VERNON
Regional Airport
MASTER PLAN

Appendix D

Runway Feasibility Report At Vernon Regional Airport

TETRA TECH EBA

OQM | Organizational Quality Management Program

RUNWAY FEASIBILITY REPORT AT VERNON REGIONAL AIRPORT

PRESENTED TO
City of Vernon

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CONSULTING ENGINEERS & SCIENTISTS · www.eba.ca

Tetra Tech EBA Inc.
150, 1715 Dickson Avenue
Kelowna, BC V1Y 9G6 CANADA
Tel 250.862.4832 Fax 250.862.2941

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the City of Vernon and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the City of Vernon, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech EBA) has been retained by the City of Vernon to undertake a feasibility study for three potential runway extension options at the Vernon Regional Airport (YVK) with respect to the civil and environmental impacts. The three potential runway extension options are provided to better serve business and general aviation aircraft at YVK.

The current Transport Canada Aerodrome Standards and Recommended Practices manual TP312E 4th Edition (TP312E), 1993 applies as the reference manual for the civil requirements. Although TP312E classifies the runway Code by runway length, it has been our experience that some flexibility can exist that may allow a Code 2 runway to exceed the standard 1,200 metre length. During the production of this study, a 5th edition of the TP312E document has been released in DRAFT format and some brief comments are provided in this report.

This report will provide the civil components of the runway extension options first followed by the environmental components.

2.0 CIVIL BACKGROUND INFORMATION REVIEWED

Airfield Expansion and Rehabilitation Project drawings done by Pryde Schropp McComb Inc. – September 2006.

3.0 DESIGN CRITERIA

Current TP312E standards classify the runway as Code 2B which allows aircraft with a wingspan up to but not including 24 m and a runway length up to but not including 1,200 m. Increasing the runway beyond that length would technically increase the runway to a Code 3 thereby requiring wider runway separation distances etc., effectively making the runway non-compliant with current regulations. However, as mentioned above and discussed later, we anticipate a runway length in excess of 1,200 m to be achievable.

The design aircraft has been the Beechcraft B1900 twin propeller but the critical aircraft for design purposes of this study is the Citation Encore turbojet.

All distances provided are based on estimates derived from computer aided drawings (CAD) and aerial photo information and will have to be verified at a later date with a topographic survey. Additionally, these options presume no obstacles conflict with the Obstacle Limitation Surfaces (OLS) or Zoning Bylaw 4888. Any obstacles within the OLS have not been identified or assessed.

Three options for the lengthening of the runway are provided as follows:

- Option 1: Provides a total runway length of 1,100.5 m (3,610 feet). This is the maximum length possible without encroaching onto Vernon Creek to the west while maintaining a 60 m wide runway strip within the current airport boundaries to the east. This provides an 8.8 m extension to the west and a 19.6 m extension to the east. The longitudinal 60 m long strip off the west end of the runway is shown at a slope of 2.5% which exceeds the recommended TP312E slope of 2%. The runway extension design drawings done by Pryde Schropp McComb Inc. shows a 2.5% strip which was likely provided due to the proximity of Vernon Creek. For the purposes of this study, we show the same slope.

- Option 2: Provides a total runway length of 1,219.2 m (4,000 feet) by extending the runway to the east as per Option 1 and extending to the west by diverting Vernon Creek through a new culvert. The new culvert would be built adjacent to the existing creek bed to prevent disturbing the watercourse during construction.

- Option 3: Provides the identical configuration as Option 2 except Vernon Creek would be diverted around the western end of the runway and associated strip, eliminating the culvert requirement under the runway structure.

The key design criteria for this study are as follows:

- Design aircraft – Citation Encore.
- Asphalt construction based on previous runway extension done in 2006.
- Grassed compacted earthworks for graded areas to the edge of asphalt runway edges.
- Runway asphalt length: 1,219.2 m (4,000 feet) except for Option 1.
- Runway asphalt width: 23 m.
- Runway strip length – 60 m beyond both asphalt runway ends (grass surface). Designed to support aircraft in case of run-off.
- Graded portion of strip either side of asphalt runway edge: 11.5 m at 3%.
- Side slopes beyond the graded portion of runway strip: maximum 25% (4:1).
- Longitudinal slope on 60 m runway end strips: maximum 2.5% on west end only.
- Runway cross section complies with requirements for a Code 2B Non-Instrument runway.
- Runway take-off/approach surfaces of option drawings remain within the City of Vernon Bylaw 4888 protected surfaces.
- An option for 30 m long asphalt blast pads on each runway end is included which may provide a higher level of safety by reducing FOD potential and scour of grass surfaces caused by take-off thrust jet blast.
- Turning D's are provided at both ends of the extended runway.
- Precision Approach Path Indicators (PAPIs) would be relocated on the west end of the runway.
- Displaced threshold on east end of runway (Runway 23) would remain as is.
- Additional runway edge lights required.
- Runway end and threshold lights will be relocated as required.

4.0 STAKEHOLDER INPUT

Various stakeholders were contacted in regards to their specific runway requirements and how a runway extension may impact their operations. Stakeholders were informed that the purpose of this study is to review the potential impacts of providing an approximate 1,219 m (4,000 feet) long runway. The following stakeholder responses are provided based on that.

Stakeholder	Response
Kal Tire – Rod Barnard	▪ Runway lengthening to 4,000 feet would enhance key safety and efficiency issues. ▪ Better instrument approach/departure procedures should be reviewed. ▪ Runway grooving is key to safety as a wet runway is the most restrictive element to their operations and grooving eliminates 95% of the penalties.
NT Air – Doug Brown (Chief Pilot)	▪ Would welcome extension that would allow their B1900's access for charters.
BDK Air – John Rogers	▪ Very interested in a potential runway extension. ▪ Would increase safety dramatically. ▪ Runway grooving and better instrument approach/departures requested.
Dax Air – Greg McQuaid (Chief Pilot)	▪ No problem for PC12 with current runway length. ▪ A Runway extension could potentially allow use of their jet aircraft
Aurora Jet Partners – Brice Knelson (Chief Pilot)	▪ Supports runway extension as it would allow more of their aircraft access to Vernon. Would like a WAAS LPV approach procedure. Runway grooving would be welcomed.
BC Air Ambulance – Paul Bouchard	▪ Can't comment specifically on Vernon but generally they reduce fuel loads between May 1 and September 30 for shorter runways due to increased ambient temperatures.
Carson Air	▪ Supports runway extension and believes this could allow their Medevac jets to get in. ▪ Suggests an improved Instrument Approach Procedure.
Airsprint – Chief Pilot	▪ Supports runway extension as it would allow their Citation XL and CJ2+ jets access to Vernon. A RNAV approach would also be welcomed if possible.
Pacific Coastal – Jeff Tillapaugh	▪ Extension to 4,000' would make it more feasible to access Vernon however a weight penalty due to runway length/temperature/gradient etc. would reduce passenger loads of the B1900. A business case study would have to be done but there is potential for service.

5.0 CIVIL DESIGN CONSIDERATIONS

We note that the 2006 runway extension drawings denote an obstacle approximately 298 m from the existing runway end that would protrude through the proposed take-off/approach surface on the west end of Runway 05-23. Our understanding in discussions with the City of Vernon is the take-off/approach surface on the west end should be free of obstacles within the Zoning Bylaw 4888 protected surface. As the take-off/approach surfaces in the following options lie above the Bylaw 4888 protected surface, permanent obstacles should therefore not be an issue. Obstacles within the OLS transitional surface have not been identified or assessed.

Therefore by relocating the existing displaced threshold of Runway 05 and associated lighting, PAPIS etc. to the existing runway end, additional landing distance on Runway 05 of approximately 111 m (364 feet) should be possible.

5.1 Option 1 - Extend the Runway East and West

This option provides a small extension on each end of the existing runway in order to maximize runway length without impacting Vernon Creek. See Figure 1A and Figure 1B.

East End

The displaced threshold of Runway 23 would remain in the present location due to existing obstacles in the take-off/approach surface. The existing runway does not have a Turning D however this design provides that. The ground topography to the east is relatively flat with a rising grade that closely matches the existing runway profile therefore earthworks required for this runway extension should be minimal. The runway strip width (30 m each side of centreline) should fall within the airport property boundary. To provide that, the runway length potential is reduced since the eastern airport property boundary is skewed to the runway alignment.

A blast fence is shown near the eastern property boundary to ensure impacts of potential jet blast are minimal to surrounding properties. A future study may determine jet blast is manageable but a blast fence should be considered with this extension.

Paint markings would be unaffected.

Additional edge lights would be required along with relocation of existing runway end lights.

Extending this end of the runway would not increase the landing distance for approaches on Runway 23 but it would provide a longer take-off distance from Runway 23. Technically, it would also provide a longer take-off distance from Runway 05 as per current TP312E standards.

West End

The current displaced threshold of Runway 05 would be relocated to the new runway end. The existing Turning D would be lengthened to the new runway end. Paint markings including threshold and runway designation number would be relocated. Centreline marking stripes and gaps distances would need to be reviewed. These could possibly be designed to ‘best fit’ the relocated threshold on a temporary basis with a contingency plan to paint all new markings with a future runway asphalt rehabilitation program. Existing paint markings being replaced would be eradicated.

A Code 2B Non Instrument runway requires a 30 m wide strip each side of the runway centreline that must be obstacle free. Additionally, the first 23 m each side of the runway centreline should be graded at a maximum 3% crossfall from the runway edge in the event an aeroplane should run off the runway. Vernon Creek currently encroaches within the runway strip near the current southwest side of runway end hereafter referred to as the right bank. Stabilization of the creek bank with a rip rap fence or equivalent is required.

Additional edge lights would be required and relocation of existing runway end lights and PAPIS. Existing threshold wing bar lights would be relocated to the new runway end adjacent the end lights.

5.1.1 Runway Declared Distances

See Figure 1A for existing and potential declared distances for this option. This option provides an approximate additional 28 m (93 feet) of runway length, from 3,517 feet to 3,610 feet. The most significant impact is this option increases the landing distance by 139 m (456 feet) on Runway 05. Note that this is based on an obstacle free approach surface.

5.1.2 Project Costs

See Table 1 for estimated costs for this option. Project costs are estimated at $800,000 which includes construction, engineering, project management and contingencies.

5.2 Option 2 - Extend the Runway East and West with a Culvert in Vernon Creek

This option provides a total runway length of 1,219.2 m (4,000 feet) by extending the runway to the east as per Option 1 and extending to the west by diverting Vernon Creek through a new culvert. The new culvert would be built adjacent to the existing creek bed to prevent disturbing the watercourse during construction.

East End

The east end extension would be identical to Option 1.

West End

The current displaced threshold of Runway 05 would be relocated to the new runway end. The existing Turning D would be either decommissioned by providing a runway edge line in this area or by providing actual removal of the asphalt surface and replacement with topsoil and hydroseed. For the purposes of this study, we would provide a runway edge paint marking in order to minimize construction costs.

A new culvert for Vernon Creek is required with this option as mentioned above. For this study, we have estimated a concrete box culvert approximately 85 m long in order to encompass the 60 m wide runway strip and projected toe of fill each side of the new construction. The preferred style of culvert is the box culvert due to ease of installation and bedding soil type is not as critical to the culvert design. We understand that the bottom of the box culvert could be designed with baffles in order to hold gravel resembling a creek bottom. The alternate style of culvert would be an open bottom that provides concrete footings on each side of the creek channel for a steel multi-plate culvert to be anchored. This design is more susceptible to soil type and installation is more labour intensive. Future designs may consider an overflow dyke that would divert water away from the culvert during abnormal rain events, allowing the culvert to be designed for a 5 year peak storm event.

Stabilization of the Vernon Creek bank noted in Option 1 is required.

Paint markings including threshold and runway designation number would be relocated. Centreline marking stripes and gaps distances would need to be reviewed. These could possibly be designed to ‘best fit’ the relocated threshold on a temporary basis with a contingency plan to paint all new markings with a future runway asphalt rehabilitation program. Existing paint markings being replaced would be eradicated.

Additional edge lights would be required and relocation of existing runway end lights and PAPIS. Existing threshold wing bar lights would be relocated to the new runway end adjacent the end lights.

5.2.1 Runway Declared Distances

See Figure 2A for existing and potential declared distances for this option. This option provides an approximate additional 118 m (483 feet) of runway length, from 3,517 feet to 4,000 feet. The most significant impact is this option increases the take-off distances on both runways. As well, the landing distance is increased on Runway 05. Note that this is based on an obstacle free approach surface.

5.2.2 Project Costs

See Table 2 for estimated costs for this option. Project costs are estimated at $3,915,000 which includes construction, engineering, project management and contingencies.

5.3 Option 3 - Extend the Runway East and West with Re-alignment of Vernon Creek

This option provides a total runway length of 1,219.2 m (4,000 feet) by extending the runway to the east and west as per Option 2; however, Vernon Creek is diverted around the end of the runway strip. This option provides relocation of approximately 741 m of Vernon Creek without the need for a culvert. Additionally, this option would maintain approximately 195 m of the abandoned portion of Vernon Creek, north of the runway.

East End

The east end extension would be identical to Option 1.

West End

The west end runway extension would be identical to Option 2; however, rather than providing a culvert under the runway, this option would relocate Vernon Creek around the future 60 m long runway strip. See the environmental portion of this report.

Stabilization of the Vernon Creek bank noted in Option 1 is required.

Paint markings, additional edge lights, relocation of existing runway end lights, PAPIS and wing bar lights would be identical to Option 2.

5.3.1 Runway Declared Distances

See Figure 3A for existing and potential declared distances for this option. This option provides an approximate additional 118 m (483 feet) of runway length, from 3,517 feet to 4,000 feet with declared distances identical to Option 2.

5.3.2 Project Costs

See Table 3 for estimated costs for this option. Project costs are estimated at $2,930,000 which includes construction, engineering, project management and contingencies.

5.4 Option 4 - Extend the Runway West with Re-alignment of Vernon Creek

This option provides a total runway length of 1,219.2 m (4,000 feet) by extending the runway to the west only with Vernon Creek diverted around the end of the runway strip. This option provides relocation of approximately 741 m of Vernon Creek without the need for a culvert. Additionally, this option would maintain approximately 195 m of the abandoned portion of Vernon Creek, north of the runway.

East End

No construction on this end.

West End

The west end runway extension would be identical to Option 3 with an extra 19.6 m (64 feet) than Option 3. This option would relocate Vernon Creek around the future 60 m long runway strip. See the environmental portion of this report.

Stabilization of the Vernon Creek bank noted in Option 1 is required.

Paint markings, additional edge lights, relocation of existing runway end lights, PAPIS and wing bar lights would be similar to Option 2.

5.4.1 Runway Declared Distances

See Figure 4A for existing and potential declared distances for this option. This option provides an approximate additional 118 m (483 feet) of runway length, from 3,517 feet to 4,000 feet. The most significant impact of this option versus Option 2 or Option 3 is it increases the landing distance available on Runway 23. Take-off distances are increased to 4,000 feet. Note that this is based on an obstacle free approach surface.

5.4.2 Project Costs

See Table 4 for estimated costs for this option. Project costs are estimated at $2,491,000 which includes construction, engineering, project management and contingencies.

6.0 ENVIRONMENTAL CONSIDERATIONS

6.1 Introduction

The environmental considerations of this study are provided with respect to: environmental effects; permitting requirements; and, avoidance, mitigation and if necessary offsetting measures. The environmental assessment includes an overview of the ecological conditions and context of Vernon Creek, local wetlands, and habitat features within the area.

6.2 Background – Ecological Context

The study reach is located within the Vernon Waterfront Plan Area in Okanagan Landing, west of Vernon's city centre and 100 m upstream of Okanagan Lake. The Waterfront Environmental Study, and associated Sensitive Habitat Inventory Mapping (SHIM) mapping, describes Lower Vernon Creek as degraded by agriculture and development. The adjacent wetlands are assessed as 'Functional – At Risk' (EBA 2004). Field assessments confirm that channelization has led to down cutting, loss of spawning and rearing habitat, and a dramatic loss of riparian vegetation and streamside cover (EBA 2008).

The Vernon Waterfront Neighbourhood Plan bylaw was approved by the City of Vernon in 2002. The plan outlines guidelines to protect the ecology and increase biodiversity while compensating for features that may be lost through development. Guidelines for habitat mitigation were provided in the Waterfront Environmental Study in Okanagan Landing (EBA 2004).

6.3 Ecological Context – Summary

Vernon Creek has been impacted over time by channelization, vegetation removal, and urbanization. The creek and most of the adjacent wetland communities are rated "Functional – At Risk" (EBA 2004). In spite of its impacted state, several rare plants and animals have been found in the study area (Appendix B).

Rare plant occurrences within the study area include mosquito fern, Awned Cyperus (Cyperus squarrosus), which is one of nine known sites in the province where this plant has been found. Of these, there may be only 1 – 3 populations with good viability (CDC 2005). The plant has been found in the oxbow across from the Marshall Fields, and also along 70 m of the main channel of Vernon Creek (CDC 2008). The creek occurrence is considered transitory, as opposed to a stable population (Martin 2008). Awned Cyperus is a Blue-listed marginal aquatic plant. It was also found in the oxbow across from Marshall Fields. This oxbow will remain undisturbed under the all the options in the present concept plan. Field dodder is a Blue-listed parasitic plant. It was found

growing on wormwood in the Marshall Fields in September of 1995 (CDC 2008), and growing on sow thistle south of the Marshall Fields in 2010 (EBA 2010). Blue vervain is a Blue-listed plant that prefers low-land moist to wet ditches, meadows and marshes and is expected within the ditch network paralleling Okanagan Landing Road (Figure 1; CDC 2008).

Rare wildlife species that reside in the study area include Spadefoot and Painted Turtle. These Blue-listed species live and reproduce in the wetlands around the creek and in the Vernon Waterfront Area. Long-toed Salamander and Tree Frog have also been found in several of the wetlands. Anecdotal occurrences of Western Rattlesnake (Blue-listed), Gopher Snake (Blue-listed) and Rubber Boa have been reported (EBA 2004). The current range of the American Badger (Red-listed) also overlaps the Study Area. Several rare birds such as Western Grebe, Short-eared Owl, American Bittern, Swainson's Hawk, and Long-billed Curlew have been known to occur in the area while historical records account for the presence of Western Screech Owl (Red-listed) and Grasshopper Sparrow (Red-listed) adjacent to the Study Area. The birds may have been using the site as a stop-over during migration, or for foraging. No nest sites of these species have been recorded in the area.

The creek supports fish species including Rainbow Trout, Kokanee, Peamouth Chub, Longnose Dace, Largescale Sucker, Prickly Sculpin, Redside Shiner, Northern Pikeminnow and Carp, an exotic fish. The exotic Pumpkinseed Sunfish have been caught in one of the wetlands. The field assessment revealed that the creek in this reach is unlikely to support spawning (EBA 2008). However, Vernon Creek within the Study Area provides an important starting point for migrating Kokanee from Okanagan Lake to the upper lakes in the watershed such as Wood Lake and Duck Lake.

The CDC also reports nine masked occurrences[1] with potential to occur at or adjacent to the Study Area.

6.4 Options Assessment – Environmental

Four options have been put forth for consideration by the City of Vernon. These are described in Section 3.0, above. In this section we will summarize and review the potential environmental effects of each, followed by an outline of environmental permitting requirements, and avoidance, mitigation and compensation measures, as required. The chart provided in Figure 5 provides a comparison of the potential environmental effects and mitigation measures for each option. Figure 6 provides a comparison of the environmental permitting requirements for each option.

For each option, filling 475 m^2 of a portion of the floodplain of Vernon Creek at the southwest corner of the existing runway is required to accommodate the required width of the graded portion of the runway strip. This will likely be backfilled, with a riprap slope towards the creek, embedded into the subgrade to remain stable in high flows.

6.5 Option 1 – Extend the Runway East and West

Option I involves extending the runway both to the east and to the west. We have outlined potential environmental effects below.

[1] Masked occurrences are confidential species accounts to protect the locations of known or expected species of management concern. Data regarding masked occurrences can only be obtained from the Ministry of Forests, Lands and Natural Resource Operations following completion of a non-disclosure agreement where potential impacts may occur.

6.5.1 Potential Environmental Effects

Potential environmental effects of this option include:

- Filling floodplain with riprap edge (475 m^2) on right bank (as indicated above for all options);
- Loss of riparian area and floodplain habitat for the filled portion of the bank; and
- Encroachment and loss of riparian area between Vernon Creek and the west end of the runway extension.

6.5.2 Avoidance and Mitigation Measures

While avoidance and mitigation measures are typically outlined in detail in an environmental management plan (EMP), we have summarized the main points here for simplicity, in order to assess each option for overall feasibility. These apply predominantly to the work areas adjacent to Vernon Creek.

Avoidance and mitigation measures for Option 1 may include:

- Enhancing floodplain backchannel habitat in another location to mitigate the loss of 475 m^2 of habitat on the right bank (as indicated above);
- Replant riparian and floodplain vegetation to replace any lost or encroached areas;
- Complete floodplain fill and right bank riprap armouring in the dry and within appropriate fish work window where appropriate; and
- Prepare an Erosion and Sediment Control (ESC) Plan, and implement ESC measures to protect the creek from sedimentation during construction.

6.6 Option 2 – Extend the Runway West and Install a Culvert in Vernon Creek

Option 2 involves installing a culvert, or a number of culverts beside each other, to conduct the flow of the creek beneath the western runway extension. The culvert is expected to be approximately 85 m long to accommodate the runway, the graded slope off the sides of the runway, and the slope down to the creek itself. The runway would be built over the culvert(s). At this location, the creek has a bend which will require straightening to accommodate the culvert length. The culvert has been proposed adjacent to the existing creek bed to avoid any disturbance to the creek during construction. We have outlined potential environmental effects below.

6.6.1 Potential Environmental Effects

Best management practices for culverts in fish bearing streams include the use of open bottom culverts, or possibly culverts that have been sub-excavated into the ground, allowing the substrate of the bottom to cover and provide continuity for fish through the length of the culvert. Potential environmental effects of the runway extension and culverting the stream at least 85 m long in this location include:

- Filling floodplain with riprap edge (475 m^2) on right bank;
- Realignment (straightening) of approximately 85 m of creek through the culvert;
- Creek shading for 85 m within the culvert;

- Alteration of flow regime within the culvert; and
- Loss of riparian area of 85 m length along both sides of the creek under the culvert.

There is a risk that the length of the culvert may present a barrier to fish passage, due to the possible deterrence of passing through a dark culvert (Dane 1978, Boubee 1999) or due to a subsequent increase in water velocity (Washington Department of Fish and Wildlife 2003, DFO 1992).

6.6.2 Avoidance and Mitigation Measures

Avoidance and mitigation measures for Option 2 include:

- Enhancing floodplain backchannel habitat in another location to mitigate loss of 475 m^2 of habitat on the right bank (see Section 6.5.1);
- Provide artificial lighting within the culvert to encourage fish passage;
- Design and install the culvert to preclude excessive water velocities;
- Construct the culverts/channel in the dry adjacent to the existing channel to avoid construction related disturbance;
- Connect the channel to the culvert during the appropriate least risk fish work window;
- Install lunkers[2], to provide undercut bank habitat for habitat offsetting, in another location;
- Riparian restoration of new floodplain;
- Engineer the culvert, inlet and outlets to avoid future blockages that could hinder migration or could entrap fish and to retain existing flow regime; and
- Conduct fish salvage to avoid entrapment during construction.

6.7 Option 3 and Option 4 – Extend the Runway and Realign Vernon Creek

- Option 3 – Extend the Runway East and West with Re-alignment of Vernon Creek
- Option 4 – Extend the Runway West with Re-alignment of Vernon Creek

Option 3 and Option 4 involve realigning the creek west and north, into the former Laker's Golf Course in order to avoid the runway extension. The proposed realignment developed in 2008 (EBA 2008; provided in Appendix B) was designed to avoid three wetlands that are known to support amphibian breeding, including Spadefoot Toad (blue-listed). One wetland, close to the juncture of Vernon Creek at the downstream side, would be impacted.

[2] A Lunker is a "stream repair practice used to provide undercut bank habitat and streambank toe protection along meander bends" (Schueler and Brown 2004).

6.7.1 Potential Environmental Effects

Potential environmental effects of realigning the creek include the following:

- Increasing length of creek by 118 m, decreasing gradient and potentially changing flow characteristics, substrate and vegetation. For example, flow may slow, resulting in sediment accretion and the ultimate colonization by wetland vegetation.
- Increased length at lower gradient may result in increased backwatering during high water period from Okanagan Lake for a longer period in spring.
- Potential increase in fish rearing habitat.
- Potential increase in bird nesting habitat.
- Removal of 150 m^2 of wetland, and the associated potential amphibian breeding habitat (e.g. spadefoot toad, long-toed salamander).
- Potential pumpkinseed sunfish assessment and removal required.

6.7.2 Avoidance and Mitigation Measures

Avoidance and mitigation measures for Option 3 and Option 4 include:

- Mimic substrate and floodplain characteristics in new channel;
- Install deflectors or other features to reduce the width of the stream, thereby increasing water velocity to reduce potential for sediment accretion;
- Construct in-stream habitat features such as undercut banks (lunkers), large woody debris, pools and floodplain benches to replicate or improve existing stream characteristics;
- Riparian restoration as above;
- Potential removal of pumpkinseed sunfish;
- Excavate new channel in dry;
- Dewatering is likely required; and
- Fish and amphibian salvage and relocation required.

7.0 ENVIRONMENTAL PERMITTING REQUIREMENTS

The permitting requirements for each option are outlined below, based on current advice from regulatory agencies.

In summary, the permitting process is similar for each option with the exception of the requirement of a Fish Collection Permit, which would be required for Option 2, Option 3 and Option 4, and a Wildlife Salvage Permit, which would be required for Option 3 and Option 4, but not the other options. Specifics are outlined below.

7.1 Federal

Recent changes to the federal *Fisheries Act* and its delivery have largely shifted the onus of responsibility for compliance with fish protection laws on the proponent. The federal *Fisheries Act* prohibits serious harm to commercial, recreational and Aboriginal fisheries (Section 35), and mandates the provision of sufficient flow and free passage for fish species that constitute such fisheries (Section 20 and Section 21)[3].

The proponent is expected to avoid and mitigate '*serious harm to fish*[4]'. If serious harm to fish can be avoided and/or mitigated, then an authorization under Subsection 35(2) is not likely required. The responsibility is on the proponent to prepare a plan, complete with avoidance and mitigation measures, and, if required, offsetting measures for any residual serious harm to fish. Where serious harm to fish cannot be completely avoided or mitigated the Project will likely require the submission of a Request for Authorization under Subsection 35(2) of the *Fisheries Act* in order to proceed.

Therefore, Option 1 is not expected to require input from DFO given that serious harm to fish can be avoided and/or mitigated. However, given that there will be serious harm to fish per Section 35 of the *Fisheries Act* for Option 2 and Options 3 and 4 (infilling of existing Vernon Creek channel), it is expected that a Request for DFO Authorization will be required, along with additional supporting information including a full environmental assessment, engineering design, and hydrological and hydraulic analysis. For realignment Option 3 and Option 4, the 2008 conceptual design report (EBA 2008; see Appendix B) would be reviewed and updated as necessary to account for DFO concerns presented at the time, then used for submission to achieve DFO Authorization. Option 2 however, has not undergone any offsetting investigation and would therefore require further biological and engineering costs for the identification, design and construction of habitat to offset losses due to culverting a portion of Vernon Creek.

An Authorization from DFO typically also includes a 3 to 5 year post construction monitoring clause, required to ensure proper design and functioning of the newly created habitat and up to 90% survivability of installed plants. Offsetting plans also generally require a financial bond to ensure compliance with the terms of the Offset/Compensation agreement.

7.2 Provincial

As outlined above, all options would require a *Water Act* approval and a Riparian Areas Regulation Assessment.

***Water Act* Approval**. For any alteration of a stream, including filling or realignment, an approval is required under the BC *Water Act.* A *Water Act* approval application requires a description of the works, potential effects to the stream and habitat, as well as proposed avoidance and mitigation measures. A location map is required and plans of the alteration are typically included. The proponent should allow a minimum of 4.5 months from time of submission to the receipt of the permit.

Riparian Areas Regulation. The Riparian Areas Regulation (RAR) Assessment (a regulation under the *Fish Protection Act*) is required for commercial, industrial and residential developments that impact riparian areas within 30 metres of a stream. The requirement for a RAR Assessment is noted within City of Vernon policy[5].

[3] Shea, G., Oct. 2013. Fisheries and Oceans Canada. Fisheries Protection Policy Statement. http://www.dfo-mpo.gc.ca/pnw-ppe/pol/index-eng.html

[4] "Serious harm to fish" defined as "the death of fish or any permanent alteration to, or destruction of, fish habitat."

[5] City of Vernon, 2013. Riparian Areas Regulation and Developing Near Waterbodies. http://www.vernon.ca/services/pde/riparian_areas_regulation.html

Scientific Fish Collection Permits. Option 2, Option 3 and Option 4 would require fish collection permits from MFLNRO, in order to salvage fish prior to/during construction. An Application to Collect Fish for Scientific Purpose under the *Wildlife Act* would have to be submitted.

***Wildlife Act* Permit.** Option 3 and Option 4 involve the removal of a wetland to allow for the realignment of Vernon Creek. Prior to realignment, a permit would be required to salvage and relocate wildlife from the wetland, including amphibians. A General Permit and Animal Care Application are required under the *Wildlife Act* for salvage and relocations of wildlife.

7.3 Municipal

The three options are similar in the City of Vernon requirements. All options are expected to require a development permit.

Development Permit. The City of Vernon policy has outlined implementation guidelines for all development within 30 metres of a stream in the Environmental Management Areas Strategy, Appendix 6. The requirements include assessments by qualified professionals in areas deemed sensitive ecosystems or habitats. The process is completed under the Development Permit Process[6]. Bonding for restoration works may be required as part of a development permit.

City of Vernon policy also outlines that a RAR Assessment is required for commercial, industrial and residential developments within 30 m of a stream.

8.0 TRANSPORT CANADA DRAFT TP312 5TH EDITION JANUARY 2014

Transport Canada has been working on a 5th edition of the current Transport Canada *Aerodrome Standards and Recommended Practices* manual TP312E 4th Edition of which a *DRAFT* version was released in January 2014.

The proposed 5th Edition is an Operational document as opposed to a Design document and, as such, is a substantive change to how standards are applied. An initial assessment of the changes brought to the new TP312 document include the application of the standards to what is defined by aircraft group numbers (AGN), obstacles and how they are handled (obstacle free zones, OLS, obstacle identification surfaces), private taxiways, runway strips, runway safety area (resolution of NPA 2010-012 pending), aerodrome data, declared distances, runway width and slopes and lighting systems. Therefore, the runway length is not the determining factor that would trigger more stringent standards.

Specific to the Vernon regional Airport environment, we provide the following brief comments on the DRAFT 5th edition, keeping in mind this is just released and full in-depth reviews have not been provided:

- Runway length is no longer the determining factor for runway strip width standards.
- Current 4th Edition Runway Strip width for Code B aircraft is 30 m, this increases to minimum 40 m for AGN II Non-Instrument with aircraft approach speeds less than 121 knots– major impact to YVK. The 5th Edition does provide Modified OLS tables to account for obstacles however the runway strip width would increase to 45 m but the transitional surface would steepen to 33% from 25%.
- Runway to taxiway centreline distance in 5th Edition increase from 42 metres to 52 metres – major impact to VYK.

[6] City of Vernon, May, 2008. Environmental Management Areas Strategy. http://www.vernon.ca/ocp/ema_strategy_final.pdf

- OLS approach surfaces are independent from take-off surfaces depending on obstacles and/or provision of clearways.
- RESA requirements may not apply to a Code 2B Non-Instrument runway.
- Declared Distances are calculated differently for runways with displaced thresholds and clearways due to the new Take-Off Surface and will likely impact YVK Runway 05 declared distances.

9.0 RECOMMENDATIONS

Option 2, Option 3 and Option 4 provide the Vernon Regional Airport's long term plan of providing 4,000 feet of runway. Based on estimated costs alone, Option 4 would be the preferred option. This option moves Vernon Creek around the future runway end versus constructing a culvert under the future runway extension. From a construction point of view, constructing a new creek channel in the dry is preferable to installing a new box culvert(s) due to simplicity and cost.

Also, Option 4 eliminates new construction on the east end of the runway, thereby concentrating all the construction on one end of the runway which is preferred from a constructability and operational stand point. This also eliminates the potential blast fence.

It is Tetra Tech EBA's opinion that Option 4 is also the preferred option from an environmental perspective. This option will avoid the requirement for the 85 m culvert that could potentially discourage fish passage and migration. The increased length of the creek and decreased gradient may result in additional wetland habitat and a potential increase in fish rearing and bird nesting habitats. Finally, the proposed creek alignment for this option was developed by Tetra Tech EBA in 2008 incorporating many environmental considerations such as wetland avoidance. The application of Option 4 would therefore be an efficient use of previous work completed for this site.

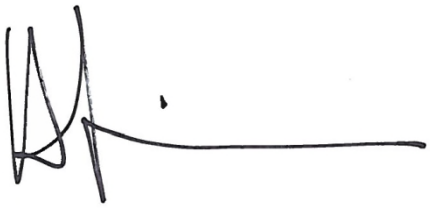
Overall, considering the estimated costs, constructability and environmental impacts, Option 4 is recommended. A topographic survey should be performed first to confirm that there are no obstacles protruding through the OLS. Additionally, TP312 5th Edition and the City Zoning Bylaw 4888 should be reviewed to ensure the future runway extension limits meet these criteria.

10.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

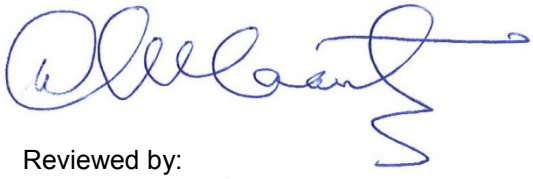
Tetra Tech EBA Inc.

Prepared by:
Kevin Alexander, AScT, CCA
Senior Airport Specialist, Airports Group
Transportation Practice
Direct Line: 250.862.3026 x226
kevin.alexander@tetratech.com



Reviewed by:
Jack Willms, AScT
Senior Airport Specialist, Airports Group
Transportation Practice
Direct Line: 778.945.5872
jack.willms@tetratech.com

Prepared by:
Cameron Kulak, B.Sc., Dipl.T., R.P.Bio.
Biologist, Aquatics & Fisheries
Environment Practice
Direct Line: 604.685.0017 x235
cameron.kulak@tetratech.com



Reviewed by:
David Morantz, M.Sc., R.P.Bio.
Senior Biologist, Aquatics & Fisheries
Environment Practice
Direct Line: 604.685.0017 x352
david.morantz@tetratech.com

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TABLES

Table 1 Class “D” Forecast – Option 1
Table 2 Class “D” Forecast – Option 2
Table 3 Class “D” Forecast – Option 3
Table 4 Class “D” Forecast – Option 4

TABLE 1

Vernon Regional Airport

Runway Feasibility Study

Option 1 - Proposed 3,610 foot Runway

Class "D" Cost Forecast

Date	May 30, 2014			Project No.	C31103234-01
Item	**Cost Forecast Summary**				**Total**
1.00	General Construction Items				$30,000
2.00	East End - 19.6m Runway Extension				$316,930
3.00	West End - 8.8m Runway Extension				$146,499
	Sub-Total Construction Cost Forecasts				**$493,429**
4.00	Allowance for Airside Insurance and Airside Escorts			6.00%	$29,606
5.00	Environmental Permitting/Construction & Post Construction Monitoring				$30,000
6.00	Engineering			15.00%	$74,014
7.00	Contingencies			35.00%	$172,700
	Total Project Cost Forecast - Excluding G.S.T.				**$799,749**
1.00	**General Construction Items**	**Unit**	**Quantity**	**Unit Price**	**Total**
1.01	Mobilization / Demobilization / Maintain Barricades & Red Lights / Quality Control / Survey	LS	1	$30,000	$30,000
	Total Section 1.0				**$30,000**
2.00	**East End - 19.6m Runway Extension**	**Unit**	**Quantity**	**Unit Price**	**Total**
	Sitework Demolition and Removal				
2.01	Sawcutting Existing Asphalt Full Depth	LM	50	$18.00	$900
2.02	Asphalt Removal (roads)	M2	160	$10.00	$1,600
	Airfield Grading				
2.03	Stripping of approx 150mm organics, stockpile for re-use	M3	260	$11.00	$2,860
2.04	Excavation and Dispose Off-Site	M3	780	$14.00	$10,920
2.05	Runway Strip Grading	M2	4,000	$4.00	$16,000
	Geotextile Fabric				
2.06	Geotextile Fabric	M2	1,700	$4.00	$6,800
	Granular Subbase Course				
2.07	300mm Thick - 100mm Well Graded Subbase For Runway and Blast Pad	M2	1,700	$15.00	$25,500
	Granular Base Course				
2.08	200mm thick - 25mm Granular Base for Runway	M2	950	$13.00	$12,350
2.09	250mm thick - 25mm Granular Base for Blast Pad	M2	750	$15.00	$11,250
	HMAC				
2.10	HMAC - 100mm For Runway (2 Lifts)	T	225	$170.00	$38,250
2.11	HMAC - 50mm For Blast Pad	T	90	$170.00	$15,300
	Painted Lines and Markings				
2.12	New Pavement Markings	LS	1	$1,000.00	$1,000
	Drainage				
2.13	Allowance For Drainage Drywells/Piping	LS	1	$15,000.00	$15,000
	Hydro-seeding				
2.14	Hydro -seeding for Graded Areas	M2	4,200	$1.00	$4,200
	Blast Fence				
2.15	New 23m Long Blast Fence c/w Concrete Foundation	LM	23	$5,500.00	$126,500

TABLE 1

Vernon Regional Airport

Runway Feasibility Study

Option 1 - Proposed 3,610 foot Runway

Class "D" Cost Forecast

	Electrical and Lighting				
2.16	Locates, Testing, Commissioning	LS	1	$1,000.00	$1,000
2.17	Trenching (for 2-50mm RPVC Duct, #8 Cable, Counterpoise, Sand Bedding etc.)	LM	125	$80.00	$10,000
2.18	Relocate End/Edge Lights	LS	1	$4,000.00	$4,000
2.19	New Edge Lights	LS	1	$4,500.00	$4,500
2.20	New Pull Pits, transformers, splice kits	LS	1	$9,000.00	$9,000
	Total Section 2.0				**$316,930**
3.00	**West End - 8.8m Runway Extension**	**Unit**		**Unit Price**	**Total**
	Sitework Demolition and Removal				
3.01	Sawcutting Existing Asphalt Full Depth	LM	23	$18.00	$414
	Airfield Grading				
3.02	Stripping of approx 150mm organics, stockpile for re-use	M3	170	$11.00	$1,870
3.03	Excavation and Dispose Off-Site	M3	175	$15.00	$2,625
3.04	Imported Engineered Fill	M3	180	$35.00	$6,300
3.05	Imported Common Fill For Strip Width	M3	1,450	$15.00	$21,750
	Geotextile Fabric				
3.06	Geotextile Fabric	M2	1,100	$4.00	$4,400
	Granular Subbase Course				
3.07	300mm Thick - 100mm Well Graded Subbase For Runway and Blast Pad	M2	1,100	$15.00	$16,500
	Granular Base Course				
3.08	200mm thick - 25mm Granular Base for Runway	M2	330	$13.00	$4,290
3.09	250mm thick - 25mm Granular Base for Blast Pad	M2	770	$15.00	$11,550
	HMAC				
3.10	HMAC - 100mm For Runway (2 Lifts)	T	80	$170.00	$13,600
3.11	HMAC - 50mm For Blast Pad	T	90	$170.00	$15,300
	Painted Lines and Markings				
3.12	Eradication of Existing Markings	LS	1	$3,000.00	$3,000
3.13	New Pavement Markings	LS	1	$6,000.00	$6,000
	Drainage				
3.14	Allowance For Drainage Drywells/Piping	LS	1	$7,000.00	$7,000
	Hydro -seeding				
3.15	Hydro -seeding for Graded Areas	M2	3,500	$1.00	$3,500
	Electrical and Lighting				
3.16	Locates, Testing, Commissioning	LS	1	$1,000.00	$1,000
3.17	Trenching (for 1-50mm RPVC Duct, #8 Cable, Counterpoise, Sand Bedding etc.)	M	130	$60.00	$7,800
3.18	Relocate End/Edge Lights	LS	1	$3,600.00	$3,600
3.19	New Pull Pits, transformers, splice kits	LS	1	$6,000.00	$6,000
3.20	Relocate PAPI c/w New Concrete Bases	LS	1	$10,000.00	$10,000
	Total Section 3.0				**$146,499**

NOTES:

1	The forecast of construction costs is provided for budgetary purposes only. This is not to be interpreted as a guarantee by Tetra Tech of the actual project cost.
2	Obstacles within the Obstacle Limitation Surface (OLS) will need to be identified, removal/relocation of any such obstacles have not been accounted for in this estimate.
3	The final cost of the project will be determined by the tendering and construction process.
4	Costs shown do not include GST.

TABLE 2
Vernon Regional Airport
Runway Feasibility Study
Option 2 - Proposed 4,000 foot Runway with Culvert Crossing
Class "D" Cost Forecast

Date	May 30, 2014			Project No.	C31103234-01
Item	**Cost Forecast Summary**				**Total**
1.00	General Construction Items				$100,000
2.00	East End - 19.6m Runway Extension				$316,930
3.00	West End - 127.6m Runway Extension				$1,666,050
	Sub-Total Construction Cost Forecasts				**$2,082,980**
3.00	Allowance for Airside Insurance and Airside Escorts			3.00%	$62,489
4.00	Environmental Permitting/Construction & Post Construction Monitoring				$95,000
5.00	Construction of Offsetting Habitat				$800,000
6.00	Engineering			7.00%	$145,809
7.00	Contingencies and Engineering			35.00%	$729,043
	Total Project Cost Forecast - Excluding G.S.T.				**$3,915,321**
1.00	**General Construction Items**	**Unit**	**Quantity**	**Unit Price**	**Total**
1.01	Mobilization / Demobilization / Maintain Barricades & Red Lights / Quality Control / Survey	LS	1	$100,000	$100,000
	Total Section 1.0				**$100,000**
2.00	**East End - 19.6m Runway Extension**	**Unit**	**Quantity**	**Unit Price**	**Total**
	Sitework Demolition and Removal				
2.01	Sawcutting Existing Asphalt Full Depth	LM	50	$18.00	$900
2.02	Asphalt Removal	M2	160	$10.00	$1,600
	Airfield Grading				
2.03	Stripping of approx 150mm organics, stockpile for re-use	M3	260	$11.00	$2,860
2.04	Excavation to Embankment at West End	M3	780	$14.00	$10,920
2.05	Runway Strip Grading	M2	4,000	$4.00	$16,000
	Geotextile Fabric				
2.06	Geotextile Fabric	M2	1,700	$4.00	$6,800
	Granular Subbase Course				
2.07	300mm Thick - 100mm Well Graded Subbase For Runway and Blast Pad	M2	1,700	$15.00	$25,500
	Granular Base Course				
2.08	200mm thick - 25mm Granular Base for Runway	M2	950	$13.00	$12,350
2.09	250mm thick - 25mm Granular Base for Blast Pad	M2	750	$15.00	$11,250
	HMAC				
2.10	HMAC - 100mm For Runway (2 Lifts)	T	225	$170.00	$38,250
2.11	HMAC - 50mm For Blast Pad	T	90	$170.00	$15,300
	Painted Lines and Markings				
2.12	New Pavement Markings	LS	1	$1,000.00	$1,000
	Drainage				
2.13	Allowance For Drainage Drywells/Piping	LS	1	$15,000.00	$15,000
	Hydro -seeding				
2.14	Hydro -seeding for Graded Areas	M2	4,200	$1.00	$4,200
	Blast Fence				
2.15	New 23m Long Blast Fence c/w Concrete Foundation	LM	23	$5,500.00	$126,500
	Electrical and Lighting				
2.16	Locates, Testing, Commissioning	LS	1	$1,000.00	$1,000
2.17	Trenching (for 2-50mm RPVC Duct, #8 Cable, Counterpoise, Sand Bedding etc.)	M	125	$80.00	$10,000
2.18	Relocate End/Edge Lights	LS	1	$4,000.00	$4,000
2.19	New Edge Lights	LS	1	$4,500.00	$4,500
2.20	New Pull Pits, transformers, splice kits	LS	1	$9,000.00	$9,000
	Total Section 2.0				**$316,930**

TABLE 2
Vernon Regional Airport
Runway Feasibility Study
Option 2 - Proposed 4,000 foot Runway with Culvert Crossing
Class "D" Cost Forecast

Date	May 30, 2014			Project No.	C31103234-01
3.00	**West End - 127.6m Runway Extension**	**Unit**		**Unit Price**	**Total**
	Sitework Demolition and Removal				
3.01	Sawcutting Existing Asphalt Full Depth	LM	25	$18.00	$450
	Airfield Grading				
3.02	Stripping of approx 150mm organics, stockpile for re-use	M3	660	$11.00	$7,260
3.03	Excavation to Embankment	M3	2,900	$15.00	$43,500
3.04	Imported Engineered Fill	M3	5,600	$35.00	$196,000
3.05	Imported Common Fill For Strip Width	M3	9,500	$15.00	$142,500
	Geotextile Fabric				
3.06	Geotextile Fabric	M2	4,400	$4.00	$17,600
	Granular Subbase Course				
3.07	300mm Thick - 100mm Well Graded Subbase For Runway and Blast Pad	M2	4,400	$15.00	$66,000
	Granular Base Course				
3.08	200mm thick - 25mm Granular Base for Runway	M2	3,630	$13.00	$47,190
3.09	250mm thick - 25mm Granular Base for Blast Pad	M2	770	$15.00	$11,550
	HMAC				
3.10	HMAC - 100mm For Runway (2 Lifts)	T	860	$170.00	$146,200
3.11	HMAC - 50mm For Blast Pad	T	90	$170.00	$15,300
	Painted Lines and Markings				
3.12	Eradication of Existing Markings	LS	1	$3,000.00	$3,000
3.13	New Pavement Markings	LS	1	$6,000.00	$6,000
	Creek Culvert				
3.14	Concrete Box Culvert	LS	1	$570,000.00	$570,000
3.15	Property Protection Dyke	LS	1	$200,000.00	$200,000
	Environmental Requirements				
3.16	Vegetation Planting	LS	1	$30,000.00	$30,000
3.17	Sediment Control	LS	1	$50,000.00	$50,000
3.18	Rip-Rap and Cobbles	LS	1	$35,000.00	$35,000
	Hydro-seeding				
3.19	Hydro -seeding for Runway Strip and Embankment Areas	M2	12,000	$1.00	$12,000
	Electrical and Lighting				
3.20	Locates, Testing, Commissioning	LS	1	$1,000.00	$1,000
3.21	Trenching (for 1-50mm RPVC Duct, #8 Cable, Counterpoise, Sand Bedding etc.)	M	600	$60.00	$36,000
3.22	Relocate End/Edge Lights	LS	1	$8,500.00	$8,500
3.23	New Pull Pits, transformers, splice kits	LS	1	$11,000.00	$11,000
3.24	Relocate PAPI c/w New Concrete Bases	LS	1	$10,000.00	$10,000
	Total Section 3.0				**$1,666,050**

NOTES:

1	The forecast of construction costs is provided for budgetary purposes only. This is not to be interpreted as a guarantee by Tetra Tech of the actual project cost.
2	The final cost of the project will be determined by the tendering and construction process.
3	Obstacles within the Obstacle Limitation Surface (OLS) will need to be identified, removal/relocation of any such obstacles have not been accounted for in this estimate.
4	Costs shown do not include GST.

TABLE 3
Vernon Regional Airport
Runway Feasibility Study
Option 3 - Proposed 4,000 foot Runway with Realigned Vernon Creek
Class "D" Cost Forecast

Date	May 30, 2014			Project No.	C31103234-01
Item	**Cost Forecast Summary**				**Total**
1.00	General Construction Items				$100,000
2.00	East End - 19.6m Runway Extension				$316,930
3.00	West End - 127.6m Runway Extension				$1,528,550
	Sub-Total Construction Cost Forecasts				**$1,945,480**
3.00	Allowance for Airside Insurance and Airside Escorts			3.00%	$58,364
4.00	Environmental Permitting/Construction & Post Construction Monitoring				$90,000
5.00	Engineering			8.00%	$155,638
6.00	Contingencies and Engineering			35.00%	$680,918
	Total Project Cost Forecast - Excluding G.S.T.				**$2,930,401**
1.00	**General Construction Items**	**Unit**	**Quantity**	**Unit Price**	**Total**
1.01	Mobilization / Demobilization / Maintain Barricades & Red Lights / Quality Control / Survey	LS	1	$100,000	$100,000
	Total Section 1.0				**$100,000**
2.00	**East End - 19.6m Runway Extension**	**Unit**	**Quantity**	**Unit Price**	**Total**
	Sitework Demolition and Removal				
2.01	Sawcutting Existing Asphalt Full Depth	LM	50	$18.00	$900
2.02	Asphalt Removal	M2	160	$10.00	$1,600
	Airfield Grading				
2.03	Stripping of approx 150mm organics, stockpile for re-use	M3	260	$11.00	$2,860
2.04	Excavation to Embankment at West End	M3	780	$14.00	$10,920
2.05	Runway Strip Grading	M2	4,000	$4.00	$16,000
	Geotextile Fabric				
2.06	Geotextile Fabric	M2	1,700	$4.00	$6,800
	Granular Subbase Course				
2.07	300mm Thick - 100mm Well Graded Subbase For Runway and Blast Pad	M2	1,700	$15.00	$25,500
	Granular Base Course				
2.08	200mm thick - 25mm Granular Base for Runway	M2	950	$13.00	$12,350
2.09	250mm thick - 25mm Granular Base for Blast Pad	M2	750	$15.00	$11,250
	HMAC				
2.10	HMAC - 100mm For Runway (2 Lifts)	T	225	$170.00	$38,250
2.11	HMAC - 50mm For Blast Pad	T	90	$170.00	$15,300
	Painted Lines and Markings				
2.12	New Pavement Markings	LS	1	$1,000.00	$1,000
	Drainage				
2.13	Allowance For Drainage Drywells/Piping	LS	1	$15,000.00	$15,000
	Hydro -seeding				
2.14	Hydro -seeding for Graded Areas	M2	4,200	$1.00	$4,200
	Blast Fence				
2.15	New 23m Long Blast Fence c/w Concrete Foundation	LM	23	$5,500.00	$126,500
	Electrical and Lighting				
2.16	Locates, Testing, Commissioning	LS	1	$1,000.00	$1,000
2.17	Trenching (for 2-50mm RPVC Duct, #8 Cable, Counterpoise, Sand Bedding etc.)	M	125	$80.00	$10,000
2.18	Relocate End/Edge Lights	LS	1	$4,000.00	$4,000
2.19	New Edge Lights	LS	1	$4,500.00	$4,500
2.20	New Pull Pits, transformers, splice kits	LS	1	$9,000.00	$9,000
	Total Section 2.0				**$316,930**

TABLE 3
Vernon Regional Airport
Runway Feasibility Study
Option 3 - Proposed 4,000 foot Runway with Realigned Vernon Creek
Class "D" Cost Forecast

3.00	West End - 127.6m Runway Extension	Unit		Unit Price	Total
	Sitework Demolition and Removal				
3.01	Sawcutting Existing Asphalt Full Depth	LM	25	$18.00	$450
	Airfield Grading				
3.02	Stripping of approx 150mm organics, stockpile for re-use	M3	660	$11.00	$7,260
3.03	Excavation to Embankment	M3	2,900	$15.00	$43,500
3.04	Imported Engineered Fill	M3	5,600	$35.00	$196,000
3.05	Imported Common Fill For Strip Width	M3	9,500	$15.00	$142,500
	Geotextile Fabric				
3.06	Geotextile Fabric	M2	4,400	$4.00	$17,600
	Granular Subbase Course				
3.07	300mm Thick - 100mm Well Graded Subbase For Runway and Blast Pad	M2	4,400	$15.00	$66,000
	Granular Base Course				
3.08	200mm thick - 25mm Granular Base for Runway	M2	3,630	$13.00	$47,190
3.09	250mm thick - 25mm Granular Base for Blast Pad	M2	770	$15.00	$11,550
	HMAC				
3.10	HMAC - 100mm For Runway (2 Lifts)	T	860	$170.00	$146,200
3.11	HMAC - 50mm For Blast Pad	T	90	$170.00	$15,300
	Painted Lines and Markings				
3.12	Eradication of Existing Markings	LS	1	$3,000.00	$3,000
3.13	New Pavement Markings	LS	1	$6,000.00	$6,000
	Environmental Requirements				
3.14	New Creek Excavation	LS	1	$510,000.00	$510,000
3.15	Vegetation Planting	LS	1	$61,000.00	$61,000
3.16	Frog Fencing	LS	1	$12,500.00	$12,500
3.17	Coffer Dam	LS	1	$5,000.00	$5,000
3.18	Sediment Control	LS	1	$61,000.00	$61,000
3.19	Rip-Rap and Cobbles	LS	1	$98,000.00	$98,000
	Hydro -seeding				
3.20	Hydro -seeding for Runway Strip and Embankment Areas	M2	12,000	$1.00	$12,000
	Electrical and Lighting				
3.21	Locates, Testing, Commissioning	LS	1	$1,000.00	$1,000
3.22	Trenching (for 1-50mm RPVC Duct, #8 Cable, Counterpoise, Sand Bedding etc.)	M	600	$60.00	$36,000
3.23	Relocate End/Edge Lights	LS	1	$8,500.00	$8,500
3.24	New Pull Pits, transformers, splice kits	LS	1	$11,000.00	$11,000
3.25	Relocate PAPI c/w New Concrete Bases	LS	1	$10,000.00	$10,000
	Total Section 3.0				**$1,528,550**

NOTES:

1	The forecast of construction costs is provided for budgetary purposes only. This is not to be interpreted as a guarantee by Tetra Tech of the actual project cost.
2	The final cost of the project will be determined by the tendering and construction process.
3	Obstacles within the Obstacle Limitation Surface (OLS) will need to be identified, removal/relocation of any such obstacles have not been accounted for in this estimate.
4	Costs shown do not include GST.

TABLE 4
Vernon Regional Airport
Runway Feasibility Study
Option 4 - Proposed 4,000 foot Runway with Realigned Vernon Creek - Extension on West End Only
Class "D" Cost Forecast

Date	May 30, 2014			Project No.	C31103234-01
Item	**Cost Forecast Summary**				**Total**
1.00	General Construction Items				$100,000
3.00	West End - 147.3m Runway Extension				$1,544,550
	Sub-Total Construction Cost Forecasts				**$1,644,550**
3.00	Allowance for Airside Insurance and Airside Escorts			3.00%	$49,337
4.00	Environmental Permitting/Construction & Post Construction Monitoring				$90,000
5.00	Engineering			8.00%	$131,564
6.00	Contingencies and Engineering			35.00%	$575,593
	Total Project Cost Forecast - Excluding G.S.T.				**$2,491,043**
1.00	**General Construction Items**	**Unit**	**Quantity**	**Unit Price**	**Total**
1.01	Mobilization / Demobilization / Maintain Barricades & Red Lights / Quality Control / Survey	LS	1	$100,000	$100,000
	Total Section 1.0				**$100,000**
2.00	**West End - 147.3m Runway Extension**	**Unit**		**Unit Price**	**Total**
	Sitework Demolition and Removal				
2.01	Sawcutting Existing Asphalt Full Depth	LM	25	$18.00	$450
	Airfield Grading				
2.02	Stripping of approx 150mm organics, stockpile for re-use	M3	660	$11.00	$7,260
2.03	Excavation to Embankment	M3	2,200	$15.00	$33,000
2.04	Imported Engineered Fill	M3	5,500	$35.00	$192,500
2.05	Imported Common Fill For Strip Width	M3	11,500	$15.00	$172,500
	Geotextile Fabric				
2.06	Geotextile Fabric	M2	4,400	$4.00	$17,600
	Granular Subbase Course				
2.07	300mm Thick - 100mm Well Graded Subbase For Runway and Blast Pad	M2	4,400	$15.00	$66,000
	Granular Base Course				
2.08	200mm thick - 25mm Granular Base for Runway	M2	3,630	$13.00	$47,190
2.09	250mm thick - 25mm Granular Base for Blast Pad	M2	770	$15.00	$11,550
	HMAC				
2.10	HMAC - 100mm For Runway (2 Lifts)	T	860	$170.00	$146,200
2.11	HMAC - 50mm For Blast Pad	T	90	$170.00	$15,300
	Painted Lines and Markings				
2.12	Eradication of Existing Markings	LS	1	$3,000.00	$3,000
2.13	New Pavement Markings	LS	1	$6,000.00	$6,000

TABLE 4
Vernon Regional Airport
Runway Feasibility Study
Option 4 - Proposed 4,000 foot Runway with Realigned Vernon Creek - Extension on West End Only
Class "D" Cost Forecast

	Environmental Requirements				
2.14	New Creek Excavation	LS	1	$510,000.00	$510,000
2.15	Vegetation Planting	LS	1	$61,000.00	$61,000
2.16	Frog Fencing	LS	1	$12,500.00	$12,500
2.17	Coffer Dam	LS	1	$5,000.00	$5,000
2.18	Sediment Control	LS	1	$61,000.00	$61,000
2.19	Rip-Rap and Cobbles	LS	1	$98,000.00	$98,000
	Hydro -seeding				
2.20	Hydro -seeding for Runway Strip and Embankment Areas	M2	12,000	$1.00	$12,000
	Electrical and Lighting				
2.21	Locates, Testing, Commissioning	LS	1	$1,000.00	$1,000
2.22	Trenching (for 1-50mm RPVC Duct, #8 Cable, Counterpoise, Sand Bedding etc.)	M	600	$60.00	$36,000
2.23	Relocate End/Edge Lights	LS	1	$8,500.00	$8,500
2.24	New Pull Pits, transformers, splice kits	LS	1	$11,000.00	$11,000
2.25	Relocate PAPI c/w New Concrete Bases	LS	1	$10,000.00	$10,000
	Total Section 2.0				**$1,544,550**

NOTES:

1	The forecast of construction costs is provided for budgetary purposes only. This is not to be interpreted as a guarantee by Tetra Tech of the actual project cost.
2	The final cost of the project will be determined by the tendering and construction process.
3	Obstacles within the Obstacle Limitation Surface (OLS) will need to be identified, removal/relocation of any such obstacles have not been accounted for in this estimate.
4	Costs shown do not include GST.

FIGURES

Figure 1 Species of Management Concern Occurrence
Figure 1A Runway 05-23 Extension Option 1 Plan and Profile
Figure 1B Runway 05-23 Extension Option 1 Details
Figure 2A Runway 05-23 Extension Option 2 Plan and Profile
Figure 2B Runway 05-23 Extension Option 2 Details
Figure 3A Runway 05-23 Extension Option 3 Plan and Profile
Figure 3B Runway 05-23 Extension Option 3 Details
Figure 4A Runway 05-23 Extension Option 4 Plan and Profile
Figure 4B Runway 05-23 Extension Option 4 Details
Figure 4C YVK Runway Extension Typical Sections
Figure 5 Potential Environmental Effects and Mitigations
Figure 6 Environmental Permitting Requirements

LEGEND

- Phase I Study Area

Species at Risk and Locally Important Wildlife (observed in the field)[1]

- EBA 2004
- Summit 2006
- EBA 2008

Species at Risk as Mapped by CDC (includes BC Listing)[2]

- ANIMAL, Red
- ANIMAL, Blue
- PLANT, Red
- PLANT, Blue

NOTES

1. Species occurences are approximate.
2. Species at risk data (non-confidential occurrences) was collected and mapped by the BC Conservation Data Centre (CDC) and downloaded on January 9, 2014 from DataBC (www.data.gov.bc.ca, keyword: endangered).
3. Imagery source: City of Vernon (2007).

STATUS
ISSUED FOR REVIEW

YVK RUNWAY FEASIBILITY STUDY AT VERNON REGIONAL AIRPORT

Species of Management Concern Occurrences

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	CITY OF Vernon

Scale: 1:4,000

50 25 0 50

Metres

TETRA TECH EBA

FILE NO.				
C31103234-01_Figure01_Species.mxd				
PROJECT NO.	**DWN**	**CKD**	**APVD**	**REV**
C31103234-01	SL	MEZ	CK	0
OFFICE	**DATE**			
Tt EBA-VANC	January 13, 2014			

Figure 1

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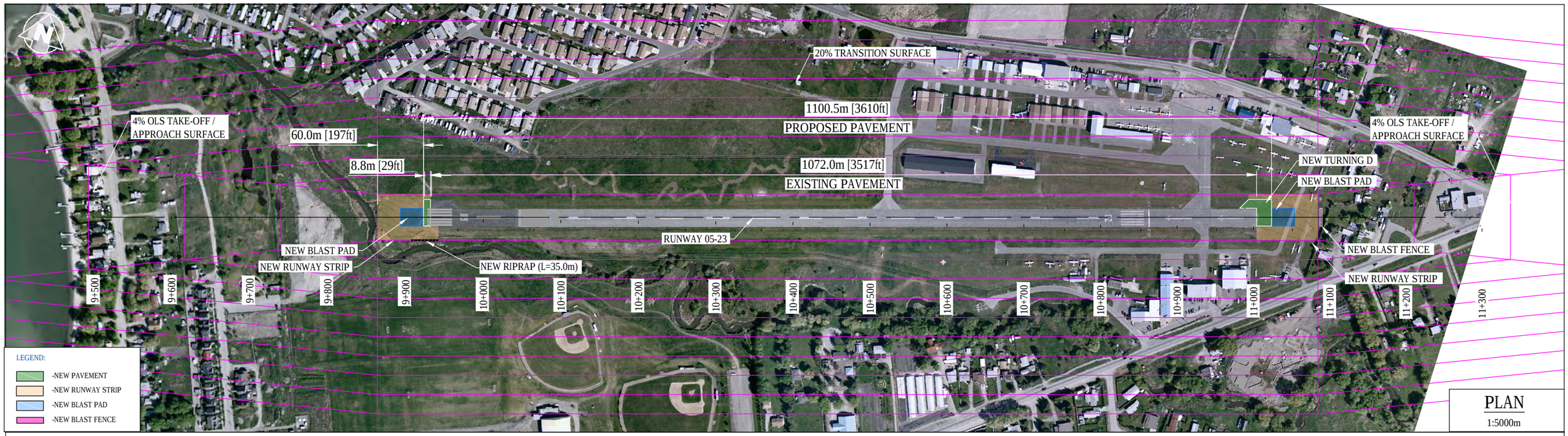

PLAN
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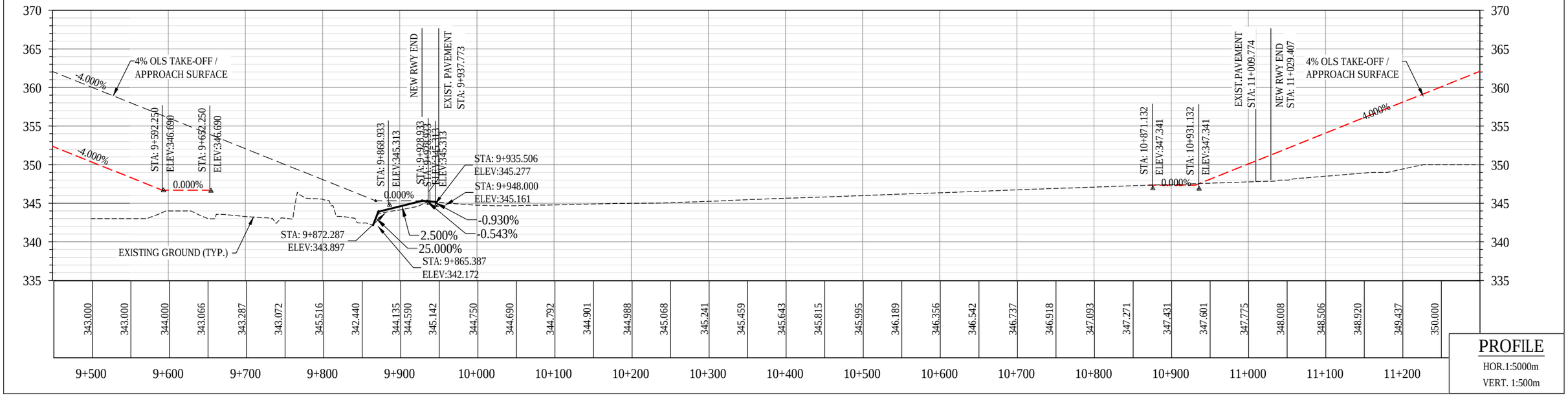


PROFILE
HOR.1:5000m
VERT. 1:500m

DECLARED DISTANCES				
	EXISTING		OPTION 1	
	RWY 05	RWY 23	RWY 05	RWY 23
TORA	1072.0m [3517ft]	1072.0m [3517ft]	1100.5m [3610ft]	1100.5m [3610ft]
TODA	1072.0m [3517ft]	1072.0m [3517ft]	1100.5m [3610ft]	1100.5m [3610ft]
ASDA	1072.0m [3517ft]	1072.0m [3517ft]	1100.5m [3610ft]	1100.5m [3610ft]
LDA	961.0m [3154ft]	933.3m [3062ft]	1100.5m [3610ft]	942.2m [3091ft]

LEGEND:

TORA - TAKE-OFF RUN AVAILABLE
TODA - TAKE-OFF DISTANCE AVAILABLE
ASDA - ACCELERATE-STOP DISTANCE AVAILABLE
LDA - LANDING DISTANCE AVAILABLE
-OLS AS PER CITY ZONING BYLAW 4888

NOTE:

1. CLEARWAYS HAVE NOT BEEN ASSESSED.
2. A TOPOGRAPHIC SURVEY IS REQUIRED TO DETERMINE ANY CONFLICTS WITH OLS.

H 1:5000 (metres)
0 50 100 150 200 250m
V 1:500 (metres)
0 5 10 15 20 25m

STATUS
ISSUED FOR REVIEW

CLIENT
CITY OF Vernon

TETRA TECH EBA

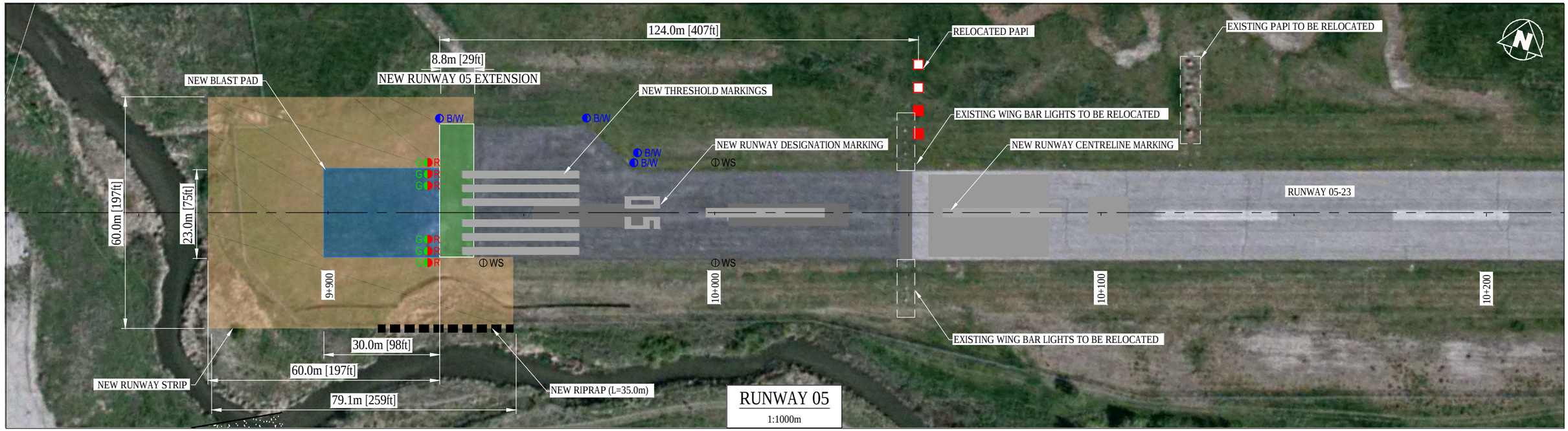
YVK - RUNWAY FEASIBILITY STUDY
VERNON, BRITISH COLUMBIA

RUNWAY 05-23 EXTENSION - OPTION 1
PLAN AND PROFILE

PROJECT NO.	DWN	CKD	REV
C31103234	MD	KA	0
OFFICE	DATE		
VANC	May 13, 2014		

Figure 1A

V:\C31103234.01 YVK-Runway Feasibility Study\01\Design\C31103234-FIG1.dwg [FIGURE 1A] May 13, 2014 - 10:03:48 am (by: domingo, mario)



V:\C31103234\01 YVK-Runway Feasibility Study\01\Design\C31103234-FIG1.dwg [FIGURE 1B] May 13, 2014 - 10:02:37 am (by: domingo, mario)

LEGEND:

B/W	BLUE \ WHITE SYMMETRICAL EDGE LIGHT
R	RED RWY END LIGHT
□ □ ■ ■	PRECISION APPROACH PATH INDICATOR (PAPI)
WS	RUNWAY EDGE LIGHT
G	GREEN RWY THRESHOLD LIGHT

	-NEW PAVEMENT
	-NEW RUNWAY STRIP
	-NEW BLAST PAD
	-NEW BLAST FENCE

0 50

Scale: 1: 1000 (metres)

NOTES

STATUS
ISSUED FOR REVIEW

CLIENT
CITY OF Vernon

TETRA TECH EBA

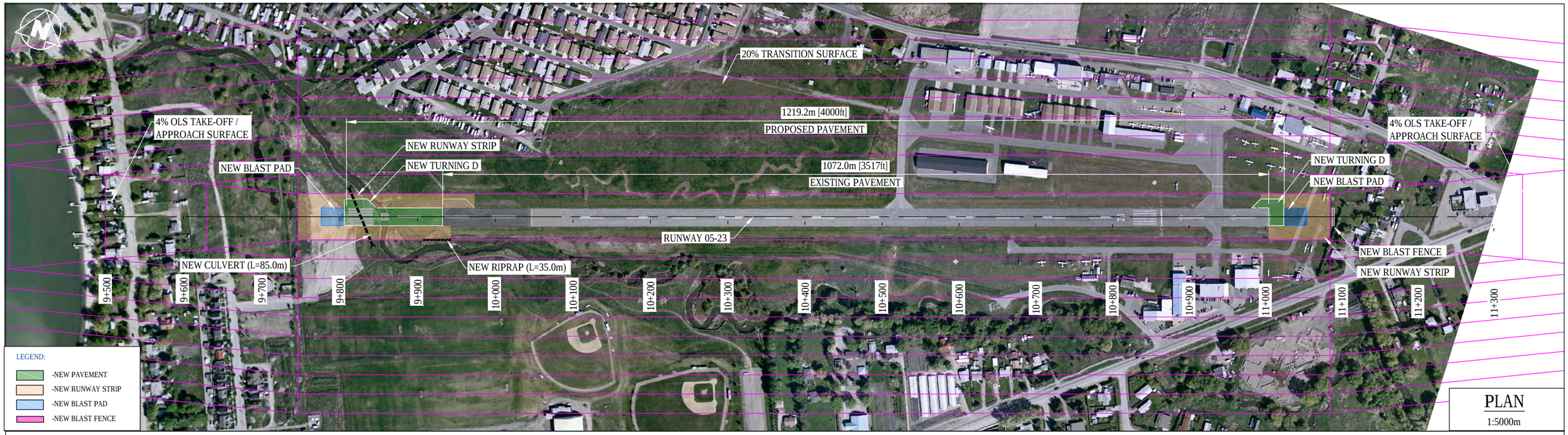
YVK - RUNWAY FEASIBILITY STUDY
VERNON, BRITISH COLUMBIA

RUNWAY 05-23 EXTENSION - OPTION 1
DETAILS

PROJECT NO.	DWN	CKD	REV
C31103234	MD	KA	0

OFFICE: VANC
DATE: May 13, 2014

Figure 1B



PLAN
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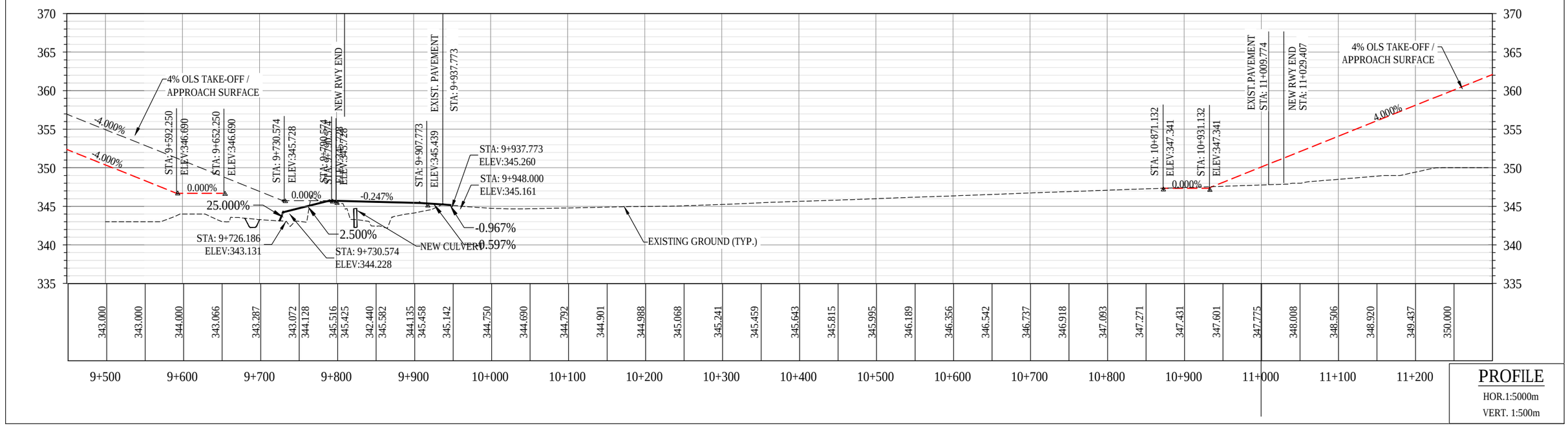


PROFILE
HOR.1:5000m
VERT. 1:500m

DECLARED DISTANCES				
	EXISTING		OPTION 2	
	RWY 05	RWY 23	RWY 05	RWY 23
TORA	1072.0m [3517ft]	1072.0m [3517ft]	1219.2m [4000ft]	1219.2m [4000ft]
TODA	1072.0m [3517ft]	1072.0m [3517ft]	1219.2m [4000ft]	1219.2m [4000ft]
ASDA	1072.0m [3517ft]	1072.0m [3517ft]	1219.2m [4000ft]	1219.2m [4000ft]
LDA	961.0mm [3154ft]	933.3m [3062ft]	1219.2m [4000ft]	1060.9m [3481ft]

LEGEND:

TORA - TAKE-OFF RUN AVAILABLE
TODA - TAKE-OFF DISTANCE AVAILABLE
ASDA - ACCELERATE-STOP DISTANCE AVAILABLE
LDA - LANDING DISTANCE AVAILABLE
-OLS AS PER CITY ZONING BYLAW 4888

NOTE:

1. CLEARWAYS HAVE NOT BEEN ASSESSED.
2. A TOPOGRAPHIC SURVEY IS REQUIRED TO DETERMINE ANY CONFLICTS WITH OLS.

H 1:5000 (metres)
0 50 100 150 200 250m
V 1:500 (metres)
0 5 10 15 20 25m

STATUS
ISSUED FOR REVIEW

CLIENT
CITY OF Vernon

TETRA TECH EBA

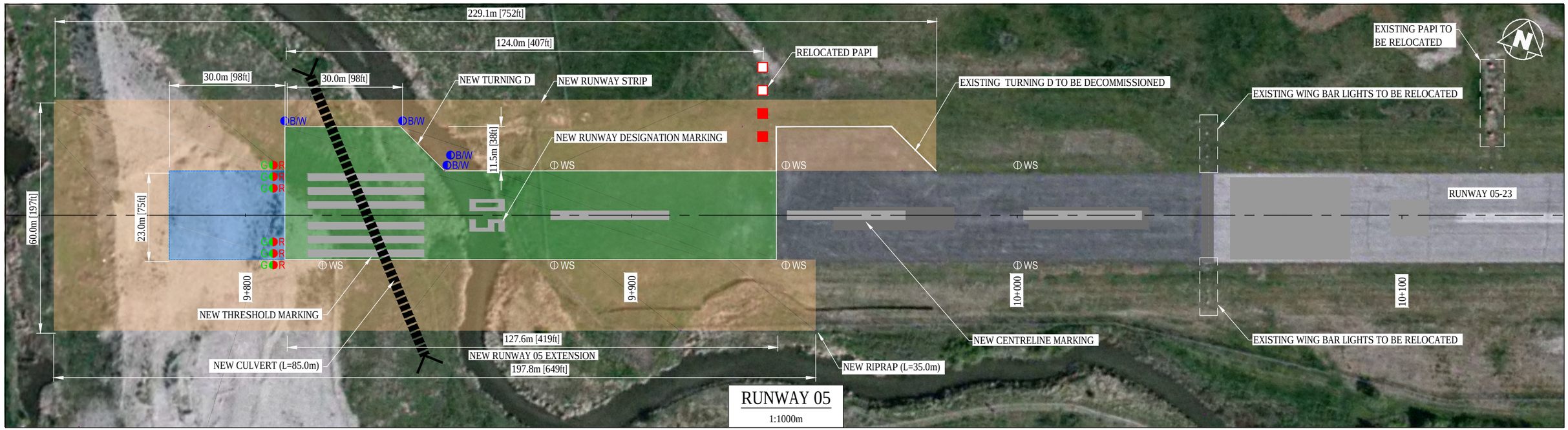
YVK - RUNWAY FEASIBILITY STUDY
VERNON, BRITISH COLUMBIA

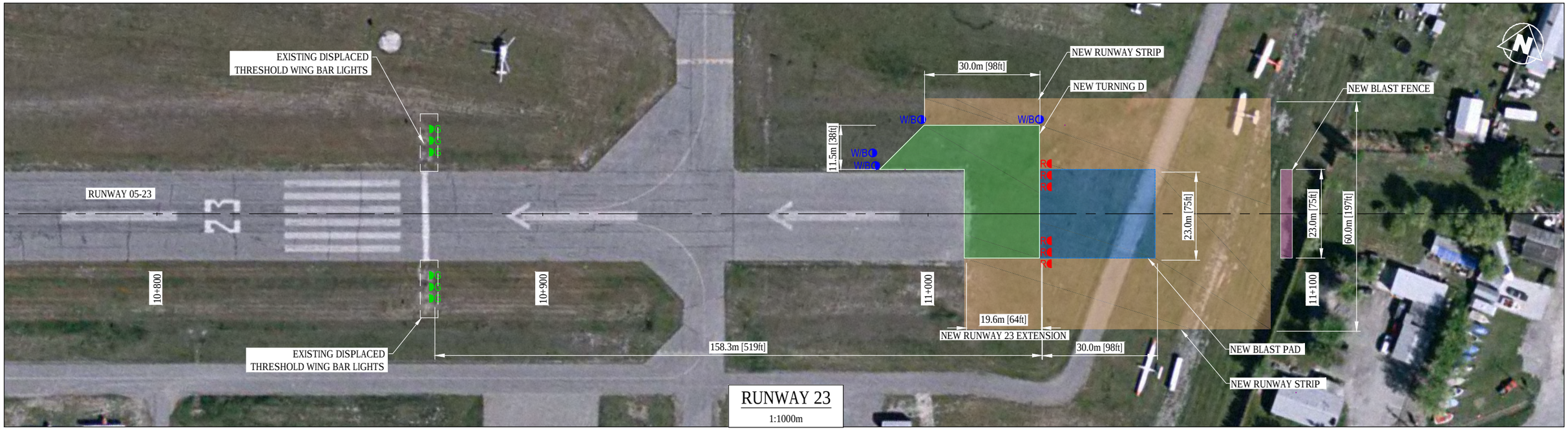
RUNWAY 05-23 EXTENSION - OPTION 2
PLAN AND PROFILE

PROJECT NO.	DWN	CKD	REV
C31103234	MD	KA	0
OFFICE	DATE		
VANC	May 13, 2014		

Figure 2A

V:\C31103234-01 YVK-Runway Feasibility Study\01Design\C31103234-FIG2.dwg [FIGURE 2A] May 13, 2014 - 9:16:35 am (by: domingo, mario)





LEGEND:

- B/W — BLUE \ WHITE SYMMETRICAL EDGE LIGHT
- R — RED RWY END LIGHT
- PRECISION APPROACH PATH INDICATOR (PAPI)
- WS — RUNWAY EDGE LIGHT
- G — GREEN RWY THRESHOLD LIGHT
- -NEW PAVEMENT
- -NEW RUNWAY STRIP
- -NEW BLAST PAD
- -NEW BLAST FENCE

0 — 50

Scale: 1: 1000 (metres)

NOTES

STATUS
ISSUED FOR REVIEW

CLIENT
CITY OF Vernon

TETRA TECH EBA

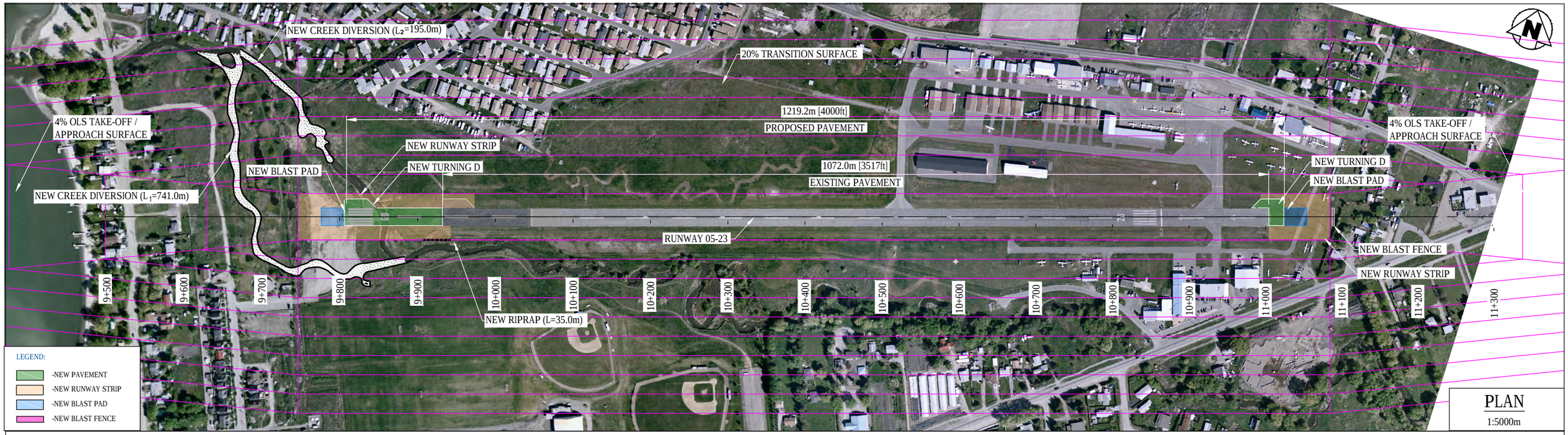
YVK - RUNWAY FEASIBILITY STUDY
VERNON, BRITISH COLUMBIA

RUNWAY 05-23 EXTENSION - OPTION 2
DETAILS

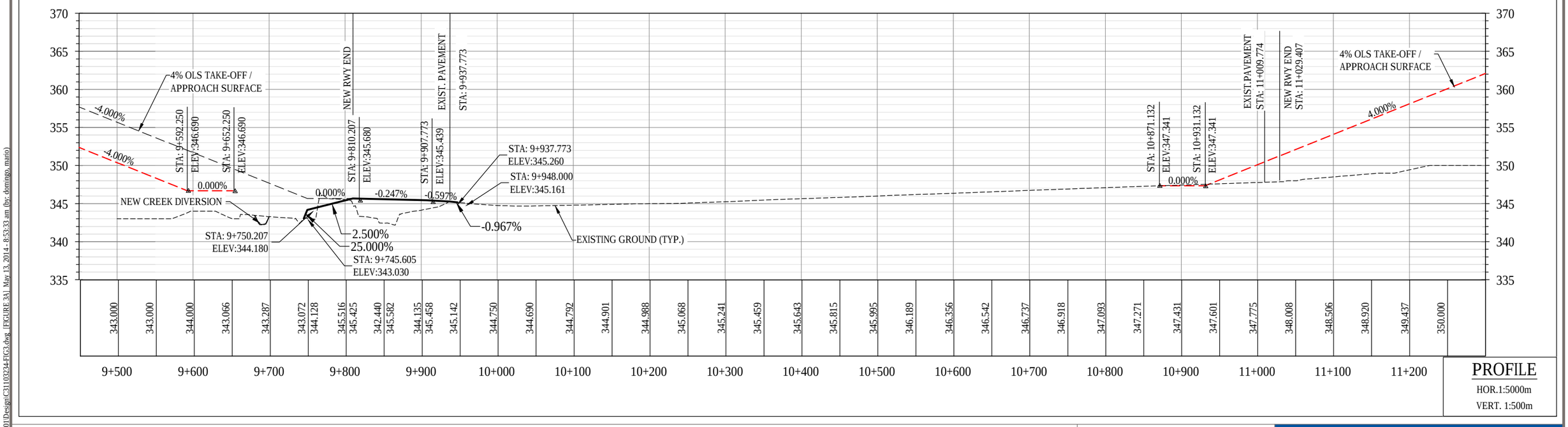
PROJECT NO.	DWN	CKD	REV
C31103234	MD	KA	0
OFFICE: VANC	DATE: May 13, 2014		

Figure 2B

V:\C31103234-01 YVK-Runway Feasibility Study\01\Design\C31103234-FG2.dwg [FIGURE 2B] May 13, 2014 - 9:18:06 am (by: domingo, mario)



PLAN
1:5000m



PROFILE
HOR.1:5000m
VERT. 1:500m

DECLARED DISTANCES				
	EXISTING		OPTION 3	
	RWY 05	RWY 23	RWY 05	RWY 23
TORA	1072.0m [3517ft]	1072.0m [3517ft]	1219.2m [4000ft]	1219.2m [4000ft]
TODA	1072.0m [3517ft]	1072.0m [3517ft]	1219.2m [4000ft]	1219.2m [4000ft]
ASDA	1072.0m [3517ft]	1072.0m [3517ft]	1219.2m [4000ft]	1219.2m [4000ft]
LDA	961.0m [3154ft]	933.3m [3062ft]	1219.2m [4000ft]	1060.9m [3481ft]

LEGEND:

TORA - TAKE-OFF RUN AVAILABLE
TODA - TAKE-OFF DISTANCE AVAILABLE
ASDA - ACCELERATE-STOP DISTANCE AVAILABLE
LDA - LANDING DISTANCE AVAILABLE
-OLS AS PER CITY ZONING BYLAW 4888

NOTE:

1. CLEARWAYS HAVE NOT BEEN ASSESSED.
2. A TOPOGRAPHIC SURVEY IS REQUIRED TO DETERMINE ANY CONFLICTS WITH OLS.
3. CREEK DIVERSION LAYOUT WAS TAKEN FROM FIGURE 3 OF EBA'S K23101307-DETAILED VERNON CREEK REALIGNMENT AND ENHANCEMENT DESIGN DATED SEPT. 11, 2008 AS REVISED.

H 1:5000 (metres)
0 50 100 150 200 250m
V 1:500 (metres)
0 5 10 15 20 25m

STATUS
ISSUED FOR REVIEW

CLIENT
CITY OF Vernon

TETRA TECH EBA

YVK - RUNWAY FEASIBILITY STUDY
VERNON, BRITISH COLUMBIA

RUNWAY 05-23 EXTENSION
OPTION 3

PROJECT NO.	DWN	CKD	REV
C31103234	MD	KA	0
OFFICE	DATE		
VANC	May 13, 2014		

Figure 3A

V:\C31103234-01 YVK-Runway Feasibility Study\01 Design\C31103234-FIG3.dwg [FIGURE 3A] May 13, 2014 - 8:53:33 am (by: domingo, mario)

NEW CREEK DIVERSION (L $_2$=195.0m)

NEW CREEK DIVERSION (L=513.0m)

229.1m [752ft]

127.6m [419ft]

124.0m [407ft]

60.0m [197ft]

30.0m [98ft]

30.0m [98ft]

NEW TURNING D

NEW RUNWAY DESIGNATION MARKING

RELOCATED PAPI

EXISTING TURNING D TO BE DECOMMISSIONED

NEW RUNWAY CENTRELINE MARKING

EXISTING PAPI TO BE RELOCATED

23.0m [75ft]

60.0m [197ft]

RUNWAY 05-23

NEW THRESHOLD MARKING

EXISTING WING BAR LIGHTS TO BE RELOCATED

NEW BLAST PAD

NEW RUNWAY STRIP

NEW RIPRAP (L=35.0m)

197.8m [649ft]

9+500

9+600

9+700

9+800

9+900

10+000

10+100

10+200

PLAN

1:2000m

LEGEND:

- B/W — BLUE \ WHITE SYMMETRICAL EDGE LIGHT
- R — RED RWY END LIGHT
- PRECISION APPROACH PATH INDICATOR (PAPI)
- WS — RUNWAY EDGE LIGHT
- G — GREEN RWY THRESHOLD LIGHT
- -NEW PAVEMENT
- -NEW RUNWAY STRIP
- -NEW BLAST PAD

0 100

Scale: 1: 2 000 (metres)

NOTES

STATUS
ISSUED FOR REVIEW

CLIENT
CITY OF Vernon

YVK - RUNWAY FEASIBILITY STUDY
VERNON, BRITISH COLUMBIA

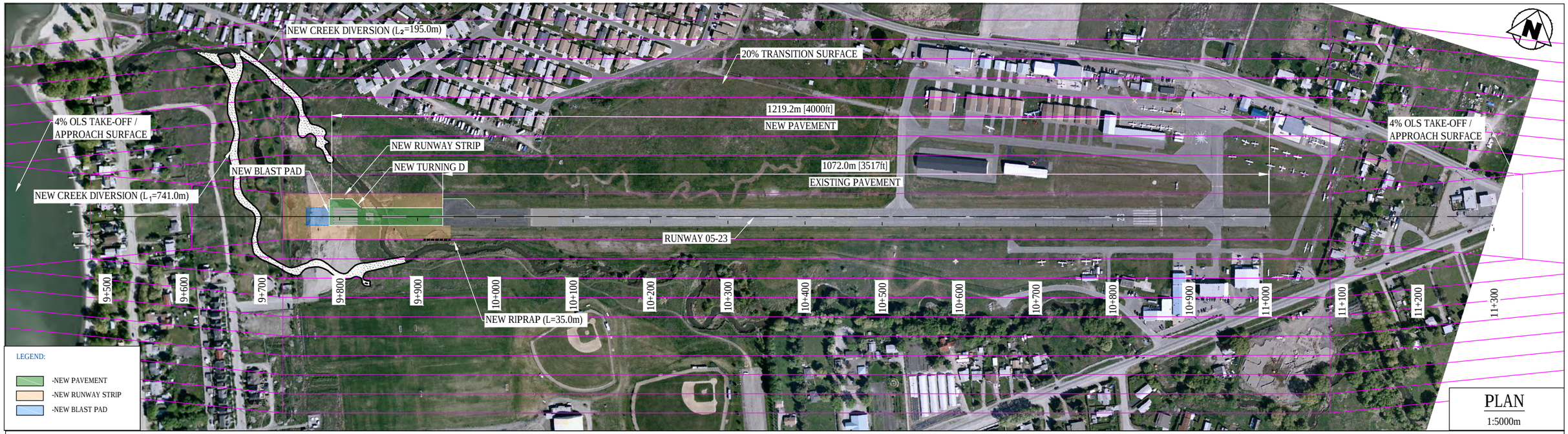
RUNWAY 05-23 EXTENSION
OPTION 3

TETRA TECH EBA

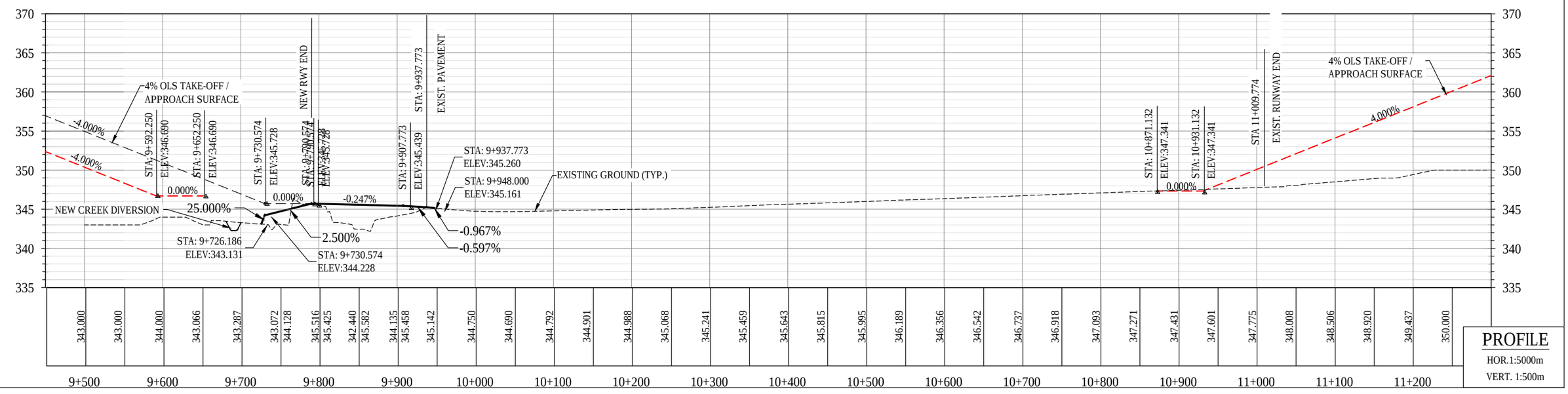
PROJECT NO.	DWN	CKD	REV
C31103234	MD	KA	0
OFFICE: VANC	DATE: May 13, 2014		

Figure 3B

V:\C31103234-01 YVK-Runway Feasibility Study\01\Design\C31103234-FIG3.dwg [FIGURE 3B] May 13, 2014 - 8:58:04 am (by: domingo, mario)



PLAN
1:5000m



PROFILE
HOR.1:5000m
VERT. 1:500m

DECLARED DISTANCES				
	EXISTING		OPTION 4	
	RWY 05	RWY 23	RWY 05	RWY 23
TORA	1072.0m [3517ft]	1072.0m [3517ft]	1219.2m [4000ft]	1219.2m [4000ft]
TODA	1072.0m [3517ft]	1072.0m [3517ft]	1219.2m [4000ft]	1219.2m [4000ft]
ASDA	1072.0m [3517ft]	1072.0m [3517ft]	1219.2m [4000ft]	1219.2m [4000ft]
LDA	961.0m [3154ft]	933.3m [3062ft]	1219.2m [4000ft]	1080.6m [3545ft]

LEGEND:

TORA - TAKE-OFF RUN AVAILABLE
TODA - TAKE-OFF DISTANCE AVAILABLE
ASDA - ACCELERATE-STOP DISTANCE AVAILABLE
LDA - LANDING DISTANCE AVAILABLE
-OLS AS PER CITY ZONING BYLAW 4888

NOTE:

1. CLEARWAYS HAVE NOT BEEN ASSESSED.
2. A TOPOGRAPHIC SURVEY IS REQUIRED TO DETERMINE ANY CONFLICTS WITH OLS.
3. CREEK DIVERSION LAYOUT WAS TAKEN FROM FIGURE 3 OF EBA'S K23101307-DETAILED VERNON CREEK REALIGNMENT AND ENHANCEMENT DESIGN DATED SEPT. 11, 2008 AS REVISED.

H 1:5000 (metres)
0 50 100 150 200 250m
V 1:500 (metres)
0 5 10 1.5 20 25m

STATUS
ISSUED FOR REVIEW

CLIENT
CITY OF Vernon

TETRA TECH EBA

YVK - RUNWAY FEASIBILITY STUDY
VERNON, BRITISH COLUMBIA

RUNWAY 05-23 EXTENSION
OPTION 4

PROJECT NO.	DWN	CKD	REV
C31103234	MD	KA	0
OFFICE: VANC	DATE: May 13, 2014		

Figure 4A

V:\C31103234.01 YVK-Runway Feasibility Study\01 Design\C31103234-FIG4.dwg [FIGURE 4A] May 13, 2014 - 9:11:34 am (by: domingo, mario)

PLAN

1:2000m

LEGEND:

- B/W — BLUE \ WHITE SYMMETRICAL EDGE LIGHT
- R — RED RWY END LIGHT
- PRECISION APPROACH PATH INDICATOR (PAPI)
- WS — RUNWAY EDGE LIGHT
- G — GREEN RWY THRESHOLD LIGHT
- -NEW PAVEMENT
- -NEW RUNWAY STRIP
- -NEW BLAST PAD

NOTES

0 100

Scale: 1: 2 000 (metres)

STATUS
ISSUED FOR REVIEW

CLIENT
CITY OF Vernon

YVK - RUNWAY FEASIBILITY STUDY
VERNON, BRITISH COLUMBIA

RUNWAY 05-23 EXTENSION
OPTION 4

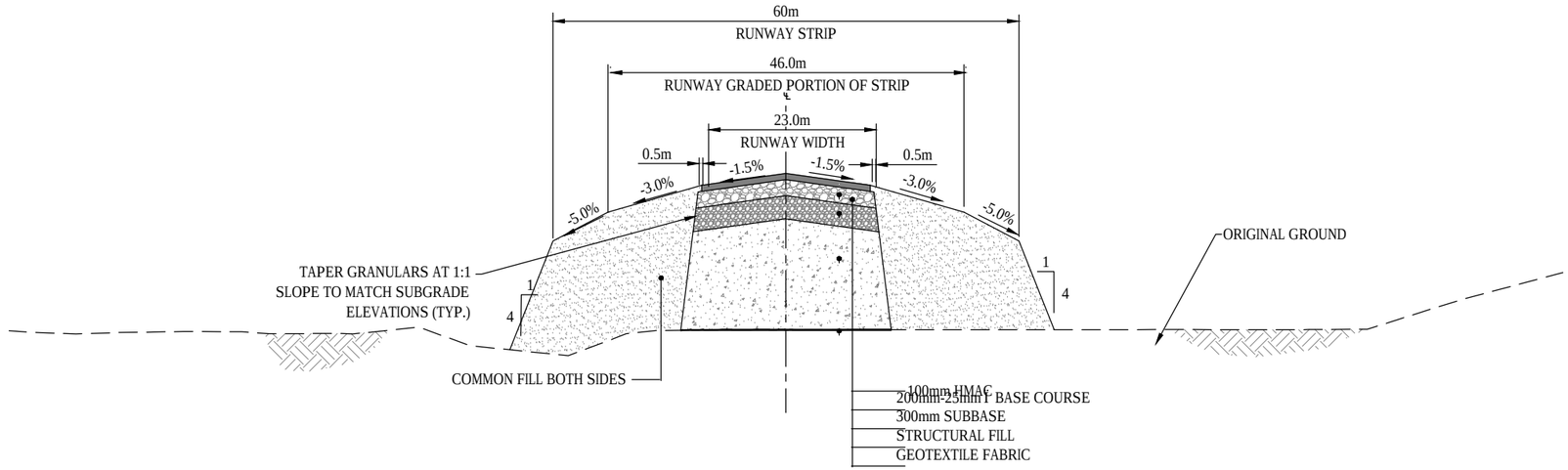
TETRA TECH EBA

PROJECT NO.	DWN	CKD	REV
C31103234	MD	KA	0

OFFICE: VANC
DATE: May 13, 2014

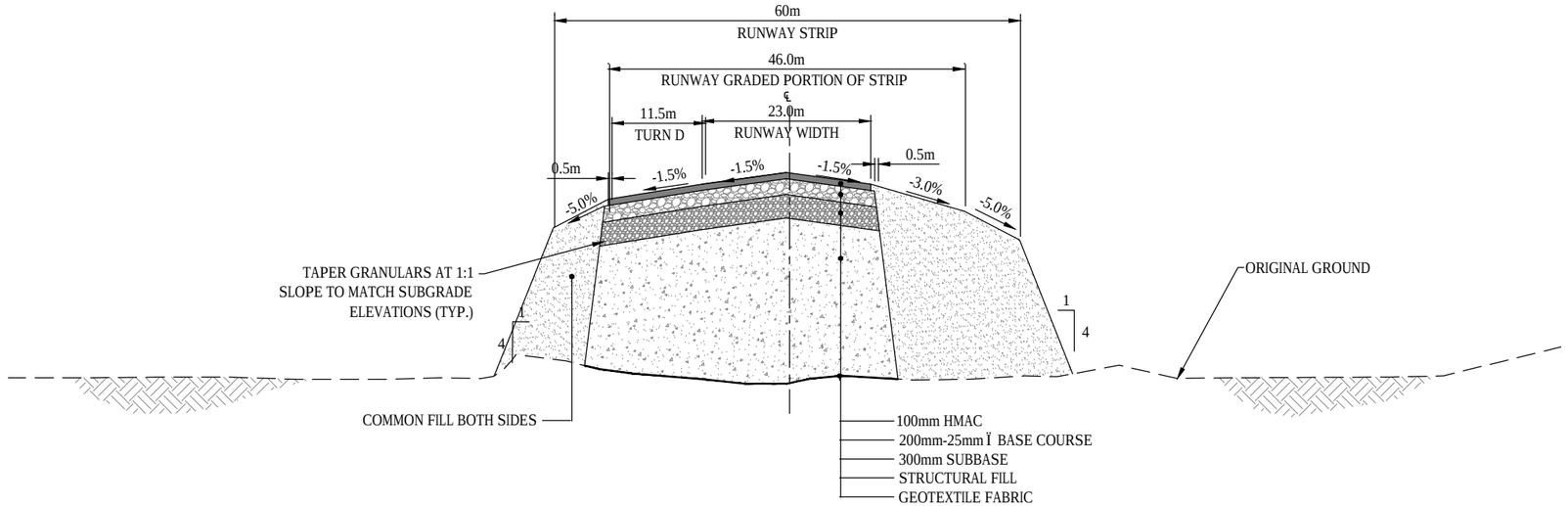
Figure 4B

V:\C31103234-01 YVK-Runway Feasibility Study\01Design\C31103234-FIG4.dwg [FIGURE 4B] May 13, 2014 - 9:13:04 am (by: domingo, mario)



TYPICAL RUNWAY SECTION

NOT TO SCALE



RUNWAY SECTION WITH TURNING D

NOT TO SCALE

LEGEND:

NOTES

STATUS
ISSUED FOR USE

CLIENT

CITY OF Vernon

YVK - RUNWAY FEASIBILITY STUDY
VERNON, BRITISH COLUMBIA

YVK RUNWAY EXTENSION
TYPICAL SECTIONS

TETRA TECH EBA

PROJECT NO.	DWN	CKD	REV
C31103234	MD	KA	0

OFFICE: VANC
DATE: May 13, 2014

Figure 4C

V:\C31103234\01 YVK-Runway Feasibility Study\01Design\C31103234-FIG4C.dwg [FIGURE 4C] May 14, 2014 - 9:01:12 am (BY: DOMINGO, MARIO)

Figure 5: Potential Environmental Effects and Mitigations

RUNWAY FEASIBILITY STUDY AT VERNON REGIONAL AIRPORT ENVIRONMENTAL

ENVIRONMENTAL

POTENTIAL EFFECTS AND MITIGATION MEASURES

OPTION 1
EXTEND RUNWAY EAST & WEST

POTENTIAL EFFECTS TO CREEK

- Fill floodplain with riprap edge (475 m^2) on right bank
- Loss of riparian area and floodplain habitat for the filled portion of the bank
- Encroachment and loss of riparian area between Vernon Creek and the west end of the runway extension

POTENTIAL MITIGATION MEASURES

- Enhancing floodplain backchannel habitat by 475 m^2 in another location
- Riparian Restoration of new floodplain
- Work "in-the-dry" and during approved least risk windows
- Prepare and implement ESC Plan

OPTION 2
EXTEND RUNWAY WEST AND CULVERT CREEK OPEN BOTTOM (PREFERRED) OR EMBEDDED

POTENTIAL EFFECTS TO CREEK

- Fill floodplain with riprap edge (475 m^2) on right bank
- Realignment (straightening) of approximately 85 m of creek through culvert
- Creek shading for 85 m under the culvert / lack of light for fish orientation
- Alteration of stream flows
- Loss of riparian area under the culvert

POTENTIAL MITIGATION MEASURES

- Enhancing floodplain backchannel habitat by 475 m^2 in another location
- Providing artificial light in the culvert
- Design and install the culvert to preclude excessive water velocities;
- Work "in-the-dry" and during approved least risk windows for hydraulic connections
- Provide undercut bank habitat in another location for offsetting
- Riparian Restoration of new floodplain
- Maintain existing flow regime and avoid blockages at culvert inlets and outlets
- Fish salvage required

OPTION 3

POTENTIAL EFFECTS TO CREEK

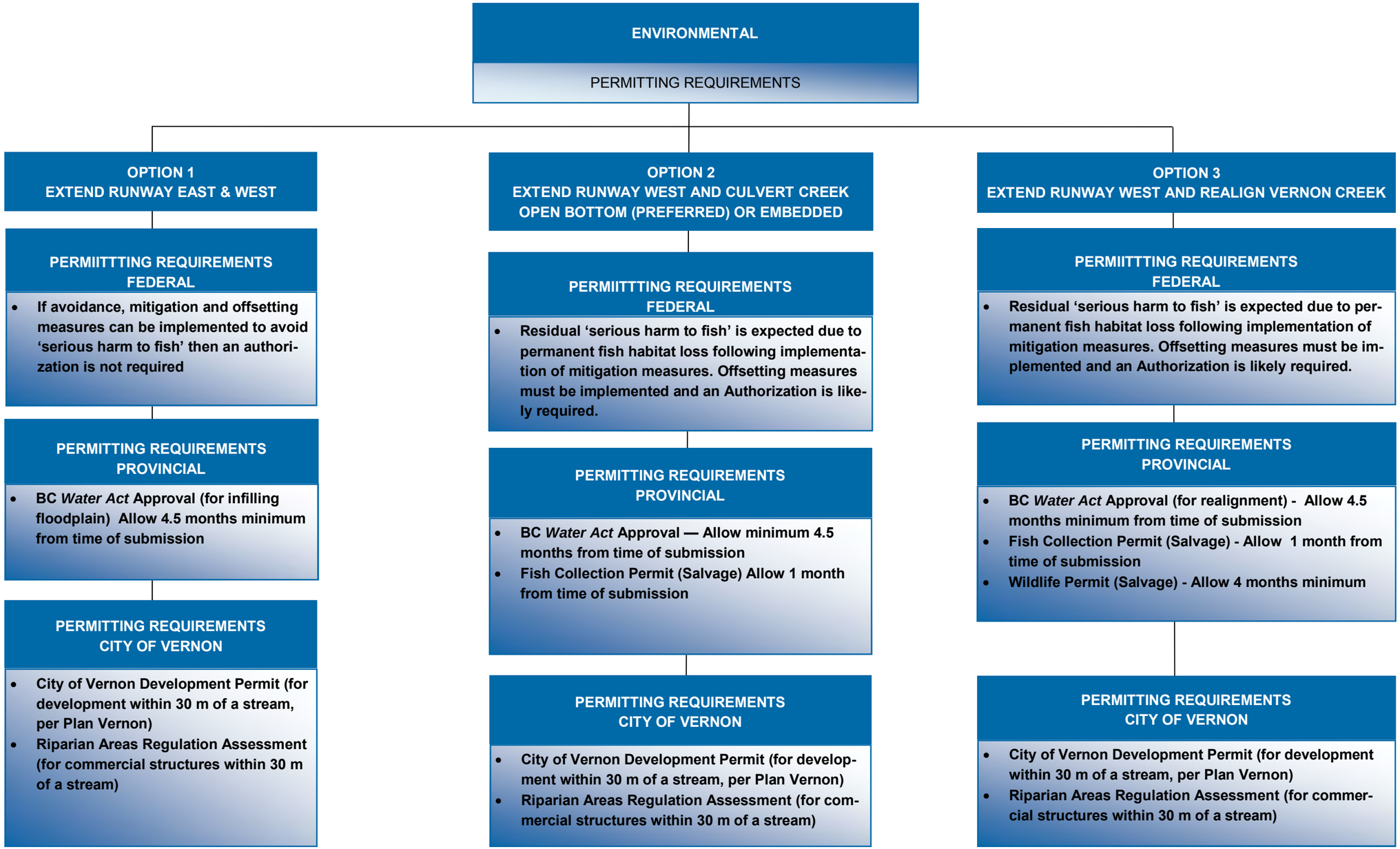
- Increases length of creek by 118 m, decreasing gradient & potentially changing flow characteristics, substrate & vegetation (e.g. may become more of a wetland)
- Increased length at lower gradient may mean more of creek will backwater from Okanagan Lake for longer period in spring
- Potential increase in fish rearing habitat
- Potential increase in bird nesting habitat
- Removal of 150 m^2 of wetland, and potential amphibian breeding habitat (e.g. spadefoot toad, long-toed salamander)
- Potential pumpkinseed sunfish removal required

POTENTIAL MITIGATION MEASURES

- Mimic substrate and floodplain characteristics in new channel
- Install deflectors or other features to reduce the width of the stream, thereby increasing water velocity to reduce potential sediment accretion
- Construct in-stream habitat features such as undercut banks, large woody debris, pools and floodplain benches
- Riparian restoration
- Potential removal of pumpkinseed sunfish
- Excavate new channel in dry
- Dewatering is likely required
- Fish and amphibian salvage required

Figure 6: Environmental Permitting Requirements

RUNWAY FEASIBILITY STUDY AT VERNON REGIONAL AIRPORT ENVIRONMENTAL



APPENDIX A
TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

DESIGN REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This Design Report pertains to a specific site, a specific development, and a specific scope of work. The Design Report may include plans, drawings, profiles and other support documents that collectively constitute the Design Report. The Report and all supporting documents are intended for the sole use of Tetra Tech EBA’s Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, analyses or other contents of the Design Report when it is used or relied upon by any party other than Tetra Tech EBA’s Client, unless authorized in writing by Tetra Tech EBA. Any unauthorized use of the Design Report is at the sole risk of the user.

All reports, plans, and data generated by Tetra Tech EBA during the performance of the work and other documents prepared by Tetra Tech EBA are considered its professional work product and shall remain the copyright property of Tetra Tech EBA.

2.0 ALTERNATIVE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless so stipulated in the Design Report, Tetra Tech EBA was not retained to investigate, address or consider, and has not investigated, addressed or considered any environmental or regulatory issues associated with the project specific design.

4.0 CALCULATIONS AND DESIGNS

Tetra Tech EBA has undertaken design calculations and has prepared project specific designs in accordance with terms of reference that were previously set out in consultation with, and agreement of, Tetra Tech EBA’s client. These designs have been prepared to a standard that is consistent with industry practice. Notwithstanding, if any error or omission is detected by Tetra Tech EBA’s Client or any party that is authorized to use the Design Report, the error or omission should be immediately drawn to the attention of Tetra Tech EBA.

5.0 GEOTECHNICAL CONDITIONS

A Geotechnical Report is commonly the basis upon which the specific project design has been completed. It is incumbent upon Tetra Tech EBA’s Client, and any other authorized party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the geotechnical information that was reasonably acquired to facilitate completion of the design.

If a Geotechnical Report was prepared for the project by Tetra Tech EBA, it will be included in the Design Report. The Geotechnical Report contains General Conditions that should be read in conjunction with these General Conditions for the Design Report.

6.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B

EDITION II – PHASE 1 ENVIRONMENTAL IMPACT ASSESSMENT AND CONCEPT DESIGN REPORT (EBA 2008)

The Corporation of the City of Vernon

ISSUED FOR USE

EDITION II — VERNON CREEK REALIGNMENT AND ENHANCEMENT PHASE 1 - ENVIRONMENTAL IMPACT ASSESSMENT AND CONCEPT DESIGN

K23101307

September 12, 2008

EBA Engineering Consultants Ltd.
p. 250.862.4832 • f. 250.862.2941
150, 1715 Dickson Avenue • Kelowna, British Columbia V1Y 9G6 • CANADA

EXECUTIVE SUMMARY

EBA Engineering Consultants Ltd. (EBA), together with Kerr Wood Leidal Associates Ltd. (KWL), is pleased to submit the Edition II of the Vernon Creek Realignment Environmental Impact Assessment and Concept Design. The realignment is required to accommodate a runway expansion of the Vernon Regional Airport. Edition II of this report has been prepared in response to changes resulting from correspondence with the Ministry of Environment from February 2008 and an on-site meeting in June 2008. Based on the meeting, we've moved the proposed channel approximately 20 metres to the west from the end of the runway. This shift preserves several wetlands and increases the safety distance between the creek and the runway (Figure 1).

The Vernon Regional Airport Master Plan indicates that a new runway length of 4000 feet (1219 m) would ensure safe operating conditions for existing aircraft and would aid in attracting larger industry to the airport site. This proposed runway length is the benchmark for Transport Canada Code B aircraft and serves as the optimal safety margin for smaller Code A aircraft.

Vernon Creek has been impacted over time by channelization, vegetation removal, and urbanization. The creek and most of the adjacent wetland communities are rated "Functional – At Risk" (EBA, 2004). In spite of its impacted state, several rare plants and animals have been found in the study area.

Rare plant occurrences within the study area include Mosquito fern, awned cyperus and field dodder. Mosquito fern is a **Red-listed** floating aquatic plant. Vernon Creek is one of 9 known sites in the province. Of these, there may be only 1 – 3 populations with good viability (CDC, 2005). The plant has been found in the oxbow across from the Marshall Fields, and also along 70 m of the main channel of Vernon Creek (CDC, 2008). The creek occurrence is considered transitory, as opposed to a stable population (M. Martin, 2008). Awned cyperus is a **Blue-listed** marginal aquatic plant. It was also found in the oxbow across from Marshall Fields. This oxbow will remain undisturbed under the present concept plan. A portion of the 70 m stretch will be impacted. Field dodder is a **Blue-listed** parasitic plant. It was found growing on wormwood in the Marshall Fields in September of 1995 (CDC, 2008).

Rare wildlife species that reside in the study area include spadefoot toad and painted turtle. These **Blue-listed** species live and reproduce in the wetlands around the creek. Long-toed salamander and tree frog have also been found in several of the wetlands. Anecdotal occurrences of Western rattlesnake (**Blue-listed**), gopher snake (**Blue-listed**) and rubber boa have been reported (EBA, 2004). Several rare birds such as western grebe, short-eared owl, American bittern, Swainson's hawk, and long-billed curlew have been known to occur in the area. The birds may have been using the site as a stop-over during migration, or for foraging. No nest sites have been recorded in the area.

The creek supports fish species including rainbow trout, kokanee, peamouth chub, longnose dace, largescale sucker, prickly sculpin, redside shiner and northern pikeminnow. The **exotic** pumpkinseed sun fish have been caught in one of the wetlands. This **exotic** species, as well as carp, are also found in Vernon Creek.

The realignment of Vernon Creek presents a unique opportunity to preserve the wetlands and increase the quantity and quality of aquatic and **riparian** habitat. The Edition II alignment avoids wetlands 30a, 31a, 31c, 32a, 32b, 32c, 32d, 34 and 35. Thus, these known habitat sites for **Blue-listed** painted turtle and Great Basin spadefoot, as well as Pacific tree frog and long-toed salamander, will be retained with this alignment. The design achieves this by wrapping the new channel to the west, around the wetlands. The runway will lie to the east. The proposed trail will wind along the creek on the west, away from the wetlands. Therefore, the wetlands will lie between the creek and the runway, and thereby be protected from people and pets.

All wetlands except for one wetland and two small ditches are retained in the plan. To compensate for the lost wetland area and ditches, we have designed three new wetlands north of the runway. The life requisites of spadefoots and painted turtle form the design criteria for these wetlands. A large, deep pond will target painted turtle, and two smaller, ephemeral pools will target spadefoot and other amphibians. A turtle nesting area is proposed nearby. In addition, a portion of the original channel will remain as a backwater stem. This is likely to grow over with cattails and rushes and provide marsh habitat. A number of low lying marshy areas, likely to be salamander habitat, are preserved.

We have designed the new channel around existing trees. Their roots will give stability to the new banks. Within the new channel, bioengineered undercut banks will provide important cover for fish such as rainbow trout. Finally, we propose to plant the length of the new channel with **riparian** vegetation, within the height restrictions of the airport.

The design seeks to protect rare species habitat first and foremost, and secondly enhance the aquatic and terrestrial habitat for all species. The project team believes that the design, together with proper plant, fish and animal salvage and construction practices, will result in no net loss of habitat. Conversely, a net gain of habitat is anticipated.

Pulling the creek farther to the west also increases the safety margin for the airport, providing an extra buffer, in the case of aircraft brake failure. Therefore, the proposed creek alignment creates a 'win-win' for both aircraft safety and wildlife habitat.

Overall, 659 m^2 additional wetland habitat, 1253 m^2 of riverine aquatic habitat, and 5122 m^2 of addition riparian habitat will be created.

In accommodating the proposed airport expansion, we have a unique opportunity to preserve wetland habitat, restore Vernon Creek's natural stream pattern, and improve fish habitat. As development rapidly proceeds in the Vernon Waterfront Area this opportunity is considered limited. There may never be a better time to initiate this restoration project.

ACKNOWLEDGEMENTS

Jennifer Clarke, M.Sc., P.Geo. — Geoscientist, Clarke Geoscience Ltd., (formerly with EBA)

Grahame Go — Airport Manager, Vernon Regional Airport

Susan Latimer, R.P.Bio. — Ecosystem Biologist, Ministry of Environment, Vernon (now retired)

Lisa Tedesco, B.Sc., BIT — Ecosystem Biologist, Ministry of Environment, Vernon

Dave Smith, R.P.Bio. — Habitat Biologist, Department of Fisheries and Oceans (now retired)

Mike Nolan, P.Eng. — Project Engineer, Kerr Wood Leidal Associates Ltd.

Troy Jones, P.Eng. — Hydrologist, formerly with Kerr Wood Leidal Associates Ltd.

Kyle Hawes, R.P.Bio. — Biologist, formerly with EBA

GLOSSARY

Alluvial	Soil or sediment characteristics deposited by a river or other running water.
Avulsion	When a stream jumps its banks to create a new channel.
Blue-listed	Includes any ecological community, and indigenous species and subspecies considered to be of **special concern** (formerly vulnerable) in British Columbia. Elements are of **special concern** because of characteristics that make them particularly sensitive to human activities or natural events. **Blue-listed** elements are at risk, but are not Extirpated, **Endangered** or Threatened (CDC, 2008).
COSEWIC	Committee on the Status of **Endangered** Wildlife in Canada
Ecotone	An **ecotone** is the transition area between two ecological zones, for example, between aquatic and upland zones. **Ecotone**s have a high ecological value due to the adjacency of both zones together.
Element Occurrence Record	A record from the BC Conservation Data Centre containing information about an element occurrence, such as location, condition, and type of occurrence.
Endangered	Facing imminent extirpation or extinction.
Exotic	Species that have been moved beyond their natural range as a result of human activity. **Exotic** species are also known as alien species, foreign species, introduced species, non-indigenous species and non-native species. **Exotic** species are excluded from the Red, Blue and Yellow lists.
Extinct	Species that no longer exist.
Extirpated	Species that no longer exist in the wild in British Columbia, but do occur elsewhere. Ecological communities that no longer exist in British Columbia, but do occur elsewhere.
MAF	Mean Annual Flow
QEP	Qualified Environmental Professional
Red-listed	Includes any ecological community, and indigenous species and subspecies that is **extirpated**, **endangered**, or threatened in British Columbia. **Extirpated** elements no longer exist in the wild in British Columbia, but do occur elsewhere. **Endangered** elements are facing imminent extirpation or extinction.

	Threatened elements are likely to become **endangered** if limiting factors are not reversed. **Red-listed** species and sub-species may be legally designated as, or may be considered candidates for legal designation as **Extirpated**, **Endangered** or Threatened under the *Wildlife Act* (see http://www.env.gov.bc.ca/wld/faq.htm#2). Not all **Red-listed** taxa will necessarily become formally designated. Placing taxa on these lists flags them as being at risk and requiring investigation. (CDC, 2008)
Riparian	Ecosystem Group in BC Species and Ecosystems Explorer: ecological communities influenced by proximity to water bodies (rivers, streams, lakes) and processes associated with moving water.
Special Concern	Particularly sensitive to human activities or natural events but not **endangered** or threatened [as used by **COSEWIC** - A wildlife species that may become a threatened or an **endangered** species because of a combination of biological characteristics and identified threats.] **Special Concern** was formerly referred to as Vulnerable **Species at Risk.**
Species at Risk	An **extirpated**, **endangered** or threatened species or a species of **special concern** (formerly called vulnerable).

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1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA), together with Kerr Wood Leidal Associates Ltd. (KWL), is pleased to submit the Edition II of the Vernon Creek Realignment Environmental Impact Assessment and Concept Design. The realignment is required to accommodate a runway expansion of the Vernon Regional Airport. Edition II has been prepared in response to changes resulting from meetings and correspondence with the Ministry of Environment.

1.1 BACKGROUND

The study reach is located within the Vernon Waterfront Plan Area in Okanagan Landing, west of Vernon's city centre (Figure 1) and 100 m upstream of Okanagan Lake. Vernon Creek has been significantly impacted by agriculture, infrastructure, and residential development. The loss of **riparian** vegetation, increase in paved surfaces, storm water runoff, and loss of wetlands due to infilling have adversely affected its hydrology, water quality, and fish and wildlife habitat.

The Vernon Waterfront Neighbourhood Plan bylaw was approved by the City of Vernon in 2002. The plan outlines guidelines to protect the ecology and increase biodiversity while compensating for features that may be lost through development. Guidelines for habitat mitigation were provided in the Waterfront Environmental Study in Okanagan Landing (EBA 2004).

The expansion of the Vernon Regional Airport is included in the Waterfront Plan. To accommodate a runway extension of 209 m, approximately 300 m of Vernon Creek will require relocation. The realignment plan requires habitat enhancement plans for approximately 1 km length of channel. The plan also requires a 3 m wide recreational trail along the creek, in keeping with the City of Vernon's 'Ribbons of Green" trail plan.

1.2 SCOPE OF WORK

This report includes a concept design for the realignment of Vernon Creek and habitat mitigation and enhancement plans. We have prepared an environmental impact assessment, hydrological analysis, and a restoration plan. A schedule outlining timing for salvage, construction, and enhancement is included.

The overall project is defined by three major phases, including:

- Phase I. Design Phase (including Environmental Impact Assessment and Concept Design, presented here);
- Phase II Construction Document Phase; and,
- Phase III Implementation Phase (Monitoring Portion).

1.2.1 Phase 1 – Design Phase

The Design Phase is made up of the following tasks:

- Task 1 - Start-up Meetings and Consultation. This task included several meetings and on-going consultation with the City of Vernon, Greater Vernon Services (GVS), the Vernon Regional Airport, Ministry of Environment, and Department of Fisheries and Oceans.
- Task 2 - Stream Realignment and Fish Habitat Restoration Design. The proposed designs allow for a 2:1 compensation ratio for realigned portions of the creek.
- Task 3 - Hydrological Analysis and Design, including completion of HEC-RAS model for existing and proposed conditions.
- Task 4 - **Riparian** Restoration Design.
- Task 5 - Preparation of an Environmental Impact Assessment Report.

1.2.2 Phase 2 – Construction Document Phase

Detailed construction drawings and specifications will be prepared. The project team will develop pre-construction, during and post construction monitoring programs. The data prepared in the Waterfront Environmental Study in Okanagan Landing (EBA, 2004) provides much of the baseline information required.

These plans will accompany a BC Water Act Section 9 Approval application for "Works In and About a Stream". Given the extensive nature of the proposed realignment, it is also anticipated that an Authorization for Harmful Alteration, Disruption or Destruction (HADD) of fish habitat will be required from Fisheries and Oceans Canada (DFO).

1.2.3 Phase 3 – Permitting Period

A Section 9 Application that involves a HADD will be referred to DFO and will trigger a Canadian Environmental Assessment Act determination. This involves public input and referral by other federal agencies. The permitting timeline can take from three to six months.

1.2.4 Phase 4 – Implementation Phase (Monitoring)

The Implementation Phase includes short and long-term monitoring. On-site monitoring will coincide with construction activities. Long-term monitoring will take place for 3 to 5 years following construction to address agency requirements to report on viability of the stream restoration and planting plan.

2.0 PROJECT RATIONALE

2.1 RATIONALE FOR AIRPORT EXPANSION

The Vernon Regional Airport proposes to extend their runway by 209 m[2] from the existing 1024 m to a final length of 1233 m. In order to achieve this, Vernon Creek needs to be relocated for approximately 300 m. With careful design and implementation, we have an opportunity to improve both airport safety and habitat protection for several **Species at Risk**.

2.1.1 Airport Master Plan – Runway Extension Rational

The Airport Master Plan, commissioned by the City of Vernon, incorporates long-range capabilities, airport requirements, and economic development strategies. The plan seeks to ensure the long-term viability of the airport and to enhance aviation service for the North Okanagan. This includes the current proposal to extend the runway.

Vernon Regional Airport has one operating non-instrument runway. The runway configuration was designed to accommodate the prevailing winds, which are from the northwest off of Okanagan Lake. Runway 05-23 is 1024 m long and 23 m wide, with an adjacent clearing strip of 30 m on either side. It was constructed of asphalt in 1986 and is due for an overlay.

The design aircraft for the airport is the Beech 1900, which is the largest aircraft that will be using the facility on a regular basis. Transport Canada classifies the Vernon Regional Airport as a CODE 2B (non-instrument runway) airport. This is based on regulation TP312(e), which relates runway specifications to aircraft wingspan and wheelbase. While the proposed extension will not affect the classification of the airport, it will increase user safety.

The site conditions affecting runway length are airport elevation and the mean temperature of the hottest month of the year. The extreme summer heat coupled with an elevation of 347 m a.s.l. limits the ability for the Vernon Regional Airport to support larger high performance aircraft. On hot days, lift is harder to create due to reduced air density. To make up for the lost air density from heat or elevation, the aircraft needs to move faster and farther down the runway to create the lift needed to get airborne. In winter conditions, where air density is not as much of a safety factor to pilots, icy conditions become a safety concern. Aircraft require a longer runway surface to extend their landing roll in icy and wet conditions.

The Airport Master Plan indicated that, a new runway length of 4000 feet (1219 m) would ensure safe operating conditions for existing aircraft and help attract larger industry to the

[2] The Vernon Regional Airport Master Plan specifies a proposed runway length extension of 195 m. However, 209 m is the measured distance on concept drawings provided at the time of this assessment.

airport site. This proposed runway length is the benchmark for Code B aircraft with reference to balanced field length and serves as the optimal safety margin for smaller Code A aircraft. The proposed runway length is slightly short of 4420 ft, which is the ideal runway length to facilitate a privately registered Cessna Citation II at full gross weight at 30° Celsius (Table 1), and represents a significant improvement in safety from present conditions.

The Master Plan acknowledges that a 209 m extension of the runway would necessitate a crossing or relocation of Vernon Creek. There is no other viable location for an airport in the Vernon area. This report includes the environmental assessment required for the project, as per the Master Plan.

TABLE 1: DESIGN AIRCRAFT PERFORMANCE NUMBERS

Operation Class	Temperature	Gross	Field Length Required
Private	15° C	Loaded	3370 ft
Private	30° C	Loaded	4420 ft
Commercial	15° C	Loaded	5729 ft
Commercial	30° C	Loaded	7514 ft

2.2 CHANNEL REALIGNMENT DESIGN CONSIDERATIONS

According to the Land Development Guidelines, permanent relocation or diversion of a stream must be considered absolutely necessary (Chilibeck *et al.* 1992). It has long been recognized that this creek relocation may be required due to airport expansion. In applications to the Habitat Conservation Fund in 1985/86, the Ministry of Environment indicated that verbal agreement to relocate the channel had been reached between regional fisheries staff, the City of Vernon, and the North Okanagan Regional District.

The Waterfront Environmental Study, and associated SHIM mapping, describes Lower Vernon Creek as degraded by agriculture and development. The adjacent wetlands are assessed at 'Functional – At Risk' (EBA, 2004). Field assessments confirm that channelization has led to down cutting, loss of spawning and rearing habitat, and a dramatic loss of **riparian** vegetation and streamside cover.

Airports and streams present inherent conflicts. Large birds, such as waterfowl and raptors, are a safety hazard for aircraft. Therefore, it is better for airport and wildlife safety that the channel is as far away from the runway as possible. Trees must be low enough to comply with Transport Canada's standards. While some species conflict with the needs of airports, other species complement quite well. The requirements of certain reptiles and amphibians, for example, present few conflicts with airport needs, which can be managed through careful design.

In accordance with the Land Development Guidelines, the realignment was designed under the guidance of a fisheries biologist, fluvial geomorphologist, hydrotechnical engineer, and landscape ecologist. The team designed the new channel to achieve no net loss of aquatic

habitat and stability over time. The report demonstrates that the constructed channel improves upon the existing channel condition and resulting fish and wetland habitat.

2.3 PROJECT CONSTRAINTS

The realignment of Vernon Creek is constrained to the north by the proposed runway and clearing strip, to the south by the Marshall playing fields, to the west by Cummins Road, and to the east by residences. The Okanagan Indian Band, Reserve No. 1 lies north of the runway.

The project is also constrained by Transport Canada regulations. Regulations TP312E specify the following for a Code 2B runway:

- Clearing strip comprised of level ground must extend 30 m from runway centreline;
- Clearing strip comprised of level ground must extend 60 m from the end of the runway; and
- Height restrictions are limited to a 1V:20H slope extending from the end of the clearing strip off the end of the runway and a 1V:5H slope extending from the clearing strip off the side of the runway.

3.0 METHODS

3.1 REGULATORY AGENCY CONSULTATION

Consultation with senior regulatory agencies began during June 2003 when City of Vernon staff, Mr. D. Arsenault (EBA), Mr. D. Smith (DFO, now retired), and Ms. S. Latimer (MoE) met to discuss the Vernon Waterfront Plan and implications of regional planning. The plan presented the opportunity to enhance Vernon Creek, through realignment and natural parkland creation that would follow the principals of the "Ribbons of Green" Greater Vernon Services planning document.

The DFO had concerns over design and requested that designs consider low flow conditions, whereby out-migrating salmonid fry could become trapped. Both regulatory agencies appeared to be in agreement with the principals of stream restoration, while at the same time expressing concern that designs would successfully improve fish and wildlife habitat and result in a net gain in habitat.

In response to the first edition of this report, Ms. L. Tedesco (MoE) provided a letter with a request for more detailed information. In June 2008, the project team met with Ms. Tedesco and Ms. Latimer to address these data gaps. The results of this meeting include the decision to move the proposed channel further west in order to preserve four additional wetlands, and construct additional ponds for the compensation north of the creek. This edition presents these changes and additional information regarding soils, **Species at Risk**, potential impacts, mitigation techniques and sequencing.

3.2 HYDRAULIC ANALYSIS METHODS

A hydraulic analysis conducted for this study builds upon that which was completed for the Waterfront Environmental Study (EBA 2004). The hydrologic information and restoration concept, and the hydraulics analysis, including HEC-RAS modeling to confirm function of the concept was completed by T. Jones and M. Nolan, of Kerr Wood Leidal.

A hydraulic model of the existing Vernon Creek system near the mouth was completed to gain an understanding of the performance of the creek system under a range of flow conditions and lake levels. In addition, a hydraulic model of the proposed creek realignment was completed to assess the adequacy of the design.

The hydraulic modeling software HEC-RAS version 3.1.3 (Hydrologic Engineering Center – River Analysis System) was used for this assessment. HEC-RAS is a one dimensional computer model used to analyze creeks/rivers and hydraulic structures. It takes the physical creek information, in the form of surveyed cross sections, lengths and channel roughness estimates, and provides flow characteristics at specified cross sections for a given flow. Among other things, the model output includes water surface elevations, velocities, surface widths and tractive forces.

The following sections describe the model inputs.

3.2.1 Flows

Discussed further in Section 4.2, there are a number of estimates of flow in Vernon Creek available from studies undertaken over the past 20 years. For the purpose of the hydraulic analysis in this study a Low Flow, the Mean Annual Flow (**MAF**) and an estimated existing channel capacity were selected to compare the proposed channel to the existing conditions.

The high variation in design peak flows (11 m^3/s (DOE 1976) to 54.7 m^3/s (Dayton & Knight 2001)) indicates a large level of uncertainty in the hydrologic response of the system. Additional hydrologic study to better clarify design flows is required during the detailed design stage, as per MOE recommendations (L. Tedesco, Sept. 8, 2008). Once complete, the model can be re-run to estimate the channel response.

However, the existing channel capacity is large and using it as a design flow provides a comparison between the proposed and existing channels to ensure the proposed configuration will have a capacity equal to or greater than the existing channel. This will ensure any existing flooding problems are not increased as a result of the realignment.

The values and sources used are summarised in Table 2.

TABLE 2: FLOWS FOR HYDRAULIC MODELLING

Description	Value	Source
Low Flow	0.108m^3/s	Water Survey Canada #08NM160
Mean Annual Flow	1.47 m^3/s	Waterfront Environmental Study, EBA, 2004
Existing Channel Capacity	20 m^3/s	KWL model result, as discussed later in this report

The low flow value was taken to be the minimum monthly mean discharge from WSC #08NM160, from the period of record from 1969 to 1999.

3.2.2 Channel Capacity Conditions

The existing conditions HEC-RAS hydraulics model was run for the flows described in Table 2. As part of this analysis, a channel capacity of approximately 20 m^3/s was estimated, this being the flow that can currently be conveyed within the banks of the main channel when there is no backwater effect.

Typical velocities in the creek are 0.3 m/s, 0.6 m/s and 1.2 m/s for low flow, Mean Annual Flow (**MAF**) and channel capacity conditions respectively with minimum lake water levels. Under typical lake water levels during the peak runoff period (June), a backwater effect occurs leading to reduced velocities in the creek, particularly in the downstream areas. Under maximum lake water levels, the backwater effect reaches as far as the upstream model extent. Some flooding has occurred over the years along the trailer park to the north of the airport. The flooding has been managed with sandbags and did not extend far into the trailer park. Flooding potential is greatest in June, when high lake levels can coincide with rain events. (M. Nolan, pers. comm. 2008).

3.2.3 Boundary Conditions

Water levels in Okanagan Lake at the mouth of Vernon Creek are currently not recorded. The closest available water level readings are at Kelowna (WSC #08NM083) with a period of record from 1943 to 2004. The monthly values used in the hydraulic analysis are summarized in Table 3 below.

TABLE 3: OKANAGAN LAKE MEAN MONTHLY WATER LEVELS (WSC #08NM083) (1943- 2004)

Description	Lake Level	
	Gauge (m)	Geodetic (m)
Minimum Recorded (January)	1.046	341.270
Mean Maximum (June)	2.042	342.266
Maximum Recorded (July)	2.704	342.928

3.2.4 Physical Characteristics

A topographic survey of the existing channel was completed from the downstream boundary of the model (the creek discharge point to Okanagan Lake) to the upstream boundary (approximately 1 km upstream of the Lakeshore Road culvert). Cross sections were surveyed approximately every 150 m. Cross section information was entered into the HEC-RAS model.

The culvert at Lakeshore Road was determined to be inlet controlled and therefore has a backwater effect on upstream flows and levels. For the purposes of this study, it was assumed that this restriction would be removed in the future and would not be restricting flow from either discharging to or backwatering from Okanagan Lake. Therefore, the

culvert was removed from the model under existing and proposed conditions. If the culvert is not removed, the backwater effects will continue.

Channel roughness was estimated with reference to Surface Water Field Techniques (United States Geological Survey). Manning's n values of 0.03 and 0.05 for the channel and over bank areas respectively were chosen. These values are considered typical of similar streams and are also comparable to those used in the City of Vernon, Master Drainage Plan (Dayton and Knight 2001). A sensitivity analysis of the results to changes in channel roughness was also undertaken as part of the analysis.

3.3 GEOMORPHOLOGICAL ASSESSMENT METHODS

A geomorphological assessment of lower Vernon Creek, including current channel condition, was completed by J. Clarke, M.Sc., P.Geo. of EBA. It assessed channel pattern and form and provides direction on restoration. Restoration objectives dovetail with fish habitat objectives. Enhancement of lower Vernon Creek will promote a stable, diverse stream channel that will support a healthy aquatic ecosystem.

The following tasks were completed for the geomorphological assessment:

- Information review and air photo assessment;
- Determine the current channel condition;
- Develop a concept plan for channel realignment and restoration by determining the stable channel geometry, pattern and in-stream forms;
- Provide design specifications for the development of in-stream structures, in conjunction with fish habitat restoration.

3.3.1 Information Review and Air Photo Assessment

An analysis of stream channel pattern evolution in context of land development activities was conducted through an assessment of historical air photographs. The following stereo air photos, spanning a 59-year period, were examined to document changes in the channel condition of lower Vernon Creek and the adjacent floodplain within the project study area:

- 1938, Flight Line #BC90, No. 12-14;
- 1949, Flight Line #BC741, No. 109-111;
- 1958, Flight Line #BC5002, No. 156-157;
- 1963, Flight Line #BC4196, No. 130-131;
- 1974, Flight Line # BC7594, No. 97-98;
- 1984, Flight Line #BC84048, No. 114-16;
- 1990, Flight Line #BCC90080, No. 161-162; and

- 1997, Flight Line #BCB97027, No. 79-80.

More recent (2003/2004) orthophographs were also consulted. Additional information on historical stream channel characteristics is provided in an Erosion Study completed by the Department of Environment (1976).

3.3.2 Channel Condition Assessment

Based on the results of the air photo assessment, combined with a review of fish habitat assessments and SHIM mapping (EBA 2004), and a field reconnaissance, an assessment of current channel condition was completed. Methods employed were consistent with other channel assessment techniques (MOF/MELP 1995) (Hogan et al. 1996).

A common approach for determining whether a particular channel reach is in a stable, degrading, or aggrading condition, is to compare it with an undisturbed, stable reach. Although the entire lower Vernon Creek has been historically modified, leaving very little in a natural condition, a relatively undeveloped, natural channel reach immediately upstream of Okanagan Landing Road was considered a fairly representative template for the more extensively modified reaches through the project study area.

3.3.3 Channel Restoration Plan Development

In consideration of stream channel design criteria dictated by flow condition, and of fish habitat requirements, a conceptual channel restoration plan was developed. Using empirical hydraulic relationships, combined with known site conditions, channel pattern and sinuosity for the realigned channel was conceptualized. Hydraulic feasibility of the concept, including several typical cross-sections, was then determined using the HEC-RAS flow model (Section 3.2.2). Model output results determined design flow depths and velocities, which were used to determine stable substrate composition and fish habitat features.

Soil erodibility was considered in the design, taking into consideration the design velocity and bank grading.

Elements of habitat heterogeneity are also key features for fish habitat. Thus, riffle-pool spacing and dimensions, and large-woody debris frequency and orientation were designed together with the fisheries biologist.

3.4 ECOLOGICAL INVENTORY AND RIPARIAN RESTORATION METHODS

An ecological inventory and strategy for **riparian** restoration was completed by M. Steppuhn, B.C.S.L.A., of EBA. The following steps were completed:

- Data compilation and review;
- Field inventory;
- Eco-site profile preparation; and,
- **Riparian** planting table preparation.

3.4.1 Data Compilation and Review

The following documents were compiled and reviewed in preparation for the field inventory:

- Proposed runway extension plan;
- Meeting minutes – May 19, 2005 (EBA, May 19, 2005) (Client, agencies, EBA personnel);
- City of Vernon Parks Plan (City of Vernon);
- Waterfront Environmental Study in Okanagan Landing, BC (EBA 2004);
- Rare Element Occurrence Search (Conservation Data Centre, 2008, http://srmwww.gov.bc.ca/cdc/); and
- E-flora BC: Electronic Atlas of the Plants of British Columbia (http://www.eflora.bc.ca/).

The wetland classification outlined in Waterfront Environmental Study in Okanagan Landing, BC (EBA 2004) was reviewed. City of Vernon parks personnel (S. Abbott, personal communication, Oct. 18, 2005) and the Vernon Regional Airport manager (G. Go, personal communication, Oct. 26, 2005) were contacted regarding issues for consideration. Published documents regarding **Species at Risk** habitat recovery programs and habitat requirements were reviewed.

3.4.2 Field Inventory

A field inventory was conducted on August 10, 2005. The current functioning condition of Vernon Creek and adjacent areas was assessed and noted on Ground Inspection Forms (ftp: //ftp.env.gov.bc.ca/dist/wis/deif/fieldmanual/giffrm98. pdf). Soil conditions, moisture, slope, aspect, and plant species (both indigenous and introduced), were noted.

3.4.3 Eco-site Classification

Following the field inventory, in-stream and **riparian** habitats were described for each vegetation community using eco-site sheets. The eco-site profiles were developed to guide restoration planning.

3.4.4 Vegetation Impact Assessment

The study team classified the pre and post-development vegetation communities. These include:

- Seasonally wetted floodplain;
- Shrub carr;
- Wetland (including both isolated wetlands and creek associated wetlands);

- Upland riparian; and
- Disturbed areas.

3.4.5 Riparian Restoration Plan Preparation

The study team prepared a **riparian** planting table. The eco-site profiles were used as guides to create specifications in accordance with airport safety standards. Planting species, densities, spacing, and plant size were noted. Locations of noted rare and **endangered** species were noted and will be maintained wherever possible.

3.5 FISH AND WILDLIFE METHODS

Fish and wildlife considerations are important for restoration, to satisfy the habitat needs of target fish and wildlife species. The Waterfront Environmental Study (EBA 2004) provided much of the base data for species present in the area. Additional information and the development of in-stream restoration components were provided by senior fisheries biologist, D. Arsenault, M.Sc., R.P.Bio. of EBA.

The following tasks describe methods used to address fish and wildlife concerns:

- Review background information, including baseline fish inventory and habitat assessment work completed for the Vernon Waterfront Environmental Study and included Stream Habitat Inventory Mapping (SHIM) mapping (EBA, 2004). Information provided in other documents was also reviewed (Sisiutl Resources 1986) (Summit 2002), (CDC, 2008).
- Site visit, to examine site-specific details associated with proposed realignment of Vernon Creek.
- Prepare Impact Assessment.
- Prepare Restoration Plan, including development of specific design criteria for fish habitat restoration.

4.0 BIOPHYSICAL SETTING

4.1 SOILS

The study area lies in the valley between Kalamalka Lake and the Vernon Arm of Okanagan Lake. Late glacial to post-glacial sequences of events deposited layers of silts and clays (Photos 1 and 2, Appendix A). More recently, sands and silts have been deposited across the Vernon Creek floodplain, which was once a broadly meandering stream with numerous ox-bow wetlands and adjacent wetland areas.

Borehole logs for water wells in the area indicate that underlying materials include layers of clay and sand, silty clay, and fibric to humic organics (MWLAP 2003). There is approximately 0.5 to 1.7 m of **alluvial** sands and silts, over lacustrine clay of unknown

thickness. The top of the clay is exposed along the channel banks at approximately the water level.

The soil layers vary from clay to sand overlain by peat in some places. The composition of these layers varied as different sediments were laid down in different locations as the creek moved through the valley over time (T. Eddy, pers. comm., 2008). Test pit results from Fletcher Paine Associates Ltd. are included in Appendix B.

4.2 HYDROLOGY

4.2.1 Basin Characteristics

Lower Vernon Creek flows from Kalamalka Lake to Okanagan Lake through Vernon. The drainage basin is 851 km^2, of which 572 km^2 lies above the regulated outlet at Kalamalka Lake. Runoff from 172 km^2, including 120 km^2 from BX Creek, flows into Lower Vernon Creek. Much of this runoff is affected by urban and rural development.

The dam, which regulates flows on lower Vernon Creek at Kalamalka Lake, is owned and operated by the City of Vernon. Excess water is released in April/May and minimum flows are maintained throughout the year in preparation for peak flows.

Water Survey of Canada (WSC) gauging stations have operated on Vernon Creek at the Kalamalka Lake outlet for 30 years (WSC #08NM065) and for 16 years at the mouth at Okanagan Lake (WSC #08NM160). The record indicates that maximum mean monthly flows on Vernon Creek occur in June as a result of precipitation and late snowmelt. Maximum peak flows occur in the summer as a result of rain storm events over the intermediate drainage area (largely urban) between Kalamalka Lake and Okanagan Lake. Natural and regulated storage and attenuation attributed to Kalamalka Lake and Swan Lake moderate peak stream flows on Lower Vernon Creek.

Based on a hydrologic analysis conducted for the Waterfront Environmental Study in Okanagan Landing (EBA 2004) and additional available information, the characteristic flows of Lower Vernon Creek at the mouth are presented in Table 4 below. Flows that were considered in the hydraulic modeling component of this study are summarized previously in Table 2 and discussed in Section 3.2.1. Results of the model are presented in Appendix C.

TABLE 4: ESTIMATED CHARACTERISTIC DISCHARGE FOR LOWER VERNON CREEK

	Estimated Discharge	Flows Used for Hydraulic Design
Low Flow	0.108 m^3/s (Nov-Dec)	Yes
Low Flow (7 day)	0.071-0.562 m^3/s (from Swain 1994)	
Mean Annual Flow	1.47 m^3/s	Yes
Maximum Recorded Flow	8.0 m^3/s (June)	
Channel Capacity	20 m^3/s (calc.)	Yes

TABLE 4: ESTIMATED CHARACTERISTIC DISCHARGE FOR LOWER VERNON CREEK		
	Estimated Discharge	Flows Used for Hydraulic Design
1:100 year flow	54.7 m^3/s (from Dayton and Knight 2001)	
1:200 year flow	11.7 m^3/s (from DOE 1976)	

4.2.2 Flood Frequency Analysis

Outflows on Vernon Creek from Kalamalka Lake are regulated, making it difficult to perform a flood frequency analysis. For future flow conditions, it is assumed continued similar operation of the regulating weir structure.

There is not enough flow data available to calculate the flood frequency for Vernon Creek near the mouth (WSC Station #08NM160; seasonal data 1969-1985). Regionalization approaches to flood frequency analysis are also not applicable due to lake storage and regulation. In addition, regionalization approaches cannot account for the unregulated runoff component from the City of Vernon. Impervious area runoff and storm water retention will have a considerable influence on downstream flows.

Storm water management planning by Dayton and Knight (2001) completed for the City of Vernon Master Drainage Plan estimated that runoff from a 1:100 year event could contribute a flow of 57.4 m^3/s at the outlet of Vernon Creek. Despite some unknowns regarding the effect of developed areas in the City of Vernon on runoff, this number appears high and was not used as a design flow for the study reach.

4.3 CHANNEL CONDITION

Historical air photographs indicate that between Okanagan Landing Road and Okanagan Lake, lower Vernon Creek previously had a longer, more sinuous course. Between 1938 and 2004, Vernon Creek lost approximately 180 m in length over a 1.6 km distance that incorporates the study area. Shortening of the channel has led to down cutting through valley silts and sands into a glaciolacustrine clay material. Because the creek is so deeply incised, rates of lateral movement are slow despite the relatively tight meanders. As the channel banks are eroded, the cohesionless sands slump into the creek (Appendix A, Photo 11).

The upstream progression of channel degradation is limited by the culvert at Okanagan Landing Road. As a result, by the late 1980s, a free drop had developed at the outlet of the culvert that limited upstream fish passage. In 1989, a fish way was constructed and then later repaired/replaced in the early 1990s.

Air photos indicate that valley bottom adjacent to Vernon Creek experienced periodic flooding and had numerous wetland complexes. Normally, the creek would have braided channels in its lower section. Development of the floodplain for agricultural uses led to wetland infilling, channelization of flows into ditches, and loss of channel complexity.

As Vernon Creek approaches Okanagan Lake, the flow conditions become dependant upon lake surface elevation. When lake levels are high, flow velocities are considerably low, resulting in deposition of coarse-textured sediment. When lake levels are low, the creek flows much faster and thus scours bed and bank materials. This alternating sequence of deposition and scour has led to current channel conditions.

Urbanization results in a disequilibrium between flow and sediment transport. Channel degradation occurs because bed load and sediment concentrations are less than in natural systems. Flows enter at a higher rate due to the imperviousness of urbanized surfaces, and greater volumes of water enter the system quickly with less sediment than a natural stream.

4.4 WATER QUALITY

Water quality impacts on lower Vernon Creek are primarily attributed to non-point source discharges and possible groundwater contamination from irrigation with treated sewage (Swain 1994).

Based on a data review and on results of a water quality monitoring program conducted in the summer of 2003, it was determined that water quality in Vernon Creek has generally improved (EBA 2004). This was attributed primarily to upgrades to the City of Vernon sewage treatment plant.

Water quality parameters of concern for Vernon Creek, and the Vernon Arm of Okanagan Lake include: total phosphorous, E-coli, metals (aluminum, iron, and lead), and dissolved oxygen (EBA 2004) (Swain 1994).

Water quality sampling in 2003 found that all measured parameters met criteria for aquatic life, with the exception of total phosphorus (10 mg/L). Phosphorus concentrations were high enough to cause excessive algal growth. E-coli values also exceeded criteria for recreation in a wetland sample.

Lower Vernon Creek is considered to be well-buffered to acidic inputs, and to have moderate water hardness (Swain 1994). The only known source of metals to lower Vernon Creek is from storm water runoff. Maximum concentrations of ammonia, nitrite, and nitrate were all below criteria.

4.4.1 Pollution Sources

A pollution-source risk assessment, completed as part of the Waterfront Environmental Study, identified 10 point-source discharges to lower Vernon Creek (EBA, 2004). Most of the sources were identified as storm drains. Non-point sources were more difficult to define. However, land uses that were identified as probable sources of pollution to lower Vernon Creek include the following:

- Stream bank erosion (near Vernon airport and baseball diamonds);
- Vernon Golf and Country Club;

- Nearby areas subject to spray irrigation of wastewater;
- Developments not currently connected to City of Vernon sewer treatment system, including trailer park at mouth of Vernon Creek; and,
- Untreated storm water runoff from paved surfaces.

4.5 FISH AND FISH HABITAT VALUES

Fish and fish habitat values data were taken from the Vernon Waterfront Study (EBA 2004). Additional references were consulted to develop a baseline condition and impact assessment and to guide the restoration plan. A summary is included below.

4.5.1 Fish Species Present

Native fish species known to reside in Lower Vernon Creek are rainbow trout, kokanee, peamouth chub, longnose dace, largescale sucker, prickly sculpin, redside shiner, and northern pikeminnow (EBA 2004). In addition, juvenile lake trout may be using the creek as a downstream migration corridor since lake trout are beginning to be caught in Okanagan Lake (which has never been stocked with this species). The dam at the outlet of Kalamalka Lake prevents all species from migrating from Okanagan Lake into Kalamalka Lake. **Exotic** fish species found in lower Vernon Creek and in the small constructed ponds within the former golf course include carp, and pumpkinseed sunfish (EBA 2004).

Average annual kokanee escapement in lower Vernon Creek over the period 1990-2004 is 494 fish (MELP 2004), whereas over the previous decade of 1983-1991, escapements averaged 844 fish. Figure 2 illustrates that the kokanee spawning population is down from 1800 fish in 1990 to 69 fish in 2003, and most recently to about 243 fish in 2004 (MELP 2005). The potential kokanee spawning population for lower Vernon Creek is >5,000 fish, although it is doubtful that Vernon Creek, in its present state, could support such populations (B. Jantz 2006). The rainbow trout population in Vernon Creek is estimated at 50 to 150 fish, and spawning is thought to occur in late March or early April (two weeks earlier than other Okanagan Lake tributaries) due to warmer stream temperatures (Houston 1979). However, little is known about the Vernon Creek rainbow trout population.

Of the species found in Vernon Creek, Kokanee are of regional concern. Stream spawners are of particular concern to fisheries managers.

4.5.2 Fish Habitat Values

Vernon Creek ranks fourth out of seventeen Okanagan Lake tributaries in terms of fisheries importance (Shepherd 1990).

Table 5 summarizes reach characteristics and Table 6 presents fish habitat features within the study area. The assessment indicates that lower Vernon Creek has little to no suitable spawning habitat and a lack of quality rearing habitat in the study area. Here fish habitat is generally open-channel, riffle habitat, lacking in cover and habitat complexity.

Limiting factors to fish production in the creek include:

- physical barriers (beaver dams);
- low flows (attributed to water extractions);
- channelization;
- sedimentation; and
- water quality.

TABLE 5 REACH CHARACTERISTICS WITHIN THE LOWER VERNON CREEK PROJECT STUDY AREA

Reach	Length (m)	Substrate	Cover and Shade	Rearing Habitat for Fish	Spawning Habitat for Fish
1	270	Sand	All cover provided by overhanging grasses and few small shrubs.	Lack of pools, undercut banks and woody debris.	None.
2	395	Larger proportion of gravel mixed with sand. Some exposures of clay substrate.	All cover provided by overhanging grasses.	Lack of undercut banks, woody debris, and deep pools. Very limited rearing potential.	None.
3	610	Clay, with veneer of gravel and sand	Provided by overhanging grasses and sparse shrubs. Banks do not support deep undercuts.	Deep pools associated with woody debris and tight meander bends (limited).	Little to no significant spawning habitat.

TABLE 6: SUMMARY OF FISH HABITAT FEATURES WITHIN THE LOWER VERNON CREEK PROJECT STUDY AREA

Habitat Feature	Count	Total Length (m)	Mean Width (m)	Mean Depth (m)	Area (m^2)
Deep (>1m) Pool	5	39	4	1.6	152
Large Woody Debris	6	23	6	0.8	126
Off-Channel Habitat	1	7	4	0.2	25
Over Stream Vegetation	2	13	5	0.2	59
Small Woody Debris	2	5	5	0.9	24
Spawning Habitat	1	8	4	0.1	27
Undercut Bank	2	9	1	1.0	8

A number of enhancement projects have been undertaken on lower Vernon Creek through the Habitat Conservation Fund from 1985. The projects have included:

- beaver dam removal to improve fish access;
- the placement of spawning gravels; and
- bank stabilization.

Two spawning gravel platforms with log weir deflectors were installed in the project reach. However, utilization rates are not known. Other projects involve extensive stream cleanup work by the Environment Youth Corps and through the Vernon Creek Committee, established in 1988.

4.6 RIPARIAN VEGETATION AND WETLAND HABITAT VALUES

Within the study area, very little **riparian** vegetation remains alongside Vernon Creek. It has been constrained by the adjacent land uses of the airport operations, recreation fields, and the former golf course.

During the field assessment, we identified four major **riparian** vegetation/habitat types. These include:

- grass/low rush;
- tall rush (off-channel wetland);
- mixed shrub; and
- hardwood treed.

Data sheets summarizing vegetation species are provided in Appendix D.

Because little **riparian** forest remains within the study area, the study team examined the habitat upstream. This was used to develop restoration objectives.

Very few wetlands remain in the Okanagan Very Dry Hot Interior Douglas-fir Variant (IDF xh1), those in the study area provide important an ecological, hydrological, and educational role. The Waterfront Environmental Study delineated and classified wetlands within the Vernon Waterfront Area. The wetland and **riparian** communities are shown in Appendix E. We have kept the same numbering system, and these are also shown in Figure 3.

The following is a summary of the vegetation and wetland assessment, with commentary on the relevance to the proposed realignment project:

- the habitat surrounding the wetlands has a low to moderate biodiversity;
- shallow open water wetlands in the study area lack complex meandering shorelines;
- the interspersion measure of edge habitat between **ecotone**s is low to moderate (relevant to wildlife species that depend on more than one habitat type and also an indicator of biodiversity);
- wetlands within the study area have developed on mineral substrates and are recharged by combination of groundwater and seepage flows;
- the current small size and absence of slow-moving back-water wetlands along Vernon Creek reduces water residence time and, therefore, limits the capability for water quality improvements; and

- overall, wetlands in the study area had experienced a high-level of modification. Vernon Creek and the majority of its riverine and adjacent wetland communities are rated "Functional – At Risk". Only those in the oxbow near Marshall Fields (Communities 24-27), are in Proper Functioning Condition.

Wetland Communities are shown in Figure 3. We have used the same numbering system as the Waterfront Environmental Study (Appendix E), for consistency. Wetland Communities 21, and 23 through 27 lie at the upstream end of the study area. Communities 24 through 27 are the only ones that are rated as 'Proper Functioning'. Community 21 is a ditch that drains in from Okanagan Landing Road, and is rated as 'Non-functioning'. Community 23 is rated as 'Functioning – at Risk'. All of these communities will remain undisturbed with the new alignment.

The remaining **riparian** and wetland communities on the site are rated as 'Functional – at Risk'. The new alignment avoids the majority of the wetlands. It crosses the low lying depressions along 30b and 32b, but leaves all but 120 square metres intact. Wetland 31b must be filled due to the runway extension. This has an area of 144 square metres. Great Basin spadefoots, along with Pacific tree frogs and long-toed salamander, are known to occur here. See Section 7.0 for recommendations on species salvage and sequencing. To compensate for its loss, two ephemeral wetlands, totalling 300 square metres, will be constructed. We will use the spadefoot, and other amphibians, as our target species for the design parameters of these wetlands. Spadefoots prefer ephemeral ponds (i.e., that dry up in late summer or fall) because these ponds will not support predators such as fish (Appendix F). In addition to these ephemeral wetlands, we have designed a permanent wetland of 630 square metres for compensation, with painted turtle as our target species for design. Painted turtle hibernate in soft mucky bottoms of their ponds, and prefer those with water year round. (See Figure 3).

4.6.1 Plant Species at Risk

Three plant **Species at Risk** have recorded occurrences within the study area according to the Conservation Data Centre (CDC, 2008). These species are Mexican mosquito fern (*Azolla mexicana*), awned cyperus (*Cyperus squarrosus*), and field dodder (*Cuscuta campestris*). (See the Rare Species Map, Appendix G).

Mexican mosquito fern is **Red-listed** within British Columbia. It was first recorded on the creek in 1997 and last recorded in 2006. It is an aquatic fern that floats on the surface of the water. It was found in the oxbow across from Marshall Fields (Wetland Community 27), and along 70 metres of the main channel of Vernon Creek. The fern is sensitive to water level changes and salinity, pH, mineral levels and water temperature. Mosquito fern is able to remain dormant for many years, and reappear when conditions are favourable. The study area is one of nine known locations in British Columbia, of which, only four or five are considered viable (CDC, 2008). The new alignment will not disturb the oxbow in which it has occurred, but is likely to disturb a portion of the main channel where an occurrence was recorded.

Awned cyperus is **Blue-listed** and was found in 1998 in the oxbow (Wetland Community 27) along Vernon Creek. Six plants were noted, growing in a 4 x 2 metre patch surrounded by cattail and hemp dogbane. They were threatened to be overtopped by surrounding vegetation, and the location had been flooded by high water for a number of years. The new alignment will not disturb the occurrence location.

Field dodder is a parasitic **Blue-listed** plant. It was found in 1995 growing on wormwood (*Artemisia absinthium*) on the drier portion of Marshall Fields with smooth brome (*Bromus inermis*) and field bindweed (*Convolvulus arvense*). We did not find any dodder within the creek realignment area during the site survey EBA personnel have not observed any plant **Species at Risk** near the proposed alignment. However, we have found Blue Vervain (*Verbena hastata*) south of the study area near Okanagan Landing Road. These plants are at risk from ditch maintenance and future road expansion. Relocation of these plants is recommended. A patch of field dodder is currently being confirmed. Both of these occurrences are located across Marshall Fields near Okanagan Landing Road and not at risk with the proposed alignment. Table 7 summarizes plant **Species at Risk** occurrences within the study area.

TABLE 7: PLANT SPECIES AT RISK

Plant Species	CDC Listing	COSEWIC Listing	First / Last Occurrence	Location	Comments
Mexican mosquito fern (*Azolla Mexicana*)	**Red-listed**	Threatened (T May 2000)	1997 / 2006	Community 27, 70 m along Vernon Creek	Community 27 will be preserved; creek populations were considered transitory (M. Martin, 2008)
Awned cyperus (*Cyperus squarrosus*)	**Blue-listed**	n/a	1998 / 1998	Community 27	Community 27 will be preserved. Not recorded recently (M. Martin, 2008).
Field dodder (*Cuscuta campestris*)	**Blue-listed**	n/a	1995 / 1995	Marshall Fields	Found near Okanagan Landing Road (EBA, 2008).
Blue vervain var. scabra *(Verbena hastate)*	**Red-listed**	n/a	1964/ 1977 (CDC) / 2008 (EBA)	Okanagan Landing Road ditch	Approx. 20 plants have been flagged along the north side of Okanagan Lake Road

4.7 WILDLIFE AND WILDLIFE HABITAT VALUES

A wildlife inventory and habitat assessment was completed for the Waterfront Environmental Study (EBA 2004). The inventory provides baseline information on small mammal presence, birds, herptiles, and invertebrates.

4.7.1 Small Mammals

Potential small mammal presence was determined by comparing available habitat to species requirements. Small mammal species known to make use of the study area include, but are not limited to, the following:

- Beaver - Meadow Vole - Columbian ground squirrel - River Otter

- Muskrat - Vole Species - Yellow-bellied marmot - Red squirrel
- Mink - Skunk - Bushy-tailed wood rat - Raccoon
- Chipmunk

The majority of these species would utilize the riverine and **riparian** communities of Vernon Creek, while others, such as the marmot and ground squirrel, inhabit more open upland sites. Suitable beaver habitat is limited by food availability due to lack of woody vegetation.

Based on a review of the Blue and **Red-listed** wildlife species within the Vernon Forest District according to the CDC (CDC, 2008), species that may occur in the study area are listed in Table 8.

TABLE 8: RARE WILDLIFE WITH POTENTIAL OCCURRENCE IN THE STUDY AREA

English Name / Scientific Name	CDC Listing	COSEWIC Status	Likelihood of Occurrence	Habitat Comments
Townsend's Big-eared Bat *Corynorhinus townsendii*	**Blue-listed**	-	May forage in the study area, but there is no suitable day or maternity roost sites within the affected area.	Roosts in rocky crevices. Often maternity colonies occur in caves, mine shafts, buildings, or large trees. The species may change roost location for winter hibernation (Blood, D.A. 1998).
Spotted Bat *Euderma maculatum*	**Blue-listed**	SC (May 2004)	May forage in the study area, but there is no suitable day or maternity roost sites within the affected area.	Forages over fields and marshes and pine forests. Maternity roots are generally in rock crevices and cliffs (CDC, 2008)
Northern Myotis *Myotis septentrionalis*	**Blue-listed**	-	May forage in the study area, but there is no suitable day or maternity roost sites within the affected area.	Roosts in rock crevices. Day roosts include buildings and under the bark of trees. Winter hibernacula can be up to 56 km away in caves or in rock crevices (MELP. 1999).
Fringed Myotis *Myotis thysanodes*	**Blue-listed**	DD (May 2004)	May forage in the study area, but there is no suitable day or maternity roost sites within the affected area.	Roosts in rock crevices. Also known to roost in buildings, caves, and, in one Arizona example, under the bark of a ponderosa pine tree. Not much is known about the habitat requirements of bats, though, generally, they are known to occur in **riparian** areas and open ponderosa pine bunchgrass habitat.
Western Small-footed Myotis *Myotis ciliolabrum*	**Blue-listed**	Blue / -	May forage in the study area, but there is no suitable day or maternity roost sites within the affected area.	Roosts in rock crevices, abandoned buildings and under loose bark (CDC, 2008).

TABLE 8: RARE WILDLIFE WITH POTENTIAL OCCURRENCE IN THE STUDY AREA				
English Name / Scientific Name	CDC Listing	COSEWIC Status	Likelihood of Occurrence	Habitat Comments
Badger *Taxidea taxus*	**Red-listed**	E (May 2000)	May occasionally forage in the project area.	Grasslands, deep soil. Generally occur in open grassland or ponderosa pine forests. They occur where abundant prey, such as pocket gophers, voles, squirrels and marmots are abundant.
Western Harvest Mouse *Reithrodontomys megalotis*	**Blue-listed**	Blue / SC (Apr 2007)	May be present within the study area. Anecdotal observations nearby (Summit, 2006).	Old fields, meadows, weedy roadsides, agricultural areas, grassy situations within pine-oak forest, and **riparian** borders. Prefers dense vegetative cover. Also may be found in shrubby arid regions. In Canada, ideal habitat includes dry gullies with dense shrub cover bordering grassland and shrub-steppe rangeland (Nagorsen, 1994 **COSEWIC** report). Climbs in vegetation. Uses runways made by voles. Spherical nests usually are constructed on the ground under heavy vegetation or in shrubs (CDC, 2008).

Generally, maternity and day roosting opportunities for the bat species are currently absent within the study area. However, they may be foraging over the fields and wetlands. No occurrences of Western harvest mouse have been recorded. However, this may indicate non-detection rather than absence. Badgers have not been recorded in the Study Area but could occur. Road mortality is a hindrance to their use of the area. Restoration improvements to the wetlands and **riparian** area could benefit these species.

4.7.2 Birds

Distribution of breeding birds in the study area, with a special emphasis on **Species at Risk** was investigated by EBA (2004) and summarized from others (Natural Heritage Shop Ecological Consultants 1992).

The surveys recorded 75 bird species within the study area, the greatest numbers of which were found in sites along the creek with dense **riparian** vegetation. Habitat diversity (i.e. riverbank, dense **riparian** shrubs, trees, open water and adjacent field) was a key factor affecting species richness. Marsh areas adjacent to the fields and golf course also had relatively high numbers of birds.

Rare and **endangered** bird species that potentially occur within the area are listed in Table 9.

TABLE 9: LIST OF RARE, ENDANGERED, OR VULNERABLE BIRD SPECIES FOUND, OR POTENTIALLY FOUND IN THE STUDY AREA			
Species	CDC Listing / COSEWIC	Habitat Type	Comments
Western Grebe *Aechmophorus occidentalis*	**Red-listed** / -	Lake	Non-breeding (S. Latimer, personal communication, 2002)
Great Blue Heron herodias subspecies *Ardea herodias herodias*	**Blue-listed** / -	Open Water, **riparian**	Nests in large deciduous species such as cottonwoods in mature / old growth forests in rookeries with multiple breeding pairs (Structural stages 5, 6 & 7). Interior population feeds in wetlands and along shallow shorelines of lakes and rivers. (BC MWLAP, 2004). Known to occur in creek and wetlands. No heron nests were observed in study area.
Grasshopper Sparrow *Ammodramnus savannarum*	**Red-listed** / -	Open grasslands	Has been observed nearby in open grasslands (CDC, 2008; Summit, 2006). Make cup nests on the ground. No nesting records within the study area.
Short-eared Owl *Asio flammeus*	Blue / SC (May 1994)	Open, treeless areas	Ground nesting species. Breeding occurs in shrub thickets or old growth fields (structural stages 2 – 3). They hunt over grasslands, marshes or other open areas with an abundant prey base (e.g. small rodents). They typically migrate south except in the Fraser Basin. (BC MWLAP, 2004). Anecdotal occurrence (P. Wise, personal communication, 2003)
American Bittern	Blue / -	Tall, dense cattail marshes	Possible habitat enhancement opportunity since habitat type not common in area.
Swainson's Hawk	Red / -	Open fields / **riparian** areas	Potential foraging within the study area. No suitable woodlands for nesting. No nests found during field study.
Sandhill Crane *Grus canadensis*	Blue / NAR	Bogs, marshes and meadows with bulrushes and sedges.	Low likelihood of occurrence because of the disturbance level of the site.
Western Screech-Owl, macfarlanei subspecies	Red / E (May 2002)	Breeding habitat occurs near or in **riparian** forests in black cottonwood, aspen or water birch stands. Foraging likely occurs in adjacent forests.	Potential foraging habitat on site. Nests in large diameter cottonwood snags, in cavities typically excavated by Northern flickers. Preserving and recruiting large diameter snags and trees is important in the long term protection of this species (BC MWLAP, 2004). No nest sites were observed during field study.
Long-billed Curlew, *Numenius americanus*	Blue / SC (Nov 2002)	Grassy meadows	Shorebird. Anecdotal occurrence in Marshall Fields, likely a stopover during migration. They breed in open grasslands, but will also use planted fields and ploughed areas during migration, rearing and also nesting. Winter habitat occurs in shallow water habitats.

4.7.3 Herpetiles

A herpetile survey was conducted to determine presence/absence and relative abundance of amphibian and reptile species in the study area (EBA 2004).

Amphibians detected (observed or audible) in the study area include: Pacific tree frog, long-toed salamander, and the Great Basin spadefoot toad. Of these, the Great Basin spadefoot toad is most significant as it is provincially **Blue-listed** and protected under the **Species at Risk** Act (SARA). Information on the amphibians noted and their associated habitats is provided in Table 10.

TABLE 10: DETECTED AMPHIBIANS AND THEIR ASSOCIATED HABITATS IN THE STUDY AREA

Species / Listing*	Method of Detection	Habitat Type (Community #)
Great Basin Spadefoot Toad / **Blue-listed** (T, Apr 2007)	Audible (3 adult males)	Wetlands (#30 & 31) adjacent to golf course
Pacific Tree Frog (Not listed)	Audible and visual (>50)	Almost all wetlands in study area, especially abundant in golf course ponds (#30, 31, 32) but also found in oxbow areas (#24, 25, 27)
Long-Toed Salamander / Yellow-listed (NAR, Apr. 2006)	Visual (6) (tadpoles and juvenile)	Wetlands (#10, 11, 12) and (#30, 31) Maintain vegetative connectivity between wetlands

* CDC/**COSEWIC** Listings: T = Threatened; NAR = Not at Risk

Based on the above information, wetland communities 30 and 31 were found to support a variety of amphibian species, including the **Blue-listed** Great Basin spadefoot toad. More information on spadefoot habitat requirements and restoration considerations is provided in Appendix F. Salvage and wetland compensation recommendations are included in Sections 6.0 and 7.0.

4.7.4 Reptiles

Painted turtles, a **Blue-listed** species in British Columbia, were found within numerous wetlands (five sites) in the Vernon Waterfront area. The revised alignment within this edition of the plan successfully avoids all but one pond. Wetland 31b must be filled as part of the runway extent, in order to conform to airport safety requirements. To mitigate the loss of this pond, a thorough salvage and monitoring program is outlined in Section 7.0. Compensation ponds are shown in Figure 3 and discussed in Section 6.0.

Three snake species of concern were not observed but anecdotal occurrences have been noted within the study area. These include the western rattlesnake, the gopher snake, and the rubber boa. Habitat requirements for these species are included in Table 11.

TABLE 11: DETECTED REPTILES AND THEIR ASSOCIATED HABITATS IN THE STUDY AREA		
Species	CDC Listing / COSEWIC	Habitat Type (Community #)
Painted Turtle Intermountain population *Chrysemys picta pop. 2*	Blue – listed / SC (Apr 2006)	Observed on site (6). Wetlands (#30, 31, 32) within and adjacent to golf course. Require undisturbed upland areas for nesting.
Western Rattlesnake *Crotalus oreganus*	Blue / T (May 2004)	Have been seen in area (P. Wise, 2003; EBA, 2004). Dry, rocky outcrops, foraging in open grassy meadows. Forage in **riparian** areas (Blood, 1993).
Gopher Snake deserticola subspecies *Pituophis catenifer deserticola*	Blue - listed / T (May 2002)	Have been seen in area (P. Wise, 2003; EBA, 2004). Occurs on south and west facing slopes in association with boulder outcrops and talus slopes. Grasslands, scrublands, wetlands, woodlands, farmlands
Rubber Boa *Charina bottae*	Yellow – listed / (SC, May 2003)	Have been seen in area (P. Wise, 2003; EBA, 2004). Requires abundant low cover of woody debris and shrubs for burrows and rock outcrops for sunning.

4.7.5 Invertebrates

Agriculture and development within the Vernon Waterfront Area is thought to have had a negative effect on invertebrate species richness and diversity. Although a detailed study of invertebrate species was not conducted for the Waterfront Study, invertebrate species of concern were identified. These include the following two **Blue-listed** species of dragonfly and damselfly (Odonata), the only taxonomic order of aquatic invertebrate fauna in BC where rare and **endangered** species have been identified:

- Hagen's bluet (*Enallagma hageni*) – may occur in shallow open water wetland communities south of the project area; and,
- Western river cruiser (*Macromia magnifica*) – adults prefer warm lake margins and sandy rivers, while larvae inhabit sandy shorelines and matted tree roots along rapid streams.

These aquatic invertebrates are upper-level predators in the invertebrate food chain and have often been identified as indicators of ecosystem health (Walker and Corbet 1975).

5.0 IMPACT ASSESSMENT

The following impact assessment is based on the biophysical inventory. To determine the positive and negative environmental effects of the proposed alignment, a habitat balance was produced. Net gains or losses of particular habitat types are calculated using GIS and an opinion is provided as to the nature of these gains and losses with respect to the surrounding aquatic and terrestrial ecosystems.

5.1 HABITAT BALANCE SUMMARY

A habitat balance summary table is presented in Tables 12 and 13. By comparing the proposed post-development area extent of particular habitat types with the existing

condition, gains or losses are quantified. Existing habitat types are based on the primary vegetative classification, as noted in Section 4.6 and identified and mapped in the baseline Waterfront Study.

To summarize, the main components of the habitat balance are as follows:

- Under existing, pre-development conditions there is approximately 18,500 m^2 of in-stream and **riparian** habitat. Most of this area has a sub-aquatic/forb habitat type and is situated within the stream channel or associated backchannels. The second most prominent habitat type is mixed shrub situated above the bank full condition.
- The proposed realignment of Vernon Creek will result in a net gain of 1253 m^2 of in-stream habitat, 2086 m^2 additional backwater habitat, and 5122 additional **riparian** areas. The planting will result in a more diverse **riparian** environment, with about nine (9) habitat types represented (as opposed to the existing six).
- The compensation wetlands result in a net gain of 679 m^2 of wetland habitat, which represents a compensation ratio of 3.4:1.

5.2 STREAM CHANNEL AND FISH HABITAT IMPACT ASSESSMENT

The realignment of Vernon Creek, as shown in Figure 3, will result in a net gain in stream length and wetted area. The proposed realignment will add 132 m to the overall length of the stream channel through the study area. This increase makes up a large portion of the 180 m lost channel length experienced between 1938 and 2004 as a result of channelization and agricultural development.

By widening the channel, the proposed realignment will also allow for increased habitat complexity and flood storage capacity, which is a net gain in stream habitat. In addition, stream bank stabilization and vegetation enhancement are positive environmental effects and will result in a net gain in fish habitat.

Channel reconstruction has potential to improve in-stream fish habitat quantity and quality. The creation of additional off-channel and bank under-cuts will provide suitable rearing habitat. The proposed channel includes:

- Two back channel wetlands;
- 2086 m^2 of backwater stream arm for capacity (truncated Vernon Creek);
- 10 undercut banks;
- 9 floodplain benches; and
- 1253 m^2 amount of additional in-stream channel.

The increase in slow-moving wetland communities with associated emergent vegetation should benefit water quality. Table 12 summarizes the pre- and post-development fish habitat features.

TABLE 12: SUMMARY OF PRE- AND POST-DEVELOPMENT IN-STREAM FISH HABITAT FEATURES		
	Pre-Development (Existing) Condition	Post-Development (Proposed) Condition
Feature	Quantity	Quantity
Deep (>1m) Pool	5	15
Large Woody Debris	6	18
Off-Channel Habitat	1	4
Spawning Habitat	1	7
Undercut Bank	2	10
Flood Bench	3	9

Through the project area, Lower Vernon Creek currently provides little to no spawning habitat. Sources of spawning gravel sized material from upstream sources has been reduced though urbanized and streamside development. Reconstruction and regrading of the channel will allow for the placement and installation of suitable spawning gravel. The upper reaches are the best for spawning gravel placement.

The creek experiences backwater effects when Okanagan Lake's levels are high through much of the study area. We have prescribed undercut banks as the preferred enhancement feature in these locations. Undercut banks provide security cover for fish, which is important for rearing habitat. Large woody debris and undercuts will be combined with overhanging trees and shrubs to maximize protective cover over pools. The overall plan will greatly increase overhead cover from shrubs and trees.

Other positive features such as low-lying flood benches, found to have high biodiversity, will be recreated along the new channel. These areas will be larger than the existing channel to increase flood control capacity. There will be a net gain in flood plain area.

Restoration of Vernon Creek may benefit aquatic invertebrates such as the Western river cruiser by providing additional undercut banks and root mats within the creek and retaining a more suitable substrate other than clay, which currently dominates the lower reaches of Vernon Creek. Invertebrates such as Hagen's bluet might benefit from wetland restoration and development since newly constructed wetlands will have a significantly greater proportion of shallow open-water wetlands with an adequate cover-to-water ratio, creating a diverse open water/emergent vegetation marsh ecosystem.

5.3 RIPARIAN AND WETLAND IMPACT ASSESSMENT

Land development in the lower Vernon Creek valley has led to a diminished **riparian** area along the creek. Little has been done to restore a functioning **riparian** ecosystem.

The realignment of Vernon Creek and the corresponding **riparian** restoration plan will result in a net gain of **riparian** habitat. A total net gain of 5122 m^2 of **riparian** vegetation (above the high-water level) will result from the proposed restoration.

The restoration plan includes specifications to replace the existing vegetation, much of which is weeds, with native species. The plants chosen will maximize **riparian** function (aquatic and terrestrial), while meeting strip requirements for airport safety. Airport safety considerations include height restrictions and a desire to minimize attraction of large birds.

Realignment of Vernon Creek may have a potential impact on several rare plants (Appendix G). Awned cyperus (*Cyperus squarrosus*) and Mexican mosquito fern (*Azolla mexicana*) were documented in Community 27, which will be preserved. Mexican mosquito fern was also found along 70 metres of Vernon Creek, a portion of which will be impacted. Field dodder (*Cuscuta campestris*) is a parasitic plant that was recorded growing on wormwood (*Artemisia absinthinium*) in Marshall Fields. To minimize the impact to these rare species, the oxbow within which the plant was found will be preserved and similar habitat will be created along the reconstructed/enhanced portion of the stream in an effort to restore stream function and encourage establishment of more awned cyperus and Mexican mosquito fern. As well, thorough identification and salvage efforts of the creek channel and the impacted field area is required. (See Section 7.0).

Potential impacts to wetland habitat and wildlife in the study area include:

- permanent loss of 246 m^2 of wetland habitat; and,
- disruption and temporary loss of wildlife and wildlife habitat during channel realignment activities.

TABLE 13: SUMMARY OF PRE- AND POST-DEVELOPMENT RIPARIAN AND WETLAND FEATURES

	Pre-Development (Existing) Condition	Post-Development (Proposed) Condition
Feature	Area (m^2)	Area (m^2)
Main channel (Community 39)*	8356	10195
Truncated main channel	0	2086
Riparian area	5002	10124
Wetland 21	1200	1200
Wetland 23	1860	1860
Wetland 24	1476	1476
Wetland 25	400	400
Wetland 26	331	331
Wetland 27	221	221
Wetland30a	414	414
Wetland 30b (ditch)	98	79
Wetland 31a	199	199
Wetland 31b	136	0
Wetland 31c	333	333
Wetland 32a	292	292
Wetland 32b	907	907

TABLE 13: SUMMARY OF PRE- AND POST-DEVELOPMENT RIPARIAN AND WETLAND FEATURES		
	Pre-Development (Existing) Condition	Post-Development (Proposed) Condition
Feature	Area (m^2)	Area (m^2)
Wetland 32c	128	128
Wetland 32d (ditch)	178	73
Wetland 32e	88	88
Wetland 34	550	550
Wetland 35	124	124
Compensation Wetland A	0	161
Compensation Wetland B	0	608
Compensation Wetland C	0	170
Planted Rip Rap	0	1819

* Wetland Community #s as per Vernon Waterfront Study (Appendix E)

The proposed channel realignment will result in the loss of 136 m^2 of wetland community #31b, located at the end of the runway. The new channel will cut through 19 m^2 of a low depression connected to Wetland # 30b and 105 m^2 of a low depression connected to Wetland 32d. Compensation Wetlands A, B and C are proposed to offset the loss of these wetlands. Wetland B will be a deeper, larger pond, of 608 m^2, and is designed to hold water all year. Painted turtle is the target species for Wetland B. Wetland Wetlands A and C are designed to hold water only until late summer. Spadefoot is the target species for Wetlands B and C. They have a combined area of 331 m^2. Together, the wetland area lost is compensated at a 3.4 to 1 ratio.

The new alignment avoids Wetlands # 30a, 31a, 31c, 32a, 32b, 32c, 32d, 32e, 34 and 35. Thus, these known habitat sites for the **Blue-listed** painted turtle, **Blue-listed** Great Basin spadefoot, as well as Pacific tree frog and long-toed salamander will be retained with this alignment.

Wetland # 32c supports **exotic** fish such as pumpkinseed sunfish. These will need to be **extirpated** as part of the mitigation program. (See Section 7.1.7).

5.4 POTENTIAL IMPACTS DURING CONSTRUCTION

A number of risks to water quality, vegetation, fish, aquatic life and wildlife are possible during construction. We have designed the realignment to avoid as many impacts as possible, first and foremost. Where impacts are unavoidable, we have prescribed mitigation measures such as the salvage program, erosion control, and timing windows. Where impacts cannot be avoided or mitigated, compensation is required. For example, Wetland 31b must be filled in order for the runway to comply with safety regulations. To compensate for this, we have prescribed the creation of three additional wetlands (Figure 3). Pre and post baseline conditions should be monitored, in addition to construction

monitoring, to assess the results. In addition, we have outlined contingency measures, should impacts occur. An Impact Assessment Table is included in Appendix H.

Potential hydrological and soils risks include:

- Risk of creating isolated ponds that trap fish;
- Undersized culvert at Lakeshore Road (current condition);
- Risk of low water flows;
- Risk of back watering from Okanagan Lake during high water; and
- Risk of bank erosion / scouring.

Most of these risks can be minimized through careful design such as adequate channel capacity, positive drainage, erosion protection with mats and rip-rap in selective locations, and monitoring with mitigation. A full description of the avoidance, mitigation, compensation, monitoring and contingency details is included in Appendix G.

Potential risks to vegetation include:

- Mexican mosquito fern impacts;
- Awned cyperus impacts;
- Field dodder impacts;
- Poor survival of restoration plantings;
- Animal damage to plantings; and
- Weed invasion.

The plan avoids the oxbow where the location of awned cyperus and one location of Mexican mosquito fern were found. A thorough assessment of the current and proposed alignment must be undertaken for these, as well as field dodder and other potential rare plants prior to construction. Should any be found a salvage program must be undertaken.

Risks to the restoration plantings include mortality through lack of water before their roots are established, animal damage, and weed invasion. Plantings should be protected with animal protection fencing and guards, and properly maintained through the first three years of growth.

Potential risks to fish and aquatic life include:

- Water quality degradation during construction;
- **Exotic** fish escape;
- Fish entrapment;
- Pesticide and herbicide impacts in the long term; and

- Alteration or disruption of fish habitat.

The plan includes proper fish and aquatic invertebrate salvage during construction, sediment control measures during and post-construction, planting **riparian** vegetation, inclusion of additional pools, undercut banks, large woody debris, and riffles through the new channel. A pesticide free zone should be posted 10 - 30 m from Vernon Creek and any wetland. Pesticide use in the area should be in accordance with an Integrated Pest Management (IPM) program, together with biological and mechanical controls, to achieve successful invasive plant management, as per MOE recommendations (L. Tedesco, 2008). A detailed fish habitat impact assessment will be completed during detailed design creation.

Potential risks to wildlife include:

- Spadefoot and Pacific tree frog habitat impacts;
- Long-toed salamander habitat impacts;
- Painted turtle habitat impacts; and
- Songbird habitat reduction.

The plan includes compensation habitat for painted turtle, spadefoot, Pacific tree frog and long-toed salamander. (See Figure 3). In addition, the **riparian** thickets will provide habitat for songbirds. Construction should be avoided from March 15th to July 15th to avoid nesting disruption. A **QEP** must assess the work area prior to construction to ensure there are no active nests, to avoid a contravention of the Wildlife Act.

A full description of the avoidance, mitigation, compensation, monitoring and contingency details is included in Appendix H.

5.5 DATA GAPS – RECOMMENDED INVESTIGATIONS

Upon compilation and review of the biophysical baseline information, although quite comprehensive in scope, a number of data gaps are identified. These data gaps represent further additional work that is recommended prior to finalizing the design plans.

5.5.1 Hydrology

It is recommended that estimates of peak flow be reviewed and a comprehensive analysis be completed to develop an appropriate design flow for Vernon Creek. The recommended analysis should include a review and update of the existing rainfall-runoff model developed as part of the Vernon Master Drainage Plan for the urban components of the watershed, development of a lake routing model for the Kalamalka Lake and Swan Lake components of the watershed, and finally, combination of the different components of the watershed with a kinematic model. The hydrologic analysis should also review the different types of design events (rainfall only, rainfall-on-snowmelt, snowmelt only) to determine the appropriate design flow.

In addition, the impacts regarding the Lakeshore Road culvert needs to be addressed.

5.5.2 HADD Authorization Report

The need for HADD Authorization under Section 35(2) of the Fisheries Act will trigger the Canadian Environmental Assessment Act. Since DFO will be the Responsible Authority, they will require a report that meets their screening criteria. Most of the required information is contained within this report. However, they may require a more detailed assessment of impacts, mitigation, and compensation.

6.0 ENVIRONMENTAL MANAGEMENT PLAN

6.1 ENVIRONMENTAL MANAGEMENT OBJECTIVES

The environmental management objective of the channel realignment project is to restore lower Vernon Creek to a functioning ecological condition. Goals to protect the ecology and further enhance the in-stream habitat components and the adjacent **riparian**/wetland communities include:

- Restore natural channel pattern (sinuosity and wavelength) based on historical conditions.
- Increase quantity and quality of spawning and rearing habitat for kokanee, rainbow trout and largescale suckers.
- Increase fish rearing habitat through the channel, by including more complexity including undercut banks pools, riffles,, backwater channels, and sandbars.
- Restore the **riparian** vegetation to provide cover, shade, and insect and leaf litter inputs to the stream as well as improve wildlife habitat conditions.
- Protect as much of the wetland habitat as possible, thereby protecting the **Species at Risk** dependant on them.
- Establish a thorough mitigation plan for effective salvage and impact management through the process of construction.
- Monitor results.

The plan will also satisfy objectives of the City of Vernon's 'Ribbons of Green' to promote and enhance the natural environment within the Vernon Waterfront Plan Area and construct a recreational access trail along the newly aligned creek. The project will provide opportunities for recreational enjoyment as well as education to the public.

6.2 RESTORATION CONCEPT

The restoration concept plan is presented in Figure 3**.** Typical cross-sections developed for sections of the reconstructed channel are presented in Figure 4 to 6.

The new channel will accommodate flows corresponding to the current channel capacity. The newly constructed channel will have a larger cross-sectional area in general such that

stream flow velocities are reduced. Stream bank slopes will be no steeper than 3H:1V wherever possible, to minimize stream bank erosion and requirements for hard armour. Erosion control mats will be used where needed, to control surface erosion and conserve moisture. Near vertical banks and hard-armour will, however, be required along sections of lower Vernon Creek that will be constrained by the nearby runway clearing strip, and where needed to preserve existing wetlands (see Figure 3).

The new channel will incorporate shallow open-water communities in a wide **riparian** floodplain. Although return periods for floods affecting the existing channel are unclear, the design will be larger than the existing channel capacity. Therefore, flood risk to adjacent areas along the creek will be no greater than it already exists. Flood risk will be further reduced by incorporating a sediment catchment and clean-out basin (where the channel flattens and near the corner before the golf course, Figure 3). This feature should result in avoidance of sediment build-up in the lower section, and avoiding channel **avulsion**[3].

6.3 HYDRAULICS ANALYSIS OF PROPOSED CHANNEL

The proposed new channel has three typical cross section forms (Figures 4 to 6) with lengths and locations as shown in Appendix D. Each of these section types was entered into a new HEC-RAS model as the typical section for their proposed lengths. A constant channel gradient was assumed between the existing channel invert at the upstream extent of works and the downstream reconnection point with the existing channel. Introduction of a sediment basin may require changing the gradient to flatten out the basin area. This will be done at the detailed design phase.

Table 14 shows the stream flow characteristics for each typical cross-section in the proposed channel from the HEC-RAS model.

TABLE 14: TYPICAL CROSS SECTION STREAM FLOW CHARACTERISTICS

Parameter	XS-B	XS-A	XS-C
River Station Used for Results	360	420	660
Average channel slope (%)	0.075	0.075	0.075
Average bankfull width (m)	6.50	9.72	9.67
Average bankfull depth (m)	0.78	0.78	0.77
Tractive/Shear force (kg/m^2)*	1.1	1.5	1.4
Stable bed material size (mm)*	15	20	20
Low Flow Discharge (m^3/s)	0.108	0.108	0.108
Low Flow Depth (m)	0.19	0.27	0.27
Low Flow Velocity (m/s)	0.97	0.15	0.15

[3] **Avulsion** is when a stream jumps its banks to create a new channel.

TABLE 14: TYPICAL CROSS SECTION STREAM FLOW CHARACTERISTICS			
Parameter	XS-B	XS-A	XS-C
Mean Annual Discharge (m^3/s)	1.47	1.47	1.47
Mean Annual Depth (m)	0.78	0.78	0.77
Mean Annual Velocity (m/s)	0.70	0.32	0.33
Design Discharge (m^3/s)	20	20	20
Design Depth (m)	1.68	1.72	1.80
Design Velocity (m/s)	0.79	1.27	1.18

*Maximum of the low flow, **MAF** and design flow conditions

The model results indicate that the proposed new channel design is adequate to convey the design discharge (equal to the existing channel capacity). The proposed new channel system performs in a similar manner to the existing channel, with respect to flow velocities, tractive forces, and flow depths.

6.4 DESIGN ELEMENTS

6.4.1 Spawning Gravel Specifications

Specifications for gravel suitable for kokanee spawning and stable under flood flow conditions are provided in Table 15. Using a design flood flow velocity of 1.3 m/s, tractive forces were calculated. The results indicate that a stable bed material size is 20 mm. Table 15 provides a recommended gravel gradation that is based on the stable bed material size and is consistent with previous gravel placement projects on Vernon Creek. The majority of gravel will be from 20 – 37.5 mm.

The spawning gravel should be screened material, not crushed, and will likely require washing to remove fines. Due to the clay substrate of the newly constructed channel, the bottom of the channel (or portions of it) may need to be sub-excavated and filled with larger rock to prevent the loss of gravels into the clay. Angular rock will be placed at 0.5 m with gravels placed to depth of 0.2 m above.

If necessary, kokanee eggs may be planted in the completed channel to accelerate spawner recruitment to (and subsequent fry production from) the placed spawning gravels.

TABLE 15: SPAWNING GRAVEL SPECIFICATIONS	
Sieve Opening Size	% Passing (by weight)
37.5 mm	100
25 mm	65-95
19 mm	40-75
13 mm	10-45
9.5 mm	3-20
6.3 mm	0-3

6.5 RIPARIAN RESTORATION PLAN

EBA has prepared a **riparian** planting list for the new channel alignment and any areas affected by its construction (Table 16). The **riparian** area, from the new top of bank to the water's edge, will be planted. Areas impacted by machinery will be seeded. The list is based on our understanding of the moisture, nutrient and topographic characteristics of the restoration area and the requirements of airports as outlined in the Transportation Canada regulation TP312. It has also been drafted to meet the Planting Criteria and Recommended Native Tree and Shrub Species for Restoration and Enhancement of Fish and Wildlife Habitat of the Ministry of Water, Land and Air Protection (MWLAP July 1998), adapted for our region.

The list consists of twelve (12) zones, which have been chosen based on the distinct nature of the area and airport height requirements. The zones vary based on their location within the creek profile and height level of mature plants. Consideration has also been given to preserve security site lines along the recreation trail. Two grass mixes have been specified, one for the **riparian** restoration area, and one for the airport and adjacent to the soccer fields.

The total area planted is 11,843 m^2. Zones will be identified at the detailed design stage. As per MWLAP requirements, the area will be planted to an overall average density of one tree or shrub per square meter. Shrubs are specified at a density of 1 metre on center. The trees will be spaced apart by 2 metres, while the grasses and forbs will be spaced apart by 0.5 metres. A mix of deciduous shrubs and aquatic plants and forbs has been selected for this site. Some low growing deciduous trees have been specified for the polygons furthest from the airport. Conifers were not specified for this site due to height restrictions.

Details for each zone are provided in Table 16 and are summarized below.

TABLE 16: PLANT LIST FOR EACH HABITAT TYPE

Habitat Code [1]	Habitat Code [1]	Habitat Type	Scientific Name	Common Name	Type [2]	Height (Optional)	Spacing [3] (m)	Ratio of Area per species	Size of Plant [4]
1	SFc	Sub-aquatic / Forb	plants are expected to colonize from upstream sources						
2	RRp	Riprap	*Salix exigua*	Coyote willow		3.0 m	0.75 m	100%	1 m stake
3	LRp	Low Rush	*Eleocharis palustris*	Common spike-rush		0.5 m	0.5 m	50%	plug
			Juncus balticus	Baltic rush		0.5 m	0.5 m	50%	plug
4	TRp	Tall Rush	*Juncus balticus*	Baltic rush		0.5 m	0.5 m	20%	plug
			Lemna minor	Duckweed		water surface	0.5 m	10%	10 cm pot
			Scirpus validus	Soft-stemmed bulrush		1.5 m	0.5 m	30%	plug
			Typha latifolia	Cattail		1.5 m	0.5 m	30%	plug

TABLE 16: PLANT LIST FOR EACH HABITAT TYPE

Habitat Code [1]	Habitat Code [1]	Habitat Type	Scientific Name	Common Name	Type [2]	Height (Optional)	Spacing [3] (m)	Ratio of Area per species	Size of Plant [4]
5	GRp	Grass/Low Rush	*Eleocharis palustris*	Common spike-rush		0.5 m	0.5 m	20%	plug
			Juncus balticus	Baltic rush		0.5 m	0.5 m	20%	plug
			Salix exigua	Coyote willow		3.0 m	0.5 m	10%	1 m stake
			Scirpus validus	Soft-stemmed bulrush		1.5 m	0.5 m	25%	plug
			Typha latifolia	Cattail		1.5 m	0.5 m	25%	plug
6	LSp	Low Shrub	*Ribes lacustre*	Black gooseberry	b	2.0 m	1.0 m	20%	15 cm pot
			Rosa woodsii	Woods rose	b	2.0 m	1.0 m	20%	15 cm pot
			Rubus idaeus	Red raspberry	b	1.5 m	1.0 m	20%	15 cm pot
			Mahonia aquifolium	Oregon-grape	b	1.2 m	1.0 m	20%	15 cm pot
			Symphoricarpos albus	Snowberry	b	1.5 m	1.0 m	20%	15 cm pot
7	MSp	Mixed Shrub	*Cornus stolonifera*	Red-osier dogwood	b	4.0 m	1.0 m	15%	21 cm pot
			Mahonia aquifolium	Oregon-grape	b	1.2 m	1.0 m	10%	15 cm pot
			Ribes lacustre	Black gooseberry	b	2.0 m	1.0 m	15%	15 cm pot
			Rosa woodsii	Woods rose	b	2.0 m	1.0 m	10%	15 cm pot
			Rosa nutkana	Nootka rose	b	3.0 m	1.0 m	15%	15 cm pot
			Rubus idaeus	Red raspberry	b	1.5m	1.0 m	15%	15 cm pot
			Symphoricarpos albus	Snowberry	b	1.5m	1.0 m	20%	15 cm pot
8	TSp	Tall Shrub	*Cornus stolonifera*	Red-osier dogwood	b	4.0 m	1.0 m	20%	21 cm pot
			Crataegus douglasii	Black hawthorn	b	6.0 m	1.0 m	10%	21 cm pot
			Mahonia aquifolium	Oregon-grape	b	1.2 m	1.0 m	10%	15 cm pot
			Prunus virginiana	Chokecherry	b	5.0 m	1.0 m	15%	21 cm pot
			Rosa nutkana	Nootka rose	b	3.0 m	1.0 m	15%	15 cm pot
			Rosa woodsii	Woods rose	b	2.0 m	1.0 m	10%	15 cm pot
			Symphoricarpos albus	Snowberry	b	1.5m	1.0 m	20%	15 cm pot
9	Htpa	Hardwood Treed Type A	*Acer glabrum var. douglasii*	Douglas maple		10.0 m	1.0 m	5%	1.2 m ht
			Alnus incana ssp. tenuifolia	Mountain alder		10.0 m	1.0 m	5%	15 cm pot
			Betula occidentalis	Water birch		10.0 m	1.0 m	5%	1.2 m ht
			Crataegus douglasii	Black hawthorn	b	6.0 m	1.0 m	10%	21 cm pot
			Mahonia aquifolium	Oregon-grape	b	1.2 m	1.0 m	10%	15 cm pot
			Prunus virginiana	Chokecherry	b	5.0 m	1.0 m	10%	21 cm pot
			Rosa woodsii	Woods rose	b	2.0 m	1.0 m	15%	15 cm pot
			Ribes lacustre	Black gooseberry	b	2.0 m	1.0 m	10%	15 cm pot
			Rubus idaeus	Red raspberry	b	1.5 m	1.0 m	15%	15 cm pot
			Salix lucida laciandra	Pacific willow		12 m	1.0 m	5%	1.2 m ht
			Symphoricarpos albus	Snowberry	b	1.5 m	1.0 m	10%	15 cm pot
10	Htpb	Hardwood Treed Type B	*Acer glabrum var. douglasii*	Douglas maple		10.0 m	2.0 m	25%	1.2 m ht
			Betula occidentalis	Water birch		10.0 m	2.0 m	25%	1.2 m ht
			Prunus virginiana	Chokecherry	b	5.0 m	2.0 m	25%	21 cm pot
			Salix lucida laciandra	Pacific willow		12.0 m	2.0 m	25%	1.2 m ht
11	Ga	Grass - Airport	See Airport Seed Mix specification			0.5 m or mowed			
12	Gr	Grass - **Riparian**	See **Riparian** Seed Mix specification			0.5 m			

TABLE 16: PLANT LIST FOR EACH HABITAT TYPE

Habitat Code [1]	Habitat Code [1]	Habitat Type	Scientific Name	Common Name	Type [2]	Height (Optional)	Spacing [3] (m)	Ratio of Area per species	Size of Plant [4]

1	Habitat types were chosen based on three criteria: moisture regime, height, and function of vegetation (i.e. erosion control, access management w/ prickles etc.)
2	b = berry producing shrubs. By MWLAP standards, a minimum of 50% of trees and shrubs should be berry producing. It also states that coniferous trees should comprise a minimum of 10% of the tree stock planted. However, coniferous trees were not recommended due to Transport Canada height limitations adjacent the airport.
3	All **riparian** plantings are based on an overall density of 1 tree or 1 shrub per 1 square meter density as per MWLAP Criteria July 1998. Specific variations include the 0.5m o.c. density of the rush and grass habitat types, and the HTPb habitat type, which is only trees at the recommended spacing of 2.0 meters apart, to improve site lines for security.
4	Tree stock is a minimum of 1.2m in height in accordance with MWLAP Guidelines (July 1998).

6.5.1 Zone 1 – Sub-aquatic/Forb Created (SFc)

No plants are specified for Zone 1.

This is the area of constructed open channel. It is expected that the aquatic species upstream of the new channel (primarily *Potamogeton* sp. and *Lemna minor*) will float down and colonize the new channel naturally in this zone.

6.5.2 Zone 2 – Rip-Rap Planted (RRp)

Coyote willow stakes are specified for Zone 2.

Coyote willow (*Salix exigua*) stakes will be planted within the rip-rap. Coyote willow is a low growing, fine textured willow with a maximum height of 3.0 metres. It will only be planted where this height is permitted according to Transportation Canada's requirements. Where lower height is required, Woods rose (*Rosa woodsii*), red raspberry (*Rubus idaeus*) and black gooseberry (*Ribes lacustre*) are recommended.

6.5.3 Zone 3 – Low Rush Planted (LRp)

Zone 3 corresponds to the area of fluctuating water flows directly adjacent to the low water mark of the channel, up to the annual high water mark. Therefore, a variety of emergent plants are specified for this zone. *Juncus balticus* and *Eleocharis palustris* are rush species that are specified for this zone. The mature plant height of these species is 0.5 metres, and this zone has been designated for the end of the runway.

6.5.4 Zone 4 – Tall Rush Planted (TRp)

This zone occurs in off-channel wetland habitats. Water levels will fluctuate annually and may even dry up in the winter months. The zone will be planted with emergent and wetland species, according to their moisture requirements.

6.5.5 Zone 5 – Grass / Low Rush Planted (GRp)

This zone occurs along sandbars within the channel, adjacent to the low water mark up to the annual high water mark. Rushes, cattail (*Typha latifolia*) and coyote willow (*Salix exigua*) are specified for this zone.

6.5.6 Zone 6 – Low Shrub Planted (LSp)

This zone corresponds to the areas between the annual high water mark and the bankfull width of the channel. This zone is specified next to the airport that requires low plant heights. The mature plant height limit is 2.0 metres. In addition, the zone lies below bankfull width, such that the plant bases will be below the level of the runway. This zone has also been specified along the recreation trail in locations where low plant heights are preferred.

6.5.7 Zone 7 – Mixed Shrub Planted (MSp)

This zone corresponds to the area between the annual high water mark and the bankfull width of the channel, where height regulations permit a taller shrub. The zone is also designated for areas adjacent to tall rush wetland habitats (Zone 4). The mix of low and tall shrubs provides erosion protection and plant diversity.

6.5.8 Zone 8 – Tall Shrub Planted (TSp)

This zone occurs along the creek's banks, where height regulations permit a taller shrub.

6.5.9 Zone 9 – Hardwood Treed Planted – Type A (Htpa)

This zone occurs on upland areas where height regulations permit small trees such as Douglas maple (*Acer glabrum* var. *douglasii*) and water birch (*Betula occidentalis*). A variety of **riparian** shrubs are specified for this zone also, in accordance with the natural plant composition of this zone.

6.5.10 Zone 10 – Hardwood Tree Planted – Type B (HTpb)

This zone corresponds with a similar upland **riparian** habitat as Zone 9, but this zone is designed with only trees to provide security site lines adjacent to the recreation trail and proposed viewing platforms.

6.5.11 Zone 11 – Grass – Airport (Ga)

This zone corresponds to upland unfilled areas adjacent the airport runway. It also occurs in any areas disturbed by construction between the recreation trail and the sports fields.

6.5.12 Zone 12 – Grass – Riparian Restoration (Gr)

A **riparian** grass seed mix including blue wildrye (*Elymus glaucus*) 22% (by weight), fringed brome (*Bromus ciliatus*) 20%, slender wheatgrass (*Elymus trachycaulus*) 20%, perennial ryegrass (*Lolium perenne*) 12%, rough fescue (*Festuca campestris*) 12%, timber oatgrass (*Danthonia intermedia*) 12%, and hair bentgrass (*Agrostis scabra*) 2%, is recommended for along the creek.

6.5.13 Beaver Considerations

Fencing of all planted single-stem trees and shrubs will be required due to the presence of beavers. It is recommended that stucco wire mesh cages be used to prevent loss of planted trees and shrubs.

6.6 WETLAND ENHANCEMENT PLAN FOR WILDLIFE SPECIES AT RISK

The relocation of the channel presents a unique opportunity in habitat enhancement and protection. As noted in Section 4.7.3, several **Species at Risk** have been recorded in the study area. Wetland species include the Great Basin spadefoot (**Blue-listed**) and painted turtle (**Blue-listed**). Pacific tree frog and long-toed salamander have also been recorded in the wetlands.

For habitat protection, the first strategy is always avoidance. We have therefore designed the channel to avoid disrupting as many of the existing wetlands as possible. We believe that by having the creek with the trail to the southwest of the wetlands, they will experience fewer disturbances from people and pets on a day to day basis. A wildlife / herpetile fence will protect the wildlife from inadvertently moving onto the airport, where they are at risk from aircraft and predators such as raptors.

Where filling is unavoidable, as it is for Wetland 31b, which is within the runway area, mitigation and compensation is required. A thorough salvage and monitoring program is required. To compensate for the loss of this wetland and the 125 m^2 of low depression area of Wetlands 30b and 32d, we recommend creating wetlands A, B, and C (Figure 3) in advance of wetland destruction.

Painted turtles also require undisturbed upland areas for nesting. Therefore, a turtle nesting area has been specified near the new wetlands (Figure 3). This will provide turtle nesting habitat, as well as an opportunity for public education.

6.7 MANAGEMENT PLAN FOR PLANT SPECIES AT RISK

As noted in Section 4.6.1, three plant **Species at Risk** have been identified on site. The oxbow across from the Marshall Fields is a recorded habitat for two of the occurrences, awned cyperus, and mosquito fern. This area is to remain undisturbed. We recommend that the area be flagged during construction to restrict machinery and activity. This will be monitored during construction.

Mosquito fern, a floating aquatic plant, has also been identified along 70 metres of the main channel of Vernon Creek, some of which will be diverted with the realignment (Appendix G and Figure 3). The area should be monitored for any occurrence of the plant, which emerges when water quality and quantity parameters are favourable. This typically happens during late spring or through the summer and into fall. It may remain dormant until conditions are right (CDC, 2008). This is why monitoring for this species is important. The monitor must be trained in the recognition of mosquito fern. Monitoring must start in the spring prior to construction, and continue through the maintenance period. Should the

plant be found, the MOE should be contacted. In conjunction with MOE consultation, the plants should be salvaged and relocated to positions upstream that will not be affected, and the newly constructed turtle pond. If the new channel does not yet have flow through it, some of the plants should be kept upstream, secured with netting, prior to being transplanted to the backwater locations on the new channel.

The third rare plant known to occur in the study area is field dodder. This is a parasitic plant that was documented in 1995 growing on wormwood, a weedy species in the Marshall Fields (CDC, 2008).Two occurrences of field dodder found in between the Marshall Fields and Okanagan Landing Road are being confirmed. The creek realignment will not affect these occurrences. The environmental monitor should be trained in the recognition of field dodder. The plants along the alignment, especially wormwood, should be systematically assessed for the presence of field dodder prior to the construction of the new channel. Should field dodder be found, the Ministry of Environment must be contacted, and an avoidance or salvage plan developed.

Blue vervain has been found along Okanagan Landing Road and in Community 24 (Figure 3). The Okanagan Landing road plants are at risk from road maintenance and future road expansion. We recommend these be transplanted to suitable locations where the plants are less at risk, as discussed with the Ministry of Environment (L. Tedesco, 2008).

6.8 RECREATION TRAIL

A 3.0 metre wide gravel recreation trail has been designed along the south side of the new channel of Vernon Creek, in accordance with guidelines outlined in Plan Vernon. The trail has been designed 15 metres from the creek except where constrained by existing soccer fields, buildings, or ponds that are to be retained. Along the trail, a viewing platform is proposed, to provide access to the creek and adjacent habitats.

Functioning wetlands have the potential to provide a variety of recreational activities. Presently, Vernon Creek is utilized by nature enthusiasts and school groups. Wildlife viewing and natural history interpretation is enjoyed by local bird watchers and organizations.

For further streamside access issues it is recommended that the City follow guidelines provided in "Access near Aquatic Areas" (DFO/MELP 1995) and "Community Greenways: Linking Communities to Country, and People to Nature" (DFO/MELP 1996).

6.9 VEGETATION MANAGEMENT PLAN

A Vegetation Management Plan should to be developed for the Vernon Regional Airport to provide a balance between safety (i.e., sightlines and wildlife/bird attraction) and ecological function. The restoration plan, presented here aims to meet both objectives. However, long-term issues regarding maintenance require the input of wildlife biologists with airport specialization.

7.0 IMPLEMENTATION PLAN

7.1 ACTIVITY SCHEDULE

The sequencing of activities, corresponding to the life cycles of the wildlife and fish present, is critical to the success of the environmental management plan. We have prepared a schedule that considers the mating, breeding and migratory requirements of the species involved. Timing windows of least-risk are identified for terrestrial activities and for in-water activities and a resultant summary schedule is presented in Table 17.

7.1.1 Construct New Channel and Compensation Wetlands Prior to Diversion

We recommend that the new channel is constructed seeded and planted at least one year prior to the diversion. The new channel will be constructed in isolation of the old channel outside the Fisheries Sensitive Work Window. Habitat preparation in terms of gravel placement, stream bank construction, and planting shall be completed and established prior to redirecting stream flows into the new channel to minimize scouring effects of the diverted flows. This will give the plants time to establish, and provide a more hospitable habitat for aquatic life once the flows are diverted. It will also give the banks stability from erosion.

To maximize the chances for success of the compensation wetlands and turtle nesting area, we recommend that they are constructed and seeded as soon as possible. This will give the grasses and aquatic plants time to establish before the ponds are needed for the salvaged plants and animals. This will also give the monitor time to see if any adjustments are needed in terms of pond depth, to function for the turtles and amphibians, with relation to ground water. Ideally, the turtles, amphibians, and aquatic invertebrates will find the ponds and start to colonize them prior to construction of the new channel. At the very least, if the vegetation has a chance to grow prior to construction, it will be a more stable and protected environment once the animals are salvaged and placed in them.

We recommend that monitoring begin before construction of the new wetlands or channel begins. The monitor should gather baseline data on fish, wildlife and plant presence and use, including the species of concern. This baseline data will be useful in developing salvage efforts, as well as assessing the relative success of the habitat restoration efforts in the seasons following the diversion.

Specific species considerations are included below.

7.1.2 Great Basin Spadefoot, Tree frog, Long-toed Salamander Salvage

The sequencing of spadefoot and other amphibian management should begin with monitoring for presence, as noted above. The compensation wetlands should be constructed and planted at least one year prior to runway construction. Spadefoot breeding occurs from mid-April to July. Larval development takes 6-8 weeks. Construction must not occur during the mating or larval period, until the adults have emerged (EBA, 2004).

Early in the spring prior to construction, the area should be assessed for use through auditory and visual surveys. A thorough salvage program should be developed. Once mating has begun, herpetile fencing should be placed around Wetland 31b. Salvage should include terrestrial drift fences with pitfall traps, and aquatic drift fences with funnel traps. Rectangular minnow traps set in the wetland, floating with constant access to air, are more effective when used with drift fences, for capture of both adult and larval amphibians (J.D. Willson and M.E. Dorcas, 2004). The use of dip nets may be used to salvage egg masses and larvae. The use of seine nets when tadpoles are larger may be investigated. The herpetile fence should be maintained until the filling is complete, to prevent individuals returning to the wetland. Salvaged larvae and adults should be placed in the constructed wetlands and also those that have been retained on site. The salvage team must ensure that the destination wetlands are free of fish prior to larvae transfer.

Exclusion fencing should be placed around the construction area, preventing amphibians and small mammals from entering the work site.

7.1.3 Aquatic Invertebrate Salvage

The breeding period for aquatic invertebrates such as dragonflies and damselflies is similar to the amphibian breeding period. Therefore, filling of Wetland 31b should wait until August, when larvae are likely to have become flight born. The salvage team should relocate any invertebrate larvae to the remaining or compensation wetlands, if encountered. In addition, prior to the diversion, the salvage team should use seine nets and dip nets to salvage any remaining larvae in Vernon Creek.

7.1.4 Rare and Riparian Plant Salvage

Prior to construction, the salvage team should check the study area for mosquito fern within the channel and field dodder within the fields. Should either of these plants be found, MOE should be contacted. In consultation with MOE personnel, a strategy of avoidance or salvage must be enacted.

Salvaging of aquatic and **riparian** plants should be assessed during construction. Native plant salvage and transplanting is encouraged where soils are suitable, in consultation with the environmental monitor.

7.1.5 Bird Nesting Avoidance

Construction must be timed to avoid disrupting bird mating, nesting and fledging times. Therefore, construction must not occur between March 15th and July 15th.

7.1.6 Fisheries Work Window

In-stream and stream bank work in the project area is limited to the Fisheries Sensitive Work Window for Vernon Creek. This period, approximately from, July 22nd to September 10th dictates the sequencing of all in-stream work, including the diversion of Vernon Creek into the newly constructed channel.

The new channel can be constructed in isolation of the old channel any time. Habitat preparation in terms of gravel placement, bank construction, and planting shall be completed and established at least one year prior to redirecting stream flows into the new channel to minimize scouring effects on newly vegetated stream banks.

7.1.7 Exotic Fish Species Extirpation

The **exotic** fish species of carp and pumpkinseed sunfish present in Wetland 32c will need to be caught and extirpated as part of the implementation plan.

TABLE 17: ACTIVITY SEQUENCING FOR THE VERNON CREEK REALIGNMENT

	Year 1								
Activity	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bird Nesting & Early Mammal Rearing	No terrestrial veg removal								
Compensation wetland construction, seeding and planting		Construct compensation wetlands							
Fish Window - Kokanee (July 22 – Sept 10)		In-Stream Work Window							
Flight period for Dragonflies and Damselflies (Odanata sp.)			Low impact period for Odanata						
Great-Basin Spadefoot breeding and larval development	Avoid wetland disturbance								
Amphibian emergence	Amphibian emergence								
Survey – Layout					x	x	x		
Prep area of new channel (sweep and salvage for birds, reptiles, amphibians)						x	x		
Excavate new channel in isolation of flowing water							x	x	x
Habitat Preparation incl. Gravel placement and planting							x	x	x

	Year 2											
Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bird Nesting & Early Mammal Rearing			No terrestrial veg removal									
Fish Window - Kokanee (July 22 – Sept 10)					In-Stream Work Window							
Flight period for Dragonflies and Damselflies (Odanata sp.)						Low impact period for Odanata						
Great-Basin Spadefoot breeding and larval development				Avoid wetland disturbance								
Amphibian emergence (trapping period)			Amphibian trapping period									
Monitor amphibians and reptiles			Monitor amphibians and reptiles									
Salvage amphibians and reptiles			Salvage amphibians and reptiles									
Prep area to be diverted (sweep for birds and herpitiles)							x	x				
Isolate channel to be cut-off and conduct fish and invertebrate salvage							x	x				
Construct by-pass and divert flow							x	x				
Salvage veg., backfill existing channel and plant									x	x	x	

7.2 MONITORING

Pre-construction, during construction, and post-construction monitoring is a key component in the success of the project.

Pre-Construction Monitoring

In order to properly assess the impacts of the creek realignment, and the relative success of the restoration and compensation habitats, it is important to have a strong understanding of baseline conditions. This report, and the Vernon Waterfront Study (EBA, 2004), provide much of this data. However, monitoring of aquatic life in the creek and wetlands in the months prior to the diversion, during the diversion, and after the diversion will give an accurate picture of the realignment's impacts, and the relative success of the restoration measures. Pre-construction information on the following will be instrumental on determining the success of the project:

- Recent and current fish use of the creek;
- Recent and current bird nesting activity;
- Recent erosion events;
- Recent and current amphibian and reptile use of the creek, wetlands and upland habitats;
- Aquatic invertebrate species richness and diversity;
- Water quality of the creek and surrounding wetlands; and
- Anecdotal wildlife use of the area.

The Ministry of Environment contracts someone to enumerate Kokanee spawning in Okanagan creeks each year. The City should request that the Ministry place extra emphasis on the creek section within the study area during fall 2008. Additional info listed above should be collected during the detailed design phase to provide baseline data from which to compare long-term reconstruction success.

Construction Monitoring

The role of the environmental monitor is to supervise on-site activities and ensure that contractors are following Best Management Practices.

A Quality Environmental Professional (**QEP**) will conduct a pre-work meeting on-site with contractors to discuss environmental requirements and conditions of the agency permits (i.e., Section 9 Approval and DFO Authorization). Environmental monitoring may be conducted on a part-time basis during all upland activities, such as excavation of the new channel "in the dry". Full-time environmental monitoring will be required for all in-water activities, including the fish, amphibian, and aquatic invertebrate salvage, and the diversion to the newly constructed channel.

Post-Construction Monitoring

Post-construction inspections and evaluation of the realigned channel and other in-stream habitat structures need to be conducted on a regular interval to determine the success and effectiveness of the project. MOE guidelines specify that 80% of the planted vegetation must be successful. The plant material must be inspected by a **QEP** twice per year for two full growing seasons after the growing season planted. The inspections should occur once in the spring and once in the fall for the monitoring period. The channel must be assessed for stability during and after the spring freshet. The monitor should look for bank slumping, failures, erosion, excessive sediment loading and isolated ponds where fish could be trapped. Monitoring will determine whether adjustments or corrections are required.

In addition, the compensation wetlands should be assessed in the spring and summer for turtle and amphibian breeding, basking and foraging habitat. In particular, water levels in the ephemeral ponds should be checked to ensure they keep water long enough in the summer to allow frogs and toads to go through tadpole stage to adulthood, before the water dries up.

8.0 PERMITTING REQUIREMENTS

Due to the nature of disturbance to a fish-bearing stream, several permits and authorizations will be required prior to commencing work. These include:

- **DFO Authorization** – Although the proposed area of restoration is more than twice the area of disturbance, there will no doubt be a short-term disruption to fish and fish habitat. Thus, under the Canadian *Fisheries Act*, there will be a requirement for the preparation of an Authorization for Harmful Alteration, Destruction or Disruption (HADD) to fish habitat. This application is submitted to the federal Department of Fisheries and Oceans. The HADD will trigger the requirement that an environmental assessment is conducted according to the Canadian Environmental Assessment Act (CEAA). DFO will be the responsible authority.
- **Section 9 Application** – Under the BC *Water Act*, a Section 9 Application for "Approval" for Changes In and About a Stream will be required. This application, along with an Environmental Impact Assessment report, is submitted to the Integrated Land Management Bureau of the Ministry of Environment (formerly Land and Water BC). The Section 9 application will be reviewed by Vernon Ministry employees.
- **Fish Collection Permit** – The BC Government requires a Fish Collection Permit for a coordinated fish salvage during the dewatering component of the original channel.

9.0 NEXT STEPS

The next steps for the project involve having the Edition II report and concept plans reviewed by agency personnel. Following their feedback, detailed construction drawings can be produced. These steps are outlined below:

- MOE consultation;
- DFO consultation;
- Submit environmental assessment to CEAA standards in order to receive a HADD;
- Hydrology review, including a review of design peak flow data and downstream culvert implications, during the detailed design stage, as required by MOE (L. Tedesco, Sept. 8, 2008), and rerunning the hydrological model with the revised design flows and alignment;
- Detailed construction drawings;
- Detailed mitigation / enhancement / planting plans;
- Construct the compensation wetlands as soon as possible, to give time for the plants to establish prior to salvaging amphibians and aquatic invertebrates; and
- Start pre-monitoring, to gather data on current use of rare species and other fish and wildlife, and to monitor water quality conditions in the constructed wetlands (i.e., grad student under the guidance of a registered biologist).

10.0 CLOSURE

This report incorporates EBA's General Terms and Conditions (Appendix I). We trust that this report meets your present requirements. Should you have any questions regarding this report, please contact the undersigned.

Yours truly,
EBA Engineering Consultants Ltd.

Melanie Steppuhn, B.E.S., B.C.S.L.A.
Environmental Scientist
Environmental Practice
msteppuhn@eba.ca

Darryl Arsenault, M.Sc., R.P.Bio.
Senior Biologist
Environmental Practice
darsenault@eba.ca

/bi/tmkp

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FIGURES

LEGEND

Study Area

ISSUED
FOR USE

Base data sources:

Orthophoto (2004) provided by the City of Vernon

Disclaimer

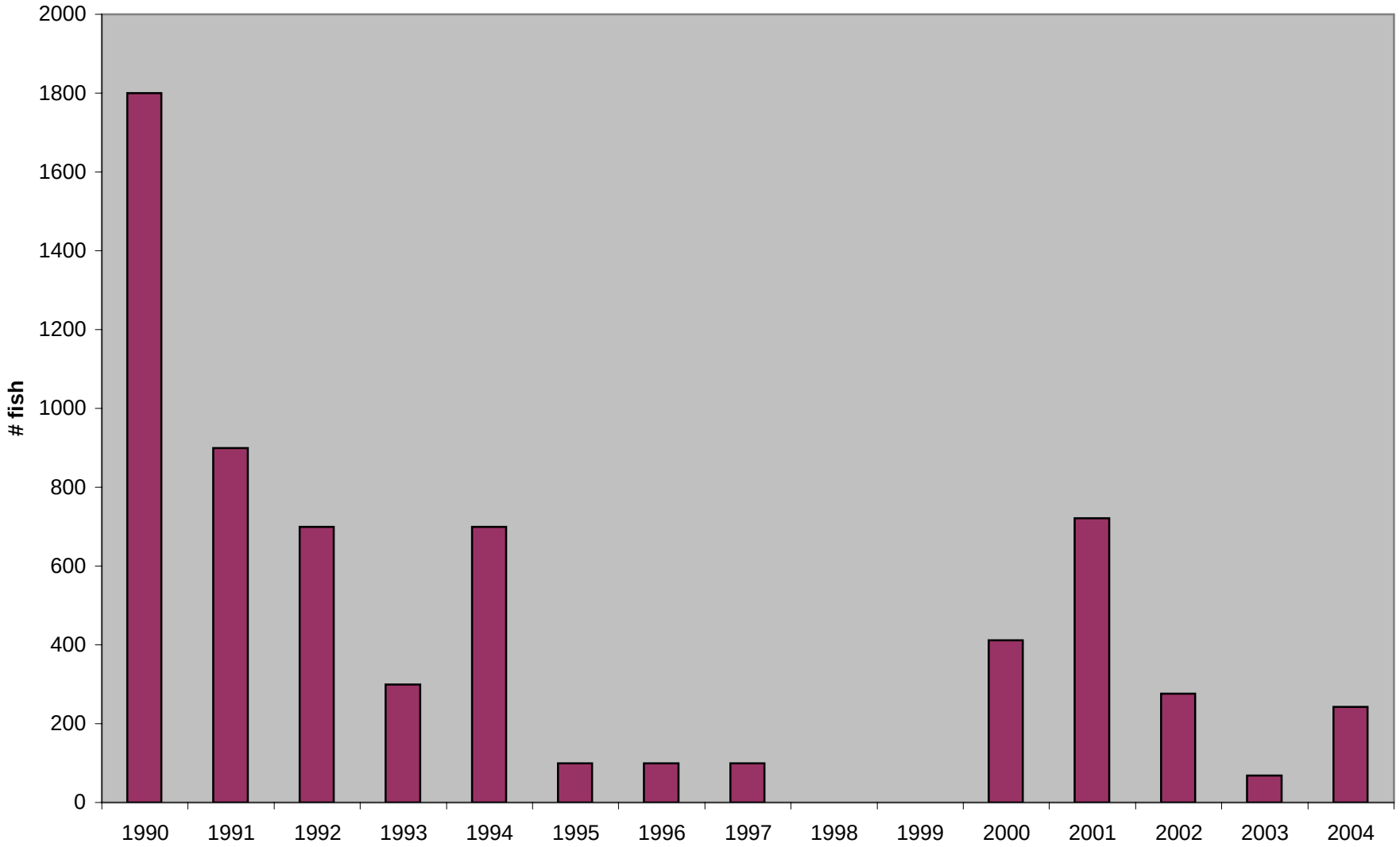
Detailed Vernon Creek Realignment and Enhancement Design

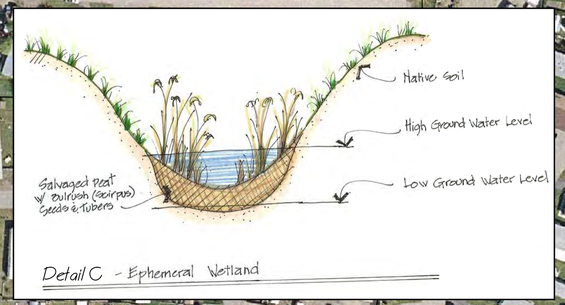
Site Location

PROJECTION: UTM Zone 11	DATUM: NAD83	
Scale: 1:10,000 100 50 0 100 200 300 Meters		EBA Engineering Consultants Ltd.
FILE No: Site_Location.mxd		DATE: September 12, 2008
JOB NO: K23101307	REVISION NO: 2	
OFFICE: EBA-KELOWNA	DRAWN: SF / CHECK: MS	Figure 1

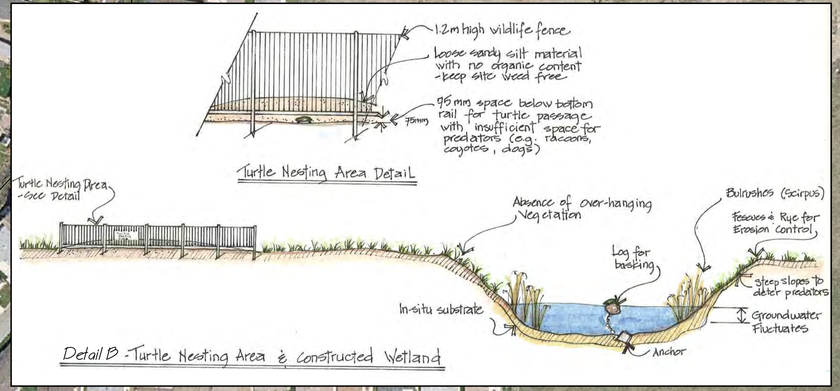
Q:\Kelowna\GIS\0808\Projects\Environmental\2005\9840278 Vernon Creek\Maps\Site_Location.mxd

Figure 2 - Kokanee Escapements in Lower Vernon Creek (1990-2004)

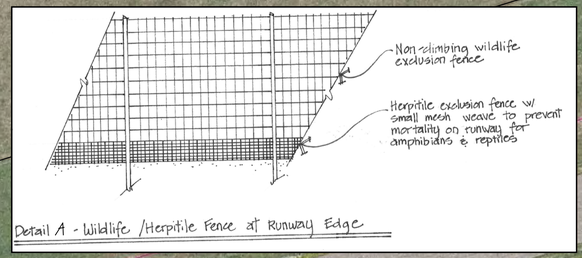




Detail C - Ephemeral Wetland



Detail B - Turtle Nesting Area & Constructed Wetland



Detail A - Wildlife /Herpitile Fence at Runway Edge

Existing Pond:
- Ensure exotic fish species are extirpated prior to diversion

Wetland B:
Target Species
- Painted Turtle (blue-listed)

Species to Deter for Airport Safety
- Waterfowl
- Large Nesting Birds

Features
- Fenced tutrle nesting area adjacent
- Floating log for turtle basking

Wetlands A & C:
Wetland is isolated from creek to avoid fish predation of larval amphibians and tadpoles

Target Species
- Great Basin Spadefoot (blue-listed)
- long-toed Salamander (yellow-listed)
- Pacific Treefrog

Island
Floating Logs
Turtle Nesting Area
Ephemeral Wetland
Ephemeral Wetland
Wildlife Fence with Herpitile Exclusion Border (see Detail A)
VERNON REGIONAL AIRPORT
Conduct repetitive fish, amphibian, and rare plant salvage in depressions prior to channel diversion
Marlon Trees and Depressions
Monitor depression for fish presence
Preserve Existing Wetland
Preserve Existing Wetland
Conduct repetitive fish, amphibian, aquatic, and rare plant salvage efforts prior to channel diversion
Start of Diversion
Extent of Proposed Runway
Wetland to be filled, see Wetlands A, B, and C for compensation
Preserve Existing Wetland
Proposed Recreation Trail
Sediment Clearing Station
Sediment Retention Weir
Pool
Bridge
Cumming Road
MARSHALL FIELDS
Upland
see Detail B
see Detail C
see Fig 4
see Fig 5
see Fig 6
see Fig 3
see note

Note:

Wetland Community number as per Vernon Waterfront Study Figure 2.2, EBA, 2004 (included as Appendix E to this report)

Data Sources:

Proposed Airport Runway Designs provided by the City of Vernon, March, 2006.
Base Data provided by Kerr Wood Leidal, June, 2000.
Orthophoto (2004) and Property Lines provided by the City of Vernon.

Legend

- Legal Lot Lines
- Edge of Runway Strip - no planting zone
- Proposed Runway Extension
- Proposed High Water Mark
- Proposed Top of Bank
- Cross Section
- Existing Trees
- Rip Rap with Planting
- Waterbodies (Proposed and Existing)

Proposed Instream Features
- Large Woody Debris
- Undercut Bank
- Riffle / Spawning Gravel
- Pool
- Floodplain Bench

Wetland Community* (see note)
- Not Classified
- Sub-aquatic
- Tall Rush
- Grass
- Low Shrub
- Tall Shrub
- Mixed Shrub

Proposed Recreational Trail
- 1.5m Wide Mowing Strip
- 3.0m Wide Gravel Walkway
- Viewpoint
- Proposed Gravel Walkway

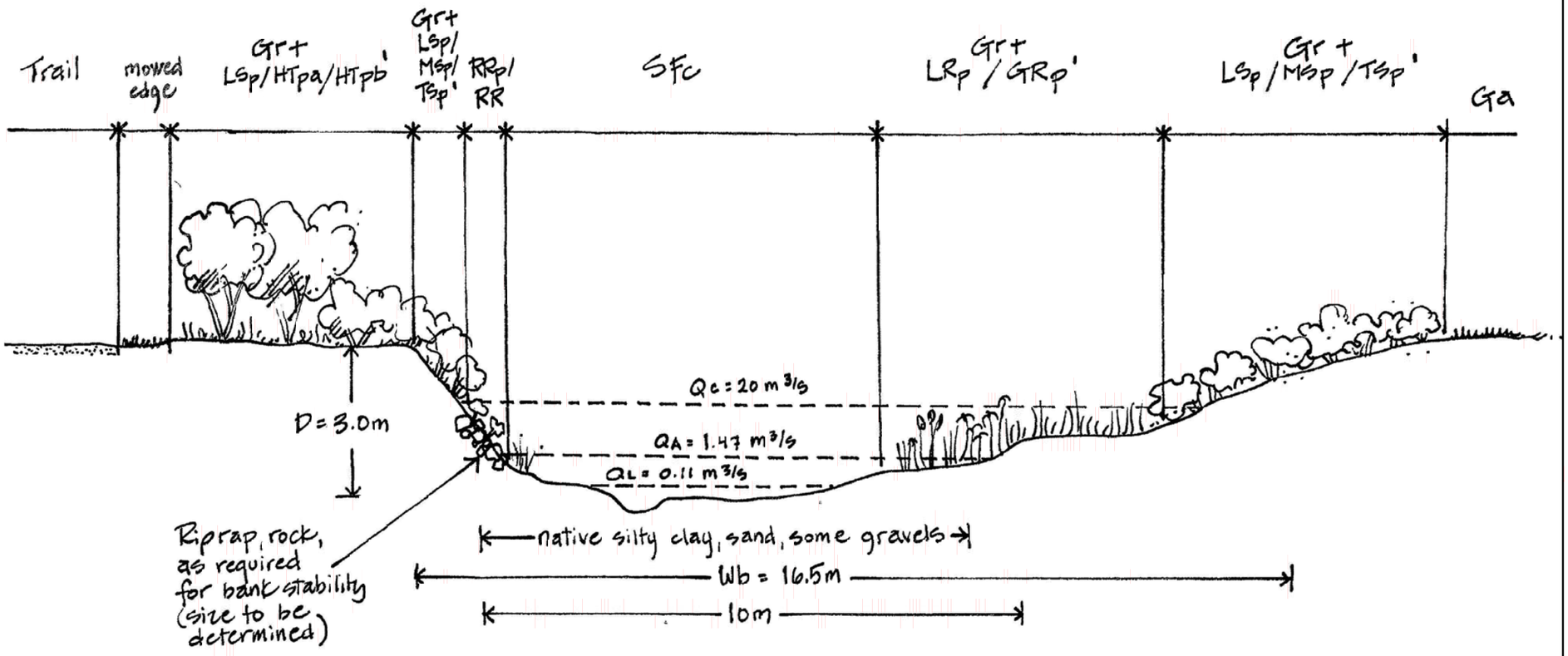
ISSUED FOR USE

Detailed Vernon Creek Realignment and Enhancement Design

Vernon Creek Realignment Concept Design

PROJECTION: UTM Zone 11	DATUM: NAD83
Scale: 1:1,000 (10 5 0 10 20 30 Meters)	EBA Engineering Consultants Ltd.
FILE No: Figure 3 - Vernon Creek Realignment Concept Design.mxd	DATE: September 11, 2008
JOB NO: K23101307	REVISION NO: 3
OFFICE: EBA-KELOWNA	DRAWN: SF / CHECK: MS

Figure 3



1- See Plan for specified Habitat Type, in order to comply w/ Transport Canada height requirements.

Typical Cross Section A
Substrate Materials & Schematic

ISSUED FOR USE

Detailed Vernon Creek Realignment and Enhancement Design

Typical Cross-Section A

PROJECTION: N/A	DATUM: N/A	EBA Engineering Consultants Ltd.
Scale: Not to Scale		
FILE No: Figure_4_Cross_Section_A.mxd		DATE: September 11, 2008
JOB NO: K23101307	REVISION NO: 1	
OFFICE: EBA-KELOWNA	DRAWN: MS / CHECK: DA	Figure 4

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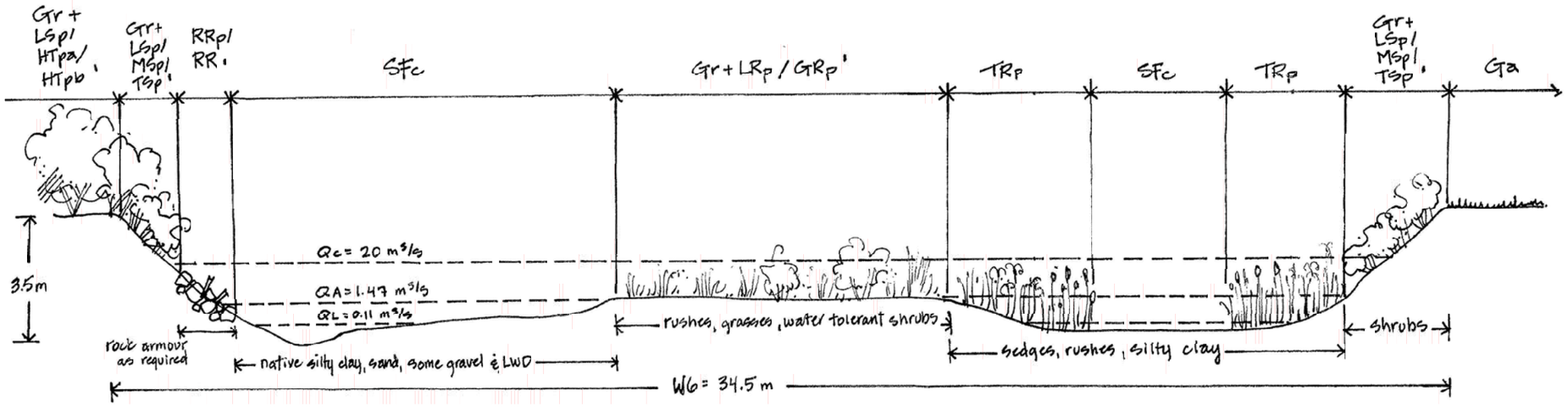

1- See Plan for specified Habitat Type, in order to comply w/ Transport Canada height requirements

Typical Cross Section B - Substrate Materials & Schematic

ISSUED FOR USE

Detailed Vernon Creek Realignment and Enhancement Design

Typical Cross - Section B

PROJECTION: N/A	DATUM: N/A	EBA Engineering Consultants Ltd.
Scale: Not to Scale		
FILE No: Figure_5_Cross_Section_B.mxd		DATE: September 11, 2008
JOB NO: K23101307	REVISION NO: 1	
OFFICE: EBA-KELOWNA	DRAWN: MS / CHECK: DA	Figure 5

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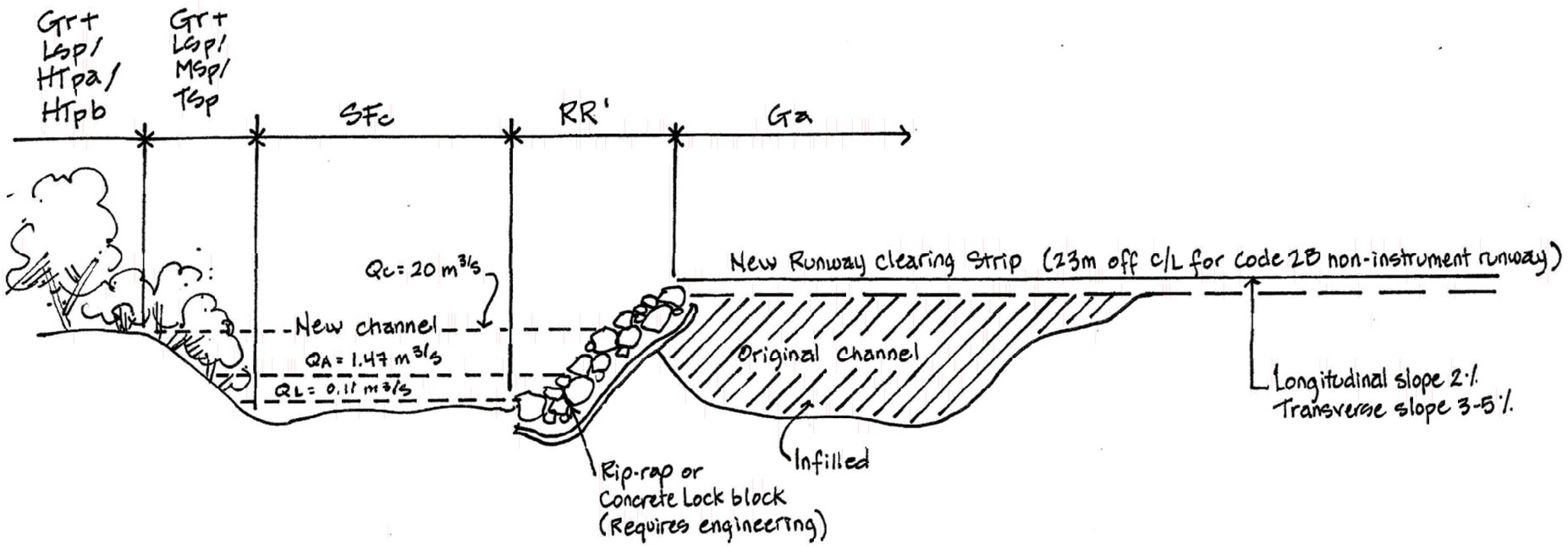

1- See Plan for specified Habitat Type, in order to comply w/ Transport Canada height requirements

Typical Cross Section C - Schematic Only (not to scale)

ISSUED FOR USE

Detailed Vernon Creek Realignment and Enhancement Design

Typical Cross - Section C

PROJECTION: N/A	DATUM: N/A	EBA Engineering Consultants Ltd.
Scale: Not to Scale		
FILE No: Figure_6_Cross_Section_C.mxd		DATE: September 11, 2008
JOB NO: K23101307	REVISION NO: 1	
OFFICE: EBA-KELOWNA	DRAWN: MS / CHECK: DA	Figure 6

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APPENDIX

APPENDIX A PHOTOGRAPHS

Photo 1
End of proposed runway with Marshall Fields in foreground - note wetlands (August 2006)

Photo 2
Typical flood bench on right side of photo (August 2006)

Photo 3
Great Blue Heron on Vernon Creek (August 2006)

Photo 4
Lower Vernon Creek - view east

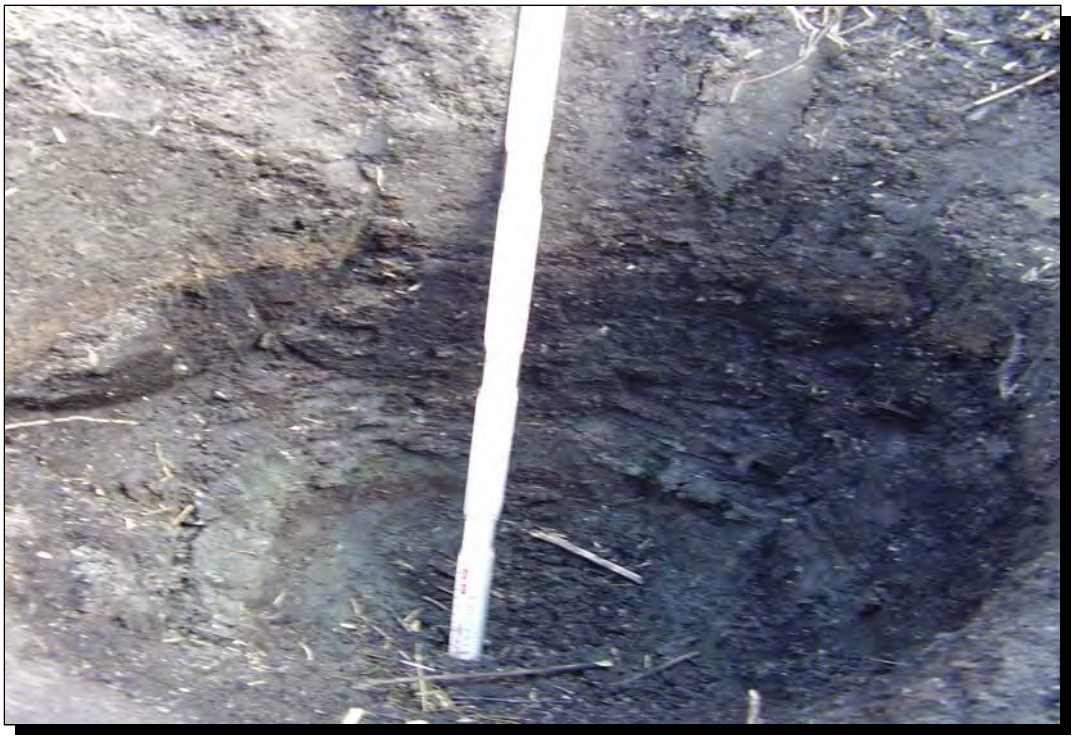


Photo 5
Soil pit at Marshall Fields (August 2006)

Photo 6
Swallow nesting cavities in stream bank at upstream end of study area (August 2006)

Photo 7
Vernon Creek - view northwest downstream of Community24 (August 2006)

Photo 8
Vernon Creek - view west across from Community24 (August 2006)

Photo 9
Vernon Creek - view upstream near end of runway (August 2006)

Photo 10
Vernon Creek – view east at upstream extent of study area (August 2006)

Photo 11
Vertical silt banks and evidence of sloughing near golf course (August 2006)

Photo 12
Wood weir and beaver activity (August 2006)

Photo 13
Wood weirs in Vernon Creek (August 2006)

APPENDIX

APPENDIX B FLETCHER PAINE ASSOCIATES LTD. SOILS DATA


TP4
TP5
TP2
TP6
TP7
TP3
TP8
TP1
N

Moisture Content Determination

Project: City of Vernon - Airport Extension **Project No.** 5356

Location: Vernon, BC **Date of Testing:** May 21, 2005

Tested by: RS

Test hole No.	1	1	1	2	2	2	4
Sample No.	1	2	3	1	2	3	1
Depth (m)	0.6	1.2	1.6	0.6	0.9	1.4	0.3
Moisture content %	8.1	25.9	48.5	27.5	34.6	44.1	11.4

Test hole No.	4	4	4	8	8
Sample No.	2	3	4	1	2
Depth (m)	0.4	0.8	1.2	0.8	1.1
Moisture content %	60.9	83.8	168.7	51.7	45.9

From: Ryan Stearns [mailto:rstearns.fpa@shawlink.ca]
Sent: Tue 10/06/2008 4:57 PM
To: Melanie Steppuhn
Cc: Terry Eddy
Subject: RE: Vernon Creek Test Pit Data Request

Hi Melanie,

I have written out rough descriptions of soil types below, please call me if you need anything more detailed.

TP 1

0 - 0.3m	topsoil
0.3m - 1.1m	sand
1.1m - 1.6m	sandy silt
1.6m - 1.8m	silt, some clay

End of test pit at 1.8 m

TP 2

0 - 0.4m	topsoil
0.4m - 0.6m	clayey silt
0.6m - 0.9m	sand
0.9m - 1.2m	silty sand
1.2m - 1.7m	silt, some sand and clay

End of test pit at 1.7 m

TP 3

0 - 0.3m	topsoil
0.3m - 0.4m	silty clay
0.4m - 0.8m	sand
0.8m - 1.2m	sandy silt
1.2m - 1.4m	silt, some clay

End of test pit at 1.4 m

TP 4

0 - 0.3m	topsoil
0.3m - 0.4m	sand
0.4m - 0.8m	silt, some clay
0.8m - 1.7m	clayey silt

End of test pit at 1.7 m

TP 5

0 - 0.4m	topsoil
0.4m - 0.5m	sandy silt
0.5m - 0.7m	peat
0.7m - 1.3m	clayey silt
1.3m - 1.5m	sandy silt

End of test pit at 1.5 m

TP 6

0 - 0.3m	topsoil
0.3m - 0.5m	clayey silt, peaty
0.5m - 1.5m	silty sand

End of test pit at 1.5 m

TP 7

0 - 0.5m	topsoil
0.5m - 0.6m	clayey silt, peaty
0.6m - 0.9m	sand
0.9m - 1.4m	silty sand

End of test pit at 1.4 m

TP 8

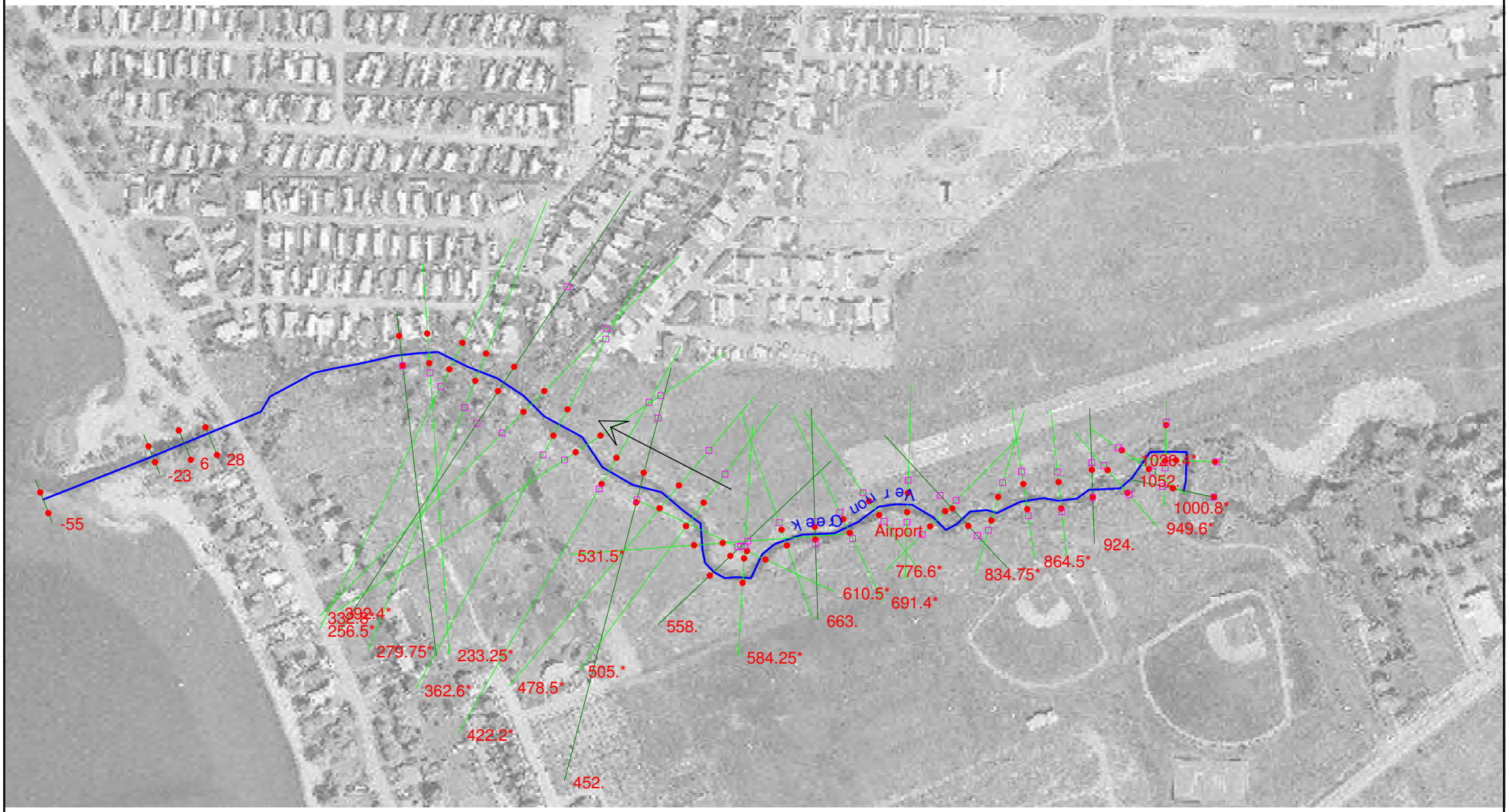
0 - 0.3m	topsoil
0.3m - 0.4m	peat
0.4m - 0.6m	clayey silt
0.6m - 1.1m	silt and clay
1.1m - 1.4m	silt, some sand and clay

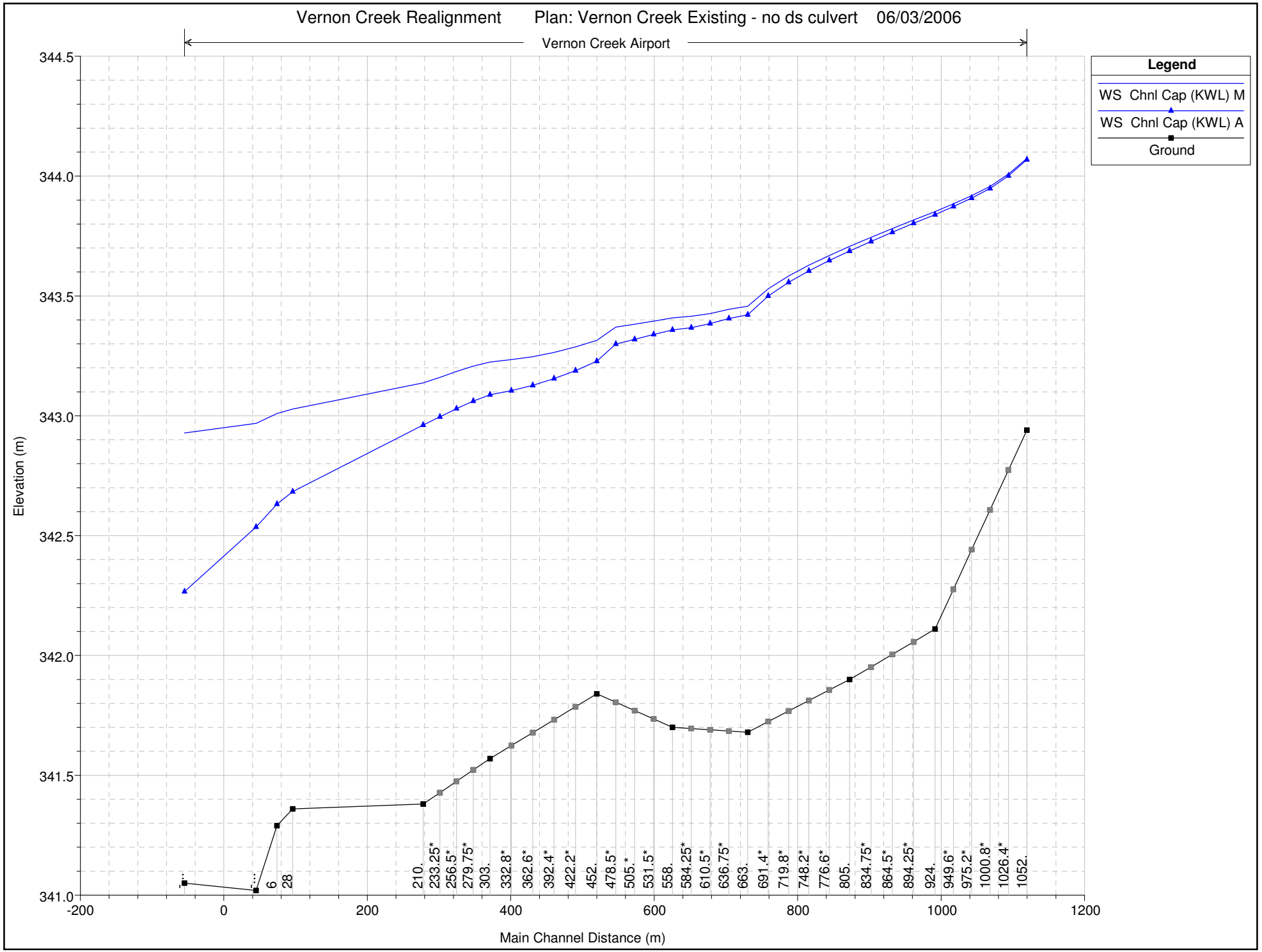
End of test pit at 1.4 m

Ryan Stearns, E.I.T.
Fletcher Paine Associates Ltd.
Consulting Geotechnical and Materials Engineers
Phone: (250) 542-0377
Fax: (250) 542-1220

APPENDIX

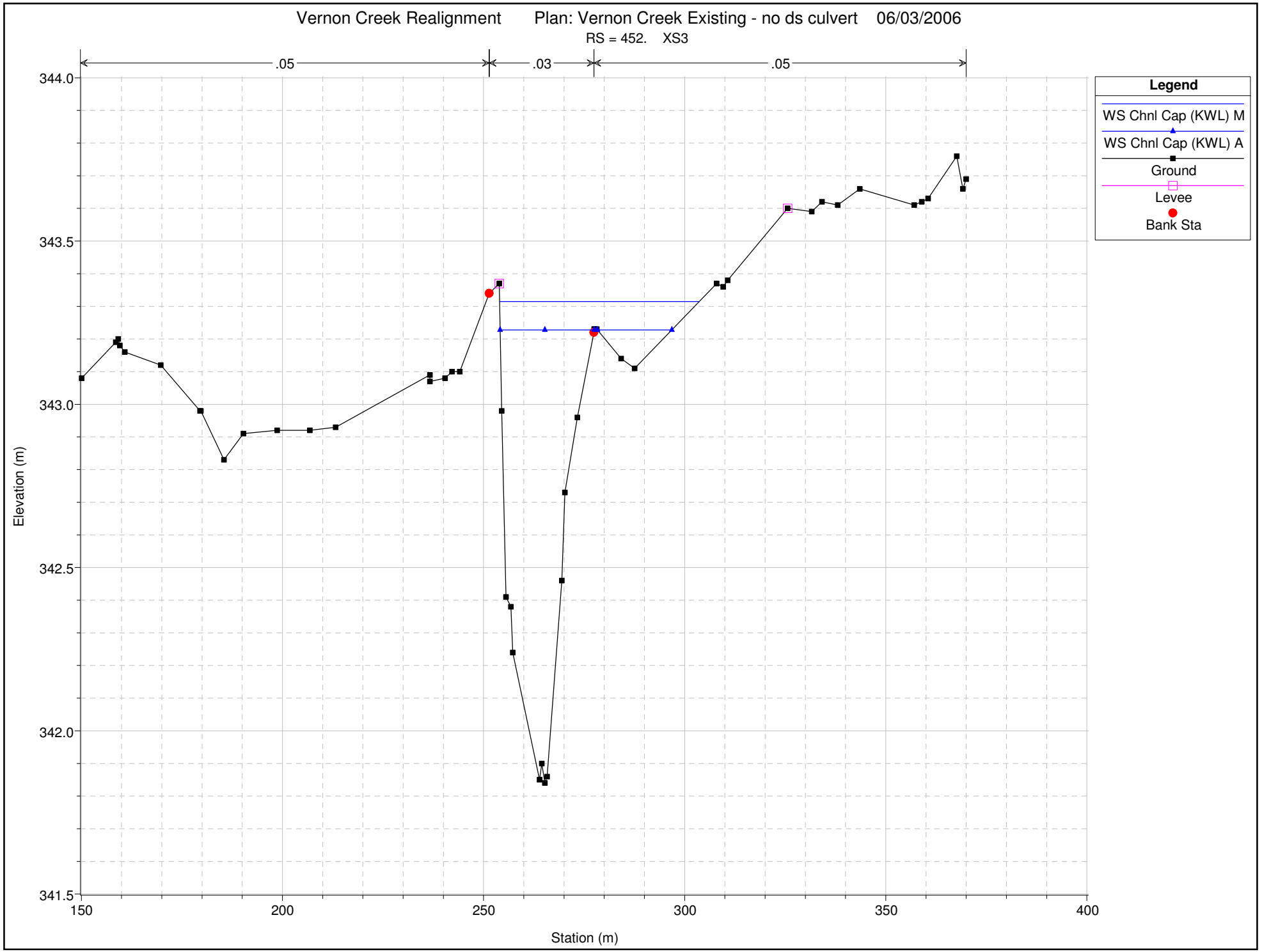
APPENDIX C HEC-RAS MODEL OUTPUT RESULTS

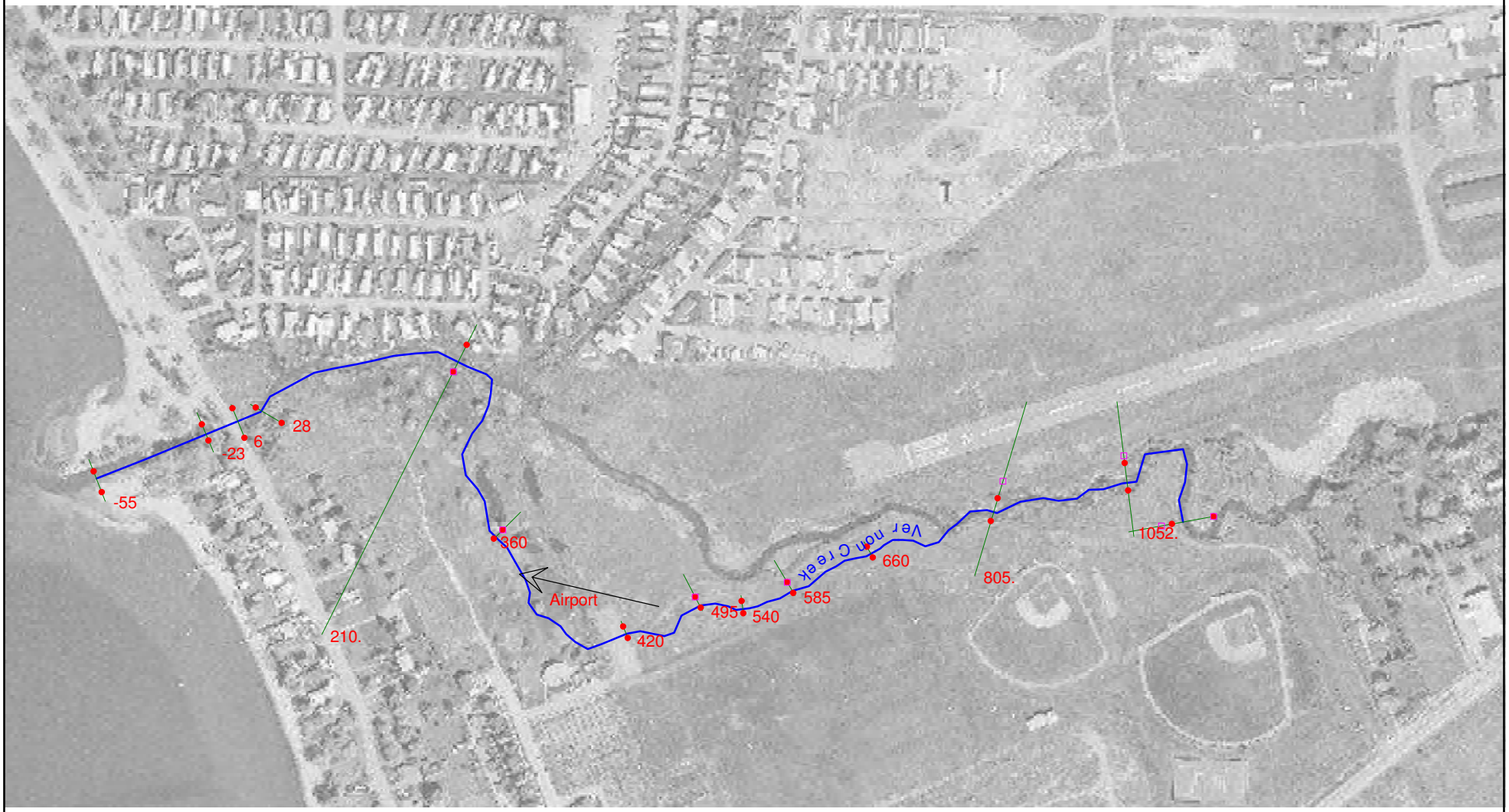

-55
-23
6
28
256.5*
279.75*
233.25*
362.6*
422.2*
478.5*
505.*
452.
531.5*
558.
584.25*
663.
610.5*
691.4*
776.6*
834.75*
864.5*
924.
949.6*
1000.8*
1052.
Airport
Creek
River

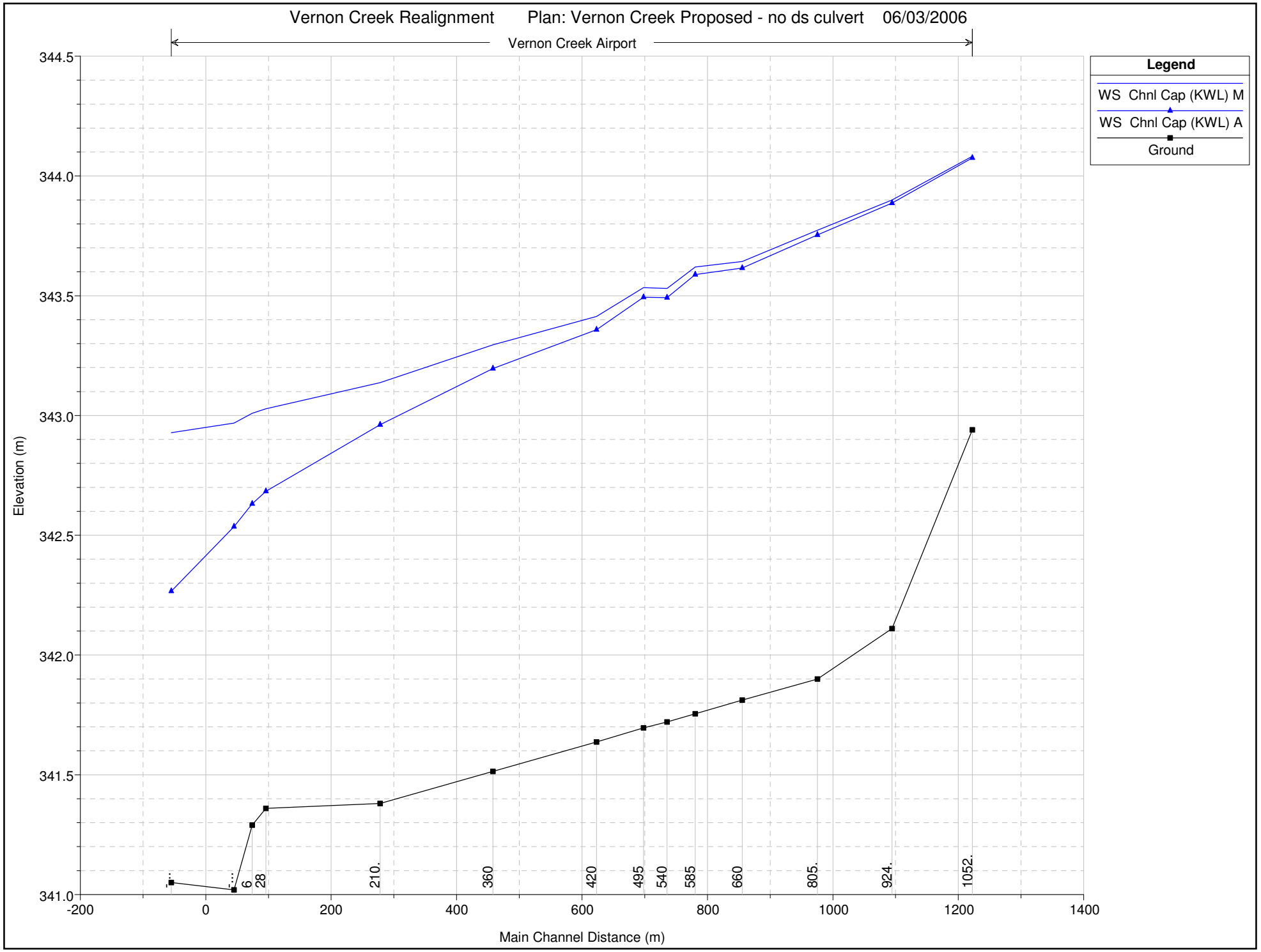

Vernon Creek Realignment
Plan: Vernon Creek Existing - no ds culvert
06/03/2006
Vernon Creek Airport
Legend
WS Chnl Cap (KWL) M
WS Chnl Cap (KWL) A
Ground
Elevation (m)
Main Channel Distance (m)
344.5
344.0
343.5
343.0
342.5
342.0
341.5
341.0
-200
0
200
400
600
800
1000
1200
6
28
210.
233.25*
256.5*
279.75*
303.
332.8*
362.6*
392.4*
422.2*
452.
478.5*
505.*
531.5*
558.
584.25*
610.5*
636.75*
663.
691.4*
719.8*
748.2*
776.6*
805.
834.75*
864.5*
894.25*
924.
949.6*
975.2*
1000.8*
1026.4*
1052.

HEC-RAS Plan: Exist NoCulv River: Vernon Creek Reach: Airport

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Airport	1052.	Chnl Cap (KWL) M	20.00	342.94	344.07	343.79	344.12	0.001783	0.98	20.42	34.77	0.41
Airport	1052.	Chnl Cap (KWL) A	20.00	342.94	344.07	343.79	344.12	0.001834	0.99	20.24	34.76	0.41
Airport	924.	Chnl Cap (KWL) M	20.00	342.11	343.85	343.15	343.92	0.001134	1.17	17.06	15.24	0.35
Airport	924.	Chnl Cap (KWL) A	20.00	342.11	343.84	343.15	343.91	0.001172	1.19	16.87	15.20	0.36
Airport	805.	Chnl Cap (KWL) M	20.00	341.90	343.71	343.01	343.78	0.001260	1.22	16.35	14.93	0.37
Airport	805.	Chnl Cap (KWL) A	20.00	341.90	343.69	343.01	343.77	0.001319	1.24	16.07	14.80	0.38
Airport	663.	Chnl Cap (KWL) M	20.00	341.68	343.46	342.81	343.58	0.001822	1.57	12.71	9.78	0.44
Airport	663.	Chnl Cap (KWL) A	20.00	341.68	343.42	342.81	343.55	0.001968	1.62	12.36	9.69	0.46
Airport	558.	Chnl Cap (KWL) M	20.00	341.70	343.41	342.84	343.43	0.000654	0.74	38.22	71.73	0.26
Airport	558.	Chnl Cap (KWL) A	20.00	341.70	343.36	342.84	343.39	0.000833	0.82	34.62	70.11	0.29
Airport	452.	Chnl Cap (KWL) M	20.00	341.84	343.31	342.70	343.36	0.000976	0.95	23.77	49.64	0.32
Airport	452.	Chnl Cap (KWL) A	20.00	341.84	343.23	342.70	343.29	0.001416	1.07	19.75	41.83	0.38
Airport	303.	Chnl Cap (KWL) M	20.00	341.57	343.22	342.34	343.25	0.000387	0.69	39.14	85.53	0.21
Airport	303.	Chnl Cap (KWL) A	20.00	341.57	343.09	342.34	343.12	0.000631	0.83	29.25	60.88	0.26
Airport	210.	Chnl Cap (KWL) M	20.00	341.38	343.14	342.31	343.19	0.000762	0.99	20.20	17.60	0.29
Airport	210.	Chnl Cap (KWL) A	20.00	341.38	342.96	342.31	343.03	0.001162	1.16	17.25	16.27	0.36
Airport	28	Chnl Cap (KWL) M	20.00	341.36	343.03		343.06	0.000586	0.80	25.25	27.09	0.25
Airport	28	Chnl Cap (KWL) A	20.00	341.36	342.68		342.76	0.002015	1.20	16.71	23.10	0.45
Airport	6	Chnl Cap (KWL) M	20.00	341.29	343.01		343.05	0.000607	0.86	23.19	21.02	0.26
Airport	6	Chnl Cap (KWL) A	20.00	341.29	342.63		342.71	0.001797	1.27	15.74	18.08	0.43
Airport	-23	Chnl Cap (KWL) M	20.00	341.02	342.97		343.03	0.000753	1.06	18.91	18.61	0.29
Airport	-23	Chnl Cap (KWL) A	20.00	341.02	342.54		342.65	0.002069	1.52	13.13	12.38	0.47
Airport	-55	Chnl Cap (KWL) M	20.00	341.05	342.93	341.97	342.96	0.000446	0.82	26.24	26.52	0.23
Airport	-55	Chnl Cap (KWL) A	20.00	341.05	342.27	341.97	342.40	0.003242	1.60	12.47	15.50	0.57

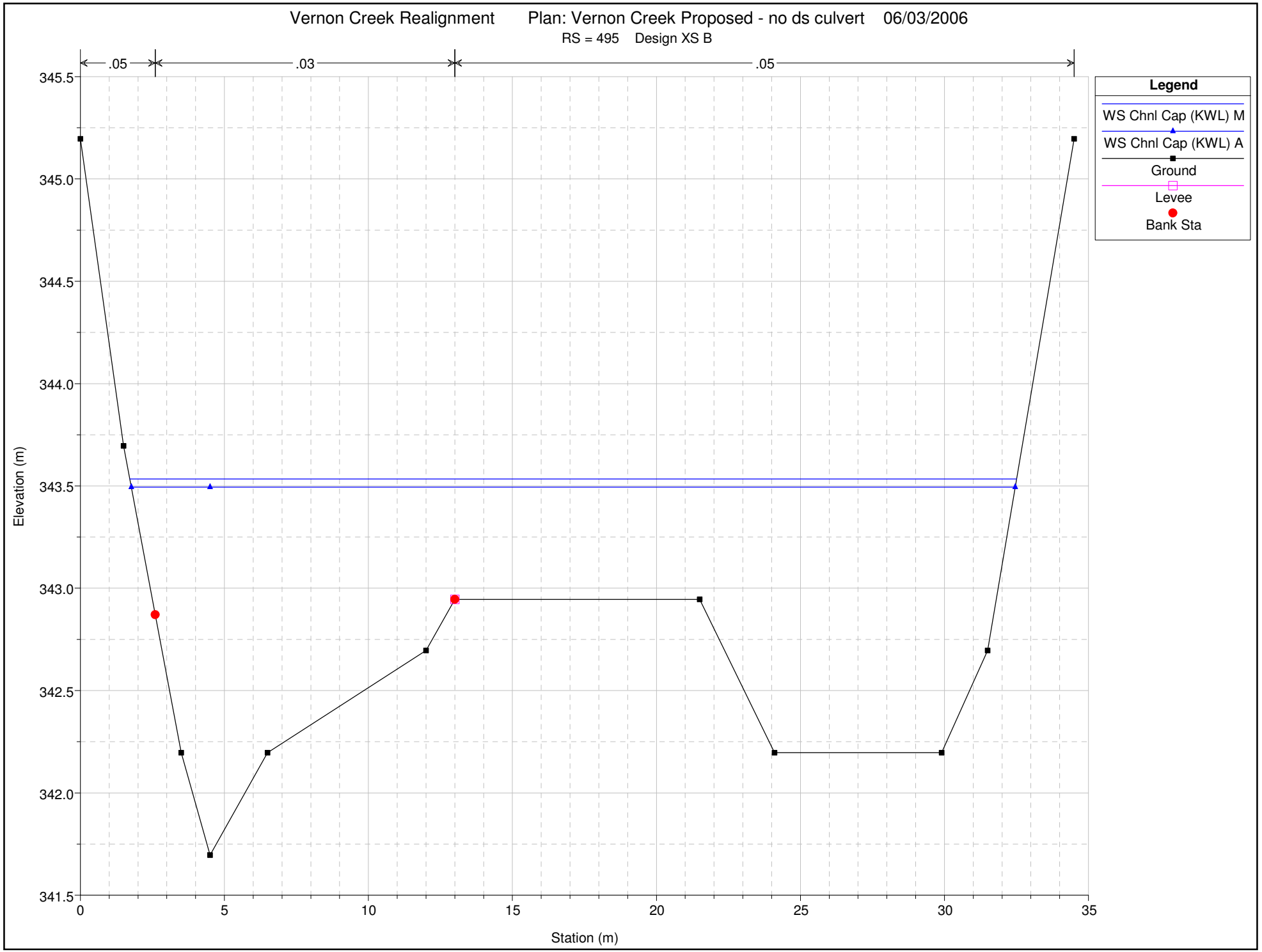

Vernon Creek Realignment
Plan: Vernon Creek Existing - no ds culvert
06/03/2006
RS = 452.
XS3
.05
.03
.05
Legend
WS Chnl Cap (KWL) M
WS Chnl Cap (KWL) A
Ground
Levee
Bank Sta
Elevation (m)
344.0
343.5
343.0
342.5
342.0
341.5
150
200
250
300
350
400
Station (m)


-55
-23
6
28
210.
360
Airport
420
495
540
585
660
805.
1052.
Vernon Creek


Vernon Creek Realignment
Plan: Vernon Creek Proposed - no ds culvert
06/03/2006
Vernon Creek Airport
Legend
WS Chnl Cap (KWL) M
WS Chnl Cap (KWL) A
Ground
Elevation (m)
Main Channel Distance (m)
344.5
344.0
343.5
343.0
342.5
342.0
341.5
341.0
-200
0
200
400
600
800
1000
1200
1400
6
28
210.
360
420
495
540
585
660
805.
924.
1052.

HEC-RAS Plan: Prop NoCulv River: Vernon Creek Reach: Airport

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Airport	1052.	Chnl Cap (KWL) M	20.00	342.94	344.08	343.79	344.13	0.001702	0.97	20.71	34.78	0.40
Airport	1052.	Chnl Cap (KWL) A	20.00	342.94	344.08	343.79	344.12	0.001768	0.98	20.47	34.77	0.41
Airport	924.	Chnl Cap (KWL) M	20.00	342.11	343.90	343.15	343.96	0.000999	1.12	17.80	15.39	0.33
Airport	924.	Chnl Cap (KWL) A	20.00	342.11	343.89	343.15	343.95	0.001034	1.14	17.59	15.35	0.34
Airport	805.	Chnl Cap (KWL) M	20.00	341.90	343.77	343.01	343.84	0.001071	1.15	17.36	15.38	0.35
Airport	805.	Chnl Cap (KWL) A	20.00	341.90	343.75	343.01	343.82	0.001122	1.17	17.07	15.22	0.35
Airport	660	Chnl Cap (KWL) M	20.00	341.81	343.64		343.72	0.000930	1.25	17.34	14.41	0.33
Airport	660	Chnl Cap (KWL) A	20.00	341.81	343.62		343.70	0.000993	1.28	16.94	14.33	0.34
Airport	585	Chnl Cap (KWL) M	20.00	341.75	343.62	343.01	343.65	0.000620	0.92	30.92	30.86	0.27
Airport	585	Chnl Cap (KWL) A	20.00	341.75	343.59	343.01	343.62	0.000684	0.95	29.95	30.78	0.28
Airport	540	Chnl Cap (KWL) M	20.00	341.72	343.53		343.61	0.000980	1.27	17.02	14.35	0.34
Airport	540	Chnl Cap (KWL) A	20.00	341.72	343.49		343.58	0.001077	1.31	16.47	14.24	0.35
Airport	495	Chnl Cap (KWL) M	20.00	341.70	343.53	342.95	343.57	0.000675	0.94	30.08	30.79	0.28
Airport	495	Chnl Cap (KWL) A	20.00	341.70	343.49	342.95	343.53	0.000769	0.98	28.84	30.69	0.29
Airport	420	Chnl Cap (KWL) M	20.00	341.64	343.41		343.50	0.001063	1.30	16.55	14.25	0.35
Airport	420	Chnl Cap (KWL) A	20.00	341.64	343.36		343.45	0.001221	1.36	15.77	14.10	0.37
Airport	360	Chnl Cap (KWL) M	20.00	341.51	343.30	342.77	343.33	0.000813	1.00	28.33	30.65	0.30
Airport	360	Chnl Cap (KWL) A	20.00	341.51	343.20	342.77	343.24	0.001150	1.12	25.30	30.39	0.35
Airport	210.	Chnl Cap (KWL) M	20.00	341.38	343.14	342.31	343.19	0.000762	0.99	20.20	17.60	0.29
Airport	210.	Chnl Cap (KWL) A	20.00	341.38	342.96	342.31	343.03	0.001162	1.16	17.25	16.27	0.36
Airport	28	Chnl Cap (KWL) M	20.00	341.36	343.03		343.06	0.000586	0.80	25.25	27.09	0.25
Airport	28	Chnl Cap (KWL) A	20.00	341.36	342.68		342.76	0.002016	1.20	16.71	23.10	0.45
Airport	6	Chnl Cap (KWL) M	20.00	341.29	343.01		343.05	0.000607	0.86	23.19	21.02	0.26
Airport	6	Chnl Cap (KWL) A	20.00	341.29	342.63		342.71	0.001798	1.27	15.74	18.08	0.43
Airport	-23	Chnl Cap (KWL) M	20.00	341.02	342.97		343.03	0.000753	1.06	18.91	18.61	0.29
Airport	-23	Chnl Cap (KWL) A	20.00	341.02	342.54		342.65	0.002070	1.52	13.13	12.38	0.47
Airport	-55	Chnl Cap (KWL) M	20.00	341.05	342.93	341.97	342.96	0.000446	0.82	26.24	26.52	0.23
Airport	-55	Chnl Cap (KWL) A	20.00	341.05	342.27	341.97	342.40	0.003242	1.60	12.47	15.50	0.57


Vernon Creek Realignment
Plan: Vernon Creek Proposed - no ds culvert
06/03/2006
RS = 495
Design XS B
.05
.03
.05
Legend
WS Chnl Cap (KWL) M
WS Chnl Cap (KWL) A
Ground
Levee
Bank Sta
Elevation (m)
345.5
345.0
344.5
344.0
343.5
343.0
342.5
342.0
341.5
0
5
10
15
20
25
30
35
Station (m)

APPENDIX

APPENDIX D VEGETATION DATA SHEETS

Vernon Creek Habitat Profile #1
Habitat Type: Grass / Low Rush

Typical Plant Species

Latin Name	Common Name
Salix exigua	Coyote willow
Salix lucida lasiandra	Pacific willow
Cornus stolonifera	Red-osier dogwood
Typha latifolia	Cattail
Scirpus validus	Soft-stemmed bulrush
Calamagrostis canadensis	Bluejoint
Mentha arvensis	Canada Mint
Epilobium ciliatum	Purple-leaved Willowherb
Eleocharis palustris	Common spike-rush
Juncus balticus	Baltic rush

Non-indigenous Plant Species

Latin Name	Common Name	Physical Attributes
Tanacetum vulgare	Common tansy	Slope position: level
Arctium lappa	Great burdock	Slope (%): 0-2%
Lythrum salicaria	Purple loosestrife	Aspect: none
Cirsium arvense	Canada thistle	Soil Moisture Regime: subhygric
		Soil Nutrient Regime: medium
		Soil type: silts and sands
		Terrain: fluvial
		Structural Stage: low shrub
		Realm/Class:
		Site Association:
		Wetland Form: riparian floodplain
		Wetland Type: grass / forb
		Vegetation Form: herbs

Cross Section	Comments / Management
	8840278 Plot #2

Vernon Creek Habitat Profile # 2
Habitat Type: Tall Rush (Off Channel Wetland)

Typical Plant Species

Latin Name	Common Name
Scirpus validus	Soft-stemmed bulrush
Juncus balticus	Baltic rush
Typha latifolia	Cattail
Lemna minor	Common duckweed

Non-indigenous Plant Species

Latin Name	Common Name		Physical Attributes
Lythrum salicaria	Purple Loosestrife		Slope position: Depression
			Slope (%): 0
			Aspect: none
			Soil Moisture Regime: hydric
			Soil Nutrient Regime: rich
			Soil type: organic
			Terrain: fluvial
			Structural Stage: herb 2b - graminoid
			Realm/Class: Wm – wetland marsh
			Site Association:
			Wetland Form: riparian / spring
			Wetland Type: tall rush
			Vegetation Form: roburst emergent

Cross Section		Comments / Management
		8840278 Plot #6

Vernon Creek Habitat Profile #3
Habitat Type: Mixed Shrub / Tall Shrub / Low Shrub

Typical Plant Species

Latin Name	Common Name
Crataegus douglasii	Black hawthorn
Cornus stolonifera	Red-osier dogwood
Prunus virginiana	Choke cherry
Ribes lacustre	Black gooseberry
Rosa nutkana	Nootka rose
Rosa woodsii	Woods rose
Rubus idaeus	Red raspberry
Salix exigua	Coyote willow
Symphoricarpos albus	Common snowberry

Non-indigenous Plant Species

Latin Name	Common Name	Physical Attributes
Lythrum salicaria	Purple loosestrife	Slope position: lower slope
		Slope (%): 35%
		Aspect: south
		Soil Moisture Regime: subhygric
		Soil Nutrient Regime: medium
		Soil type: sands and silts
		Terrain: fluvial
		Structural Stage: tall shrub
		Realm/Class: shrub carr
		Site Association:
		Wetland Form: riparian
		Wetland Type: low or tall shrub

Cross Section

Comments / Management

8840278 Plot # 3

Vernon Creek Habitat Profile #4
Habitat Type: Hardwood Treed

Typical Plant Species

Latin Name	Common Name
Prunus virginiana	Choke cherry
Salix lucida laciandra	Pacific Willow
Betula occidentalis	Water birch
Alnus incana ssp. tenuifolia	Mountain alder
Rosa woodsii	Wood's rose
Rubus idaeus	Red raspberry
Symphoricarpos albus	Snowberry
Ribes lacustre	Black gooseberry
Calamagrostis canadensis	Bluejoint
Populus trichocarpa	Cottonwood

Non-indigenous Plant Species

Latin Name	Common Name		Physical Attributes
Acer negundo	Box-elder		Slope position: mid
Cirsium vulgare	Bull thistle		Slope (%): 35%
Taraxacum officinale	Common dandelion		Aspect: south
Solanum dulcamara	Woody nightshade		Soil Moisture Regime: subhygric
			Soil Nutrient Regime: medium
			Soil type: sands and silts
			Terrain: fluvial
			Structural Stage: young forest
			Realm/Class: middle bench
			Site Association:
			Wetland Form: riparian
			Wetland Type: hardwood treed
			Vegetation Form: broadleaf deciduous

Cross Section

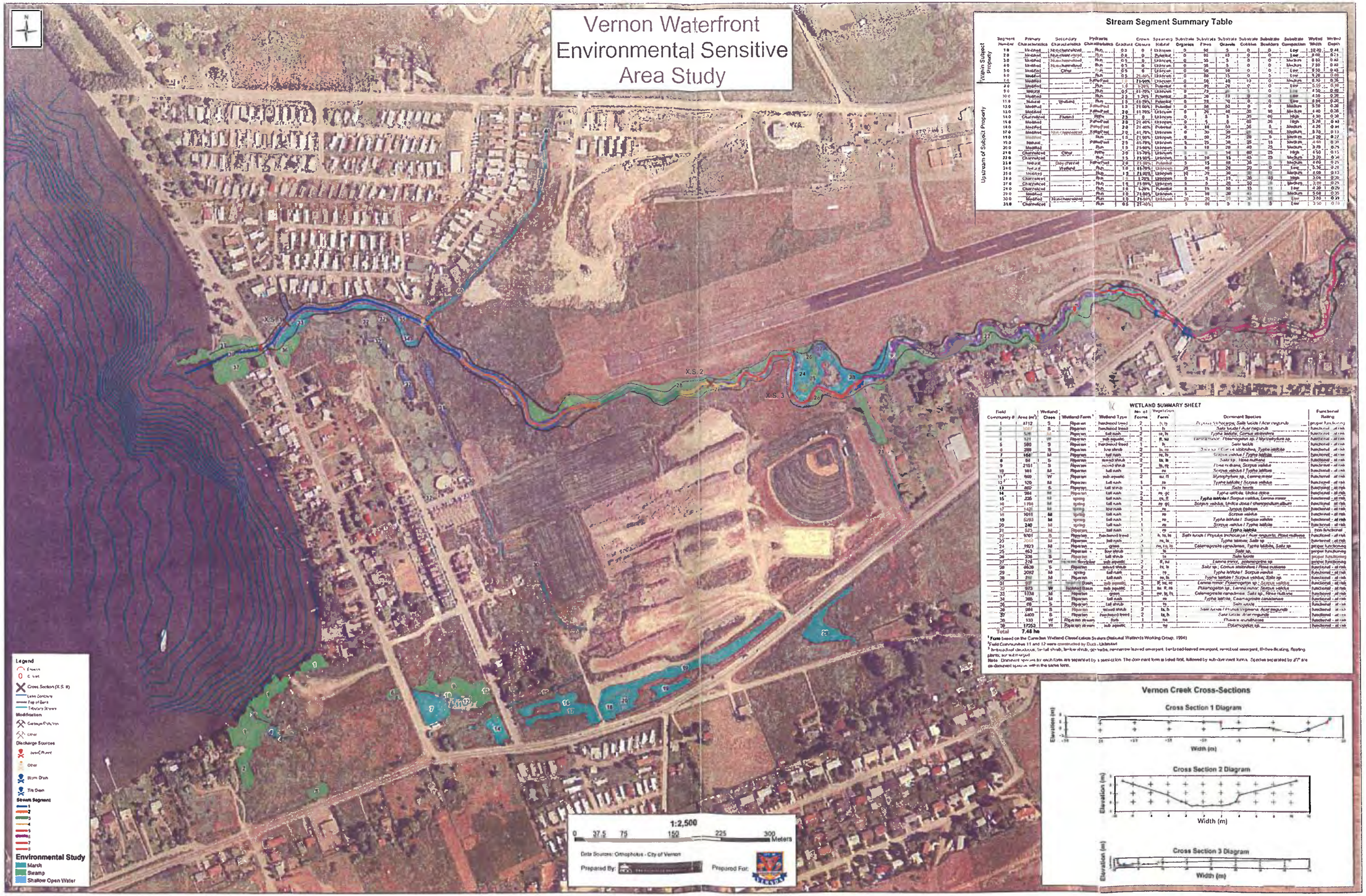
Comments / Management

		8840278 # 4,5

APPENDIX

APPENDIX E VERNON WATERFRONT ENVIRONMENT SENSITIVE AREA STUDY MAP (EBA 2004)

Vernon Waterfront Environmental Sensitive Area Study



Stream Segment Summary Table

	Segment Number	Primary Characteristics	Secondary Characteristics	Hydraulic Characteristics	Gradient	Crown Closure	Spawning Habitat	Substrate Organics	Substrate Fines	Substrate Gravels	Substrate Cobbles	Substrate Boulders	Substrate Composition	Wetted Width	Wetted Depth
Within Subject Property	1.0	Modified	Non-channelized	Run	0.3	0	Unknown	0	90	5	1	0	0	Low	10.00	0.48
	2.0	Modified	Non-channelized	Run	0.8	0	Potential	0	60	40	0	0	0	Low	8.00	0.23
	3.0	Modified	Non-channelized	Run	0.5	0	Unknown	0	90	5	0	0	5	Medium	8.00	0.40
	4.0	Modified	Non-channelized	Run	0.5	0	Unknown	0	95	5	0	0	0	Medium	7.00	0.40
	5.0	Modified	Other	Run	0.5	0	Unknown	0	50	10	0	0	0	Low	5.50	0.43
	6.0	Modified		Run	0.5	21-40%	Unknown	0	90	5	0	0	5	Low	12.00	0.60
	7.0	Modified		Pool/Pool	1.0	21-40%	Unknown	0	60	40	10	0	0	Medium	8.10	0.35
	8.0	Modified		Run	1.0	1-20%	Potential	0	70	30	0	0	0	Low	5.00	0.30
	9.0	Natural		Run	0.5	61-80%	Unknown	0	70	30	0	0	0	Low	4.50	0.40
	10.0	Modified		Run	2.0	1-20%	Potential	0	70	30	0	0	0	Low	4.50	0.20
	11.0	Natural	Wetland	Run	1.0	41-60%	Potential	0	70	30	0	0	0	Low	6.00	0.30
	12.0	Modified		Pool/Pool	1.0	21-40%	Potential	0	50	50	0	0	0	Medium	5.50	0.28
	13.0	Modified		Pool/Pool	2.0	61-80%	Unknown	0	50	40	10	0	0	Medium	5.00	0.38
	14.0	Channelized	Fluvial	Rifflo	2.5	0	Unknown	0	5	5	30	60	0	High	6.30	0.58
	15.0	Modified		Pool/Pool	2.0	21-40%	Unknown	0	5	5	50	35	5	High	5.30	0.43
	16.0	Modified		Pool/Pool	2.0	21-40%	Potential	0	5	5	50	35	5	Medium	4.20	0.34
	17.0	Modified	Non-channelized	Pool/Pool	2.0	41-60%	Unknown	0	30	20	40	10	0	Medium	3.70	0.13
	18.0	Modified		Run	1.0	21-40%	Unknown	0	90	10	0	0	0	Low	3.20	0.27
	19.0	Natural		Pool/Pool	2.5	41-60%	Unknown	0	70	30	0	0	0	Low	4.60	0.30
	20.0	Modified		Run	1.5	21-40%	Unknown	0	5	10	60	25	0	Medium	3.70	0.25
	21.0	Channelized	Other	Rifflo	2.0	61-80%	Unknown	0	5	5	50	25	15	High	6.50	0.15
	22.0	Channelized		Run	1.5	21-40%	Unknown	0	50	15	45	25	15	Medium	3.20	0.34
	23.0	Natural	Ditch/Fluvial Wetland	Pool/Pool	2.0	61-80%	Potential	0	50	15	45	25	15	Medium	4.00	0.25
	24.0	Natural		Run	1.0	61-80%	Unknown	20	90	20	0	0	0	Low	3.50	0.25
	25.0	Modified		Run	1.0	21-40%	Unknown	10	90	20	0	0	0	Medium	4.00	0.13
	26.0	Channelized		Run	1.0	1-20%	Unknown	0	5	20	30	45	0	High	3.00	0.20
	27.0	Channelized		Run	1.0	61-80%	Unknown	0	5	20	30	45	0	Medium	3.00	0.25
	28.0	Channelized		Run	1.0	61-80%	Potential	0	5	15	50	30	0	Medium	4.00	0.25
	29.0	Modified		Run	1.0	61-80%	Unknown	0	90	20	40	10	0	Medium	5.00	0.35
	30.0	Modified	Non-channelized	Run	1.0	21-40%	Unknown	20	20	40	40	0	0	Low	3.50	0.20
	31.0	Channelized		Run	0.5	21-40%		0	5	60	5	5	5	Low	3.50	0.13

WETLAND SUMMARY SHEET

Field Community #	Area (m²)	Wetland Class	Wetland Form	Wetland Type	No. of Forms	Vegetation Form	Dominant Species	Functional Rating
1	4712	S	Riparian	hardwood treed	2	fo, fp	*Populus trichocarpa, Salix lucida / Acer negundo*	proper functioning
2	648	M	Riparian	hardwood treed	1	fo	*Salix lucida / Acer negundo*	functional - at risk
3	648	M	Riparian	tall marsh	2	ww, fo	*Typha latifolia, Cornus stolonifera*	functional - at risk
4	931	M	Riparian	sub aquatic	2	ff, ww	*Lemna minor, Potamogeton sp. / Myriophyllum sp.*	functional - at risk
5	580	S	Riparian	hardwood treed	1	fo	*Salix lucida*	functional - at risk
6	288	S	Riparian	low shrub	2	ss, ep	*Salix sp. / Carex stipatoides, Typha latifolia*	functional - at risk
7	168	M	Riparian	tall marsh	2	ww, fo	*Scirpus validus / Typha latifolia*	functional - at risk
8	84	S	Riparian	tall shrub	2	ss, fo	*Salix sp., Rosa nutkana*	functional - at risk
9	2151	S	Riparian	mixed shrub	2	ss, fo	*Rosa nutkana, Scirpus validus*	functional - at risk
10	981	M	Riparian	tall marsh	1	ww	*Scirpus validus / Typha latifolia*	functional - at risk
11	909	W	Riparian	sub aquatic	2	aa, ff	*Myriophyllum sp., Lemna minor*	functional - at risk
12	109	M	Riparian	tall marsh	1	ww	*Typha latifolia / Scirpus validus*	functional - at risk
13	807	S	Riparian	tall shrub	1	ss	*Salix lucida*	functional - at risk
14	284	M	Riparian	tall marsh	2	ww, ep	*Typha latifolia, Lindica dubia*	functional - at risk
15	235	M	spring	tall marsh	2	ww, ep	*Typha latifolia / Scirpus validus, Lemna minor*	functional - at risk
16	1 196	M	spring	tall marsh	2	ww, ep	*Scirpus validus, Lindica dubia / chlamydium album*	functional - at risk
17	1 421	M	spring	low marsh	1	ww	*Juncus balticus*	functional - at risk
18	1011	M	spring	tall marsh	1	ww	*Scirpus validus*	functional - at risk
19	6353	M	spring	tall marsh	1	ww	*Typha latifolia / Scirpus validus*	functional - at risk
20	240	M	spring	tall marsh	1	ww	*Scirpus validus / Typha latifolia*	functional - at risk
21	671	M	Riparian	tall marsh	1	ep	*Typha latifolia*	non functional
22	9761	S	Riparian	hardwood treed	2	fo, ss	*Salix lucida / Physocarpus trichocarpa / Acer negundo, Rosa nutkana*	functional - at risk
23	2021	M	Riparian	tall marsh	2	ww, fo	*Typha latifolia, Salix sp*	functional - at risk
24	7823	M	Riparian	grass	1	ms, fo, ss	*Calamagrostis canadensis, Typha latifolia, Salix sp*	proper functioning
25	663	S	Riparian	low shrub	1	ss	*Salix sp.*	proper functioning
26	336	S	Riparian	tall shrub	1	ss	*Salix lucida*	proper functioning
27	278	W	Riparian	sub aquatic	2	ff, aa	*Lemna minor, potamogeton sp*	proper functioning
28	4626	S	Riparian	mixed shrub	2	ss, fo	*Salix sp., Cornus stolonifera / Rosa nutkana*	functional - at risk
29	2092	M	spring	tall marsh	2	ep	*Typha latifolia / Scirpus validus*	functional - at risk
30	292	M	Riparian	tall marsh	2	ww, fo	*Typha latifolia / Scirpus validus, Salix sp*	functional - at risk
31	937	W	Isolated Basin	sub aquatic	3	ff, ww, aa	*Lemna minor, Potamogeton sp / Scirpus validus*	functional - at risk
32	973	W	Isolated Basin	sub aquatic	3	aa, ff, ep	*Potamogeton sp, Lemna minor, Scirpus validus*	functional - at risk
33	1134	M	Riparian	grass	3	ep, fo, ss	*Calamagrostis canadensis, Salix sp., Rosa nutkana*	functional - at risk
34	286	M	Riparian	tall marsh	1	ep	*Typha latifolia, Calamagrostis canadensis*	functional - at risk
35	69	S	Riparian	tall shrub	1	ss	*Salix lucida*	functional - at risk
36	984	S	Riparian	mixed shrub	2	ss, fo	*Salix lucida / Physocarpus trichocarpa, Acer negundo*	functional - at risk
37	4400	S	Riparian	hardwood treed	2	fo, ss	*Salix lucida, Acer negundo*	functional - at risk
38	133	W	Riparian stream	fish	1	aa	*Potamogeton sp.*	functional - at risk
39	17252	W	Riparian stream	sub aquatic	1	aa	*Potamogeton sp.*	functional - at risk
Total	7.48 ha							

[1] **Form** based on the Cameron Wetland Classification System (National Wetlands Working Group, 1994)
[2] Field Communities 11 and 12 were constructed by Duck Unlimited
[3] broadleaved deciduous, tall tall shrub, tall/low shrub, ep= herbs, narrow-leaved emergent, tall broad-leaved emergent, nymphaeid emergent, floating-leaved, floating plants, submergent
Note: Dominant species for each form are separated by a semi-colon. The dominant form is listed first, followed by sub-dominant forms. Species separated by a/" are co-dominant species within the same form.

Vernon Creek Cross-Sections

FIGURE 2.

APPENDIX

APPENDIX F GREAT BASIN SPADEFOOT TOAD INFORMATION

APPENDIX F - GREAT BASIN SPADEFOOT TOAD INFORMATION

The Great Basin Spadefoot Toad (*Spea intermontana*) is a relatively small toad, measuring between 4 to 6.5 cm from snout to vent. It is grey-green in colour, with numerous dark brown or reddish tubercles and spots, and a grayish-white belly. Generally the males are smaller than the females, have dark throats, and develop black pads on their three inner fingers during breeding season. These toads have a few unique traits, such as vertical lens shaped pupils, a glandular bump between the eyes, a distinct black keratinous "spade" on the sole of each hind foot, which helps them to dig into the soil. These toads are also unique in that they spend a large part of their life underground. They dig burrows in which they undergo dormancy during cold or dry periods and can remain underground for up to 8 months of the year. Additionally, they are unlike most other amphibians in that they are a dry-land species and occupy open, semiarid to arid habitats. Spadefoots have been highly adapted to dry climates, and are able to recover from extreme desiccation; they can loose up to 48 percent of their body weight in water and still survive. There is relatively little known about this species due to the fact that it is nocturnal and spends much of its time underground. The maximum longevity of the Great Basin Spadefoot Toad is unknown, however, other Spadefoot species can live 10 years or more (MELP, 1999).

The Great Basin Spadefoot Toad is limited in Canada to the dry grassland valleys in south-central British Columbia, with the Okanagan Valley having the largest population concentrations. These low-elevation grasslands of the Okanagan are one of Canada's most endangered ecosystems with less than 9 percent of this habitat remaining undisturbed. The Okanagan Valley is facing tremendous development pressure from both urbanization and agricultural needs. The Great Basin Spadefoot Toad requires three quite separate habitats: breeding ponds, foraging areas, and hibernating sites. They also require dispersal routes between these habitats.

Breeding typically begins in mid to late April, usually following heavy rains; however, weather and temperature greatly affect this. During cool, wet years, breeding may not start until July. The availability of water is the most critical variable for breeding. Spadefoot Toads become sexually mature by their second or third year, when the males measure about 4 cm in length and the females about 4.5cm. The length of the breeding season is measured by the presence of calling males; this may range from one month to less than a week. The males call in response to each other, and can be heard up to 200 meters away. They typically breed in small ponds that must last at least 6 weeks for larval development to occur, which is usually finished by the end of June. The females lay between 300 and 800 black eggs, which are in clusters of 20 to 40, and attached to pebbles, sticks, or aquatic vegetation. Eggs hatch in two to three days, but it may take up to seven days or longer in cool weather. Hatchlings are 5 to 7mm long and grow quickly, metamorphosing into toadlets when they are 30 to 70mm long, six to eight weeks after hatching and often still have a substantial tail when they leave the water. Dispersal from natal ponds can happen en masse, and hundreds of toadlets are often seen crossing roads, which may lead to high mortality in urbanized areas (MELP, 1999).

The Great Basin Spadefoot Toad is protected under the British Columbia Wildlife Act, however, this legislation only cover the capture or killing of individuals, not matters affecting their habitat. This species is listed on the provincial Blue List, meaning that it is vulnerable. The Committee on

the Status of Endangered Wildlife in Canada (COSEWIC) has also designated the species as Vulnerable. Additionally, the species is protected under the federal Species at Risk Act (SARA).

Additional Info - From Nature Conservation Management Advice in Relation to Amphibians

*Amphibians are vulnerable to changes in their breeding sites, but especially to interruption of access between these breeding sites and their land habitat. Any highway operation causing such interruption can therefore result in population decline. Individual amphibians may continue to search for habitats that they previously used. As a result, amphibian population may not readily adjust to newly constructed or managed areas, and it may take between three and ten years (or more) for the population to stabilize (P4).

*Amphibians generally prefer fish free waters, without islands that encourage waterfowl. Ponds that readily warm up (i.e. those that are not too heavily choked with silt or plants or too shaded by trees) are often preferred.

*it is preferable when considering mitigation proposals for amphibians, to keep the population centered and located on the same land and water areas wherever possible, and to maintain favourable conditions there.(P9/1)

*during construction enclose the working area with temporary amphibian fencing, to keep them excluded from the area to minimize mortality. (P9/2)

*where it is essential that a breeding site or land habitat be altered or removed, appropriate mitigation should be designed and implemented at least one (but preferably two) years in advance in order to minimize the impact on amphibians and to allow for the seasonal constraints of habitat preparation and amphibian trapping. Habitat preparation often requires tree planting and grass seeding (during Oct-April season) and amphibian trapping (during March to September activity period). Measures may involve excluding amphibians from affected areas using fencing, and/or trapping and transferring them to alternative well established and suitable habitat nearby. In practice it may be necessary, following extensive exclusion and trapping, to drain (through screens) and carefully check water areas for amphibians prior to their being infilled. (P9/2)

*habitat creation for amphibians requires both the construction of aquatic breeding sites and the provision of adjacent terrestrial habitat. The pond size and shape should be designed for the particular species assemblages and wildlife community for which it was intended. Wherever possible a range of ponds should be provided to minimize the impact of any unpredictable environmental events. (9/2)

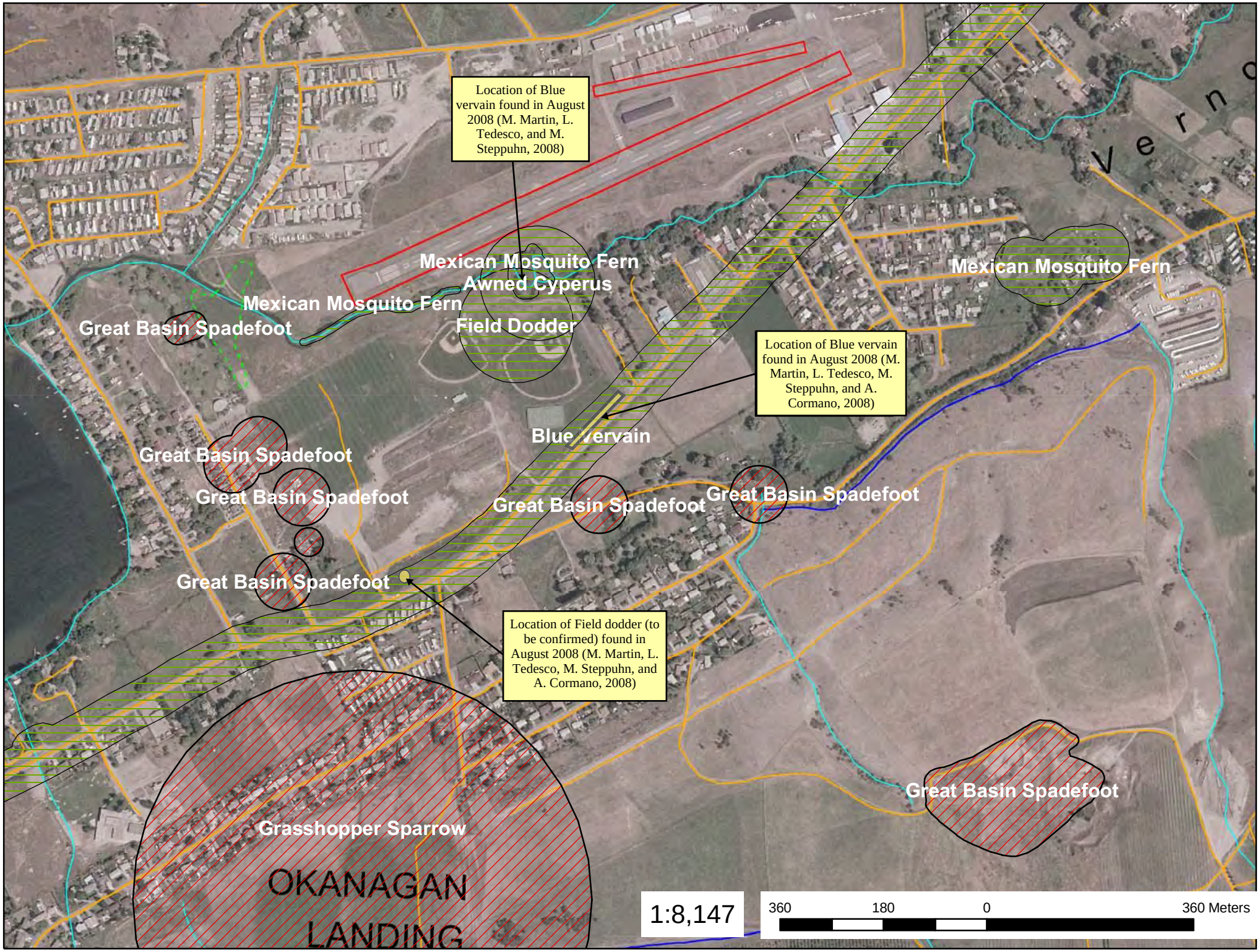
*Amphibian translocation normally requires a trapping period of several months, trapping should be carried out both on land, and in water, and should ideally cover a period of at least one year or one season as a minimum. (9/4)

References

Ministry of Environment, Land and Parks. 1999. Great Basin Spadefoot Toad. Fact Sheet. Wildlife Branch. Victoria, B.C.

APPENDIX

APPENDIX G RARE SPECIES MAP


Location of Blue vervain found in August 2008 (M. Martin, L. Tedesco, and M. Steppuhn, 2008)
Mexican Mosquito Fern
Awned Cyperus
Mexican Mosquito Fern
Field Dodder
Great Basin Spadefoot
Mexican Mosquito Fern
Location of Blue vervain found in August 2008 (M. Martin, L. Tedesco, M. Steppuhn, and A. Cormano, 2008)
Blue vervain
Great Basin Spadefoot
Great Basin Spadefoot
Great Basin Spadefoot
Great Basin Spadefoot
Great Basin Spadefoot
Location of Field dodder (to be confirmed) found in August 2008 (M. Martin, L. Tedesco, M. Steppuhn, and A. Cormano, 2008)
Great Basin Spadefoot
Grasshopper Sparrow
OKANAGAN LANDING
1:8,147
360
180
0
360 Meters

APPENDIX

APPENDIX H IMPACT ASSESSMENT TABLE

Vernon Creek Realignment - Impact Assessment Table					
Potential Impact	**Avoidance**	**Mitigation**	**Compensation**	**Monitoring**	**Contingency**
Hydrological / Soils					
Risk of creating fish entrapment	Ensure positive drainage through construction grading	—	—	Monitor after freshet for isolated pockets	Fish salvage into main channel and recontour later during the fish work window
Culvert impact on hydrological model of new realignment	Replace with clear span bridge	Allow for more flood storage capacity		Check for flooding of roadways and properties	Add a culvert to pass additional high flows
Risk of Low water flows	Provide a main channel through which the creek will travel during low water.	—	—	Monitor flow depths at low water	Recontour main channel during the next fish work window.
Risk of back watering from Okanagan Lake during high water	Provide sufficient channel width to accommodate backwater effects coupled with high stream flows	—	—	Monitor during freshet.	Create additional channel volume if insufficient.
Risk of erosion / scouring	Rip rap in high risk areas.	Incorporate bioengineering	—	Monitor for erosion / scouring	Place additional rip rap and plant material (e.g. willow, red-osier dogwood) during fish work window
Vegetation					
Risk of Mexican mosquito fern (*Azolla mexicana*) having insufficient water depth to sustain population	Realigning creek away from known previous locations of fern.	Salvage any specimens found in the abandoned channel and relocate them in backwater channels and / or the new channel	Create new back channels that are supported by ground water as well as creek water for additional habitat potential	Monitor each summer for the presence of mosquito fern	Work with recovery efforts to continue the population
Risk of awned cyperus (*Cyperus squarrosus*) being disturbed during construction	Avoid the backwater location of awned cyperus	Flag area as a 'No Disturb' area during construction	Create new isolated ponds and backwater channels for potential additional habitat	Monitor each summer for the presence of awned cyperus	Investigate the opportunity to split and transplant into new ponds once ponds are established
Risk of poor survival of plantings along new alignment	Provide high quality topsoil along the new alignment. Place maintenance and survival requirements into the installation (landscapre) contract	Installation contractor should provide temporary irrigation over the first and second growing season to establish	Planting numbers should meet DFO's criteria for riparian tree and shrub replacement at minimum	Monitor plant survival to report whether it meets MOE's criteria of 90% survival over 3 years	Installation contract should include provisions for replanting until criteria is achieved
Risk of animal damage of new plantings	Include responsibility for animal damage in the installation contract	Specify mouse guards for shrubs and animal screens around trees	Planting numbers should meet MOE's criteria for riparian tree and shrub replacement at minimum	Monitor plant survival to report whether it meets MOE's criteria of 90% survival over 3 years	Installation contract should include provisions for replanting until criteria is achieved

Vernon Creek Realignment - Impact Assessment Table					
Potential Impact	**Avoidance**	**Mitigation**	**Compensation**	**Monitoring**	**Contingency**
Risk of weed invasion	Specify a weed free topsoil and a fescue based seed cover crop for newly planted areas	Maintain weeds along the airport and playing fields (e.g. by mowing) and hand pulling as req'd (e.g. purple loosestrife)	—	Monitor weed invasion	Increase weed control efforts where required (e.g. youth teams). Note: herbicides and pesticides are not permitted in riparian areas).
Fish / Aquatic Life					
Risk of water quality degradation	Plant the riparian area along new channel in advance of water diversion	Use silt fence and other erosion control methods during construction	—	Monitor water quality prior, during, and after construction	Qualified Environmental Monitor shall have a 'Halt Work' Authorization
Risk of water and wildlife impacts due to pesticide / herbicide use	Post a pesticide and herbicide free area within 50 metres of Vernon Creek and adjacent ponds, including airport and ball fields	Use mowing, hand-pulling, and biocontrols against noxious weeds in area	—	Monitor weed invasion	Continue using non-chemical weed control methods along all the water bodies
Risks of exotic fish impact	Extirpate exotic fish in ponds in early spring just after the ice thaws	—	Create more pools isolated from the main channel suitable for amphibian breeding. These pools should be isolated from potential creek flooding	Monitor spring and early summer for exotic species presence	Work with recovery teams to preserve spadefoot and salamander populations in area
Risk of degradation of fish habitat	Create wider and longer creek channel with more diversity than already exists	Use erosion control methods during construction	Install fish large woody debris and gravel suitable for spawning in the new channel (185m of addition channel length)	Monitor in spring and fall for fish use and spawning activity	Replant as required and restore fish habitat enhancements as necessary
Risk of fish entrapment during construction	Create and plant new channel prior to water diversion	Salvage during the creek diversion and relocate to new creek	Create more creek length and more riparian area	Monitor during construction, salvage any entrapped fish or amphibians	—
Risk of aquatic invertebrate entrapment during construction	Divert channel when most invertibrates are in flight stage, and salvage remainder as water goes down	Salvage larval invertebrates, scraping rocks and substrate, and relocate to new creek	Create more creek length and more riparian area	Monitor during construction, salvage any entrapped macroinvertebrates (such as dragonflies)	Leave water in old channel long enough for most macroinvertebrates to relocate themselves
Wildlife					

Vernon Creek Realignment - Impact Assessment Table					
Potential Impact	**Avoidance**	**Mitigation**	**Compensation**	**Monitoring**	**Contingency**
Risk of spadefoot and Pacific tree frog impacts	Maintain as many of the existing isolated ponds as possible	Flag ponds and protect from disturbance during construction	Create more pools isolated from the main channel suitable for amphibian breeding	Monitor in spring and summer for amphibian use	Work with recovery teams to preserve spadefoot populations in area
Risk of Long-toed salamander population impacts	Maintain as many of the existing isolated ponds as possible	Flag ponds and protect from disturbance during construction	Create more pools isolated from the main channel suitable for amphibian breeding	Monitor in spring and summer for amphibian use	—
Risk of small bird habitat reduction	Work outside of the main breeding season (avoid March 1 to July 15)	Flag and avoid disturbing existing riparian thickets	Plant riparian plants along new channel prior to water diversion	Monitor spring migration and breeding use of area	Replant if riparian plant survival is not in accordance with Moe's criteria

APPENDIX

APPENDIX I EBA TERMS AND CONDITIONS

ENVIRONMENTAL REPORT – GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT

This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

This report and the assessments and recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 LIMITATIONS OF REPORT

This report is based solely on the conditions which existed on site at the time of EBA's investigation. The client, and any other parties using this report with the express written consent of the client and EBA, acknowledge that conditions affecting the environmental assessment of the site can vary with time and that the conclusions and recommendations set out in this report are time sensitive.

The client, and any other party using this report with the express written consent of the client and EBA, also acknowledge that the conclusions and recommendations set out in this report are based on limited observations and testing on the subject site and that conditions may vary across the site which, in turn, could affect the conclusions and recommendations made.

The client acknowledges that EBA is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the client.

2.1 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of this report, EBA may have relied on information provided by persons other than the client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

3.0 LIMITATION OF LIABILITY

The client recognizes that property containing contaminants and hazardous wastes creates a high risk of claims brought by third parties arising out of the presence of those materials. In consideration of these risks, and in consideration of EBA providing the services requested, the client agrees that EBA's liability to the client, with respect to any issues relating to contaminants or other hazardous wastes located on the subject site shall be limited as follows:

1. With respect to any claims brought against EBA by the client arising out of the provision or failure to provide services hereunder shall be limited to the amount of fees paid by the client to EBA under this Agreement, whether the action is based on breach of contract or tort;
2. With respect to claims brought by third parties arising out of the presence of contaminants or hazardous wastes on the subject site, the client agrees to indemnify, defend and hold harmless EBA from and against any and all claim or claims, action or actions, demands, damages, penalties, fines, losses, costs and expenses of every nature and kind whatsoever, including solicitor-client costs, arising or alleged to arise either in whole or part out of services provided by EBA, whether the claim be brought against EBA for breach of contract or tort.

4.0 JOB SITE SAFETY

EBA is only responsible for the activities of its employees on the job site and is not responsible for the supervision of any other persons whatsoever. The presence of EBA personnel on site shall not be construed in any way to relieve the client or any other persons on site from their responsibility for job site safety.

5.0 DISCLOSURE OF INFORMATION BY CLIENT

The client agrees to fully cooperate with EBA with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The client acknowledges that in order for EBA to properly provide the service, EBA is relying upon the full disclosure and accuracy of any such information.

6.0 STANDARD OF CARE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

7.0 EMERGENCY PROCEDURES

The client undertakes to inform EBA of all hazardous conditions, or possible hazardous conditions which are known to it. The client recognizes that the activities of EBA may uncover previously unknown hazardous materials or conditions and that such discovery may result in the necessity to undertake emergency procedures to protect EBA employees, other persons and the environment. These procedures may involve additional costs outside of any budgets previously agreed upon. The client agrees to pay EBA for any expenses incurred as a result of such discoveries and to compensate EBA through payment of additional fees and expenses for time spent by EBA to deal with the consequences of such discoveries.

8.0 NOTIFICATION OF AUTHORITIES

The client acknowledges that in certain instances the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by EBA in its reasonably exercised discretion.

9.0 OWNERSHIP OF INSTRUMENTS OF SERVICE

The client acknowledges that all reports, plans, and data generated by EBA during the performance of the work and other documents prepared by EBA are considered its professional work product and shall remain the copyright property of EBA.

10.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by EBA shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by EBA shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. The Client warrants that EBA's instruments of professional service will be used only and exactly as submitted by EBA.

The Client recognizes and agrees that electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.