the lower sewage lagoon berm indicated that the lower portion of the berm is leaking at several locations and fines have been washed out from the berm in these areas.

The Hamlet uses Lake Fundo as its water source. The water is pumped from the lake to a truck fill station where it receives chlorination. It is then pumped into trucks and supplied to the community. Review of the facilities revealed that the on-ground fuel storage tank with secondary containment has been disconnected and replaced with a single wall tank with no containment.

The enhanced sewage disposal facility has not been commissioned since the Hamlet has the following concerns:

1.) Leakage of lower sewage lagoon berm;

2.) Narrow access road with no passing lanes;

3.) Possibility of contaminating Lake Fundo due to operation of the new lagoon.

Recommendations have been made in the report to remediate the leakage of the berm of the lower lagoon either by construction of a rockfill toe or a rockfill bench. It is recommended that passing lanes should be provided at strategic locations to facilitate passing of vehicles. The potential of contaminating

Lake Fundo due to operation of the new lagoon was reviewed. Although the lagoons are located at a higher elevation than Lake Fundo, they are separated by a mountainous ridge. The effluent from the lagoon will flow downhill via ditches to the wetlands which are located at a lower elevation than Lake Fundo. Therefore, in our opinion, the potential of contaminating the water supply due to operation of the enhanced sewage disposal facility is extremely small to none.

The above and other related considerations have been discussed in greater detail in the report.

Table of Contents

Page

List of Figures

List of Appendices

1 Introduction

A representative of **Exp** Services Inc. (**exp**) visited Kimmirut on July 22 and 23, 2013. The purpose of the visit was to undertake a safety review of the water retaining structures. The visit was in response to one of the requirements of the Water Licence issued by the Nunavut Water Board to the Hamlet of Cape Dorset, Nunavut.

The following facilities were reviewed:

1.) Existing sewage disposal facility;
2.) Enhanced sewage disposal facility; and
3.) Water reservoir and truck fill station.

The locations of the various waste disposal facilities are shown on Figure 1. The locations of the various components of the water supply system are shown on Figure 2.

2 Existing Sewage Disposal Facility

The Hamlet currently discharges its sewage to a ditch adjacent to the solid waste site. The existing discharge point is located approximately 400 m southwest of the closest residence and immediately to the south of the tank farm. The location of the existing sewage disposal site is shown on Figure 1.

The sewage flows downhill in the ditch and discharges into a lake located east of Lake Fundo.

3 Enhanced Sewage Disposal Facility

3.1 Background Information

The sewage disposal facility, as defined in the Water Licence, comprises of an engineered lagoon and an area located south of the lagoon. The sewage disposal facility was constructed in 2001 and was located approximately 1.5 km west of the community. It comprised of a single cell sewage lagoon, a natural valley downstream of the sewage lagoon, which was intended for over winter storage of the sewage in the form of an ice field and a natural wetland. The sewage disposal facility was never commissioned due to Hamlet's concerns with the facility and the access road. The location of the sewage disposal facility is shown on Figure 2.

An assessment of the sewage disposal facility was undertaken in 2007. It concluded that the sewage lagoon did not have sufficient capacity for over winter storage and that the gulch would be required as the main storage facility for the sewage generated over winter months. This sewage would be released to the wetlands in an uncontrolled manner during the spring melt. In addition, the assessment revealed that the berm forming the sewage lagoon required upgrading to stabilize its slopes and to prevent erosion and overtopping. Upon recommendations of the assessment, the existing facility was upgraded and is referred to in the water licence as the enhanced storage disposal facility.

3.2 Enhanced Sewage Disposal Facility

The enhanced sewage disposal facility (Figure 2) comprises of the upper sewage lagoon, a secondary lagoon cell (lower sewage lagoon) constructed at the base of the valley to delay the release of the sewage during spring melt until the wetlands become active, and the wetlands. The 20 ha wetland located downstream of the two sewage lagoons is the primary treatment facility of the enhanced sewage disposal facility.

3.2.1 Review of Design Drawings

Design drawings of the upper and lower sewage lagoons and most of the access road to the sewage lagoon site were available and were reviewed.

A review of the design drawing for the lagoons prepared by **exp** revealed the following:

3.2.1.1 Upper Sewage Lagoon

The Upper Sewage Lagoon berm is ~ 6.0 m high, 4.0 m wide and with side slopes of 3H:1V. The design effluent level is Elevation 97.5 m. The spillway is located at the mid-length of the berm. It is 1 m wide and 1 m deep with side slopes of 3H:1V for a distance of 1m and at a slope of 4H:1V beyond (Figure 4). The spillway channel has been provided with layer of rip rap to control the erosion. Two discharge chutes have been provided. The summer discharge chute is located north of the berm and will discharge the effluent into the lagoon whereas the winter discharge chute is located south of the berm and will discharge the effluent in the gulch south of the lagoon.

3.2.1.2 Lower Sewage Lagoon

The lower sewage lagoon (Figure 5) is located in the gulch approximately 400 m south of the upper sewage lagoon. It was constructed by installing a berm across the valley. The design lagoon level is at Elevation 71.5 m. The crest of the berm is 4 m wide with upstream and downstream slopes of 3H:1V. The spillway is located at the west end of the berm. Its construction is similar to that of the upper sewage lagoon spillway.

3.2.2 Site Visit

3.2.2.1 Upper Sewage Lagoon

The sewage disposal facility was reviewed. The upper sewage lagoon comprises a natural valley, which has been dammed by construction of an earth berm across the valley (Photo 1). The upstream slope of the berm is approximately 5 m high whereas the downstream slope of the berm is approximately 9 m high. The crest width of the berm is approximately 4 m. The berm slopes are approximately 3H:1V. The berm consists of silty sand and gravel. Visual examination of the berm did not reveal any signs of seepage, erosion or slope instability.

A 150 mm diameter inlet pipe extending from the bottom of the lagoon to the top of the berm has been provided along the upstream slope of the berm. Similarly, a 150 mm diameter outlet pipe has been provided from the top of the berm to the gulch along the downstream slope of the berm (Photo 2). A spillway is located at the mid-length of the berm. The spillway comprises of a 1 m deep and 1 m wide channel with side slopes of 3H:1V for a distance of 1 m and 4H:1V beyond. The spillway has been lined with a 300 mm thick layer of 100 mm nominal rip rap.

Two discharge chutes have been provided at the lagoon. The summer storage discharge chute is located upstream of the berm and would discharge the effluent into the lagoon. The winter storage discharge chute is located downstream of the berm (Photo 2) and would discharge the effluent to the gulch. The discharge chutes have been provided with 3 m wide gabion mats to minimize erosion at the discharge points.

3.2.2.2 Lower Sewage Lagoon

The lower sewage lagoon comprises of the gulch, which has been converted to a lagoon by construction of a berm across the gulch (Photo 3). The height of the berm is 6 m approximately. The crest width of the berm is approximately 4 m. The slope of the berm is at an approximate inclination of 3H:1V. The berm has been constructed with silty sand and gravel with cobbles.

The lower lagoon has also been provided with 150 mm diameter inlet (Photo 4) and outlet pipes (Photo 5) similar to the upper lagoon. A spillway has been provided at the west end of the berm. The design of the spillway is similar to that of the upper sewage lagoon.

A visual examination of the berm was undertaken. At the time of the inspection, the berm contained approximately 1 m of water, which is reported to be the snow melt water. The examination of the berm

revealed that the berm is leaking. Water was observed to seep out of the berm from the bottom of the berm to a height of 1.5 m approximately at a number of locations along the length of the berm (Photo 6). Seepage of water at these locations has resulted in removal of fines from the berm and exposure of the coarse aggregate. It is understood that the berm has been designed as a seepage berm. However, concentrated zones of water seepage in the berm are a concern since, in time, these could form erosion gulleys, eventually leading to failure of the berm. The concentrated zones of water seepage are likely due to presence of pockets of coarser material in the berm.

Apart from seepage out of the downstream slope of the berm, there were no signs of instability of the upstream and downstream slopes of the berm. In addition, there was no evidence of erosion since the facility was never commissioned.

3.3 Wetlands

Wetlands are located approximately 150 m southeast of the lower sewage lagoon. The path of the seepage water from the lower sewage lagoon to the wetlands was traced. Based on these observations, it is considered that the effluent from the sewage lagoon would flow in a southerly direction through a number of drainage ditches and low lying areas a distance of 300 m approximately before entering the wet lands (Photos 7 and 8). The flow path has been plotted on Figure 2.

3.4 Access Road

The access road from the Hamlet to the enhanced sewage disposal facility is approximately 1.5 km long. It is 600 m wide. The road traverses through mountainous terrain and contains a number of bends. It traverses through valleys and knolls. Its elevation varies from Elevation 60 m approximately at the Hamlet to Elevation 100.0 m approximately at the sewage dumping station. The gradient of the road varies from 0.14 percent to 12 percent.

It is reported that the old road was very narrow and steep. This road was widened and its profile adjusted to reduce the grades of the road.

4 Water Supply and Truck Fill Station

The Hamlet currently uses Lake Fundo as its water source (Photo 9). Supply is taken from Fundo Lake via an inclined shaft which is equipped with a submersible pump located below the water level in the lake. Water is pumped from the lake to the truck fill station (Photo 10). Water treatment at the truck fill station is limited to chlorination (Photo 11) and freeze prevention. The water is transported by trucks from the truck fill station to the community.

The truck fill station is generally in good operating condition and appears to be well maintained. Chlorine concentrations are logged on a regular basis and appropriate safety equipment is available within the facility.

It was observed that the original exterior fuel tank which is a double walled tank has been disconnected and not used to store diesel fuel. This operating tank is provided with a containment unit so that any spills or leakage from the tank would be contained in the containment unit. A single wall fuel tank has been installed without appropriate secondary containment (Photo 12). Consequently, in the case of accidental spillage or leakage of the tank, there is a potential of contaminating the water source with hydrocarbons.

Visual observations did not reveal any signs of slope instability or erosion.

5 Interview with Staff

Informal interviews were held with Government of Nunavut and Hamlet of Kimmirut staff.

As indicated previously, the new sewage lagoons were never commissioned as the Hamlet of Kimmirut has following concerns regarding the commissioning of this facility.

1.) Leakage of the Lower Lagoon berm;

2.) Narrow access road with steep gradient and no passing lanes; and

3.) Possibility of contamination of Lake Fundo (which is the community's water source) due to its proximity to the sewage lagoons and the wetlands.

6 Remedial Measures

In order to render the facility operational, the following remedial measures are suggested:

6.1 Leaking Berm

It is understood that the berm of the lower sewage lagoon was designed as a seepage berm and a liner was not installed in the berm. As a result, seepage of effluent out of the berm is to be expected since in a completely homogeneous section, it is inevitable that seepage will emerge on the downstream slope regardless of its flatness and impermeability of the soil. The downstream slope is affected by seepage to a height of roughly one third of the depth of the reservoir pool (See Figure 6).

In order to prevent removal of fines from the berm, it is considered that there are two options available:

1.) Provision of a rockfill toe of the berm;

2.) Construction of a rockfill bench along downstream slope of the berm.

6.1.1 Provision of a Rockfill Toe of the Berm

This option would require providing a rockfill toe for the berm. For this purpose, it would be necessary to dewater the lagoon and remove the toe of the berm to a height of 2 m. The excavation should then be lined along the cut and base of the berm with a suitable filter cloth, such as Terrafix 400R or equivalent. The toe of the berm may then be re-constructed using rockfill. Construction of the rockfill toe in this manner will prevent migration of fines from the berm and it will lower the phreatic line such that it will not daylight along the slope.

6.1.2 Construction of a Rockfill Bench

The second option is to construct a rockfill bench at the downstream toe of the berm. The advantage of this approach is that it can most likely be installed without having to dewater the lagoon. This method would require placement of filter cloth, such as Terrafix 400R or equivalent along the downstream slope of berm to a height of at least 2 m and along the ground surface. A rockfill bench may then be constructed. The rockfill bench should be at least 2 m high and 2 m wide at the base.

It is noted that both the remedial measures suggested would maintain the functionality of the berm as an exfiltration berm. However, from a geotechnical perspective, the latter option of rockfill benches is to be preferred because of the following reasons:

1.) Construction of a rockfill toe will require undertaking excavation at the toe of the slope. This would affect the stability of the slope and may result in localized failures of the slope.

2.) Construction of the rockfill toe would require emptying the lagoon.

3.) The ability of the rockfill toe to lower the phreatic line in the berm is a function of relative permeability of the berm material and that of the rockfill toe material since it is based on the

premise that water takes path of least resistance. A proper design of the rockfill toe will require gradation analysis of the berm material and that of the proposed rock fill to enable construction of flow nets through the berm. Sampling and testing of the materials is expected to be quite difficult and expensive.

In the case of the rockfill bench, it will not be necessary to empty the lagoon. The phreatic surface in the berm will be maintained. Placement of the filter cloth and rockfill bench will prevent the removal of fines from the berm material as well as increase the stability of the berm slope.

6.2 Access Road

It is recommended that passing lanes should be provided at strategic locations along the access road to facilitate passing of vehicles.

6.3 Potential of Water Source Contamination

The Hamlet has expressed concern regarding the possibility of contamination of the water source if the lagoon is put into operation. It is noted that the sewage lagoon is located at a higher altitude (Elevation 97.5 m and Elevation 71.5) compared to Lake Fundo (Elevation 33 m). However, the lagoon is located at least 200 m away from the lake and is separated by a mountainous ridge. The effluent from the upper lagoon will be discharged into a gulch, which is confined. As a request, the effluent will flow to the lower lagoon. From the lower lagoon, the effluent will be discharged downhill to the wetland, which at Elevation 22 m is located lower than Lake Fundo (Elevation +/- 33 m). During the site visit, the flow of water from the lower lagoon to the wetlands was traced. The approximate path has been plotted on Figure 2. Therefore, in our opinion, the potential of the effluent from the sewage lagoons or from the wetlands contaminating the water in Lake Fundo is extremely low to none.

7 Consequences of Dam Failure

Since the facility has not been commissioned to date, presently there is no consequence of failure of the dam. Once the facility is operational, failure of dam would result in uncontrolled discharge of the effluent to the wetlands. This may result in eutrophication of the wetlands, which may adversely impact aquatic life, e.g. fish habitat, etc. There are no other developments located downhill of the lagoon, and as such, there is no danger to humans in case of failure of the berms of the lagoons.

8 Conclusions

Based on a review of the design drawings and site conditions, it is considered that the new sewage lagoon should not be used until such time that one of the remediation options have been implemented and the access road to the lagoon has been provided with a passing lane at strategic locations. The potential of effluent from the lagoons impacting the Lake Fundo water source was investigated. It is concluded that the effluent from the sewage lagoons is unlikely to adversely impact the water quality of Lake Fundo.

No safety concerns related to the existing lagoon, emergency lagoon, and the water reservoir were identified during the site review.

Figures

Photos

Photograph No. 1
Upstream view of upper sewage lagoon berm

Photograph No. 2
View of gulch, winter discharge chute and outlet pipe

Photograph No. 3
View of lower sewage lagoon berm

Photograph No. 4
Inlet pipe of lower sewage lagoon

Photograph No. 5
Outlet pipe of lower sewage lagoon

\

Photograph No. 6
Leakage of lower sewage lagoon berm

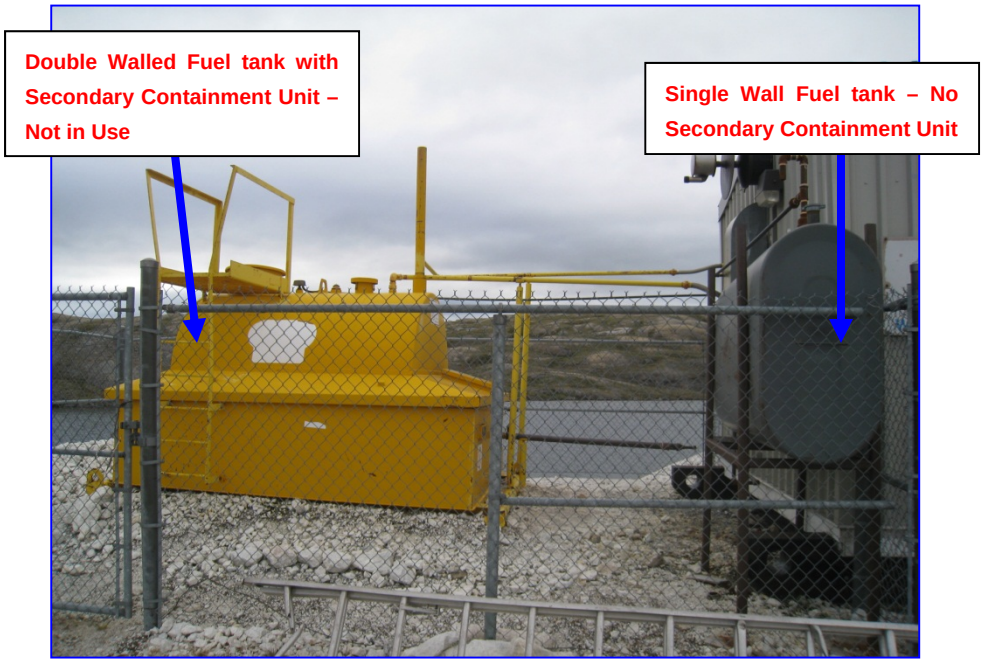
Photograph No. 7
View of wetland area

Photograph No. 8
Another view of wetland area

Photograph No. 9
Lake Fundo (water source)

Photograph No. 10
Intake pipe and truck fill station

Photograph No. 11
View of chlorination plant



Photograph No. 12
View of diesel fuel storage tank with secondary containment and single wall fuel tank

List of Distribution

Report Distributed To:

Ralph Ruediger, Government of Nunavut - RRuediger@gov.nu.ca