PEACE RIVER REGIONAL DISTRICT

PEACE RIVER LOOKOUT
DRAINAGE PLAN

JULY 26, 2019

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PROJECT NO.: 181-13098-00
DATE: JULY 26, 2019

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July 26, 2019

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Dawson Creek, BC V1G 4H8

Attention: Bryna Casey

Subject: Peace River Lookout Drainage Plan

WSP is pleased to submit the attached design report for the drainage system plan for the Peace River Lookout in Fort St. John. If you have any questions, please contact me.

Kind regards,

Kevin Wiens
Project Manager

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1 BACKGROUND

The PRRD has been considering purchasing land and developing a park at the Peace River lookout. Several studies in recent years have looked at the feasibility and upgrades required. The most recent studies have recommended a comprehensive drainage plan.

This report reviews some of the drainage considerations and propose a conceptual drainage plan.

During the course of this study, WSP met with the PRRD staff, visited the site, reviewed historical LIDAR data, and met with contractors to review construction constraints.

In light of the landslide in the Old Fort area in October 2018 the drainage paths have had to be altered and a new plan proposed. This plan takes this recent slide and potential future slides into consideration.

1.1 SITE LOCATION

The PRRD is considering creating a park at the existing Peace River lookout approximately 3 km south of Fort St. John at the end of 100th Street. The existing lookout area was developed by MOTI with a portion of the area on MOTI right of way and a portion on crown land.

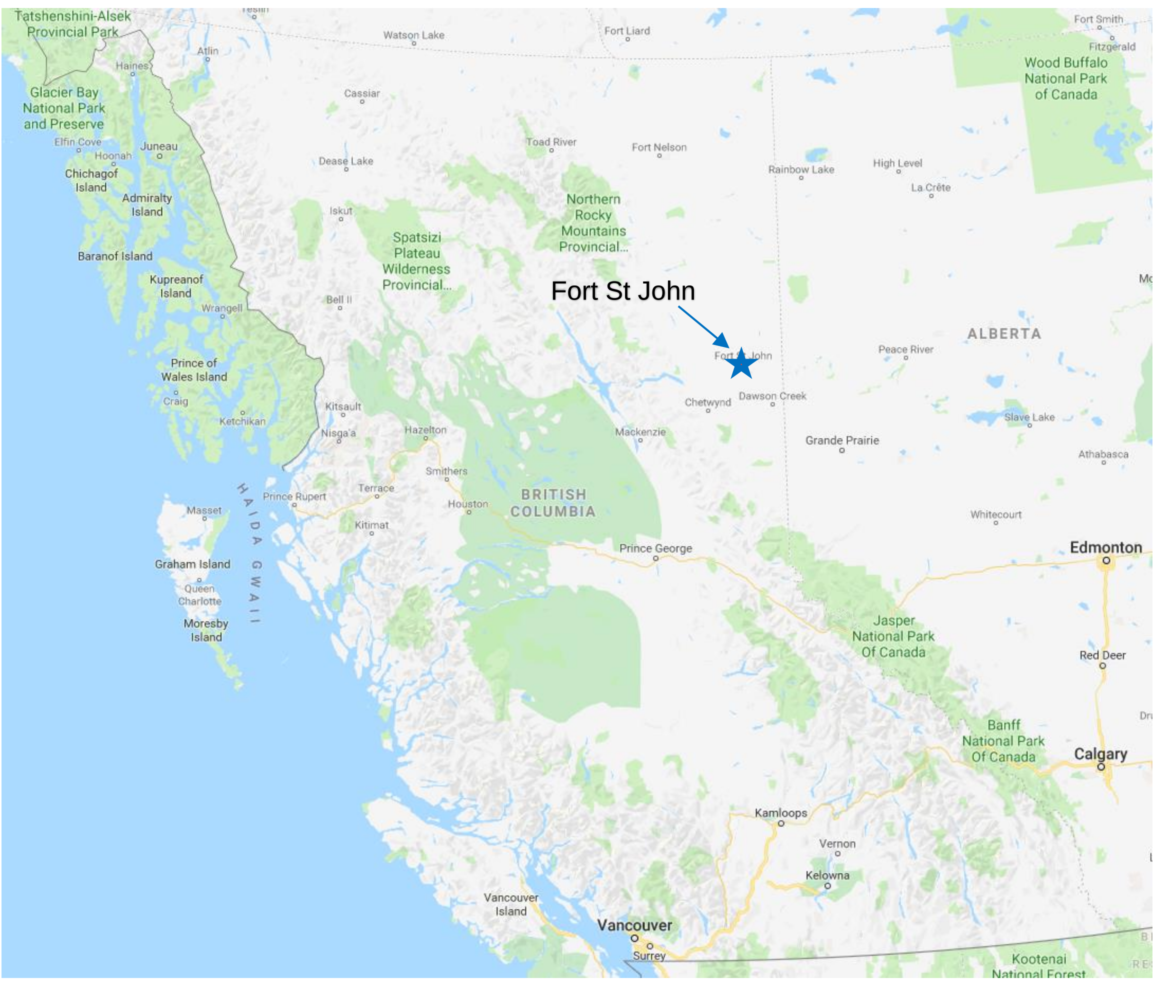

Figure 1. Google Maps imagery displaying the location of Fort St John within British Columbia.

Figure 2. Google Maps imagery showing the Peace River Lookout with reference to Fort St John.

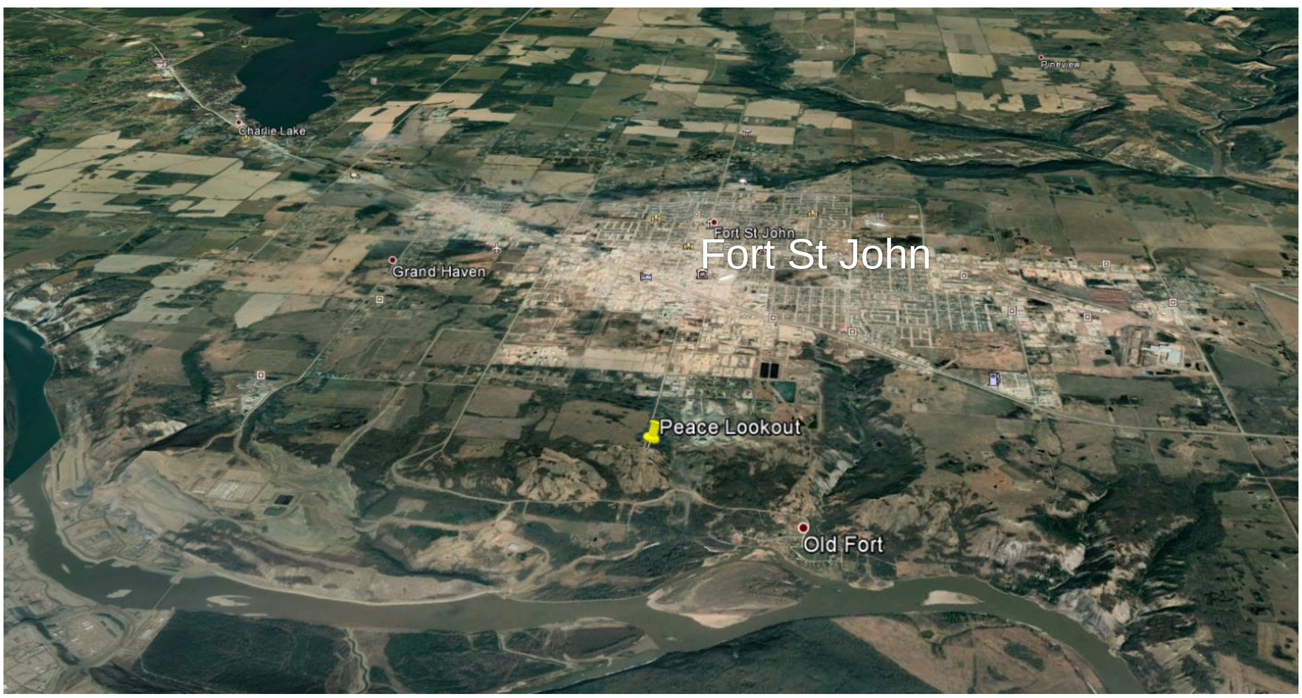

Figure 3. Google Earth imagery that displays the surrounding topography of the Peace River Lookout.

1.2 PAST STUDIES

The PRRD would like to understand costs and the work required to effectively manage the drainage from this lookout area in order to ensure the potential park is safe for public use.

Several studies over the last 10 years have considered the feasibility, geohazards, and potential development costs. The recommendations of these studies are expressed in the following sections.

1.2.1 PEACE VALLEY LOOKOUT PLANNING FEASIBILITY STUDY (MARCH 2010) – CONDUCTED BY: FOCUS

The recommendations of the March 2010 report entitled Peace Valley Lookout Planning Feasibility Study, are copied below.

> *The Peace Valley Lookout presents a unique opportunity to expand upon something that is currently unique and special to the residents in the Fort St. John and surrounding areas. The view of the valley from the Lookout site is meaningful both historically and aesthetically.*
>
> *Given the remoteness of the site, problems have surfaced including vandalism, improper use and safety concerns. Through proper site planning, monitoring and maintenance, these problems can be minimized. Some next steps and recommendations that this report summarizes include:*
>
> 1. *Gather geotechnical data to gauge the stability of the slope with possible on-going monitoring.*
> 2. *Gain knowledge of the environmental history and possible solutions in terms of impact to surrounding water courses and habitat.*
> 3. *Retain an engineer to design the proper handling of drainage and run-off.*
> 4. *Obtain a detailed survey of the site for grading and drainage purposes.*
> 5. *Phase the development of the site to first address public safety.*
> 6. *Seek opportunities for partnerships / sponsors to aid in cost-sharing, monitoring and maintenance.*
> 7. *Partner with the local RCMP in a strategy to monitor the site at night.*
> 8. *Seek locally-made materials, products and services where appropriate during construction.*
> 9. *Set up a maintenance and preservation schedule to ensure vandalism is kept to a minimum and public safety is maintained.*
> 10. *Consult local First Nation communities and local historians for content in interpretive components.*
> 11. *Market the Lookout site in a variety of methods including signage, print and online sources to gain the most exposure.*
> 12. *In the future, consider linking the Lookout site with the historic graveyard below by means of a trail or stair system.*
> 13. *In the future, provide vehicle baffles at the bottom of the bank to prevent vehicular and off-road equipment access.*
> 14. *When the opportunity arises, approach the Ministry of Transportation and Infrastructure to consider upgrading the access road (100th Street) to include asphalt paving and a dedicated pedestrian lane.*

Following this report, the recommendations were all enacted on.

1.2.2 STAGE 1 & LIMITED STAGE 2 PRELIMINARY SITE INVESTIGATIONS: PEACE VALLEY LOOKOUT UPGRADE (MARCH 2011) – CONDUCTED BY: FOCUS

The following excerpt from the March 2011 report entitled Stage 1 & Limited Stage 2 Preliminary Site Investigations: Peace Valley Lookout Upgrade, is a copy of the summarized findings.

> *FOCUS completed a Stage 1 and Limited Stage 2 PSI at the Property that included a review of the current and historical conditions for potential environmental concerns both on the Property and adjacent sites. A total of seven boreholes were drilled to a maximum depth of 3.05 m below surface grade to assess the subsurface soil quality in the close vicinity of the potential dumping areas on the Property. The following conclusions were made based on the findings of this investigation.*
>
> - *The Property has been used for dumping of municipal wastes (garbage, appliances, furniture and etc.) and abandoned vehicles for a number of years. FOCUS considers the potential for environmental impairment to the Property from APEC A – illegal dumping to be moderate;*
> - *One off-site APEC was identified from historical and current activities on the surrounding sites (McRae Metallizing Services). FOCUS considers the potential for environmental impairment to the Property from this APEC, to be low;*
> - *Based upon the existing and future land use, FOCUS considers the CSR AL and PL soil standards are applicable to the Property; and*
> - *Twelve soil samples, including two blind duplicate, were submitted to the laboratory for analysis of BTEXS, VPH, VOCs, EPHs, PAHs, LEPH and HEPH and/or metals concentrations. All concentrations were found to be below the applicable CSR AL and PL standards.*
>
> *Based on the findings of this Stage 1 and Limited Stage 2 PSI, it is FOCUS's opinion that further work is not required at this time.*

Following this report, the recommendations were all enacted on.

1.2.3 PEACE VALLEY LOOKOUT: REMEDIAL OPTIONS REPORT (OCTOBER 2012) – CONDUCTED BY: FOCUS

The October 2012 report, entitled Peace Valley Lookout Remedial Options Report conducted by Focus recommended 6 follow-up actions. Of these 4 have been completed as follows:

a. Clean-up and Disposal of Car Hulks and Appliances

b. Clean-up of Surface Garbage (litter)

c. Installation of Garbage Bins

d. Preventative Plan

The following recommendation is resulting in this study.

> ***e. Drainage Study to Prevent Further Surface Erosion***
> *The major geotechnical concern for this site is drainage and surface erosion. It is our recommendation that the PRRD completes a surface erosion and drainage study and report. From this a storm water management plan should be implemented so that runoff does not continue to flow over the banks causing erosion and further slumping. An estimate of the cost to complete a storm water drainage study and management plan can be found in Table 5.1.*

This report will complete this recommendation.

The following recommendation is for ongoing geotechnical monitoring at this site.

f. Geotechnical Recommendations:
Due to the potential for slide movement to occur, is it is recommended that annual monitoring of slope movement be implemented. As per Northern Geo's report, it is recommended that staff from PRRD monitor the slope (take photographs) monthly for visual changes. If changes are noted, it is recommended to seek Geotechnical advice. This task could be incorporated into the monthly maintenance plan.

To ensure public safety, it is recommended that the current fence be maintained, and signs be installed warning the public of the potential for slides to occur. If additional shallow slides occur, a setback of the fence should be provided to maintain the stability of the fence.

1.2.4 SURVEY DATA

The Peace River Lookout stormwater drainage design is based on LiDAR data from December 4th, 2018. At this time, data was assembled into a contour map and aerial photography image by the WSP Fort St John office.

Existing drainage paths are shown on this image and the proposed drainage paths were identified using this data. Through utilizing the contour map, overland flow and catchment areas were determined.

2 EXISTING CONDITION

2.1 SITE CONDITION

Figures 4 to 12 display the Peace River Lookout site condition as of spring/summer 2018. These site visit photos provide a visual of the drainage paths, erosion prevention measures, and the erosion that has occurred.

Figure 4 provides a guide to the photo capture locations throughout the report.

Figure 5 shows the 3 drainage paths flowing from the Peace River Lookout to Old Fort Road in the valley. The west (left), middle, and north drainage paths are represented with thin white lines.

Figure 4. Google maps imagery showing locations of photos captured at Peace River Lookout (April 2019)

Figure 5. Google Earth imagery of the sites outflow drainage paths pre-landslide.

Figure 6. Google Earth aerial perspective view of the Peace River Lookout (April 2019).

Figure 7. West drainage path as of June 2018.

Figure 8. East drainage path as of June 2018.

Figure 9. Existing north collection ditch conveying drainage at the top of the lookout as of April 2018.

Figure 10. Existing west collection ditch conveying drainage at the top of the lookout as of April 2018.

Figure 11. Erosion from the top of the east drainage as of April 2018.

Figure 12. Erosion from the top of the west drainage as of April 2018.

2.2 OCTOBER 2018 LANDSLIDE

Over the course of several days a slow-moving landslide made its way down a hill adjacent to the Peace River Lookout. This slide eventually crossed Old Fort Road and cut of the community of Old Fort as this route provided the only method of travelling to and from the community. An evacuation of Old Fort commenced in October of 2018 as a result. Figures 13 to 16 show photos of the development of the creeping landslide making its way down the slope towards Peace River.

Figure 13. Landslide movement prior to the slide crossing Old Fort Road, as seen from Peace River Lookout (October 2018).

This slide was immediately adjacent to the Peace River Lookout and the area considered for development. There was no structural damage to the lookout area, but the down stream drainage courses were altered. We are unsure what effect continued runoff through the slide.

Figure 14. Landslide movement across Old Fort Road, as seen from Peace River Lookout (October 2018).

Figure 15. Zoomed image of landslide movement across Old Fort Road (October 2018).

Figure 16. Photo showing the extent of the landslide blocking Old Fort Road (October 2018).

3 DRAINAGE PLAN

3.1 SITE PLAN

Figures 17 and 18 provide a visual of the site drainage plan as it pertains to Peace River Lookout. There are three catchment areas, where the north and west catchments drain to the north and west detention ditches adjacent to Peace River Lookout. The lookout catchment drains out of the park site as overland flow retained during a storm event.

Figure 17 shows the catchment areas and Figure 18 indicates the location of the detention ditches and the drainage at the top of the slope. Yellow arrows represent overland flow within the catchment areas, while red arrows show culvert piping connecting the detention ditches. In Figure 18, green arrows represent existing drainage paths that convey stormwater off-site, while blue arrows show proposed new drainage paths.

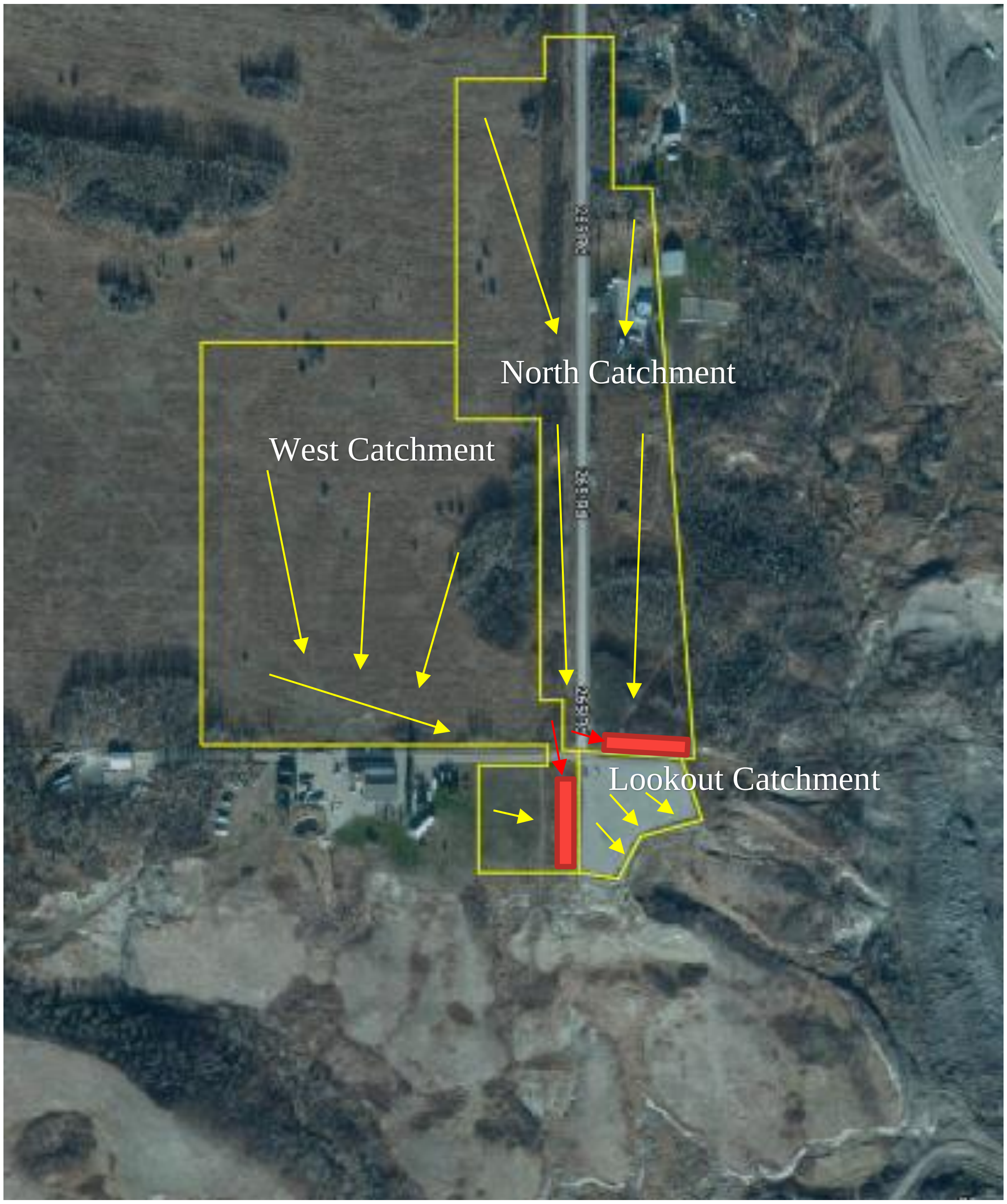

Figure 17. Stormwater drainage site plan for Peace River Lookout, showing the 3 catchment areas.

Figure 18. Stormwater drainage site plan for Peace River Lookout, showing proposed drainage paths and detention ditches.

3.2 DESIGN GUIDELINES

The design complies with the Master Municipal Design Guidelines – 2014. Where this guide is silent, the City of Fort St. John Subdivision Servicing Bylaw was used.

3.3 EXISTING DRAINAGE

The area that drains towards the Peace River Lookout property is 16.2 hectares and slopes to the south along 265 Road and the properties on either side. At the north and west sides of the proposed park exists a collection ditch used to drain the surface flow from the property to the drainage paths down the eroding slope.

The land slopes at approximately 1.0% from the north end of the north and west catchments to the south side of the Peace River Lookout. From the top of the lookout to the bottom of the slope and Old Fort Road, the land slopes at approximately 9.0%.

The north catchment area drains overland flow to the north collection ditch. This stormwater is then conveyed through the north outfall, down the gully, and towards Old Fort Road. The stormwater that falls within the lookout catchment drains to the south and into the center outfall where it flows towards Old Fort Road. Similarly to the north catchment, the west catchment area drains overland flow to the west collection ditch. This stormwater is then conveyed through the west outfall, down the gully, and towards Old Fort Road.

3.4 PROPOSED DRAINAGE

The proposed storm water management plan will involve expanding the existing north and west collection ditches into detention ditches to provide detained stormwater volume. These new detention ditches will drain stormwater at a reduced rate to prevent erosion.

Overland stormwater flow draining from the property will follow one of three drainage paths down the slope towards Old Fort Road.

The C factor used in the rational method won't change when calculating the minor vs major stormwater runoff due to no development on-site from the existing to proposed condition.

3.4.1 UPSTREAM CATCHMENT AREAS

There are 3 catchment drainage areas on the property as seen in the Figure 16. The north catchment has an area of 7.2 ha and slopes down at about 3.7% from north to south. The west catchment has an area of 9.0 ha and slopes down at about 3.0% from north to south. The lookout catchment has an area of 0.7 ha and slopes down at about 0.3% from the lookout entrance towards the Peace River valley.

3.4.2 MAJOR STORM RUNOFF

Major Storm Runoff is the 1 in 100-year event as per G-2.01 from the City of Fort St. John Subdivision Servicing Bylaw. Any runoff volumes in excess of that created by the 24-hour 2-year return period will be conveyed safely from the Peace River Lookout property by way of a drainage channel or an overland flow route to one of the two detention ponds. The detention ponds will convey the water along the length of the ditch, draining into one of three drainage paths down the slope towards Peace River to the south.

For drainage areas 10 ha and smaller, the Rational formula can be used, as per G-2.01 from the City of Fort St. John Subdivision Servicing Bylaw.

Runoff from the north catchment for a 100-year storm at post development is estimated at

Q = C x Area x Intensity / 360, where

C = 0.15 (For undeveloped land, as per Table G.1 from the City of Fort St. John Subdivision Servicing Bylaw)

A = 7.2 ha

I = 49.7 mm/hr (26.7-minute T_c, 10-minute minimum, as per G-2.01 from the City of Fort St. John Subdivision Servicing Bylaw)

Q(100 Post) = 0.149 m^3/s (at post development)

Runoff from the west catchment for a 100-year storm at post development is estimated at

Q = C x Area x Intensity / 360, where

C = 0.15 (For undeveloped land, as per Table G.1 from the City of Fort St. John Subdivision Servicing Bylaw)

A = 9.0 ha

I = 54.4 mm/hr (23.5-minute T_c, 10-minute minimum, as per G-2.01 from the City of Fort St. John Subdivision Servicing Bylaw)

Q(100 Post) = 0.204 m^3/s (at post development)

Runoff from the lookout catchment for a 100-year storm at post development is estimated at

Q = C x Area x Intensity / 360, where

C = 0.15 (For undeveloped land, as per Table G.1 from the City of Fort St. John Subdivision Servicing Bylaw)

A = 0.7 ha

I = 82.2 mm/hr (13.1-minute T_c, 10-minute minimum, as per G-2.01 from the City of Fort St. John Subdivision Servicing Bylaw)

Q(100 Post) = 0.024 m^3/s (at post development)

3.4.3 MINOR STORM RUNOFF

Minor Storm Runoff is defined as the 2-year return flow for low density residential areas as per G-2.01 from the City of Fort St. John Subdivision Servicing Bylaw.

Utilizing the Rational method, runoff from the north catchment for a 2-year storm at predevelopment is estimated at:

Q = C x Area x Intensity / 360, where

C = 0.15 (As per Table G.1 from the City of Fort St. John Subdivision Servicing Bylaw)

A = 7.2 ha

I = 19.7 mm/hr (26.7-minute T_c, 10-minute minimum as per G-2.01 from the City of Fort St. John Subdivision Servicing Bylaw)

Q (2 Pre) = 0.059 m^3/s (at predevelopment)

Utilizing the Rational method, runoff from the west catchment for a 2-year storm at predevelopment is estimated at:

Q = C x Area x Intensity / 360, where

C = 0.15 (As per Table G.1 from the City of Fort St. John Subdivision Servicing Bylaw)

A = 9.0 ha

I = 21.4 mm/hr (23.5-minute T_c, 10-minute minimum as per G-2.01 from the City of Fort St. John Subdivision Servicing Bylaw)

Q (2 Pre) = 0.080 m^3/s (at predevelopment)

Utilizing the Rational method, runoff from the lookout catchment for a 2-year storm at predevelopment is estimated at:

Q = C x Area x Intensity / 360, where

C = 0.15 (As per Table G.1 from the City of Fort St. John Subdivision Servicing Bylaw)

A = 0.7 ha

I = 31.2 mm/hr (13.1-minute T_c, 10-minute minimum as per G-2.01 from the City of Fort St. John Subdivision Servicing Bylaw)

Q (2 Pre) = 0.009 m^3/s (at predevelopment)

3.4.4 STORMWATER DETENTION

Site grading will ensure the property drains towards the detention ditches.

The north detention ditch will drain out of the east end at the allowable 2-year predevelopment release rate of 0.059 m^3/s. This flow rate corresponds to 1.20 m/s in a 250 mm diameter pipe, which is within the design guidelines as per G-2.02 from the City of Fort St. John Subdivision Servicing Bylaw. Similarly, the west detention ditch will flow out of its south end at the allowable release rate of 0.080 m^3/s. This flow rate corresponds to 1.63 m/s in a 250 mm diameter pipe, which is within the design guidelines as per G-2.02 from the City of Fort St. John Subdivision Servicing Bylaw.

Storage requirement for stormwater detention in the north detention ditch is estimated as

Storage = 100 yr Post – 2 yr Pre

= (100 yr Runoff at 60 min x Storm Duration) – [(2 yr Runoff at 60 min x Storm Duration) / 2]

= (0.084 m^3/s x 3600 s) – [(0.059 m^3/s x 3600 s) / 2]

Storage = 196 m^3 (max storage occurs at 50-minute storm duration, use 60-minute storage requirement as per G-2.01 of City of Fort St. John Subdivision Servicing Bylaw)

Storage requirement for stormwater detention in the west detention ditch is estimated as

Storage = 100 yr Post – 2 yr Pre

= (100 yr Runoff at 60 min x Storm Duration) – [(2 yr Runoff at 60 min x Storm Duration) / 2]

= (0.105 m^3/s x 3600 s) – [(0.080 m^3/s x 3600 s) / 2]

Storage = 234 m^3 (max storage occurs at 40-minute storm duration, use 60-minute storage requirement as per G-2.01 of City of Fort St. John Subdivision Servicing Bylaw)

Due to the relatively small surface area of the lookout catchment, storm water detention of runoff from this area isn't required.

Therefore, the total detention volume required from the north and west catchment areas is 196 m^3 and 234 m^3 respectively. The detention ditches must detain 186 m^3 and 224m^3 while the channels in the drainage system hold an additional 10 m^3 per detention ditch. This provides a minimum of 430 m^3 of total detention storage to the drainage system.

The design drawing generates a storage volume of 262.5 m^3 to both the north and west detention ditches. This produces an actual storage volume much larger than the calculated design storage volume.

Therefore, the storage capacity of the stormwater system meets requirements.

An option to combine the detention ponds would require the pond to hold 430m^3 of runoff.

Table 1. North catchment storage calculations.

Rational Method Post-Development				
Development	Area	Runoff Coefficient	Intensity	*Peak Runoff*
	(ha)		(mm/hr)	(m3/s)
Post 100 yr	7.200	0.15	49.673	0.149
Pre 2 yr	7.200	0.15	19.651	0.059
Storage Required				
Storm Duration (min)	Storm Duration (sec)	Intensity (mm/hr)	Peak Runoff (m³/s)	Storage Requirement (m³)
2	120	311.1	0.933	108.474
5	300	162.6	0.488	137.530
10	600	99.6	0.299	161.524
15	900	74.7	0.224	175.206
20	1200	60.9	0.183	184.042
25	1500	52.0	0.156	189.972
30	1800	45.7	0.137	193.934
40	2400	37.3	0.112	197.893
50	3000	31.9	0.096	198.294
60	3600	28.0	0.084	196.287

Table 2. West catchment storage calculations.

Rational Method Post-Development				
Development	Area	Runoff Coefficient	Intensity	*Peak Runoff*
	(ha)		(mm/hr)	(m3/s)
Post 100 yr	9.000	0.15	54.372	0.204
Pre 2 yr	9.000	0.15	21.354	0.080
Storage Required				
Storm Duration (min)	Storm Duration (sec)	Intensity (mm/hr)	Peak Runoff (m³/s)	Storage Requirement (m³)
2	120	311.1	1.167	135.210
5	300	162.6	0.610	170.955
10	600	99.6	0.373	199.989
15	900	74.7	0.280	216.134
20	1200	60.9	0.229	226.221
25	1500	52.0	0.195	232.675
30	1800	45.7	0.172	236.671
40	2400	37.3	0.140	239.703
50	3000	31.9	0.119	238.289
60	3600	28.0	0.105	233.864

Table 3. Lookout catchment storage calculations.

Rational Method Post-Development				
Development	Area	Runoff Coefficient	Intensity	*Peak Runoff*
	(ha)		(mm/hr)	(m3/s)
Post 100 yr	0.700	0.15	82.236	0.024
Pre 2 yr	0.700	0.15	31.239	0.009

Storage Required				
Storm Duration (min)	Storm Duration (sec)	Intensity (mm/hr)	Peak Runoff (m^3/s)	Storage Requirement (m^3)
2	120	311.1	0.091	10.343
5	300	162.6	0.047	12.864
10	600	99.6	0.029	14.690
15	900	74.7	0.022	15.513
20	1200	60.9	0.018	15.865
25	1500	52.0	0.015	15.935
30	1800	45.7	0.013	15.813
40	2400	37.3	0.011	15.184
50	3000	31.9	0.009	14.209
60	3600	28.0	0.008	13.000

3.4.5 DETENTION DITCH OUTLET CONTROL

The Detention Ditch Outlet Control conforms with section G-2.19 of the City of Fort St. John Subdivision Servicing Bylaw. The drainage flow from the outlet of the north and west detention ditches must achieve the allowable predevelopment release rate of 0.059 m^3/s and 0.080 m^3/s respectively. Using these values, the diameter of pipe required can be determined.

North DIA = $4 \times (Q \times \text{Manning's \#} / (4 \times \pi \times \text{Slope}^{0.5}))^{3/8}$, where

$Q = 0.059\ m^3/s$

Manning's # = 0.013 (PVC, dirty water)

Slope = 0.02 m/m

North DIA = 0.219 m

The required diameter of the north detention outlet control is 219 mm. Therefore, the pipe size necessary is 250Ø pipe at 2% slope.

West DIA = $4 \times (Q \times \text{Manning's \#} / (4 \times \pi \times \text{Slope}^{0.5}))^{3/8}$, where

$Q = 0.080\ m^3/s$

Manning's # = 0.013 (PVC, dirty water)

Slope = 0.02 m/m

West DIA = 0.245 m

The required diameter of the west detention outlet control is 245 mm. Therefore, the pipe size necessary is 250Ø pipe at 2% slope.

3.4.6 DETENTION DITCH DESIGN

The design of the two stormwater detention ditches meets the requirements of the MMCD Design Guidelines and the City of Fort St. John Subdivision Servicing Bylaw. Theses requirements are as follows:

- Effective length 3 times larger than the width (5:1 preferred)
- Volumetric sizing using 1:100 year post-development design storm event
- Peak discharge rate using the 2 year return period pre-development flow rate for 1 hour duration event
- Emergency spillway designed for 100 year return period post-development design storm event plus freeboard
- Minimum 24 hour active storage detention
- Maximum pond depth of 1.5 m plus 0.6 m freeboard
- Side slopes not steeper than 4:1 on internal slopes and 3:1 on for exterior slopes (vegetated surfaces)
- Minimum 50 mm diameter orifice outlet (100 mm preferred)
- 3.0 m wide berms of ditch for vehicle access
- 8.0 m turning radius on berms
- Riprap and grating at outlet/inlet of ditch

Figure 19 shows the AutoCAD detention ditch design while Table 4 displays the calculated specifications of both the north and west detention ditches.

Table 4. Detention Ditch Parameters

	North Detention Ditch	West Detention Ditch	Lookout Runoff
Catchment Area	North Catchment - 7.2 ha	West Catchment- 9.0 ha	Lookout Catchment - 0.7 ha
Catchment Infrastructure	Field/Road with West and East Ditches	Field/Driveway to the West	Existing Lookout Parking Lot
Q_{100} Post	0.149 m^3/s	0.204 m^3/s	0.024 m^3/s
Q_2 Pre	0.059 m^3/s	0.080 m^3/s	0.09 m^3/s
Minimum Outlet Diameter	219 mm	245mm	NA
Outlet Diameter Used	250 mm	250 mm	NA
Minimum Storage Required	196 m^3	234 m^3	13 m^3
Design Storage Attained	262.5 m^3	262.5 m^3	NA

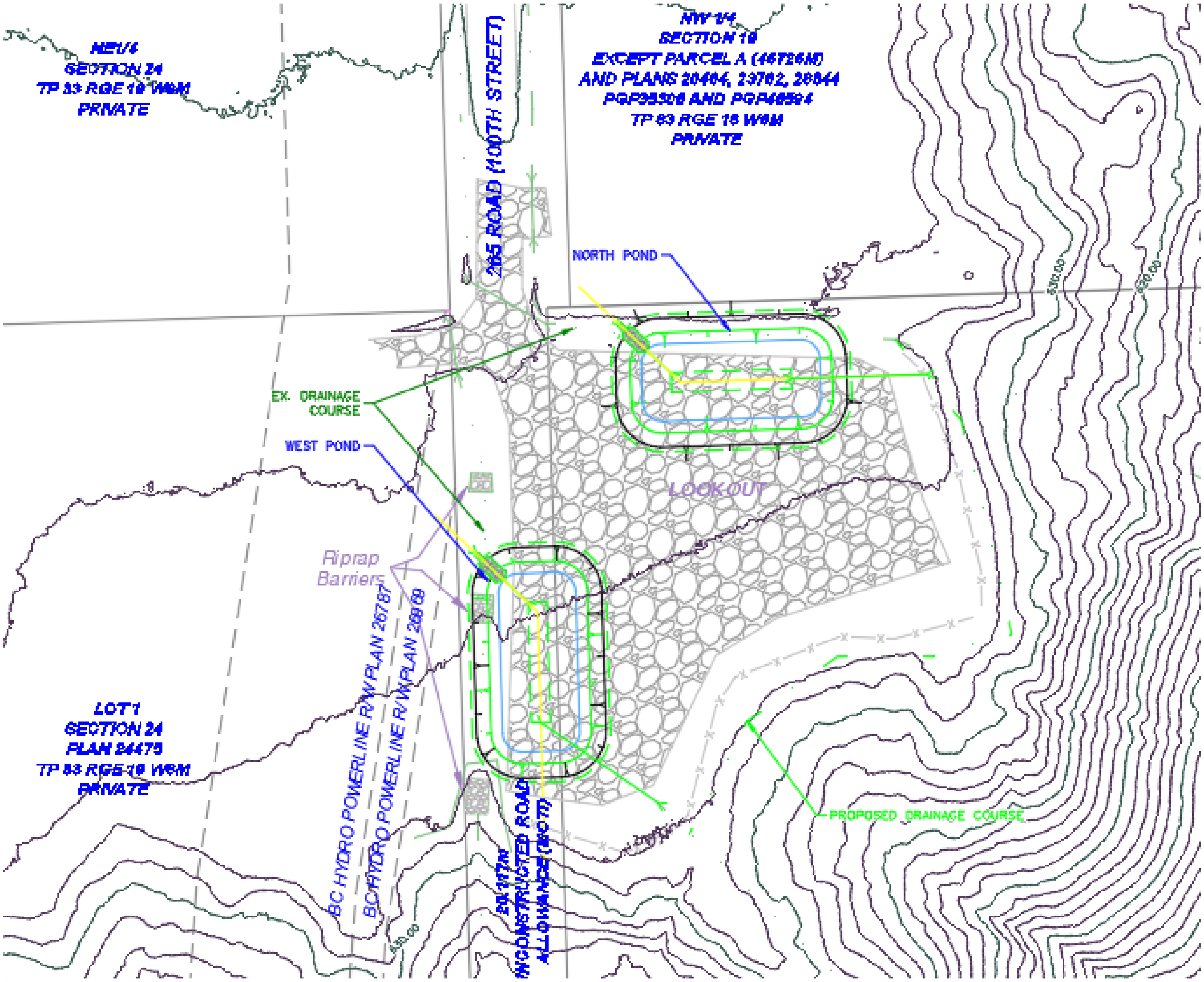

Figure 19. Plan view of the North and West detention ditch design.

3.5 DOWNSTREAM UPGRADES

It is recommended to pursue one of the three downstream drainage path options. Further evaluation of the downstream upgrades is provided in section 4 – options analysis.

3.5.1 DRAINAGE PATH OPTIONS

1. Riprap / Armouring

Pros:	Prevents erosion, Decreases water velocity, Benefits to water quality
Cons:	Expensive, Difficult to maintain, Difficult to access

 

Figure 20. Examples of a riprap drainage path.

2. Piping
   - Corrugated Steel Flume Pipe
   - 800mm diameter for 100-year flow
   - Semi-circle cross section (open top)

Pros:	Prevents erosion, Easy to maintain
Cons:	Visually displeasing

Figure 21. Example of a flume pipe drainage path.

3. No upgrades
   - No construction of the drainage paths down the slope

Pros:	No erosion during construction, Save money
Cons:	May erode, Could result in poor drainage and regular maintenance, Unsightly for park users

*Downstream upgrades 1 and 2 are assuming that stormwater from the north detention ditch flows around the lookout, collecting the lookout catchment overland flow, and joins with the west detention ditch outflow. This stormwater is then conveyed down the slope through the west drainage path.

3.5.2 DRIANAGE PATH SIZING

The proposed drainage path must have the capacity to convey the runoff from a 100 year storm event. This value can be determined through the addition of the Q_{100} post development values found in Table 4. Therefore, the drainage path downstream from the detention ditches must be able to transmit 0.38 m^3/s.

The purposed drainage paths parameters for riprap /armouring and flume piping is calculated as follows:

1. Riprap / Armouring

   Known characteristics of the riprap drainage path include the use of 0.3m diameter drain rock and a maximum depth of 0.5m. The required dimensions of the trapezoidal riprap drainage channel to achieve a flow rate of 0.38 m^3/s is as follows:

   - Bottom width 0.5m
   - Side slopes 2:1 (H:V)
   - Riprap diameter 0.3m

   *Riprap diameter has no effect on manning's formula calculation.

   The following calculation determines the extent of the maximum and minimum water depths throughout the drainage path. This calculation will ensure optimization of the drainage path cross-section so that flooding doesn't occur and the minimum quantity of riprap is used. The equation used for this calculation is the Manning's formula.

   Trapezoidal Drainage Channel – Minimum Capacity:

   Q = Area x ($Rh^{2/3}$) x ($Slope^{0.5}$) / Manning's #, where

   Area = 0.10 m^2

   Rh = 0.09

   Slope = 0.60 m/m

   Manning's # = 0.04

   Q = 0.38 m^3/s *Equivalent velocity = 3.90 m/s

   Water Depth = 0.13m

   Trapezoidal Drainage Channel – Maximum Capacity:

   Q = Area x ($Rh^{2/3}$) x ($Slope^{0.5}$) / Manning's #, where

   Area = 0.24 m^2

   Rh = 0.15

   Slope = 0.05 m/m

   Manning's # = 0.04

   Q = 0.38 m^3/s *Equivalent velocity = 1.59 m/s

   Water Depth = 0.24m

   The water depth throughout the riprap drainage path will vary from 0.13-0.24m while achieving a flow rate of 0.38 m^3/s. A cross-sectional view of the trapezoidal riprap drainage path is shown in Figure 22.

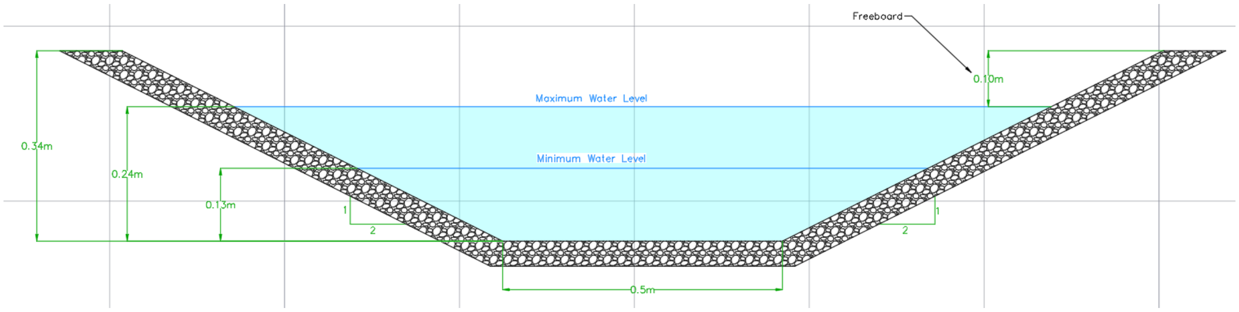

Figure 22. Trapezoidal riprap drainage path design.

2. Piping

   The Manning's formula was used to determine the diameter of the flume piping required for the drainage path while achieving a flow rate of 0.38 m^3/s. To perform this calculation for a semicircular cross-sectional pipe, the flow rate of 0.38 m^3/s must be converted to the equivalent flow rate for a circular cross-sectional pipe filled to capacity.

   Given piping with a semi-circular cross-section at 80% capacity can covey water at 0.38 m^3/s, a pipe with the same dimensions but a circular cross-section at full capacity can covey water at the following corresponding flow rate:

   Q = 1.52 m^3/s

   A slope of 5% is used in the Manning's formula calculation. This is because the point throughout the drainage path that would require the largest pipe size to transport 0.38 m^3/s is the point with the smallest slope.

   Circular Cross-Sectional Drainage Pipe (full capacity):

   Dia = 4 x [Q x Manning's # / (4 x π x Slope$^{1/2}$)]$^{3/8}$, where

   Q = 1.52 m^3/s

   Slope = 0.05 m/m (minimum slope)

   Manning's # = 0.026 (for metal corrugated flume pipe)

   Diameter = 0.808m ≈ 800mm

It is recommended that a metal corrugated flume pipe with a diameter of 800mm is used to obtain a minimum flow rate of 0.38 m^3/s throughout the drainage path.

4 OPTIONS ANALYSIS

4.1 CONSTRUCTABILITY

As a measure to control downstream impacts when releasing stormwater from the detention ditches, drainage path options were presented. A large factor in determining the feasibility of these drainage paths is the constructability of each option. The following subsections examine the constructability of the riprap and flume pipe downstream solutions.

4.1.1 RIPRAP / AMOURING

Although riprap drainage is the most common and effective approach to erosion prevention, there are some important construction methods required to move past this site's limitations. Such limitations and required actions include the following:

- Riprap isn't cheaply available in Northeastern BC
- Expensive to acquire and construct
- Installation would prove very difficult without damaging the slope and causing erosion
- Galvanized wire mesh or chain link fencing might be needed to hold riprap in place on steep sections
- Well graded, angular riprap might be required to increase the ability of the material to interlock and resist movement and adapt to uneven surfaces
- If using ungraded riprap, maintenance would be required more often due to increased displacement of rock material
- Ungraded riprap also requires careful placement to achieve proper thickness and a uniform pattern to prevent displacement of rock
- Requires stripping and grubbing of subgrade to remove vegetation or debris
- Excavate the drainage path deep enough for geotextile fabric and riprap

4.1.2 FLUME PIPING

Using metal corrugated flume pipe as a method for conveying storm water down the slope may seem like a straight forward approach, but certain limitations exist. These limitations and methods to avoid these limitations include but aren't restricted to the following:

- Difficult to construct and assemble 800mm diameter flume pipe on steep slopes
- Significant safety concern in constructing large flume pipe on unstable surface
- Difficult to adjust and bend the large pipe to match topography
- Could require heavy equipment to transport the flume pipe on the steep slopes

4.2 MAINTENANCE & MONITORING

Upstream maintenance and monitoring should occur regularly to preserve the functioning of the system and detention ditches. This maintenance and monitoring includes the following:

- Culvert blockages can often cause flooding problems and can usually be traced back to two sources:
    - erosion and deposition of bedload material
    - transport of floatable debris such as branches, brush, garbage, etc

- Deposition of bedload material also results in the progressive reduction of drainage channel capacity, which increases flooding risk and can create an ongoing channel maintenance problem
- Sediment and debris must be regularly removed from debris catchers, inlets and outlets
- Plan for fluids leaking from vehicles
- Re-vegetate disturbed and bare areas to maintain vegetative stabilization
- Monitor the detention pond as to check for signs of flooding along banks and look for evidence of seepage along the berms
- Ensure the safety measures of the detention pond are in good condition

4.2.1 RIPRAP / ARMOURING

Monitoring of a riprap drainage path should occur periodically and after major storm events to evaluate their performance and upgrade where required. Necessary maintenance that must occur to sustain this drainage option includes the following:

- Slumps or displacement of riprap rock should be restored or replaced as they are observed.
- If damage has occurred to geotextile fabric, it should be replaced immediately
- For large slumps of rock in a particular section of the drainage path, assessment of the cause of failure should happen prior to repair.
- Given failure of the drainage path is deep and is due to rotational slump on a failure plane well behind the riprap and filter layer, it may be a result of instability in the slope material. If this is the case, a geotechnical engineer should be consulted prior to reconstruction.
- Trees, shrubs, and other vegetation growing with close proximity to the riprap drainage path shouldn't be disturbed as they provide vegetative stabilization. Inspection should ensure that tree roots don't displace riprap, if vegetation has potential to dislodge riprap should be removed annually. Vegetation that interrupts inspection is acceptable to remove.
- When inspecting the riprap system, look for signs of erosion and scour or sediment accumulation.
- Removal of accumulated material within the drainage path such as sediment, trash, and vegetative debris should occur once identified.
- If displacement of riprap stone is a continuous problem, replace material with larger stones in the area experiencing issues.

*Stockpiling of riprap is considered best practice due to the adherent need for replacement of drain rock as its displaced during major storm events and prolonged periods of rain.

4.2.2 FLUME PIPING

Monitoring for a metal corrugated flume pipe drainage path should occur periodically and after major storm events to evaluate their performance and upgrade where required. The necessary maintenance that must occur to sustain this drainage option includes the following:

- Flush out the pipe system if evidence of silt / sand build up exists
- Through flushing inspect the flume pipe drainage path from top to bottom to ensure there are no leaks in the pipe system
- If any evidence of pipe failure, or silt entering the system through broken pipe, then identify the broken locations and repair as required
- Ensure the drainage pipe remains clear of debris such as vegetation, trash, and bedload material to prevent flooding

- Clear inlets and outlets of debris and obstructions to ensure storm water drains into pipe network and flooding doesn't occur

4.2.3 NO DOWNSTREAM UPGRADES

If no upgrades are constructed downstream of the stormwater detention system, significantly more monitoring and maintenance is required to prevent erosion of the slope below the Peace River Lookout. The monitoring and maintenance actions needed are as follows:

- Site visits to ensure the existing drainage paths maintain their course down the slope. Erosion can increase storm water floods out of the existing drainage paths
- Inspection of the storm water system must occur after a major storm events and prolonged periods of rain due to the susceptibility to erosion of the slope
- The slope movement should be monitored frequently to access the rate of movement and changes the state of erosion on the slope. Methods or technology that are capable of performing slope movement monitoring include:
    - Topographical Survey
    - Lidar
    - Inclinometer
    - Slope gauge
    - Bore-hole motion sensors / slope alarms

4.3 COST ESTIMATE

The construction costs for the purposed storm water management design are provided in Table 5.

Table 5. Cost of the proposed drainage plan construction.

ITEM	DESCRIPTION	UNIT	EST. QNTY	UNIT PRICE	ESTIMATED AMOUNT
A	**Earthworks**				
1	Stripping - 300mm Depth	m^3	750	$ 8	$ 6,000.00
2	Common Excavation to Fill	m^3	3,000	$ 25	$ 75,000.00
3	Scarify and Compact Subgrade - 150mm Depth	m^2	2,500	$ 8	$ 20,000.00
4	Class 25kg Riprap c/w Non-woven Geotextile - 500mm Tl	m^3	300	$ 100	$ 30,000.00
5	Erosion and Sediment Control	L.S.	1	$ 5,000	$ 5,000.00
6	Topsoil and Seeding	L.S.	1	$ 5,000	$ 5,000.00
7	Fencing	L.S.	1	$ 5,000	$ 5,000.00
8	Trail on Berm	L.S.	1	$ 10,000	$ 10,000.00
				Subtotal	**$ 156,000.00**
B	**Drainage Piping**				
1	800mm dia. CSP (half pipe) anchored to ground	L.M.	50	$ 200	$ 10,000.00
2	Inlet / Outlet c/w headwalls	ea	4	$ 5,000	$ 20,000.00
				Subtotal	**$ 30,000.00**
C	**Ditches**				
1	Ditching	m	200	$ 50	$ 10,000.00
2	Piping and Outlet Structures	L.S.	1	$ 15,000	$ 15,000.00
				Subtotal	**$ 25,000.00**
				Works Subtotal	**$ 211,000.00**
				Insurance, Mobilization and Demobilization	$ 15,000.00
				Engineering Services @ 15%	$ 31,650.00
				Contingency @ 30%	$ 63,300.00
				Total Probable Cost of Construction	**$ 320,950.00**

APPENDIX

A DESIGN DRAWINGS