APPENDIX C

GEOTECHNICAL ASSESSMENT

CITY OF COURTENAY

THURBER ENGINEERING LTD.

November 20, 2019 File: 25690

Urban Systems Ltd.
#550 - 1090 Homer Street
Vancouver, B.C.
V6B 2W9

Attention: Jody Rechenmacher, P.Eng.

RIVER AND STREAM CHANNEL RECONNAISSANCE AND GEOTECHNICAL STABILITY ASSESSMENT COURTENAY, B.C.

Dear Jody:

Thurber has completed an air photograph review, site reconnaissance, and screening-level geotechnical stability assessment of the steep slope areas and river and stream channels of the City of Courtenay, B.C. This letter provides the results of the office and field assessments and recommendations for the locations reviewed. Thurber's study was completed as part of Urban Systems Ltd. integrated rainwater management plan (IRMP) which will be issued to the City later in 2019.

It is a condition of this letter that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

1. BACKGROUND

The topography of the City of Courtenay comprises a relatively flat floodplain to the north of the Puntledge and Tsolum rivers, and gently sloping lowlands and uplands with steeper terrain concentrated along the rivers, several major creeks, and the escarpments along portions of Back Road and Ryan Road.

Thurber's scope of work for this assignment was to review the steep slope areas and water courses and assess the level of geotechnical risk. Comments are also provided that discuss potential regulatory risk management approaches to address natural hazards.

2. AIR PHOTOGRAPH REVIEW

Thurber obtained air photographs from the Geographic Information Centre of the University of British Columbia showing the City of Courtenay between 1949 and 1996. The air photographs were supplied as sets that allowed for stereoscopic viewing. When using special viewing equipment this gives the user a sense of the relative height of the areas covered by the photo sets for a given year. This allows for relatively small features to be identified when viewing low altitude photos of good quality (see Photos 1 and 2 for examples).

No large-scale slope failures were observed in the air photographs between 1949 and 1996. The observed slope failures were generally small bank failures along the Puntledge and Tsolum rivers which were likely initiated by undercutting or trees toppling. The meanders of the Tsolum River upstream of the confluence with the Puntledge were slowly shifting with time and have been locally stabilised with rip-rap at various locations. Detailed comments by area, feature, and year are provided in Table 1 at the end of this report.

3. FIELD METHODOLOGY

Thurber completed a high-level reconnaissance of the Puntledge and Tsolum rivers, and selected creeks and culverts within City of Courtenay boundaries on October 23 and 24, 2019. The field program executed was based on feedback on a preliminary field program provided to the City in mid-September and comprised the following significant traverses:

- Arden Creek
- Morrison Creek
- Puntledge River – right bank following Rotary Trail from City limits to the east end of Bear James Park at Rod and Gun Road, Puntledge Park, and from Condensory Bridge to the confluence with the Tsolum.
- Tsolum River – left bank between Dove Creek Road and the south end of the trails in the Exhibition Grounds and the abandoned channel between Headquarters Road and the current river channel at its confluence with the Puntledge.
- Urquhart Creek upstream of Hobson Avenue to Malahat Storm Park.
- Selected culverts along Arden, Mallard, Millard, Morrison, Piercy, and Urquhart creeks.

The final pre-fieldwork plan incorporating City comments is attached as Table 2. Assessment of the Puntledge and Tsolum rivers was envisioned at the start of the project. The City GIS website was used to identify significant creek drainages and the location of culverts for preliminary screening using Google Street View. Culverts were selected for field review on the basis of road importance, topography / fill height, apparent slope angle, and general condition as could be seen from the road. Review of some culverts was not considered necessary as there did not appear to be any geotechnical issues. It should be noted that hydraulic capacity of culverts is not a geotechnical issue.

The traverse was completed by following the channels and banks of rivers and creeks except where they were located within private property. Access to the river channels was limited by high water levels and would be easiest is mid- to late-summer. The reaches of the Puntledge not reviewed generally comprise those with the greatest development along the top-of-bank. The Puntledge was not assessed downstream of its confluence with the Tsolum as the channel is largely artificial (i.e. retaining walls, armoured with rip-rap).

The banks, channels, and culverts were visually reviewed with regards to geotechnical stability. Our reconnaissance assessed visible signs of severe or recent erosion and bank / slope instabilities, and other potential risks which may lead to erosion or bank failure. Thurber formulated conceptual-level options to address identified areas of concern in the field.

The identified areas of concern were qualitatively assessed for geotechnical risk, based on the combination of perceived likelihood and potential consequences to property and public safety. For example, a landslide in a remote area may be very hazardous but assessed as low risk due to low exposure to that hazard. Such assessments are inherently subjective and are based on the experience of the engineer and conditions observed that day. The evaluation of potential consequences is a difficult, but important as part of a screening-level study to put the significance of identified hazards into context. Thurber adopted the qualitative probability categories and descriptions in Table 3.

Our assessment of risk did not include potential environmental impacts where these result from natural processes, unless these appeared to be exacerbated by development or infrastructure. Very low risk areas were not typically logged as the objective was to identify significant risks.

Table 3 – Qualitative Probability Categories for Risk Assessment (after Hungr, 1997)

Classification	Estimated Annual Probability Range	Typical Description of Risk
Very High	>1:20	Very likely event with significant consequences, appears imminent.
High	1:100 – 1:20	Likely event with significant consequences.
Moderate	1:500 – 1:100	Less likely event with significant consequences.
Low	1:2500 – 1:500	Less likely event with limited consequences.
Very Low	< 1:2500	Unlikely event or common event without consequences.

4. RESULTS

During the reconnaissance our observations were recorded at each significant feature using a standardized Watercourse Stability Assessment Data Sheet, which includes a hazard description, location, risk assessment and possible remedial options.

As summarised on the attached Table 4, Thurber observed 28 locations of interest of which 1 was assessed as very high risk, 3 as high risk, 12 as moderate risk, and 12 as low or very low risk. Of the 28 locations, 7 were natural features and 21 were man made. The attached Data Sheets provide detailed descriptions and should be used in preference to the general discussions below.

To facilitate follow up review, each Data Sheet provides the approximate GPS coordinates of the feature of interest. Figure 1 shows the locations of interest at small scale. Figures 2 through 5 show the locations of interest at larger scale. The location markers have been colour-coded to reflect the assessed risk levels. Note that these Figures are not hazard maps.

Figure 1 – Locations of interest in Courtenay.

Red = (Very) High Risk
Yellow = Medium Risk
Green = Low Risk
Blue = Very Low Risk

Figure 2 – Locations of interest along Back Road escarpment.

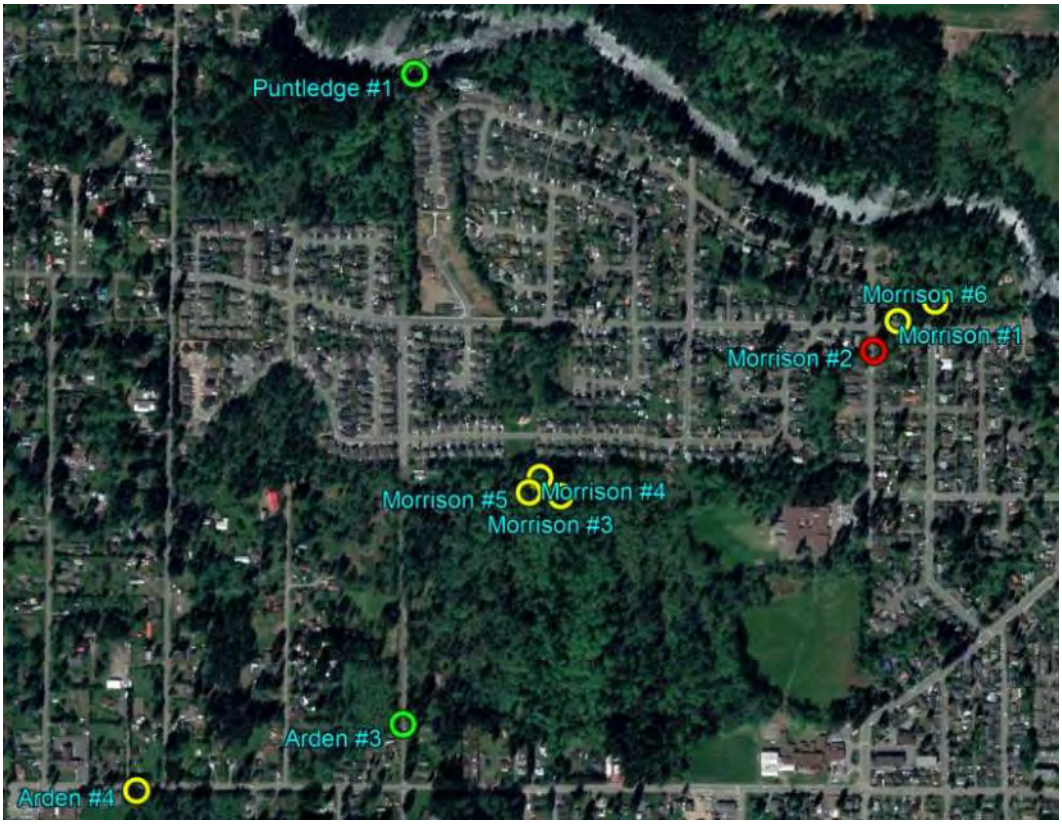

Figure 3 – Locations of interest between Lake Trail Road and Puntledge River.

Figure 4 – Locations of interest in south Courtenay.

Figure 5 – Location of interest along Tsolum River.

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5. DISCUSSION AND RECOMMENDATIONS

5.1 Typical Geotechnical Hazards

The typical geotechnical hazards observed during our traverse comprised erosion, shallow landslides, debris floods, fill embankments, and culverts and other structures.

Erosion

Erosion of the channel base (down-cutting) and banks was observed in localised areas of creeks as noted in the Data Sheets. In general, both processes appeared to be linked with high flow events as the soils underlying active channel beds and exposed on the banks appeared to comprised soils with some resistance to erosion. Exposure to this hazard along the creeks is generally low to negligible as there is no nearby development except for formal and informal trail systems and thus the corresponding risk would be low or very low. The risk assessed for Morrison #3, #4, and #5 was considered to be medium given the height and length of the banks but in practical terms the risk exposure for users of the park is low.

The Puntledge River runs through bedrock upstream of Puntledge Park. This stabilises the alignment of the river as the banks and channel are reasonably resistant to erosion. The erosion hazard increases downstream of the Park as the river flattens out and the banks increasingly comprised fine grained overbank flood deposits as suggested by water well #85130 near Condensory Bridge. Detailed assessment of the banks would be best done in the summer when access to the river channel is easier. The risk associated with erosion is probably low to very low where the channel and lower banks are rock, moderate where overbank deposits are present, and low where overbank deposits have been armoured with rip-rap.

The Tsolum River runs through fine grained overbank flood deposits, in other words, its own floodplain. Without human intervention the tendency would be for its meanders to slowly shift as material is eroded from the outside bends, deposited on the inside bends, which eventually results in the river cutting through its own meander. This is a long-term natural process which can be mitigated by armouring the banks with rip-rap to increase resistance to erosion. Extensive armouring would reduce the riparian area available for wildlife and could change the hydraulic characteristics (e.g. flow speed, channel depth). Non-emergency channel armouring should be reviewed in detail before being done to assess potential long-term consequences.

Landslides

The topography and geology of the creeks and rivers traversed does not generally favour the occurrence of large landslides. Likely hazards include localised small landslides where down-cutting of the channel or under-cutting of a bank has occurred and bank toppling associated with trees along the top-of-bank. The risk associated with the likely hazards would be expected to be low except where development has occurred too close to the top-of-bank.

The air photograph review did not give any visual indication of recent large- or small-scale slope failures away from the rivers. Accordingly, the risk associated with large- or small-scale failures is expected to be low.

It should be noted that the risk discussed above is in the context of static conditions, in other words, no earthquakes.

Obstructions Leading to Debris Floods

The accumulation of wood debris in Urquhart Creek has led to the formation of steps in the creek bed (i.e. Urquhart #8 and #9). Over time as the log obstructions decay there is the potential that high flow events could wash away the obstruction and mobilise the retained creek bed material. This is a natural process for which the assessed risk is considered low provided that the steps are not greater than 0.3 m to 0.6 m and not near a steep part of the drainage that would allow the released material to gain momentum. Consideration should be given to removing or reducing the height of large obstructions to reduce the future risk of debris floods.

This hazard may be present along other creeks. This hazard is not likely to occur along the Puntledge and Tsolum rivers within the City due to the channel geometry and nearby topography.

Fill Embankments

Fill embankments constructed across or adjacent to creeks can result in embankment instability, erosion, and drainage problems. The likelihood of poor performance depends on the slope angle, vegetation cover, surface runoff, condition of penetrating culverts, and potential for toe erosion.

During our traverse we did not assess any embankments to be a significant risk in their own right. However, poor maintenance of drains and culverts could result in embankments becoming significant risk items. Significant in this context is greater than very low to low.

Culverts and Other Structures

75% of the locations assessed during the traverse were artificial structures and most of those were culverts. All of the very high and high rated risk items were culverts. The other structures included two pedestrian bridges and two retaining walls. Typical hazard features comprised:

- Erosion – plunge pools at the outlet end where a combination of flow velocity and vertical drop eroded a pool at the end of the pipe (e.g. Back Road #1).
- Undermining – flow down the embankment or creek flow near plunge pool erodes the embankment or soil supporting a structure (e.g. Millard #1, Urquhart #12).
- Age – structure has degraded with age and no longer functions as intended (e.g. Morrison #2, Morrison #6).

In the context of infrastructure, hazard management is a matter of inspection, maintenance, and eventual replacement with new structures designed in accordance with applicable standards. Particular attention should be given to the following structures:

- Morrison #2 – the banks near the culvert outlet are a series of ad-hoc repairs and currently support the sidewalk.
- Morrison #6 – the flue has failed and is leaking water which is eroding the slope.
- Back Road #1 – ongoing erosion near the culvert outlet has potential to destabilise the embankment slope supporting road.
- Millard #1 – ongoing erosion of slope near headwall has potential to destabilise the retaining wall supporting Old Island Highway.
- Urquhart #3 – ongoing erosion has potential to destabilise the east side of 10th Street.

5.2 Seismic Hazards

There is a moderate to high probability that a significant seismic event will affect the region within the next 50 years. Detailed assessment of seismic slope stability was beyond the scope of the present study and the following presents only a qualitative assessment of seismic hazards:

- The risk of large-scale catastrophic failure of natural, unmodified slopes is considered low as they have been subject to past major earthquakes (e.g. Cascadia 1700, Beaufort 1946).
- Bedrock controlled portion of the Puntledge River – the banks have a reasonable chance of surviving with small to moderate movements (0.3 m to 0.5 m) and only localised failures / bank toppling.
- Puntledge and Tsolum rivers where overbank deposits are present – the banks will likely fail for anything more than a small earthquake (1:100-year). Horizonal and vertical movements along the top-of-bank have the potential to be large (+1 m) and will decrease with increased distance from the top-of-bank.
- Creeks – shallow slope failures and bank toppling are likely to occur. The extent and magnitude of movements will depend on size of creek channel and ground conditions. Slope failures could lead to the impoundment of water which could subsequently drain quickly as a debris flood or more slowly with little associated risk.
- Steep slope areas along Back Road / Ryan Road – there will be a tendency for downslope movement during strong shaking and may be some potential for localised, shallow slope failures.
- Embankments – there will be a tendency for embankments to settle and spread during an earthquake. The magnitude of movement will depend on the embankment material and geometry, and underlying soil.
- Seismic damage to buried pipes located near the top-of-bank could also result in geotechnical issues (e.g. ruptured watermains could cause erosion or landslides).

There may also be potential for deep-seated slope instability as a result of seismic loading, however this is difficult to assess and was beyond the present scope.

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5.3 Steep Slope Development Permit Area

The City of Courtenay does not appear to have a DPA for steep slope areas. Clause 6.4 of the Environmental DPA states that the City may require review by a Geotechnical Engineer for land development where the slope is greater than 30% (i.e. 16.7° or 3.3H:1V). This is not as rigorous or specific as other BC municipalities which generally require rather than may require review:

- Abbotsford – slope greater than 20% and land within 20 m of slopes greater than 20% (20% = 11.3° = 5H:1V).
- Campbell River – slope greater than 30% and at least 10 m high.
- District of North Vancouver – slope greater than 36% and land within 20 m of slopes greater than 36%, slope must be more than 10 m high (36% = 19.8° = 2.8H:1V).
- Port Moody – slopes greater than 20% over a horizontal distance of at least 10 m.

Among B.C. municipalities, a development setback of 10 m from the top- and bottom-of-bank is relatively common. Abbotsford increases the setback to 15 m if the slope is greater than 30%. Hydraulic structures such as pools and ponds should be avoided within the setback as leaks could be detrimental to the stability of the slope. Development within the setback is usually permitted as recommended by a Qualified Professional.

We recommend that the City develop more detailed guidance for development of steep slope areas. The guidance should include slope angle, setback distances from top- and bottom-of-slope and -bank in the case of watercourses.

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6. CLOSURE

We trust that this information is sufficient for your needs. Should you require clarification of any item or additional information, please contact us at your convenience.

Yours truly,
Thurber Engineering Ltd.
David J. Tara, M.Sc.A, P.Eng.
Review Principal

Marc C. Bossé, M.Sc., P.Eng.
Project Engineer

Attachments
Statement of Limitations and Conditions
Watercourse Stability Assessment Sheets
Photo 1 – Example of a good quality airphoto showing the developing confluence of the Tsolum and Puntledge Rivers
Photo 2 – Example of a good quality airphoto showing Sid Williams Theater
Table 1 – Summary of Air Photograph Review
Table 2 – Final Pre-Fieldwork Plan
Table 4 – Summary of Watercourse Stability Assessment Data Sheets
28 Watercourse Stability Assessment Data Sheets

References:

Oldrich Hungr; 1997; Some methods of landslide hazard intensity mapping; Proceedings of the Landslide Risk Workshop

Photo 1 – Example of a good quality airphoto showing the developing confluence of the Tsolum and Puntledge Rivers. (UBC Airphoto Collection, 1980)

Photo 2 – Example of a good quality airphoto showing area around Sid Williams Theater. (UBC Airphoto Collection, 1980)

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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

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25690 Courtenay IRMP

Table 1 - Summary of Air Photograph Review

Area	Region / Feature	Year	Comment
General	N/A	1946	Airphoto coverage poor (west Courtenay), mid-altitude, focus fair.
General	South Courtenay	1946	No apparent recent slope failures.
Tsolum	N/A	1946	Tsolum River joins Puntledge at Lewis Park
General	N/A	1950	Airphoto coverage poor (east Courtenay), high altitude, focus fair.
General	Back Road, Ryan Road, OIA	1950	No apparent recent slope failures.
Back Road	Hairpin Turn	1950	Back Road has its modern alignment and crosses the gully near the upslope head. No large vegetation on side slopes.
Old Island Highway	near end of Chapman Road	1950	There is a subdued feature which may have been an old slope failure.
General	N/A	1957	Airphoto coverage good, high altitude, focus fair.
General	South Courtenay, Tsolum, Ryan Road, Veterans Parkway	1957	No apparent recent slope or bank failures.
Puntledge	N/A	1957	There were two small features on the left bank near Keeneland Ave and Willemar Ave which may have been slope failures or tree toppling.
Back Road	Hairpin Turn	1957	Gully is vegetating. No indication of movement.
Back Road	West of 10 St. E	1957	There is a cleared area with regular geometry. Excavation?
Ryan Road	above Anderton Farm	1957	Slope has been logged.
General	N/A	1964	Airphoto coverage good, mid-altitude, focus fair to good.
General	South Courtenay	1964	No apparent recent slope failures.
Back Road	Hairpin Turn	1964	Potential fill placement or re-grading on left bank of gully below road.
Puntledge	N/A	1964	No apparent recent bank failures.
Tsolum	N/A	1964	Small scale bank and channel changes. No major soil movements.
General	Back Road, Ryan Road, Old Island Highway, Veterans Parkway	1964	No apparent recent slope failures.
Ryan Road	Gravel Pit near Anderton Road	1964	Clearings in forest near Ryan and Anderton, small but will expand
General	N/A	1968	Airphoto coverage good, mid/low altitude, focus good.

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Table 1 - Summary of Air Photograph Review

Area	Region / Feature	Year	Comment
General	South Courtenay	1968	No apparent recent slope failures/movements.
Puntledge	N/A	1968	No apparent recent bank failures.
Tsolum	N/A	1968	Small scale bank and channel changes. No major soil movements.
Back Road	West of 10 St. E	1968	Higher resolution photo shows geometry which could be an excavation or a failure with a downslope runout pattern. However, downslope vegetation suggests this was an excavation.
Back Road	Hairpin Turn	1968	Vegetation is growing, no apparent slope movement. Pond present about 200 m below culvert.
General	Back Road, Ryan Road, Old Island Highway, Veterans Parkway	1968	No apparent recent slope failures/movements.
Ryan Road	Gravel Pit near Anderton Road	1968	Area and depth of excavation expanded.
General	N/A	1975	Airphoto coverage good, mid/low altitude, focus good.
General	South Courtenay	1975	No apparent recent slope failures/movements.
Puntledge	N/A	1975	Potential small toppling of left bank near Leighton Ave.
Tsolum	N/A	1975	Small scale bank and channel changes. No major soil movements, hairpin near Glacier Road eroding on outer bank.
Back Road	Hairpin Turn	1975	Vegetation is growing, no apparent slope movement. Pond still present.
General	Back Road, Ryan Road, Old Island Highway, Veterans Parkway	1975	No apparent recent slope failures/movements.
Ryan Road	Gravel Pit near Anderton Road	1975	Area and depth of excavation expanded somewhat.
General	N/A	1980	Airphoto coverage good, low altitude, focus good.
General	South Courtenay	1980	No apparent recent slope failures/movements.
Puntledge	N/A	1980	No apparent recent bank failures.

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25690 Courtenay IRMP
Table 1 - Summary of Air Photograph Review

Area	Region / Feature	Year	Comment
Tsolum	N/A	1980	Small scale bank and channel changes. No major soil movements, erosion of outer bank of hairpin near Glacier Road continuing.
Tsolum	N/A	1980	Tsolum has breached the bank and is partially flowing into the Puntledge at the current confluence. Significant log debris.
Back Road	Hairpin Turn	1980	Vegetation has been partially cleared. Pond dam is present but there does not appear to be any retained water.
General	Back Road, Ryan Road, Old Island Highway, Veterans Parkway	1980	No apparent recent slope failures/movements.
Ryan Road	Gravel Pit near Anderton Road	1980	Area and depth of excavation considerably expanded. Base of pit well below road.
General	N/A	1984	Airphoto coverage good, mid-altitude, focus good.
General	South Courtenay	1984	No apparent recent slope failures/movements.
Puntledge	N/A	1984	No apparent recent bank failures.
Puntledge	Beach	1984	The outside bank in Puntledge Park appears to be changing slightly over time.
Tsolum	N/A	1984	Tsolum River uses its modern mouth. There appears to be rock on the ground behind the hairpin bank. Suggests that repairs were done.
Back Road	Hairpin Turn	1984	No significant changes.
General	Back Road, Ryan Road, Old Island Highway, Veterans Parkway	1984	No apparent recent slope failures/movements.
Ryan Road	Gravel Pit	1984	No significant changes. May be inactive.
General	N/A	1991	Airphoto coverage good, mid/low-altitude, focus good.
General	South Courtenay	1991	No apparent recent slope failures/movements.
Puntledge	N/A	1991	No apparent recent bank failures.

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Table 1 - Summary of Air Photograph Review

Area	Region / Feature	Year	Comment
Puntledge	Beach	1991	The bar island has now be incorporated merged with the land. Natural deposition or fill?
Tsolum	N/A	1991	Small scale bank and channel changes. No major soil movements.
Back Road	Hairpin Turn	1991	Possible minor bank sloughs or disturbance on right bank near location of dry pond.
General	Back Road, Ryan Road, Old Island Highway, Veterans Parkway	1991	No apparent recent slope failures/movements.
Ryan Road	Gravel Pit	1991	No significant changes. May be inactive.
General	N/A	1996	Airphoto coverage good, high altitude, focus good.
All Areas	N/A	1996	The high altitude photos make it difficult to resolve small scale features. There does not appear to be any large scale slope movements, failures, or changes from 1991.
General	N/A	2004-2019	Google Earth airphoto coverage very good, low altitude, focus good.
General	South Courtenay		No apparent recent slope failures/movements.
Puntledge	N/A		Potential small toppling of left bank near Keeneland Ave. Potential slough of right bank near 1701 Robert Lang Dr.
Tsolum	N/A		Small scale bank and channel changes. No major soil movements.
Back Road	Hairpin Turn		No significant changes.
General	Back Road, Ryan Road, Old Island Highway, Veterans Parkway		No apparent recent slope failures/movements.

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25690 - Courtenay IRMP
Table 2 - Pre-Fieldwork Plan

Name	Location Notes	Estimated Time (hr)	Comment
Puntledge River	access from parks	4	review banks of river
Tsolum River	access from Dove Creek or Exhibiton Grounds	4	review banks of river, access limited if water high
Morrison #1	Willemar and 1st	1	review culvert and nearby stream including 'Creek Channel'
Morrison #2	Willemar and 1st	0.75	review culvert and nearby stream
Cumberland #1	Cumberland and 20th	0.5	review culvert
Piercy #3	Cliffe Ave near Sandpiper	0.5	review culvert
Milard Creek #2	Comox Logging Road after Fraser Road	0.5	review culvert
Milard Creek #1	Comox Logging Road before CVP	0.5	review culvert
Back Road #1		0.75	review culvert, check for culverts to east and review if appropriate
Urquhart #1		0.5	review culvert
Urquhart #2		0.5	review culvert
Urquhart #3		0.5	review culvert
Urquhart #4		0.5	review culvert
Urquhart #5		0.5	review culvert
Urquhart #6		0.5	review culvert
Urquhart #7		0.5	review culvert
Urquhart Creek	run below #1	-	Difficult access due to vegetation, channel width, and access points. Topography also relatively flat.
	Hwy 19A @ Beachwood	-	Geotechnical review of culvert not considered necessary as topography is relatively flat.
	Hwy 19A @ Chinook	-	
	Piercy Creek @ 20th	-	
Bonner #1	west of end of Williams	-	Culverts were identified during our initial assessment. Geotechnical review was not considered necessary as the topography is relatively flat.
M/P	Arden at Falconcrest	-	
Arden #2	Arden west of Cumberland	-	
Arden #3	Arden west of Lake Trail	-	
	Total =	16	

THURBER

25690 - Courtenay IRMP

Table 4 - Summary of Watercourse Stability Assessment Data Sheets

Data Sheet Report #	Watercourse	Latitude	Longitude	Type	Risk Assessment
Arden #2	Piercy Creek	49.66996	125.00943	Culvert	Medium
Arden #3	Arden Creek	49.67719	125.01886	Culvert	Low
Arden #4	Arden Creek	49.67371	125.02273	Retaining Wall	Medium
Back Road #1	Mallard Creek	49.68948	124.95992	Culvert	High
Cumberland #1	Piercy Creek	49.67057	125.00870	Culvert	Medium
Milliard #1	Millard Creek	49.66461	124.97365	Culvert	High
Milliard #2	Millard Creek	49.65814	124.98856	Culvert	Medium
Morrison #1	Morrison Creek	49.68711	125.01605	Culvert	Medium
Morrison #2	Morrison Creek	49.68650	125.01603	Culvert	Very High
Morrison #3	Morrison Creek	49.68153	125.01955	Erosion	Medium
Morrison #4	Morrison Creek	49.68154	125.02024	Erosion	Medium
Morrison #5	Morrison Creek	49.68125	125.02019	Erosion	Medium
Morrison #6	Morrison Creek	49.68774	125.01566	Storm Outfall	Medium
Piercy #3	Piercy Creek	49.65932	124.99583	Culvert	Low
Puntledge #1	Puntledge River	49.68510	125.02899	Erosion	Low
Tsolum #1	Tsolum River	49.70684	125.01195	Erosion	Low
Urquhart #1	Glen Urquhart Creek	49.70038	124.99778	Culvert	Medium
Urquhart #2	Glen Urquhart Creek	49.70101	124.97622	Culvert	Very Low
Urquhart #3	Glen Urquhart Creek	49.70037	124.97305	Culvert	High
Urquhart #4	Glen Urquhart Creek	49.69920	124.97181	Culvert	Very Low
Urquhart #5	Glen Urquhart Creek	49.69714	124.96606	Culvert	Very Low
Urquhart #6	Glen Urquhart Creek	49.69786	124.96394	Culvert	Low
Urquhart #7	Glen Urquhart Creek	49.70232	124.46297	Culvert	Very Low
Urquhart #8	Glen Urquhart Creek	49.70001	124.97262	Obstruction	Low
Urquhart #9	Glen Urquhart Creek	49.69700	124.46475	Obstruction	Low
Urquhart #10	Glen Urquhart Creek	49.69767	124.96414	Pedestrian Bridge	Medium
Urquhart #11	Glen Urquhart Creek	49.69792	124.96222	Retaining Wall	Medium
Urquhart #12	Glen Urquhart Creek	49.70115	124.96342	Pedestrian Bridge	Low

Watercourse Stability Assessment Data Sheet

Report: Arden #2
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Piercy Creek
Date: Oct-24-19
Site Location: Arden Road - West of Cumberland Road
Coordinates: Lat. 49.66996 +- 3m
Time: 09:25:00 AM Bank: Within Channel
Long. 125.00943
Weather: Overcast 10°C
Inspector: CHS

Description:

Construction of Culvert
1.1m x 1.7m oval multiplate corrugated steel.

Upstream of Culvert
1m high concrete sack wall above culvert, 2m high wingwalls in good condition. see photo 1.
Riprap lined ditch discharges from right bank just upstream of wing wall.

Downstream of Culvert
Scour at outlet has eroded a pool, resulting in a 0.5m drop in the channel. See photo 2.
Downstream embankment slope is a 2.5 m high eroded scarp with a 1m wide gravel shoulder above.
No cracking or settlement on road/pavement. See photo 2.
Embankment erosion has exposed and undermined culvert, which now protrudes 1m from the bank. See photo 2.
Downstream channel very dense gravely sand, silty and till like. See photos 3 and 4.

Consequence:

Continued outlet headwall embankment erosion may destabilized embankment and damage roadway and culvert.

Drop in channel at outlet may be fish barrier if applicable.

Likelihood:

Has not yet damaged roadway.
Erosion likely only during peak flows.

Risk: Very Low Low **Medium** to **High** Very High

Possible Remedial Options:

Repair eroded embankment and build headwall at outlet.
Consider measures to reduce channel drop at outlet, transitional flume.

Additional Comments:

Access good from Arden road.

Watercourse Stability Assessment Data Sheet

Report: Arden #2
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Piercy Creek
Date: Oct-24-19

Photos:

Photo 1, Culvert Inlet, concrete bag wall.

Photo 2, Culvert outlet, erosion of embankment and undermining of culvert visible.

Photo 3, Erosion of right bank downstream of culvert.

Photo 4, Downstream of culvert outlet.

Watercourse Stability Assessment Data Sheet

Report: Arden #3
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Arden Creek
Date: Oct-24-19
Site Location: Arden Road - West of Lake Trail Road
Coordinates: Lat. 49.67719 +- 4m
Time: 09:50:00 AM Bank: Within Channel
Long. 125.01886
Weather: Overcast 10°C
Inspector: CHS

Description:

Construction of Culvert
1.2m Diameter CSP.

Upstream of Culvert
Inlet headwall protected by 1.5m high, battered dry stack boulder wall. Top of wall is 2m setback from EOP. See photos 1 and 2.
100mm diameter PVC drain discharges from right bank at inlet. See photo 1.

Downstream of Culvert
2.5m high embankment, on left side of culvert outlet the fill has been eroded to sub vertical scarp with 1m setback from EOP.
Concrete barriers installed on the shoulder above the outlet, presumably in response to erosion of scarp.
There is a 0.3m drop from outlet into channel, see photo 3.

Consequence:
Continued erosion may result in undermining that will cause instability of road embankment at outlet. However single lane no through road with few houses, low volume road.
Drop in channel may be barrier to fish.

Likelihood:

Episodic erosion during peak flows, moderate chance of damaging the roadway within 20 years.

Risk: Very Low | **Low** | Medium | High | Very High

Possible Remedial Options:

Repair eroded embankment and construct headwall at outlet, options include concrete, gabions and soil bags.
Monitor and check after winter storms.

Additional Comments:

Access very good from Arden road, low volume traffic.

Watercourse Stability Assessment Data Sheet

Report: Arden #3
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Arden Creek
Date: Oct-24-19

Photos:

Photo 1, Upstream channel.

Photo 2, Culvert inlet, PVC outlet visible.

Photo 3, Culvert outlet, drop in channel visible.

Photo 4, Culvert outlet headwall, erosion visible beneath vegetation, barriers visible at crest of bank.

Watercourse Stability Assessment Data Sheet

Report: Arden #4
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Arden Creek
Date: Oct-24-19
Site Location: Lake Trail Road (at Powerhouse Road)
Coordinates: Lat. 49.67371 +- 5m
Time: 10:15:00 AM Bank: Within Channel
Long. 125.02273
Weather: Overcast 10°C
Inspector: CHS

Description:

Erosion
1.5m high lock block wall supporting northbound lane of Lake Trail Road. Lock block wall has been mildly undermined by left bank erosion of creek, See photo 2.
Pavement crack 6m long, with up to 25mm of apparent settlement. See photo 1.
Part of a 35m long reach where creek is channelled on the left bank by this wall. See photo 3.
Very dense glacial soils exposed in creek channel base, approximately 10m upstream of undermined section, see photo 4.

Consequence:

Damage to retaining wall and pavement (bike lane/roadway).

Likelihood:

Low gradient channel, likely slow erosion except in peak flows.
Pavement cracking indicates likely to get worse within 10 years.

Risk: Very Low | Low | **Medium** | High | Very High

Possible Remedial Options:

Consider widening channel by excavating right bank, then repair undermining and protect toe of wall with riprap.

Additional Comments:

Access good from Lake Trail Road, high volume traffic.

Watercourse Stability Assessment Data Sheet

Report: Arden #4
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Arden Creek
Date: Oct-24-19

Photos:

Photo 1, Roadway with creek, cracking on pavement visible.

Photo 2, Lock block wall making up left bank of creek.

Photo 3, left bank lock block and creek channel.

Photo 4, glacial soils exposed in channel base.

Watercourse Stability Assessment Data Sheet

Report: Back Road #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Mallard Creek
Date: Oct-23-2019
Site Location: Back Road - at hairpin corner
Coordinates: Lat. 49.68948 +/- 3m
Time: 09:05:00 AM Bank: Within Channel
Long. 124.95992
Weather: Sunny, 5°C
Inspector: CHS

Description:

Construction of Culvert

1.15m diameter CSP.

Downstream of Culvert

Severe erosion of the fill embankment and the embankment toe at the culvert outlet. A pool has eroded exposing till-like soils in the channel creek bed, and resulting in an approximately 1.5m drop into eroded pool from the culvert, see photos 2 and 5. Erosion of the embankment toe has exposed the culvert pipe 1.5m back from the outlet, undermining the culvert and road embankment slope, see photo 2.

Above the culvert outlet, the road embankment has a slope of 1.25H:1V at 6m high with mild surface erosion due to runoff from low point in paved road surface, there is no shoulder or barrier. See photo 3.

Downstream of the culvert outlet, very dense till like soil exposed at channel base with mild localized erosion of left and right banks which extends up to 1.5m high.

Right gulley slope between culvert outlet and Marsland Drive has mild erosion, the slope is 10m high at 1.5H:1V, gravelly sand with some silt (possible old fill) exposed on slope. Slope crest is set back 10m to 15m from road.

A small tributary channel descends the left gulley slope near the Municipal Boundary sign, has resulted in mild erosion with up to 0.5m incision into the left slope exposing very stiff clay (possible glaciomarine). The tributary appears ephemeral, no culvert found, possible result of stormwater runoff from road.

Upstream of Culvert

No significant erosion upstream of the culvert, inlet headwall is armoured with cobbles and small boulders.

Channel sidewalls vary 3m to 5m high at approximate slope of 2H:1V.

Road embankment approximately 5m high at 1.5H:1V at culvert inlet, shrubby vegetation. See photos 7 and 8.

Consequence:

Downstream embankment slope and Back Road shoulder instability if erosion continues unabated.
Undermined culvert may be damaged or collapse if erosion continues unabated.
Drop in channel at culvert outlet, may be impassible for fish if applicable.
Buried pipes (if present) in downstream embankment slope may be damaged by slope creep/instability.

Likelihood:

Episodic erosion during peak flows, moderate potential for culvert failure or slope instability within next 20 years.

Risk: Very Low | Low | Medium | **High** | Very High

Possible Remedial Options:

Repair eroded toe of embankment slope with rock fill. Extend or replace culvert to facilitate slope grading (especially if roadway widening to include shoulder planned).

A soil bag retaining wall or culvert headwall structure will be required at outlet if culvert not extended.

Drainage improvements on roadway to reduce runoff onto slope.

Additional Comments:

Access good from road, would require single lane traffic for repair work.

Photos:

Photo 1, Hairpin Corner on Back Road

Photo 2, Erosion around culvert outlet, undermining culvert and embankment.

Photo 3, Embankment slope above culvert outlet.

Photo 4, Looking across at erosion on right slope. Downstream of culvert outlet.

Watercourse Stability Assessment Data Sheet

Report: Back Road #1
Client: Urban Systems (for City of Courtney)
File No. 25690
Watercourse: Mallard Creek
Date: Oct-23-2019

Photos:

Photo 5, Culvert outlet with 1.5m drop into pool, erosion is visible underneath culvert.

Photo 6, looking downstream from culvert outlet.

Photo 7, Culvert inlet.

Photo 8, looking upstream from culvert inlet.

Watercourse Stability Assessment Data Sheet

Report: Cumberland #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Piercy Creek
Date: Oct-24-19
Site Location: Cumberland Road near 20th Street
Coordinates: Lat. 49.67057 +- 3m
Time: 08:50:00 AM Bank: Within Channel
Long. 125.00870
Weather: Overcast 10°C
Inspector: CHS

Description:

Culvert Construction
1.1m x 1.7m oval multiplate corrugated steel.

Upstream of Culvert
Headwall is 1.5m high wall with lock blocks, concrete traffic barriers and dry stack boulders.
Top of wall is EOP (Bike Lane). See photo 2.
Pavement has been laid recently, in good condition.
Cumberland Road ditch discharges at inlet from right hand bank, channel is riprapped.
Mild erosion on right hand bank approximately 5m upstream on inlet, erosions extends to 1.5m high with forested area above. See photo 3.

Downstream of Culvert
Pool scoured 0.5m deep, eroded banks on left and right extending to 2m high. See photo 5.
Outlet headwall eroded on left side of culvert to 2m high, See photo 5.
Four large conifers on right bank 10m downstream of outlet have been undermined by erosion exposing stiff clay with gravel (possible glaciomarine) on right bank, see photos 6 and 7.

Consequence:

Trees may topple if undermining erosion continues.
Continued erosion at outlet headwall may destabilize embankment slope and damage bike lane.
Paths and houses are well set back from banks.

Likelihood:

Tree stability uncertain (large trees).
Erosion at outlet likely to continue, especially during peak flows, High chance of affecting bike lane within 20 years.

Risk: Very Low | Low | **Medium** | High | Very High

Possible Remedial Options:

Repair eroded embankment at outlet, install headwall retaining structure (concrete or soil bag wall).
Riprap banks at outlet and adjacent to large trees on bank to mitigate undermining.
Tree specialist should assess tree stability.

Additional Comments:

Access good from Cumberland Road.

Watercourse Stability Assessment Data Sheet

Report: Cumberland #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Piercy Creek
Date: Oct-24-19

Photos:

Photo 1, Location of culvert.

Photo 2, Culvert inlet and headwall.

Photo 3, Channel upstream of culvert.

Photo 4, Channel looking downstream from culvert o

Watercourse Stability Assessment Data Sheet

Report: Cumberland #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Piercy Creek
Date: Oct-24-19

Photos:

Photo 5 , Downstream culvert outlet, erosion visible on left bank.

Photo 6, Large trees with visible undermining.

Photo 7, Downstream of culvert, 4 large trees with undermining erosion visible on right bank.

Watercourse Stability Assessment Data Sheet

Report: Millard #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Millard Creek
Date: Oct-23-19
Site Location: Cliff Ave / Old Island Highway @ Millard Rd
Coordinates: Lat. 49.66461 +- 4m
Time: 04:25:00 PM Bank: Within Channel
Long. 124.97365
Weather: Overcast 10°C
Inspector: CHS

Description:

Upstream of Culvert
Large concrete retaining structure - serial #3505R, see photo 2.
Consists of three 1.8m diameter concrete pipe culverts and headwall structure, with a 3m high lock block wall above, supporting the Cliff Ave road embankment (see photo 1).
No guard rails present.

Downstream of culvert
At the outlet a similar construction, Serial 3506R.
The left (north) wing wall (lock block) has been undermined severely and is at risk of collapse. See photo 4.
The right (south) wing wall (lock block) has suffered similar undermining but is less severe.
See photo 3.
Unclear if this erosion occurred due to back up of water at outlet during a period of high flow or due to erosion of the embankment slope independent of the creek.

Consequence:

If erosion continues, the currently undermined blocks may collapse, undermining adjacent blocks and the embankment slope. High traffic roadway.
Falling hazard at the crest of the walls.

Likelihood:

Erosion episodic during peak flows and storm events. High likelihood of problem with 20 years.

Risk: Very Low | Low | Medium | **High** | Very High

Possible Remedial Options:

Repair slope erosion with rockfill and riprap, potentially supplemented by grouting below undermined blocks.
Guard rails should be installed at top of large walls.

Additional Comments:

Access is good from Cliff Avenue, difficult traffic management.

Watercourse Stability Assessment Data Sheet

Report: Millard #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Millard Creek
Date: Oct-23-19

Photos:

Photo 1, location of culvert.

Photo 2, Upstream of culvert, serial number visible.

Photo 3, Downstream of culvert, undermining of left and right bank lock block walls visible.

Photo 4, Severe undermining of left bank lock block wall visible. Outlet structure.

Photo 5. Undermined lock block on left bank at outlet structure.

Photo 6. Undermined lock block on right bank at outlet structure.

Watercourse Stability Assessment Data Sheet

Report: Millard #2
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Millard Creek
Date: Oct-23-19
Site Location: Comox Logging Road (Paved - 2 lane)
Coordinates: Lat. 49.65814 +- 4m
Time: 04:50:00 PM Bank: Within Channel
Long. 124.98856
Weather: Overcast 10°C
Inspector: CHS

Description:

Construction of Culvert
1.2m x 2.4m concrete box culvert inlet with concrete arch outlet.

Upstream of Culvert
Shale bedrock exposed at underside of concrete structure and in channel bed.
Concrete wing wall/diversion wall on left bank, see photo 3.
Embankment slope is 1H:1V and 8m high, EOP is top of slope, no shoulder. Some longitudinal cracking and mild settlement at the crest. See photo 1.
Ditch discharges down left bank at inlet causing mild erosion, see photo 2.

Downstream of culvert
Shale bedrock exposed in channel base.
Outlet is a concrete arch structure, See photo 4.
Embankment slope is 1.25H:1V and 10m high, EOP is top of slope with similar cracking and settlement at upstream side.

Consequence:

Potential for embankment slope instability due to over-steepened fill and lack of shoulder.

Likelihood:

Erosion appears infrequent, slopes are vegetated with no active erosion.

Risk: Very Low | Low | **Medium** | High | Very High

Possible Remedial Options:

Consider extending culvert and flattening embankment slope, especially if road widening for shoulders is planned. Alternatively could rebuild road embankment as a geogrid reinforced structure.
Monitor and document pavement distress, stabilize slope if required or during road upgrades.

Additional Comments:

Access is good from the road. Long reach to the toe.

Watercourse Stability Assessment Data Sheet

Report: Millard #2
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Millard Creek
Date: Oct-23-19

Photos:

Photo 1, Upstream embankment showing pavement cracking.

Photo 2, Upstream left bank showing mild erosion.

Photo 3, Upstream culvert inlet.

Photo 4, Downstream culvert outlet.

Watercourse Stability Assessment Data Sheet

Report: Morrison #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19
Site Location: 1st Street
Coordinates: Lat. 49.68711 +- 6m
Time: 11:00:00 AM
Bank: Within Channel
Long. 125.01605
Weather: Overcast 10°C
Inspector: CHS

Description:

Construction of Culvert
Approximately 4m wide multiplate culvert.

Upstream of Culvert
2.3m high concrete headwall and wingwalls, See photo 2.
Banks armoured with 0.5m to 1m diameter riprap for 10m upstream of inlet. See photo 2.

Downstream of Culvert
3m high concrete headwall structure, mildly undermined to right of outlet by scour erosion. Gap below wall extends up to 0.5m horizontally from face. See photo 4.

Consequence:

If erosion continues unabated there is a risk of damage to the headwall structure.

Likelihood:

Erosion mild at present and likely only occurs during peak flows.
Likely will damage wall within next 20 years if not mitigated.

Risk: Very Low | Low | **Medium** | High | Very High

Possible Remedial Options:

Place additional riprap at toe of wall at outlet to mitigate rate of erosion.

Monitor wall and pavement for signs wall sustaining damage.

Additional Comments:

Salmon actively spawning in channel.

Watercourse Stability Assessment Data Sheet

Report: Morrison #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19

Photos:

Photo1, Upstream channel.

Photo 2, Culvert inlet.

Photo 3, Outlet of culvert and left bank.

Photo 4, Erosion undermining culvert headwall structure to right of outlet.

Watercourse Stability Assessment Data Sheet

Report: Morrison #2
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19
Site Location: Willemar Avenue
Coordinates: Lat. 49.68650 +- 3m
Time: 11:25:00 AM Bank: Within Channel
Long. 125.01603
Weather: Overcast 10°C
Inspector: CHS

Description:

Culvert Construction
Approximately 4m wide multiplate steel culvert.

Downstream of Culvert
Gabions in headwall have corroded at creek level and failed to retain gravel infill. Resulted in severe undermining of the sidewalk with an approximately 1.2m x 1.2m wide x 0.5m high void below the concrete slab on the left side of the outlet. It appears that concrete debris has been used to partially fill the void. See photos 6, 7 and 8.

Upstream of Culvert
Right bank gabion wall at inlet has been undermined and this has resulted in the gabion overturning/rotating towards the channel, wire is still intact. see Photos 2 and 3.

Left bank of channel protected with lock block and riprap shows no erosion, see photo 4.

Consequence:

The undermined sidewalk could collapse, there is potential for injury if a pedestrian is present.

The hazard is not visible from sidewalk.

Likelihood:

The gabions will continue to degrade, further undermining the headwall/embankment and sidewalk.
There is a low chance a pedestrian will step into a hole if the sidewalk collapses, but the location is an urban setting with high traffic.
There is uncertainty in predicting how long the concrete sidewalk will bridge across the void before it collapses.

Risk:	Very Low	Low	Medium	High	**Very High**

Possible Remedial Options:

The undermined sidewalk should be closed and repaired.

Failed gabions should be replaced with similar or alternative headwall, concrete should be considered for below the water line to avoid reoccurrence.

Additional Comments:

Access good from Willemar Avenue.

Watercourse Stability Assessment Data Sheet

Report: Morrison #2
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19

Photos:

Photo 1, Upstream channel.

Photo 2, Upstream of culvert, undermining and rotation of gabion basket visible on right bank.

Photo 3, Upstream of culvert, close up of overturning gabion on the right bank.

Photo 4, Upstream of culvert left bank with riprap and lock block protection (behind vegetation).

Watercourse Stability Assessment Data Sheet

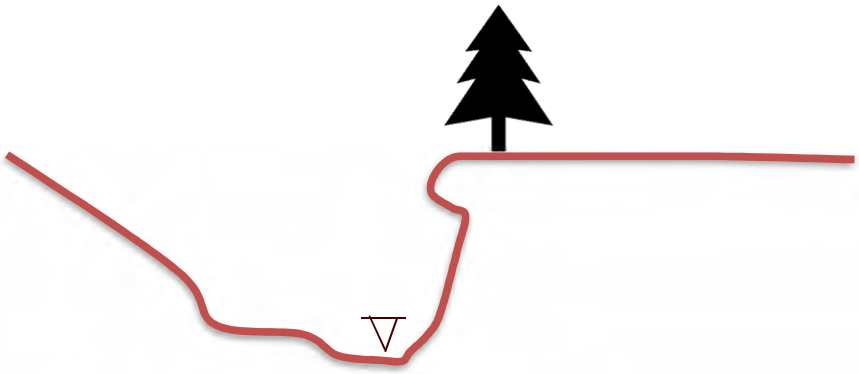
Report: Morrison #3
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19
Site Location: Roy Morrison Park
Coordinates: Lat. 49.68153 +- 4m
Time: 12:20:00 PM Bank: Right
Long. 125.01955
Weather: Overcast 10°C
Inspector: CHS

Description:

Right Bank Erosion

Right bank has eroded up to 6m high over a 30m long reach. See photo 3.
Erosion has exposed very stiff clay.
Erosion undermining roots of treats at the crest of the bank, see photos 3 and 4 and schematic section below.

At the upstream end of the reach the crest of the bank has collapsed, likely where a tree has overturned. This appears to have forced the relocation of the park path at the crest to increase setback. See photo 2.



Consequence:

The erosion is a natural process within the park.
There is potential for falling if a pedestrian comes close to the edge.
Erosion may increase turbidity and sediment downstream.

Likelihood:
Slow episodic natural process.
Erosion accelerates when trees overturn.
Low chance of falling if pedestrians remains on paths.

Risk: Very Low | Low | **Medium** | High | Very High

Possible Remedial Options:

Post "caution unstable slope" signs or equivalent along trail and consider installing a railing near large bluffs. Relocate trails as required to maintain setback of at least 3 m from the top of bank.
If required to mitigate effects on fish habitat, could cut back crest to flatten slope and install bio- remediation structures to mitigate erosion.

Additional Comments:

Machine access difficult, narrow path in park (forested).

Watercourse Stability Assessment Data Sheet

Report: Morrison #3
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19

Photos:

Photo 1, Looking down at right bank erosion where crest collapsed.

Photo 2, old trail (before relocated) at crest of bank where collapsed.

Photo 3, Right bank erosion with undermined crest, exposed clay visible.

Photo 4, Right bank erosion. Collapsed crest at right side of photo.

Watercourse Stability Assessment Data Sheet

Report: Morrison #4
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19
Site Location: Roy Morrison Park
Coordinates: Lat. 49.68154 +- 4m
Time: 12:55:00 PM Bank: Within Channel
Long. 125.02024
Weather: Overcast 10°C
Inspector: CHS

Description:

Left Bank Erosion

Erosion of the left bank has formed a scarp up to 3 m high over a 30m long reach. See photos.
Exposed vey stiff clay on the bank and in the channel bed with undermining of tree roots. See photos.
No formal trails are present on this bank but there are informal paths in the forrest above this bank.
Houses and fences are well set back from crest of bank, along Embelton Crescent.

Consequence:

The erosion has created a potential falling hazard.
Erosion may contribute to turbidity and sediment downstream, natural process.

Likelihood:

The erosion is slow and ongoing but will accelerate during storm and peak flow or when a tree overturns.
Low use area with informal paths, low chance of a pedestrian walking along the edge.

Risk: Very Low Low **Medium** High Very High

Possible Remedial Options:

Post unstable bank signs nearby.

Additional Comments:

Access poor, on foot through the forest.

Watercourse Stability Assessment Data Sheet

Report: Morrison #4
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19

Photos:

Photo 1, Left bank with erosion and undermining of tree roots visible.

Photo 2, Left bank and channel with exposed stiff clay, erosion and undermining of tree roots visible.

Photo 3, Left bank with undermining of tree roots, stiff clay exposed is visible.

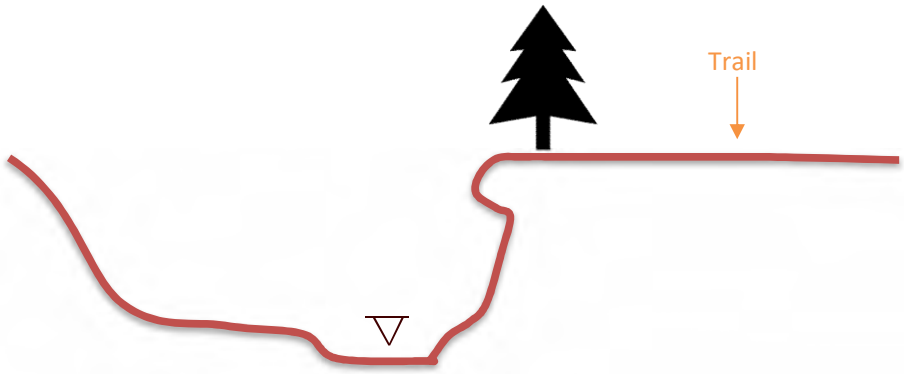
Watercourse Stability Assessment Data Sheet

Report: Morrison #5
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19
Site Location: Roy Stewart Morrison Park
Coordinates: Lat. 49.68125 +- 4m
Time: 01:10:00 PM Bank: Right
Long. 125.02019
Weather: Overcast 10°C
Inspector: CHS

Description:

Right Bank Erosion

Erosion on right bank has formed a scarp up to 5m high over a 20m long reach. Located on an outside bend in the creek alignment. See photo 1.
Exposes stratified very dense sand and gravel interbedded with sand and silt (possible glaciofluvial) see photos 2,3 and 4.
Bank slope is approximately 60°, with undermining of the tree roots.
Trail at the edge of the crest has been relocated away from the edge.



Consequence:

Erosion has created a potential falling hazard.
Erosion may contribute to turbidity and sediment downstream (natural process).

Likelihood:

The trail is currently well setback from the crest.

Risk:	Very Low	Low	**Medium**	High	Very High

Possible Remedial Options:

Post "unstable slope signs", monitor erosion and maintain minimum 3 m setback between path and crest of slope.
If necessary to protect fish habitat, could cut back crest, riprap the toe of the embankment and install bio-remediation structures on the slope for erosion control.

Additional Comments:

Access poor, narrow path in the park.

Watercourse Stability Assessment Data Sheet

Report: Morrison #5
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19

Photos:

Photo 1, Right bank erosion and bend in creek visible.

Photo 2, Erosion on right bank, undermined roots visible.

Photo 3, Erosion on right bank, undermined roots visible.

Photo 4, Erosion on right bank.

Watercourse Stability Assessment Data Sheet

Report: Morrison #6
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19
Site Location: Puntledge Park
Coordinates: Lat. 49.68774 +- 6m
Time: 03:15:00 PM Bank: Right
Long. 125.01566
Weather: Overcast 10°C
Inspector: CHS

Description:

Erosion
1 meter diameter concrete pipe, stormwater outfall. See photo 1.

Pipe discharges onto concrete apron near crest of slope and into timber flume which extends to creek at toe of slope, timber flume is approximately 6m high.

Timber flume has failed near crest allowing water to spill out of the left side onto the bank below. Failure of flume appears to be caused by degradation/rotting of the timber. See photos 2 and 3.

Failure of the timer flume has resulted in severe erosion of the slope below and has undermined the concrete apron. See photos 2 and 3.

Public path is setback 5m from the crest of bank and behind a fence.

Consequence:

Continued erosion of the slope may result in further damage to the flume and may eventually damage outflow pipe.
Erosion may contribute to turbidity and sediment downstream.

Likelihood:

Erosion appears active, flume has reach the end of its service life.

Risk: Very Low Low **Medium** High Very High

Possible Remedial Options:

Repair slope erosion with rockfill and replace flume with extended pipe anchored to slope and discharging at toe of slope.

Additional Comments:

Good access for service vehicles from Puntledge Park.

Watercourse Stability Assessment Data Sheet

Report: Morrison #6
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Morrison Creek
Date: Oct-24-19

Photos:

Photo 1, Concrete stormwater pipe flowing into timber flume.

Photo 2, Failure point of timber flume with water leaking onto bank, erosion is visible on the bank.

Photo 3, Failure point of timber flume with water leaking onto bank, erosion is visible on the bank.

Photo 4, Flume exiting into the creek at toe of bank.

Watercourse Stability Assessment Data Sheet

Report: Piercy #3
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Piercy Creek (?)
Date: Oct-24-19
Site Location: Comox Logging Road, east of Comox Valley Parkway.
Coordinates: Lat. 49.65932 +- 5m
Time: 05:30:00 PM
Bank: Within Channel
Long. 124.99583
Weather: Overcast 10°C
Inspector: CHS

Description:

Construction of Culvert

1.2m Diameter CSP Culvert.

Upstream of Culvert

No significant erosion is evident upstream of the culvert, good condition. See photo 1.

Embankment slope is 1.5H:1V, 3m high, dry stacked boulders armouring slope and 2m wide gravel shoulder between crest and EOP. See photos 1 and 2.

Downstream of Culvert

Mild erosion at outlet with a 0.5m drop into 0.3m deep pool. See photo 3.

Very dense till-like soil exposed at channel base in pool.

Embankment slope is 1.5H:1V and 5m high with a sloping 2m wide grass shoulder. See photo 4.

Consequence:

If erosion continues it could undermine culvert and embankments.

Drop at culvert outlet may be a barrier to fish.

Likelihood:

The erosion appears slow and slopes are not over-steepened.

Risk:	Very Low	**Low**	Medium	High	Very High

Possible Remedial Options:

Monitor and repair if necessary.

Additional Comments:

Access good from the Comox Logging Road.

Watercourse Stability Assessment Data Sheet

Report: Piercy #3
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Piercy Creek (?)
Date: Oct-24-19

Photos:

Photo 1, Upstream of culvert and culvert inlet.

Photo 2, Culvert inlet, dry stack boulder armouring visible on embankment slope.

Photo 3, Culvert outlet, mild erosion visible.

Photo 4, Grassy sloping shoulder leading to downstream embankment slope.

Watercourse Stability Assessment Data Sheet

Report: Puntledge #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Puntledge River
Date: Oct-24-19
Site Location: Near municiple boundary at Robert Lang Drive
Coordinates: Lat. 49.68510 +- 6m
Time: 02:05:00 PM Bank: Right
Long. 125.02899
Weather: Overcast 10°C
Inspector: CHS

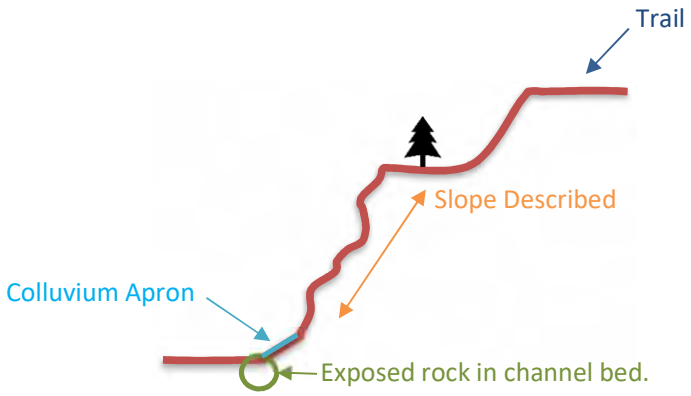
Description:

Erosion on Right Bank

The lower portion of the right bank is approximately 10m high with a slope of 0.5H:1V and locally overhanging. See photos 1 and 2.
Located along a 30m long eroded section, immediately downstream of confluence with a creek from the right bank, Just upstream of Rotary Trail stairs.

Exposed shale bedrock on bank extending up to crest and in channel bed. See photos 1, 2 and 3.

No formal trails near crest of lower portion of the slope, although informal trails do exist. The Rotary Trail located at the crest of the overall slope has signs at the entrance of the park warning of cliff.



Consequence:

Falling hazard, rockfall hazard and potential for bank crest instability.

Likelihood:

Erosion process typically slow in bedrock, but active and hazardous.
Formal trail at the top of the slope is well set back.

Risk:	Very Low	**Low**	Medium	High	Very High

Possible Remedial Options:

Review signage, consider increasing quantitiy of warning signs. No formal trails to river bank but fisherman and swimmers may find their way down.

Monitor bank erosion and setback of trail.

Additional Comments:

Access is from park trails.

Watercourse Stability Assessment Data Sheet

Report: Puntledge #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Puntledge River
Date: Oct-24-19

Photos:

Photo 1, Right bank slope with coluvium apron at base and exposed shale above.

Photo 2, Exposed shale on right bank with overhanging roots and vegetration.

Photo 3, River channel looking upstream.

Photo 4, Looking downstream from crest of lower slope.

Watercourse Stability Assessment Data Sheet

Report: Tsolum #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Tsolum River
Date: Oct-23-19
Site Location: Exhibition Grounds - Public Trail
Coordinates: Lat. 49.70684 +- 4m
Time: 02:55:00 PM Bank: Left
Long. 125.01195
Weather: Overcast 10°C
Inspector: CHS

Description:

Left River Bank
Fine sand and silt (alluvium) exposed on the river bank and has eroded adjacent to the public footpath. See photos 1, 2 and 3.

A wooden fence has been installed along the bank. See photo 1.

The erosion on the bank forms a scarp up to 1.5m high, See photo 3.

Consequence:

If erosion continues it may damage the fence and footpath. Potential for personal injury if pedestrian does not see the damage to path.

Likelihood:

Sand and silt is highly erodible during floods and heavy rains.
Pedestrians likely to notice any damage and would walk around.

Risk:	Very Low	**Low**	Medium	High	Very High

Possible Remedial Options:

Redirect path locally to increase set back from natural erosion process.
Erosion could potentially be repaired/mitigated with the installation of riprap.
Erosion should be monitored with the risk managed appropriately.

Additional Comments:

Access along the path.

Watercourse Stability Assessment Data Sheet

Report: Tsolum #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Tsolum River
Date: Oct-23-19

Photos:

Photo 1, Public footpath and left bank of river, erosion visible.

Photo 2, Left bank erosion.

Photo 3, Left bank erosion.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-2019
Site Location: 6th Street East at Back Road
Coordinates: Lat. 49.70038 +/- 4m
Time: 10:45:00 AM Bank: Within Channel
Long. 124.97778'
Weather: Sunny 10°C
Inspector: CHS

Description:

Culvert Construction

Two CSP culverts pass creek below back road, 0.9m and 1.2m diameter.

Downstream of culvert

Culvert outlets riprapped but significant erosion below pipes, eroding embankment 1.5m back into slope. Embankment slope is approximately 2.5m high. See photos 2 and 3.

Downstream of outlets, very dense glacial till-like soil exposed in banks, approximately 2m high.

Downstream channel contains riprap up to 0.5m diameter, discontinuous coverage.

Upstream of culvert

Modern concrete culvert headwall at inlets.

0.6m diameter (HDPE?) storm outlet at culvert inlet, built into the concrete headwall, see photo 1.

Upstream of inlet, channel is in good condition - no erosion, gully approximately 2m deep with recent 150mm to 300mm diameter riprap armoring edges of headwall.

Consequence:

Significant to the roadway, if erosion at the outlet persists could eventually undermine south shoulder of Back Road and damage culverts.
0.3m drop at culvert outlets may not be passable for fish if applicable.

Likelihood:

Erosion episodic in peak flows, moderate chance of a problem affecting roadway within next 20 years.

Risk: Very Low | Low | **Medium** | High | Very High

Possible Remedial Options:

Repair undermining erosion at culvert outlets, riprap/rockfill. Relatively straightforward repair due to short embankments.

Additional Comments:

Access is good from the road.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #1
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-2019

Photos:

Photo 1, Concrete headwall at inlet.

Photo 2, Culvert outlets, erosion visible.

Photo 3, Erosion undermining culvert outlets.

Photo 4, Downstream of culvert outlets, mild erosion on left hand bank visible.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #2
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: Aston Place
Coordinates: Lat. 49.70101 +/- 4m
Time: 11:15:00 AM Bank: Within Channel
Long. 124.97622
Weather: Cloudy 10°C
Inspector: CHS

Description:

Culvert Construction

Concrete box culvert approximately 1.2m x 2m.

Upstream of Culvert

Concrete headwall at inlet. Timber bracing across top between wing walls (abandoned formwork?). Upstream of inlet, left bank supported by a lock block wall, 3 blocks high, and right bank supported by a concrete CIP wall 1.5m high. See photos 1 and 2.

Downstream of Culvert

Concrete wing walls at culvert outlet.
Observed several fish up to 0.2m long in creek.
Downstream of outlet structure, private retaining walls to 1m high, timber and concrete, retaining back yard fill. See photos 3 and 4.

Consequence:

Degradation of private timber walls downstream of culvert could result in increased sediment/turbidity or wood debris.

Likelihood:

Slow progress as wood degrades and retained soil erodes.

Risk: **Very Low** Low Medium High Very High

Possible Remedial Options:

Private wall should be maintained or removed if in disrepair.

Additional Comments:

Access to walls downstream of culvert is through private property.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #2

Client: Urban Systems (for City of Courtenay)

File No. 25690

Watercourse: Glen Urquhart Creek

Date: Oct-23-19

Photos:

Photo 1, up stream of culvert, concrete walls and bracing visible.

Photo 2, Inlet of box culvert.

Photo 3, Outlet of culvert, and private retaining walls further downstream.

Photo 4, Private timber retaining walls on left bank.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #3
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: 10th Street East
Coordinates: Lat. 49.70037 +/- 6m
Time: 11:40:00 AM Bank: Within Channel
Long. 124.97305
Weather: Cloudy 10°C
Inspector: CHS

Description:

Culvert Construction

1.2m diameter CSP.

Upstream of Culvert

Wide gully in Hobson Park.

Approximately 10m upstream of inlet there is mild localized erosion on the right bank forming a 1.5m high bank. See photos 1 and 2.

Upstream road embankment slope covered with ivy, 4m high with a slope of 2H:1V. See photo 2.

Downstream of Culvert

Severe erosion at the culvert outlet, 1m drop into 1m deep eroded pool, exposing very dense till like soil, erosion has undermined culvert extending 1.5m back into embankment, downstream road embankment slope was 1.5H:1V and 4m high. To the right of the culvert outlet there is a 0.6m diameter storm outfall.

To the left of the culvert outlet, the embankment fill slope has been eroded at the outlet of a presently dry 150mm diameter PVC pipe which extends from the nearby catch basin. This fill erosion extends to within 1m of edge of sidewalk at crest of slope.

Consequence:

Potential for instability of downstream fill embankment slope and 10th Street East sidewalk if erosion continues unabated.

Drop in creek channel at culvert outlet may be a barrier to fish passage.

Likelihood:

Episodic during peak flows and storms. Erosion more rapid in fill than till-like soil.

Moderate chance of instability in next 20 years. High chance of an issue with the sidewalk due to the catch basin drain pipe.

Risk: Very Low | Low | Medium | **High** | Very High

Possible Remedial Options:

Connect CB to storm sewer or extend pipe to toe of slope.

Repair erosion of embankment and toe with rockfill or soil bag retaining wall or similar.

Additional Comments:

Access good from 10th Street East, long reach to toe of slope.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #3
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19

Photos:

Photo 1, Mild erosion on right bank upstream of culvert.

Photo 2, inlet of culvert.

Photo 3, Outlet of culvert, storm and PVC pipe, Erosion visible below culvert outlet and pvc outlet near crest of slope.

Photo 4, Downstream of culvert outlet, erosion visible on left bank.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #4
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: 12th Street East
Coordinates: Lat. 49.69920 +/- 6m
Time: 12:20:00 AM Bank: Within Channel
Long. 124.97181
Weather: Cloudy 10°C
Inspector: CHS

Description:

Culvert Construction

1.1m x 1.8 m concrete box culvert. At culvert outlet there are also a 0.3m diameter PVC pipe and a 0.45m diameter CSP storm outlet which discharge to the creek.

Upstream of Culvert

In good condition, relatively new concrete structure, see photo 1.
Very dense till-like soil exposed in channel base just upstream, see photo 2.

Downstream of Culvert

Outlet in good condition, relatively new concrete structure with 150mm to 300mm diameter riprap protecting banks.
Further downstream, very dense till like soils exposed in channel base.
0.2m high drop at outlet of concrete structure.
See photos 3 and 4.

Consequence:

N/A

Likelihood:

N/A

Risk: **Very Low** Low Medium High Very High

Possible Remedial Options:

Monitor and maintain.

Additional Comments:

Good access from 12th Street East.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #4
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19

Photos:

Photo 1, Inlet of Culvert.

Photo 2, Upstream of culvert inlet, channel base visible.

Photo 3, Downstream of Culvert outlet, riprap and channel base visible.

Photo 4, Outlet of Culvert and other pipes, riprap bank protection is visible.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #5
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: Hobson Avenue - East of Segers St
Coordinates: Lat. 49.69714 +/- 8m
Time: 12:40:00 AM Bank: Within Channel
Long. 124.96606
Weather: Cloudy 10°C
Inspector: CHS

Description:

Culvert Construction
1.2m diameter concrete pipe with concrete headwalls at inlet and outlet.

Upstream of Culvert
Good condition, channel lined with riprap, 150mm to 450mm diameter. See photo 1.
A one block high lock-block wall above the concrete wing wall on the left bank, see photo 1.

Downstream of Culvert
Good condition, no significant erosion at culvert outlet.
A 0.45m diameter stormwater corrugated plastic pipe outfalls.
Downstream of the culvert in Hurford Hill Nature Park, the channel banks are 0.5m to 2m high exposing very stiff clay (possibly glaciomarine), see photo 3.

Consequence:

Park trails are well setback from the eroded banks within the reach observed downstream of the culvert outlet.

Likelihood:

N/A

Risk: **Very Low** Low Medium High Very High

Possible Remedial Options:

Monitor and Maintain.

Additional Comments:

Access is good from Hobson Avenue.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #5

Client: Urban Systems (for City of Courtenay)

File No. 25690

Watercourse: Glen Urquhart Creek

Date: Oct-23-19

Photos:

Photo 1, Upstream of culvert with riprap and concrete block wall visible.

Photo 2, Inlet of culvert.

Photo 3, Downstream of culvert, left bank erosion has exposed clay.

Photo 4, outlets of culvert and storm drainage.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #6
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: Thorpe Avenue
Coordinates: Lat.49.69786 +-5m
Time: 01:25:00 PM Bank: Within Channel
Long. 124.96394
Weather: Overcast 10°C
Inspector: CHS

Description:

Culvert Construction
Two Culverts, 0.75m diameter and 0.9m diameter concrete pipes.
Also a 0.6m diameter corrugated plastic storm pipe outfall to left of culvert outlet (see photo 1).

Downstream of Culvert
Mild erosion, exposing very dense sand and silt (possible glacialfluvial).
Banks armoured with 150mm to 500mm riprap. See photos 1 and 2.

Upstream of Culvert
Riprap and concrete sack wall as culvert headwall, in good condition. See photos 3 and 4.

Consequence:

If significant erosion occurs in the future, could undermine pipes, road embankment and public path.

Likelihood:

Very dense soils typically erode slowly, may accelerate during peak flows.

Risk:	Very Low	**Low**	Medium	High	Very High

Possible Remedial Options:

Monitor and repair erosion as needed.

Additional Comments:

Good from Hobson Avenue.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #6
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19

Photos:

Photo 1, Culvert outlets and storm outlet, mild erosion visible.

Photo 2, Downstream of outlet, riprap visible.

Photo 3, Upstream of culvert inlets.

Photo 4, Culvert inlets, concrete bag wall and riprap visible.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #7
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: Mallard Drive
Coordinates: Lat. 49.70232 +- 3m
Time: 02:10:00 PM Bank: Within Channel
Long. 124.46297
Weather: Overcast 10°C
Inspector: CHS

Description:

Culvert Construction
0.9m diameter concrete pipe.

Upstream of Culvert
Inlet is concrete headwall structure with debris rack, clear and good condition.

Downstream of Culvert
Outlet is lock block wall, 1.5m High - no erosion and good condition.

Consequence:

N/A

Likelihood:

N/A

Risk: **Very Low** Low Medium High Very High

Possible Remedial Options:

Monitor and maintain.

Additional Comments:

Access is good from Mallard Avenue.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #7

Client: Urban Systems (for City of Courtenay)

File No. 25690

Watercourse: Glen Urquhart Creek

Date: Oct-23-19

Photos:

Photo 1, Upstream channel and culvert.

Photo 2, Culvert inlet.

Photo 3, Culvert outlet.

Photo 4, Downstream of culvert outlet.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #8
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: Hobson Park
Coordinates: Lat. 49.70001 +- 6m
Time: 12:10:00 PM
Bank: Within Channel
Long. 124.97262
Weather: Cloudy 10°C
Inspector: CHS

Description:

Obstruction
Within Hobson Park several fallen trees and other woody debris have formed a small dam, backing up water and sediment. See photos 1-3.

Consequence:

If debris dam collapses during peak flow, will exacerbate flooding and erosion downstream.

May also be a barrier to fish passage.

Likelihood:

Timing depends upon the condiiton of fallen logs, high likelihood within next 20 years.

Risk:	Very Low	**Low**	Medium	High	Very High

Possible Remedial Options:

During low flow cut up logs and release impounded water and sediment in controlled manner (e.g. public works crew with chainsaws and shovels).

Additional Comments:

Access is good by foot from the park.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #8
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19

Photos:

Photo 1, Fallen trees creating dam, sediment bulid up visible.

Photo 2, Fallen trees creating dam, sediment bulid up visible.

Photo 3, Fallen trees creating dam.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #9
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: Hurford Hill Nature Park
Coordinates: Lat. 49.6970 +- 6m
Time: 01:00:00 PM Bank: Within Channel
Long. 124.46475
Weather:
Inspector: CHS

Description:

Obstruction
Log jam within channel is impounding water and sediment, located approximately 20m downstream of pedestrian bridge, see photos 2 and 3.

Consequence:

Sudden release of impounded water and debris may exacerbate erosion, flooding and blocking of culverts downstream, especially if it occurs during a peak flow event.

Debris jam may be an obstruction to fish passage.

Likelihood:

Timing depends on the condition of logs, very likely within next 20 years.

Risk:	Very Low	**Low**	Medium	High	Very High

Possible Remedial Options:

During low flow, cut up logs and release impounded water and sediment in controlled manner (e.g. public works crew with chainsaws and shovels).

Additional Comments:

Access is good from public path.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #9
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19

Photos:

Photo 1, Channel condition downstream of obstruction.

Photo 2, Log jam viewed from upstream, impounded water visible.

Photo 3, Log jam viewed from downstream.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #10
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: Hurford Hill Nature Park (south of Thorpe Avenue)
Coordinates: Lat. 49.69767 +- 7m
Time: 01:10:00 PM Bank: left
Long. 124.96414
Weather: Overcast 10°C
Inspector: CHS

Description:

Pedestrian Bridge on Park Trail

Erosion has down cut channel/banks 1.2m high and under cut the root mat on the left bank. Left abutment of the timber pedestrian bridge sits on root mat that is undermined.

Right bridge abutment set back from top of bank by 1.0m.

Exposed soils are 0.5m of topsoil and roots overlying very dense sand interbedded with silt (possible glacialfluvial).

Consequence:

Damage to bridge and pedestrian path if the undermined left abutment collapses.
Could result in injury if someone is on the bridge when collapses.

Likelihood:

Soils very dense with slow erosion, may stand despite undermining for several years, high chance of damage to bridge within 20 years. Low likelihood of someone on the bridge during collapse but possible.

Risk: Very Low | Low | **Medium** | High | Very High

Possible Remedial Options:

Repair eroded / undermined banks with riprap or soil bag retaining wall.
Or extend bridge to increase setback between abutments and bank.
Monitor regularly.

Additional Comments:

Access good from public path.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #10
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19

Photos:

Photo 1, Pedestrian bridge and left bank undermining visible.

Photo 2, Left bank undermining , bridge abutment visible.

Photo 3, Left and right banks, looking downstream.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #11
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: Upstream of Thorpe Avenue
Coordinates: Lat. 49.69792 +- 4m
Time: 01:40:00 PM Bank: Left
Long. 124.96222
Weather: Overcast 10°C
Inspector: CHS

Description:

Retaining wall on left bank, 0.7m high, is leaning outward and degrading.

Retaining wall consists of horizontal timber boarding and woven bags and bricks with steel T- bar fencing posts.

Stiff clay is exposed nearby at channel base.

New looking timber railings and "narrow trail" signs are present on the pedestrian trail.

Consequence:

If wall collapses, trail may be closed until repaired.

Debris from collapsed wall could obstruct flow downstream.

Likelihood:

Failing wall could collapse at anytime, especially likely during storms.

Risk: Very Low Low **Medium** High Very High

Possible Remedial Options:

Remove failing wall before collapses.
Replace with a more durable wall, e.g. concrete block, large riprap or soil bags.

Additional Comments:

Access is good from within the park.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #11
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19

Photos:

Photo 1, Looking upstream towards failing wall and trail.

Photo 2, failing wall looking upstream.

Photo 3, failing wall looking downstream.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #12
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19
Site Location: Downstream of Malahat Drive
Coordinates: Lat. 49.70115 +- 4m
Time: 02:00:00 PM Bank: left/Right
Long. 124.96342
Weather: Overcast 10°C
Inspector: CHS

Description:

Pedestrian bridge in Park
Timber bridge with concrete pier and abutment footings.

The edge/corner of the left and right pier footings have been mildly undermined by erosion.

Creek bank is 0.5m high, very dense sand and silt (possible glaciofluvial) exposed in the channel base.

Consequence:

Pedestrian bridge may be damaged if erosion continues to undermine footings.

Likelihood:

Only likely during peak flows and heavy rains.

Risk:	Very Low	**Low**	Medium	High	Very High

Possible Remedial Options:

Monitor and repair as needed.

Additional Comments:

Access is good from within the park.

Watercourse Stability Assessment Data Sheet

Report: Urquhart #12
Client: Urban Systems (for City of Courtenay)
File No. 25690
Watercourse: Glen Urquhart Creek
Date: Oct-23-19

Photos:

Photo 1, Pedestrian Bridge Looking Downstream, right bank abutment visible.

Photo 2, Right bank abutment undermining.

Photo 3, Looking upstream at right bank abutment.

Photo 4, undermining on left bank abutment.