TECHNICAL MEMORANDUM

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TO: Cumberland Resources Ltd. **DATE:** October 6, 2005

FROM: Cameron Clayton **JOB NO:** 05-1413-036A

EMAIL: **cclayton@golder.com**

RE: **ITEM #85/85A – MEADOWBANK GOLD PROJECT – BLASTING ADDENDUM**

A Technical Meeting was held in Baker Lake on June 2 and 3, 2005 to review the Draft Environmental Impact Statement (DEIS) for Cumberland Resources Limited (CRL), Meadowbank Gold Project. Following the technical meeting, a list of commitments by CRL was prepared, which would either be addressed as soon as possible or appear in the Final Environmental Impact Statement. This technical memorandum responds to Items #85 and #85a from this list which requested additional information relating to the annotation of a permafrost cross section through the project area.

Specifically, Items #85 and 85a requested to:

85. "Ensure that the blast management plan in the FEIS accounts for DFO addendum relating to blast design during periods when water bodies are ice covered:
    a. A Blast Design Report will be submitted, taking into account the DFO addendum relating to blast design during frozen conditions."

1.0 INSTANTANEOUS PRESSURE CHANGE FOR CANADIAN FISHERIES GUIDELINES

Two blast design reports have been produced previously for the project:

- Golder Associates Ltd., Report on *Blast Design, Meadowbank Gold Project, Nunavut*, February 10, 2004.
- Addendum: Blasting Report Addendum, Golder Associates, May 25, 2004.

The reader is directed to review the two previous reports which describe in greater detail the development of assumptions on which the evaluations have been based, the procedures used to carry out the evaluations, and other parameters used in the evaluations that may be presented below but are not described.

The previous report, and the report addendum, included consideration of blast induced vibration from the perspective of the stability of the perimeter dikes and tailings dike, and from the perspective of the effect of blast induced vibration on fish and fish habitat. Estimates of blast induced vibration and instantaneous pressure change were presented for various charge weights based on initial evaluation of blast design. The feasibility study recently completed by Amec Americas Ltd recommended that a charge weight of 77 kg for a bench height of 6 m be used. The previously completed blast designs have been modified to reflect this recommendation, and are presented below.

The following sections are based on the previous work, and on new analyses to address additional concerns presented by Department of Fisheries and Oceans (DFO) and presented during the meetings in Baker Lake.

1.1 Blast Induced Vibration

Blast induced vibrations have the potential to reduce the stability and performance of nearby earthen structures such as dikes. Where saturated conditions exist within the foundation materials and within the earthen structural fills of the de-watering dikes and the tailings dike, blast induced vibrations could result in the development of increased pore water pressures within the foundation and structural fill materials. This could lead to potential settlement of the structures and consequently impact to the water retaining capacity of the dikes.

The effects of blasting are typically assessed in terms of Peak Particle Velocity (PPV).

1.1.1 Estimates of Peak Particle Velocity

The preliminary estimates of Peak Particle Velocity (PPV) are based on the current understanding of the site layout, mine plan, and blast design. Changes to the current site layout, mine plan, and blast design will result in changes to the estimates of PPV. Certain site specific factors that are required to calculate PPV have been estimated based on published values. However, site specific parameters can only be determined by site vibration monitoring of actual blasts. Consequently, the actual PPV values may differ from those presented here.

The US Bureau of Mines has established that the peak particle velocity, PPV, is related to the scaled distance by the following relationship:

$$PPV = k * (R/W^{0.5})^{-b}$$

Where:

PPV = Peak Particle Velocity, mm/s
R = Distance from blast to point of concern, m
W = Charge weight per delay, kg
k = confinement factor – specific to site
b = site factor

The constants k and b are specific to the site, and can be determined by blast vibration monitoring.

For this evaluation, a value of b = 1.6 was assumed. The PPV was evaluated for a range of values of confinement, ‘k’, of 400, 800, and 1500, for down hole blasting. This range in values is considered to be reasonable for the site and to provide an estimate of the sensitivity of PPV to different values of confinement.

Based on the current understanding of site conditions and blast monitoring experience at two other northern sites, the confinement value of 800 is expected to be the most likely representative value for average conditions at the site. The actual value for confinement can only be determined through a detailed field monitoring program.

1.1.2 Minimum Setback Distance for Canadian Fisheries Guidelines

Design guidelines governing the use of explosives adjacent to Canadian fisheries waters (Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Wright and Hopky, 1998) indicate that no explosive is to be detonated that produces a peak particle velocity greater than 13 mm/s in a spawning bed during the period of egg incubation.

The PPV’s were evaluated for the Second Portage Lake East Dike, the Third Portage Peninsula east shoreline, the Bay Dike, and the Goose Island east shoreline.

1.1.3 Setback Distance for Peak Particle Velocity

The minimum setback distances to achieve a Peak Particle Velocity, PPV, of 13 mm/s have been estimated for various values of confinement, ‘k’, and for four potential charge weights per delay. The following table summarizes the estimates of minimum setback required to achieve a PPV value of 13 mm/s.

Table 1: Minimum Setback Distance for 13 mm/s Peak Particle Velocity Guideline

k	12 kg charge weight per delay (3 m bench, 76 mm hole)	77 kg charge weight per delay (6 m bench, 165 mm hole)	250 kg charge weight per delay, (12 m bench, decked charge, 229 mm hole)
	Minimum Setback Distance to Achieve PPV = 13 mm/s		
400	30 m	75 m	135 m
800	46 m	115 m	208 m
1500	67 m	171 m	308 m

The relationships presented in the above table are shown on Figure 1 for a confinement value, k, of 800.

With the exception of a short segment of shoreline adjacent to the Portage Pit wall at the south end of the pit, the proposed charge weight of 77 kg per hole on 6 m benches will result in PPV less than the required 13 mm/s.

For the portions of the dike or shoreline where the 13 mm/s guideline is exceeded, modified blast designs consisting of lower charge weights on lower bench heights have been shown to result in PPV that meet the guideline requirement. For example, the figure indicates that a charge weight of 12 kg would result in acceptable PPV in the area of concern. Alternatively, additional fill materials could be placed along the shoreline or dike upstream (lake side) face to increase the distance from the blasting area.

1.1.4 Minimum Setback Distance for Threshold Damage Levels

General guidelines for blasting nears dams indicate vibration damage thresholds on the order of 50 mm/s to be reasonable for dams having medium to dense sand or silts within the dam or foundation materials. The following table summarizes the estimates of minimum setback required to achieve a PPV value of 50 mm/s for the charge weights considered.

Table 2: Comparison of Minimum Setback Distance for a Peak Particle Velocity of 50 mm/s for Various Blast Configurations

k	12 kg charge weight per delay (3 m bench, 76 mm hole)	77 kg charge weight per delay (6 m bench, 165 mm hole)	250 kg charge weight per delay, (12 m bench, decked charge, 229 mm hole)
	Minimum Setback Distance to Achieve PPV = 50 mm/s		
400	13 m	32 m	58 m
800	20 m	50 m	89 m
1500	29 m	74 m	133 m

The analysis indicates that for the proposed 80-m toe setback for the dikes at the Meadowbank Project, and the proposed 77 kg charge weight, PPV of 50 mm/s will not be exceeded in the toe areas of the perimeter dikes or tailings dike (see Figure 2).

1.1.5 Instantaneous Pressure Change for Canadian Fisheries Guidelines – 100 kPa Criteria

The required setback distance for confined explosives to achieve the 100 kPa instantaneous pressure change guideline can be estimated from relationships presented in "Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters" (Wright and Hopky, 1998).

The following properties were used to assess the minimum setback distance.

Table 3: Properties Used to Assess Setback Distance for Instantaneous Pressure Change

Medium	Density, g/cm^3	Compressional Wave Velocity, cm/s
Water	1	146,300[1]
Rock (Intermediate Volcanic)	2.8	457,200[1]

1. Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters; Wright and Hopky, 1998

Based on the above properties, the range of potential charge weights, and the range in confinement value, k, the following minimum setback distances, below which the 100 kPa overpressure guideline will not be exceeded, are estimated.

Table 4: Minimum Setback Distance for Instantaneous Pressure Change Guideline (<100kPa)

Charge Weight per Delay (kg)	Minimum Setback Distance (m)		
	k=400	k=800	k=1500
12	10 m	15 m	22 m
77	25 m	38 m	57 m
250	45 m	69 m	102 m

The results in the above table are presented on Figure 3 for a confinement of 800. For the proposed charge weight of 77 kg the instantaneous pressure change will not exceed the guideline of 100 kPa on the outside of the dikes.

1.1.6 Instantaneous Pressure Change for Ice Covered Waters – 50 kPa Criteria

In addition to the legislated criteria Department of Fisheries and Oceans has requested that Cumberland assess the effect of blast induced vibration and instantaneous overpressure resulting from blasting adjacent to waters during ice cover periods, although this is not currently legislated. For these conditions, Department of Fisheries has recommended an additional evaluation to consider an instantaneous pressure change of 50 kPa.

For the range of potential charge weights, and for a range in confinement value, k, the following minimum setback distances, below which the 50 kPa overpressure guideline will not be exceeded, are estimated.

Table 5: Minimum Setback Distance for Instantaneous Pressure Change Guideline (50 kPa Ice Covered Water)

Charge Weight per Delay (kg)	Bench Height (m)	Hole Diameter (mm)	Minimum Setback Distance (m)		
			k=400	k=800	k=1500
12	3 m (ore)	76	15	23	34
77	6 m (ore and waste)	165	38	59	87
250	6 m (waste)	165	69	106	157

The relationships presented in the above table are shown on Figure 4 for a confinement value, k, of 800. Based on the analysis, an instantaneous pressure change of 50 kPa will not be exceeded for the proposed 77 kg charge weight per hole, and for a confinement value, ‘k’, of 800.

1.2 Conclusions

The following summarizes the conclusions of the previous and current assessment:

- With the exception of a short segment of shoreline adjacent to the southeast wall of the Portage Pit, the Peak Particle Velocity of 13 mm/s will not be exceeded for the proposed 77 kg charge weight per hole. This relates to fisheries guidelines.
- The Peak Particle Velocity of 50 mm/s will not be exceeded in the toe region of the perimeter dikes or tailings dike for the proposed 77 kg charge weight per hole. This relates to the structural stability of the dikes.
- The instantaneous pressure change along the upstream (lake side) face of the East Dike, Bay Zone Dike, and Goose Dike is predicted to be less than the 100 kPa guideline for the proposed 77 kg charge weight per hole. This relates to fisheries guidelines.
- The instantaneous pressure change along the upstream (lake side) face of the dikes during periods of ice cover is predicted to be less than 50 kPa for the proposed 77 kg charge weight per hole. This relates to an additional request by DFO to assess instantaneous pressure change for ice covered water conditions.
- For the Vault deposit, Peak Particle Velocity and instantaneous pressure change guidelines along the Vault Dike face will not be exceeded for any of the proposed blast designs or charge weights. The Vault Dike lies about 750 m from the nearest crest of the Vault Pit.

The analyses have shown that peak particle velocities and instantaneous overpressure can be effectively managed through the use of lighter charge weights, decreased blasthole diameters, and decreased operating bench heights, or a combination of these mitigative measures. During mine development and operations, a vibration monitoring program will be required in order to measure the response of the de-watering dikes and tailings dike to pit blasting, and to measure peak particle velocities on the upstream (lake side) of the dikes to assess the current blast designs. This will allow modifications to be made to the operational blast designs.

1.2.1 Monitoring

As part of the mine development, a vibration monitoring program will be required in order to measure the response of the de-watering dikes and tailings dike to pit blasting. The data from this program would be assessed in conjunction with continuous measurements from piezometers that would be installed in the dikes, and within the dike foundation materials. From this analysis, the blasting could be adjusted to minimize the impact on the dikes. Mitigative measures to the blast design to minimize the development of blast induced vibration could include modifications to the blasthole patterns, reduction in blasthole size and hence charge weight in critical areas of the pit walls within a certain distance from the proposed de-watering and tailings dike, single blasthole initiation per delay, reduction in operating bench height in critical areas, or a combination of all these measures.

A more comprehensive program of blast vibration modelling and test blasting may be required during operations if blast vibration levels remain high and their frequency (cycles per second) is low.

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05-1413-036A
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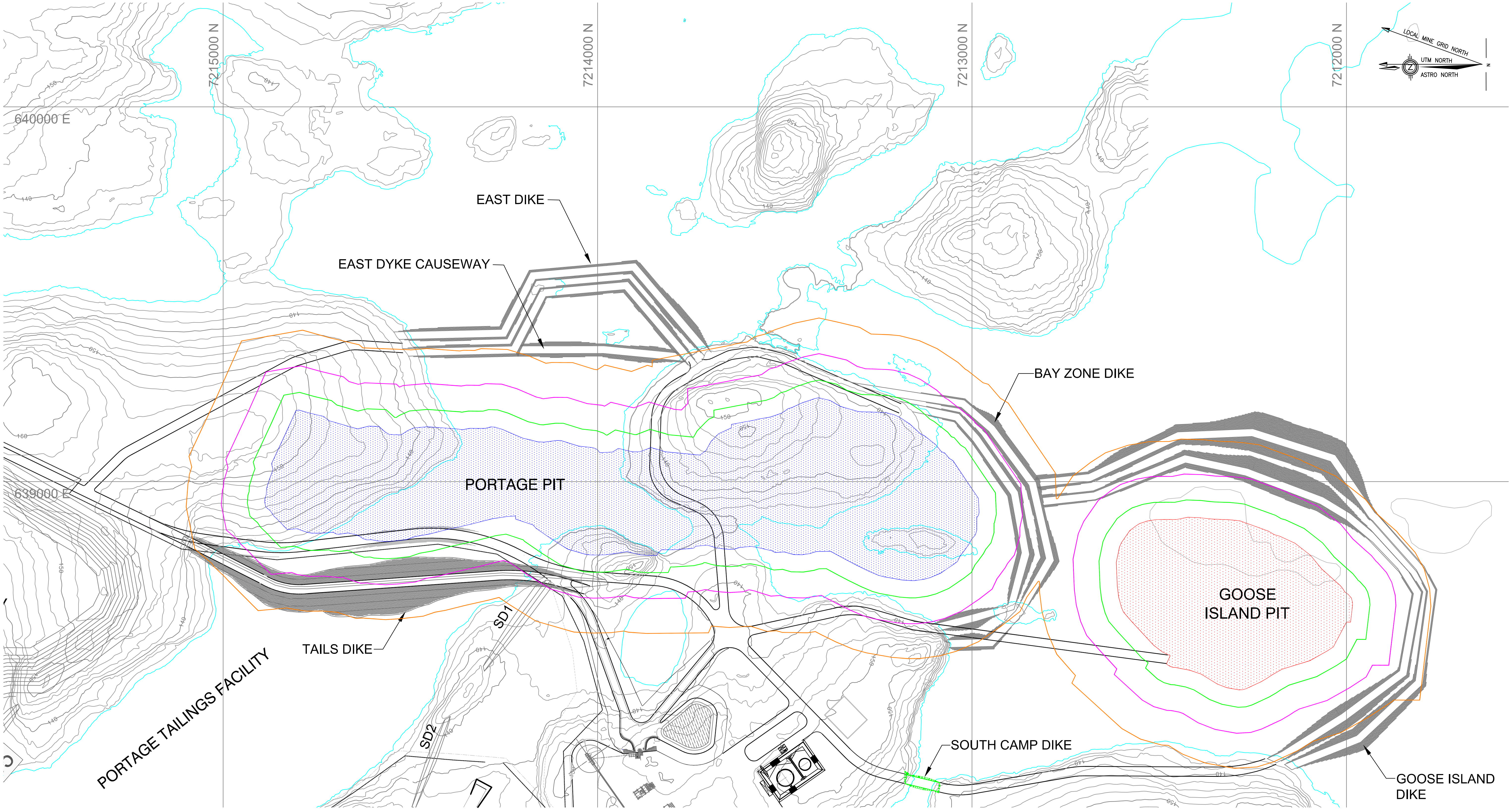

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Scale in Meters

LEGEND

Green line	12 kg Charge Weight, 46m Offset
Magenta line	77 kg Charge Weight, 115m Offset
Orange line	250 kg Charge Weight, 208m Offset
Yellow box	Recommended Charge Weight

Confinement, k = 800

NOTES

1. Contour Interval 2 Metre.
2. All Dimensions in Metres.
3. Elevations in Metres above Sea Level.
4. UTM Zone 14, NAD83.
5. Area behind Dikes is De-watered during Operations.
6. Reference: Feasibility Study Report, AMEC, June 2005.

REFERENCES

1) AMEC Americas LTD, Drawing # A1-131395-100-C-0001 (100-C-0001.dwg), Meadowbank Feasibility Study, April 2005.
2) Golder Associates: Report on Blast Design, Meadowbank Golder Project, February 2004.
3) Golder Associates: Blasting Report Addendum, May 2004.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

PEAK PARTICLE VELOCITY
13 mm/s ISOPLETH

Golder Associates

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CHECK	CJC	03OCT05	FIGURE 1	
REVIEW				

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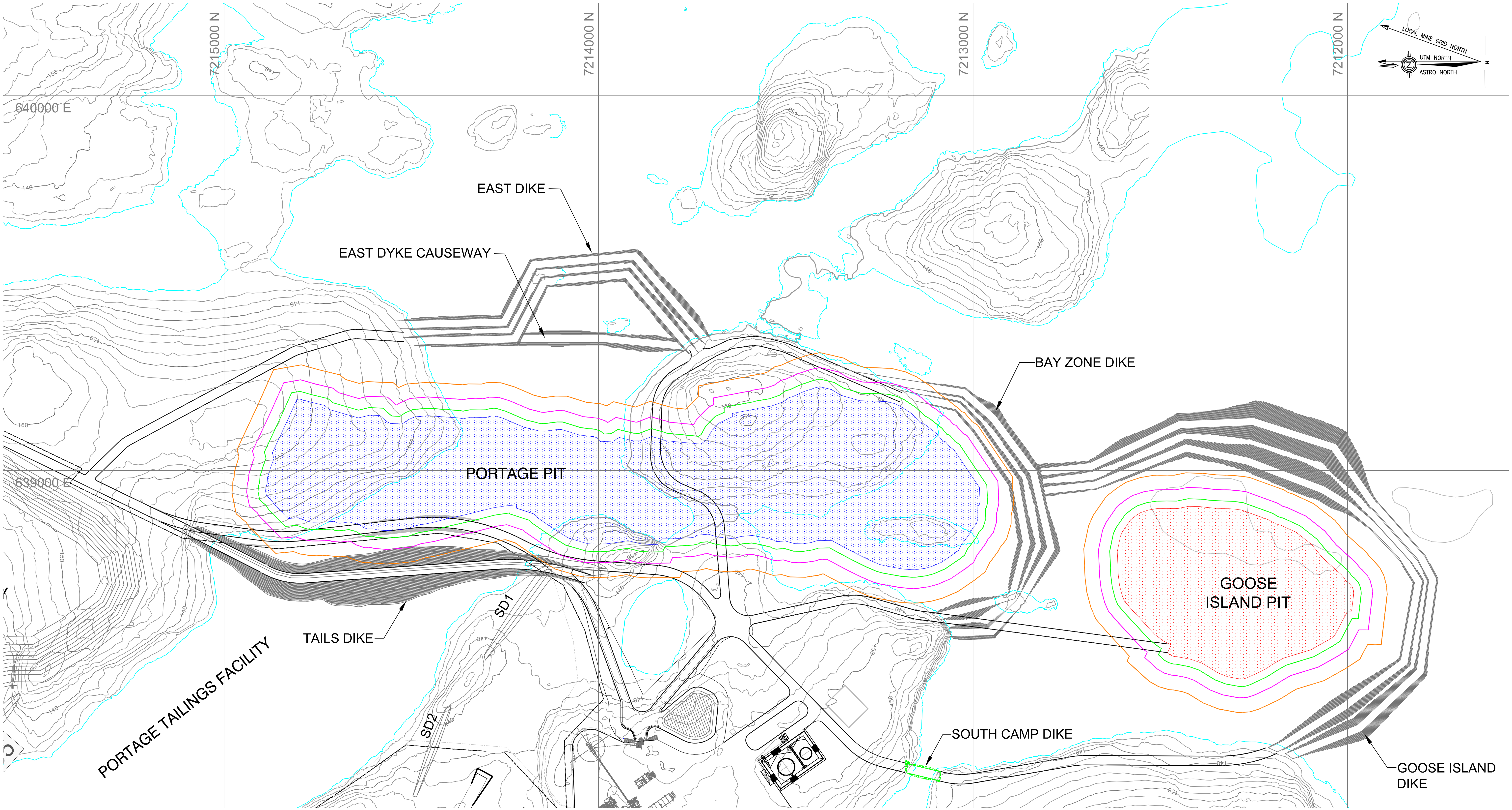

0 100 200 300 400 500
Scale in Meters

LEGEND

Green line	12 kg Charge Weight, 20m Offset
Magenta line	77 kg Charge Weight, 50m Offset
Orange line	250 kg Charge Weight, 89m Offset
Confinement, k = 800	Yellow box: Recommended Charge Weight

NOTES

1. Contour Interval 2 Metre.
2. All Dimensions in Metres.
3. Elevations in Metres above Sea Level.
4. UTM Zone 14, NAD83.
5. Area behind Dikes is De-watered during Operations.
6. Reference: Feasibility Study Report, AMEC, June 2005.

REFERENCES

1) AMEC Americas LTD, Drawing # A1-131395-100-C-0001 (100-C-0001.dwg), Meadowbank Feasibility Study, April 2005.
2) Golder Associates: Report on Blast Design, Meadowbank Golder Project, February 2004.
3) Golder Associates: Blasting Report Addendum, May 2004.

PROJECT
CUMBERLAND RESOURCES LTD.

TITLE
PEAK PARTICLE VELOCITY 50 mm/s ISOPLETH

Golder Associates

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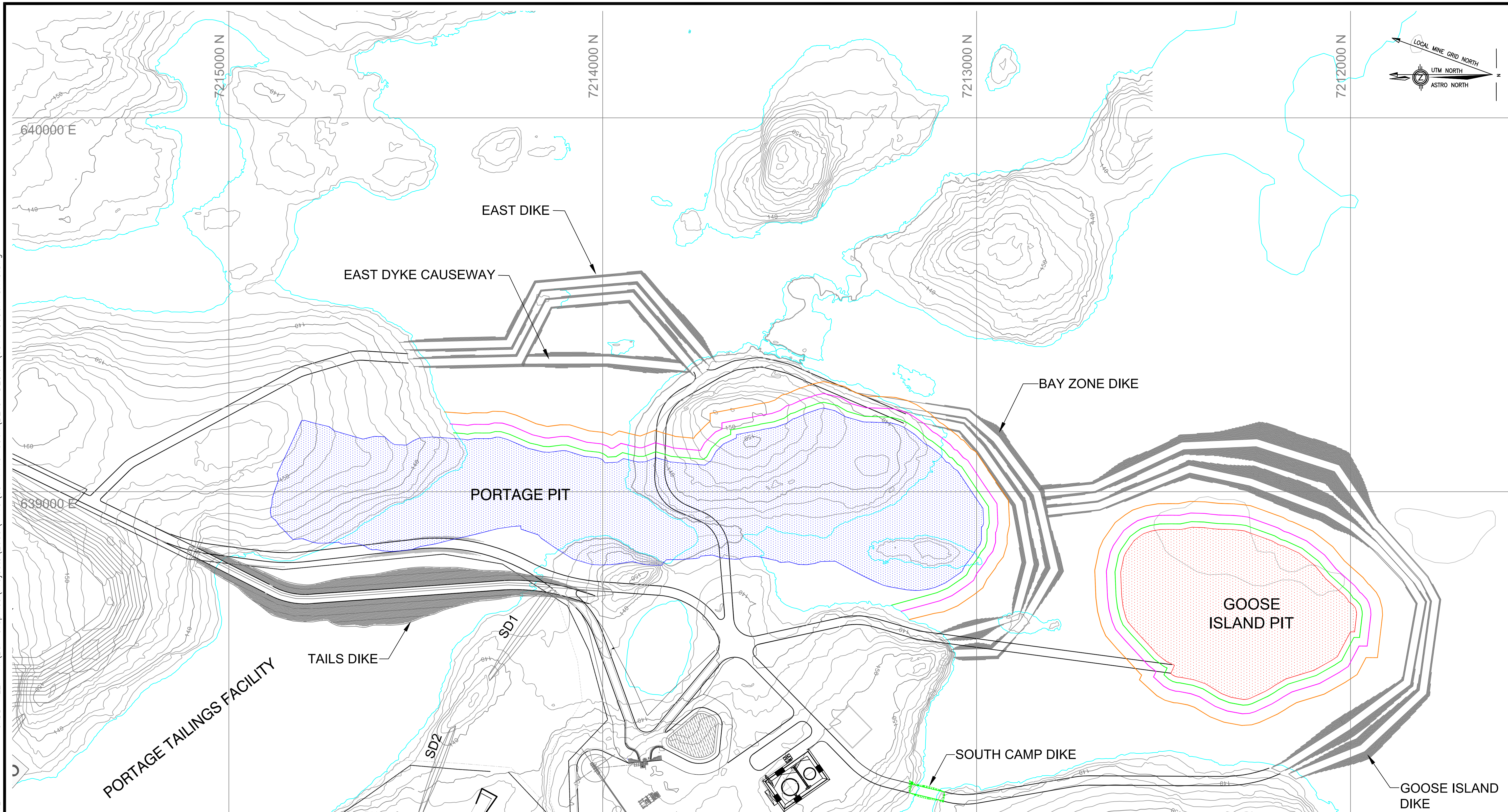

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By: WLi

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LEGEND

Green line	12 kg Charge Weight, 15m Offset
Magenta line	77 kg Charge Weight, 38m Offset
Orange line	250 kg Charge Weight, 69m Offset
Confinement, k = 800	Yellow box: Recommended Charge Weight

NOTES

1. Contour Interval 2 Metre.
2. All Dimensions in Metres.
3. Elevations in Metres above Sea Level.
4. UTM Zone 14, NAD83.
5. Area behind Dikes is De-watered during Operations.
6. Reference: Feasibility Study Report, AMEC, June 2005.

REFERENCES

1) AMEC Americas LTD, Drawing # A1-131395-100-C-0001 (100-C-0001.dwg), Meadowbank Feasibility Study, April 2005.
2) Golder Associates: Report on Blast Design, Meadowbank Golder Project, February 2004.
3) Golder Associates: Blasting Report Addendum, May 2004.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

INSTANTANEOUS OVERPRESSURE 100kPa ISOPLETH

Golder Associates

PROJECT No. 05-1413-036A		
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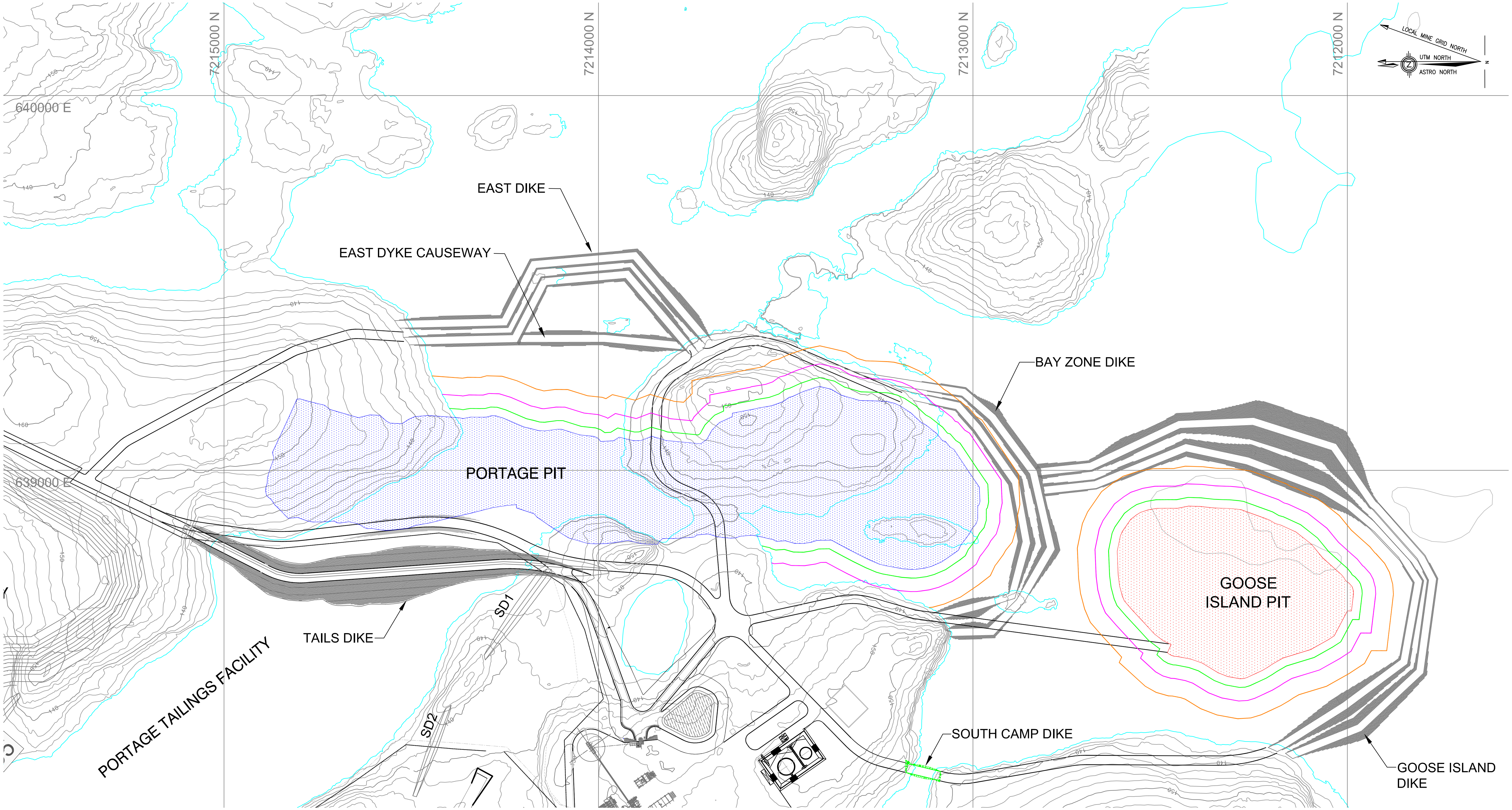
CHECK	CJC	03OCT05
REVIEW		

FILE No. 051413036A-SK15

SCALE AS SHOWN REV. A

FIGURE 3



LEGEND

(green line)	12 kg Charge Weight, 23m Offset
(magenta line)	77 kg Charge Weight, 59m Offset (highlighted)
(orange line)	250 kg Charge Weight, 106m Offset
Confinement, k = 800	(yellow box) Recommended Charge Weight

NOTES

1. Contour Interval 2 Metre.
2. All Dimensions in Metres.
3. Elevations in Metres above Sea Level.
4. UTM Zone 14, NAD83.
5. Area behind Dikes is De-watered during Operations.
6. Reference: Feasibility Study Report, AMEC, June 2005.

REFERENCES

1) AMEC Americas LTD, Drawing # A1-131395-100-C-0001 (100-C-0001.dwg), Meadowbank Feasibility Study, April 2005.
2) Golder Associates: Report on Blast Design, Meadowbank Golder Project, February 2004.
3) Golder Associates: Blasting Report Addendum, May 2004.

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

INSTANTANEOUS OVERPRESSURE 50 kPa ISOPLETH UNDER ICE CONDITION

Golder Associates

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REVIEW			

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