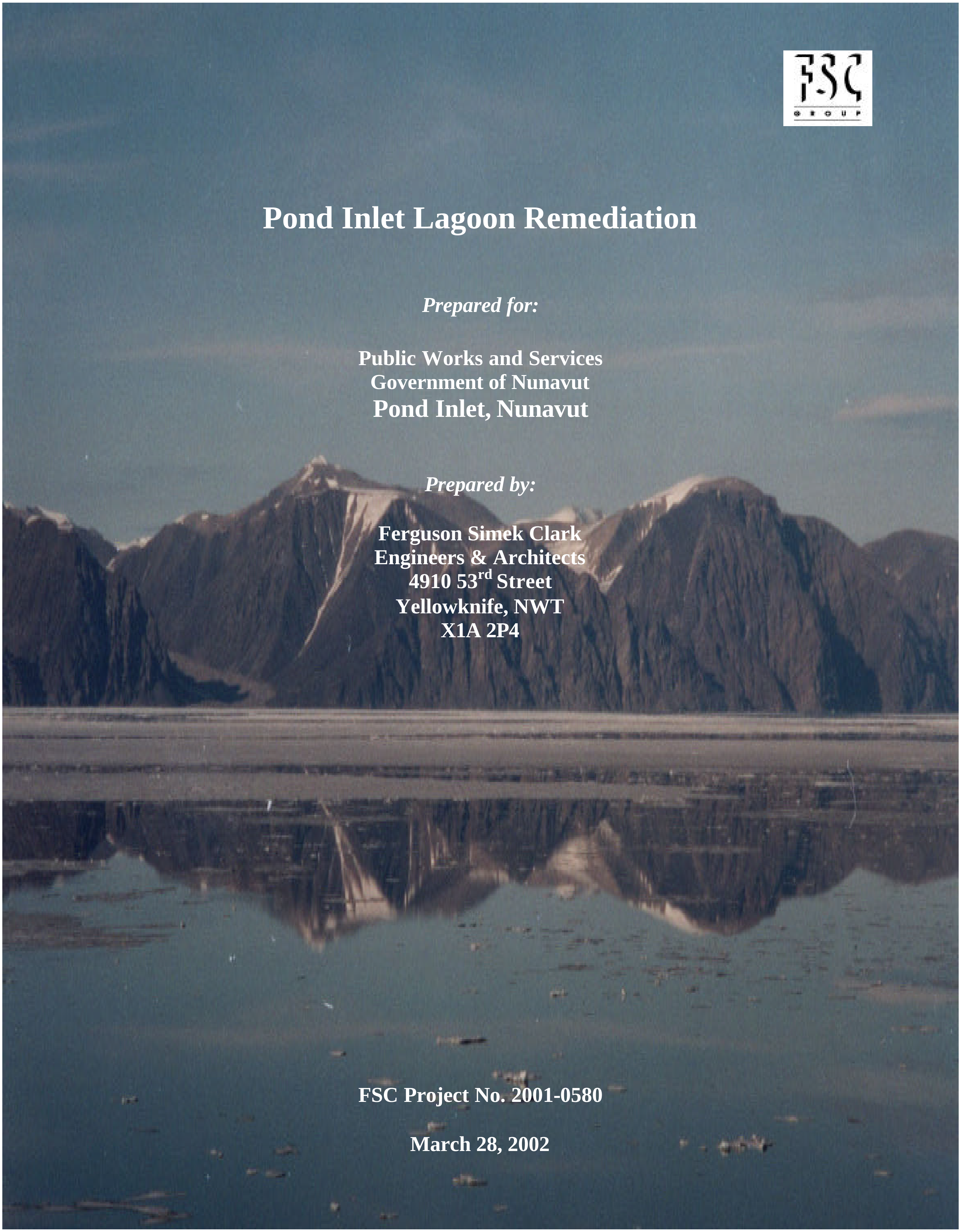

Pond Inlet Lagoon Remediation

Prepared for:

Public Works and Services
Government of Nunavut
Pond Inlet, Nunavut

Prepared by:

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FSC Project No. 2001-0580

March 28, 2002

Pond Inlet Sewage Lagoon

Final Report

prepared for:

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Government of Nunavut
Pond Inlet, Nunavut

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1 INTRODUCTION

1.1 PURPOSE OF REPORT

The purpose of this report is to:

- Review the preliminary options, including the Bentomat ST liner, for the sewage lagoon in Pond Inlet; and
- Provide a Class D cost analysis for the options.

1.2 BACKGROUND

1.2.1 EXISTING LAGOON

Commissioned in 1996, the lagoon is located about 1.6 kilometres south-east of the Hamlet. It is an irregularly shaped 6 sided earthen fill structure. Based on a September 2001 survey, it has 47,600m^2 surface area and an estimated depth of 2.5 metres to provide a working volume with 1 metre freeboard of 37,600 m^3.

The original lagoon design was with 4:1 side slopes and an 8 metre top. The berm was to built over soil which had been scarified to a depth of 150mm to 200mm. Based on the geotechnical report, the lagoon was intended not to seep.

The site is a glacial rubble field with 300mm+ rocks layered over each other. David Parker, P. Eng. advised that he had been the Project Officer during the construction. The rubble field made it impossible to scarify the soil as per the design. Instead, the berm was constructed directly over the rubble.

1.2.2 SEEPAGE FROM LAGOON

During the first year following commissioning there was no seepage evident. In the second year, it was reported by Hamlet authorities that there was a seepage problem. The exterior of the corner of the northeast berm and the east berm were wet.

Remedial work was attempted. The wet areas were excavated and additional fill placed. However, this did not reduce the problem.

Each following year more of the northeast berm became affected. More recently, liquid began to pipe through and under the northeast corner.

An Environment Canada Inspector witnessed seepage from the northeast corner of the lagoon in April 2001 and issued a direction to contain the seepage.

FSC staff inspected the site on July 23, 2001. Liquid was flowing freely under the northeast corner and elsewhere through and under the northeast berm. The Hamlet was following the Inspector's direction by collecting the seepage in a sump and pumping it back into the lagoon. This operation was further exacerbating the situation. The liquid was obviously transporting berm materials. Longitudinal cracking was observed along the berm. Concern was held for the structural integrity of the berm.

The Nunavut Water Board and the DIAND Inspector were contacted. Permission was granted to discharge the lagoon. Doing so relieved the pressure on the berms and may have prevented further structural damage. Samples of the effluent collected at SNP Station PON-3, showed that the lagoon effluent was in compliance.

1.2.3 LINER

FSC provided a preliminary analysis and options to meet the Inspector's direction. One option was to build a new lined lagoon and reclaim the existing lagoon as a sludge farm. Based on a very preliminary estimate hurried to meet the sealift schedule, 83,600 m^2 of Bentomat ST liner was purchased and shipped to Pond Inlet.

1.2.4 CURRENT SEWAGE DISPOSAL

The Hamlet is now operating under amended water licence that allows the direct discharge of untreated sewage to a nearby gully/wetland while repairs/modifications are made.

2 PRELIMINARY DESIGN CONSIDERATIONS

2.1 POPULATION

The population of Pond Inlet during the 1996 census was 1154. Population projections are based on the 1996 census projected to 2021.

Table 2.1 Population Projection to 2021

Year	Population
1996	1154
2001	1325
2006	1521
2011	1746
2016	2005
2021	2302

2.2 SLUDGE ACCUMULATION

The rate of sludge accumulation is unknown in the high arctic.

Research in the 1970's suggested that sludge accumulation could be estimated as a function of increasing latitude from 0.24 to 0.4 m^3/1000 people/day.

A second estimation method is to assume that the lagoon removes 90% of influent solids. Additionally the lagoon grows approximately 200 mg/l of algae, which could be removed in a fill and draw system at 90%. It may be further assumed that no degradation of the solids occurs and the sludge reaches a density of 40%.

Neither of these estimates appear to reflect the existing conditions experienced on site and now shown in the photographic record. The sludge accumulation appears to be much greater. How much impact the vegetation with in the area may be an influence is also unknown.

After further study, we concluded that the detritus was not removed from the former lake before the lagoon was commissioned. However, we do not know how much detritus was present. To account for this material, for planning purposes, we will assume the amount of sludge generated in the first five years is double the amount projected. After that period, we will assume that the sludge will accumulate at the projected rates.

2.3 LINER

Based on a very preliminary pre-design of a new sewage lagoon, 83,600 m^2 of liner material was pre-purchased. This also included a 10% increase for the lagoon plus a 20% overall increase at the client's request.

Table 2.2 Sewage Generation Pond Inlet

Pond Inlet Water/Sewage Production Rate 1996-2020

Census Population				1154				
Census Year				1996				
% Population Increase				2.8				
Water Use per capita				70				
Algae in the lagoon				200				
Solids accumulated (%)				40				
Solids Accumulated Estimate Correction Factor				1.4E-09				
				Daily	Annual			Solids
Planning	Calendar	Total	Projected	Projected	Projected	Suspended	Solids	Accumulated
Year	Year	Population	Water Use	Volume	Volume	Solids	Retained	Estimate
		#	lpcd	litres	litres	(mg/l)	(mg/l)	(m3)
	1996	1154	70.00	80,780	29,484,700	686	797	33
	1997	1186	89.10	105,700	38,580,483	539	665	69
	1998	1220	89.63	109,312	39,898,786	536	662	106
	1999	1254	90.18	113,062	41,267,519	532	659	144
	2000	1289	90.75	116,956	42,688,862	529	656	183
0	2001	1325	91.33	121,000	44,165,098	526	653	223
	2002	1362	91.93	125,202	45,698,623	522	650	265
	2003	1400	92.54	129,567	47,291,945	519	647	308
	2004	1439	93.17	134,103	48,947,697	515	644	352
	2005	1480	93.82	138,818	50,668,638	512	640	397
5	2006	1521	94.49	143,720	52,457,663	508	637	444
	2007	1564	95.17	148,816	54,317,809	504	634	492
	2008	1607	95.88	154,116	56,252,259	501	631	542
	2009	1652	96.60	159,628	58,264,357	497	627	593
	2010	1699	97.35	165,363	60,357,611	493	624	646
10	2011	1746	98.11	171,331	62,535,702	489	620	700
	2012	1795	98.90	177,541	64,802,494	485	617	756
	2013	1845	99.71	184,006	67,162,045	481	613	814
	2014	1897	100.54	190,736	69,618,615	477	610	873
	2015	1950	101.40	197,744	72,176,679	473	606	935
15	2016	2005	102.28	205,044	74,840,935	469	602	998
	2017	2061	103.18	212,647	77,616,320	465	599	1,063
	2018	2119	104.11	220,570	80,508,020	461	595	1,130
	2019	2178	105.06	228,826	83,521,484	457	591	1,199
	2020	2239	106.05	237,431	86,662,437	453	587	1,270
20	2021	2302	107.06	246,402	89,936,898	448	584	1,344

3 OPTIONS

3.1 TWO CELL LAGOON OPTIONS

The first options proposed to meet the 20-year needs of the community are four, two-cell lagoon options. Options now under consideration include:

1. Remediate existing lagoon at the current elevation and construct a second lagoon in different location to provide a combined storage for the 20 year population; and

2. Close out existing site and construct two new cells at another location or locations

Locations for proposed new lagoon cells:

1. Cell 2: Near the existing road

2. Cell 3: Distant from the existing road

3. Cell 4: Twin cell of Cell 3

For locations of all the proposed cells see Figure 1. The first two options look at remediating the existing lagoon as shown in Figure 2 and then constructing an a second lagoon. The second two options require closing out of the existing lagoon and construction of two new cells.

3.1.1 OPTION 1 – CELL 1: REMEDIATE EXISTING LAGOON, CELL 2: NEAR EXISTING ROAD

To remediate the existing lagoon all the sludge and rubble will be scraped to the SE end of the lagoon. The north berm indicated on Figure 2 will be reworked by excavating the slope on the interior of the lagoon and then to replace and compact the materials.

A new berm will then be constructed to separate the new lagoon from the sludge disposal area. The liner cushion, liner, and liner cover will then be installed. The new lagoon will cover 28,000m^2 of the existing lagoon and the other 18,000m^2 will be sludge disposal area.

For planning purposes of Cell 2, we are assuming a one meter cut for the rubble. This cut must verified through a geotechnical survey prior to beginning construction. Rubble removed from the cut will be used to level the site and additional fill will be needed. New berms will be built and the liner cushion, liner and liner cover installed. Cell 2 is close to the existing road, however, short road and turnaround are required. See Figure 3.

Table 3.1 Estimated Cost Analysis, Option 1

Remediation of Existing Lagoon	Quantity	Unit Cost	Extended Cost
Bentomat ST Liner	37,126	$6	pre-purchased
Volume of North berm to be reworked (m^3)	2,392	$15	$35,880
Sludge from existing lagoon to be scraped to SE corner (m^3)	28,000	$15	$420,000
Cover rubble to level surface (m^3)	5,400	$35	$189,000
Volume of new Berm between lagoon and sludge (m^3)	7,325	$35	$256,368
Area to be covered with liner (m^2)	37,126	$1	$37,126
Berm cover material (m^3)	1,358	$50	$67,900
Cover materials for liner (m^3)	13,000	$50	$650,000
Liner cushion material (m^3)	7,590	$50	$379,500
Subtotal			$2,035,774
Engineering & Contingencies @40%		40%	$814,310
Total			$2,850,084
Construction of Cell 2	**Quantity**	**Unit Cost**	**Extended Cost**
Bentomat ST Liner	28,650	$5.56	pre-purchased
Clear rubble to 1m (m^3)	2,530	$15	$37,950
Volume required for new berms (m^3)	34,793	$35	$1,217,755
Area to be covered with liner (m^2)	39,024	$1	$39,024
Volume of berm cover material (m^3)	1,544	$50	$77,200
Cover materials for liner (m^3)	14,500	$50	$725,000
Liner cushion material (m^3)	8,460	$50	$423,000
Base fill to bottom of berm (m^3)	26,200	$35	$917,000
Access road and turnaround (m)	20	$1,000	$20,000
Sub-total			$3,436,929
Engineering and Contingency @40%			$1,374,772
Total			$4,811,701

OPTION 1			
Total			**$7,661,784**

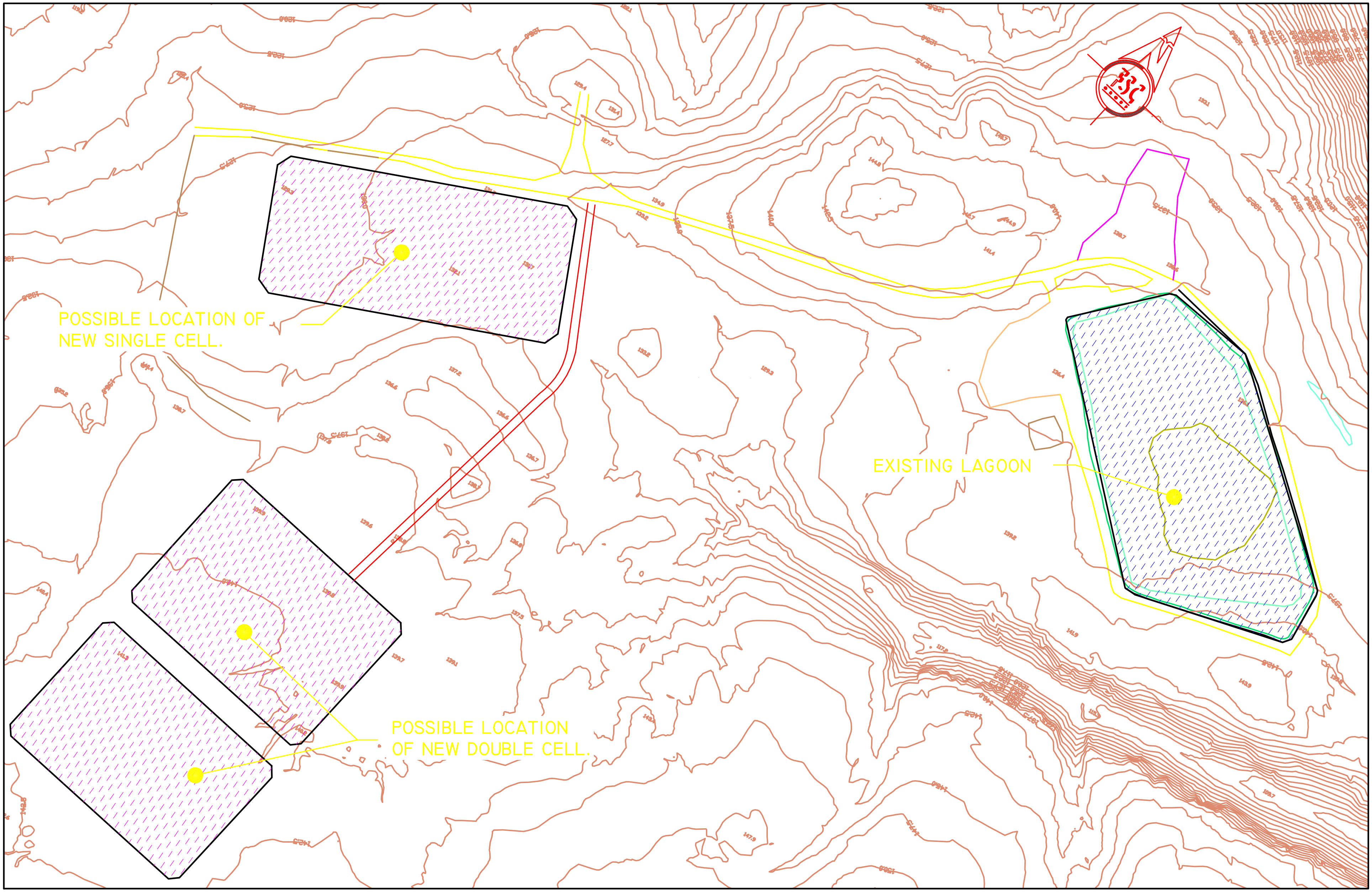

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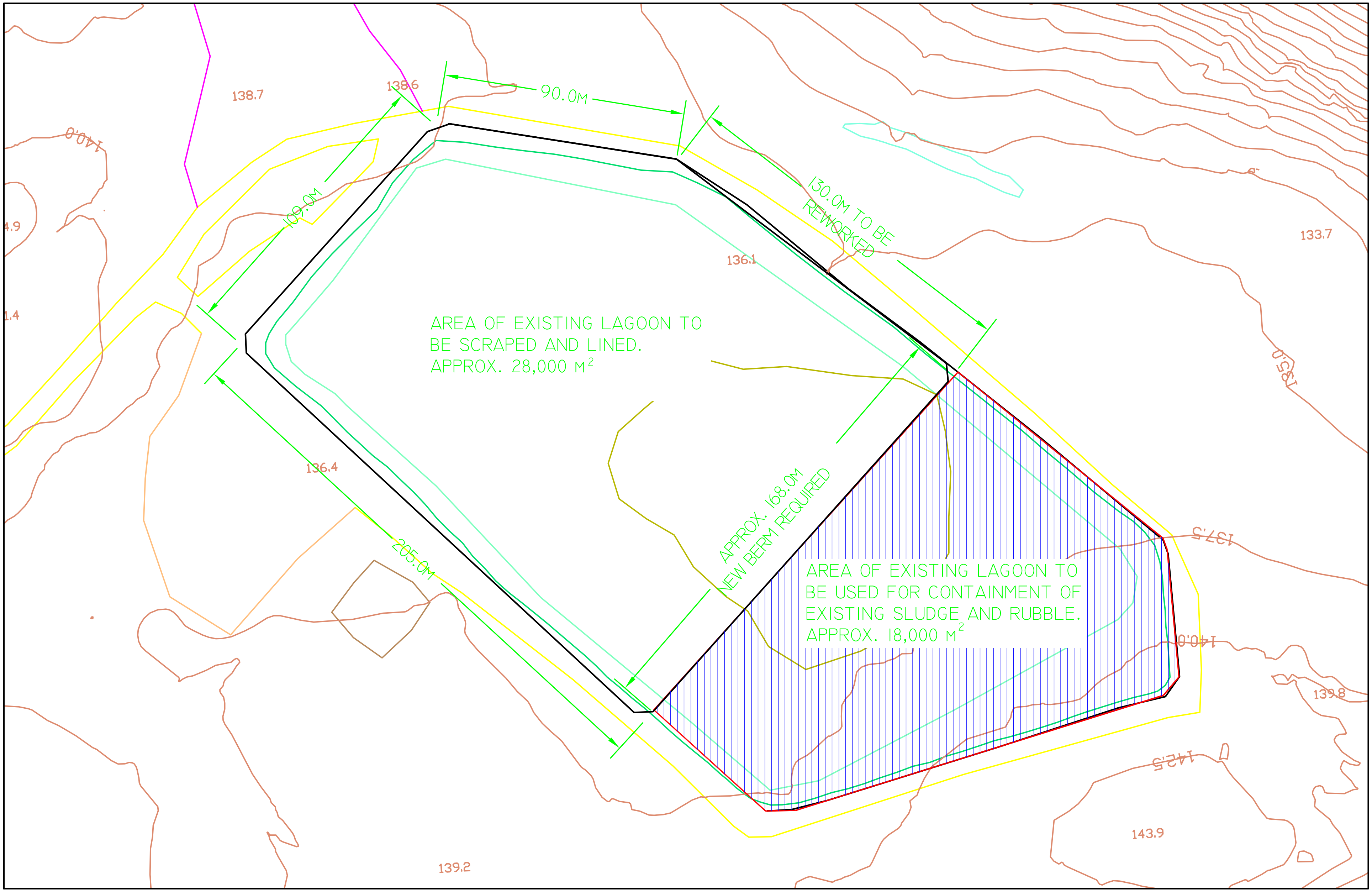
FIGURE NO.
1



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Pond Inlet Sewage Lagoon - Existing Lagoon Reclamation

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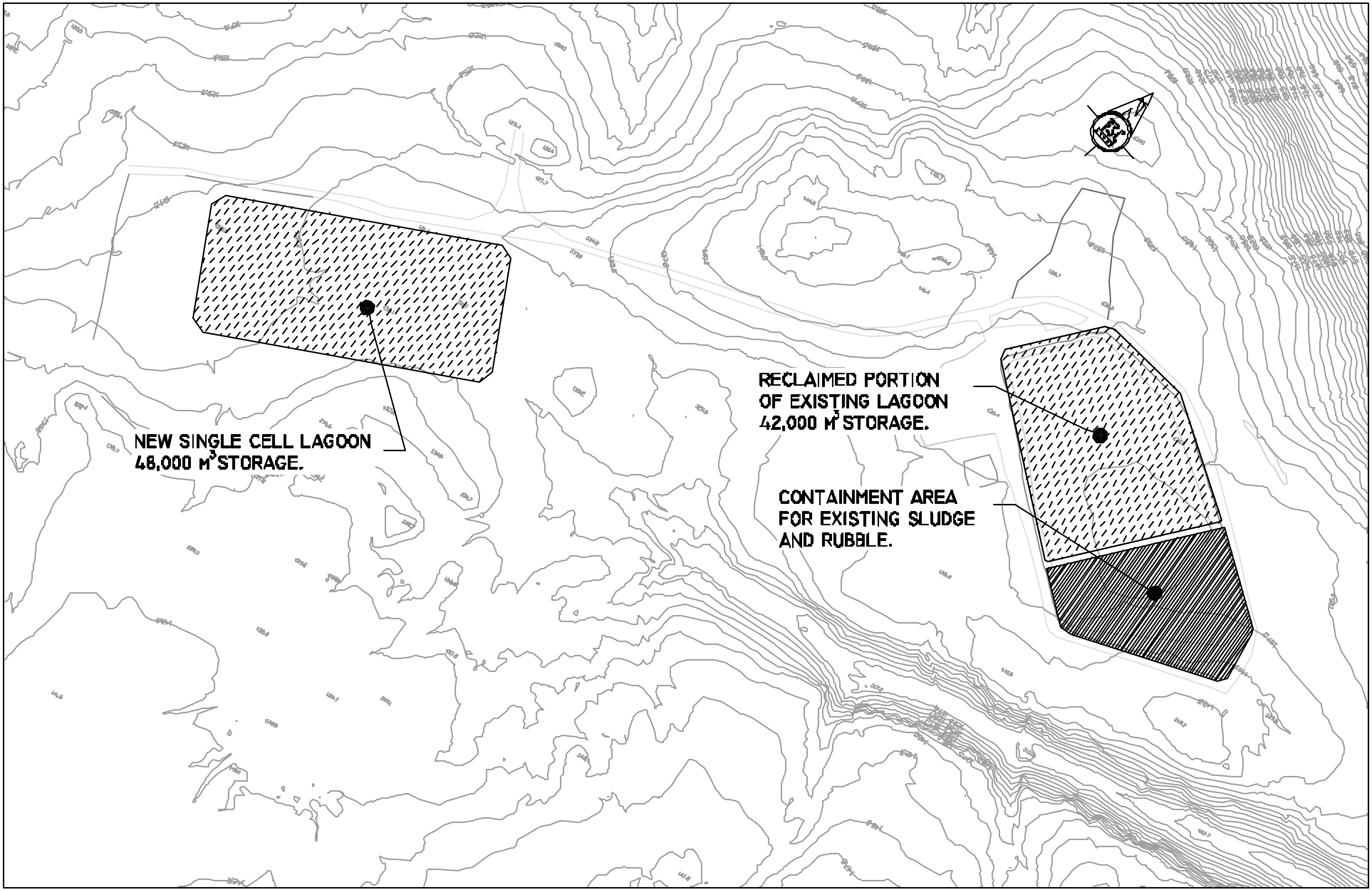
FIGURE NO. 2



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Pond Inlet Sewage Lagoon - Option 1

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FIGURE NO. 3

3.1.2 OPTION 2 – CELL 1: REMEDIATE EXISTING LAGOON, CELL 3: DISTANT FROM THE ROAD

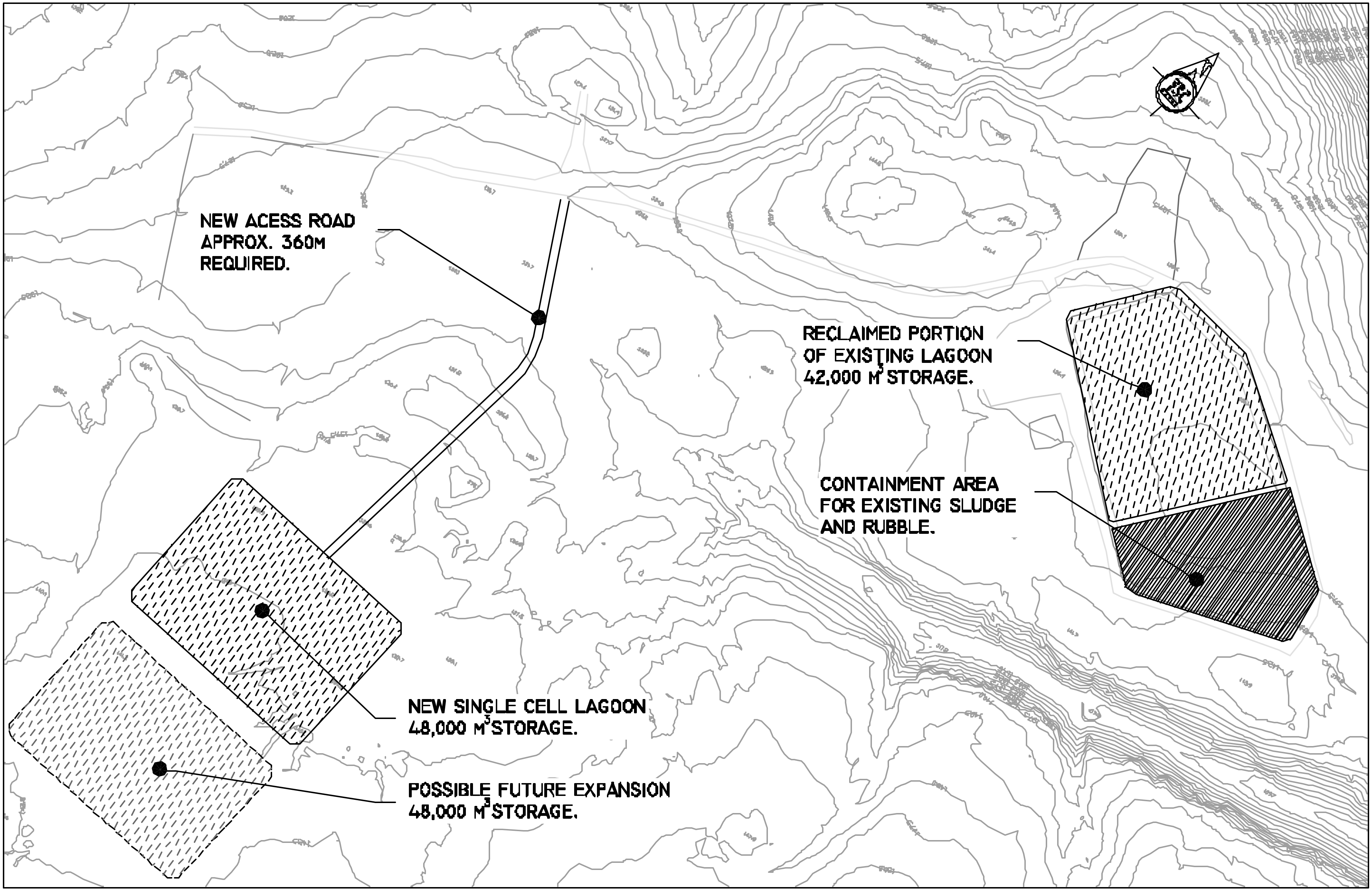
To remediate the existing lagoon all the sludge and rubble will be scraped to the SE end of the lagoon. The north berm indicated on Figure 2 will be reworked by digging out the slope on the interior of the lagoon and repacking it.

Once the scraping and repacking are complete a new berm will be constructed to separate the new lagoon from the sludge disposal area. The liner cushion, liner and liner cover will then be installed. The new lagoon will cover 28,000m^2 of the existing lagoon and the other 18,000m^2 will be sludge disposal area.

For the construction of Cell 3, we are assuming a one meter cut for the rubble. New berms will be built and the liner cushion, liner and liner cover installed. Cell 3 is 360m from the existing road, therefore a new road and truck turnaround must be built. See Figure 3.

Table 3.2 Estimated Cost Analysis Option 2

Remediation of Existing Lagoon	**Quantity**	**Unit Cost**	**Extended Cost**
Bentomat ST Liner	37,126	$6	pre-purchased
Volume of North berm to be reworked (m^3)	2,392	$15	$35,880
Sludge from existing lagoon to be scraped to SE corner (m^3)	28,000	$15	$420,000
Cover rubble to level surface (m^3)	5,400	$35	$189,000
Volume of new Berm between lagoon and sludge (m^3)	7,325	$35	$256,368
Area to be covered with liner (m^2)	37,126	$1	$37,126
Berm cover material (m^3)	1,358	$50	$67,900
Cover materials for liner (m^3)	13,000	$50	$650,000
Liner cushion material (m^3)	7,590	$50	$379,500
Subtotal			$2,035,774
Engineering & Contingencies @40%		40%	$814,310
Total			$2,850,084
Construction of Cell 3	**Quantity**	**Unit Cost**	**Extended Cost**
Bentomat ST Liner	28,650	$5.56	pre-purchased
Clear rubble to 1m (m3)	7,225	$15	$108,375
Volume required for new berms (m^3)	32,656	$35	$1,142,960
Area to be covered with liner (m^2)	38,937	$1	$38,937
Volume of berm cover material (m^3)	1,449	$50	$72,450
Cover materials for liner (m^3)	14,500	$50	$725,000
Liner cushion material (m^3)	8,460	$50	$423,000
Base fill to bottom of berm (m^3)	16,890	$35	$591,150
Access road and turnaround (m)	360	$1,000	$360,000
Sub-total			$3,461,872
Engineering and Contingency @40%			$1,384,749
Total			$4,846,621
OPTION 2			
Total			**$7,696,704**



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Pond Inlet Sewage Lagoon - Option 2

2001-0580

FIGURE NO. 4

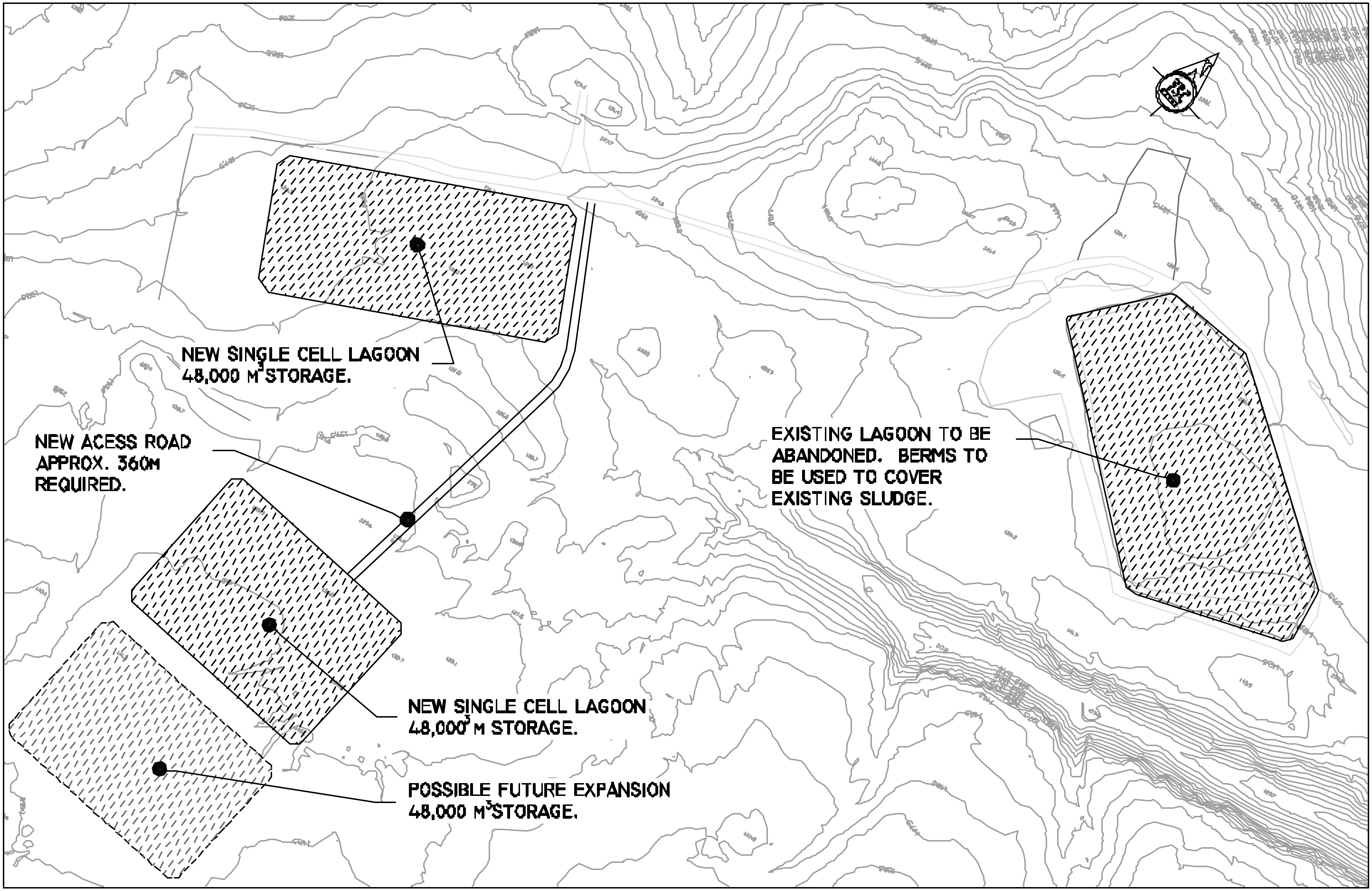
3.1.3 Option 3 –Cell 2: Near existing road, Cell 3: Distant from the road

A close out procedure for the existing lagoon must also be included in this option. The existing berms will be pushed in and then the site will be covered with 300 mm of fill.

Construction of the new lagoons assumes a one meter cut of rubble for both sites. New berms will be built and the liner cushion, liner, and liner cover installed. Cell 3 is 360m from the existing road, therefore a new road must be built. A short road is required for Cell 2. See Figure 5.

Table 3.3 Estimated Cost Analysis Option 3

Construction of Cell 2	**Quantity**	**Unit Cost**	**Extended Cost**
Bentomat ST Liner	28,650	$5.56	pre-purchased
Clear rubble to 1m (m^3)	2,530	$15	$37,950
Volume required for new berms (m^3)	34,793	$35	$1,217,755
Area to be covered with liner (m^2)	39,024	$1	$39,024
Volume of berm cover material (m^3)	1,544	$50	$77,200
Cover materials for liner (m^3)	14,500	$50	$725,000
Liner cushion material (m^3)	8,460	$50	$423,000
Base fill to bottom of berm (m^3)	26,200	$35	$917,000
Access road and turnaround (m)	20	$1,000	$20,000
Sub-total			$3,456,929
Engineering and Contingency @40%			$1,382,772
Total			$4,839,701
Construction of Cell 3	**Quantity**	**Unit Cost**	**Extended Cost**
Bentomat ST Liner	28,650	$5.56	pre-purchased
Clear rubble to 1m (m3)	7,225	$15	$108,375
Volume required for new berms (m^3)	32,656	$35	$1,142,960
Area to be covered with liner (m^2)	38,937	$1	$38,937
Volume of berm cover material (m^3)	1,449	$50	$72,450
Cover materials for liner (m^3)	14,500	$50	$725,000
Liner cushion material (m^3)	8,460	$50	$423,000
Base fill to bottom of berm (m^3)	16,890	$35	$591,150
Access road and turnaround (m)	360	$1,000	$360,000
Sub-total			$3,461,872
Engineering and Contingency @40%			$1,384,749
Total			$4,846,621
Close out of existing lagoon	**Quantity**	**Unit Cost**	**Extended Cost**
Volume of berms to push in	38,478	$15	$577,170
Cover rubble (300mm)	13,800	$35	$483,000
Subtotal			$1,060,170
Engineering & Contingencies		40%	$424,068
Total			$1,484,238
OPTION 3			
Total			**$11,170,559**



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Pond Inlet Sewage Lagoon - Option 3

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FIGURE NO. 5

3.1.4 OPTION 4 – CELL 3: DISTANT FROM THE ROAD, CELL 4: TWIN CELL OF CELL 3

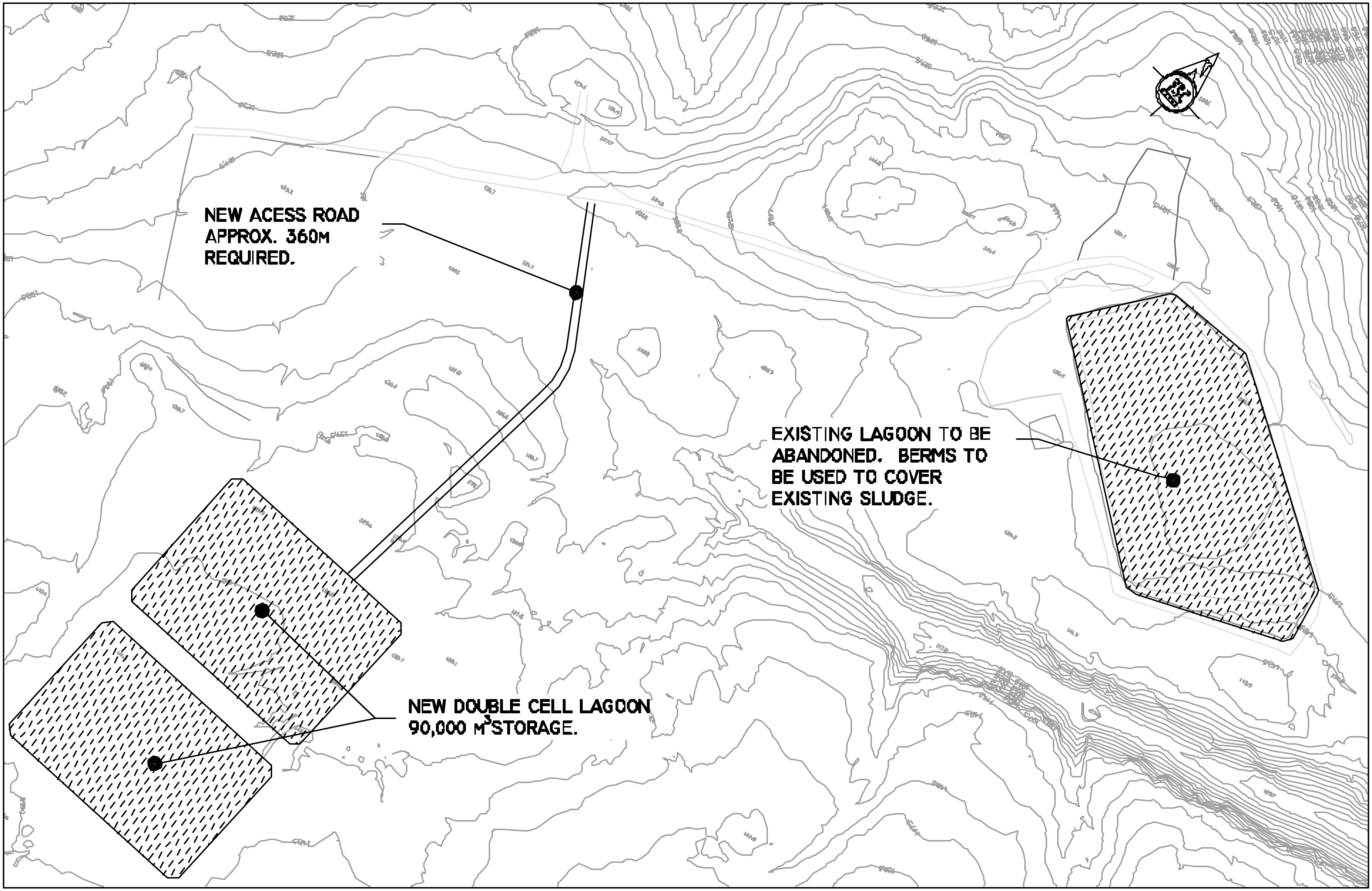
A close out procedure for the existing lagoon must also be included in this option. The existing berms will be pushed in and then the site will be covered with 300 mm of fill.

Construction of the new lagoons assumes a one metre cut of rubble for both sites. New berms will be built and the liner cushion, liner and liner cover installed. Cell 3 and 4 are 360m from the existing road, therefore a new road must be built. For this option there is a common berm separating the two cells. See Figure 6.

Table 3.4 Estimated Cost Analysis, Option 4

Construction of Cells 3 and 4	**Quantity**	**Unit Cost**	**Extended Cost**
Bentomat ST Liner	28,650	$5.56	pre-purchased
Clear rubble to 1m (m3)	1,450	$15	$21,750
Volume required for new berms	61,133	$35	$2,139,655
Area to be covered with liner	72,872	$1	$72,872
Volume of berm cover material	2,814	$50	$140,700
Liner cover material	27,300	$50	$1,365,000
Liner cushion material	15,960	$50	$798,000
Base fill to bottom of berm	33,780	$35	$1,182,300
Access Road (m)	360	$1,000	$360,000
Sub-total			$6,080,277
Engineering and Contingency @40%			$2,432,111
Total			$8,512,388
Close out of existing lagoon	**Quantity**	**Unit Cost**	**Extended Cost**
Volume of berms to push in	38,478	$15	$577,170
Cover rubble (300mm)	13,800	$35	$483,000
Subtotal			$1,060,170
Engineering & Contingencies		40%	$424,068
Total			$1,484,238

OPTION 4			
Total			**$9,996,626**



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Pond Inlet Sewage Lagoon - Option 4

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FIGURE NO. 6

3.2 SLUDGE DISPOSAL OPTIONS

Fill and draw lagoon systems accumulate sludge at a rate which includes the accumulation of algae as they complete their life cycle and settle to the bottom. Estimation algorithms follow. Generally, the sludge that accumulates over the 20 life of a lagoon, if spread evenly, will not protrude into the working volume from the dead storage zone. In practice, the area where trucks dump the raw sewage may protrude into the working volume. Sludge may have to be removed because:

1. It is protruding into the working volume to such an extent that it affects the effluent quality; or

2. It has become a requirement of the Nunavut Water Board (NWB).

The NWB has prepared revised guidelines, which are now in the consultation phase. These revised guidelines consider that industrial / commercial wastes may contaminate on raw sewage and the sludge that accumulates and concentrates in the lagoon.

The goal of the revised guidelines is to minimize costs for future generations. Accumulated sludge that has become contaminated and/or has concentrated contaminants will be considered to cause the lagoon to become a "toxic waste site" (sic). It is costly to remediate such a site. Further, it will be difficult to use simple methods to manage the sludge, such as composting.

In the future, the NWB may require the sludge in the lagoon to be monitored by sampling, and if it begins to exceed a certain quality, then it may require it be removed before it becomes a problem.

For planning purposes, each of the lagoon options presented in this report will include a sludge disposal area suitable for that option's configuration.

The sludge generation was calculated assuming a dry solid generation of 48 g/person/day. The daily suspended solids or daily sewage generation was calculated as follows:

SS (mg/L) = Dry solid generation * Population / Projected daily water use*1000

As mentioned earlier, the algae grows in the lagoon to 200 mg/L and 90% of the solids are retained. The solids retained within the lagoon where calculated using the following formula.

Solids Retained (mg/L) = (SS + 200 mg/L)*90%

The accumulated solids, or sludge, in a lagoon per year were then calculated by:

Accumulated solids (m^3) = Solids Retained*Projected annual water use*Correction Factor

The correction factor is used to convert mg to m^3.

The total accumulated solids in the lagoon are 40% solids.

The next two options are proposed sludge disposal area options to coincide with the lagoon options stated earlier. There is not enough pre-purchased liner material left from lagoon construction to line a sludge disposal area.

3.2.1 USE EXISTING LAGOON SITE

This option is only valid for Options 1 and 2 because both options remediate the existing lagoon.

The area required to hold the sludge was designed using a five-year accumulation. After five years the sludge will be treated sufficiently that it can be removed from the area.

This sludge disposal area will also have to accommodate the sludge accumulated since 1996. From the Sewage Generation table, the accumulated solids at year 5 are 444 m^3. This number was doubled as per assumptions made earlier, then multiplied by 40% to get a value for the dry solids only. The result is 355 m^3.

The sludge disposal area can contain a layer of 0.5m of sludge, resulting in a required area of 710 m^2. This falls well within the allowable areas of 18000 m^3 for Option 1 and 16 000 m^3 for Option 2.

No new construction would be required and the costs for covering the rubble and existing sewage are already included in the lagoon design options.

3.2.2 CONSTRUCT NEW SLUDGE DISPOSAL AREA

For Options 3 and 4 it would be impractical to use the existing lagoon site for the sludge disposal area because the sludge would have to be transported from both lagoons. To save on construction costs one sludge disposal area adjacent to one of the cells will be built. The cell selected will be the cell distant from the road and the common wall will be the north berm of that cell.

A new sludge disposal area does not require the same area as the sludge disposal area using the existing lagoon site because no allowance has to be made for sludge accumulated prior to construction in 2002. All prior sludge will be buried during the close out of the existing lagoon.

The five-year sludge accumulation is 269m^3 from the following table.

Table 3.5 Modified Sewage Generation Table

Census Population	1154
Census Year	1996
% Population Increase	2.8
Water Use per capita	70
Algae in the lagoon	200
Solids accumulated (%)	40
Solids Accumulated Estimate Correction Factor	1.4E-09

Planning Year	Calendar Year	Total Population	Projected Water Use	Daily Projected Volume	Annual Projected Volume	Suspended Solids	Solids Retained	Solids Accumulated Estimate
		#	lpcd	litres	litres	(mg/l)	(mg/l)	(m3)
	1996	1154	70.00	80,780	29,484,700	686	797	
	1997	1186	89.10	105,700	38,580,483	539	665	
	1998	1220	89.63	109,312	39,898,786	536	662	
	1999	1254	90.18	113,062	41,267,519	532	659	
	2000	1289	90.75	116,956	42,688,862	529	656	
0	2001	1325	91.33	121,000	44,165,098	526	653	
	2002	1362	91.93	125,202	45,698,623	522	650	42
	2003	1400	92.54	129,567	47,291,945	519	647	84
	2004	1439	93.17	134,103	48,947,697	515	644	129
	2005	1480	93.82	138,818	50,668,638	512	640	174
5	2006	1521	94.49	143,720	52,457,663	508	637	221
	2007	1564	95.17	148,816	54,317,809	504	634	269
	2008	1607	95.88	154,116	56,252,259	501	631	319
	2009	1652	96.60	159,628	58,264,357	497	627	370
	2010	1699	97.35	165,363	60,357,611	493	624	422
10	2011	1746	98.11	171,331	62,535,702	489	620	477
	2012	1795	98.90	177,541	64,802,494	485	617	533
	2013	1845	99.71	184,006	67,162,045	481	613	590
	2014	1897	100.54	190,736	69,618,615	477	610	650
	2015	1950	101.40	197,744	72,176,679	473	606	711
15	2016	2005	102.28	205,044	74,840,935	469	602	774
	2017	2061	103.18	212,647	77,616,320	465	599	839
	2018	2119	104.11	220,570	80,508,020	461	595	906
	2019	2178	105.06	228,826	83,521,484	457	591	975
	2020	2239	106.05	237,431	86,662,437	453	587	1,047
20	2021	2302	107.06	246,402	89,936,898	448	584	1,120

Table 3.6 Estimated Cost of Sewage Disposal for Options 3 and 4

Sludge Disposal Area for Option 3 & 4	Quantity	Unit Cost	Extended Cost
Clear rubble to 1m (m^3)	225	$15	$3,375
Volume required for new berms	2,230	$35	$78,050
Sub-total			$81.425
Engineering and Contingency @40%			$32,570
Total			$113,995

3.3 EXISTING LAGOON REMEDIATION OPTIONS

At the client's request two other options were considered to reduce the cost of the project. Executing the following reduced costs,

- The existing lagoon would be remediated;
- No new lagoons would be constructed;
- Instead of scraping and cutting to one meter the existing lagoon, only minimal remediation is proposed;
- Sludge accumulation is assumed not to be a factor, therefore sludge disposal will not be considered; and
- The minimum required liner cover and cushion by the manufacturer would be used.

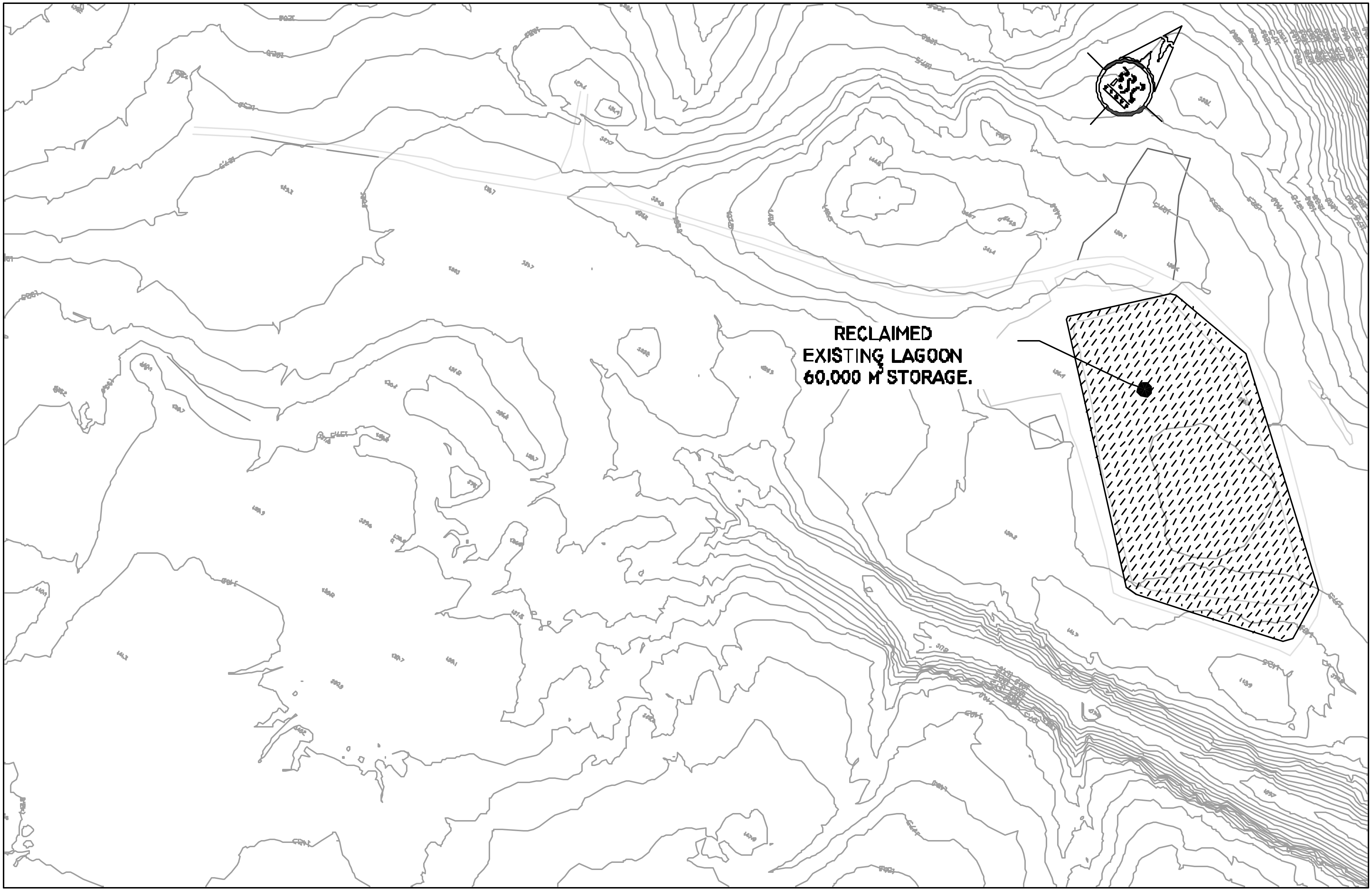
3.3.1 OPTION 5: REMEDIATION OF EXISTING LAGOON

In this option the existing lagoon will be remediated and lined. The berms will remain at their current elevations and approximate footprints.

For planning purposes 100 mm of fill is estimated to fill in the voids in the glacial rubble, the actual volume may be more or less. FSC has concerns that 100 mm across the area of the lagoon may be insufficient to fill the voids and bring the rubble to a smooth grade. Please refer to the pictures in Figures 3.1 and 3.2 taken of the bottom of the lagoon in September 2001. A contingency of $100, 000 has been allotted to remove large rocks or boulders.

Figure 3.1 Large rocks in lagoon September 2001

Figure 3.2 Bottom of lagoon September 2001



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Pond Inlet Sewage Lagoon - Option 5

2001-0580

FIGURE NO.

7

By installing the liner FSC has concerns that the volume of the lagoon will be reduced.

The entire length of the north berm will be excavated and rebuilt. The length of the berm to be reworked is 230 m. To keep the same approximate dimension and footprint of the north berm, 0.6 m of material will be removed and used as void fill. An additional 2994 m^3 of void fill is needed. The 0.6 m depth is required for cushion and cover material for the liner.

The liner cushion of 300 mm will be placed over top rubble, as per the manufacturer's specifications. Then the liner will be installed followed by 300 mm of liner cover. The 300 mm of liner cover is the minimum requirement from the manufacturer. This depth may not allow for heavy equipment to clean the sludge out of the lagoon should sludge become a problem.

Following construction the lagoon will have an estimated working volume of 52000 m^3. According to FSC sewage generation projections the lagoon should last for an estimated 5 years.

Table 3.7 Estimated cost analysis, Option 5

Remediation of Existing Lagoon	**Quantity**	**Unit Cost**	**Extended Cost**
Bentomat ST Liner	59,434	$6	pre-purchased
Volume of North berm to be reworked (m^3)	4,227	$15	$63,405
Contingency to remove large boulders			$100,000
Volume of extra material to fill voids (m3)	2,994	$35	$104,790
Area to be covered with liner (m^2)	59,434	$1	$59,434
Cover materials for liner (m^3)	17,830	$50	$891,500
Liner cushion material (m^3)	17,830	$50	$891,500
Subtotal			$2,110,629
Engineering & Contingencies @40%		40%	$844,252
Total			**$2,954,881**

3.3.2 OPTION 6: REMEDIATION AND EXPANSION OF EXISTING LAGOON

In this option the existing lagoon will be remediated, lined, and expanded by:

- Filling voids with 100mm of soil to cover the glacial rubble;
- Removing large rocks and boulders;

- Re-working 230 metres of the North berm to repair damage from water piping;
- Elevating the berms to increase the volume to the year 2021 demand;
- Laying the liner, cushion and cover; and
- Modifying the sewage truck turnaround area.

For planning purposes 100 mm of fill was estimated to fill in the voids in the glacial rubble, the actual volume may be more or less. Material used to fill voids will come from the inside slope of the North berm plus an additional 1268 m^3.

FSC has concerns that 100 mm across the area of the lagoon may be insufficient to fill the voids and bring the rubble to a smooth grade. See Figures 3.1 and 3.2 taken of the bottom of the lagoon in September 2001.

The north berm will be repaired by excavating and re-packing the inside slope. The 600 mm of material removed from the North berm will be replaced with the cushion and cover material for the liner, maintaining the existing inside 4:1 slope.

The liner for remaining berms will be placed on the existing slope. The berms will be raised 1.7 meters, maintaining the inside slope and re-grading the outside slope to 3:1. A 2.5 metre top will allow four-wheel or walking access.

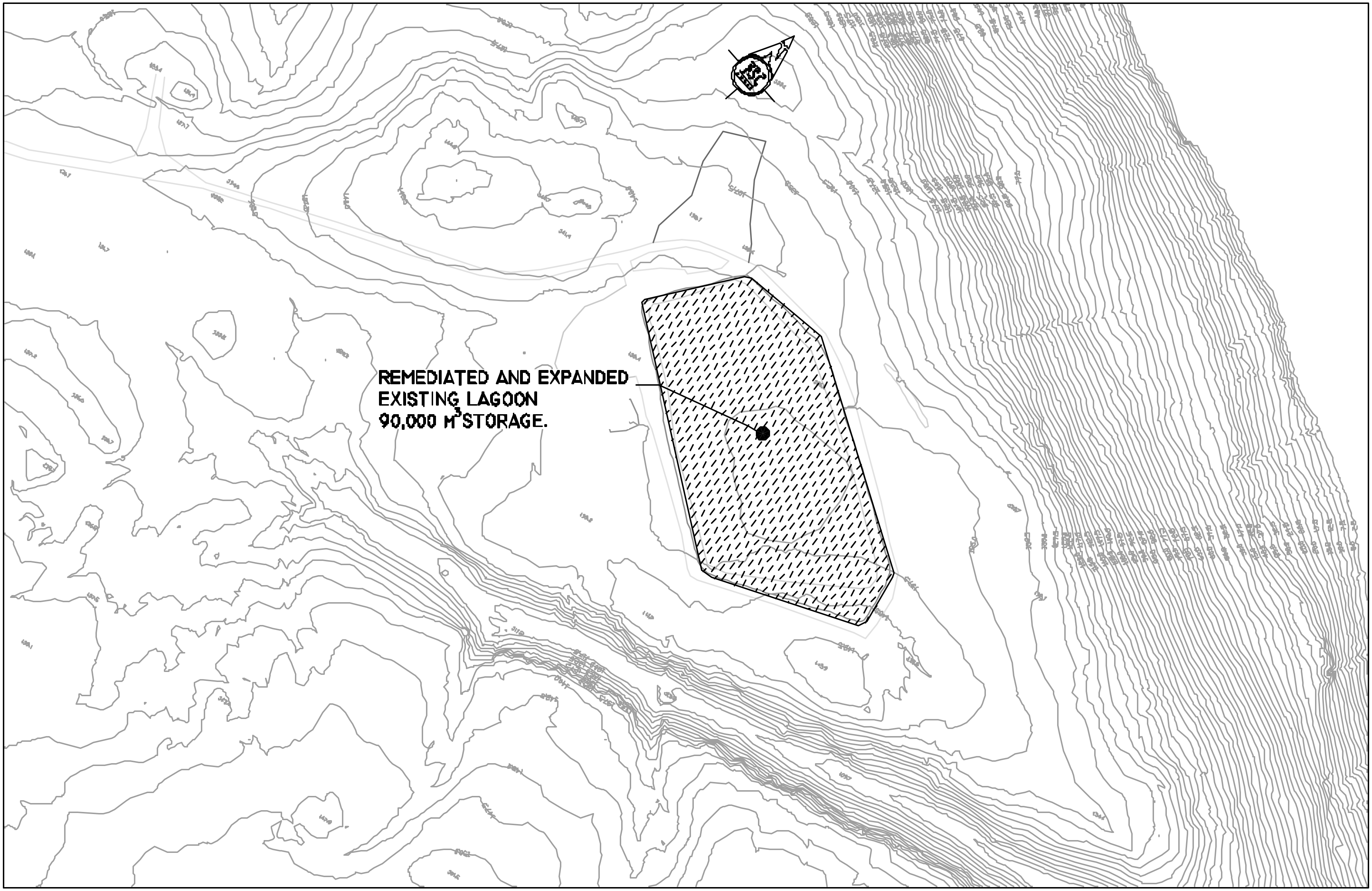
Calculations were also done to determine if it was beneficial to remove 600 mm from all the berms to maximize the volume. The cost to remove the 600 mm was greater then the savings of only a slight reduction in additional height.

The height of the new berm is 4.2 m and the working depth is now 2.3 m. This depth exceeds the recommended depth of 1 m to 1.5 m (Heinke et al. 1988) and (Smith ed. 1996). By having a working depth greater than 1.5 m, the sunlight may not be able to penetrate sufficiently and treatment may be hampered.

The terrain changes along the perimeter of the lagoon were taken into account in the amount of fill needed to raise the berms. Extra fill was also required along the west berm for the truck turnaround.

Table 3.8 Estimated Cost Analysis, Option 6

Remediation of Existing Lagoon	Quantity	Unit Cost	Extended Cost
Bentomat ST Liner	53,068	$6	pre-purchased
Volume of North berm to be reworked (m^3)	2,875	$15	$43,125
Contingency to remove large boulders			$100,000
Volume of extra material to fill voids (m^3)	1,268	$35	$44,366
Area to be covered with liner (m^2)	53,068	$1	$53,068
Cover materials for liner (m^3)	16,583	$50	$829,139
Liner cushion material (m^3)	16,583	$50	$829,139
Volume of fill to raise berms (m^3)	26,982	$35	$944,370
Subtotal			$2,843,206
Engineering & Contingencies @40%		40%	$1,137,282
Total			**$3,980,488**



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Pond Inlet Sewage Lagoon - Option 6

2001-0580

FIGURE NO. 8

4 COST SUMMARY

The preliminary cost estimates have been made separately to complete equivalent projects which includes a two cell lagoon designed to 2021, a sludge disposal area, and remediation or closing of the existing lagoon.

4.1 PROJECT 1

Project 1 is a combination of lagoon Option 1 plus a sludge disposal area within the existing lagoon site.

Table 4.1 Cost Summary, Project 1

Project 1	Cost
Lagoon Option 1	$7,661,784
Sludge Disposal Area - Use Existing Lagoon Site	$0
Total	**$7,661,784**

4.2 PROJECT 2

Project 2 is a combination of lagoon Option 2 and a sludge disposal area within the existing lagoon site.

Table 4.2 Cost Summary, Project 2

Project 2	Cost
Lagoon Option 2	$7,696,704
Sludge Disposal Area - Use Existing Lagoon Site	$0
Total	**$7,696,704**

4.3 PROJECT 3

Project Option 3 consists of lagoon Option 3 with a new sludge disposal area adjacent to the cell distant from the road.

Table 4.3 Cost Summary, Project 3

Project 3	Cost
Lagoon Option 3	$11,170,559
Sludge Disposal Area - Construct new site	$177,625
Total	**$11,348,184**

4.4 PROJECT 4

Project 4 consists of lagoon Option 4 and building a new sludge disposal area adjacent to the north cell.

Table 4.4 Cost Summary, Project 4

Project 4	Cost
Lagoon Option 4	$9,996,626
Sludge Disposal Area - Construct new site	$177,625
Total	**$10,174,251**

4.5 PROJECT 5

Project 5 is identical to Option 5, remediating the existing lagoon without expanding it or including a sludge disposal area. The need for a sludge disposal area would be assessed in five years.

Table 4.5 Cost Summary, Project 5

Project 5	Cost
Lagoon Option 5	$2,954,881
Sludge Disposal Area - none	$0
Total	**$2,954,881**

4.6 PROJECT 6

Project 6 is the same as Option 6 with no sludge disposal area. The existing lagoon is remediated and expanded to accept the projected 20-year demand of the community. The need for a sludge disposal area would be assessed in five years.

Table 4.6 Cost Summary, Project 6

Project 6	Cost
Lagoon Option 6	$3,980,488
Sludge Disposal Area - none	$0
Total	**$3,980,488**

5 MODIFIED K-T ANALYSIS FOR SOLID WASTES

5.1 GENERAL

To evaluate potential alternatives objectively, a decision making tool called modified Kepner-Tregoe (K-T) analysis or a weighted factor analysis has been used. This tool/method involves two distinct steps, which are outlined as follows.

5.2 INITIAL SCREENING

The initial screening process involves the creation of constraints, which each option/alternative **must** meet. Only options/alternatives that meet each constraint will be included in the final analysis. The client in the project scope of work has provided these constraints. They are:

- **Must** meet the *Public Health Act*
- **Must** meet Nunavut Water Board Acts and Regulations;
- **Must** meet the intent and spirit of Environment Canada's Inspectors Direction; and
- **Must** meet the 20-year demand of the community.

Table 5.1 – Results of Initial Screening

	Project 1	**Project 2**	**Project 3**	**Project 4**	**Project 5**	**Project 6**
Public Health Act	Pass	Pass	Pass	Pass	Pass	Pass
Nunavut Water Board	Pass	Pass	Pass	Pass	Pass	Pass
Environment Canada Inspector's Direction	Pass	Pass	Pass	Pass	Pass	Pass
20-year demand of community	Pass	Pass	Pass	Pass	**Fail**	Pass

5.3 OPTIONS ANALYSIS

If an option passes our initial screening process it will be included in our final evaluation process. The final process consists of evaluating each option on a set of objectives that has been deemed the "want" criteria.

The want criteria are a list of objectives that are weighted according to their importance to the decision to be made. Each option is then objectively ranked against these criteria and scores assigned based on the ranking multiplied by the weight of the criteria. The weighted scores for the various options are added to provide a total score for each option.

The total score for different options can be compared to provide an indication of which option best meets the stated objectives for a new solid waste disposal system.

The following "want" objectives have been established for this project:

1. Lowest Capital Cost;
2. Lagoon can be expanded using a common wall;
3. Use of the Existing Site; and
4. Design meets the maximum recommended working depth.

5.4 SELECTING WEIGHTS

A binary choice decision model was used to generate preliminary weighting for each objective.

In this model, only two objectives are considered at a time, the more important objective receiving a "1" and the other a "0". When all objectives are considered the scores are summed and the results placed in descending order. The highest-ranking objective is then assigned a "10". Others receive a lesser weight.

The following table shows the decision process.

Table 5.2 - Binary Decision Model to Assign Weights to Objectives

Objective	Capital Cost	Expand using common wall	Use Existing Site	Working Depth	Total	Assigned Weight
Capital Cost	-	1	1	1	3	10
Expand Using Common Wall	0	-	0	0	0	6
Use Existing Site	0	1	-	1	2	9
Working Depth	0	1	0	-	1	8

5.5 SCORING

1. Lowest Capital Cost

The lowest capital cost will be scored "10". Others will be scored on percentage.

2. Expand Lagoon Using a Common Wall

If the design uses a common wall for expansion it will be scored “10”.

If the design does not use a common wall for expansion it will be scored “0”.

3. The Existing Site is used in the Design

If the existing site is used in the design it will be scored “10”.

If the existing site is not used it will be scored “0”.

4. Working depth

If the design working depth falls within the recommended 1 to 1.5 m it will be scored “10”.

If the design working depth does not fall within the recommended 1 to 1.5 m it will be scored “0”.

Table 5.3 Results of the “Want” Analysis

	Project 1	Project 2	Project 3	Project 4	Project 6
Total	**220.0**	**281.7**	**175.1**	**119.1**	**190.0**
Rank	2	1	4	5	3

The want analysis calculations are appended.

5.6 SENSITIVITY ANALYSIS

In this analysis, non-monetary factors were reduced to determine how they impacted on the scoring. Such an analysis suggests the acceptability of a project.

Table 5.4 Sensitivity Analysis Revised Weights

Objective	Assigned Weight
Capital Cost	10
Expand using Common Wall	3
Use Existing Site	4.5
Working Depth	4

5.7 RESULTS OF SENSITIVITY ANALYSIS

Table 5.5 - Results of Sensitivity Analysis

	Project 1	Project 2	Project 3	Project 4	Project 6
Total	88.2	97.0	60.1	55.1	120.3
Revised Rank	2	1	4	5	3
Previous Rank	3	2	4	5	1

6 CONCLUSIONS

1. Based on the KT analysis, Project 6 is the best option for Sensitivity Analysis and third for the "Want" Analysis. Project 6 involves remediating the existing lagoon site and building up the existing berms to meet the 20-year requirement of the community. The need for a sludge disposal area would be assessed in five years.

2. Project 2 is the second best option according to the Sensitivity Analysis and the best option according to the "Want" Analysis.

3. Project 1 is the third best option according to the Sensitivity Analysis

4. Project 3 and 4 scored the lowest options.

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Appendix 1
Photographs

Photo 1 Sewage Lagoon – July 2001

Photo 2 Detritus mat on surface of lagoon – July 2001

Photo 3 Wet spot on NE berm from piping – July 2001

Photo 4 Catwalk to outflow valve – August 2001

Photo 5 | Longitudinal cracking along NE berm – July 2001

Photo 6 | Pumping out lagoon – July 2001

Photo 7 | Bottom of discharge gully – July 2001

Photo 8 | Top of discharge gully – July 2001

Appendix 2
Bentomat Liner Specifications

CETCO LINING TECHNOLOGIES

Bentomat® Panel & Roll Specifications

BENTOMAT® "ST" PANEL AND ROLL SPECIFICATIONS

STANDARD PANEL SPECIFICATIONS

PANEL DIMENSIONS*: **15**-ft. (**4.6** m) wide; **150**-ft (**45.7** m) long

TOTAL PANEL AREA: **2,250**-sq. ft. (**209.0** sq. m)

EFFECTIVE AREA: **2,145**-sq. ft. (**200**-sq. m) (Assumes 6-in. (150 mm) edge overlap and 2-ft. (600 mm) end overlap)

STANDARD ROLL SPECIFICATIONS

DIMENSIONS: **16**-ft. (**4.9** m) wide w/ core; **24**-in. (**610**-mm) diameter

NOMINAL WEIGHT: **2600** lbs. (**1180** kg)

CORE SIZE (I.D.): **4** in. (**100** mm).

PACKAGING: **Minimum 2.5**-mil (**0.15** mm) U.V.-resistant polyethylene sleeve

STANDARD SHIPPING SPECIFICATIONS

SHIPMENT SIZE: **16** rolls per truckload or container load

GRANULAR BENTONITE: **50**-lb (**23-kg**) bags

UNLOADING AND HANDLING EQUIPMENT

CORE PIPE AND SPREADER BAR: **18**-ft (**5.5** m) long, **3** in. (**75** mm) Nominal Pipe Size, XXH
OR: Solid steel pipe
OR: Stinger attachment for forklift

CHAINS OR STRAPS: **2** required; approximately **12**-ft. (**3.7** m) long each
EQUIPMENT: Front end loader or forklift (typical)

*Custom widths/lengths available.

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