APPENDIX L

Dam Classification Report

December, 2015

REPORT ON

Long Pond Weir Classification Canadian Dam Association

Submitted to:
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REPORT

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Distribution:

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1.0 INCREMENTAL CONSEQUENCE CLASSIFICATION OF LONG POND WEIR

According to the Canadian Dam Association's 2007 Dam Safety Guidelines (CDA 2007 Dam Safety Guidelines), the standard of care and due diligence expected of a dam owner relates to the incremental losses due to a dam failure, that is, losses above and beyond those that would have occurred due to a natural event if the dam had not failed. The incremental consequences of failure are defined as the total consequences from an event with dam failure minus the consequences that would have resulted from the same event had the dam not failed. According to the CDA 2007 Dam Safety Guidelines, the incremental consequence classification of a dam takes into consideration consequences that fall into three broad categories: (1) potential loss of life, (2) infrastructure and economic losses, and (3) losses of environmental and cultural values.

1.1 Loss of Life

The CDA 2007 Dam Safety Guidelines state that, in addition to economic and environmental losses, the consequences of a dam failure should be evaluated in terms of life safety. The population at risk (PAR) in an inundated area provides an indication of the number of people exposed to the hazard. The CDA 2007 Dam Safety Guidelines provide a qualitative definition of PAR as "the number of people who would be exposed to floodwaters and would experience consequences that could range from inconvenience and economic losses to loss of life".

The potential loss of life (LOL) would be a proportion of the PAR, depending on factors such as warning time, location, elevation, flood depth, flow velocity, season of the year, and time of day or night. The PAR would include people who are permanently in the potential flood path downstream of a dam and those who are temporarily in the flood path, such as recreational users, traffic on roads or bridges, or seasonal cottage owners.

The CDA 2007 Dam Safety Guidelines state that the potential for loss of life would depend on many highly uncertain and variable factors, including depth of flow, flow velocity, time of day and advance warning. The CDA 2007 Dam Safety Guidelines also recognize that consistent estimates of expected loss of life are very difficult to develop, with no simple, reliable, or universally applicable methodology available.

1.1.1 Empirical Methods for Estimating Loss of Life

There are a number of empirical approaches for estimating the potential loss of life (LOL) from a hypothetical dam failure. McClelland and Bowles (2002) provide a detailed description and discussion of methods developed by various agencies and researchers for estimating LOL. Empirical approaches for estimating LOL can result in a range of estimates depending on many factors, including whether there is adequate warning time for downstream populations to evacuate, whether there is an existing evacuation plan, the level of emergency preparedness and the topography of the downstream areas (narrow and fast flowing waters or flat and slow flowing waters but of greater depth). Three approaches to estimate potential loss of life from McClelland and Bowles (2002) are described in the following sections. The approaches are identified by the author and year the approach was published.

Graham 1999

The general approach suggested by Graham (1999) is to divide the PAR into subPAR, classify each subPAR according to a trichotomous division of flood severity (Low, Medium, High), a trichotomous division of (official) warning time (No Warning, Some Warning, Adequate Warning), and a dichotomous division of flood severity understanding (Vague, Precise).

Flood severity (FS) is classified as low when homes are flooded but not destroyed; medium when some homes or businesses are destroyed but others remain un-submerged; and high when the flood plain is swept clean. To distinguish between low and medium severity, Graham (1999) suggested two criteria, one based on depth and the other based on a composite flood severity index parameter (DV).

Graham (1999) defined DV as DV = $(Q_{df} - Q_{2.33})/W_{df}$, where

Q_{df} = discharge at a particular site caused by the dam failure

$Q_{2.33}$ = mean annual flood discharge at that site (approximately bankfull flow rate)

W_{df} = maximum width of flooding caused by the dam failure at the same site

When flood depths are less than 3.3 m (10 ft) or DV is less than 4.6 m^2/s (50 ft^2/s), flood severity should be low. When depths are greater than 3.3 m, or DV is greater than 4.6 m^2/s, then flood severity should be medium when not high. Flood severity should only be classified as high when a dam fails nearly instantaneously, thereby failing with seconds, and only where flood waters are close enough to the dam to be "very deep".

Warning is defined as one that comes from the media or an official source and warning time (WT) is categorized as follows:

None : Only the sight and sound of the approaching flood serves as a warning, quantified as less than 15 minutes.

Some : Officials or the media begin warning the subpopulation 15 – 60 minutes before the flood arrives.

Adequate : Officials or the media begin warning the subpopulation more than one hour before the flood arrives.

Flood severity understanding (FSU) is either vague (V: warning issuers have not yet seen an actual dam failure or do not comprehend the true magnitude of the flooding) or precise (P: warning issuers have an excellent understanding of the flooding due to observations of the flooding by themselves or others). FSU is not applicable when WT is less than 15 minutes.

Figure 1 from Graham (1999) provides an expected mean value (mid), a low value and a high value for the proportional life loss (P) for each category of flood severity, warning time, and flood severity understanding.

Flood Severity Index (m^2/s)	Warning Time (mins)	Warning Time (mins)	Warning Time (mins)	Flood Severity Understanding	Flood Severity	Loss of Life as a Proportion (P) of Population at Risk		
DV	WT: Trichotomous Defintion in Graham (1999)	WT - Numerical Definition	WT - Simplified Representation	FSU	FS	Low Value of P	Mid Value of P	High Value of P
DV <= 4.5	None	WT <= 15	15	N/A	L	0	0.01	0.02
DV <= 4.5	Some	15 < WT <= 60	30	V	L	0	0.007	0.015
DV <= 4.5	Some	15 < WT <= 60	30	P	L	0	0.002	0.004
DV <= 4.5	Adequate	WT > 60	90	V	L	0	0.0003	0.0006
DV <= 4.5	Adequate	WT > 60	90	P	L	0	0.0002	0.0004
4.5 < DV <= 10	None	WT <= 15	15	N/A	M	0.03	0.15	0.35
4.5 < DV <= 10	Some	15 < WT <= 60	30	V	M	0.01	0.04	0.08
4.5 < DV <= 10	Some	15 < WT <= 60	30	P	M	0.0005	0.02	0.04
4.5 < DV <= 10	Adequate	WT > 60	90	V	M	0.0005	0.03	0.06
4.5 < DV <= 10	Adequate	WT > 60	90	P	M	0.0002	0.01	0.02
DV > 10	None	WT <= 15	15	N/A	H	0.3	0.75	1
DV > 10	Some	15 < WT <= 60	30	V	H	0.3	0.75	1
DV > 10	Some	15 < WT <= 60	30	P	H	0.3	0.75	1
DV > 10	Adequate	WT > 60	90	V	H	0.3	0.75	1
DV > 10	Adequate	WT > 60	90	P	H	0.3	0.75	1

V: Vague	L: Low
P: Precise	M: Medium
N/A : Not Applicable when WT <= 15 mins	H: High

Figure 1: Rate of Life Loss as a Function of Flood Characteristics

Brown and Graham 1988

Brown and Graham (1988) developed an empirical formula to estimate the loss of life due to a dam failure for the US Bureau of Reclamation (USBR). The regression-type equation relate loss of life to warning times based on fatalities recorded during past dam failures. The flood events they analyzed appeared to fall in two groups: cases in which warning times and implementation of evacuation plans were quite successful and loss of life was low or absent, and cases where warning was minimal or non-existent and the fatality rate was high. The warning time was defined as the time between when people find out the dam is going to fail and when the dam actually fails. By measuring the loss of life against the total population of past dam failures, Brown and Graham (1988) constructed graphs for two cases: one for insufficient warning times, i.e., under an hour and a half, and another for sufficient warning times.

For insufficient warning time (defined as less than 1.5 hrs),

$$LOL = PAR^{0.6}$$

For adequate warning time (greater than 1.5 hrs),

$$LOL = 0.0002PAR$$

where,

LOL = estimated loss of life

PAR = population at risk

T = warning time (hrs)

If lead time is very short (less than 15 minutes), then DeKay and McClelland (1993), in reviewing the results of further analysis carried out by the USBR on the data used by Brown and Graham (1988), gives a very approximate estimate of LOL as

$$LOL = 0.5(PAR)$$

DeKay and McClelland 1993

Using the same dataset as Graham and Brown (1988) and additional historical events, DeKay and McClelland (1993) developed an empirical equation relating LOL to PAR and warning time as a continuous variable:

$$L(p) = 0.146 - 0.478(\ln[PAR]) - 1.518T$$

where,

$L(p) = \ln([LOL/PAR]/[1-\{LOL/PAR\}])$

LOL = estimated loss of life

PAR = population at risk

T = warning time (hrs)

McClelland (2000) defines warning time as the difference in time from when the first warning is given of a dam break or an impending dam break and the time of the leading edge of potentially lethal flood waters first arrive at the leading edge of a PAR zone. DeKay and McClelland (1993) suggest that “no one who is more than 3 hr travel time below the dam should be included in the PAR”. DeKay and McClelland (1993) also modified their equation to consider cases where the flood is confined to narrow valleys (high flood depth and flow velocity) and other cases where the flood is conveyed along wide flood plains (low flood depth and flow velocity).

1.1.2 Estimation of Incremental Loss of Life from Long Pond Weir Failure due to Overtopping Failure during a 1,000-year Flood Event

Permanent Population at Risk

The permanent population at risk (PAR) includes people occupying residences, businesses, commercial entities, institutions, etc., for most of the day or night and who may be affected by a flood following the breach of a dam. The effect may range from inconvenience to loss of life.

The flood extents prepared by CBCL Limited Consulting Engineers (CBCL) during the 1,000-year flood event for a dam failure (Dam Breach) scenario of the Long Pond Weir and a no-dam failure (Dam Safe) were reviewed to estimate the number of residences within the flood extents for each scenario. The flood extents were along Rennies River from the Long Pond Weir to the inlet of Quidi Vidi Lake. The results suggest that 22 residences and 29 residences are located within the Dam Safe and Dam Breach flood extents, respectively. Assuming a permanent PAR of three (3) for each residence results in PARs of 66 and 87 for the Dam Safe and Dam Breach scenarios, respectively.

Loss of Life Estimates

CBCL provided inundation maps showing the maximum flood depth [1000 year Peak Depth Breach.pdf and 1000 year Peak Depth Safe.pdf] and flow velocity within the flood extents for both the Dam Breach [1000 year Peak Velocity Breach.pdf] and Dam Safe [1000 year Peak Velocity Safe.pdf] scenarios.

LOL based on Graham 1999

Except within the Rennies River itself, flood depth near residences and other buildings closest to the river appears to be generally less than 2 m for the Dam Breach scenario and generally less than 1.5 m for the Dam Safe scenario. Similarly, except within the Rennies River itself, flow velocity near residences and other buildings closest to the river appears to be generally less than 2 m/s for the Dam Breach scenario and generally less than 1.5 m/s for the Dam Safe scenario. The factor DV in the Graham 1999 approach would then be less than 4.5.

Warning time for extreme flood conditions along the Rennies River is expected to be more than 30 minutes to perhaps more than one hour because the 1,000-year flood causes significant increases in flood depth in the river even without a dam breach. Hence, officials or the media would likely have already warned the population along the river before a dam breach were to occur. Consequently, the flood severity understanding (FSU) is expected to be precise because warning issuers would likely have an excellent understanding of the flooding due to observations of the flooding by themselves or others, but this understanding may be less precise until a dam breach actually starts to occur. In the latter case, the FSU may be classified conservatively as vague.

Based on the above flood characteristics and the factors provided in Figure 1, the assessment of LOL for the 1,000-year flood event is as follows:

Dam Breach:	DV<4.5	WT: Adequate	FSU: V	Flood Severity: L
	LOL/PAR:	Low Value: 0	Mid Value: 0.0003	High Value: 0.0006
	PAR=87	Low LOL:0	Mid LOL:0.03	High LOL:0.05
Dam Safe:	DV<4.5	WT: Adequate	FSU: P	Flood Severity: L
	LOL/PAR:	Low Value: 0	Mid Value: 0.0002	High Value: 0.0004
	PAR=66	Low LOL:0	Mid LOL:0.01	High LOL:0.03

The incremental LOL (*LOL for Dam Breach – LOL for Dam Safe*) is therefore essentially zero.

LOL based on Brown and Graham 1988

Warning time for extreme flood conditions along the Rennies River is expected to be more than 30 minutes to perhaps more than one hour because the 1,000-year flood causes significant increases in flood depth in the river even without a dam breach. Hence, officials or the media would likely have already warned the population along the river before a dam breach were to occur. Consequently, it is reasonable to expect that warning time would be adequate (greater than 1.5 hrs) and hence Brown and Graham 1988 equation "LOL = 0.0002PAR" would apply. Application of this equation results in an incremental LOL of (0.0002*87-0.0002*66) or essentially zero.

LOL based on DeKay and McClelland 1993

Warning time for extreme flood conditions along the Rennies River is expected to be more than 30 minutes to perhaps more than one hour because the 1,000-year flood causes significant increases in flood depth in the river even without a dam breach. Hence, officials or the media would likely have already warned the population along the river before a dam breach were to occur. Assuming that warning time is about 1.5 hrs, the DeKay and McClelland 1993 equation results in an LOL estimate of 1.2 for the Dam Breach scenario and 1.0 for the Dam Safe scenario, or essentially zero.

Temporary Population at Risk

The temporary population at risk includes recreational users of Rennies River and traffic on roads or bridges crossing the river. It is expected that during a 1,000-year event the temporary population at risk would be zero. Hence, no loss of life is expected from the temporary PAR.

Conclusion on Incremental LOL for 1,000-year Flood Event with and without Dam Failure

Based on the analysis and discussion presented above, the expected incremental loss of life during the 1,000-year event is essentially zero.

1.1.3 Estimation of Incremental Loss of Life from Long Pond Weir Failure due to Piping Failure during a 100-year Flood Event

Permanent Population at Risk

The permanent population at risk (PAR) includes people occupying residences, businesses, commercial entities, institutions, etc., for most of the day or night and who may be affected by a flood following the breach of a dam. The effect may range from inconvenience to loss of life.

The flood extents prepared by CBCL Limited Consulting Engineers (CBCL) during the 100-year flood event for a dam failure (Dam Breach) scenario of the Long Pond Weir and a no-dam failure (Dam Safe) were reviewed to estimate the number of residences within the flood extents for each scenario. The flood extents were along the Rennies River from the Long Pond Weir to the inlet of Quidi Vidi Lake. The results suggest that 6 residences and 9 residences are located within the Dam Safe and Dam Breach flood extents, respectively. Assuming a permanent PAR of three (3) for each residence results in PARs of 18 and 27 for the Dam Safe and Dam Breach scenarios, respectively.

Loss of Life Estimates

CBCL provided inundation maps showing the maximum flood depth [100 year Peak Depth Breach.pdf and 100 year Peak Depth Safe.pdf] and flow velocity within the flood extents for both the Dam Breach [100 year Peak Velocity Breach.pdf] and Dam Safe [100 year Peak Velocity Safe.pdf] scenarios.

LOL based on Graham 1999

Except within Rennies River itself, flood depth near residences and other buildings closest to the river appears to be generally less than 1.5 m for the Dam Breach scenario and generally also less than 1.5 m for the Dam Safe scenario. Similarly, except within the Rennies River itself, flow velocity near residences and other buildings closest to the river appears to be generally less than 1.5 m/s for the Dam Breach scenario and generally less than 1 m/s for the Dam Safe scenario. The factor DV in the Graham 1999 approach would then be less than 4.5.

Warning time for extreme flood conditions along the Rennies River is expected to be more than 30 minutes to perhaps more than one hour because the 100-year flood causes significant increases in flood depth in the river even without a dam breach. Hence, officials or the media would likely have already warned the population along the river before a dam breach were to occur. Consequently, the flood severity understanding (FSU) is expected to be precise because warning issuers would likely have an excellent understanding of the flooding due to observations of the flooding by themselves or others, but this understanding may be less precise until a dam breach actually starts to occur. In the latter case, the FSU may be classified conservatively as vague.

Based on the above flood characteristics and the factors provided in Figure 1 the assessment of LOL for the 100-year flood event is as follows:

Dam Breach:	DV<4.5	WT: Adequate	FSU: V	Flood Severity: L
	LOL/PAR:	Low Value: 0	Mid Value: 0.0003	High Value: 0.0006
	PAR=27	Low LOL:0	Mid LOL:0.01	High LOL:0.02
Dam Safe:	DV<4.5	WT: Adequate	FSU: P	Flood Severity: L
	LOL/PAR:	Low Value: 0	Mid Value: 0.0002	High Value: 0.0004
	PAR=18	Low LOL:0	Mid LOL:0.00	High LOL:0.01

The incremental LOL (*LOL for Dam Breach – LOL for Dam Safe*) is therefore essentially zero.

LOL based on Brown and Graham 1988

Warning time for extreme flood conditions along the Rennies River is expected to be more than 30 minutes to perhaps more than one hour because the 100-year flood causes significant increases in flood depth in the river even without a dam breach. Hence, officials or the media would likely have already warned the population along the river before a dam breach were to occur. Consequently, it is reasonable to expect that warning time would be adequate (greater than 1.5 hrs) and hence Brown and Graham 1988 equation "LOL = 0.0002PAR" would apply. Application of this equation results in an incremental LOL of (0.0002*27-0.0002*18) or essentially zero.

LOL based on DeKay and McClelland 1993

Warning time for extreme flood conditions along the Rennies River is expected to be more than 30 minutes to perhaps more than one hour because the 100-year flood causes significant increases in flood depth in the river even without a dam breach. Hence, officials or the media would likely have already warned the population along the river before a dam breach were to occur. Assuming that warning time is about 1.5 hrs, the DeKay and McClelland 1993 equation results in an LOL estimate of 0.6 for the Dam Breach scenario and 0.5 for the Dam Safe scenario, or essentially zero.

Temporary Population at Risk

The temporary population at risk includes recreational users of Rennies River and traffic on roads or bridges crossing the river. It is expected that during a 100-year event the temporary population at risk would be zero. Hence, no loss of life is expected from the temporary PAR.

Conclusion on Incremental LOL for 100-year Flood Event with and without Dam Failure

Based on the analysis and discussion presented above, the expected incremental loss of life during the 100-year event is essentially zero.

2.0 INFRASTRUCTURE LOSS

An assessment of possible infrastructure damages during a dam breach flood event can be based on the following considerations.

Bridges (except for low level crossings) are not designed to be overtopped. A crossing that can pass the peak flow without drift touching the girders has a good chance of "surviving" the event, albeit with some damage possible at the abutments. During a dam breach flood event, substantial drift (e.g., trees) picked up by the flood wave can be expected. So, a freeboard (from maximum water level to bottom of bridge deck) of less than nominally one (1) m could result in significant structural damage.

Damages to houses can range from total replacement cost to costs for clean-up, furniture replacement and temporary accommodation.

2.1.1 Incremental Infrastructure Loss from Long Pond Weir Failure due to overtopping Failure during a 1,000-year Flood Event

A review of the inundation maps provided by CBCL showing the maximum flood depth and velocity [1000 year Peak Depth Breach.pdf, 1000 year Peak Depth Safe.pdf, 1000 year Peak Velocity Breach pdf, and 1000 year Peak Velocity Safe pdf] for the Dam Breach and Dam Safe scenarios suggest that the primary road crossings and bridges (such as, Allendale, Prince Philip Drive, Elizabeth Avenue, Portugal Cove Road and King's Bridge Road) along Rennies River downstream of the dam would be seriously damaged under both scenarios and the potential incremental damages are not anticipated to warrant a classification of high.

A review of the flood extents along the Rennies River from the Long Pond Weir to the inlet of Quidi Vidi Lake suggest that 22 residences and 29 residences are located within the Dam Safe and Dam Breach flood extents, respectively. The potential incremental damages associated with the seven (7) residences are not expected to warrant a classification of high.

A review of the flood extents along Rennies River from Long Pond Weir to the inlet of Quidi Vidi Lake suggest that the incremental loss in recreational infrastructure is one (1) tennis court, and one (1) basketball court. These potential incremental losses can be classified as low.

2.1.2 Incremental Infrastructure Loss from Long Pond Weir Failure due to Piping Failure during a 100-year Flood Event

A review of the inundation maps provided by CBCL showing the maximum flood depth and peak velocity [100 year Peak Depth Breach.pdf, 100 year Peak Depth Safe.pdf, 100 year Peak Velocity Breach pdf and 100 year Peak Velocity Safe pdf] for the Dam Breach and Dam Safe scenarios suggest that the primary road crossings and bridges (such as, Allendale and Portugal Cove Road) along Rennies River downstream of the dam would be seriously damaged under both scenarios.

A review of the inundation maps provided by CBCL showing the maximum flood depth and peak velocity [100 year Peak Depth Breach.pdf, 100 year Peak Depth Safe.pdf, 100 year Peak Velocity Breach pdf and 100 year Peak Velocity Safe pdf] for the Dam Breach and Dam Safe scenarios suggest that one primary road crossing/bridge (Prince Philip Drive) would be completely flooded under the Dam Breach scenario compared to the Dam Safe scenario. However, given the flood depth and flow velocity in this area under the Dam Safe Scenario, it is expected that this section of roadway would still experience damage and need repair even under the Dam Safe scenario, even though the roadway is only partially inundated, as such the potential incremental damages are not anticipated to warrant a classification of high.

A review of the flood extents along the Rennies River from the Long Pond Weir to the inlet of Quidi Vidi Lake suggest that 6 residences and 9 residences are located within the Dam Safe and Dam Breach flood extents, respectively. The potential incremental damages associated with the three (3) residences are not expected to warrant a classification of high.

A review of the flood extents along Rennies River from the Long Pond Weir to the inlet of Quidi Vidi Lake suggest that the incremental loss of recreational infrastructure is a portion of the Rennies River Walking Trail and a portion of a parking lot. These potential incremental loses are minor and therefore can be classified as low.

3.0 LOSSES OF ENVIRONMENTAL AND CULTURAL VALUE

An assessment of possible environmental and cultural value losses that would result from a dam breach flood event can be based on the following:

- Extent of habitat affected by the flooding;
- Whether restoration of the environment is feasible;
- How long restoration would take; and,
- If any irreplaceable historic and cultural features are affected by flooding.

In the environmental assessment registration document for the Long Pond Weir (CBCL, 2015), it discusses the project's effect on fish and wildlife. The registration document identified five (5) different species of fish currently inhabiting the Rennie's River watershed that would be affected by flooding. These fish are Brown Trout, Brook Trout, American Eel, Atlantic salmon, and Three Spined Stickleback. There are also prime spawning grounds at the outlet of Long Pond and the beginning of Rennies River for brown trout which will also be affected during flooding scenarios.

Three fish species that are considered culturally significant and/or would impact recreational activities are brown trout, brook trout and Atlantic salmon. It should be noted that adult Atlantic salmon have not been seen in Long Pond for over sixty (60) years, however; parr and smolt have been seen recently in Long Pond.

3.1.1 Incremental Environmental and Cultural Value Loss from Long Pond Weir Failure due to overtopping Failure during a 1,000-year Flood Event

A review of the velocity maps provided by CBCL showing the maximum river velocities (1000 year Peak Velocity Breach pdf and 1000 year Peak Velocity Safe pdf) for the Dam Safe and Dam Breach scenarios suggest that the average velocity in Rennies River is 3.0 m/s and 3.25 m/s respectively.

In both cases the velocity is greater than the swimming speeds for all three species; therefore under both scenarios fish migration through the river would be impacted.

The spawning gravels will also be disturbed due to the river velocity. Referring to the standard Hjulstrom diagram, river bed gravels begin to move at an approximate water velocity of 10 cm/s (1 m/s). Thus under both scenarios, spawning gravels would be affected, however the incremental loss is expected to be negligible.

This incremental change in velocity for a 1000 year flooding event with respect to fish and fish habitat can be considered negligible and can be classified as low.

3.1.2 Incremental Environmental and Cultural Value Loss from Long Pond Weir Failure due to overtopping Failure during a 100-year Flood Event

A review of the velocity maps provided by CBCL showing the maximum river velocities (100 year Peak Velocity Breach pdf and 100 year Peak Velocity Safe pdf) for the Dam Safe and Dam Breach scenarios suggest that the average velocity in Rennies River is 2.5 m/s and 2.7 m/s respectively. This incremental change in velocity for a 100 year flooding event can be considered negligible.

In both cases the velocity is greater than the swimming speeds for all three species; therefore under both scenarios fish migration through the river would be impacted. The spawning gravels will also be disturbed due to the river velocity. Referring to the standard Hjulstrom diagram, river bed gravels begin to move at an approximate water velocity of 10 cm/s (1 m/s). Thus under both scenarios, spawning gravels would be affected.

This incremental change in velocity for a 100 year flooding event with respect to fish and fish habitat can be considered negligible and would be classified as low.

4.0 CDA CLASSIFICATION OF LONG POND WEIR

The CDA 2007 Dam Safety Guidelines base dam classification on three broad consequence categories which are (1) potential loss of life, (2) infrastructure and economic losses, and (3) losses of environmental and cultural values. The various consequences can be found in Table 2-1 in CDA 2007. The overall dam classification is determined by the highest potential consequence. Based on the above analysis of the three consequence categories, the Long Pond Weir would be classified as Significant. The highest potential consequence for incremental losses was the infrastructure category. There were potential incremental damages associated with seven (7) houses, in the 1000 year flooding event, however this is not considered to be extensive enough to justify the classification of the dam as High and therefore the dam has been classified within the Significant category. In addition, while a permeant population is at risk, which would generally indicate that a dam classification of High should be used. It has been shown through the loss of life calculations that the anticipated LOL for both scenarios is essentially zero. This is further support for assigning the dam to the Significant classification.

Report Signature Page

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APPENDIX M

Slope Stability and Erosion Assessment

March, 2016

SLOPE STABILITY AND INTERNAL EROSION ASSESSMENTS

Long Pond Weir
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REPORT

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1.0 INTRODUCTION

1.1 Background & Objective

Golder Associates Ltd. (Golder) was engaged by CBCL Limited (CBCL) to provide assistance with completing some of the requirements outlined in the Guidelines for an Environmental Preview Report (EPR) that were issued on June 9, 2015. The guidelines were issued in response to the Environmental Registration document prepared by CBCL for the proposed weir structure at Long Pond, located in the City of St. John's, NL, which was submitted on February 6, 2015. Within the guideline document there are several requirements related to the Dam Safety Guidelines (2013) published by the Canadian Dam Association which must be addressed in the proponent's EPR. This report specifically address the requirements to provide geotechnical analysis related to slope stability and internal erosion assessments, for the dam as per the Canadian Dam Association (CDA) Dam Safety Guidelines (2013).

The hydrotechnical requirements including freeboard analyses, stage-discharge analyses, spillway capacity, sizing of hydrologic rip-rap, etc. were performed by CBCL. Based on the results of the hydrotechnical work, CBCL has provided Golder with the required minimum dam elevation needed to satisfy the freeboard criteria and have prepared their own recommendation for the rip-rap sizing required along the upstream slope to protect against wave erosion. It should be noted that Golder has not reviewed the supporting calculations and are relying on the accuracy of the information provided by CBCL. It is also worth noting that CBCL will remain the engineer of record for the dam design.

1.2 Description of the Weir

Long Pond Weir is a flood retention structure designed to attenuate the flow into the downstream area. The main purpose of the weir is to increase the holding capacity of Long Pond during a storm event, which in turn will decrease the flow going downstream and reduce the probability of flooding.

Based on the information provided to Golder the elevation of the dam crest will be 56.3 m. The weir is approximately 30 m in width, 3 m wide at the crest, and approximately 5 m above the final grade. Under normal operating conditions the water level will be the same on both the upstream and downstream side with an approximate elevation of 53.2 m. Under the design maximum flood conditions reported by CBCL the water elevation on the upstream side of the weir will rise to 55.7 m and the water elevation on the downstream side will rise to 55.2 m. The weir will be a homogenous embankment dam, and the main portion of the dam will be constructed using 100 mm minus, angular, blast rock fill. A Geosynthetic Clay Liner (GCL) is included in the upstream slope to reduce the seepage through the embankment. A 600 mm thick layer of rip-rap will then be placed along both the upstream and downstream slopes and along the crest which will be underlain by filter fabric. Both the upstream and downstream slopes have a profile of (1.8H:1.0V). There will be a 6 m wide precast concrete channel (spillway) constructed within the weir, with two (2), 2 m wide openings with hand operated gates. The spillway will be lined with hydrologic rip-rap appropriately sized based on the anticipated velocities under maximum flood conditions. The spillway channel will be lined with hydraulic rip-rap. In addition a water level monitoring system will be installed to monitor water level elevations.

1.3 Dam Construction

CBCL have indicated that the weir will be constructed in the dry and will require a cofferdam and dewatering. All Unsuitable Material (USM) will be removed from within the footprint of the weir to allow the dam to be founded on competent native till. Based on the results of a previous geotechnical investigation performed by Golder it is assumed that the foundation for the dam will be compact, undisturbed till at an elevation of approximately 49.0 m. Further details on the construction sequence and the source of the materials have not been provided to Golder at this time.

1.4 Previous Studies

The following reports were provided by Golder for review:

- Long Pond Weir – Environmental Assessment Registration Document (File Ref No. 200.20.2321, CBCL Limited, February 6, 2015. Including the following appended report:
  - Proposed Weir Structure Long Pond, NL Golder Associates Limited, November 2014.
- Additional Geotechnical Recommendations, Long Pond Weir, St. John's, NL, Golder Associates Limited, February 9, 2015.

2.0 DESIGN SELECTION, OBJECTIVES & CRITERIA

2.1 Design Selection

A detailed review of all pertinent information was performed and a model was created using the slope stability program *Slide 6.0*. The following sections identify the objectives and basic design criteria for the proposed weir.

2.2 Design Objectives

The design objectives for the overall project include:

- Provide a stable dam configuration for both short and long term conditions. The design must be easy to construct and must satisfy the CDA factor of safety acceptance criteria.
- The elevation of the dam crest should be such that the required freeboards are available along the entire length of the dam.
- Provide rip-rap protection along the upstream and downstream slopes to prevent erosion and undercutting of the slopes.

2.3 Design Criteria

Dam Design-Criteria (Geotechnical)

The dam under consideration at Long Pond has recently been assigned a CDA classification of “Significant” by Golder (Golder, 2015). The Earthquake Design Ground Motion (EDGM) used in the seismic analysis (pseudo-static) was selected to correspond to an Annual Exceedance Probability (AEP) of 1:1,000 AEP. The Peak Ground Acceleration (PGA) was incorporated into the slope stability program (*Slide 6.0*) to generate the stability analyses present herein.

In order to perform the analysis, the CDA recommends that the mean hazard value for the selected EDGM be used in the seismic hazard evaluation rather than the median value. In order to get the mean values, a seismologist at the Geological Survey of Canada was contacted and the mean values for the horizontal PGA for different AEPs were obtained.

The mean horizontal PGA value for a 1:1,000 AEP was 0.039 *g*, where *g* is the gravitational acceleration (Dr. Stephen Halchuk, email communication, January 13, 2016).

A vertical PGA was also used in the analysis and published literature indicates that, as a general rule, the vertical PGA will not exceed two-thirds the horizontal PGA. Therefore, 0.026 *g* was used in the analysis to represent a vertical PGA.

The upstream and downstream slopes of the dam were then modelled to determine if the minimum factor of safety according to the CDA (2013) would be achieved under the following conditions:

- Static (long term, steady state seepage)– 1.5
- Seismic (Pseudo-static) - 1.0
- End of Construction (before filling) – 1.3

Dam Design-Criteria (Hydrotechnical)

The hydrotechnical requirements for the dam were determined by CBCL and have been reported under separate cover. For further information the reader is directed to CBCL’s Environmental Preview Report.

3.0 ANALYSES

This section presents the different geotechnical analyses performed in support of the dam design provided by CBCL. The proposed dam includes a GCL to act as a seepage barrier. The GCL will be embedded in the dam fill to provide the necessary confining pressure. Detail of the GCL is currently not available. We understand that the GCL is intended to reduce the seepage gradient in the dam fill and therefore the potential for removing the fine particles under peak flow conditions. Leakage through the dam is permissible as long as dam stability is maintained. The overall performance of the dam with respect to flood water retention will not be adversely affected. Golder recommends that a bedding layer of sand and gravel be provided to protect the GCL from being damaged by the rockfill. It is assumed that the GCL will be placed at a steep angle in the body of the dam and will not affect slope stability. Once the full details of the liner are known, including details of the bedding materials and backfill that will be placed on top of the liner, they should be sent to Golder so that we can determine if the slope stability analyses presented herein remain valid.

For the purpose of the stability analysis the GCL was ignored and the phreatic surface within the dam was assumed to vary linearly between the upstream and downstream pools. Dam foundation preparation will require the construction of a coffer dam beyond the existing dam footprint. The coffer dam and the material that is used to backfill the toes of the dam have been conservatively excluded from the analysis.

Slope stability analyses were performed to demonstrate that the proposed design provided by CBCL will allow the dam to remain stable under both static and seismic (pseudo-static) loadings as well as at the end of construction before reservoir filling.

3.1 Slope Stability

According to the CDA and the International Commission on Large Dams (ICOLD), embankment sliding under static and seismic conditions accounts for 6% of dam failures throughout the world. While this represents a small proportion of the total failures, deep seated rotational failures must be considered in any dam design.

In order to evaluate the possibility of these types of failures, slope stability models for the proposed weir were prepared for a variety of possible conditions. A limited amount of data for the analyses was obtained from the geotechnical investigation performed by Golder in October, 2014 for CBCL.

A copy of the records for the three boreholes that were collared in the general area of the proposed weir, as well as the location plan can be found in **Appendix A**. The borehole logs have been used to assess the elevation at which a competent stratum would likely be reached and to assign the geotechnical properties for the foundation of the dam.

Based on the Dam Safety Guidelines published by the Canadian Dam Association (2013), a minimum factor of safety of 1.3 is required for the end of construction before filling. A minimum factor of safety of 1.5 is required for static conditions (steady-state seepage) and 1.0 for seismic (pseudo-static) conditions. In order to satisfy the CDA factor of safety criteria the geometry of the upstream and downstream slopes were varied in order to determine what slope angle would be required to achieve a factor of safety of 1.5 or greater under static, steady state conditions. Once the required factor of safety was reached, analyses were also performed under seismic conditions (pseudo-static analysis) to determine if the factor of safety was 1.0 or higher. It is unlikely that a rapid drawdown condition will exist in the dam because of the way the gates of the spillway are intended to be operated, i.e., according to CBCL the gates will be hand operated and will only be opened in the event that the water level in the pond exceeds the 55.7 m elevation.

The slope stability analyses were performed using *Slide 6.0*, which is a two dimensional limit equilibrium analysis program licensed to Golder through Rocscience.

Model Setup

The initial profile of the dam was provided to Golder by CBCL. The geotechnical properties of the foundation were based on the information contained on the borehole records presented in **Appendix A**. However, due to the general lack of information regarding the blast rock fill, i.e., no specific gradation curve from an approved quarry source has been provided, most of the assigned geotechnical properties were based on professional judgment and in consultation with several geotechnical references, i.e., Bowles, 1996; Holtz *et al*., 2011 and Hough, 1969.

With respect to the properties of the angular, blast rock fill, it is known that a well graded, dense, crushed rock (e.g., 100 mm minus, well graded, gravel with a low percentage of fines), can have an internal friction angle of approximately 60° under low stress conditions. In our analysis a value of 45°, which is somewhat conservative, was used for the rock fill. For the rip-rap, which is a much larger diameter angular blast rock compared to the 100 mm minus rock fill, an internal friction angle of 40° was used. This is due to the fact that the rip-rap will likely not undergo any formal compaction techniques and will be placed along the slopes with an excavator and "knuckled" into place.

In order to run the various analyses, the initial slope profile provide by CBCL was imported into *Slide 6.0* and some minor adjustments were made, i.e., the elevation of the bottom of the dam was lowered to the expected foundation elevation and the various material types, thicknesses and geotechnical properties were incorporated. Using the initial profile, several modifications were made to the downstream slope until the required factor of safety was achieved under static conditions. Once the required Factor of Safety (FOS) was achieved, additional analyses were completed to determine if the slopes would remain stable under the other conditions previously mentioned. The results of the slope stability model have been provided to CBCL, who will then use the results to perform the detailed designed of the structure.

Slope Stability Results

Table 3.1 presents the geotechnical parameters used in the slope stability analyses. In addition, a horizontal PGA of 0.039 g and vertical PGA of 0.026 g were used as pseudo-static seismic coefficients. The unit weight of water used in these calculations was 9.81 kN/m^3.

Table 1: Summary Table of Slope Stability Parameters

Material	Angular Rock Fill	Compact *in situ* Till	Angular Rip Rap
Unstaurated Unit Weigh (kN/m^3)	17.5	18.5	15.5
Saturated Unit Weight (kN/m^3)	20.0	21.0	19.0
Friction Angle (°)	45	36	40
Cohesion (kPa)	0	0	0
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb

Figure 1 in **Appendix B** shows the general geometry of weir and the detailed results of the stability analyses are presented on Figures 2 through 9 in **Appendix B**, also Table 3.2 provides a summary of the results. The Factor of Safety (FOS) shown on each analysis in **Appendix B** is the minimum FOS determined for each analysis. The results of each analysis have also been filtered to show all the possible failure surfaces, meaning that the FOS associated with the other failure surfaces is greater than the minimum FOS displayed on the figure.

The factors of safety presented in Table 3.2 and in the stability analyses presented in **Appendix B** are based on the Bishop Simplified Limit Equilibrium Method. Pore pressures in each model were automatically calculated in the analysis program based on the position of the water table.

Slide 6.0 automatically takes into consideration the weight of any ponded water that is resting against a slope and therefore an additional load to represent the buttressing effect is not required. Although the saturated unit weight is assigned to materials below the water table, the buoyant (effective) unit weight is calculated automatically in the analysis by the software.

Looking at the legend on the figures contained in **Appendix B**, and the trace of the deep seated rotational failures it is easy to see that the minimum FOS for a deep seated failure surface under the various conditions modeled is much higher than the global minimums presented on the figures, which are associated with surficial failures. Therefore the factor of safety against deep seated failures exceeds the CDA requirements.

There are many other details that could be discussed regarding the way the slope analyses were setup, however, in most cases the program default settings were used. Golder can provide additional detail on how each model was set up upon request.

Based on the loading conditions modelled as part of this work, it can be seen that the proposed weir, will meet or exceed the acceptance criteria advocated by the Dam Safety Guidelines (CDA, 2013) for a “Significant” consequence dam.

Table 2: Summary Table of Stability Results and Factors of Safety

Modelled Condition	Crest Elevation (m)	Overall Slope H:V	Upstream Water Level (m)	Downstream Water Level (m)	Predicted FOS (minimum)	Required FOS (minimum)
Normal Water Level (Static) Upstream Slope	56.3	1.8:1.0	53.2	53.2	1.5	*1.5
Normal Water Level (Seismic) Upstream Slope	56.3	1.8:1.0	53.2	53.2	1.2	*1.0
Normal Water Level (Static) Downstream Slope	56.3	1.8:1.0	53.2	53.2	1.5	*1.5
Normal Water Level (Seismic) Downstream Slope	56.3	1.8:1.0	53.2	53.2	1.3	*1.0
Maximum Water Level (Static) Downstream Slope	56.3	1.8:1.0	55.7	55.2	1.5	**1.2
Maximum Water Level (Static) Upstream Slope	56.3	1.8:1.0	55.7	55.2	1.5	**1.2
End of Construction Before Filling (Static) Upstream Slope	56.3	1.8:1.0	N/A	N/A	1.5	*1.3
End of Construction Before Filling (Static) Downstream Slope	56.3	1.8:1.0	N/A	N/A	1.5	*1.3

** Required FOS as per CDA, 2013. **Based on professional judgement.*

3.2 Internal Erosion

According to the CDA and the International Commission on Large Dams (ICOLD, 2013), failures due to internal erosion account for 46% of embankment dam failures throughout the world. In combination with external erosion due to overtopping, erosion accounts for 94% of worldwide dam failures. In any dam design internal erosion must be accounted for. The following sections address the four main types of internal erosion which include; (1) concentrated leaks, (2) backward erosion, (3) contact erosion, and (4) suffusion.

The rockfill material for dam construction is not susceptible to internal erosion. Seepage is expected to occur in the highly permeable rockfill. The concentrated seepage may remove some fines and cause minor dam settlement but rockfill cannot be dislodged with the flow anticipated. As such it is not expected that the seepage pathway will enlarge to a stage that would threaten dam integrity.

Backfill around the concrete structures will require careful consideration. The backfill material should provide uniform support to the structure with minimal settlement. Typically this can be achieved by the use of granular fill and cut off walls or collars that maximize the seepage pathway.

Concentrated Leaks

Concentrated leaks may occur through a crack in an embankment dam caused by differential settlement during construction, desiccation at high levels in the dam, hydraulic fracturing due to low stresses around conduits, or frost action. Cracking or a gaps may also form adjacent to a spillway or abutment wall due to the embankment materials settling away from the wall during or after construction. Properly designed walls with uniform contact slopes flatter than about 0.25H:1.0V are unlikely to have gaps form, whereas vertical walls are likely to have gaps. In addition, the effects of frost action against a spillway structure can also lead to crack formation (ICOLD, 2013). Rock fill is free draining; high seepage gradients can only exist where the GCL develops a leak under high flow conditions. Some fines will be removed but the rock fill will remain in place.

Backward Erosion

Backward erosion begins at a free surface on the downstream side of a dam. The free surface may be a seepage surface on the downstream face of the dam. The backward erosion process progresses beneath the dam or in the embankments and, for this to occur, the dam or cohesive strata must form a roof for the eroding “pipe”. Granular materials are generally not susceptible to roof forming.

For backward erosion piping to occur within a dam, levee or dike embankment, the following three (3) criteria would have to be met (ICOLD, 2013):

- The soil where the pipes develop would need to be non-plastic.
  - The classification of plasticity is reserved for fine grained soils, i.e., 50% or more by mass passes the No. 200 sieve. The 100 mm minus rock fill is non-plastic but it contains very little fines. The rock fill matrix cannot be removed by seeping water.
- There would have to be a free surface at the downstream side of the dam at which erosion could initiate; e.g., the free surface could be the seepage surface on the downstream face of the dam.
  - This condition is met as seepage may occur along the downstream face. The non-woven geotextile that will be placed to separate the rock fill from the rip rap could only be partially effective in retaining fines as open flow paths will develop through the panel joints. Also, if the geotextile becomes damaged then there will be free surfaces within the dam and along the downstream face where internal erosion could initiate.
- The foundation or embankment dam would have to form a roof for the pipe to progress. This cannot occur in rock fill because the rock particles cannot be removed from the host matrix and therefore the seepage pathway cannot progress and enlarge.

Contact Erosion

Contact erosion occurs where a coarse soil such as gravel is in contact with a fine soil and flow parallel to the contact in the coarse soil erodes the fine soil. The phenomenon requires two conditions. First, the coarse layer has to be geometrically open to the other layer, i.e., the pores within the coarse layer need to be sufficiently large so that fine particles can pass through them. Secondly, the hydraulic conditions must be such that the flow velocity is sufficient to detach particles and transport them.

With a fines content of typically less than 10% rock fill is highly permeable. It is unlikely that a concentrated flow path will form in this material and propagate in the upstream direction.

There is no upward seepage gradient from the foundation till to the rockfill. Fines in the till will not be eroded.

Suffusion

Suffusion can occur when fine particles are removed by water flowing through widely graded or gap graded cohesionless soils. Fines removal from the relatively clean rockfill will not affect dam stability as the coarse matrix will remain.

4.0 SUMMARY

Based on the results of the slope stability analyses presented herein, the proposed design presented by CBCL is sufficient for the Long Pond weir structure and will adhere to CDA requirements. The rock fill material is not susceptible to piping failure. Some settlement of the dam can occur due to fines being removed over time.

The proposed GCL should be fully incorporated in the rock fill. Laying the GCL on the slope face will not provide a stable interface for the rip rap. Embedding the GCL in the dam will ensure a more effective seepage barrier due to the higher confining stress.

The foundation surface of the dam should be inspected by a geotechnical professional to determine if the surface is consistent with a competent material, e.g., compact, undisturbed till. After stripping of all unsuitable materials the surface should be proof rolled using a 10 - 12 tonne roller, or heavy plate, vibrating tamper if space restrictions or accessibility issues apply.

Areas softened by water, disturbed by construction activity or in a loose condition, should be further excavated to a suitable depth and replaced with an approved structural fill. If bedrock is encountered then all weathered and highly fractured rock must be removed down to competent bedrock and the bedrock surface must be inspected by a licensed professional. If water is present during construction, which will likely be the case, it must be properly controlled to prevent softening of the *in situ* soils.

The 100 mm minus blast rock fill should be placed in thin horizontal lifts of 250 mm thick loose layers, wetted and compacted using no more than six (6) passes of an appropriately sized vibratory roller. Again if soil pumping becomes an issue, the number of passes should be reduced to three (3). If further issue with respect to soil pumping arise then a geotechnical professional should be called in to investigate.

The natural foundation material (till) and the imported rock fill material may not be compatible from a particle size gradation standpoint. Fines migration during could occur during construction due to the vibratory load. A nonwoven geotextile may be placed over the subgrade, if necessary.

5.0 CLOSURE

The reader is referred to the “Important information and Limitations of This Report”, which is presented in **Appendix C** and forms an integral part of this document.

We trust this report meets with your current requirements. Should additional information be required, please do not hesitate to contact our office at your convenience.

Report Signature Page

GOLDER ASSOCIATES LTD.

REGISTERED PROFESSIONAL GEOSCIENTIST
PEG Newfoundland and Labrador
PROFESSIONAL ENGINEERS AND GEOSCIENTISTS
Andrew C. Peach
SIGNATURE
March 3, 2016
DATE
NEWFOUNDLAND & LABRADOR

Andrew Peach, P.Geo., EP
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AP/SK/kl

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PROVINCE OF NEWFOUNDLAND AND LABRADOR
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PERMIT HOLDER
This Permit Allows
GOLDER ASSOCIATES LTD.
To practice Professional Geoscience
in Newfoundland and Labrador.
Permit No. as issued by PEGNL D0029
which is valid for the year 2016

Member in Responsible Charge

6.0 REFERENCES

Bowles, J.E., 1996. Foundation Analysis and Design, Fifth Edition, McGraw-Hill.

Dam Safety Guidelines, 2013. Canadian Dam Association.

Golder Associates Limited, 2015, Technical Memorandum: Additional Geotechnical Recommendations, Long Pond Weir, St. John's, NL

Holtz, R. D., Kovacs, W. D. and Thomas, S.C. 2011. An Introduction to Geotechnical Engineering, Second Edition, Pearson Education Limited.

Hough, B.K., 1969. Basic Soils Engineering, Second Edition, Ronald Press Co.

ICOLD, 2013. Internal Erosion of Existing Dams, Levees, and Dikes, and Their Foundations. Bulletin 164, Volume 1: Internal Erosion Processes and Engineering Assessment.

Long Pond Weir – Environmental Assessment Registration Document, 2015

APPENDIX A

Borehole Records

PROJECT: 1407587

RECORD OF BOREHOLE: BH1

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: October 3-4, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

DRILL RIG: CME 55

DRILLING CONTRACTOR: Logan Geotech

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	REC. LENGTH (mm) / SA. LENGTH (mm)	BLOWS/0.15m	N VALUE	STANDARD PENETRATION RESISTANCE, N VALUE / SHEAR STRENGTH Cu, kPa	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT	REMARKS, ADDITIONAL LAB. TESTING & GRAIN SIZE DISTRIBUTION (%)	PIEZOMETER OR STANDPIPE INSTALLATION
		WATER SURFACE		53.00								GR SA SI CL	
0	Continuous Split Spoon, 90 mm Diam. Casing	WATER		0.00									
1													
				51.20									
2		(ML) CLAYEY SILT; dark grey brown, with organics; w>PL, cohesive, very soft		1.80									
3													
				49.20									
4		(Cl) gravelly CLAY, fine to coarse gravel; pale grey; w<PL, very stiff		3.80	1	SS	305 / 610	0 7 23 19	30	30			
				48.50									
5		(GP) sandy GRAVEL, fine to coarse, subangular; pale grey to greenish grey, with low plasticity fines, cobbles and boulders (GLACIAL TILL); compact to dense		4.50	3	SS	356 / 610	13 13 12 32	25	25			
					4	SS	305 / 610	18 27 22 22	49	49			
6	Rotary Drill, NQ Core				5	SS	203 / 534	33 16 21 50/0.08	37	37			
					6	SC	——						
7					7	SC	——						
8				44.85									
		Borehole continued on RECORD OF DRILLHOLE BH1		8.15									
9		Note:											
		1. Drill string sank under it's own weight from 1.8 m to 3.8 m.											
10													
11													
12													
13													
14													
15													

STANDARD PENETRATION RESISTANCE, N VALUE: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● / rem V. ⊕ U - ○; 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp W Wl; 20 40 60 80

DEPTH SCALE

1 : 75

LOGGED: BW

CHECKED: ML

Golder Associates

MIS-BHS 012 1407587 TEMP.GPJ GAL-MIS.GDT 11/04/14 JM

PROJECT: 1407587

RECORD OF DRILLHOLE: BH1

SHEET 2 OF 2

LOCATION: See Site Plan

BORING DATE: October 3-4, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Logan Geotech

JN - Joint, FLT - Fault, SH - Shear, VN - Vein, CJ - Conjugate
BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL -
PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular
PO - Polished, K - Slickensided, SM - Smooth, RO - Rough, MB - Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

Point Load Index Legend:
● Diametral Test on Intact Sample
○ Diametral Test on Microdefect/Foliation
■ Axial Test on Intact Sample
□ Axial Test on Microdefect/Foliation

UCS Legend:
▲ Intact Rock
△ Partial Failure

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE % (80 60 40 20)	RECOVERY: SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.25 (5 10 15 20)	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	UCS (MPa) (20 40 60 80) / Point Load Index (MPa) (4 8 12 16)	WEATHERING INDEX (W1 W2 W3 W4 W5 W6)	NOTES
		BEDROCK SURFACE		44.85														
	Rotary Drill NQ Core	Fresh, thinly bedded, red grey SILTSTONE, very poor quality		8.15 / 44.40	1	100		■	■									
		End of Drillhole		8.60														

DEPTH SCALE
1 : 75

LOGGED: BW
CHECKED: ML

MIS-RCK 020 1407587 TEMP.GPJ GAL-MISS.GDT 11/04/14 JM

PROJECT: 1407587

RECORD OF BOREHOLE: BH2

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: October 4, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

DRILL RIG: CME 55

DRILLING CONTRACTOR: Logan Geotech

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	REC. LENGTH (mm) / SA. LENGTH (mm)	BLOWS/0.15m	N VALUE	STANDARD PENETRATION RESISTANCE, N VALUE (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q -, U -) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	REMARKS, ADDITIONAL LAB. TESTING & GRAIN SIZE DISTRIBUTION (%)	PIEZOMETER OR STANDPIPE INSTALLATION
		WATER SURFACE		53.00								GR SA SI CL	
0	Continuous Split Spoon 90 mm Diam. Casing	WATER		0.00									
				51.55									
1		(ML) CLAYEY SILT; brown to dark grey, with organics; w>PL, cohesive, very soft to firm		1.45									
2					1	SS	178/610	3 3 4	7	7			
				50.20				4					
3		(SP) gravelly SAND, medium to coarse, subangular; pale grey to greenish grey, with low plasticity fines, cobbles and boulders (GLACIAL TILL); compact to very dense		2.80	2	SS	229/610	5 12 29 35	41	41			
					3	SS	229/610	29 15 11 10	26	26			
4					4	SS	432/610	2 15 11 10	26	26			
5													
					5	SS	330/610	11 31 21 14	52	52			
				47.20									
6		End of Borehole		5.80									
		Note:											
7		1. Borehole terminated at 5.8 m depth due to encountered cobbles or boulders within the fill, which caused the drill string to move out of vertical alignment.											
		2. Drill rods sank by own weight from 1.45 m to 2.2 m.											
8													
9													
10													
11													
12													
13													
14													
15													

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: BW

CHECKED: ML

MIS-BHS 012 1407587 TEMP.GPJ GAL-MIS.GDT 11/04/14 JM

PROJECT: 1407587

RECORD OF BOREHOLE: BH3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: October 4, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

DRILL RIG: CME 55

DRILLING CONTRACTOR: Logan Geotech

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	REC. LENGTH (mm) / SA. LENGTH (mm)	BLOWS/0.15m	N VALUE	STANDARD PENETRATION RESISTANCE, N VALUE (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl)	REMARKS, ADDITIONAL LAB. TESTING & GRAIN SIZE DISTRIBUTION (%)	PIEZOMETER OR STANDPIPE INSTALLATION
		WATER SURFACE		53.00								GR SA SI CL	
0	Continuous Split Spoon, 90 mm Diam. Casing	WATER		0.00									
				52.15									
1		(ML) CLAYEY SILT, some gravel and wooden fragments; dark brown, with organics; w>PL, cohesive, very soft to firm		0.85									
2					1	SS	152/610	1 1 1 2	2	2			
3					2	SS	127/610	4 9 3 5	12	12			
					3	SS	127/585	1 2 1 50/0.13	3	3			
4				49.00									
		(GP) sandy GRAVEL, fine to coarse, subangular, some fines; greenish grey, pale brown and red (GLACIAL TILL); compact to dense		4.00									
5					4	SS	305/610	8 17 21 26	38	38			
					5	SS	305/610	21 20 29 7	49	49			
6					6	SS	483/610	15 16 15 21	31	31			
					7	SS	381/610	17 12 12 13	24	24			
				46.10									
7		End of Borehole		6.90									
		Note:											
8		1. Borehole terminated in fill as the borehole wall collapsed during drilling.											
		2. Drill rods sank by own weight from 0.85 m to 2.0 m.											
9													
10													
11													
12													
13													
14													
15													

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: BW

CHECKED: ML

MIS-BHS 012 1407587 TEMP.GPJ GAL-MIS.GDT 11/04/14 JM

LEGEND

APPROXIMATE BOREHOLE LOCATIONS

KEY MAP

0 5 10 20

1:500 METRES

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1407587.

REFERENCE(S)

1. BING IMAGERY SUPPLIED BY ESRI AND MICROSOFT © 2010 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS, IMAGE DATE: 2014-06.
2. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, DELORME, USGS, INTERMAP, INCREMENT P CORP., NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI (THAILAND), TOMTOM, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 22 VERTICAL DATUM: CGVD28

CLIENT
CBCL LIMITED

PROJECT
LONG POND WEIR

TITLE
APPROXIMATE BOREHOLE LOCATIONS

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-16
DESIGNED	----
PREPARED	BR
REVIEWED	BW
APPROVED	CR

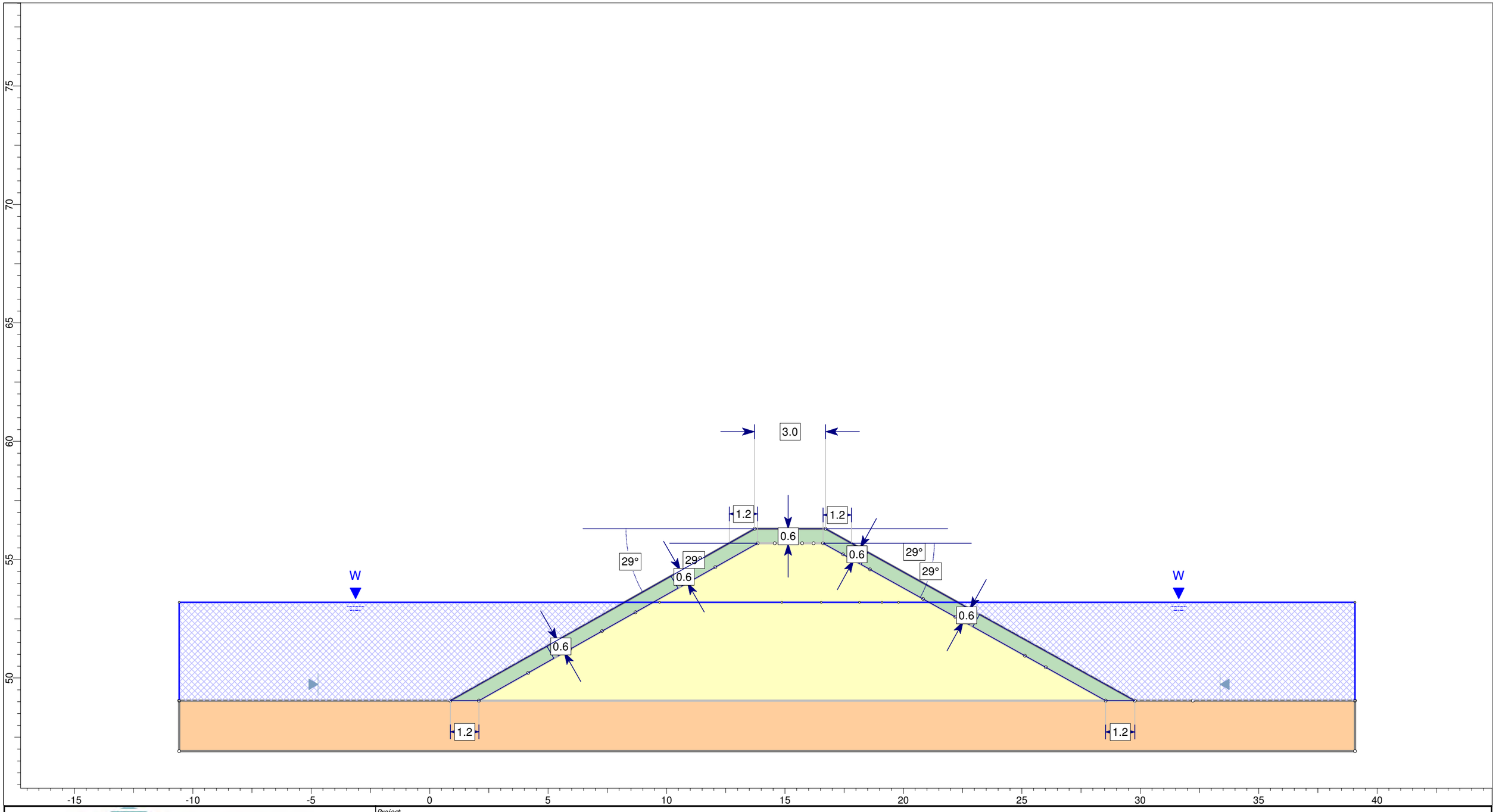
PROJECT NO.	PHASE	REV.	FIGURE
1407587	4	0	**1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 25mm

Path: N:\Active\Spatial_IM\CBCL\LongPondWeir_NL99_PROJ\1407587_CBCL_LongPond\d0_PROD\Phase4\1407587-01-SitePlan.mxd

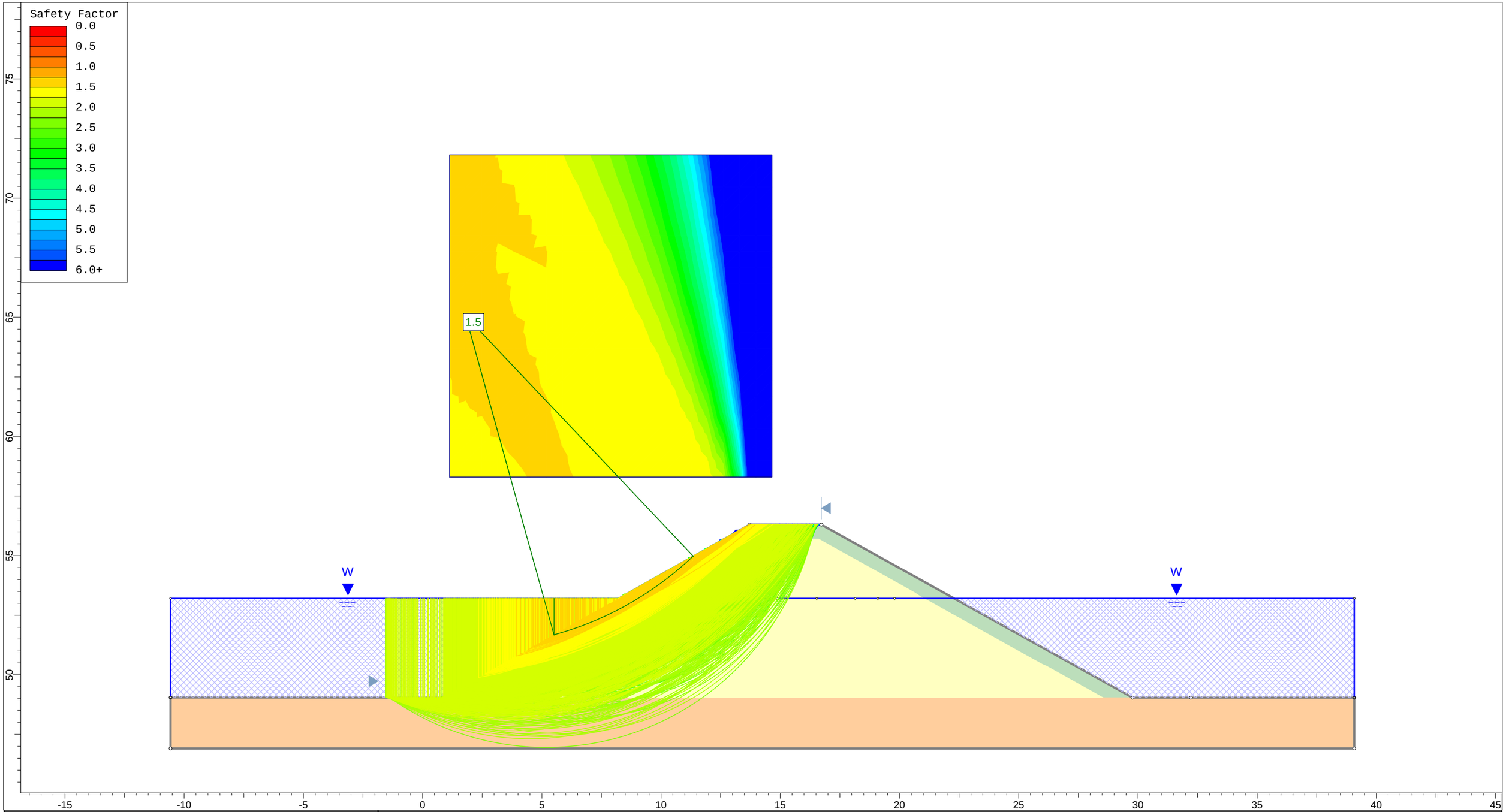
APPENDIX B

Stability Analyses



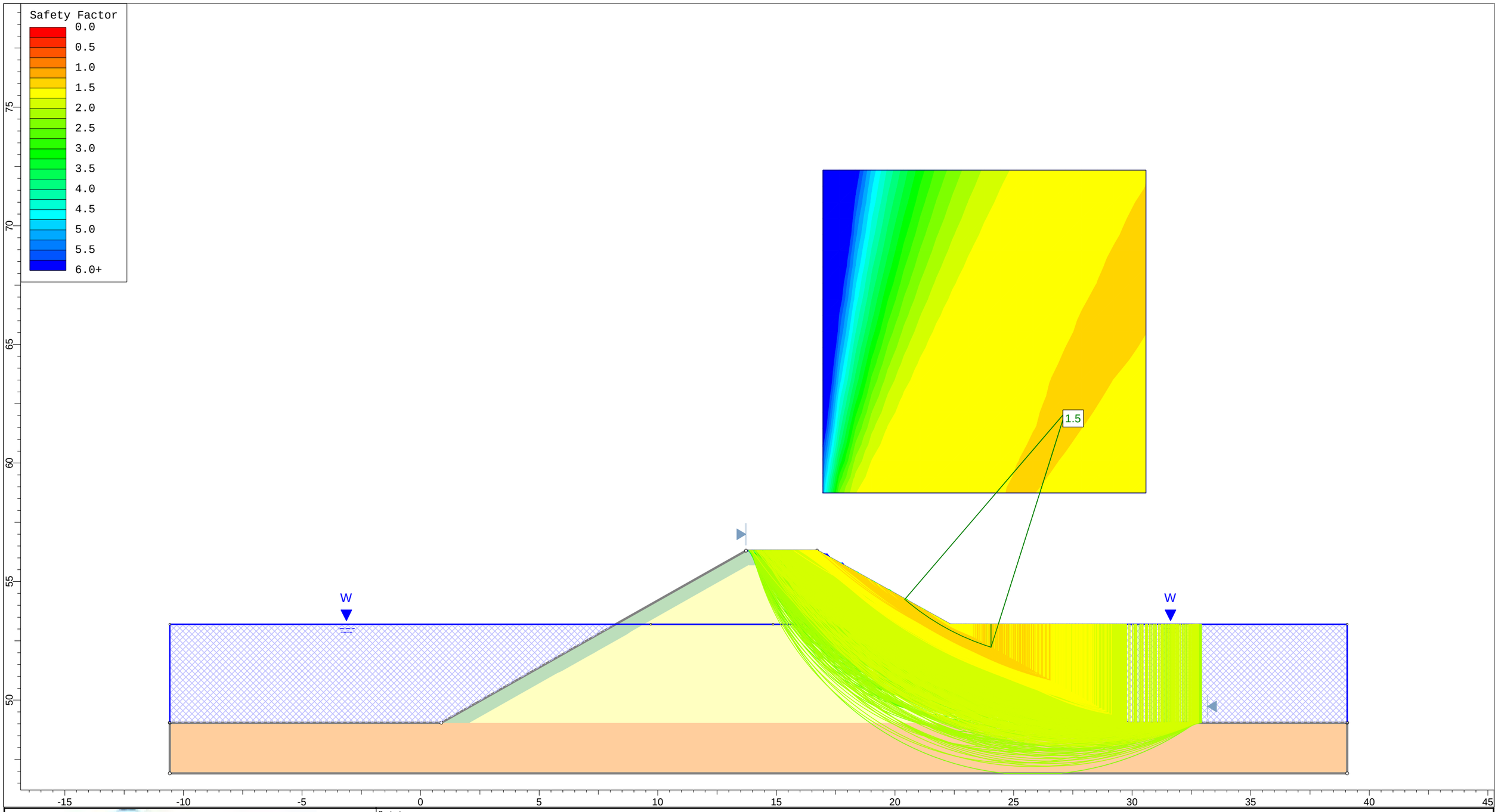
Golder Associates	*Project*	Long Pond Weir - General Geometry		
	Analysis Description	Figure 1 - Normal Water Level (53.2 m elev)		
	Drawn By	Andrew Peach, P. Geo.	*Scale* 1:150	*Company* Golder Associates Limited
	Date	2/29/2016		*File Name* Long Pond Weir - Figure 1.slim

SLIDE 6.038



SLIDEINTERPRET 6.038

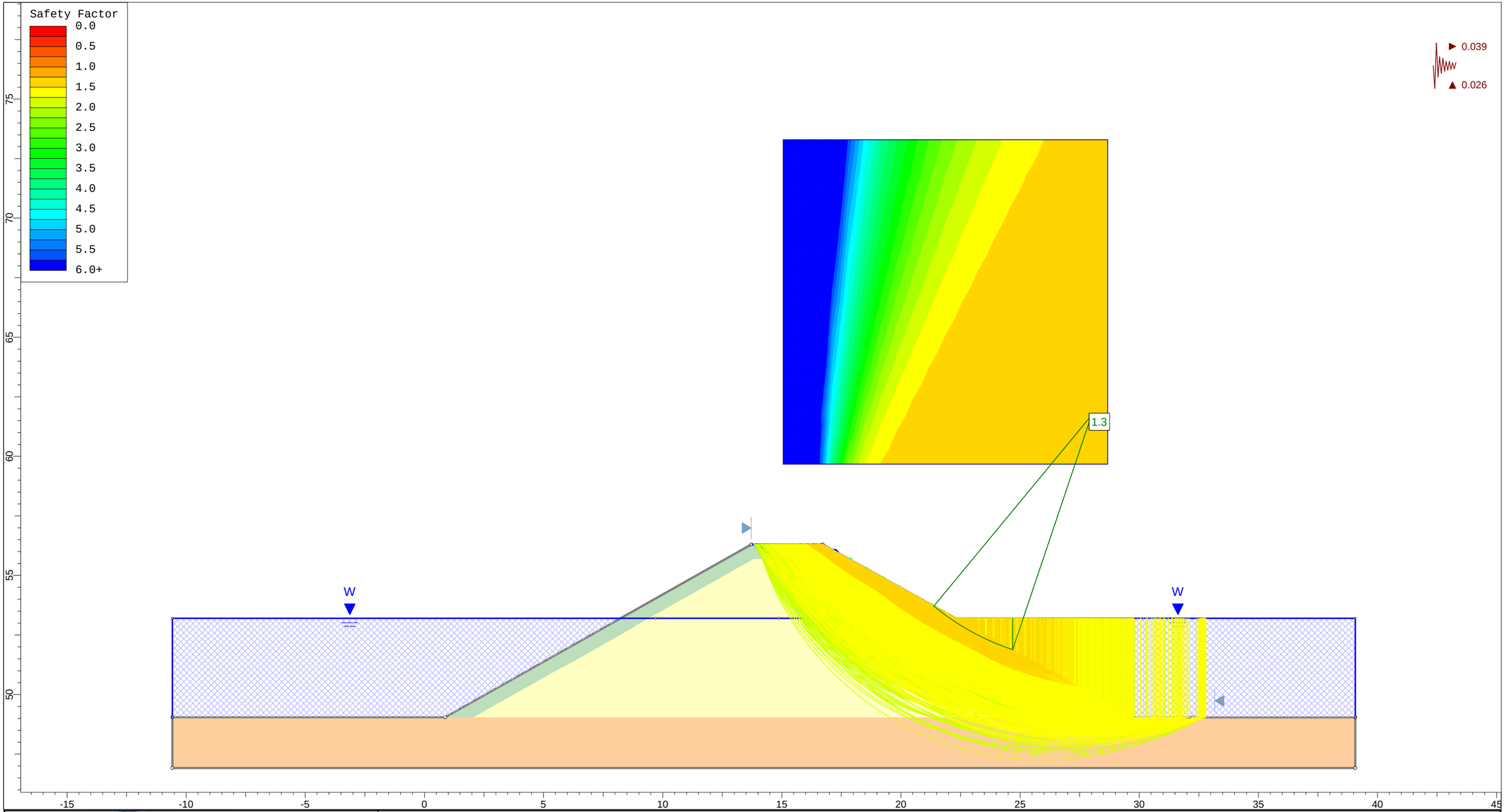
Project	Long Pond Weir - Upstream Slope (Static Assessment)		
Analysis Description	Figure 2 - Normal Water Level (53.2 m elev) Minimum FOS = 1.5		
Drawn By Andrew Peach, P. Geo.	*Scale* 1:150	*Company* Golder Associates Limited	
Date 2/29/2016		*File Name* Long Pond Weir - Figure 2.slim	



Project	Long Pond Weir - Downstream Slope (Static Assessment)		
Analysis Description	Figure 3 - Normal Water Level (53.2 m elev) Minimum FOS = 1.5		
Drawn By: Andrew Peach, P. Geo.	Scale: 1:150	Company: Golder Associates Limited	
Date: 2/29/2016		File Name: Long Pond Weir - Figure 3.slim	

Golder Associates

SLIDEINTERPRET 6.038



Golder Associates	Project: Long Pond Weir - Downstream Slope (Seismic Assessment)		
	Analysis Description: Figure 4 - Normal Water Level (53.2 m elev) Minimum FOS = 1.3		
	Drawn By: Andrew Peach, P. Geo.	Scale: 1:150	Company: Golder Associates Limited
SLIDEINTERPRET 6.038	Date: 2/29/2016		File Name: Long Pond Weir - Figure 4.slim

Safety Factor
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0+

◀ 0.039
▲ 0.026

1.2

W

W

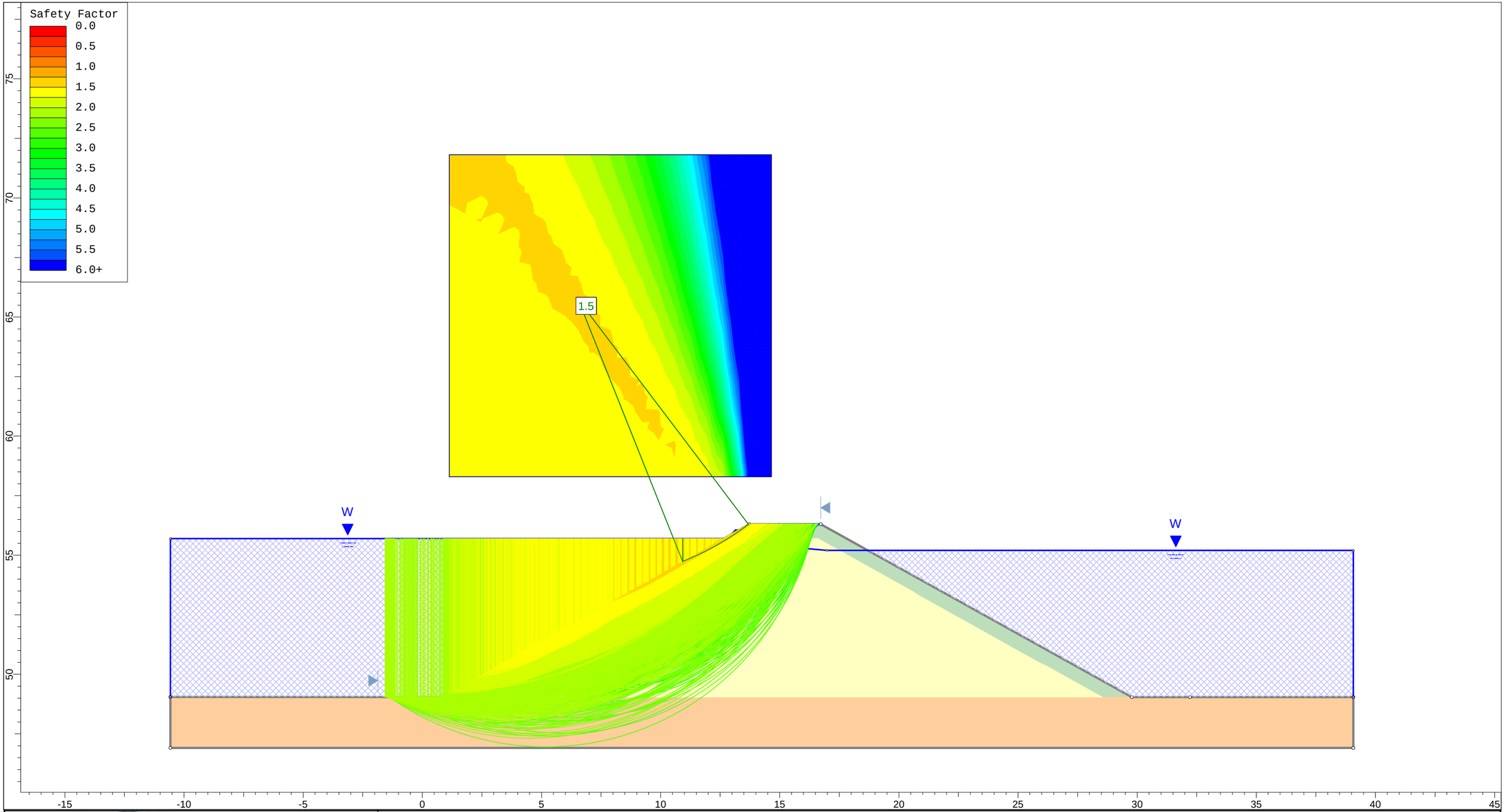
75
70
65
60
55
50

-15 -10 -5 0 5 10 15 20 25 30 35 40 45

Golder Associates

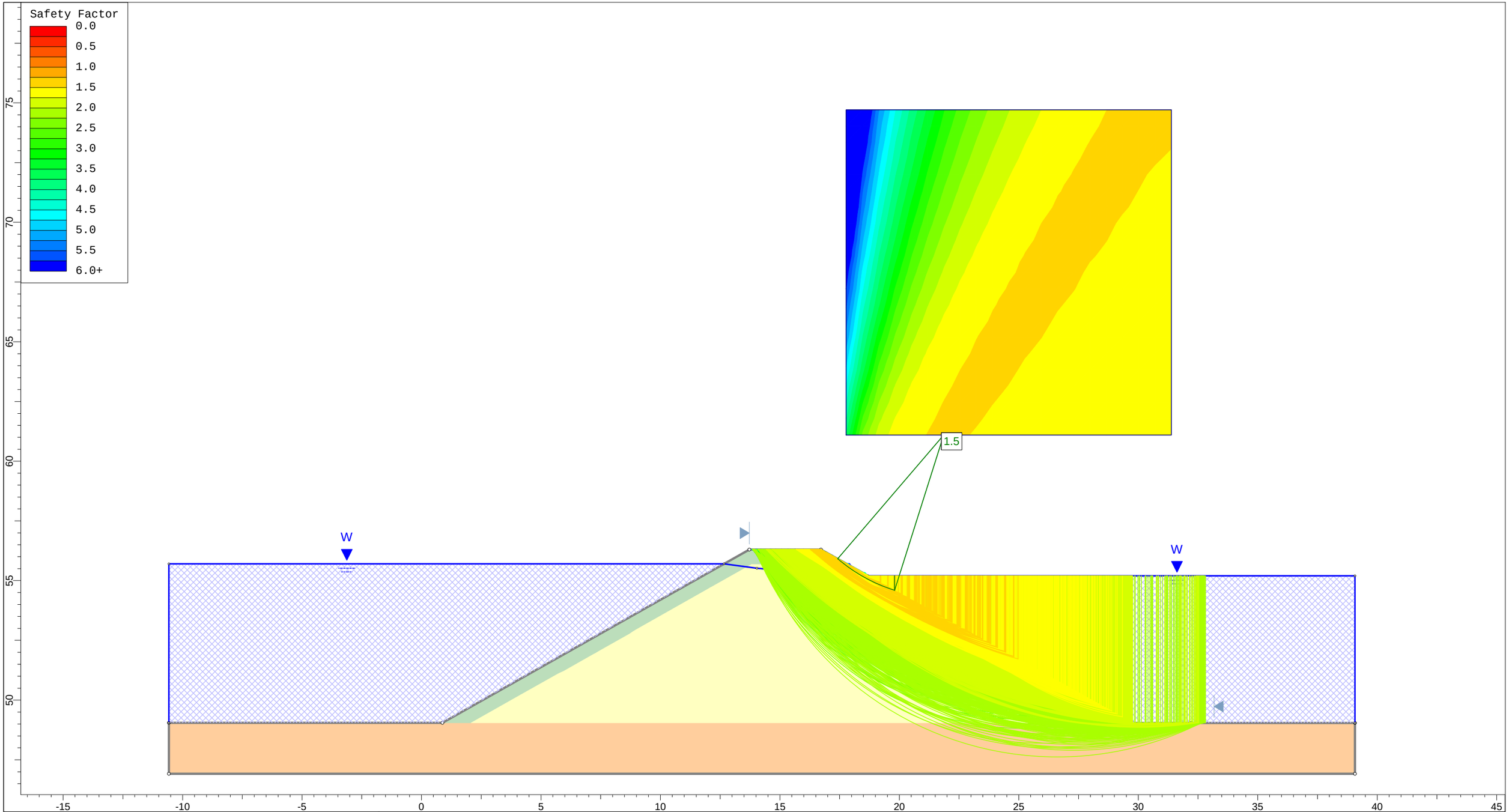
SLIDEINTERPRET 6.038

Project	Long Pond Weir - Upstream Slope (Seismic Assessment)		
Analysis Description	Figure 5 - Normal Water Level (53.2 m elev) Minimum FOS = 1.2		
Drawn By	Andrew Peach, P. Geo.	*Scale* 1:150	*Company* Golder Associates Limited
Date	2/29/2016		*File Name* Long Pond Weir - Figure 5.slim



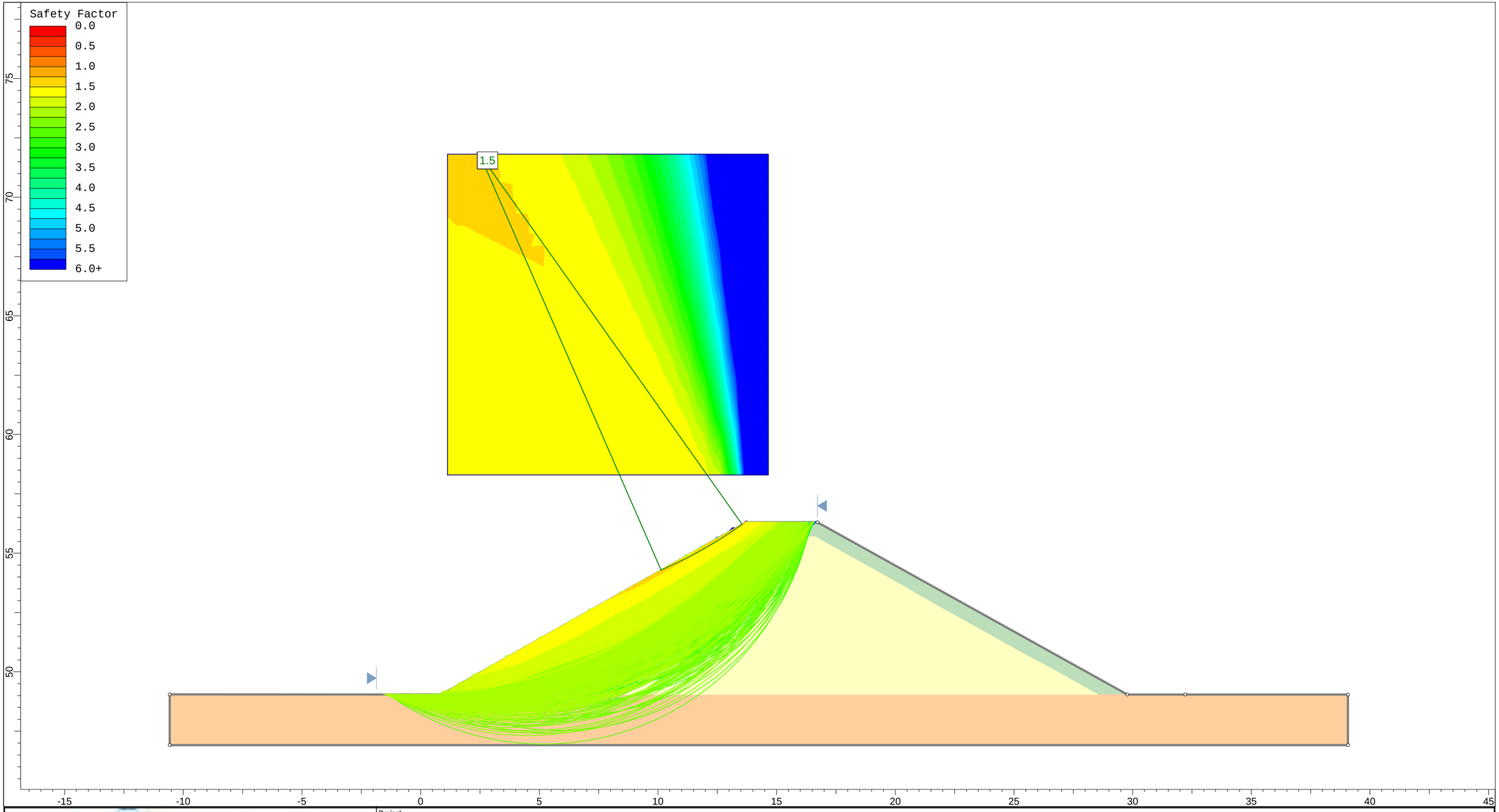
SLIDEINTERPRET 6.038

Project	Long Pond Weir - Upstream Slope (Static Assessment)		
Analysis Description	Figure 6 - Maximum Water Level (55.7 m elev) Minimum FOS = 1.5		
Drawn By Andrew Peach, P. Geo.	*Scale* 1:150	*Company*	Golder Associates Limited
Date 2/29/2016		*File Name*	Long Pond Weir - Figure 6.slim



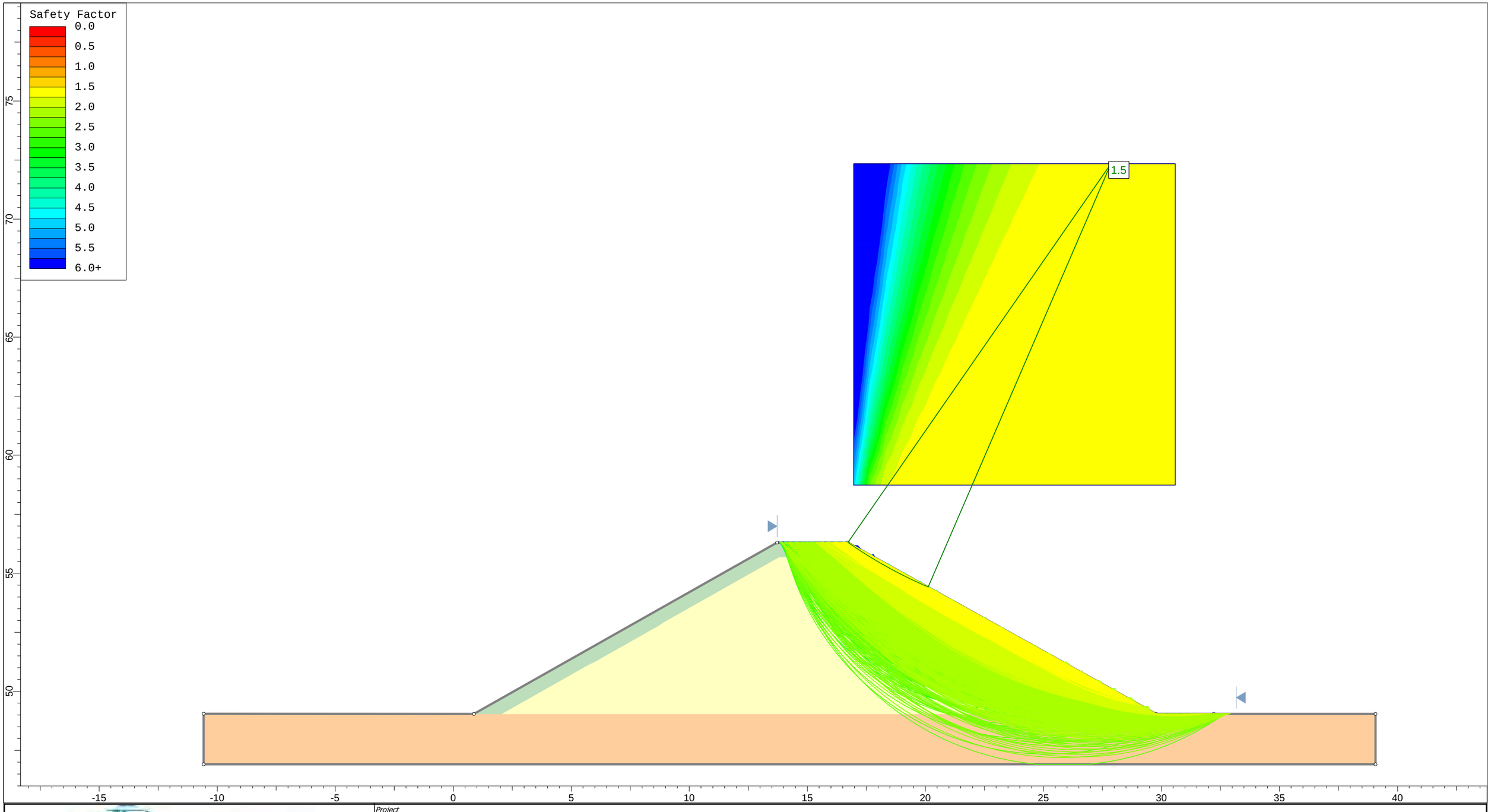
Project	Long Pond Weir - Downstream Slope (Static Assessment)		
Analysis Description	Figure 7 - Maximum Water Level (55.7 m elev) Minimum FOS = 1.5		
Drawn By Andrew Peach, P. Geo.	*Scale* 1:150	*Company* Golder Associates Limited	
Date 2/29/2016		*File Name* Long Pond Weir - Figure 7.slim	

SLIDEINTERPRET 6.038



Project	Long Pond Weir - Upstream Slope (Static Assessment)		
Analysis Description	Figure 8 - End of Construction, Minimum FOS = 1.5		
Drawn By: Andrew Peach, P. Geo.	Scale: 1:150	Company: Golder Associates Limited	
Date: 2/29/2016		File Name: Long Pond Weir - Figure 8.slim	

SLIDEINTERPRET 6.038



Golder Associates	*Project*	Long Pond Weir - Downstream Slope (Static Assessment)		
	Analysis Description	Figure 9 - End of Construction, Minimum FOS = 1.5		
	Drawn By	Andrew Peach, P. Geo.	*Scale* 1:150	*Company* Golder Associates Limited
	Date	2/29/2016		*File Name* Long Pond Weir - Figure 9.slim

SLIDEINTERPRET 6.038

APPENDIX C

Limitations

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client can not rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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Golder Associates

APPENDIX N

St. John's Specification Items 321 and 322

ITEM 321

STREET EXCAVATION

321.01 SCOPE OF WORK

The work to be done consists of the construction of subgrade for the street. The bottom of all excavation and the top of all fill, when completed shall be known as the subgrade and shall be true to lines and grades as set by the Engineer. Excavation and fill is to be made in all cases to such a depth that the compacted subgrade shall be at the required depth below the elevation of the finished roadway.

321.02 CLASSIFICATION

These are the classifications of excavation unless otherwise noted:

(a) Solid Rock (SR) which shall be solid beds or masses of igneous, sedimentary or metamorphic rock which, prior to its removal was integral with its parent mass, and cannot normally be excavated without blasting or pneumatic hammer, and boulders or rock fragments having individual volume in excess of 0.5 m^3 determined from three mutually perpendicular dimensions.

(b) Other Material (OM) - which shall include all excavated material not classified as Solid Rock or Unsuitable Material.

(c) Unsuitable Material (USM) - shall be all excavated material other than Solid Rock which is unsuitable to be placed in the subgrade.

(d) Concrete (CON) - shall be all non reinforced and reinforced concrete and rock and concrete composite structures.

(e) Asphalt (ASP) - shall be asphalt concrete.

321.03 STRIPPING

All topsoil on the streets and the area which will be cut or filled shall be removed and stockpiled on the site for use in landscaping or as otherwise directed by the Engineer.

321.04 BLASTING

The Contractor shall design a blasting pattern for solid rock so that the blasted rock will meet the requirements of Item 322.02 (b) “Rock Borrow”.

321.05 OTHER MATERIAL CUTS

Where the work is in cut the Contractor will be generally expected to excavate material to the true surface of the subgrade. Should the Contractor excavate below the true surface of the subgrade he shall place and compact other material as necessary to restore the excavation to subgrade. There shall be no payment for this work except where unsuitable material is excavated below the subgrade.

The Contractor shall remove stones larger than 150mm in greatest dimension from the top 300mm of sub-grade.

321.06 ROCK CUTS

All rock cuts shall be excavated and mucked out fully to 300mm below sub-grade.

In rock cuts where pockets which will not drain are formed below the sub-grade by blasting, the contractor shall, at his own expense, provide drainage by ditching to a free outlet, as ordered, and then backfill and compact to 95% of Proctor Density both the pockets and the trench to an elevation 300mm below subgrade. Backfill material shall be broken rock or coarse gravel.

Back slopes shall be carefully scaled down and all rock and fragments, liable to slide or roll down the slopes, removed to the satisfaction of the Engineer.

321.07 FILL

Where fill material is required to raise the embankment to the proper subgrade elevation such material shall be obtained from surplus excavation and excavated rock meeting requirements of Item 322.02.

The Contractor shall remove unsuitable material as directed by the Engineer. No fill material shall be placed until the area to be filled has been approved by the Engineer.

On no account will the Contractor be allowed to construct a core through the fill and complete the fill by side dumping.

Fill material shall be deposited and spread in uncompacted layers not exceeding 500mm for the full width of the fill, except that the Engineer may order this thickness reduced, if such thickness does not respond to compaction methods.

The thickness of each successive layer shall be maintained uniform for the full width of the fill.

All stones larger than 150mm in greatest dimension shall be removed from the material comprising the top 300mm of the fill.

The moisture content of the material in the embankment shall be controlled at all stages of construction by ensuring that the top surface of each layer of fill material is suitably compacted and sloped with a cross-fall not to exceed 5% in order to shed surplus rain water.

Material shall be compacted to 95% Standard Proctor Density.

If the moisture content of the material is deficient, the Contractor shall add sufficient water to obtain the necessary compaction. The water shall be placed in controlled amounts and added uniformly. The placing of water shall be considered as included in the unit price bid for "Street Excavation".

321.08 DISPOSAL OF SURPLUS MATERIAL

All surplus material to be legally disposed off the site and at a pit provided by the Contractor.

321.09 REMOVAL OF OBJECTS ABOVE GROUND LEVEL

Unless otherwise provided for by a separate pay item, the Contractor shall be deemed to have included in his bid price for Street Excavation the removal and disposal of trees, shrubs, hedges, fences, signs, boulders, and other objects that rise above the original ground level.

321.10 REMOVAL OF EXISTING ASPHALT AND CONCRETE WORKS

Unless otherwise provided for by a separate pay item, existing asphalt and concrete works which are to be removed shall be classified as "Street Excavation (USM)".

321.11 FILL ADJACENT TO STEEP SLOPES

Where new fill is to be placed adjacent to an existing steep slope or embankment, the Contractor shall, concurrent with the placement of new fill, bench the existing slope as described herein to provide proper bonding of new work to existing.

Each bench shall be 2 metres in width, and at the same height above original ground (or above the next bench below it) as the thickness of the adjacent layer of new fill, such that the bench forms a 2 metres wide extension of the new fill layer into the existing slope.

Material cut out of the existing slope shall be placed in the fill area and compacted.

321.12 MEASUREMENT FOR PAYMENT

The quantity to be measured shall be the number of cubic metres of material excavated, rounded to the nearest whole number, and as shown on the cross-section sheets, between the original ground lines and the completed and accepted embankment lines. On areas where clearing and grubbing is required, cross-sectioning for excavation quantities will be done after clearing and before grubbing operations. A depth of grubbing of 150mm will be assumed and deducted from the excavation quantities. Material placed or removed outside the lines of the Contract and beyond the toe of slope or top of slope, for fill and cut sections respectively, shall not be included in the calculations for pay quantities.

The volume of fill shall be computed by the average end area method of computation.

During excavation operations whenever the character of material changes from one type to another, the Contractor shall notify the Engineer in order that proper measurements or cross-sections shall be made. No allowance will be made for material excavated before such measurements or cross-sections have been made.

In areas where rock excavation is required for street excavation, rock shall be cross-sectioned after removal of overburden; shattering to 300mm below road subgrade shall be paid for as excavation.

321.13 PAYMENT

Payment shall be made at the respective unit price bid for each cubic metre of material excavated. Payment for placing and compacting materials into fill areas shall be considered included in the unit price bid for excavation.

Payment shall be full compensation for all labour, equipment, and material necessary to excavate, fill, compact, and remove surplus material in accordance with this specification.

ITEM 322

BORROW

322.01 SCOPE OF WORK

The Contractor shall supply and transport material suitable to the Engineer as may be required to bring the street or other surfaces to the necessary sub-grade in excess of that obtained from street or other excavation on site. This item shall also include Borrow required for Trench Excavation.

322.02 BORROW MATERIALS

Borrow material incorporated into the work shall be:

(a) **Gravel Borrow** - Gravel borrow shall consist of firm well graded granular materials as approved by the Engineer. Approved materials shall not contain any organic soils, vegetation, frozen materials nor excessive amounts of water.

(b) **Rock Borrow** - Rock borrow shall consist of well graded pieces of hard durable solid rock formations, as approved by the Engineer. Approved materials shall not contain any organic soils, vegetation, frozen materials or stones larger than 500mm in greatest dimension.

TABLE 1 - GRADATION REQUIREMENTS GRAVEL BORROW

Sieve Sizes	Percent Passing by Dry Weight			
	Gravel Borrow	100mm Minus Rock	150mm Minus Rock	Rock Borrow
500mm				100
150mm			100	
101.6mm		100		
90.6mm	100			
63.0mm	80-100			
31.5mm	60 - 90			
16.0mm	43 - 77			
8.00mm	33 - 65			
4.00mm	23 - 52			
2.00mm	15 - 40			
1.00mm	9 - 32			
0.500mm	7 - 25			
0.250mm	5 - 19			
0.075mm	0 - 12			

The gradation shall not show marked fluctuations from opposite extremes of the limiting sizes, and the plotted curve shall flow in a manner free from acute changes in directions.

Materials shall be considered unsuitable even though particle sizes are within the specified gradation limits if particle shape or any other characteristic precludes satisfactory compaction.

322.03 APPROVAL OF BORROW

At least seven (7) days prior to the commencement of placing the borrow materials, the Contractor shall notify the Engineer of the location of his proposed source or sources of borrow material, so that the Engineer may inspect and , if necessary, test the material and decide on its suitability. The Contractor shall supply material only from approved sites.

322.04 PLACEMENT OF BORROW

Placing of borrow material shall be in accordance with the section "Fill" as specified in the item "Street Excavation" or the section "Backfilling" as specified in the item "Trench Excavation".

322.05 MEASUREMENT FOR PAYMENT

(a) The unit of measure for payment for Gravel Borrow shall be the cubic metre rounded to the nearest whole number. The payment quantity shall be the volume in cubic metres of acceptable gravel borrow material placed to the required lines, grades and cross-sections. The volume of gravel borrow shall be computed using the cross-sectional area between the original ground position, or the position of material of other classifications (as determined by survey cross-sections) and the required lines and grades. For embankment borrow the volume shall be computed using the average end area method and for trench borrow the profile method, using theoretical measurements.

(b) The unit of measurement for payment for Rock Borrow shall be by:

(i) the tonne, rounded to the nearest whole number. The payment quantity shall be the weight in tonnes of acceptable Rock Borrow material placed to the required lines, grades and cross-sections. The weight of rock borrow shall be computed from weigh scale tickets as delivered to the site and signed by the City Road Checker upon the delivery of each load of material.

(ii) the cubic metre, rounded to the nearest whole number. Measurement shall be made in the same manner as that specified for Gravel Borrow.

(c) During fill operations, when the character of material being placed changes, the Contractor shall notify the Engineer in order that proper measurements or cross-sections may be made. No allowance will be made for borrow placed before such measurements or cross-sections have been made, nor for material placed beyond the established pay lines.

322.06 PAYMENT

Payment shall be on a unit price basis per cubic metre, or tonne, and shall be full compensation for all labour, equipment, and materials necessary to excavate, transport, place, and compact borrow material as specified.

APPENDIX O

Geosynthetic Clay Liner Product Literature

Bentofix®

Bentofix® Thermal Lock Geosynthetic Clay Liners (GCLs) are needle-punched reinforced composites which combine two durable geotextile outer layers with a uniform core of natural sodium bentonite clay to form a hydraulic barrier.

The sodium bentonite clay utilized in Bentofix® Thermal Lock GCL is a naturally occuring clay mineral that swells as water enters between its clay platelets. When hdyrated under confinement, the bentonite swells to form a low permeability clay layer with the equivalent hydraulic protection of several feet of compacted clay. Bentofix® GCLs are produced by distributing a uniform layer of the sodium bentonite between two geotextiles.

Fibers from the non-woven geotextile are then needle-punched through the layer of bentonite and incorporated into the other geotextile (either a woven or a non-woven). This process results in a strong mechanical bond between the fabrics.

A proprietary heat treating process - the Thermal Lock process - is then used to modify and more permanently lock the needle-punched fibres into place. Unique properties, including increased internal shear resistance and long term creep resistance, result from this procedure.

Multi-Functional

By needle-punching fibres through the sodium bentonite clay layer, a completely uniform, reinforced GCL is produced - with shear strength and stability advantages important to any application, such as:

- Golf course ponds.
- Stormwater management ponds.
- Recreational ponds.
- Landfill cap closures / base liner.
- Dams/dikes.
- Vertical trench cutoff Barrier.
- Groundwater protection cover.
- Environmental protection barrier under roads and railways.
- Secondary containment in above ground tanks.

Superior GCL Performance

Since the late 1980s, GCLs have been specified and used by design engineers, contractors, agencies, and owners as an alternative to soil barriers in various applications. The growing interest in these products stems from the unique properties and advantages they offer. They are very effective as a hydraulic barrier even under high gradient conditions; they are easy to install; show a high robustness against installation stresses and they can withstand elongation as well as settlement stresses without significant impact on their hydraulic performance. The wide range of GCL use includes landfill caps and base liner applications, dams, canals, ponds, rivers and lakes, even for waterproofing of buildings and similar structures. Numerous laboratory studies have shown the excellent performance capable with natural sodium bentonite GCLs.

Bentofix®

Efficient

Bentofix Thermal Lock GCLs represent a natural solution, simple and economical. To install, a core bar is inserted through the core, and the roll is suspended from a spreader bar (made available at no charge). The roll is then either unrolled, or the free end is secured in an anchor trench and the suspended roll is slowly backed away. Detailed installation recommendations may be found on our web site listed below and/or please contact us.

One truckload of GCL can carry over 6,000 sq.m. compared to a truckload carrying clay which will only cover an area of 40 sq.m. based on a 50cm compacted clay layer.

Conclusion

Simple, cost-effective installation techniques make Bentofix Thermal Lock GCL a practical alternative to a compacted clay liner or other lining systems. GCLs do not require an experienced installation contractor and can be done by a local general contractor. Site supervision is offered by either your local geosynthetic representative and/or provided by our project engineer Canada wide.

At Bentofix® Technologies, Inc. we're committed to providing you with more than GCLs - we're committed to providing the most effective and economical solution to solve your geosynthetic clay liner requirements.

Your authorized local distributor.

terrafix® geosynthetics inc.

www.terrafixgeo.com

178 Bethridge Road,
Toronto, Ontario, Canada
M9W 1N3
Tel.: **416-674-0363**
Fax: **416-674-1159**
www.bentofix.com

Themal lock geosynthetic clay liners. Made in Canada

BENTOFIX® NWL-35

Thermal Lock® Geosynthetic Clay Liners

Bentofix Thermal Lock® NWL-35 Series Geosynthetic Clay Liner (GCL) is a needlepunched, thermally reinforced composite comprised of a core of natural sodium bentonite clay between two durable geotextile layers to form a low permeability hydraulic barrier. The top layer is a staple fiber nonwoven (NW) geotextile while the bottom layer is a scrim reinforced nonwoven (SRNW) geotextile. The product is intended for steep slopes and high load applications where increased internal shear strength is required. Product intended where subgrade conditions are rough in nature, prevent shrinkage below geomembranes, and/or where hydraulic head conditions may apply.

Property	ASTM Test Method	Frequency	Value Imperial Units	Value Metric Units
Typical Geotextile Properties				
• Top / Cap Nonwoven	D 5261	200,000 sq ft	6.0 oz./yd^2 MARV	200 g / m^2 MARV(1)
• Scrim Reinforced Nonwoven Bottom Fabric	D 5261	(20,000 m^2)	6.0 oz./yd^2 MARV	200 g / m^2 MARV
Bentonite Properties (SI Units Only)				
• Swell Index	D 5890	100,000 lbs.	24 ml/ 2 g min	24 ml/ 2 g min
• Moisture Content	D 4643	(50,000 kg)	12 % max	12 % max
• Fluid Loss	D 5891	100,000 lbs.	18 ml max	18 ml max
• Smectite (Montmorillonite)	XRD	Periodic	90% min	90% min
Finished GCL Properties				
• Bentonite Mass/Unit Area[2]	D 5993	40,000 ft^2 (4,000 m^2)	0.75 lbs/ft^2 MARV	3.66 kg/m^2 MARV
• Tensile Strength[3]	D 6768	40,000 ft^2 (4,000 m^2)	50 lb/in MARV	8.8 kN/m MARV
• Peel Strength	D 6496	40,000 ft^2 (4,000 m^2)	5.3 lbs/in min	928 N/m min
• Permeability[5]	D 5887	Weekly	5 x 10^{-9} cm/s max	5 x 10^{-9} cm/s max
• Index Flux[5]	D 5887	Weekly	1 x 10^{-8} m^3/m^2/s max	1 x 10^{-8} m^3/m^2/s max
• Internal Shear Strength[6]	D 6243	Periodic	500 psf Typical	24 kPa Typical

(1) Minimim Average Roll Value.
(2) Oven-dried measurement. Equates to 0.84 lb/sqft (4.1 kg/sqm) when indexed to 12% moisture content.
(3) Tested in machine direction.
(4) Modified ASTM D4632 to use a 4 in (100mm) wide grip. The maximum peak of five specimens averaged in machine direction.
(5) Deaired, deionized water @ 5 psi (34.5 kPa) maximum effective confining stress and 2 psi (13.8 kPa) head pressure.
(6) Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf (9.6 kPa) normal stress.

APPENDIX P

St. John's Specification Division 9

DIVISION 9

ENVIRONMENTAL REQUIREMENTS

INDEX

ITEM 901

OWNER'S POLICY

901.1 OWNER'S POLICY

It is Owner's policy to protect the environment of the area where the project is located. To ensure protection of the environment, the work at all times shall be subject to inspection by the staff of relevant municipal, provincial and federal agencies. Normally, all inspections other than by the Engineer will be arranged in advance through the Engineer. Any specific matters relating to environmental protection will be dealt with between Contractor and Engineer.

Any violations of environmental permits or authorizations or any environmental related incidents which are observed by inspectors representing regulatory agencies are to be reported by them prior to leaving the site to the Engineer. Except in emergency situations, environmental protection measures required by other agencies must be approved by the Engineer prior to implementation by the Contractor.

ITEM 915

PROTECTION OF WATERCOURSES AND WATERBODIES

915.01 SCOPE

This specification covers the environmental requirements for work being carried out at watercourses and waterbodies. It includes references to Federal and Provincial Legislation and prescribed methods and procedures to employ when carrying out such work as culvert or bridge installations, stream diversions, fording, fill placements at waterbodies, and any other work which may alter or impact any watercourse or waterbody, or the quality of the water therein.

915.02 LEGISLATIVE REQUIREMENTS

The Contractor shall be aware of all Federal and Provincial Legislation governing the protection of watercourses and waterbodies and all revisions and amendments to this legislation.

.01 PROTECTION OF INLAND FISHERIES ENVIRONMENT

All permanent or temporary works or undertakings which are proposed for watercourses or waterbodies constituting fish habitat require authorization from the Fish Habitat Management Branch of the Federal Department of Fisheries and Oceans at least two (2) weeks prior to the commencement of any work. The Contractor is required to obtain such approval and provide the Engineer with a copy prior to any work

Application forms for authorization for works or undertakings affecting fish habitat are available at all Department of Fisheries and Oceans located at St. John's, Grand Bank, Grand Falls, Goose Bay and Corner Brook.

Contractors are referred to the Department of Fisheries and Oceans publication entitled "Resource Road Construction - Environmental Guidelines and Design Criteria", latest edition, (and to other technical information). The DFO "Factsheets" contain recommended guidelines for culvert installations, road and bridge construction, and other works. They include mitigative measures and procedures intended to assist Contractors in minimizing impacts on fish and fish habitat.

Contractors are advised that Environmental and Fisheries regulations require that any work done in or near a watercourse, deemed to be viable fish habitat, must be restricted to the minimum of disturbance. The establishment of temporary and permanent buffer zones are required. Great care must be taken during construction not to harmfully alter, disrupt, or destroy fish habitat or to deposit any substance which may be harmful to fish habitat in or near any watercourse where it may enter the watecourse. Culvert pipes must be constructed, according to the requirements of the applicable permits, to allow free movement of fish.

Contractors are advised to refer to the Fisheries Act with particular attention to:

- Section 35 - Outlines required authorization for work or undertaking which may affect fish habitat.
- Section 36 - Prohibits the deposit of a harmful substance of any type into water frequented by fish.
- Section 37 - Powers of the Minister for the provision of information such as plans, specifications, studies, etc., and to require any modifications to such plans and/or related information.
- Section 38 - Powers of a Ministerial Inspection.
- Section 40-42 - Enforcement and Penalties.

.02 THE ENVIRONMENTAL CONTROL (WATER AND SEWAGE) REGULATIONS

Contractors shall maintain compliance with the Environmental Control (Water and Sewage) Regulations.

.03 THE WATER RESOURCES ACT, DEPARTMENT OF ENVIRONMEN

Where the Contractor must carry out any alteration of a body of water **which is not required specifically as part of the contractual work,** the Contractor must obtain a Certificate of Approval from the Department of Environment and Conservation before carrying out the work. Alterations to watercourses and waterbodies such as culvert installations, bridges, stream diversions, rock fill placement in waterbodies, etc., which are typically required as part of the contractual work are authorized and administered by DT&W and do not require separate approval from the Department of Environment and Conservation. All such alternations to bodies of water must be carried out according to established procedures of the regulatory agencies so as to prevent pollution or damage to the environment.

The Contractor is referred to the following **Environmental Guidelines** of the Department of Environment and Conservation, Water Resources Division, regarding construction procedures at watercourses:-

CHAPTER	TITLE	CHAPTER	TITLE
3	Watercourse Crossings	7	Diversions, New Channels & Major Alterations
4	Bridges	9	Pipe Crossings
5	Culverts	13	General Construction Practices
6	Fording	7	Diversions, New Channels & Major Alterations

915.03 FORDING OF WATERCOURSES

The use of equipment or machinery in a watercourse or waterbody is generally not permitted. Should it be necessary for equipment to ford a watercourse, then the approval of the Engineer is required for the specified equipment only and at a designated location. The same crossing point shall be used each time that a fording is required. When extensive or frequent crossing of a watercourse is necessary, temporary culvert or bridge installation may be required instead of fording. The Contractor is referred to the Environmental Guidelines Chapter 6, "Fording" of the Department of Environment and Conservation, regarding the selection, site preparation, and use of fording sites. The Contractor shall discuss all proposed fording sites with DT&W a minimum of five (5) working days before any fording activity. Site selection require the written approval of the Engineer.

915.04 CLEARING & GRUBBING ADJACENT TO WATERCOURSES

The Engineer shall mark limits for clearing and grubbing adjacent to watercourses. Buffer zones of undisturbed vegetation shall be maintained at watercourse crossings as marked in the field. A permanent buffer zone shall be maintained both sides of the construction zone at watercourse crossings, wherein, no disturbance or cutting of vegetation is to take place. A temporary ungrubbed buffer zone shall be maintained on both sides of the watercourse, unless otherwise directed by the Engineer, within the construction zone at watercourse crossings until such time as the installation of the crossing is to be carried out. The Contractor shall use appropriate mitigative measures such as the use of silt fencing, sedimentation basins and take-off ditches to control sediment laiden runoff from entering watercourses.

915.05 GENERAL PROCEDURES FOR INSTALLING WATERCOURSE CROSSINGS

The Contractor shall present to the Engineer for approval, a plan for the construction of unwatering systems including diversion systems, pumping systems, settling and/or filtration systems, a minimum of **three (3) working days** prior to the start of any work at the site for the approval of the Engineer.

A pre-construction meeting shall be convened on-site between the Contractor and the Engineer to review environmental protection measures and associated contract details pertaining to the watercourse crossing, prior to any work being carried out at the proposed crossing site.

All work carried out at watercourses shall be performed in the dry and with due care and caution so as to prevent unnecessary disturbance or impact on adjacent land or downstream areas. Where watercourses are deemed fish habitat, work within the

channel is generally prohibited between September 15 and June 1, on the island portion of the province, and between September 1 and June 30 for Labrador, unless otherwise approved by DFO and the Engineer. The Contractor shall carry out all work in and around watercourses in accordance with all Federal and Provincial permits and requirements, the relevant sections of this Specification Book, and the contract drawings.

The Contractor shall give **three (3) working days** notice prior to any instream or near stream grubbing or excavation.

Buffer zones shall be established and maintained as described in section 915.04.

An approved cofferdam shall be installed at the low end of the construction zone to collect all site water which is to be disposed of in an approved manner. (See Section 915.07 Treatment of Silted Water).

The operation of heavy equipment shall be confined to dry stable areas in order to prevent the generation of mud and silted water. All flow shall be diverted or pumped around or through the work area by means acceptable to the Engineer so as to maintain flow in the watercourse immediately below the site, prevent erosion, and maintain acceptable water quality.

The flow diversion system shall have sufficient freeboard to be capable of accommodating rain events or provision shall be made to safely discharge elevated flows without causing washouts of constructed works, erosion, or siltation in downstream areas. The discharge location of the pumping or diversion system shall be stabilized to prevent erosion. All unwatering operations shall be constantly monitored by the Contractor.

Work should be carried out from the downstream section of the work area and progress to the upstream.

The Contractor shall ensure that fish are not left stranded in the work area at the time the diversion system is made operational. All stranded fish shall be removed by appropriate means and quickly returned to the watercourse below the construction area to prevent mortalities.

An impermeable cofferdam of non-erodable material, such as sandbags and sheet plastic, shall be constructed at the outlet area of the construction zone to prevent any silted water from entering downstream areas and to assist in unwatering operations.

The location, size, construction, and operation of sedimentation basins shall be carried out according to City specifications or as directed by the Engineer and so as to achieve adequate settling parameters within the basins and ensure that discharged water from the basins, which is entering any watercourse, meets the water quality standards set forth in the Environmental Control (Water and Sewage) Regulations, (See Section 915.02.02).

Operation of the sedimentation basins shall be continuously monitored by the Contractor to ensure proper functioning and maintenance.

Excavation material shall be carried out to the limits marked in the field by the Engineer. All excavations shall be carried out using a tracked excavator which will operate within the limits of the work area or as directed by the Engineer.

Excavated material shall be removed from the site and stockpiled at an approved location where it will not enter any watercourse.

When corrugated steel pipes are installed, impervious material shall be placed under the invert of the pipe and around the haunches of the pipe at the inlet area so as to ensure that all flow is confined within the pipe, particularly during low flow conditions, and not lost into the porous fill zones outside the pipe.

All sections of newly constructed channel shall be adequately stabilized so as to prevent destabilization, erosion, or scouring of the channel and fill embankments. Rip-rap on road slopes shall be placed concurrently with backfilling operations on the pipe so that inlet and outlet areas are protected by the Resident Engineer.

Any disturbed areas or exposed soils within the high water zone of the watercourse shall be stabilized by such means as placing rip-rap or well staked sodding within 48 hours of completion of backfilling operations. Other adjacent disturbed areas shall be rehabilitated by sodding or seeding, or as directed by the Engineer.

Where baffles are required as part of a culvert installation all activities associated with the baffle pipe installation including the diversion of all water flow from the natural watercourse into the baffled pipe, abandonment of any temporary stream diversion system and rehabilitation of the surrounding disturbed area shall be carried out efficiently with out delay so as to not interfere with fish migration.

Upon completion of the work, flow shall be introduced slowly into the new channel or watercourse crossing. Any silted water generated as a result shall be prevented from entering downstream areas of the watercourse, and pumped or treated as required.

All construction related waste material shall be removed from the work site(s).

Sedimentation basins shall be pumped dry and backfilled with the original excavated material and compacted. Hand seeding, hydroseeding, and/or sodding of disturbed areas shall be carried out as directed by the Engineer. Additional rehabilitation may be required by the Engineer.

915.06 USE OF FRESH CONCRETE IN OR NEAR BODIES OF WATER

When concrete is poured in or adjacent to a watercourse or waterbody, all necessary precautions shall be taken to prevent the concrete from adversely affecting water quality. Whenever possible, fresh concrete should not come in contact directly with the waters of a watercourse. Standing water zones should be drawn down prior to placing fresh concrete. All formwork shall be well secured and made tight to prevent leakage of fresh concrete into any adjacent waters. Where tremmie concrete is required, the work shall be carried out under the specific directions of the Engineer. The washing of concrete delivery trucks or chutes is not permitted within 100 metres of any watercourse or waterbody. All necessary precautions shall be taken when handling related substances such as form coatings and concrete admixtures to prevent any spill or leakage of these substances.

915.07 CONTROL AND TREATMENT OF SILTED WATER

Silted or muddy water is not permitted to be released into any watercourse or waterbody or into any ditch or area that leads directly to a watercourse or waterbody. Runoff from adjacent areas shall be channeled, piped, diverted, or confined to prevent the water from entering construction zones and becoming polluted. Where due to rain events, runoff from construction zones and areas of exposed soils contains mud or silt, appropriate measures shall be taken by the Contractor to confine, settle, or channel such water so that adjacent watercourses or waterbodies are not adversely affected. Such measures may include the provision of mud basins, settling basins, ditch blocks, silt fencing, temporary ditching, or other means necessary to prevent pollution. Silted runoff water or water released or pumped from construction zones may be discharged to an approved vegetated area where ground absorption will occur or to an approved settling area or to a settling basin constructed in accordance with contract drawings or as directed by the Engineer.

915.08 FILL PLACEMENT AT WATERBODIES

Fill material placed in or at waterbodies shall be clean blasted rock. Where in the opinion of the Engineer, significant silty bottom sediments will disperse with potential of creating water quality problems, the fill zone shall be isolated from the remainder of the waterbody by such means as a silt curtain as approved by the Engineer. Rock shall be placed into the water zone so as to create the least amount of disturbance of bottom sediments. Rock shall be placed along the outer edge of the fill zone to close off and isolate the fill zone from the rest of the waterbody. Fill placement shall proceed with runs of rock along the inside of the first outer run of fill. Successive runs of rock fill shall be placed in this manner until the zone if filled back to the inner fill limits. Height of the placed rock fill shall be maintained a minimum of 300 mm above water level during fill operations. Equipment shall not operate in standing water zones. Removal of displaced sediments and/or bog shall be carried out as directed by the Owner. Pumping of water from the fill zone to a designated area may be required by the Owner to reduce water levels in the fill zone and prevent movement of silted water through the rock fill back into the waterbody.

ITEM 920

STORAGE AND HANDLING OF FUELS AND OTHER HAZARDOUS, TOXIC, OR DANGEROUS MATERIAL

920.01 STORAGE TANK REGISTRATION, INSPECTION, AND REMOVAL

All storage tank systems must be registered under and in compliance with Newfoundland Regulation 58/03, The Storage and Handling of Gasoline and Associated Products Regulations 2003 before commencing operation. Registration does not apply to storage tank systems of a capacity less than 2500 litres that are connected to a heating appliance. Contractors shall supply verification of storage tank registration to the Engineer prior to the Commencement of work.

Storage tank systems shall be inspected on a regular basis as per Section 18 of Newfoundland Regulation 58/03 Storage and Handling of Gasoline and Associated Products. This involves, but is not limited to, gauging or dipping, reconciliation of the records, and the proper maintenance of reconciliation records for a period of two (2) years. Records shall be maintained for inspection by the Engineer, ESO and/or Government Service Centre Inspectors.

The owner of a storage tank system shall, within thirty (30) days of known abandonment, empty the system of all products, remove the tank and associated piping from the ground, remove any contaminated soil, clean the area and restore the site to the satisfaction of the Engineer and in accordance with the criteria of the Government Services Centre.

920.02 SPILL REPORTING & CLEANUP PROCEDURES

The Contractor, Subcontractors, and their personnel shall take all necessary precautions to prevent the spillage, misplacement, or loss of fuels and other hazardous material. Contractor and Subcontractors shall abide by the following measure in the event of the detection of a fuel or hazardous material spill of **70** litres or metre:-

i) make every effort to stop leakage and contain contaminant flow;

ii) **immediately** upon detection, report spill location and size to the Canadian Coast Guard spill report number **772-2083** Pesticides Control Section 729-3395 and to the Owner; follow up with a full written report containing information on the cause of the spill, remedial action taken, damage or contamination estimate, and any further action to be taken;

iii) remove contaminant from spill site by absorbent, pumping, burning, or whatever method is appropriate and acceptable to Owner. Clean-up the affected area in accordance with the requirements of the Government Services Centre and then dispose of contaminated debris at an approved waste disposal site.

iv) take all necessary action to ensure the incident does not recur.

Contractor shall apply the following criteria in reaching decisions on contaminant and clean-up procedures:

i) minimize danger to persons;
ii) minimize pollution to watercourses and wetlands;
iii) minimize the size of the area affected by a spill; and
iv) minimize the degree of disturbance to the area and watercourses during clean-up.

Any spillage of hydrocarbons less than 70 litres shall be immediately cleaned up by the Contractor and reported promptly to the Engineer.

The Contractor shall dispose of any soil contaminated by small leaks of oil or lubricating fluids from equipment in a manner approved by the Engineer and in accordance with the criteria of the Government Services Centre.

The Contractor shall have on site a suitable quantity of absorbent material such as "Oclansorb" or similar product which can be accessed quickly and effectively in the event of any hydrocarbon spill. The Contractor shall advise fuel handling staff of its location and application.

920.03 FUEL STORAGE & HANDLING PROCEDURES

Contractor shall ensure that fuels and hazardous materials are handled only by personnel who are trained and qualified in handling these materials in accordance with manufacturers' instructions and government regulations. The Contractor will be required to verify personnel qualifications as they pertain to this item and provide written confirmation of same to the Engineer. The Contractor shall supply a copy of the product safety data sheet to the Engineer of all hazardous, toxic or dangerous materials or substances which will be used during the course of the contract. Refueling operations shall be supervised at all times. Under no circumstances shall any refueling procedure be left unattended by the operator.
Handling and fueling procedures shall be carried out to prevent the contamination of soil or water. Smoking shall be prohibited within **10 metres** of a fuel storage area or during refueling operations. Fueling or servicing of mobile equipment shall not be allowed within **100 metres** of a watercourse, waterbody, or designated wetlands, Oils, greases, gasoline, diesel, hydraulic and transmission fluids or other fuels shall be stored at least **100 metres** (horizontal distance) from any water course, water body, or designated wetland unless otherwise approved by the Engineer.

Any above ground fuel containers, with the exception of those exempted under Newfoundland Regulation 58/03, shall be self dyked units that are in compliance with the terms and conditions of the approval of the Government Services Centre. Fuel storage areas and non-portable transfer lines shall be clearly marked or barricaded to ensure that they are not damaged by moving vehicles. The markers shall be visible under all weather conditions. The storage, handling and disposal of **used oils** shall be in accordance with the Used Oil Control Regulation (82-02) under the NL Environmental Protection Act..

920.04 EQUIPMENT SERVICING PROCEDURES

All heavy equipment maintenance shall be carried out by using suitable fluid collection equipment and in a manner which ensures all waste material is collected and suitably disposed of. The Contractor shall ensure that all equipment is mechanically sound to avoid leaks of grease, oil, diesel, gasoline, and hydraulic and transmission fluids. The Contractor shall ensure that no servicing or washing of heavy equipment occurs adjacent to watercourses and designated wetlands. Fueling, servicing or washing of equipment shall not be allowed within **100 metres** of a watercourse except within a refueling site approved by the Engineer where conditions allow for containment of accidentally spilled fuels. The Contractor shall remove from the work area and properly dispose of all waste oil, filters, containers of other such debris at an approved waste disposal site.

920.05 USE OF HAZARDOUS, TOXIC OR DANGEROUS MATERIAL

Toxic construction material e.g., creosote treated timber, shall be stored at least **100 metres** away from all areas where drainage is directed into any watercourse or wetlands.

Toxic or dangerous substances such as form release agents, fuels, concrete additives (including superplasticisers), and other substances, shall be transported, stored and handled with all necessary precautions so as to prevent any spillage from occurring. Drip pans shall be used at locations where such liquids are being drawn off in order to contain any minor spills, and as a safety measure for containment of a significant spillage.

ITEM 925

WASTE MANAGEMENT

925.01 SOLID WASTE DISPOSAL

Contractor shall collect and dispose of all waste produced by its employees and those of its Subcontractors in a manner approved by the Engineer, and in accordance with the Waste Material Disposal Act. Through the placement of suitable containers at the site, the Contractor shall collect and dispose of rubbish and domestic garbage generated by employees. During the progress of the work, the Contractor shall keep the areas occupied by it and access to such areas in a neat, clean, and safe condition, and free from the accumulation of all waste materials including crating materials, rubbish, drink containers, cigarette cartons, and all other waste. All solid waste shall be removed from the job site and recycled or disposed of at an Approved Waste Disposal Site, with the permission of the City. No waste material shall be deposited in any watercourse or wetland.

Upon completion of the work the Contractor shall, at its own expense, and to the satisfaction of the Engineer, dispose of or remove from the jobsite all construction plant, rubbish, unused material, including concrete forms, filter fabric material, sediment fencing, sand bags, and other equipment and material belonging to it or used under its direction during the performance of the work. The site shall be left in a neat and clean condition.

In the event of the Contractor's failure to comply with any of the foregoing, the same may be accomplished by the owner within **thirty (30) days** of the completion of the work and the cost of same may be deducted from any money due or owing to the Contractor whether under this or any other contract.

925.02 SANITARY FACILITIES / SEWAGE DISPOSAL

The Contractor shall maintain portable latrines on site or systems approved by the Government Services Centre. The sanitary facilities shall be used by all Contractor employees and those of subcontractors. The Contractor shall transport the waste from these units, using a collection company (whenever possible) licensed by Government Services Centre. Otherwise, transportation and disposal shall be by a means and at a facility or location as approved by the Government Services Centre.

ITEM 940

DUST CONTROL

940.01 DUST CONTROL

The Contractor shall ensure that dust does not become a problem for adjacent property owners or construction site personnel or a hazard to vehicular traffic. When required, or as directed by the Engineer, water or an acceptable dust suppressant such as calcium chloride shall be used by the Contractor on haul routes or other locations on the project to control dust.

All costs associated with dust control shall be borne by the Contractor.

ITEM 945

EQUIPMENT OPERATION & PREVENTION OF EROSION & SILTATION

945.01 STORMWATER MANAGEMENT

The Contractor is responsible for stormwater and drainage management during the period of the contract. This includes the collection, channeling, containment, settling, discharge and any other operation to effectively control storm runoff and prevent problems of erosion or siltation of adjacent or downstream areas. (See Section 915.07 Control and Treatment of Silted Water).

945.02 TEMPORARY TRAVEL ROUTES

Linear travel along the right of way by vehicles and equipment shall be restricted to one (1) track or travel route, particularly during the early stages of opening access along the route, unless otherwise approved by the Engineer. The route shall be maintained by the Contractor free of standing water. Surface drainage will not be permitted to run along the route which can generate extensive mud and silt, and adversely affect material to be excavated such as grubbing, unsuitable material, and overburden. Surface drainage shall be vented off the route at frequent intervals. Where drainage courses are encountered, and frequent crossings are required, temporary pipes (CSP or iron) shall be installed to permit passage of equipment and vehicles in the dry, without causing erosion and siltation. At certain locations fording may be permitted by the Engineer. (See Section 915.03 Fording of Watercourses).

945.03 EROSION & SILT CONTROL MEASURES

945.03.01 GENERAL PROTECTION MEASURES

The Contractor shall minimize terrain disturbance and erosion resulting from its activities. The Contractor shall, as part of its work, implement erosion and silt control measures where its activities result in a blockage of natural drainage, the diversion of natural drainage, or the exposure of soil or subsoil to potential erosion. Particular measures which may be required include:

i) using an erosion control blanket;
ii) using an appropriate hydraulic mulch;
iii) spreading hay over exposed soils;
iv) spreading a thin layer of brush or slash over disturbed areas;
v) the installation of baffles or sediment traps at appropriate intervals within the area of disturbance;
vi) the installation of drainage collectors across the disturbed area to channel drainage into vegetated areas;
vii) the re-routing of disturbed drainage courses back into the natural course;
viii) the stabilization of exposed soils at drainage locations with appropriate rip-rap;
ix) where so directed by the Engineer, to construct check dams to confine mud or slurry at such locations as unsodded ditchlines, catch-basins and culvert inlets.
x) the pumping of silted water to settling or designated vegetated areas;
xi) the installation of mud basins of adequate size at run-off locations from exposed areas to contain heavy silt and mud as directed by the Engineer.

945.04 LIMITATION OF OPERATION

During periods of heavy rain, where in the opinion of the Engineer, the movement of excavated material and equipment may give rise to extensive mud conditions, or the potential to seriously impact watercourses, or adjacent land, the Contractor may be required to suspend operations until such time as site conditions allow operations to resume. The Contractor shall not be paid for such downtime.

ITEM 950

PROTECTION OF VEGETATION AND WETLANDS

950.01 MAINTAIN NATURAL DRAINAGE PATTERN

Drainage is to be maintained in its natural state wherever possible, with provision being made for spring flooding. Where existing drainage patterns cannot be maintained, alternate drainage will be installed to approximate normal conditions with the approval of the Engineer.

950.02 PROTECTION OF TREES & SHRUBS

Some trees, shrubs and plants within the clearing limits may be required for use by the Owner or other groups. Where necessary, and as directed by the Engineer, such trees, shrubs and plants shall be flagged for removal. Also see Section 955.02 (Planting of Trees and Shrubs).

Where branches of trees are to be removed as a result of damage or where roots **2.5 cm** in diameter or larger are exposed as a result of contractors excavation work, the stumps shall be cut cleanly using a saw or lopping tool. The roots shall be cut back level to the surface of the cut slope within 24 hours following their exposure.

The Contractor shall adhere to the following protection measures:

i) No unnecessary cutting of trees is to be conducted. Care will be taken during construction to prevent damage to trees and shrubs adjacent to the flagged clearing limits which are to remain after construction.

ii) Care shall be taken when sloping embankments not to expose roots of trees, or put the soil at the base of such trees in danger of future erosion or extensive downslope drainage.

iii) The Contractor shall not use living trees as survey marks and shall not cut blazes or otherwise mark live trees except with removable surveyor's tape and/or tags.

iv) Where cutting is necessitated, the Contractor shall stockpile and remove all merchantable timber not required by the Owner. Other wood waste and slash remaining near the uncut zone shall be disposed of by chipping, burning, or removal, as acceptable to the Engineer.

950.03 OFF RIGHT OF WAY TRAVEL

The Contractor shall limit equipment travel to the surveyed right-of-way and existing municipal and provincial roads. Use of equipment of any type is not permitted outside the clearing limits of the right of way without prior approval. To obtain approval for additional or new travel routes, the Contractor shall notify the Engineer a minimum of five working days in advance of such requirements and not commence work until written approval is given by the Engineer.

950.04 BOGS AND WETLANDS

Bogs and wetlands are considered sensitive terrain because of their high disturbance potential . Travel by machinery across bogs and wetlands shall be avoided whenever possible. When such travel is necessary it shall be carried out as directed by the Engineer. Bog excavation shall conform with good construction practices and be carried out in accordance with other relevant sections of these specifications.

ITEM 955

REVEGETATION

955.01 REVEGATATION FOR SURFACE STABILIZATION

Immediately following and during some construction activities, the Engineer will identify areas requiring seeding/sodding or stabilization by a method to prevent erosion. These will include:

(i) Extensive cuts in overburden material. These areas shall be hydro seeded with **three (3)** calendar days of a cut being prepared and work shall be carried out as directed by the Engineer.
(ii) Stream crossing sites. Topsail placement, sodding, and shrub or tree plantings may be required as directed by the Engineer.
(iii) All remaining disturbed areas, designated, will be hydro seeded or sodded as soon as possible.

Where the potential for erosion exists, as on steep slopes, long slopes, or soft erodible type material, an appropriate erosion control material shall be applied to the surface. This can be in the form of an erosion control fabric or a sprayed on erosion control product which is approved by the Engineer and which will be in addition to hydroseeding as indicated in the contract documents or as directed by the Engineer. Also see Section 945.03 (Erosion and Silt Control Measures).

The Engineer will inspect all revegetated areas periodically to ensure that adequate results have been achieved. During adverse dry conditions watering of revegetated areas shall be carried out as directed by the Engineer. Additional REVEGETATION work will be undertaken upon direction from the Engineer if the desired results are not achieved.

955.02 PLANTING OF TREES & SHRUBS

955.02.01 GENERAL INSTRUCTION

The planting of trees will be carried out in those areas identified in the contract documents. The types of species, quantity, size, and exact location will be specified in the contract document or otherwise the Contractor will be advised by the Engineer. **Nursery stock**, (purchased trees and shrubs in pots), or **site stock**, (trees and shrubs removed from a site and held over or planted out directly), may be used as specified in the contract documents or as directed by the Engineer.

Native species of trees and shrubs are generally preferred, however, non-native species may be specified where, for example, a faster growing species or a disease resistant species or variety is needed.

The following species of trees are recommended:

SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME	COMMON NAME
Picea	Spruce	Acer Spicatum	Mountain Maple
Abies Balsamea	Fir	Acer Rubrum	Red Maple
Betula Papyrifera	Birch	Acer Platanoides	Norwegian Maple
Sorbus	Dog Berry	Salix Discolor	Willow
Larix Laricina	Larch, Juniper	Salix Bebbiana	Willow
Larix Kaempferi	Japanese Larch	Populus Tremuloides	Trembling Aspen, Poplar, Aps
Prunus Pensylvanica	Pin Cherry	Populus Balsamea	Cotton wood, Balsam Poplar

The following species of large shrubs are recommended:

SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME	COMMON NAME
Amelanchier	Chuckley Pear	Corylus Cornuta	Hazelnut
Viburnum Cassinoides	Northern Wild Raison	Aronia Melanocarpa	Eastern Chokeberry, Chokeberry
Alnus Crispa	Alder	Aronia Prunifolia	Eastern Chokeberry, Chokeberry
Cornus Stolonifera	Red Osier Dogwood		

The following species of small shrubs are recommended:

SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME	COMMON NAME
Myrica Gale	Sweet Gale, Bog Myrtle	Sambucus Patens	Red Elderberry
Rhododendron Canadense	Rodora	Rosa Nitida	Wild Rose
Nemopanthus Mucronata	Mountain Holly	Rosa Virginiana	Wild Rose
Vibernum Edule	Squashberry	Rubus Idaeus	Red Raspberry
Chamaedaphne Caliculata	Leatherleaf	Spiraea Latifolia	Meadowsweet

955.02.02 PLANTING METHODS & MAINTENANCE

The Contractor is referred to the **Manual for Native Plant Material Recovery**, available from the Department of Transportation and Works, for general information and recommended practices for the removal of trees and shrubs for either planting out directly or holding over for subsequent planting, and other aspects of care and maintenance.

All trees and shrubs do best when planted in early spring prior to the buds opening, but may also be successfully planted in late fall during their dormancy period. While it is possible to plant trees and shrubs at any time of the year, a regular watering program prepared by the Contractor and approved by the Engineer to reduce or prevent mortalities is required during the active growing period. A watering program is required for all planted stock (nursery stock or site stock) in the first year. This should commence as soon as active growth begins, and as determined by the prevailing weather conditions and dryness of the soil throughout the growth season. Watering and other necessary maintenance such as the provision of staking or supports, pruning, mulching, etc. is responsibility of the Contractor and not extra compensation will be paid for these items.

955.02.03 PAYMENT & WARRANTY

Measurement for payment shall be by the number of individual trees of the specified species and size planted. The Contractor is responsible for preventing mortalities in planted stock. Trees and shrubs which die within eighteen (18) months of being planted shall be replaced by the Contractor at not additional cost to the Owner.

ITEM 960

PROTECTION OF HISTORIC RESOURCES

960.01 PROTECTION OF HISTORIC RESOURCES

The Contractor shall be aware that the Historic Resources Act (1985) requires the protection of archaeological sites and artifacts, and sets forth procedures to be followed in the event that either are found. The Contractor shall be aware of the following sections of the Act:-

Section 10 (1) A person who discovers an archaeological object in, on, or forming part of the land within the province shall report the discovery forthwith to the Minister stating the nature of the object, the location where it was discovered and the date of the discovery.

Section 10 (2) No person, other than the one to whom a permit has been issued under this Act, who discovers an archaeological object shall move, destroy, damage, deface or obliterate, alter, add to, mark or in any other way interfere with, remove or cause to be removed from the province that object.

Section 11(1) The property in all archaeological objects found in, on or taken from the land within the province, whether or not these objects are in the possession of Her Majesty is vested in Her Majesty.

Should any archaeological remains be encountered, such as stone, bone or iron tools, concentrations of bone, fireplaces, house pits and/or foundations, work in the area of the find should cease immediately. The Contractor shall immediately notify the Owner through the Engineer, or the Senior Environmental Planner, or the ESO immediately upon discovery of any historic resources. The Owner shall immediately notify the Historic Resources Divisions.

APPENDIX Q

St. John's Specification Division 7

DIVISION 7

SPECIFICATIONS FOR TEMPORARY SIGNS & DEVICES

INDEX

ITEM 701

INTRODUCTION

701.01 SCOPE

The provisions for public protection established herein are for application by contractors working on City contracts, developments and streets. Traffic safety in construction zones should be an integral and high priority element of every project. The purpose of this specification is to provide a traffic control standard for construction, maintenance and utility operations on streets within St. John's. When construction, maintenance or utility activities interrupt the normal operating conditions of a street or highway, temporary traffic control provides for the continuity of movement of motor vehicle, bicycle, and pedestrian traffic and access to property and utilities. The goal should be to route traffic through such areas, with temporary condition signs and devices, as nearly as possible comparable to those for normal situations.

The function of temporary workplace traffic control is to:

- Provide for the safe and efficient movement of motor vehicles, bicycles and pedestrians around or through temporary workplaces.
- Protect workers in temporary workplaces from errant vehicles.

The safety of workers is of equal importance to the safety of the public traveling through a temporary workplace. Temporary work zones present constantly changing roadway conditions that are not expected by the road users. The temporary work zone traffic control must be designed considering worker safety, road user safety, and the efficiency of traffic flow at all stages of the project, from planning through to completion. The City's Traffic Control Specification provides uniformity in temporary work zone traffic control procedures by stating principles of temporary work zone traffic control and by presenting a number of traffic control application guides.

The responsibility for temporary condition signs and devices rests with the Contractor. Unless otherwise stated, this specification depicts the minimum level of traffic control for a particular application. Thus, while this specification provides standards for design and application of temporary condition sign and device installation, this specification cannot provide solutions for all variables, and is not a substitute for good engineering judgment. Traffic volume and speed, roadway and work zone conditions may vary from the 'typical' condition shown or those anticipated when the plan was prepared The decision to use a particular device at a particular location should be made on the basis of an engineering study at the location. The Traffic Division of the Department of Engineering will have final authority and approval of the configuration and layout of temporary condition signage and devices

This specification uses the words 'may', 'should' and 'must' in a specific manner to convey a specific meaning:

- may - a permissive condition; no requirement for design or application is intended.
- should - an advisory condition; recommended but not mandatory.
- must - a mandatory condition; requirements have to be met.

The provisions for public protection established herein are for application by contractors performing any work for the City of St. John's and/or working on City streets. All costs associated with temporary condition signing to standards as outlined in Division 7 will be the responsibility of the Contractor. Costs of signs, handling, installation, materials and labour will be paid by the Contractor and no payment will be considered by the City unless a specific pay item in the contract is provided.

All contractors when performing work within the City's street right-of- way will be required to submit a set of Traffic Control Plans to the City's Traffic Engineer for review and approval. The Traffic Control Plans will include a set of drawings to illustrate the construction zone and location, along with the traffic control procedures to be put in place to direct the public safely through and/or around the work area. The plans will also include a description of the traffic control procedures to be put in place and alterations that may be required to adjust the traffic control procedure to changing site conditions or work zone progression. The Contractor should note that work on Arterial and Collector roadways will not be permitted during peak hour periods.

701.02 FUNDAMENTAL PRINCIPLES

The regulation and control of traffic through a temporary work zone is an essential part of construction, maintenance and utility work on all roadways. All traffic control signs, markings, devices, and procedures used for construction, maintenance, and utility operations must conform to the applicable specifications found in this Division. Traffic, pedestrian, and worker safety must be an integral part of every project, from assessment and planning through to the design and construction.

Implementation Principles

When preparing and implementing a traffic control plan the following principals must be followed:

(a) Avoid frequent or abrupt changes in alignment that require rapid maneuvers.

(b) The length of road affected by work must be minimized. Public traffic has priority.

(c) Provide for the safe operation of work vehicles.

(d) Guide traffic in a clear and positive manner while it approaches and travels through temporary work zone:

  (i) provide adequate warning, delineation, and channelization.

  (ii) place signs and devices where they do not pose a hazard; message must be able to be understood and able to be reacted to in a safe and comfortable manner by the public.

  (iii) aim signs and devices so that they present the best viewing angle for approaching traffic, whatever the road position or passing maneuver.

  (iv) cover or remove inappropriate signs.

  (v) remove inappropriate pavement markings unless the project is short term and/or it is reasonable to leave them and compensate for their presence with delineation or other devices.

  (vi) inspect signs and devices in a temporary work zone frequently, relocating or replacing them if required.

(e) Modify traffic controls as required to meet changing conditions at the work zone.

(f) Cover or remove temporary traffic control devices that are no longer applicable due to changes in the work pattern or job shut down at the end of the work day.

(g) At the completion of the work, install or re-erect permanent:

  (i) regulatory and warning signs.

  (ii) pavement markings.

  (iii) guide and information signs.

  (iv) traffic signals and / or beacons.

Implementation Requirements

1. All traffic signs used for temporary conditions are designed and erected for the safety and convenience of the traveling public, and for the safety of the workmen on the construction projects. Additional information on temporary condition signage may be found in the Manual of Uniform Traffic Control Devices for Canada, Part D – Temporary Conditions.

2. The Engineer must be contacted three (3) weeks in advance for assistance in signing major construction detours.

3. Work sites should be carefully checked to make sure that traffic controls are changed to suit changing construction conditions due to work staging and progress, or if an immediate improvement to the traffic control is needed.

4. All signs must conform to the required standards in shape, colour, size and position as outlined in this Division or as found in the Manual of Uniform Traffic Control Devices for Canada, Part D – Temporary Conditions.

5. All temporary condition signage anticipated to be in use for longer than five (5) days in duration or during a weekend period must be installed permanently as outlined in Item 701.08. Portable or removable types of mounting stands may only be used where signage is required for five (5) days or less and are **NOT** permitted during a weekend period. Sign bases should not be appreciably wider than the signs, must be sound material and designed to adequately support the sign. Bases which require weighting so as not to turn over during wind conditions must be weighted using **ONLY** sand bags meeting the approval of the Engineer. The use of rocks, boulders, concrete blocks, or metal pieces will not be permitted. When the sign is removed from the construction zone the sand bags must also be removed. Signs on portable or removable sign stands must conform to Item 701.07 and must be approved by the Engineer.

7. Poorly maintained, defaced, damaged, or dirty temporary condition signs are ineffective and must be replaced, repaired, or cleaned without delay. Signs which have been defaced or damaged and are not replaced within twenty-four (24) hours of notification will be expropriated by the City and replaced at the Contractor's expense. All signage expropriated in this manner will remain the property of the City.

8. No construction work will be permitted to commence until after traffic control devices are erected in position, as shown in this Division and approved by the Engineer.

9. After a work zone is completed all traffic signs used on that construction zone must be removed immediately. Any erected signs not applicable during a phase of construction must be removed or covered. The City reserves the right to expropriate all signs that are left in place after the work zone is completed. All signage expropriated in this manner will remain the property of the City.

10. Objects within the street or immediately adjacent to the street, which constitute a hazard to traffic must be marked with "Hazard Markers".

11. Construction Speed Zones must be implemented only as shown in this Division.

12. After dark all signs must be checked for visibility and those that cannot be clearly seen must be cleaned, replaced, adjusted or illuminated.

13. On any project it is required that the project supervisor keep a record, in a separate field book, of all traffic control devices used on the project. The daily status of the traffic control signs and devices must be noted, along with any alterations made to the traffic control signs and devices to adjust for changing work zone conditions or location. The time and date must be noted for any changes to the traffic control signs and devices.

701.03 CLASSIFICATION OF TEMPORARY CONDITION SIGNS

1. **Regulatory Signs** - are described in the Manual of Uniform Traffic Control Devices for Canada. Reference to regulatory signs in this part will be limited to their application on portions of street where construction activities or other temporary and unusual conditions require street user response.

2. **Warning Signs** - as described in this Division are temporary condition warning signs.

3. **Information Signs** - are as described in the Manual of Uniform Traffic Control Devices for Canada. Reference to information signs in this part is limited to their application for guiding traffic through portions of streets where construction activities or other temporary and unusual conditions may otherwise create confusion. Application for guiding traffic through detours associated with the above street conditions is also included. In all cases detour signing must be continuous and complete to guide the street user back to his normal route.

701.04 SPECIFICATIONS

Unless modified by the following, the specifications outlined in the Manual of Uniform Traffic Control Devices for Canada will apply to temporary condition signs in all details concerning symbols, lettering, illumination, reflectorization, position, erection, material, support, and maintenance.

One (1) sign only must be placed on each support with the exception of tab signs erected to provide supplementary or complementary information associated with warning signs or detour signs.

701.05 COLOURS, SHAPES AND MATERIALS

Warning Signs - must have black symbols or lettering on an orange retro-reflectorized background of 3M high intensity grade or equivalent. The use of fluorescent paint on signage will not be considered.

Regulatory and Information Signs - which may be used for temporary traffic control or guidance must have the same colour and shape as described in the Manual of Uniform Traffic Control Devices for Canada.

All temporary construction signage must be made with a rigid backing consisting of either plywood or aluminum. Flexible or roll up type signs will only be permitted during daylight hours of operation.

All temporary condition signs must meet the standards described in the Manual of Uniform Traffic Control Devices for Canada for appearance, shape, colour, and level of reflectivity. They must show the same shape and appearance by night as by day. The minimum level of reflectivity for orange sheeting used on temporary condition warning signs is ASTM Type 111.

701.06 DIMENSIONS OF ALL TEMPORARY CONDITION SIGNS

The size and dimensions of temporary condition signage must meet the standards as described in the Manual of Uniform Traffic Control Devices for Canada.

701.07 USE OF PORTABLE OR REMOVABLE SIGN SUPPORTS

As outlined in Item 701.02.5, the use of portable or removable sign supports will be permitted for temporary conditions not longer than five (5) days in duration and not over a weekend period. Signs must be located on the right side of the street with the near edge from 1.5 metres to 4 metres from the edge of the traveled portion of the street. Supplementary signs will be located on the left hand side of the streets on divided arterials.

Signs 900 mm or less in width must be erected on a single post to a height of 1.5 metres to 2.5 metres above the traveled portion of the street to the bottom edge of the sign. Signs exceeding 900 mm in width must be erected on two (2) posts at a general height of 1.5 metres above the traveled portion of the street to the bottom edge of the sign.

Signs on portable stands, which are **ONLY** used during daylight hours may reduce this mounting height to 450mm above the traveled portion of the street. To compensate for their extremely low mounting height, supports should be located a minimum of 1 metre from the edge of the traveled portion of the street. Signs used in this manner must have two (2) red flags mounted on the top of the sign to compensate for their reduced mounting height.

701.08 PERMANENTLY INSTALLED TEMPORARY CONDITION SIGN SUPPORTS

As outlined in Item 701.02.5, all construction signage intended to remain in a fixed location for longer than five (5) days or over a weekend period must be installed on a permanent, rigid sign post. Signs must be located on the right side of street with the near edge from 1.5 metres to 4 metres from the edge of the traveled portion of the street. Supplementary signage must be located on the left hand side of the street on divided arterials.

Signs 1200mm or less in width/length must be erected on a single post to a height of 1.5 metres to 2.5 metres above the traveled portion of the street to the bottom edge of the sign. Most signs in this category can be securely installed on 100mm x 100mm wooden posts with a minimum of 1 metre of the post in the ground. Care should be exercised to ensure that the post is securely anchored in the ground, so that it cannot be "turned" or removed by vandals.

Signs longer than 1200mm in width/length must be installed according with the Engineer's directions.

701.09 MOUNTING CHEVRON AND HAZARD MARKERS ON REBAR FOR INSTALLATION ON PAVED SURFACES

Where traffic has to be diverted or channelized to cross multi-lanes of paved surfaces, delineator devices, such as hazard markers and chevrons, must be installed as outlined in this section.

Signs 300mm or less in width must be erected on a single piece of 25mm rebar to a height of 1 metre to 2 metres above the traveled portion of the roadway to the bottom edge of the sign.

Signs greater than 300mm in width must be erected on two (2) pieces of 25mm rebar to a height of 1 metre to 2 metres above the traveled portion of the roadway to the bottom edge of the sign.

701.10 MOUNTING CHEVRON AND HAZARD MARKERS DURING WINTER SEASON

After construction has ended for the season, signs to remain in place during the Winter season, in order to delineate traffic through a merger of a major route, are to be mounted on rebar or wooden posts. Signs must be installed as outlined in section's 701.08 and 701.09.

701.11 PAYMENT

All costs associated with temporary condition signing to standards as outlined in this section will be the responsibility of the Contractor. Costs of the signs, handling, installation, materials, and labour will be paid by the Contractor and no payment will be considered by the City unless a specific pay item in the contract is provided.

ITEM 702

COMPONENTS OF A TEMPORARY WORKPLACE

702.01 General

A plan for temporary traffic control must consider the six components of a Temporary Workplace, which consist of the entire section of road between the first advance warning sign and the return to normal roadway conditions. The six (6) component areas can be found on Figure 702.01.01 and are as follows:

- Advance Warning Area
- Approach Area
- Transition Area
- Buffer Area
- Work Area
- Termination Area.

702.02 Temporary Workplace Components

The Advance Warning Area is used to inform drivers to expect road work ahead. The advance warning may be a single sign or flashing lights on a vehicle to a series of signs in advance of the approach area signing. On freeways and expressways, where speeds are 70 km/h or greater, signs may be placed as far as 2.0 km or more in advanced of the approach area.

The Approach Area begins at the first warning sign. The driver is provided the information necessary to safely negotiate the temporary workplace, such as a lane change, passing restrictions, speed changes, or the presence of traffic control persons or signals. Drivers require the information at a sufficient distance in advance to safely adjust to the altered situation before reaching it. The devices may vary from a single sign or flashing light to a series of signs in advance of the transition area.

The Transition Area begins with the delineation devices used to channelize traffic from its normal alignment to the newly created alignment required to move around the work area. The transition area contains the channelizing devices used to form the approach transition taper. The transition area must be obvious to drivers. The intended path must be clearly delineated so that drivers will not mistakenly follow the wrong path. For long duration work, existing pavement markings may have to be removed and new markings placed. Operational traffic control devices, including Flashing Light Units, may be positioned in the Transition Area. At all times the Transition Area must be kept clear of unnecessary obstructions:

- Do not store material or equipment in the Transition Area.
- Do not park vehicles in the Transition Area. (This does not apply to vehicles active in performing a traffic management function.)

The Buffer Area is established between the Transition Area and the Work Area to provide a recovery area for errant vehicles and a margin of safety for motorists and workers. The buffer area must be defined by delineation devices.

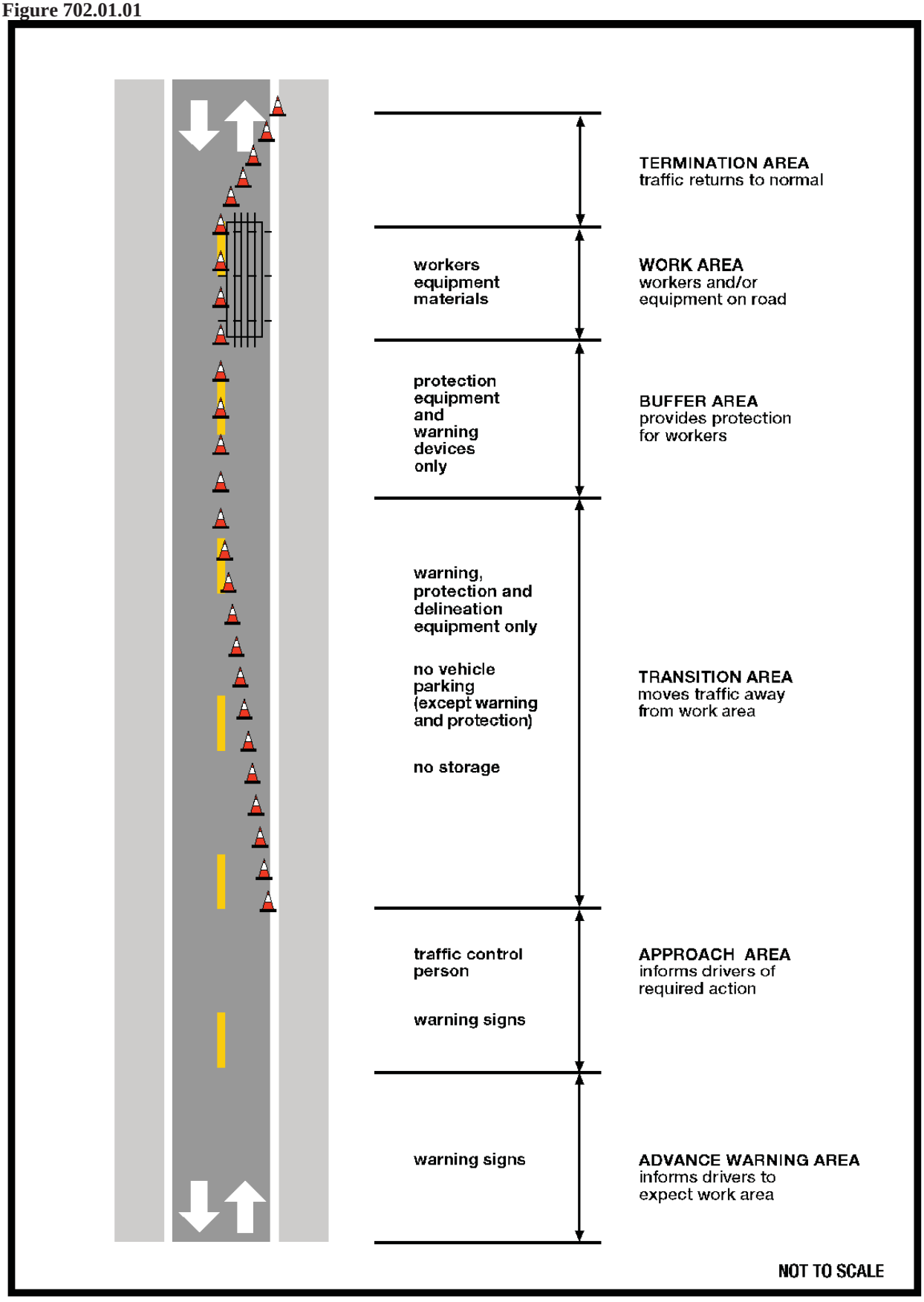
- No work material, vehicles or equipment should be stored or parked in the buffer area.
- When a Protection, Blocker or Service Vehicle is used as stationary worker protection in advance of the work area, the buffer area should be provided between the protection vehicle and the work area.

The Work Area is the specific portion of roadway where construction, maintenance, or utility operations are or have been carried out. It is typically identified by the area occupied by workers and work vehicles. A Work Area can be:

- ‘Active’ with work being carried out at the present time.
- ‘Inactive’ with work having started but temporarily stopped and the roadway not returned to normal operating conditions.

The Termination Area extends from the downstream end of the work area to the point at which traffic is able to return to its normal path and roadway conditions. The termination area allows for traffic to make the transition back to the normal path of the roadway, a short taper may be provided in the Termination Area.

Figure 702.01.01



ITEM 703

LOCATION AND PLACING OF SIGNS

703.01 GENERAL

Three (3) categories of signage are distinguished with regard to the location of the devices relative to work sites. The three (3) categories are Advance signage, Approach signage and Site signage.

Temporary work zone signs and device spacing depend on the vehicle approach speed and what is the expectation of the drivers. Drivers need clear information, the correct amount of information, and the message delivered at the right time.

- If given too early, it may be forgotten.
- If delivered too late, drivers will not have enough time to act accordingly to the information provided (Drivers must not have to perform rapid manoeuvres).
- Too much information may be ignored, or will divide the driver's attention between the messages and the driving tasks.

Signs must be positioned so that approaching motorists can interpret their message and react safely and comfortably. Where the position of a sign is specified by a Traffic Control Diagram and violates this principle, due to sight obstructions or horizontal/vertical roadway alignment, expand the placement distance by the minimum needed to make the sign effective. Signs must be placed on or by the edge of the road where they do not pose a hazard to traffic. Signs must be aimed and their alignment maintained so that they have the best viewing angle for oncoming traffic.

703.02 ADVANCE SIGNING

This category includes all the signs used to give advance notice to road users of an activity or street obstruction ahead. Advance signs will be accompanied by a tab indicating the distance to the beginning of the work site. These signs are normally required only when the work fully or partially closes a traffic lane. The requirement for Advanced signage will be as determined by the City's Traffic Engineer.

The distance between the first sign of this category and the work area must be:

a) On TCH or equivalent 450-1000 metres
b) On rural roads other than TCH or equivalent 250-500 metres
c) On urban streets 150-300 metres.

In cases of shoulder work where advance signing may be desirable the above-mentioned distance may be reduced by one-half.

703.03 APPROACH SIGNING

This category includes the warning and regulatory signs placed in the immediate approach to the work site.

They must inform the street users of the nature of the activity or obstruction, and indicate any required action. All the signs must be placed in accordance with the following distance criteria:

1. The maximum distance between the last sign in the advance sequence and the first (1^{st}) sign of the approach sequence must be 700 metres.

2. The distance between two (2) consecutive signs in the sequence is a function of the maximum regulatory speed limit and must be:

60 km/h or less	50 metres
70 km/h	75 meters
80 - 90 km/h	100 meters
100 km/h and TCH	125 meters

3. Buffer zone distance from the last sign in the approach signing to the work site must be as follows:

50 km/h or less	35 meters
60 km/h	45 meters
70 km/h	50 meters
80 km/h	60 meters
90 km/h	65 meters
100 km/h and TCH	70 meters

703.04 AT SITE SIGNS

This category includes the warning signs required to advise the motorist of activities or obstructions. Regulatory and information signs must be erected at the work site as required to advise the motorist of the regulations and to guide them through the work site area and to their destination.

703.05 POSTING SIGNS ON ONE (1) OR TWO (2) APPROACHES TO THE WORK AREA

Roads that intersect at or just prior to a temporary workplace must have signs posted, and if necessary, devices and Traffic Control Persons positioned so that motorists entering the workplace from any possible approach are provided with sufficient notice and guidance. Where entrances to homes or businesses pose a hazard, notifications and control measures must be put in place.

ITEM 704

TEMPORARY CONDITION SIGNS

704.01 GENERAL

All Temporary Condition Signs must meet the standards shown in this Division and the Manual of Uniform Traffic Control Devices for Canada, Part D – Temporary Conditions, for appearance, size, shape, colour, and level of reflectivity. The minimum level of reflectivity for orange sheeting used on temporary condition signs is ASTM Type 111 (high intensity).

704.02 SIGN DIMENSIONS

Signs must be placed on or by the edge of the road where they do not pose a hazard to traffic. Signs must be aimed and their alignment maintained so that they have the best viewing angle for oncoming traffic. For post mounting, the distances from the road surface to the bottom of the signs are:

- For 900 x 900 mm signs or larger, the sign must be installed so that their bottom edge is 1.0 to 2.5 m above the traveled portion of the roadway.
- For smaller signs, such as 750 x 750 mm signs, the sign must be installed so that their bottom edge is 1.5 to 2.5 m above the traveled portion of the roadway

The minimum sizes that should be maintained for all temporary condition signs, unless otherwise stated under the sign description, is as follows:

Road Type	Signs in Advance Warning Area	Signs Elsewhere in Work Zone
Freeway	1200mm x 1200mm	900mm x 900mm
Rural Roads	900mm x 900mm	750mm x 750mm
Urban Streets	750mm x 750mm	750mm x 750mm

704.03 SIGN DESCRIPTIONS

TC-1 Construction Ahead is used to provide advance warning of a major work area. This sign is generally used on long- term construction projects where drivers may encounter construction activities.

TC-1

TC-1A Construction Ahead Advance (with distance) is used to provide additional advance warning of construction projects. The distance shown on the sign is to be changed to show the actual distance to the work area by placing overlays or tabs in 500 m increments on the face of the sign.

TC-1A

TC-2 Road Work is used to indicate that work area activities are occurring on or near the traveled portion of the road and that workers or equipment may be at risk or may pose a risk to the driver.

TC-2

TC-4 Construction Ends is used to indicate to drivers that they have reached the end of a work zone and that they can expect normal roadway conditions on the remainder of the roadway.

TC-4

TC-5 Lane Closed Ahead is used to indicate that a lane is closed for road work. TC-5 must only be used on a multi-lane highway or street or on a highway or street with a multi-lane approach to the work area. The appropriate TC-5L (Left Lane) or TC-5R (Right Lane) version of the sign must be used.

TC-5R TC-5L

TC-6 Lane Closure Taper is erected at the beginning of a taper on Multi-Lane highways as a final warning to drivers that a lane change is necessary.

TC-6

TC-7 Lane Closure Arrow is used to indicate that traffic must pass to the Left or Right of the temporarily closed lane. The TC-7 sign is not used for Detours. Minimum size for TC-7 on Urban Residential Streets - 600mm x 1200mm

TC-7

TC-1O Detour Ahead is used to indicate that traffic will be required to follow another road to detour around the work area. TC-10 is erected in advance of detours on all streets and highways.

TC-10

TC-1OA Detour Ahead Advance (with distance) is used provide additional advance warning of detours. The distance shown on the sign is to be changed to show the actual distance to the beginning of the detour by placing overlays or tabs in 500 m increments on the face of the sign.

TC-10A

TC-11 Detour Direction Markers are used to indicate an alternate route for traffic to follow where work zone activities require the total closure of a roadway. The Detour Direction Markers should be installed in advance of and at intersections where the driver is required to follow the detour. The appropriate advanced turn arrow or direction arrow is used to show the direction of the detour route. TC-11 is available in Straight Through (TC-11), Right Turn (TC-11R), and Left Turn (TC-11L). The appropriate arrow must be used. Detour Direction Markers may be installed at intermediate locations along the detour route as confirmation to the driver. Minimum size for TC-11on Urban Residential Streets - 600mm x 600mm. Minimum size for TC-11L and TC-11R on Urban Residential Streets- 600mm x 450mm.

TC-11 TC-11R TC-11L

TC-12S End Detour should be used to indicate that motorists have reached the end of the detour and are resuming travel on their original route. Minimum size for TC-12Son Urban Residential Streets - 450mm x 300mm.

TC-12S

TC-13 Road Diversion is used to indicate a minor deviation to the right, “TC-13R” or left, “TC-13L” from the normal road alignment, TC-13 is used when the minor deviation is 200 meters or less in length.

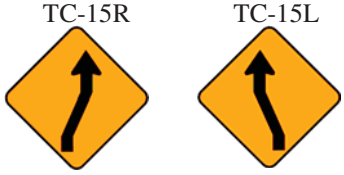
TC-13R TC-13L

TC-14 Road Diversion is used to indicate a minor deviation of two or more lanes to the right, “TC-14R” or left, “TC-14L” from the normal road alignment. TC-14 is used when the minor deviation is 200 meters or less in length.

TC-14R TC-14L

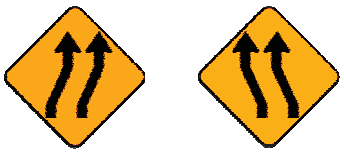
TC-15 Road Realignment is used to indicate a realignment of the roadway. A Right, "TC-15R" or Left, "TC-15L" is used as appropriate to indicate the deviation from the normal road alignment. TC-15 is used when the roadway realignment is greater than 200 meters in length.

TC-15R TC-15L



TC-16 Road Realignment is used to indicate a realignment of two or more lanes. A Right, "TC-16R" or Left, "TC-16L" is used as appropriate to indicate the deviation from the normal road alignment. TC-15 is used when the roadway realignment is greater than 200 meters in length.

TC-16R TC-16L



TC-17S Yield To Oncoming Traffic is used to indicate which direction has the right of way where only one lane is available for two-way traffic. The Yield sign (RA-2) with the To Oncoming Traffic tab sign (TC-17S) is installed in the direction of the closed lane only. The RA-2 sign with the accompanying TC-17S tab sign should only be used in situations where the one lane operation is short and where visibility is available in both directions beyond the one-lane section. Minimum size for TC-17S on Urban Residential Streets - 300mm x 600mm

TC-17S

TC-21 Traffic Control Person is used to indicate the presence of Traffic Control Persons directing traffic using a stop/slow paddle. Motorists are required to follow the direction of the Traffic Control Person. TC-21 is displayed only when traffic control persons are actively directing traffic; otherwise the TC-21 sign must be removed or covered. Minimum size for TC-21on Urban Residential Streets - 600mm x 600mm.

TC-21

TC-30 Checkerboard is used to indicate the termination of a road. It is applied where a driver cannot proceed either straight ahead or to the left or right. The sign should be installed at the point at which the road terminates. TC-30L and TC-30R are used to indicate an abrupt change in the roadway alignment at a turn or curve. The arrow indicates the direction taken by the turn or curve and should be installed at the turn or curve in the roadway.

TC-30 TC-30R TC-30L

TC-31 Chevron Alignment is used to provide additional guidance to drivers where there is a change in the horizontal alignment of the roadway. The signs are installed on the outside of a curve or sharp turn and located at right angles to oncoming traffic. Minimum size for TC-31on Urban Residential Streets - 450mm x 600mm

TC-31

TC-35 Road Narrows is used to indicate a reduction in the width of the roadway. The TC-35 sign only applies when there is no reduction in the number of traffic lanes. The Road Narrows Right "TC-35R" and Road Narrows Left "TC-35L" versions of the sign are used where only the width of the respective lane is reduced.

TC-35 TC-35R TC-35L

704.04 SITE CONDITIONS

The typical Traffic Control Diagrams located in this Division illustrate the standard signs required to notify motorists and pedestrians of the upcoming temporary traffic control conditions and lane configurations. Special attention must be paid to site conditions to warn motorists and pedestrians of any changes or specific hazards to the road surface and surrounding area. The following will illustrate the common signs and typical applications for which the specific sign must be displayed to identify a hazard.

TC-47 Grooved Pavement is used to warn motorists of road surface conditions which require extra care and attention by cyclists and motorcyclists. The sign must be erected in advance of a section of roadway where construction procedures such as milling, grinding, scarifying or cold planning create a surface condition which may affect the control and stability of motorcycles and similar vehicles. The sign must remain in place until re-surfacing is completed and the hazard is removed.

TC-47

TC-48 Soft Shoulder is used to warn motorists of possible hazards due to soft shoulder conditions along the roadway. The sign must be erected at 300 meters intervals for up to 1.0km and 900 meters intervals for sections longer than 1.0km where hazards exist due to soft shoulders. The sign must remain in place until the shoulders have been thoroughly compacted such that the hazard is no longer present.

TC-48

TC-49 Pavement Drop-Off is used to warn motorists approaching a section of roadway that due to construction activities the adjacent lane and or shoulder may be higher or lower than the current roadway surface the motorists is traveling on. The Pavement Drop-Off sign must be erected in advance of the hazard and every 1.0km throughout a section of roadway where the hazard is present. The sign must remain in place until the roadway is restored to its normal condition. Additional Hazard Markers are required to be erected along the section or roadway to delineate the hazard. Please see Drawing 704-1 for further information.

TC-49

TC-50 Pavement Ends is used to warn motorists that a hard-packed road (i.e. asphalt or concrete) is about to end, and that the roadway will continue as a gravel surface.

TC-50

TC-51 Bump is used to warn motorists of a change in the profile of the roadway which is sufficient enough to cause discomfort to passengers or a deflection of the vehicle from its course. The Bump sign must be erected in advance of every isolated "bump" caused by construction procedures. The sign may also be used to indicate that a section of road has numerous "bumps" by using the supplementary tab sign TC-36S indicating the length of the rough section. The sign must remain in place until the roadway is restored to its normal condition.

TC-51

TC-54 Truck Entrance is used to indicate a location where trucks are entering, exiting, or crossing the road and where there is no other construction activity in the area, such as entrances to gravel pits or asphalt mix plants. TC-54 should not be used at locations where construction activities are in progress as this information would be conveyed by TC-2. TC-54 must be displayed only when trucks are working; otherwise the sign must be removed or covered. TC-54 is available in R (Right Entrance), and L (Left Entrance). The appropriate version of the sign must be used..

TC-54R TC-54L

CSJ -RM Raised Manholes sign is used to warn motorists that the following section of roadway will contain obstructions in the form of raised manholes which will create a change in the profile of the roadway sufficient enough to cause discomfort to passengers or a deflection of the vehicle from its course. The Raised Manholes sign must be erected in advance of every raised manhole caused by construction procedures. The sign may also be used to indicate that a section of road has numerous raised manholes by using the supplementary tab sign TC-36S indicating the length of the rough section. The sign must remain in place until the obstructions are removed and the roadway restored to its normal condition.

CSJ-RM

ITEM 705

TEMPORARY CONDITION DEVICES

705.01 APPLICATION

Delineation devices must be used to channelize traffic when the traffic flow is impeded as a result of obstructions, work area or a narrowing of the street. They form part of the general category called Temporary Condition Devices and must be used as a supplement to temporary condition signs. Temporary Condition Devices have three functions for drivers and pedestrians:

- They warn that construction, maintenance or utility work is being carried out on or near the road immediately ahead.
- They advise of the appropriate response.
- They guide passage through the Temporary Workplace.

All Temporary Condition Devices must be removed or covered immediately after they are no longer applicable.

Where the temporary condition will exist during the hours of darkness, delineation must be achieved by the use of construction markers, traffic barrels, barricades, chevron markers, flashing beacons or similar devices. In all cases, markers and barricades used to achieve delineation during the hours of darkness must be reflectorized or illuminated to show the same colour and shape by night as by day (Fluorescent paint must not be used as a reflectorized substitute).

Delineator posts may be used to a maximum of five (5) days, not extending over the weekend period. Extended use is possible only with the approval of the Traffic Division.

Traffic cones may be used where the temporary condition will exist during daylight hours only and where the street will be in its normal operating condition throughout the hours of darkness.

705.02 LOCATION OF DELINEATION DEVICES

Any construction or maintenance activity on or within 1 m of a street must be marked by delineators along the work site and the approaches to the work site or obstruction, the angle at which the delineations are placed across the closed portion of the street is called the taper and should vary according to the maximum regulatory speed and must be as follows:

Regulatory Speed Limit	Minimum Taper
50 km/h and less	30 m
60 km/h	40 m
70 km/h	60 m
80 km/h	80 m
90 km/h	105 m
100 km/h	125 m

In 50, 60, or 70 km/h speed zones, taper lengths as noted above may be reduced to twenty-five percent (25%) of the minimum table value for utility truck operations where there is an approved flashing arrow board in operation on the utility vehicle.

If the work area affects more than one (1) traffic lane width, each traffic lane must be closed separately and a tangent section provided between the two (2) tapers. The minimum length of the tangent section must be as follows:

Regulatory Speed Limit	Minimum Tangent Between Tapers
50 km/h and less	30 m
60 km/h	40 m
70 km/h	60 m
80 km/h	80 m
90 km/h	105 m
100 km/h	125 m

705.03 SPACING OF DELINEATORS

The centre to centre distance between delineators varies with the regulatory speed limit and must be established as follows:

Regulatory Speed Limit	Maximum Centre to Centre Spacing
50 km/h and less	8 m
60 km/h	12 m
70 – 80 km/h	15 m
90 – 100 km/h	18 m

705.04 DESIGN AND COLOUR

Delineators, with the exception of traffic cones and delineator posts, must be designed with alternating striped orange and black colour placed in a horizontal position. Traffic cones must be solid orange in colour. Delineator posts must be orange in colour with two (2) reflectorized white 75mm strips per post.

705.05 FORMS OF DELINEATORS

A number of forms of delineation may be used, as outlined in the following:

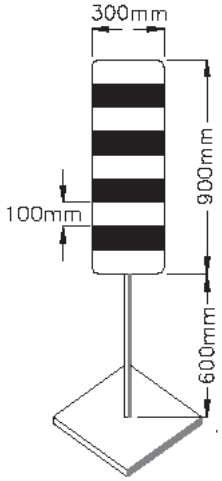
1. **Construction Markers**

Construction markers must be of the dimension indicated. They must be retro-reflectorized with high intensity grade orange reflective sheeting to indicate the same colour and shape by night as by day. Construction Markers must be marked with 100mm reflectorized horizontal orange stripes alternating with 100mm non-reflectorized horizontal black stripes.

Size – Construction Markers must be 300 X 900mm.

Spacing - The maximum hazard marker spacing is 50 metres.

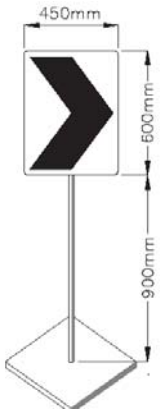
Some markers may require a weight to keep them from being knocked down or blown over. Only approved sand bags will be permitted and the use of rocks or boulders will not be considered.



CONSTRUCTION MARKER

2. **Chevron Markers**

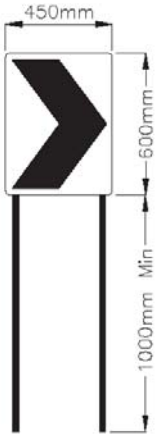
Chevron markers must be used on tapers for detours and diversions. They must replace the normal construction marker at a spacing of 30 metres. The arrowhead must point in the direction of the turn. They must be retro-reflectorized using high intensity grade orange reflective sheeting to indicate the same color and shape by night as by day. Some markers may require a weight to keep them from being knocked down or blown over. Only approved sand bags will be permitted and the use of rocks or boulders will not be considered.



Where traffic has to be diverted or channelized to cross multi-lanes of paved surfaces, delineator devices, such as hazard markers and chevrons, must be installed as outlined in this Division.

Signs 300mm or less in width, must be erected on a single piece of 25mm rebar to a height of 1 metre to 2 metres above the traveled portion of the roadway to the bottom edge of the sign.

Signs greater than 300mm in width, must be erected on two (2) pieces of 25mm rebar to a height of 1 metre to 2 metres above the traveled portion of the roadway to the bottom edge of the sign.



3. **Drums**

Drums are normally of 200 liters capacity set on end and used as delineators. Drums must be reflectorized to indicate the same colour and shape by night as by day. Drums are to be predominantly bright orange with a minimum of two (2) white reflectorized strips (100mm width minimum) per drum required.

Flexible drums may be used as an alternative method to channelize or delineate traffic and must be a minimum of 1000mm in height and a minimum of 550mm in diameter at the base. The markings on the flexible drums must be horizontal,

circumferential alternating black and reflectorized orange strips each being 100mm in width.

Use - Drums must be used as shown on the Application Guides. They are a higher standard and may be substituted for cones, or high delineators. Orange and black drums must not be used on the same project as orange and white drums. Different types of delineators must not be mixed, for the same purpose, on the same job, even when a higher standard delineator is used.

Drum stability - Drums must have bases heavy enough to keep them upright and in position during all conditions of use. Drums must not be weighted on top and Drum weighting must not be a hazard if the drum is struck. Drums that are tipped, should not roll or migrate, causing a traffic hazard.

Continuing Effectiveness - Drums that lose effectiveness through reduced reflectivity, or general appearance, must be removed from service.

5. Traffic Cones

Traffic Cones must be made from light weight, solidly coloured, bright orange material. Traffic Cones may be used to delineate work, buffer, transition and termination area tapers where their use is indicated on an Application Guide. Where Traffic Cones are specified by an Application Guide, high mounted Delineators may be used instead of the cones. Different types of delineators must not be mixed, for the same purpose, on the same job, even when a higher standard delineator is used

Night Use - The use of traffic cones is only permitted during the hours of daylight. The use of traffic cones during the hours of darkness will only be permitted for emergency situations and longitudinal pavement marking applications. During theses situations, all traffic cones in use for the hours of darkness must be reflectorized.

Cone Stability - Traffic Cones must have bases heavy enough to keep them upright and in position during all conditions of use. Their weight must not present a hazard if the cone is struck by a vehicle. Cones that are tipped, should not roll or migrate, causing a traffic hazard.

Continuing Effectiveness - Traffic Cones that lose effectiveness through reduced reflectivity, or general appearance, must not be used.

The dimensions of traffic cones should be related to the maximum speed on the street and their height comply with the following minimum requirements.

Maximum Speed km/h	Minimum Height (mm)
60 or less	450
70 or more	700

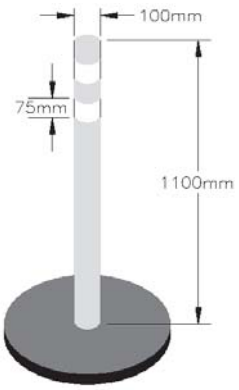
For longitudinal pavement marking applications, 450mm traffic cones may be used for speeds of 70km/h or greater.

6. DELINEATOR POSTS

Delineator posts used to channelize or delineate traffic must be 1100mm in height and 100mm in diameter. The markings must consist of two (2) high intensity reflective white horizontal, circumferential strips, 75mm in width. The unit is weighed down with a standard 7 Kg. rubber base. Extra 7 Kg. base inserts can be used when required by wind conditions.

High Delineators must be made from light weight, solidly coloured, bright orange material. Where Traffic Cones are specified by an Application Guide, High Delineators may be used instead of the cones. Different types of delineators must not be mixed, for the same purpose, on the same job, even when a higher standard delineator is used. (For example: Do not intermix cones and high delineators in an Approach Transition Taper, or drums and cones in a Buffer Area.)

Continuing Effectiveness - High Delineators that lose effectiveness through reduced reflectivity, or general appearance, must be removed from service.



705.06 FORMS OF WARNING DEVICES

A number of forms of warning devices may be used, as outlined in the following:

1. **Flashing Arrow Light Units – TC-8 / TC-9**

Flashing Arrow Boards are traffic control devices which provide an illuminated flashing display in the form of a left arrow, right arrow or a caution bar to inform drivers to change lanes or proceed with caution. There are two types of flashing arrow boards in common use:

TC-8 – displays a black arrow or bar on a reflectorized orange background. Both ends of the sign are hinged such that the board displays either a left or right arrow so that only one arrow head is visible. The board may also display a bar (arrow shaft only) with no arrow heads. The black arrow and bar modes are enhanced by the flashing lights contained in the black area of the board.

TC-9 – has a black background and displays a symbol only when the lights are activated. Depending on the light arrangement, several symbols and patterns may be displayed including left and right arrows and bars.

Arterials with a speed limit of 90 km/h or higher and detours and diversions that are anticipated to be in place longer than fifteen (15) days must have a flashing arrow light unit (TC-8 or TC-9) located within each taper length where either of the following conditions exist:

1. Lane drop situation.
2. Speed limit reduction of more than 20 km/h from the existing posted speed limit.

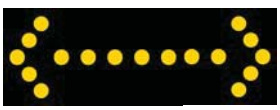
The arrow board must be a minimum of 1200mm long by 600mm high, and must be of a type and design as approved by the Engineer.

Flashing Arrow Light Units may be vehicle or trailer mounted. The height from the pavement to the centreline of the unit must be approximately 2.2 metres when it is in the upright position.

Approved Displays - Flashing Arrow Light Units have a group of lights capable of flashing a horizontal bar (Bar Mode) or a directional arrow(s) (Arrow Mode). The approved displays are:

- Left Arrow 

- Right Arrow 

- Left and Right Arrow 

- Warning Bar. 

The displays must have a minimum of:

- Six (6) working lights in Warning Bar mode.
- Nine (9) working lights in Left or Right Arrow mode (one arrowhead lit).
- Twelve (12) working lights in Left and Right Arrow mode (both arrowheads lit).

Use - When required by an Application Guide:

- A Flashing Arrow Light Unit must display a bar (caution) to draw motorist's attention to a hazard.
- A Flashing Arrow Light Unit must display an arrow only when it blocks a lane on a Multi-Lane Road and it is safe for traffic to change lanes in the direction of the arrow.
- Where a single lane is closed on a multi-lane road and more than one Flashing Arrow Light Unit is used, the first, Flashing Arrow Light Unit displays an arrow, second and subsequent units in the same lane display a bar (caution). (The arrow is normally used to indicate the need for a forced lane change on a multi-lane road.)

Position - Flashing Arrow Light Units must be positioned to obtain optimum motorist visibility. For a lane closure, Flashing Light Units must be positioned in the middle of the closed lane. For partial lane closures they should encroach into the roadway approximately the same amount as the work.

Flash Rate – Flashing Arrow Light Units must maintain a flash rate of 25 - 40 flashes per minute. The lights must be lit for approximately fifty percent (50%) of the cycle. For each Flashing Arrow Light Unit, all bulbs must show the same yellow or amber colour, and all must display the same light intensity. The Flashing Arrow Light Unit must be capable of automatically dimming at night or under low light conditions to a minimum of 50% of the normal daytime light output in order to not impair driver's vision.

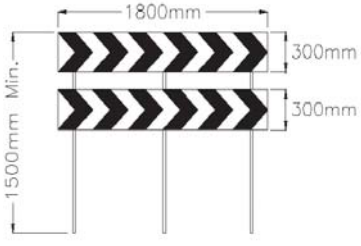
2. Barricades

For reasons of traffic safety and for the protection of workers, barricades must be used to define the work area and to close streets and roads in the area where work is being carried out. Barricades are always placed immediately preceding the work area on the approach side and act as a physical barrier between the street user and the obstruction or activity.

These barricades must be reflectorized or illuminated to indicate the same colour and shape by night as by day. All barricades must be marked with 100mm reflectorized orange stripes alternating with 100 mm non-reflectorized black stripes. The orange stripes must be reflectorized with ASTM Type 111 (high intensity) sheeting. The use of fluorescent paint on barricades will not be considered for use.

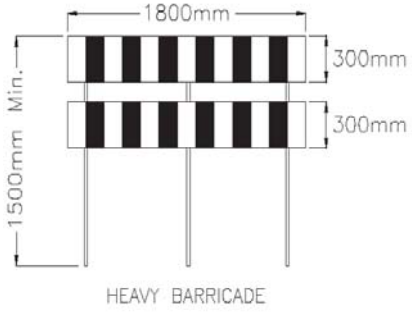
Heavy Barricades

Heavy barricades must be used to provide complete closure of a street or lane for an extended period of longer than five (5) days. Their supports must consist of posts set in the ground with two (2) TC-64C heavy barricade faces attached as shown below:



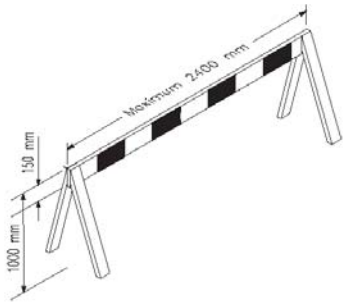
HEAVY BARRICADE
(DIRECTION OF TRAFFIC INDICATED BY ARROW)

Where no direction is required barricade TC-64B must be used, as shown below:



Light Barricades

Light barricades must be used for work of short duration to provide closure of a traffic lane or roadways or to provide protection around road excavation sites or other work site hazards. Light barricades must not be used as a channelized device. The use of fluorescent paint on light barricades will not be considered for use (TC-64A sign is required on each light barricade).



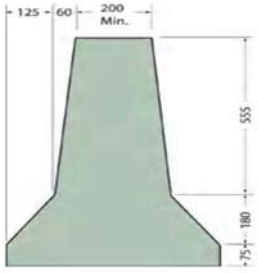
F-Shaped Barrier (New Jersey style Barrier)

For long duration work, the function of preventing errant vehicles from entering the work area may be accomplished through the use of New Jersey style barriers. When the 'New Jersey style' name is used, it referrers to a barrier conforming to F-shape Barrier standards, as tested by FHWA.

F-shape Barriers (New Jersey style Barriers) have four uses:

- Provide scaffolding protection.
- Provide worker protection by preventing errant vehicles from entering a work area.
- Separate two-way traffic, particularly when a section of a multi-lane highway is operated as two way.
- Provide protection from an exposed object or excavation.

F-shape Barrier sections must be securely fastened together, in accordance with design provisions, so that the barriers acts as a unit under impact. Any break in the barrier should be avoided. Errant vehicles must be protected from the exposed ends of an F-shape Barrier by the use of impact Attenuators or by flaring the Barrier away from approaching traffic. Approved reflective devices must be attached to the barrier ends so that they are identifiable during day and night conditions.



All dimensions are in mm

705.07 MISCELLANEOUS WARNING DEVICES

Under certain conditions, as outlined in the following sections, a number of other warning devices, including the following, may be used to augment the standard devices outlined in the preceding sections.

1. TRUCKS WITH FLASHERS

Trucks with flashers may be used as a replacement for normal signing, in some cases, where the work site is of a very temporary nature and its location changes on a continuing basis. In such instances, the truck must be equipped with a rotating amber flasher mounted on its roof, or approved equal, and standard four way flashers. This vehicle must display a bumper, a minimum of 250mm wide, with alternate orange and black stripes at a 45^{o} angle and must be equipped with the appropriate sign to properly guide vehicles approaching from the rear. The bumper and the sign must be reflectorized to indicate the same shape and colour by night as by day.

2 MISCELLANEOUS

Other miscellaneous traffic control devices, such as flares, flashlights, floodlights, lanterns, etc. may be used, as required, to supplement the signs and other devices described in this section. In all cases, the approval of the Engineer is required.

705.08 PORTABLE LANE CONTROL SIGNALS

With the authorization of the City, portable lane control signals may be used to alternate traffic past a work area, in lieu of flagpersons. The Traffic Engineering Division must be advised in each case of the intent to use this device, at least four weeks before application.

Portable lane control signals must meet the standards set by the Traffic Engineering Division and must be designed based on standards contained in, Part “B”, “Traffic Control Signals”, of the Manual of Uniform Traffic Control Devices for Canada. Portable signals must be installed so that the signal heads remain in position and properly aligned under all conditions of use. Portable signals must be used only under conditions where the lights are clearly visible to an approaching motorist such that the vehicle can be brought to a safe stop at any approach speed. Intensity of the signal lamps must be maintained in such a manner that the lights are clearly visible for a distance of at least 500 metres. The user will be required to adjust the timing to the approval of the Traffic Engineer.

Proper action must be taken to ensure that the signals are inspected regularly to verify correct operation and a plan in place to ensure safe movement of traffic should a failure occur. The plan must include keeping equipped and mobile Traffic Control Persons available, in the area of the installation, should a failure occur.

It is essential that these devices be removed immediately when conditions no longer require their use.

705.09 PORTABLE VARIABLE MESSAGE SIGNS

Portable Variable Message Signs are traffic control devices capable of displaying a variety of messages. The messages can be changed manually, by remote control, or by automatic control. Variable Message Signs help to warn motorists of construction activities or operations that are outside their normal expectations, such as lane closures associated with special operations. Messages displayed using Variable Message Signs must provide motorists with a legible, concise message directly relevant to the roadway condition they are approaching. The Variable Message Sign must have adjustable lighting levels such that under low light conditions the message will be legible while not impairing the driver’s vision.

ITEM 706

FLAGPERSON OPERATIONS

706.01 SCOPE

Traffic Control Persons otherwise known as Flagpersons have a unique and important role on construction, maintenance, and utility projects. Their main role is to regulate the flow of traffic through the temporary workplace and to prevent conflicts between pedestrians, motorists, workers and work zone activities. Flagpersons may be used to stop traffic intermittently as required by work progress, or to maintain continuous traffic flow past the work area at reduced speeds to protect workers. The following sections specify the appropriate equipment, signs, and usage of Flagpersons under such circumstances. The final decision as to the use of Flagpersons will be as directed by the Engineer.

706.02 FLAGPERSON QUALIFICATIONS

A valid City recognized Traffic Control Person course must be successfully completed prior to and as a condition of doing flagging.

706.03 FLAGPERSON EQUIPMENT

The Flagperson must wear the following clothing and protective equipment:

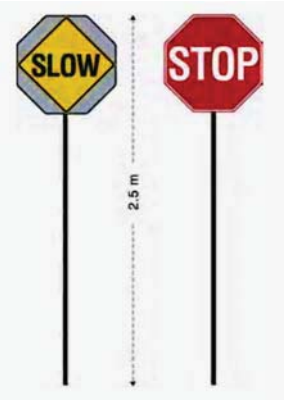
- A safety jacket or vest which must meet the requirements of a Class 2 - Vest as detailed in CSA Z96-02 with fluorescent background material and Level 2 retroreflective striping of a colour contrasting the background material. The vest must cover the entire upper torso and be worn over all clothing.
- Safety footwear, CSA compliant Grade 1 (green triangular CSA patch on the outside, green rectangular label on the inside)
- Hard hat CSA compliant, Class G or E, Type 11. Reflective material may be added for night work.

The following protective equipment may be used in response to site condition:

- Eye protection. Safety sunglasses in conditions of blinding sun and safety goggles for where there is a hazard to the eyes.
- Rain wear when needed should be highly visible orange or yellow.
- For night operation, the Flagperson should have a red signaling baton flashlight to supplement the diamond sign.

The Flagperson must be equipped with a **STOP/SLOW PADDLE**. The Stop / Slow Paddle must consist of a minimum 450mm X 450mm Stop sign and a minimum 450mm X 450mm Slow sign mounted back to back on the top of a pole so that the top of the signs are at least 2.5 metres from the bottom of the pole.

- The Stop sign must be an octagon in shape with white letters on a red background.
- The Slow sign must be a diamond in shape with black letters on a yellow background.
- The Stop and Slow signs must be reflectorized with ASTM Type 111 (high intensity) sheeting



707.04 FLAGPERSON ADVANCE SIGN

Except for very brief emergency situations, “Flagperson Ahead" (TC-21) signs must be posted in advance of each Flagperson. It must be of a design as shown in the Manual of Uniform Traffic Control Devices for Canada. Where the sign may be used during the hours of darkness, it must be reflectorized to indicate the same colour and shape by night as by day.

For the hours of daylight only, the use of Flagperson signs using a sign blank of plastic or other roll-up material made from retro-reflective sheeting will be permitted. All roll-up signs are subject to the approval of the Engineer.

All advance Flagperson signage must be removed or covered promptly when the flagging operations are terminated for a construction work zone for any period of time. Signage left up will be expropriated by the City.

706.05 GENERAL GUIDELINES

Flagpersons should be highly visible. For this reason they must stand alone, never permitting a group of workers to congregate around them.

Flagpersons should report dangerous drivers to the work site supervisor.

Flagpersons should be alert to emergency services. Ambulance, police and fire vehicles have priority over all other traffic.

The supervisor shall provide flagpersons where the activity or work zone requires their use, in accordance with the Newfoundland and Labrador Occupational Health and Safety Act. If a worker feels that a flagperson should be provided for a given situation, he/she shall advise the supervisor, who shall determine if required.

Flagpersons must stay alert at all times and always face traffic. An escape route should be planned before flagging operations begin.

Flagpersons working as a team must agree on communication signals before commencing their duties. If the Flagpersons are not visible to one another, a third flagperson or two-way radios are necessary to ensure proper communications and directing of traffic.

No flagperson will start working unless all required advance Flagperson signs are in place. No other construction signs must be located between the Flagperson position and the advance Flagperson signage.

At no time are flagpersons permitted to use flags to control traffic.

No Flagperson must leave their post unless authorized to do so or replaced by another Flagperson. As long as traffic cannot flow freely, even at mealtime, the flagperson must stay on duty.

Flagpersons should stand just outside the lane of traffic at a point from the end of the working area so as to be able to protect personnel and equipment. The distance from the flagperson to the work sits must be 10 meters for every 10 km/h of normal speed limit.

Flagpersons must place the flag sign in the right hand and use the left hand to point to indicate where they want traffic to stop. The flagperson must turn the sign from “stop “ to “ slow “ to regulate traffic and ensure traffic has cleared from job site before turning signs.

Flagpersons with co-operation from workers and equipment operators working at that location are to make every effort to keep delays to motorists to a minimum. In heavy traffic, delays should be split equally between the opposing lines of traffic and in normal operations no more than eight vehicles in one (1) direction can be kept waiting. At all times priority must be given to the motorist to proceed through the construction zone. Flagpersons not following these guidelines must be dismissed from the work site.

When the flagperson leaves their position at the end of operation on a work zone, the Contractor must remove and cover all applicable advance flagperson signage.

706.06 STANDARD OPERATING PROCEDURES

All Flagperson operations shall as a minimum, conform to the regulations set out in the Newfoundland and Labrador Occupational Health and Safety Regulations as outlined in PART XVI Traffic Control, subsection Traffic Control Person.

706.07 REQUIREMENTS AND RESPONSIBILITES

Persons employed as Flagpersons must be alert, conscientious, trained, accredited, and properly equipped. They must possess:

- Good physical health, good vision, and good hearing.
- Good physical and mental alertness
- Mature judgement.
- A pleasant, cooperative manner.

Flagpersons assigned to regulate traffic must not:

- Be assigned or attempt to carry out any other work.
- Permit the Flagperson sign to be displayed when a Flagperson is not directing traffic.
- Stand near any other persons. The Flagperson must be clearly visible.
- Stand near a vehicle or sit in a vehicle.
- Sit.
- Lean on a post or other object.
- Use a tape, disk or MP3 player, tv, radio, or any other device that impairs sight, hearing, or diverts attention.
- Turn their back on approaching traffic.
- Become impatient or enraged.
- Attempt to slow traffic by displaying the Stop sign rather than the Slow sign.
- Regulate traffic if their judgment is impaired in any way, or if for any reason they have suffered a reduction in their performance that could increase the hazard to themselves, road workers, or road users.

706.08 FLAGPERSON REQUIREMENTS

Any maintenance or construction job which results in lane blockage requires traffic control, usually in the form of Flagpersons. The following construction situations should be used as guidelines for the use of Flagpersons:

(a) At least one Flagperson must be provided on local streets when the traffic flow in one (1) direction is diverted wholly or partially into the lane of oncoming traffic and the lane of oncoming traffic is clearly visible beyond the one (1) lane section for the distance as shown in Table 706.08.01 for the appropriate speed limit.

Max Speed (km/h)	Clear Visibility Required in Each Direction
80	230 m
70	200 m
60	170 m
50	140 m
40	110 m

TABLE 706.08.01

(b) At least two (2) flagpersons must be provided on local streets when the traffic flow in one (1) direction is diverted wholly or partially into the lane of oncoming traffic and the lane of oncoming traffic is not clearly visible beyond the one (1) lane section as noted in Table 706.08.01.

(c) The Engineer may, where the normal traffic volume on a local street is less than fifteen (15) vehicles per hour,

reduce the flagpersons requirements.

(d) At least two (2) flagpersons must be provided on collector and arterial roads when the work activities require the traffic flow in one (1) direction to be diverted either wholly or partially into the lane of oncoming traffic.

(e) At least two (2) flagpersons must be provided when the traffic flow in both directions is diverted from the normal vehicle path onto a one (1) lane section. Where traffic flows in both directions is diverted from the normal vehicle path onto a two (2) lane section, the use of a flagperson is not required. Traffic flow may be safely regulated through the area by the proper use of construction signs.

(f) At least two (2) flagpersons must be provided to direct traffic at a major detour. These flagpersons must be located at each end of the detour, and must be familiar with the area of the detour route. Extended operations of a detour will require public advertising and detour signs along the complete detour route in place of the flagpersons.

(g) At least two (2) flagpersons must be located at truck entrances/exits on arterial roads when the truck traffic entering or exiting the access road is in excess of ten (10) vehicles per hour.

(h) At least one (1) flagpersons must be located at truck entrances/exits on collector and local roads with a normal traffic volume of fifty (50) vehicles per hour on the through road and when the truck traffic entering and exiting the access road is in excess of ten (10) vehicles per hour.

(i) At least three (3) flagpersons must be provided, and positioned as shown in Drawings 706-1 and 706-2, on collector and arterial roads when the work activities require that the traffic flow in one (1) direction to be diverted either wholly or partially into the lane of oncoming traffic and when the horizontal and/or vertical alignment at the work site does not have the distance of clear visibility required in Table 706.08.01.

(j) At least one (1) flagperson must be provided on arterial roads which have two (2) lanes of one-way traffic and traffic volumes in excess of one hundred (100) vehicles per hour where the work activities require that one (1) lane be closed at the work site.

(k) The use of a flagperson is not required on sections of new street which are not open to public use.

(l) At least one (1) flagperson must be provided on a temporary bridge bypass of one (1) lane width. At locations where portable traffic lights are in operation, the use of a flagperson is not required. At a two (2) lane bypass, the use of a flagperson is not required as traffic flow may be safely regulated through the area by the proper use of construction signs.

ITEM 707

CONSTRUCTION SPEED ZONES

707.01 SCOPE

Reduced speed limits may be established on construction projects or portions of projects requiring traffic control where it is determined that roadway conditions, geometrics or other factors dictate a speed reduction as approved by the Engineer.

707.02 GENERAL INFORMATION

Every effort must be made to plan and design work zones to the best possible standard and to maintain the road conditions through the work zone to the best possible condition. Special care must be taken in planning traffic control and sign placement for work zones so that vehicle speeds may be safely reduced from the normal roadway condition speeds to the speed levels required for safe passage through the work zone. Where the geometrics of the street are not reduced but public traffic is required to mingle with heavy equipment or like operations, a combination of construction signage and proper flagging procedures may provide adequate provisions for the safe passage of traffic eliminating the need for a reduced speed limit.

Where reduced speed limits have been approved for use on a construction project, the speed limit must reflect the street conditions in existence at the time. When road conditions do not warrant reduced speed limits, such as, during non-working periods, overnight or weekends, the reduced speed limit signs must be removed or covered. On a divided street, if construction involves only one side of the street, a reduced speed limit may be approved for use in the affected direction of travel only and must remain unaltered in the opposite direction.

There are many types of maintenance and construction projects where a reduction of the normal speed limit is not required. If there exists a good reason for the reduction of the speed limit through a work zone, then the motorists must be informed of the speed reduction along with the construction activities or roadway conditions which require the speed reduction. The use of speed limit signs by themselves will not be permitted, advance construction signs indicating the work activities or work zone conditions will be required.

All existing speed limit signs within the reduced speed zone must be covered while the temporary speed limit is in effect.

707.03 SPEED SIGNS

Where reduced speed limits have been approved for use the following conditions must be met:

- All speed limits must be signed using reflectorized maximum speed limit signs as specified in the Manual of Uniform Traffic Control Devices for Canada.
- All speed limits indicated on these signs must be in 10km/h increments.
- The Maximum Speed Ahead signs must be placed in advance of a construction speed sign where the speed reduction is more than 10km/h from the normal speed. On projects where the normal speed limit is 80km/h or greater or on the Trans Canada Highway, Maximum Speed Ahead signs must be 250 metres in advance of the maximum speed sign. At other locations this sign must be 50 metres to 100 metres in advance of the speed limit sign.
- At the end of a construction zone for which a reduced speed limit has been posted, the Contractor must have a speed limit sign posted indicating a return to the normal speed limit for that particular section of street. This sign may be omitted if there exists a permanently installed speed limit sign within 300 metres from the end of the reduced speed zone.
- Reduced speed limit signs left in place when the work zone condition does not warrant any reduction will be expropriated by the City.

All speed limit reductions must be submitted to the Engineer for approval prior to their establishment along a construction zone. Requests for speed limit reductions will be considered based on roadway geometrics, sight distance limitations, surface condition, the proximity and numbers of workers, equipment, and type of obstruction presented to the traffic through the work zone. Each work zone will be individually considered for a reduction in speed limits.

707.04 DOUBLE FINES FOR SPEEDING

The Government of Newfoundland and Labrador has approved a plan to enable fines for speeding between TC-1 (Construction Ahead) and TC-4 (Construction Ends) signs to be doubled when the work zone is signed in accordance with the Double Fines signage requirement. To make this law effective it is very important to ensure the Double Fines signage is erected in accordance with the Government of Newfoundland and Labrador's Traffic Control Manual. Please refer to the Department of Transportation and Works Traffic Control Manual for sign descriptions and placement regarding Double Fines.

The Double Fines signage, if chosen to be erected on site, as illustrated in the Department of Transportation and Works Traffic Control Manual, will be in addition to the temporary condition signs and devices as required by the appropriate traffic control diagram for the roadway condition as illustrated in Item 709 Temporary Traffic Control Diagrams of this Specification. The Department of Transportation and Works Traffic Control Manual will be used as a reference for the placement of Double Fines signage only.

ITEM 708

PROJECT SIGNS

708.01 SCOPE

When specified in the contract drawings and documents, the Contractor will be responsible to erect project signs on the project. One (1) sign at each end of the work sites in a location approved by the Engineer.

708.02 HANDLING AND ERECTION OF SIGNS

These project signs can be picked up by the Contractor at the Municipal Depot.

These signs must be erected and installed by the Contractor using proper methods as required for the size of the project signs used, as outlined in sign post installations detail drawing.

After the sign posts are firmly in the ground, the Contractor must affix the sign to the posts using 10mm x 80mm galvanized lag screws.

708.03 REMOVAL OF SIGNS

After the project is completed, these signs and posts must be removed by the Contractor.

708.04 PAYMENT

Project signs will be supplied by the City at no charge to the Contractor. However, all handling charges from the Municipal Depot to the project and all installation costs for all required project signs must be included in the price bid for Item 610, “Sign and Sign Post Installations”.

ITEM 709

TEMPORARY TRAFFIC CONTROL DIAGRAMS

709.01 General

The Traffic Control Diagrams contained in this Division illustrate how signs and devices for temporary traffic control may be applied in a variety of situations commonly encountered in construction and maintenance activities. The Traffic Control Diagrams are presented according to the type of work being carried out. Where available alternate configurations for varying work durations are presented.

709.02 Longitudinal Buffer and Taper Lengths

Guidelines for the recommended lane closure taper lengths and longitudinal buffer lengths are provided on the appropriate traffic control drawings. The lane closure taper lengths are approximately equal to the braking distance while the longitudinal buffer lengths are approximately equal to the brake reaction distance such that:

Lane Closure Taper Length + Longitudinal Buffer Length = Stopping Sight Distance

It is important to ensure the required signs and lengths, as illustrated in the traffic control diagrams, are installed to provide proper safety to the workers and motorists.

Conditions may arise where the recommended taper and buffer lengths cannot be achieved due to physical limitations such as closely spaced intersections within urban areas. Where all options have been exhausted the longitudinal buffer length may be reduced or eliminated to accommodate the required lane closure taper length as approved by the Engineer. During these situations additional advanced warning signs and delineation devices must be placed along the roadway.

709.03 Typical Application Guide Chart

To determine the appropriate Traffic Control Diagram, please determine the following:

- Type of Activity
- Location of Work - The four (4) levels of roadway encroachment are as follows:

  1 - Off Shoulder Work - is work within the street right-of-way, but completely beyond the shoulder of the road. Workers, equipment, and vehicles do not encroach on the shoulder. Off shoulder work requires no traffic control signs or devices if the work area is beyond the shoulder and all work vehicles, equipment and personal are beyond the shoulder.

  2 - Shoulder Work - is work on the shoulder of a road and off the travel lanes. Workers, equipment, and vehicles do not encroach into the travel lanes. Shoulder work requires traffic control signs and/or devices.

  3 - Partial Lane Closure – is work which results in part of a travel lane being closed while guiding traffic in the narrowed lane. A minimum of 3.5 meters of usable lane must be available to traffic for a partial lane closure to be considered. This width may be reduced to a minimum of 3.0 meters for roadways on which trucks and buses do not normally travel. Partial lane closures require traffic control signs and devices.

  4 - Lane Closure – is work which results in less than 3.5 meters of useable lane width available to traffic. Under this condition a travel lane is closed by blocking the lane and directing traffic around the closed portion of the lane and back into the original lane once pass the diversion. Lane Closures require traffic control signs and devices.

- Work Duration - The four (4) categories of work duration are as follows:

  1 - Mobile Operations - consist of work carried out while the equipment and workers are continuously moving, usually at slow speeds, or intermittently, with periodic stops which do not exceed a few minutes duration. The advanced warning area moves with the activity area. For some continuously moving operations where the traffic volume is light, the speed at which the operation moves is low and visibility is good, a well-marked and well signed vehicle may be sufficient. If traffic volume and/or speed is higher, a buffer vehicle equipped as a sign truck, preferably with a flashing arrow board, should follow the work vehicle. In addition, vehicles may be equipped with devices such as flashing vehicles lights, truck-mounted attenuators and appropriate signs. Where mobile operations are in effect on a high-speed travel lane on a multi-lane divided highway, flashing arrow boards should be used. Examples of mobile operations include longitudinal pavement marking and street-sweeping.

  2 - Very Short Duration Work – consists of work which occupies a fixed location for up to thirty (30) minutes. The work site may be moved along the roadway and make frequent, short stops. The time required to set up and remove normal traffic control devices in these situations often exceed the time required to complete the work. Consequently, the use of active devices such as flashers and flashing arrow boards, along with simplified set up and removal procedures, is advised for very short duration work. The investment in these active devices ensures adequate traffic control, reduces worker time spent exposed to traffic hazards and yields more efficient, productive work operations. Examples of very short duration work include utility work, minor road maintenance, crack sealing, stormwater catchbasin cleanout, etc.

  3 - Short Duration Work – consists of stationary work that requires a separate work space that is continuously attended by workers for more than 30 minutes and less than 24 hours. It may include maintenance, construction or utility work. The work crew is present to monitor and maintain the temporary traffic control zone. The road is completely restored and returned to normal operation when the work is completed.

  4 - Long Duration Work – consists of stationary work that requires a separate work space for longer than 24 hours. At long duration temporary work zones, there is ample time to install and to realize the benefits from the full range of traffic control devices and procedures that are available for use. Temporary roadways and barriers may be provided, and inappropriate marking may be removed and replaced with temporary markings.

- Type of Road - The two (2) categories of roadways are as follows:

  1 - divided roadway

  2 - undivided roadway

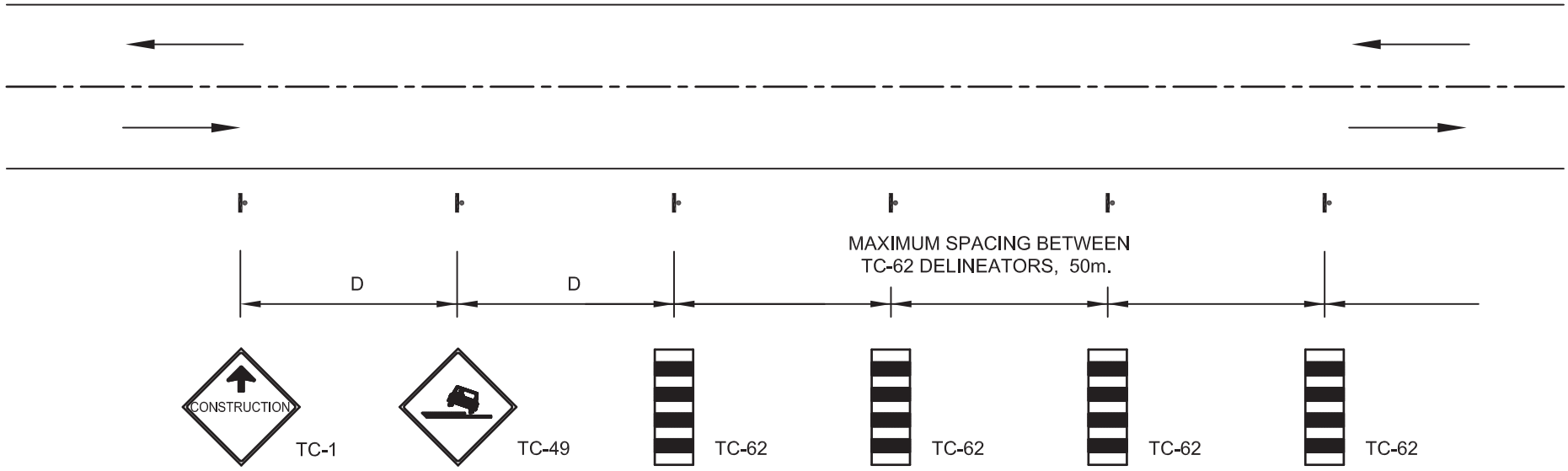
With the above information, consult the following chart, Figure 709.03.01, to help determine the appropriate Temporary Traffic Control Diagram to assist in the design of the proper Traffic Control Plan for the construction or maintenance activity.

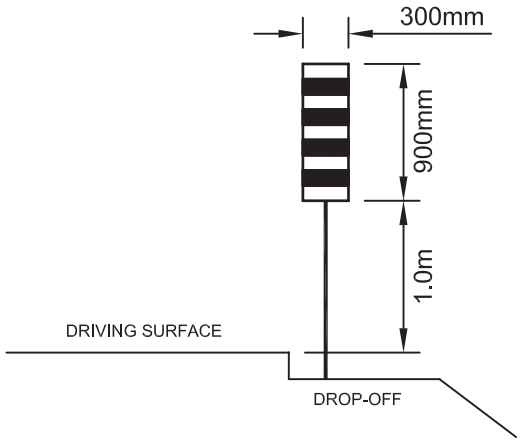
Figure 709.03.01

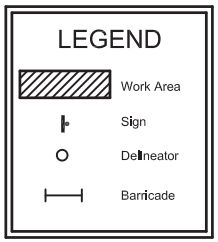
Temporary Traffic Control Diagrams								
Type of Activity	Type of Work							
	Mobile Operations		Very Short Duration		Short Duration		Long Duration	
	Divided	Undivided	Divided	Undivided	Divided	Undivided	Divided	Undivided
Roadside Work & Shoulder Work, Two-Lane Road								
Right Shoulder Work	-	Fig 1	-	Fig 1	-	Fig 2.1 & 2.2	-	Fig 2.1 & 2.2
Encroachment in Right Lane	-	Fig 3	-	Fig 4.1 & 4.2	-	Fig 4.1 & 4.2	-	Fig 5.1 & 5.2
Roadside Work & Shoulder Work, Multi-Lane Road								
Right Shoulder Work	Fig 1	Fig 1	Fig 1	Fig 1	Fig 2.1 & 2.2	Fig 2.1 & 2.2	Fig 2.1 & 2.2	Fig 2.1 & 2.2
Left Shoulder Work	Fig 6	-	Fig 6	-	Fig 7.1 & 7.2	-	Fig 7.1 & 7.2	-
Work in Median	Fig 8	-	Fig 9	-	Fig 9	-	Fig 9	-
Encroachment in Left Lane	Fig 10	-	Fig 12.1 & 12.2	-	Fig 12.1 & 12.2	-	Fig 14.1 & 14.2	-
Encroachment in Right lane	Fig 11	Fig 11	Fig 13.1 & 13.2	Fig 13.1 & 13.2	Fig 13.1 & 13.2	Fig 13.1 & 13.2	Fig 15.1 & 15.2	Fig 15.1 & 15.2
Single Lane Closed								
Two-Lane Road – Right Lane Closed	-	Fig 16	-	Fig 16	-	-	-	-
1) Yield to Oncoming Traffic	-	-	-	Fig 17	-	Fig 17	-	Fig 17
2) Traffic Control Person(s)	-	-	-	Fig 18	-	Fig 18	-	Fig 18
3) Temporary traffic Control Signals	-	-	-	Fig 19	-	Fig 19	-	Fig 19
Multi-lane Road – Left Lane Closed	Fig 20.1 & 20.2	Fig 20.1 & 20.2	Fig 20.1, 20.2, 21.1 & 21.2	Fig 20.1, 20.2, 23.1 & 23.2	Fig 25	Fig 27	Fig 29	Fig 31
Multi-Lane Road – Right Lane Closed	Fig 20.1 & 20.2	Fig 20.1 & 20.2	Fig 20.1, 20.2, 22.1 & 22.2	Fig 20.1, 20.2, 24.1 & 24.2	Fig 26	Fig 28	Fig 30	Fig 32
Five-Lane Road – Left Lane Closed		Fig 20.1 & 20.2		Fig 33	-	Fig 33	-	Fig 33
Five-Lane Road – Two-Way Left-turn Lane Closed		Fig 20.1 & 20.2		Fig 34	-	Fig 34	-	Fig 34
Two Lanes Closed								
Four-Lane Road – Two Right Lanes Closed	-	-	-	Fig 35	-	Fig 35	-	Fig 35
Five-Lane Road – Two Right Lanes Closed	-	-	-	Fig 36	-	Fig 36	-	Fig 36
Five-Lane Road – Two-Way Left-Turn & Left Lane Closed	-	-	-	Fig 37	-	Fig 37	-	Fig 37
Median Crossover								
Mid-Block Location	-	-	-	-	Fig 42	-	Fig 42	-
Approaching an Intersection	-	-	-	-	Fig 43	-	Fig 43	-
Detour								
Alternative Roads	-	-	-	-	-	Fig 44	-	Fig 44
Roadside Diversion	-	-	-	-	-	-	-	Fig 45

Figure 709.03.01 Continued

Temporary Traffic Control Diagrams								
Type of Activity	Type of Work							
	Mobile Operations		Very Short Duration		Short Duration		Long Duration	
	Divided	Undivided	Divided	Undivided	Divided	Undivided	Divided	Undivided
Ramps								
Ramp Closure	-	-	Fig 47	Fig 47	Fig 47	Fig 47	Fig 48	Fig 48
Lane Closed at Ramp Exit	-	-	-	-	Fig 49	Fig 49	Fig 49	Fig 49
Lane Closed at Ramp Entrance			-	-	Fig 50	Fig 50	Fig 50	Fig 50
Lane Closed at Intersection on Two-Lane Roads								
Near-Side Lane Closed	-	-	-	Fig 51	-	Fig 51	-	Fig 51
Far-Side Lane Closed	-	-	-	Fig 52	-	Fig 52	-	Fig 52
Intersection Near-Side Lane Closed on Multi-Lane Road								
Left Lane Closed	-	-	Fig 53	Fig 53	Fig 53	Fig 53	Fig 53	Fig 53
Right Lane Closed	-	-	Fig 54	Fig 54	Fig 54	Fig 54	Fig 54	Fig 54
Left-Turn Lane Closed	-	-	Fig 55	Fig 55	Fig 55	Fig 55	Fig 55	Fig 55
Right Turn Lane Closed	-	-	Fig 56	Fig 56	Fig 56	Fig 56	Fig 56	Fig 56
Left-Turn Lane Open & Adjacent Through Lane Closed	-	-	Fig 57	Fig 57	Fig 57	Fig 57	Fig 57	Fig 57
Right-Turn Lane Open & Adjacent Through Lane Closed	-	-	Fig 58	Fig 58	Fig 58	Fig 58	Fig 58	Fig 58
Left-Turn Lane & Adjacent Through Lane Closed	-	-	Fig 59	Fig 59	Fig 59	Fig 59	Fig 59	Fig 59
Right-Turn Lane & Adjacent Through Lane Closed	-	-	Fig 60	Fig 60	Fig 60	Fig 60	Fig 60	Fig 60
Intersection Far-Side Lane Closed on Multi-lane Road								
Left Lane Closed	-	-	Fig 61	Fig 61	Fig 61	Fig 61	Fig 61	Fig 61
Right Lane Closed	-	-	Fig 62	Fig 62	Fig 62	Fig 62	Fig 62	Fig 62
Left Lane Closed (Near-Side Left-Turn Lane Open)	-	-	Fig 63	Fig 63	Fig 63	Fig 63	Fig 63	Fig 63
Right Lane Closed (Near-Side Right-Turn Lane Open)	-	-	Fig 64	Fig 64	Fig 64	Fig 64	Fig 64	Fig 64
Pedestrian Considerations								
Mid-Block Location	-	-	-	-	Fig 65	Fig 65	Fig 65	Fig 65
Approaching an Intersection	-	-	-	-	Fig 66	Fig 66	Fig 66	Fig 66
Intersection								
Two-Lane Road	-	-	-	-	-	Fig 67	-	Fig 67
Multi-Lane Road	-	-	-	-	Fig 68	Fig 68	Fig 68	Fig 68
Sidewalk Closure	-	-	-	Fig 69	-	Fig 69	-	Fig 69







CONSTRUCTION DISTANCE TABLE

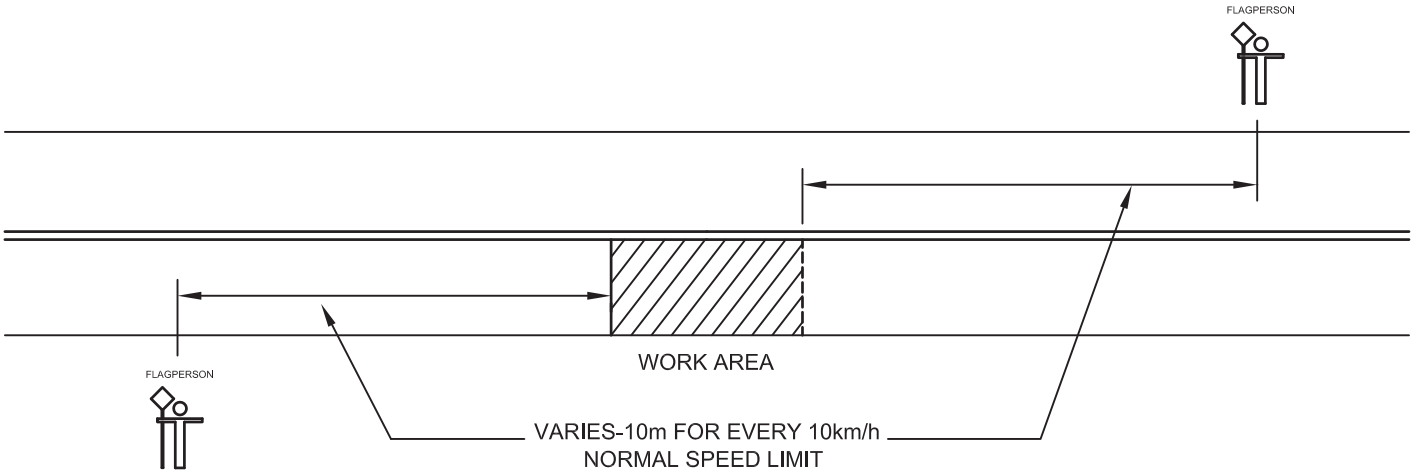
	REGULATORY SPEED LIMIT	50 km\h & LESS	60 - 70 km\h	80 km\h	90 km\h & T.C.H.
A	TAPER LANE (m)	30	60	120	240
B	MAX. DISTANCE BETWEEN DELINEATION MARKERS (m)	5	10	15	15
C	MIN. TANGENT BETWEEN TAPERS (m)	50	100	150	240
D	DISTANCE BETWEEN CONSTRUCTION SIGNS	50	100	150	150
E	BUFFER AREA (m)	15	50	50	50

ST. JOHN'S
DEPARTMENT OF ENGINEERING

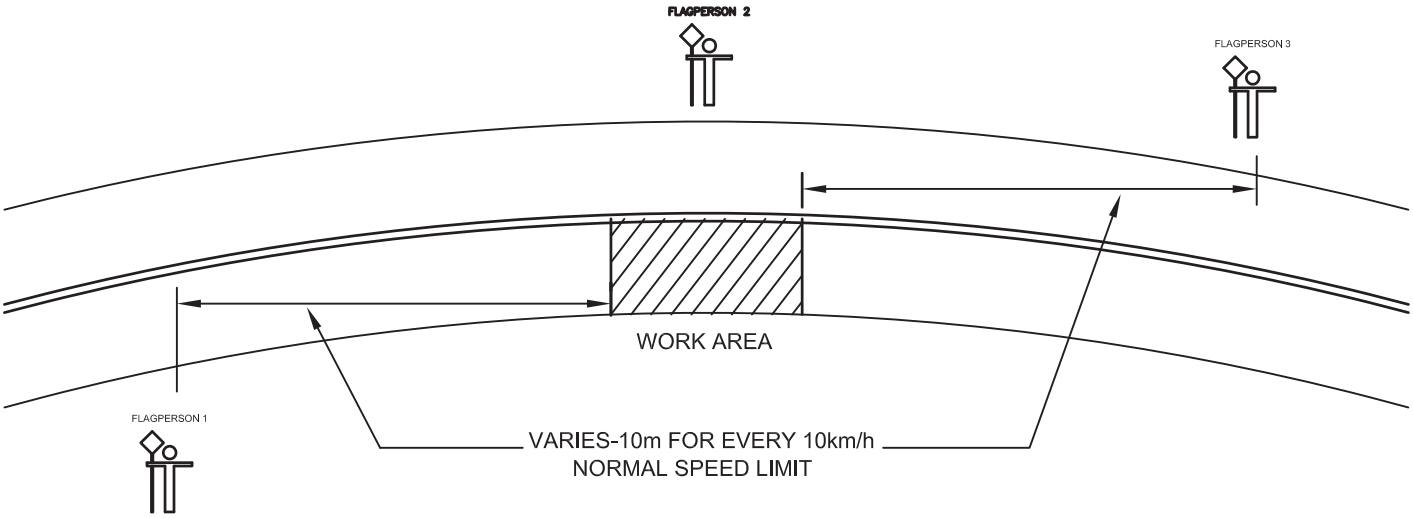
PAVEMENT DROP OFF

DRAWN BY: C. S.	DATE: MARCH 2010	SCALE: N.T.S.	DRAWING No. 705-1

ON STRAIGHT ROAD AND CURVE



STRAIGHT ROAD



CURVE

NOTES:

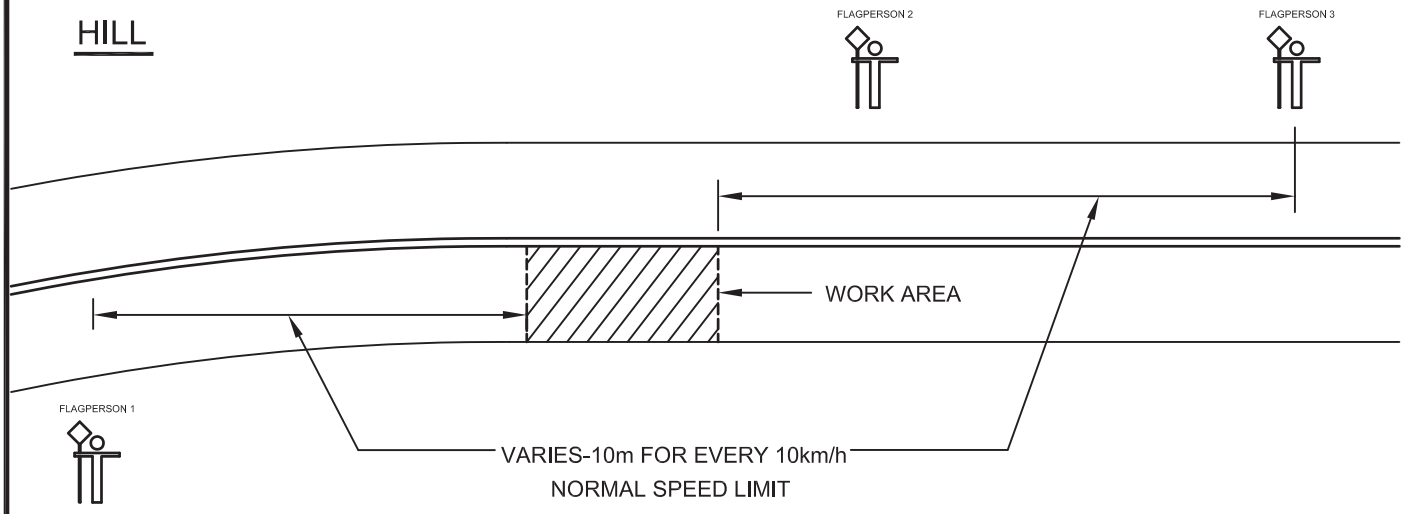
ON CURVES AND HILLS WHERE THREE FLAGPERSONS ARE REQUIRED, THE DUTY OF THE FLAGPERSON NUMBER 2 IS TO RELAY SIGNALS BETWEEN FLAGPERSON NUMBER 1 AND FLAGPERSON NUMBER 3.

ST. JOHN'S
DEPARTMENT OF ENGINEERING

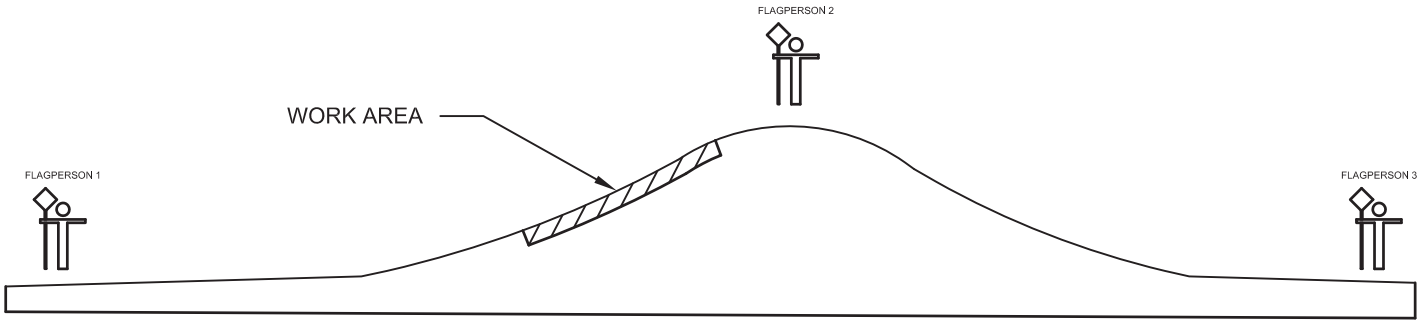
POSITIONING OF FLAGPERSONS

DRAWN BY: C. S.	DATE: MARCH 2010	SCALE: N.T.S.	DRAWING No. 706-1

ON A HILL



PLAN



PROFILE

NOTES:

ON CURVES AND HILLS WHERE THREE FLAGPERSONS ARE REQUIRED, THE DUTY OF THE FLAGPERSON NUMBER 2 IS TO RELAY SIGNALS BETWEEN FLAGPERSON NUMBER 1 AND FLAGPERSON NUMBER 3.

ST. JOHN'S
DEPARTMENT OF ENGINEERING

POSITIONING OF FLAGPERSONS

DRAWN BY: C. S.	DATE: MARCH 2010	SCALE: N.T.S.	DRAWING No. 706-2

APPENDIX R

Sensitivity Analysis Floodplain Maps

ST. JOHN'S
DEPARTMENT OF CORPORATE SERVICES

Long Pond Weir
Environmental Preview Report

Legend

1:5 AEP + 30%
Pre-Construction

1:5 AEP + 30%
Post-Construction

Drawing Title:

Sensitivity Analysis
Pre- and Post-Weir Construction
Floodplain Delineation

CBCL LIMITED
Consulting Engineers

Coordinate System:
NAD_1983_MTM_1
Units:Metre
Scale:1:6,000

N
W
E
S

ST. JOHN'S
DEPARTMENT OF CORPORATE SERVICES

Long Pond Weir
Environmental Preview Report

Legend

1:20 AEP + 30%
Pre-Construction

1:20 AEP + 30%
Post-Construction

Drawing Title:

Sensitivity Analysis
Pre- and Post-Weir Construction
Floodplain Delineation

CBCL LIMITED
Consulting Engineers

Coordinate System:
NAD_1983_MTM_1
Units:Metre
Scale:1:6,000

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ST. JOHN'S
DEPARTMENT OF CORPORATE SERVICES

Long Pond Weir
Environmental Preview Report

Legend

1:50 AEP + 30%
Pre-Construction

1:50 AEP + 30%
Post-Construction

Drawing Title:

Sensitivity Analysis
Pre- and Post-Weir Construction
Floodplain Delineation

CBCL LIMITED
Consulting Engineers

Coordinate System:
NAD_1983_MTM_1
Units:Metre
Scale:1:6,000

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ST. JOHN'S
DEPARTMENT OF CORPORATE SERVICES

Long Pond Weir
Environmental Preview Report

Legend

1:100 AEP + 30%
Pre-Construction

1:100 AEP + 30%
Post-Construction

Drawing Title:

Sensitivity Analysis
Pre- and Post-Weir Construction
Floodplain Delineation

CBCL LIMITED
Consulting Engineers

Coordinate System:
NAD_1983_MTM_1
Units:Metre
Scale:1:6,000

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ST. JOHN'S
DEPARTMENT OF CORPORATE SERVICES

Long Pond Weir
Environmental Preview Report

Legend

- 1:100 AEP Climate Change + 30% Pre-Construction
- 1:100 AEP Climate Change + 30% Post-Construction

Drawing Title:

Sensitivity Analysis
Pre- and Post-Weir Construction
Floodplain Delineation

CBCL LIMITED
Consulting Engineers

Coordinate System:
NAD_1983_MTM_1
Units:Metre
Scale:1:6,000

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APPENDIX S

City of St. John's Stormwater Detention Policy

STORMWATER DETENTION POLICY

1. POLICY STATEMENT

The purpose of this document is to provide policy direction when stormwater detention systems are required for development where an increase in stormwater runoff may:

a) contribute to risk of flooding, and/or

b) exceed the capacity of City storm sewers, bridges/culverts, river channels, or ditches.

2. POLICY OBJECTIVE

The objectives of the Stormwater Detention Policy are to:

a) Temporarily store the difference in volume between the 100-year 24-hour post-development runoff and the 100-year 24-hour pre-development runoff while limiting the post-development runoff rate from a development to the pre-development runoff rate.

b) Prevent increases in downstream flooding and drainage problems that could increase flood losses, damage public assets, reduce property values, and require additional capital works expenditures for flood mitigation.

c) Encourage integration of the detention system into a sustainable overall stormwater management plan for the development, and

d) Promote the incorporation of detention systems into the engineering design and layout of the development so that adequate storage areas are included in the initial stages.

3. POLICY APPLICATION

The Policy applies to all developments within the City of St. John's which present an immediate or foreseeable risk of flooding, with the exception of:

a) Developments in areas, such as Downtown, where the storm sewer system discharges directly into the Atlantic Ocean - subject to City storm sewer infrastructure having sufficient capacity as determined by the Director of Engineering,

b) Developments comprising a land area of less than 0.5 hectares and where the increase in stormwater runoff is less than or equal to 25 liters per second,

c) New developments in subdivisions where a stormwater detention system has already been provided for the entire subdivision,

d) The grassed playing field and vegetated area of public sports and recreational facilities that are not part of a development,

e) Locations where such a system would, due to timing of outflows, have an adverse effect on downstream properties by increasing peak rates of runoff – as determined by the Director of Engineering,

f) Where there is a written agreement between the Developer and the City to provide stormwater infrastructure improvements that remedy the downstream flooding problems in lieu of constructing a stormwater detention system. The Developer would be required to provide the City with a certified cheque or an acceptable Irrevocable Letter of Credit for the value, as determined by the City, of the downstream flood remediation work,

g) Small size developments where it can be demonstrated to the satisfaction of the Director of Engineering that the stormwater detention system would have no beneficial effect to downstream properties, and

h) Other areas where the Director of Engineering determines, based on hydrologic/hydraulic analysis, that stormwater detention is not necessary, or may be permissible at a reduced level.

4. AREA OF THE DEVELOPMENT TO WHICH STORMWATER DETENTION APPLIES

Generally, stormwater detention applies to the entire development with the following exceptions:

a) On already-developed property, the stormwater detention system requirements only apply to the area of the new development – provided runoff from previously developed areas can be excluded from the detention storage,

b) In residential subdivisions where new public roads will be created, the stormwater detention requirements will apply to the entire development area – including streets and lots. However, any areas of a lot that remain in a natural undeveloped state may be excluded from the area to be controlled by the stormwater detention system provided that flows from

these areas can be diverted around the detention system. Approval from the Director of Engineering must be obtained before excluding any area from the detention requirements.

c) Where the proposed development is on previously developed vacant site or is a complete redevelopment of an already-developed property, the stormwater detention system requirement will be applicable to the entire property.

5. EFFECTIVE DATE OF POLICY

This Policy will come into effect on January 1, 2013. Development applications which have been received by the City prior to January 1, 2013, and where construction is substantially underway by September 1, 2013, as determined by the Director of Engineering, will be exempt from this Policy – unless the City has already advised that stormwater detention is required or there is a capacity issue in the receiving storm sewer system.

6. DEVELOPER'S RESPONSIBILITY

It is the responsibility of the Developer(s) to submit for City approval a stormwater management plan which meets the requirements of this Policy. The City reserves the right to accept or reject the stormwater management plan, or propose amendments to the plan. Where requested by the Developer, the City may provide guidance as to the type of stormwater detention which might be acceptable for a particular development. The City's Stormwater Detention Design Manual provides the design standards that the Developer must use to design and construct the stormwater detention system.

7. REGIONAL DETENTION

The City may, where it is considered more effective, direct Developers to cooperate in, and fund the cost of, a regional detention system as a condition to a development(s) proceeding. A regional detention system would establish large scale stormwater detention structure(s) to meet this Policy's requirements for several developments within a geographic region. Similarly, a Developer(s) may also propose a regional stormwater detention system to the City.

8. DETENTION INFRASTRUCTURE COSTS

Developers will fund all costs of stormwater infrastructure constructed within the borders of their property. In the case of a regional stormwater detention system, where the detention infrastructure serves more than one development, the regional detention infrastructure costs will be shared among developers in proportion to the amount of stormwater volume each development is expected to detain. Where the City must upgrade its infrastructure outside the borders of the development, the City may recover its costs, including interest and financial charges, through assessment charges/fees against developable properties served by, or to be served by, the regional stormwater detention system.

9. OWNERSHIP

Stormwater detention systems in residential developments may be accepted for ownership and maintenance by the City. Detention systems in Commerical, Industrial, or Institutional developments will not be accepted for ownership by the City.

The City of St. John's provides no maintenance of stormwater detention systems located on private property. Maintenance must be provided by the owner of the property upon which the detention system resides – unless there is an agreement between the owner and the City which supercedes the preceding.

10. ACCEPTANCE

Acceptance of stormwater detention systems is subject to the following requirements:

a) A Developer owning property with an area greater than 0.5 hectares must construct a stormwater detention system in accordance with the approved engineering plans and must convey the system, and associated lands, at no cost to the City as a condition of Final Approval subject to the requirements of Section 9 of this Policy.

b) The City will not accept the detention system until (a) the system has been fully completed in accordance with the approved plans, (b) 80% of the proposed lots have been fully developed, and (c) adequate erosion control measures, as approved by the Director of Engineering, have been installed on the remaining 20% of the lots. The Developer must continue to own and maintain the detention system until accepted by the City.

APPENDIX T

Existing Conditions 1:20 AEP Floodplain

ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

Existing Conditions
1:20 AEP Floodplain

Rennies River Catchment
Stormwater Management Study

Water Depth (m)

High : 9

Low : 0

Map 1

CBCL LIMITED
Consulting Engineers

Coordinate System:
NAD_1983_MTM_1
Units:Metre
Scale:1:10,000

N
W
E
S

ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

Existing Conditions
1:20 AEP Floodplain

Rennies River Catchment
Stormwater Management Study

Water Depth (m)
High : 9
Low : 0

Map 2

CBCL LIMITED
Consulting Engineers

Coordinate System:
NAD_1983_MTM_1
Units:Metre
Scale:1:10,000

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ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

Existing Conditions
1:20 AEP Floodplain

Rennies River Catchment
Stormwater Management Study

Water Depth (m)

High : 9

Low : 0

Map 3

CBCL LIMITED
Consulting Engineers

Coordinate System:
NAD_1983_MTM_1
Units:Metre
Scale:1:10,000

N
W
E
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APPENDIX U

Leary's Brook Investigation Draft Report

CBCL LIMITED
Consulting Engineers

187 Kenmount Road
St. John's, Newfoundland
Canada A1B 3P9

Telephone: 709 364 8623
Fax: 709 364 8627
E-mail: info@cbcl.ca
www.cbcl.ca

Solving today's problems with tomorrow in mind

July 31, 2015

Daniel J. Parsons
Project Manager - Planning & Engineering
Infrastructure Support
Eastern Health
300 Prince Philip Drive
St. John's, NL A1B 3V6

Dear Mr. Parsons:

RE: Leary's Brook Investigation
Draft Report

In 2013, CBCL Limited completed the Rennies River Catchment Stormwater Management Plan (RRCSMP) for the City of St. John's. The outcome of this study was a list of flood protection improvements that could be implemented along the Rennies River system. The Health Sciences Centre (HSC) is located north of a section of Leary's Brook, which is part of the Rennies River system (see Figure 1 in Appendix A). The RRCSMP recommends that two flood protection improvements be implemented in the vicinity of the HSC: a flood control weir at the bottom of Long Pond and berms located along the south and north banks of Leary's Brook just upstream of the Clinch Crescent East Bridge.

Earlier this year, Eastern Health, as the agency responsible for the HSC, engaged CBCL Limited to review potential flooding issues around the HSC in more detail. The analysis completed as part of the RRSCMP forms the basis for this assignment.

The original scope of work for this assignment includes the following:

- Determine the effect that the existing Clinch Crescent East Bridge has on the upstream water level during the 1:100 AEP flood event (as provided in the RRCSMP) The XPSWMM model prepared for the City of St. John's will be used to ascertain the increase in water level.
- If required, recommend upgrades that could be implemented at the bridge to reduce upstream water levels during peak flow events. The XPSWMM model prepared for the City of St. John's will be used to develop recommendations.
- Determine the effect that the 1:100 AEP flood event has on existing sanitary and storm sewers in the vicinity of the section of Leary's Brook that runs adjacent to the Health Sciences Centre.
- If required, recommend upgrades that could be implemented to reduce the effect that flooding has on the existing sewers.
- Investigate the potential effect of flooding on the utility tunnel located downstream from the Clinch Crescent East Bridge.
- If required, recommend upgrades for the tunnel.

In addition to the above items, we have also reviewed the effect that the proposed flood control weir at the bottom of Long Pond would have on water levels in the immediate vicinity of the HSC.

The results of our analysis and recommendations for flood control improvements at the HSC are presented herein.

Hydrologic/Hydraulic Analysis

The modeling software XPSWMM, Version 13 (with Service Pack 1 installed), was used to create a hydrologic model of the study area. The 1:100 AEP flood flows for Leary's Brook were estimated under the calculated design event.

The purpose of the hydraulic analysis is to translate the 1:100 AEP flood flows, estimated during the hydrologic analysis, into floodplain mapping. Hydraulic modeling was carried out using 2D XPSWMM model. 2D modeling has the advantage that it can resolve various surface water paths, with varying velocities, including splitting of flows, circulation and rejoining of various flow branches, which is typical in floodplains of urban areas. Hydraulic structures such as culverts and bridges were modelled as a 1D network nested within the 2D domain representing the floodplain. The domain consisted in a mesh of 5x5 m cells.

Proposed Flood Control Improvements (from the RRCSMP)

The proposed weir at the bottom of Long Pond consists of a rectangular opening in an earth berm that extends across the upstream side of the Allandale Road Bridge. It was designed based on the following criteria:

- A maximum surface water elevation at Long Pond of 55.7 metres.
- A stream width of approximately 30 metres at the location of the weir.

Our analysis indicates that a 4-metre wide weir presents the best performance. It significantly reduces flows downstream of Allandale Road, with upstream surface water elevations less than 55.7 metres.

Options for flood mitigation measures at the HSC include new flood protection berms along the south and north sides of the river section from Clinch Crescent East to Clinch Crescent West.

Clinch Crescent East Bridge Investigation

Clinch Crescent East Bridge has a 23-metre span. The depth from the underside of the bridge deck to the river bottom ranges from 2.5 metres to 3.0 metres. For evaluation purposes, open-bottom box culverts of various spans were added to the hydraulic model at Clinch Crescent East to simulate an increase in the overall hydraulic capacity of the road crossing. Referring to Figure 2A, the estimated water levels upstream (Location 10) and downstream (Location 9) of the bridge for flow generated by a 1:100 AEP design rainfall event are presented in Table 1.

Table 1: Culvert Size Assessment

	Secondary Culvert Size	Upstream Water Level(m)	Downstream Water Level(m)
Existing Condition	No Culvert	56.92	56.75
	3m	56.91	56.75
	6m	56.90	56.75
	10m	56.88	56.74
With proposed flood control weir	No Culvert	56.92	56.75
	3m	56.92	56.75
	6m	56.90	56.75
	10m	56.88	56.75
With weir and berms located on the south and north sides of Leary's Brook	No Culvert	57.08	56.81
	3m	57.07	56.81
	6m	57.06	56.81
	10m	57.00	56.81

With the existing state of the bridge and flows from Long Pond regulated by the proposed weir, the maximum water level at the upstream side would be 56.92 metres. With an additional 10-metre wide culvert, the maximum water level would decrease by 0.04 metres to 56.88 metres. However, regardless of the size of culvert, water levels in the downstream section remained unchanged. The modelling therefore suggests that an extra culvert would not reduce the flood risks significantly.

Table 2: Water Levels along Leary's Brook

Location	Existing Condition (m)	Future Condition with Weir (m)	Future Condition with weir and Berm (m)
Location1	55.03	54.6	54.6
Location2	55.24	54.66	54.66
Location3	55.14	55.64	55.65
Location4	55.17	55.64	55.66
Location5	55.18	55.65	55.66
Location6	55.19	55.65	55.67
Location7	55.19	55.65	55.67
Location8	55.25	55.67	55.69
Location9	56.75	56.75	56.81
Location10	56.92	56.92	57.08
Location11	57.21	57.21	57.44
Location12	57.66	57.66	57.78
Location13	58.05	58.05	58.08
Location14	59.16	59.16	59.24

Water Surface Profiles

Table 2 describes the change in water levels upstream of the weir installation and the other flood control measures. Locations for the water surface profile can be found on Figures 2A and 2B.

From Table 2, it can be observed that with the proposed weir at its outlet, the peak water level in Long Pond would increase by 0.5 metres during the 1:100 AEP storm event, and then gradually diminish further upstream. Water levels remain the same along the river section from Clinch Crescent East to Clinch Crescent West with or without the weir. In the 1:100 AEP design event, berms are able to successfully contain water throughout the river, but the ponding of water behind the berm would cause an increase in water level in Leary's Brook, mainly at Location 10 and upstream (between 0.08 and 0.16 metres), but also downstream, albeit by a very small amount (0.06 metres or less).

Figures 2A and 2B shows the water surface profiles (From Location 1 to Location 14) for the scenarios with the weir proposed at Long Pond. It considers the conditions:

- Existing channel with weir at the pond.
- Existing channel with weir and berms for flood mitigation.
- Existing channel with weir and extra culvert (10 m wide).
- Existing channel with combined flood protection options which included weir, culvert, and berm construction.

From Figures 2A and 2B, it can be observed that additional culverts have very limited impact on the water levels, which infers that the existing Clinch Crescent East Bridge has the same capacity as the existing channel.

Sanitary and Storm Sewer Investigation

Survey data containing finished floor elevations and existing sewer drawings were provided by Eastern Health. The finished floor elevations and sewer locations are shown on Figure 1 (see Appendix A)

Based on the locations of existing sewers, it does not appear that water would back-up into the sewers during an extreme rainfall event and flood parking lots or buildings. The proposed berms will provide adequate flood protection for the existing buildings.

Tunnel Investigation

On May 28, 2015, Greg Sheppard and Jennifer Bursey of CBCL conducted a site investigation at the existing HSC utility tunnel that crosses under Leary's Brook just downstream from the Clinch Crescent East Bridge. The purpose of the investigation was to carry out a visual assessment of the tunnel condition with an emphasis on gathering evidence of water intrusion; a structural assessment was not completed.

The utility tunnel contains the cables that provide electrical power to the Health Sciences Complex and numerous ducts and mechanical piping. Access to the utility tunnel is provided in the Health Sciences Complex at the southwest end of the tunnel and at the Utilities Annex at the north end. Drawings provided by Eastern Health (see Appendix B) show that the low point of the tunnel is located under the brook.

Photos taken during the site visit (see Appendix C) show that water appears to enter the tunnel on a regular basis. There is a sump pump at the low point that removes water when it reaches a set level in the sump. It is our understanding that this pump is designed to remove groundwater that regularly enters the tunnel, and is not designed to handle an extreme rainfall event.

To ascertain whether the tunnel would flood during an extreme rainfall event, we checked locations where water could enter the tunnel from the ground surface against the limits of the 1:100 AEP flood. Figure 1 shows that these locations, including the finished floor of the HSC in the vicinity of the utility tunnel, the existing ventilation hatch, and the finished floor of the Utility Annex are outside of the current flooding limits.

We understand that the tunnel has flooded in the past (see email from Eastern Health contained in Appendix D). The flooding may have been due to storm water runoff entering the ventilation hatch during an extreme rainfall event; however, it is very unlikely that water ever entered the utility tunnel as a result of the river overtopping its banks.

Recommendations

We recommend that Eastern Health construct the earth berm on the north side of Leary's Brook as originally recommended in the RRCSMP. We would welcome an opportunity to further discuss this recommendation at a meeting regarding this draft report.

Please contact Jennifer or Greg to discuss any aspect of the foregoing or to arrange a meeting to discuss our analysis and recommendation.

Yours truly,

CBCL Limited

Prepared by:
Jennifer Bursey, P. Eng.
Civil Engineer
Direct: 709-364-8623, ext. 241
E-Mail: jenniferB@cbcl.ca

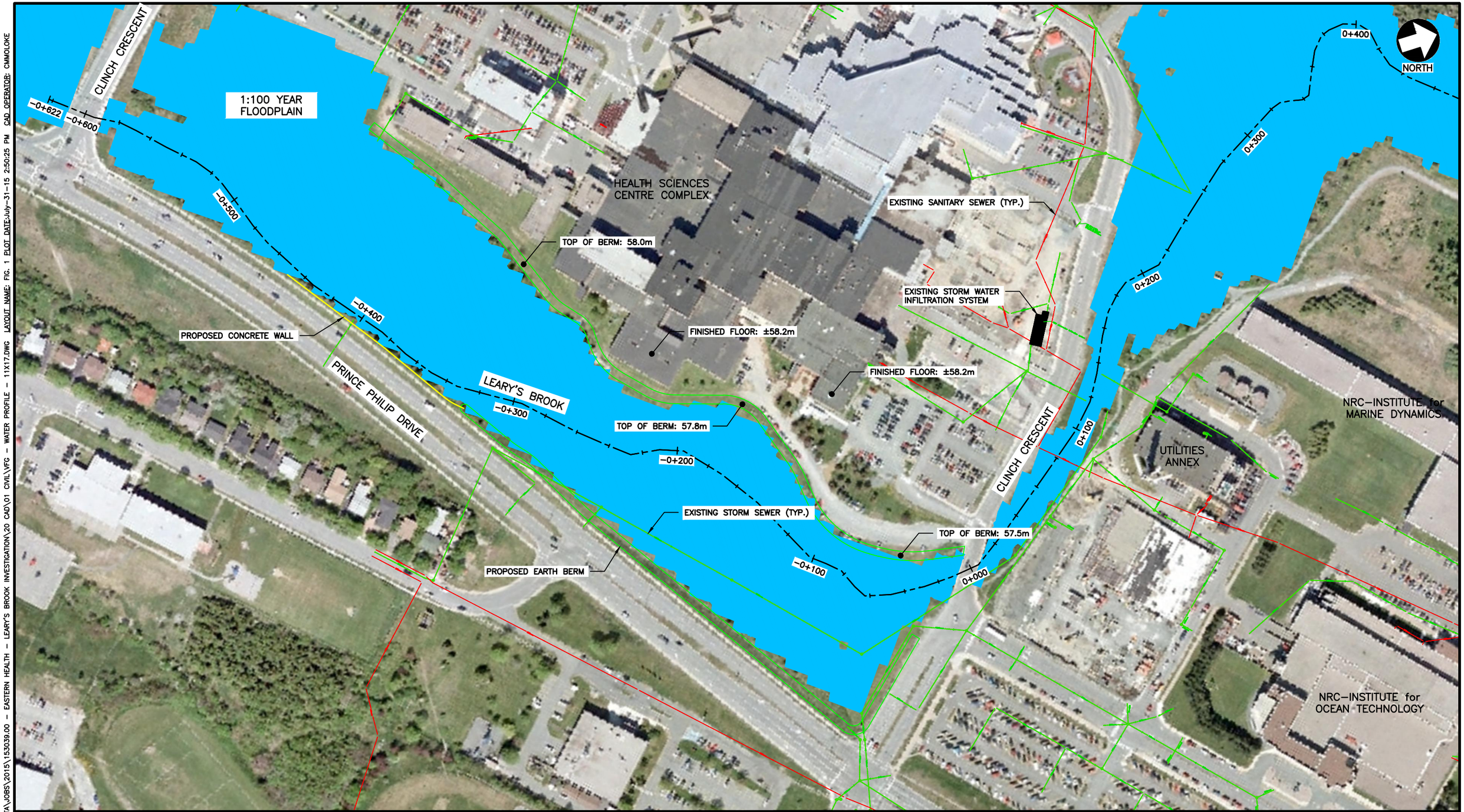
Reviewed by:
Greg Sheppard, P. Eng.
Project Manager

cc. Joe Dunford, M. Eng. P. Eng., Eastern Health, Regional Director – Infrastructure Support

Project No: 153039.00

APPENDIX A

Figures



DRAWING NAME: Y:\ST. JOHN'S\DATA\JOBS\2015\153039.00 – EASTERN HEALTH – LEARY'S BROOK INVESTIGATION\20 CAD\01 CIVIL\VFG – WATER PROFILE – 11X17.DWG LAYOUT NAME: FIG. 1 PLOT DATE:July-31-15 2:50:25 PM CAD OPERATOR: CMMOLOKE

PLAN
1:2000

No.	Description

Date	Scale	Designed	Drawn	Checked	Approved	CBCL No.	Contract
29 JUL 2015	AS NOTED	Y.O.	C.M.	–	G.S.	153039.00	–

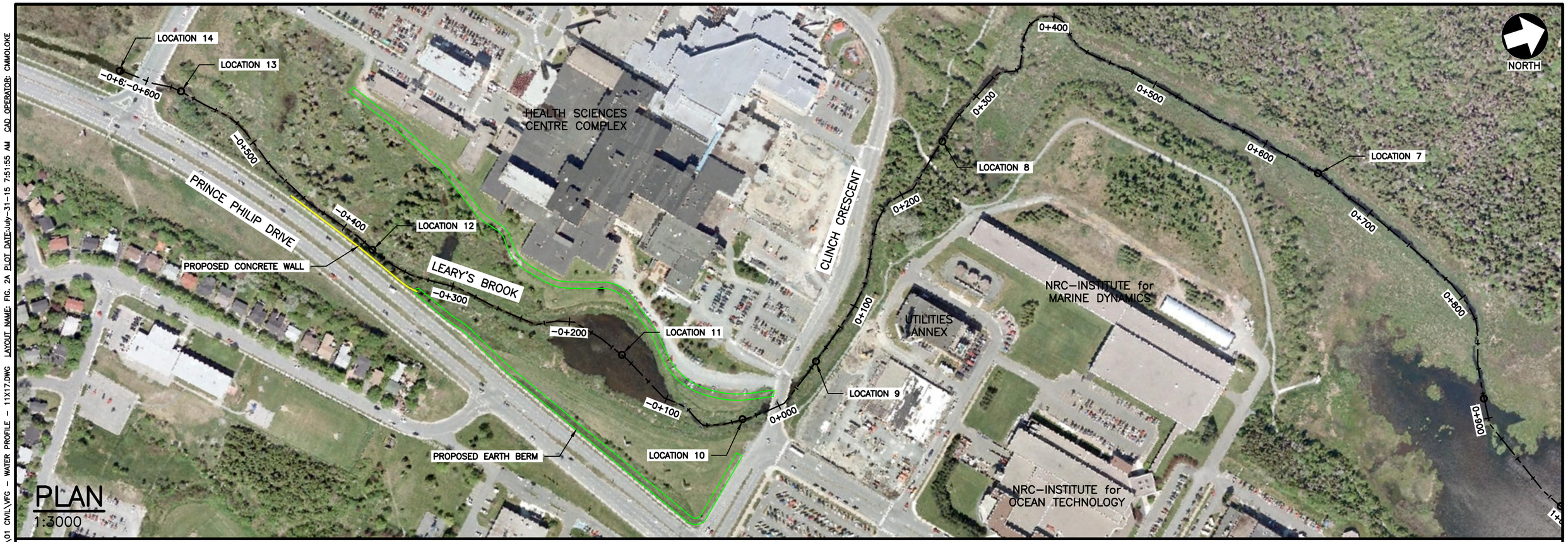
CBCL LIMITED
Consulting Engineers
ISO 9001 CERTIFIED

EASTERN HEALTH

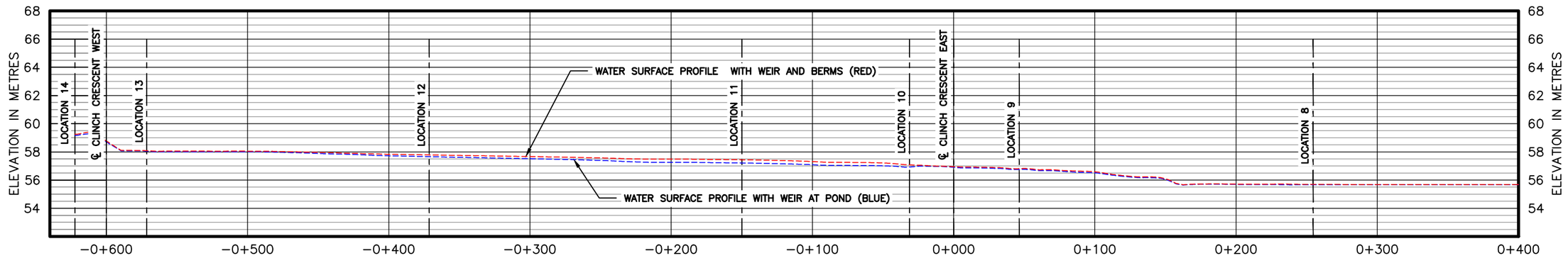
LEARY'S BROOK INVESTIGATION

Drawing

FIG. 1



PLAN
1:3000



PROFILE
1:3000 [H] 1:300 [V]

No.	Description

Date	Scale	Designed	Drawn	Checked	Approved	CBCL No.	Contract
29 JUL 2015	AS NOTED	Y.O.	C.M.	–	G.S.	153039.00	–

CBCL LIMITED
Consulting Engineers
ISO 9001 CERTIFIED

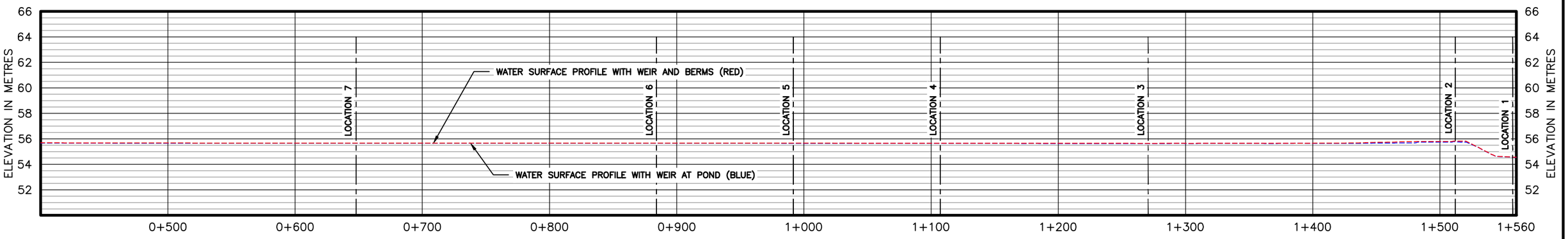
EASTERN HEALTH

LEARY'S BROOK INVESTIGATION

Drawing
FIG. 2A

DRAWING NAME: Y:\ST. JOHN'S\DATA\JOBS\2015\153039.00 – EASTERN HEALTH – LEARY'S BROOK INVESTIGATION\20 CAD\01 CIVIL\FG – WATER PROFILE – 11X17.DWG LAYOUT NAME: FIG. 2A PLOT DATE:July–31–15 7:51:55 AM CAD OPERATOR: CMMOLOKE

PLAN
1:3000



PROFILE
1:3000 [H] 1:300 [V]

No.	Description

Date	Scale	Designed	Drawn	Checked	Approved	CBCL No.	Contract
29 JUL 2015	AS NOTED	Y.O.	C.M.	–	G.S.	153039.00	–

CBCL LIMITED
Consulting Engineers
ISO 9001 CERTIFIED

EASTERN HEALTH

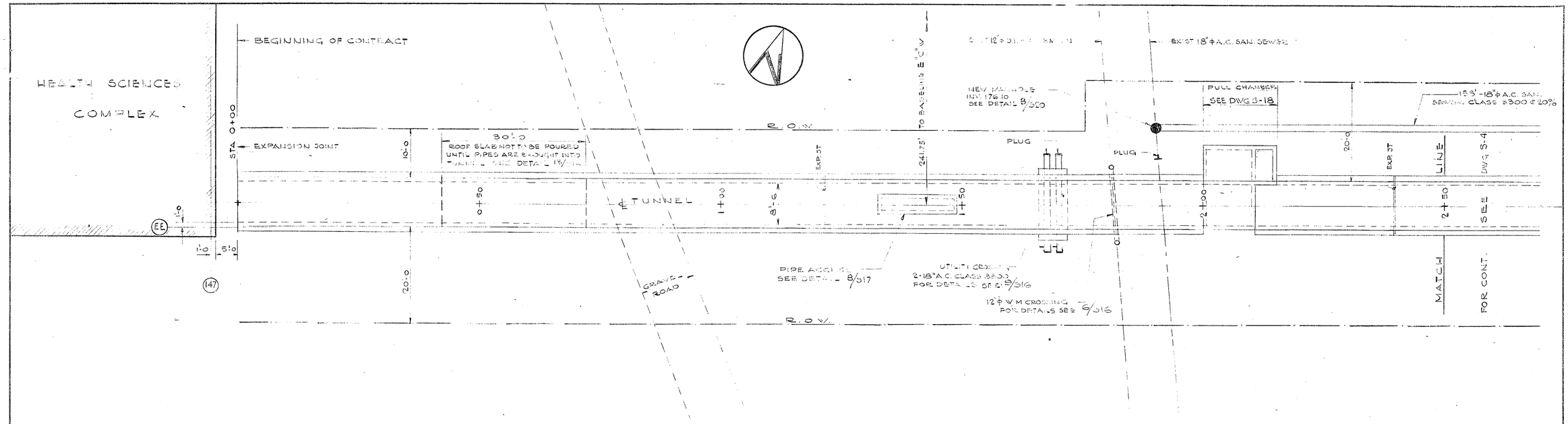
LEARY'S BROOK INVESTIGATION

Drawing
FIG. 2B

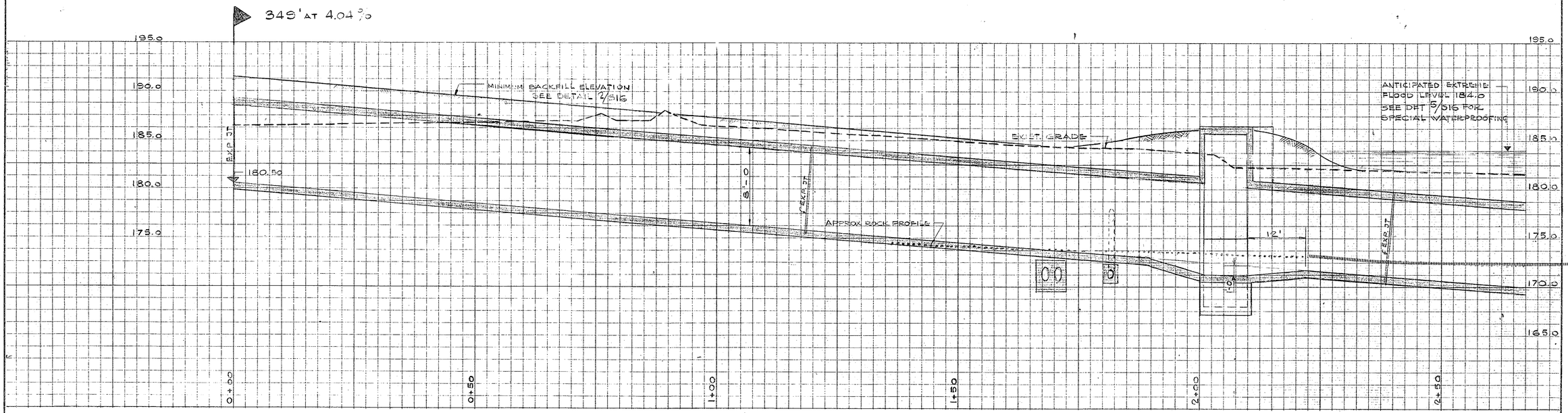
DRAWING NAME: Y:\ST. JOHN'S\DATA\JOBS\2015\153039.00 – EASTERN HEALTH – LEARY'S BROOK INVESTIGATION\20 CAD\01 CIVIL\VFG – WATER PROFILE – 11X17.DWG LAYOUT NAME: FIG. 2B PLOT DATE: July–31–15 7:52:39 AM CAD OPERATOR: CMMOLOKE

APPENDIX B

Utility Tunnel Drawings



FOR TUNNEL SECTIONS & DETAILS SEE DWGS S-15 & S-16



NOTE:
ALL STATIONS & DIMENSIONS SHOWN ARE VERTICAL & HORIZONTAL

No.	DATE	REVISION	BY

R. R. Dewhirst
REGISTERED ENGINEER
PROVINCE OF NEWFOUNDLAND

ASSOCIATION OF PROFESSIONAL ENGINEERS PROVINCE OF NEWFOUNDLAND
A. B. JOHNS
LICENCE TO PRACTICE

SCRIVENER PROJECTS NEWFOUNDLAND LIMITED

MORRISON, HERSHFIELD, BURGESS & HUGGINS, LTD.
CONSULTING ENGINEERS – TORONTO, ONT.

HEALTH SCIENCES COMPLEX & NORTH CAMPUS DEVELOPMENT
ST. JOHN'S NEWFOUNDLAND

UTILITIES TUNNELS
PLAN & PROFILE STA 0+00 to 2+50

SCALE: HOR 1"=10' VERT 1"=5' | DATE: SEPT - 28 - 72

DESIGNED: C.B.L
DRAWN: R.L
PROJ. ENG.: H.W.
APPROVED: R.B.D
DRAWING No.: S-3

1303

FOR CONT. SEE DWG S-3

MATCH LINE

NEW MANHOLE SEE B/S20

INV 175.79

INV 175.74

EXP. JT

241.75' TO BASELINE E.C.W.

BROOK

LEARY'S

R.O.W.

20'-0

10'-0

8'-6"

℄ TUNNEL

2+50

3+00

3+50

4+00

4+50

5+00

5+31

STA

EXP. JT

HEAVY TRUCKING AREA 50'-0 ±

NOTE: SEE SECT 1A/S15 FOR REINF. GRANULAR BACKFILL COMPACTED TO 95% MODIFIED PROCTOR DENSITY IN THIS AREA

30'-0

ROOF SLAB NOT TO BE PLACED UNTIL PIPES ARE BROUGHT INTO TUNNEL. SEE DETAIL 13/S16

EXPANSION JOINT

CROSSING FOR C.I.P. 14GA 2-24" ϕ SEE DETAIL 9/S16

PLUG

5'

1'-4

9"

NOTE: TUNNEL CONT. AT STA 7+16 DWG S-5

UTILITY ANNEX BLDG

(1)

(B)

20'

10'

147' - 18" ϕ A.C. SAN. SEWER

175.44

EXIST. MANHOLE

67' AT 20.27%

67' AT 0.78%

48' LEVEL

MIN. BACKFILL ELEVATION

ANTICIPATED EXTREME FLOOD LEVEL 184.0

SEE DETAIL 5/S16 FOR SPECIAL WATERPROOFING

EXIST. GRADE

NORMAL WATER LEVEL EL 178.8 ±

177.5

175.22

APPROX ROCK PROFILE

166.4

165.6 ±

10'-0

P.I.T.

179.98

180.5

5'-0

195.0

190.0

185.0

180.0

175.0

170.0

165.0

160.0

NOTE:
ALL STATIONS & DIMENSIONS SHOWN ARE VERTICAL & HORIZONTAL

No.	DATE	REVISION	BY

ASSOCIATION OF PROFESSIONAL ENGINEERS PROVINCE OF NEWFOUNDLAND

A. P. JOHNS

LICENCE TO PRACTICE

SCRIVENER PROJECTS NEWFOUNDLAND LIMITED

MORRISON, HERSHFIELD, BURGESS & HUGGINS, LTD.
CONSULTING ENGINEERS - TORONTO, ONT.

HEALTH SCIENCES COMPLEX & NORTH CAMPUS DEVELOPMENT
ST. JOHN'S NEWFOUNDLAND

UTILITIES TUNNELS

PLAN & PROFILE STA 2+50 TO 5+31

SCALE HOR. 1"=10' VERT 1"=5'

DATE: SEPT-28-72

DESIGNED C.B.L.
DRAWN R.L.
PROJ. ENG. H.V.U.
APPROVED: R.B.D.

DRAWING NO.: S-4

180.3

APPENDIX C

Utility Tunnel Photos

Photo 1 – Tunnel floor

Photo 2 – Tunnel ceiling (observed in only one location)

Photo 3 – Hose from sump pump

Photo 4 – Sump pump beneath ventilation hatch

Photo 5 – Ventilation hatch from inside tunnel

Photo 6 – Ventilation hatch from surface