



City of Richmond

Report to Committee

To: Parks, Recreation and Cultural Services **Date:** April 16, 2018
From: Serena Lusk **File:** 06-2345-20-
 General Manager, Community Services TNOV4/Vol 01
Re: **Proposed Tidally Influenced Terra Nova Slough Update**

Staff Recommendation

1. That the staff report titled "Proposed Tidally Influenced Terra Nova Slough Update" dated April 16, 2018, from the General Manager, Community Services, be received for information; and
2. That *Option 1: Enhance the Existing Freshwater Pond*, and funding of \$225,000 for the proposed habitat enhancement and management plans be considered in the 2019 Budget process.

Serena Lusk
 General Manager, Community Services
 (604-233-3344)

Att. 6

REPORT CONCURRENCE		
ROUTED TO:	CONCURRENCE	CONCURRENCE OF GENERAL MANAGER
Engineering Finance	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	
REVIEWED BY STAFF REPORT / AGENDA REVIEW SUBCOMMITTEE	INITIALS: 	APPROVED BY CAO

Staff Report

Origin

At the Parks, Recreation and Cultural Services Committee meeting on March 24, 2015, staff received the following referral:

- (1) *That staff explore the establishment of a salmon spawning slough at Terra Nova and stocking it with Chum Salmon fry as planned, and further, consider what other sloughs have the potential for day lighting and stocking with Chum Salmon.*

The purpose of this report is to provide an update on the ongoing efforts by staff to address the referral.

This report supports Council's 2014-2018 Term Goal #4 Leadership in Sustainability:

Continue advancement of the City's sustainability framework and initiatives to improve the short and long term livability of our City, and that maintain Richmond's position as a leader in sustainable programs, practices and innovations.

4.1. *Continued implementation of the sustainability framework.*

4.2. *Innovative projects and initiatives to advance sustainability.*

This report supports Council's 2014-2018 Term Goal #6 Quality Infrastructure Networks:

Continue diligence towards the development of infrastructure networks that are safe, sustainable, and address the challenges associated with aging systems, population growth, and environmental impact.

6.1. *Safe and sustainable infrastructure.*

Background

In 2004, the Terra Nova Rural Park Plan called for development of a functional estuary slough with an outlet to the Middle Arm of the Fraser River to support salmonids within the park. The first phase of the project was implemented in 2007 with the construction of the slough channel.

The second phase entailed engineering design and costing for a flood control gate and connecting pipe to link the slough to the Fraser River (Attachment 1). Costs to breach the dike and install an outlet structure were assessed in 2009; at that time, cost estimates exceeded the City's expectations and budget, and the project was put on hold. The slough has been functioning as a freshwater pond since 2007.

In order to address this referral, a review of the project has been conducted. In the intervening years since the original work was completed, there have been updates to the City's Dike Master Plan, alterations to the pond and updated engineering standards.

The project review included:

- Reviewing the design drawings to connect the pond to the estuary completed in 2009;
- Reviewing the ecological value and function of the existing freshwater pond compared to the potential value and function of a tidally influenced slough;
- Updating the risk assessment for placing an opening in the dike at this location in the context of the City's Dike Master Plan;
- Providing an updated project cost estimate; and
- Consideration of daylighting or enhancing other sloughs.

Analysis

Converting the existing approximately 7,000m² of freshwater aquatic and riparian habitat (pond) into an estuarine marsh habitat (slough) would involve:

- Construction of a dike box culvert connecting the pond to the Fraser River;
- Installation of a tide gate to regulate the flow of water;
- Modifications to the dike and a portion of River Road; and
- Modifications to the existing pond to create a tidally influenced slough.

This proposed project would impact portions of the existing park and alter the ecological function of the existing pond. There are a number of habitat and engineering benefits as well as challenges with this potential project.

Proposed Terra Nova Tidal Slough

The original design proposes one entry and exit point at the Fraser River to the existing pond. The proposed tide gate structure would regulate the slough's water level, changing with the daily natural tide cycle. The tide gate structure would be designed to protect the slough during King Tide and storms.

The purpose of the tidally influenced slough is to provide habitat for juvenile salmonids and other fish species that utilize estuarine habitats. Salmonid species would not use this habitat for spawning purposes (Attachment 2). The salmonid habitat value would be limited by the single entry and exit point. This single opening will limit tidal flushing and will also likely result in sediment accumulation, requiring ongoing maintenance. In addition, the presence of fish would likely be limited in the warmer months, as increased inland water temperatures have the potential to exceed acceptable levels.

There are two primary considerations in the review of a potential project in Terra Nova Park:

1. Flood Risk Assessment; and
2. Habitat Value Assessment.

1. Flood Risk Assessment

If the pond is connected to the Fraser River by breaching the dike at this location, the flood risk would increase. The flood risk could be mitigated with the construction of a secondary dike to isolate the pond. Two possible dike options are:

- a) A dike around the slough's perimeter (Attachment 3).

The current mean elevation of the park area surrounding the pond is approximately 0.7m; the proposed crest of dike grade is elevation 4.7m, with the targeted future elevation at 5.5m. The length of the proposed dike to be built around the slough's perimeter will be approximately 700m long. The approximate 4m elevation gain and inclusion of the standard dike crest design would result in an approximate dike foot print of 1.96 hectares (4.8 acres). The estimated cost for this dike option is approximately \$5,200,000 (+/-40%).

- b) A dike running through a portion of Terra Nova Park, as conceptually planned in the City's Dike Master Plan (Attachment 4).

The dike as envisioned in the City's Dike Master Plan is approximately 510m long with an approximate dike foot print of 1.43 hectares (3.5 acres). To install the envisioned dike, the estimated cost for this option is approximately \$3,800,000 (+/-40%). This option would potentially result in the western third of the park being occasionally flooded.

Existing park features impacted by both proposed dike options include walking paths, bridges and boardwalks, plantings (including mature trees), the Terra Nova Play Experience, and areas of high habitat value, such as old-field foraging areas for resident barn owls.

2. Habitat Value Assessment

To improve the tidal flushing action of the proposed tidal slough, channelization of the slough through the creation of a secondary entry and exit point should be considered; the slough would thus be connected to tidally influenced water sources at each end. Creation of a secondary access point would require additional study with respect to potential size, alignment, grading, cost and impact on the park. The recently restored Grauer Lands is an example of a connected intertidal channel; a 127 acre area of enhanced salmon rearing habitat was created in 2013 (Attachment 5), just south of Terra Nova Park. The area is flushed with each tide cycle, providing protected habitat to rearing juvenile Chinook and Chum salmon.

The existing pond is currently a freshwater body, however, it was originally designed to function as a tidally influenced slough. It is currently fed only by ground and surface fresh water, and flows, for the most part, are isolated from the surrounding inland drainage system.

Current management practices include mowing some of the riparian areas around the pond in order to manage invasive plant and animal species and facilitate public access. If these current management practices were enhanced, the overall ecological function and interpretive value of the pond are expected to increase.

In 2018, the existing pond was reviewed by a certified biologist. The pond and surrounding riparian zone are a functioning habitat for various species of amphibians, birds, freshwater fish and wildlife. A number of observations and recommendations were provided for both the existing pond and the proposed tidally influenced slough (Attachment 6).

The following proposed habitat enhancements and management measures would improve the pond and associated riparian habitat values:

- Creation of ephemeral wetlands to provide breeding habitat for native birds;
- Fencing around the trunks of significant trees and shrubs to prevent damage caused by beavers;
- Develop and implement a pond specific Invasive Species Management Plan for the riparian and aquatic habitat;
- Habitat enhancements such as planting and other measures to improve bird and bat habitats; and
- Introduce a water flow system to address the pond’s low oxygen levels.

Staff estimate an approximate cost of \$75,000 to fully assess the current function of the pond, develop a habitat management strategy, and provide a planting plan. The combined cost to implement the above list of recommended improvements in addition to the assessment and plan is approximately \$150,000.

Options For Consideration

Staff reviewed the proposed project at Terra Nova on the basis of:

- Flood risk management;
- Costing of the proposed design;
- Review of the original design; and
- Habitat value factors of both the existing pond and the proposed slough.

As a result of this evaluation, the following two options are proposed for Council’s consideration:

Option 1: Enhance the Existing Freshwater Pond (Recommended)

Estimated total cost: \$225,000.

Enhance the current freshwater habitat and introduce enhanced management strategies to increase its ecological value.

Pros:	Cons:
<ul style="list-style-type: none"> • Existing ecological function could be enhanced to provide a richer park visitor experience, increasing nature interpretation and education opportunities. 	<ul style="list-style-type: none"> • Additional study to provide a specific plan would be required to be developed prior to implementation.
<ul style="list-style-type: none"> • Modest investment of resources would result in an enhanced freshwater habitat. 	<ul style="list-style-type: none"> • No Chum salmon would be expected to spawn in this area as described in Attachment 2.

Pros:	Cons:
<ul style="list-style-type: none"> A high level of flood protection would be maintained without having to construct a secondary dike. 	

Option 2: Create a Tidally Influenced Terra Nova Slough

Estimated total cost: \$6,090,000 to \$7,490,000 (depending on which dike routing option is chosen).

Update and implement flood box plans to open the pond to the tidal influence from the Fraser River Estuary and initiate the design process to construct a secondary dike in Terra Nova Park.

Pros:	Cons:
<ul style="list-style-type: none"> Achieve the original plan for the pond to be a tidally influenced slough. 	<ul style="list-style-type: none"> Increased risk of flooding due to breaching the dike to create this feature. Mitigation measures (i.e., secondary dike) will be required to maintain a high level of flood protection.
<ul style="list-style-type: none"> Provide habitat opportunities for a number of salmonid species. 	<ul style="list-style-type: none"> The estimated flood gate structure construction cost with design updates and modifications would be approximately \$2,290,000 (+/- 50%) representing a prorated increase of approximately \$480,000 over the original design.
<ul style="list-style-type: none"> Create a unique natural feature, providing opportunities for nature interpretation and education. 	<ul style="list-style-type: none"> The cost of building the associated dike structures are also significant, ranging from \$3,800,000 (+/- 40%) to \$5,200,000 (+/- 40%).
	<ul style="list-style-type: none"> Adversely impacting the existing freshwater aquatic and terrestrial species by displacing them from the area. Potential benefits to salmonid and estuarine fish species are unknown at this time.
	<ul style="list-style-type: none"> Additional maintenance costs due to the current slough configuration which restrict flushing action and allowing for the accumulation of debris and sediment.
	<ul style="list-style-type: none"> Existing park features will be impacted by the installation of a secondary dike.
	<ul style="list-style-type: none"> The original design requires updating to reflect the City's target 4.7m dike elevation.

Other Slough Enhancement Opportunities

Staff considered daylighting previously existing sloughs. The excavation of sloughs currently located under existing neighborhoods and built-up areas would be quite cost prohibitive and disruptive. Additional study and public consultation would be required to further consider this option, though staff do not recommend it.

Staff are currently working on a habitat enhancement project on Woodward's Slough (connected to Horseshoe Slough). The project entails the creation of an entirely new slough. This project is a compensation project resulting from the widening of Westminster Highway. The focus of this project is to replace the Riparian Management Area (RMA) habitat impacted through the Westminster widening project. Watercourses, and associated riparian setbacks within the RMA network provide direct habitat to forage fish species, such as sculpin and stickleback and flow into and support fish life within the Fraser River Estuary. Additionally, staff continue to work on the Bath Slough revitalization initiative; an ecological corridor enhancement project.

The City's system of ditches could not be contemplated for a number of reasons. If the ditches were to become salmon bearing watercourses, a level of regulatory oversight and requirements would now be applied to this critical municipal infrastructure. This would drastically affect the City's current ability to construct, operate and maintain the municipal drainage system, and would affect private homeowners as well.

As the City moves forward with the implementation of the Dike Master Plan, opportunities to integrate, enhance or develop fish habitat within the Fraser River Estuary will be identified in consultation with Fisheries and Oceans Canada and other key stakeholders. These opportunities will be implemented through the capital project approval process to meet Fisheries and Oceans Canada's habitat off-setting requirements.

Financial Impact

Funding for Option 1 will be considered in the 2019 Budget process.

Conclusion

Staff considered enhancing existing sloughs and daylighting previously existing channels. It is recommended that efforts be focused on taking advantage of opportunities to partner with other key stakeholders to enhance fish rearing habitat in the Fraser River Estuary, outside of the City's dike system.

Staff have reviewed the original Terra Nova design, updated the flood risk and habitat value assessment for the proposed conversion of the existing pond to a tidally influenced slough. The necessity and cost of a secondary dike was not considered in the original project.

The estimated total project cost for Option 2: Create a Tidally Influenced Terra Nova Slough is between \$6,090,000 to \$7,490,000. The impact on Terra Nova Rural Park to convert the existing pond to a tidally influenced slough would be high, creating flood risks and displacing park amenities. In addition, implementing a suggested channel to connect secondary entry and exit points would add additional cost and scope to the project. If implemented, a rearing habitat for a broad range of fish species would be created, however, not a Chum salmon spawning habitat.

Therefore, staff recommend the adoption of Option 1: Enhance the Existing Freshwater Pond. This option would result in a modest investment of time and resources to increase the habitat value of the existing freshwater pond, above its present day function. Enhancing the existing freshwater pond would have a minimal impact in comparison to creating a tidally influenced Terra Nova Slough.

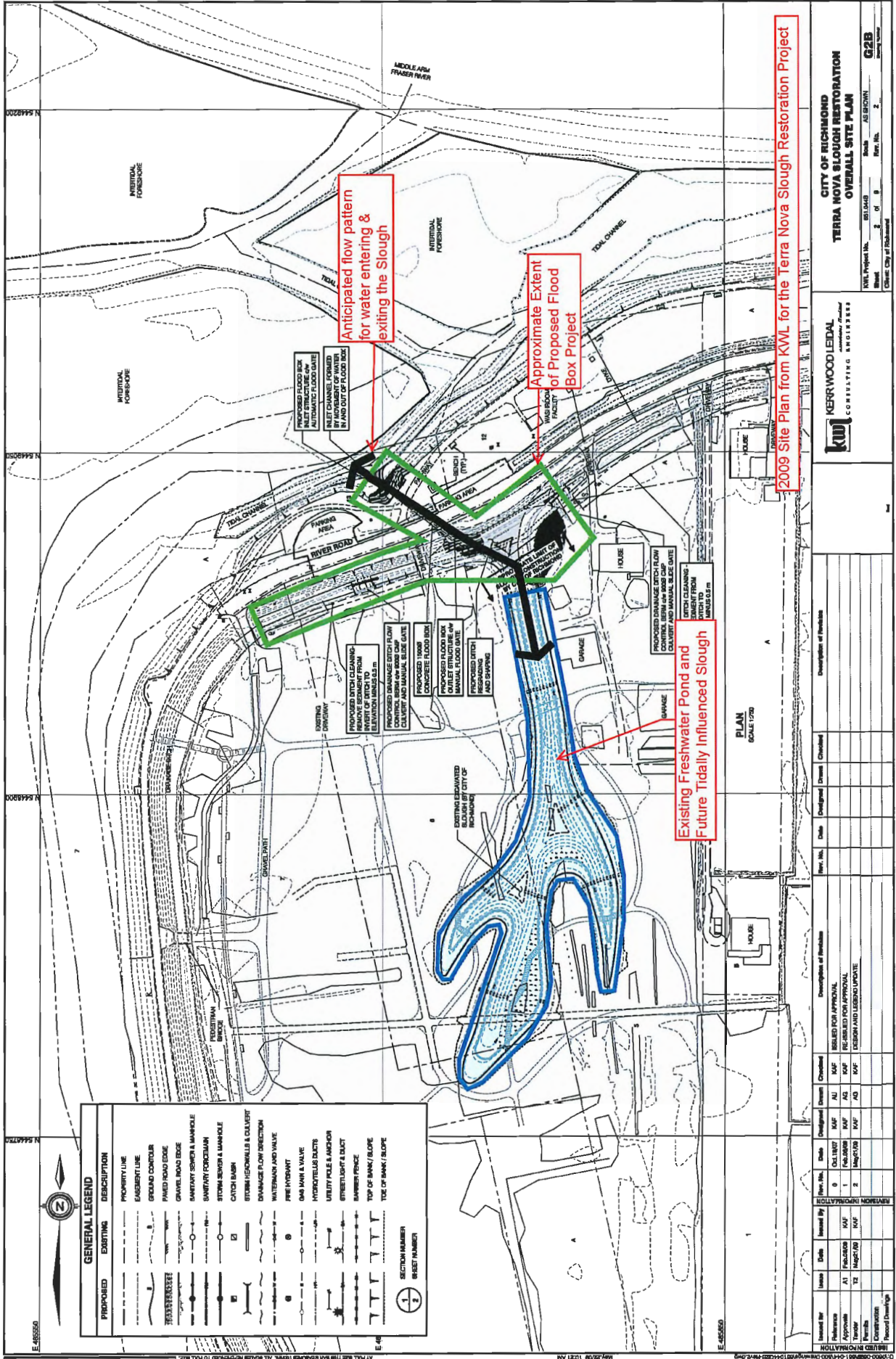


Alexander Kurnicki
Research Planner 2
(604-276-4099)



Jamie Esko
Manager, Parks Planning, Design
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(604-233-3341)

- Att. 1: 2009 KWL Terra Nova Slough Restoration Project Site Plan
- 2: Terra Nova Chum Salmon Slough Update- November 23, 2017
- 3: Conceptual Dike Design Around Proposed Slough
- 4: Page 24, Figure 8: Secondary Dike Alignment through Terra Nova- Lulu Island Dike Master Plan Phase 2- Draft Report
- 5: Grauer Lands Map
- 6: PGL Feasibility Review Report: Tidally Influenced Slough at Terra Nova Park (total 16 pages, not including Appendix 1)



GENERAL LEGEND	
PROPOSED	DESCRIPTION
	PROPERTY LINE
	EASEMENT LINE
	GROUND CONTOUR
	PAVED ROAD EDGE
	GRAVEL ROAD EDGE
	SANITARY SEWER & MANHOLE
	SANITARY STORMWATER MANHOLE
	CATCH BASIN
	STORM HEADWALLS & CULVERT
	DRAINAGE FLOW DIRECTION
	WATERMAIN AND VALVE
	FIRE HYDRANT
	GAS MAIN & VALVE
	HYDROCELLULAR CULVERT
	UTILITY POLE & AMP/BOX
	STREETLIGHT & DUCT
	BARRIER FENCE
	TOP OF BANK/SLOPE
	TOE OF BANK/SLOPE
SECTION NUMBER	
1	2
SHEET NUMBER	
1	2

CITY OF RICHMOND
TERRA NOVA SLOUGH RESTORATION
OVERALL SITE PLAN

KWL Project No. 0315418
 Scale AS SHOWN
 Rev. No. 2

KERRWOOD LEIDL
 CONSULTING ENGINEERS

6218
 03/15/18

Issue	Date	Issued By	Checked	Description of Revisions
0	03/15/18	MAF	MAF	ISSUED FOR APPROVAL
1	04/18/18	MAF	MAF	RE-DESIGNED FOR APPROVAL
2	04/25/18	MAF	MAF	DESIGN AND LEGAL UPDATE



**City of
Richmond**

Memorandum
Community Services Division
Parks Planning and Design

To: Mayor and Councillors
From: Alexander Kurnicki
Research Planner 2
Date: November 23, 2017
File: 06-2345-20-TNOV4/Vol 01
Re: **Terra Nova Chum Salmon Slough Update**

At the Parks, Recreation and Cultural Services Committee meeting on the March 24, 2015, staff received the following referral:

- (1) That staff explore the establishing of a salmon spawning slough at Terra Nova and stocking it with Chum Salmon fry as planned, and further, consider what other sloughs have the potential for day lighting and stocking with Chum Salmon; and*
- (2) That the information and videos provided by Metro Vancouver on how the Still Creek salmon run was established be referred to staff.*

The purpose of this memo is to provide an update on the ongoing efforts by staff to address the above referral.

In 2009, staff went through a design process and issued a tender for the floodgate construction for breaching the dike and creating a fish habitat in the Terra Nova Slough. The costs of this project exceeded the City's expectations by a considerable amount and the project was put on hold.

Since time has passed, a review of the project is being conducted. The review is focusing on the following tasks:

- Review of the design drawings completed in 2009;
- Review the ecological value and function of the existing slough compared to the value and function of a salt water and tidally influenced slough;
- Updating the risk assessment for placing an opening in the dike at this location in the context of the City's Dike Master Plan-Phase 2; and
- Providing an updated project cost estimate.

A review of the project by staff would be required with respect to the City's Dike Master Plan and the overall flood protection strategy for this portion of the dike system. An initial review by staff indicates that connecting the slough to the Fraser River by breaching the dike creates an inherent and significant flood risk at this location. A possible strategy to mitigate this risk and maintain flood protection would be to build a secondary dike around the slough. The potential

impacts of a secondary dike and other contemplated flood mitigation measures may have on the park, the project's scope and expense will be provided in a forthcoming report to Council.

The slough is currently a fresh water body supporting associated aquatic and riparian flora, and fauna. A review of the potential habitat benefits of an altered slough will be conducted in the current context of existing salmonid habitat in the area. Preliminary research indicates there is historical data suggesting the areas around Sturgeon Banks and the North Arm of the Fraser River have provided juvenile rearing habitat for chinook, chum, coho salmon, migratory habitat for adult salmon, and resident habitat for and various forage fish species. An altered slough would not function as a spawning habitat, which commonly occurs in the upper reaches of the Fraser River. Assessment of the value of an altered slough as a rearing habitat will be summarized in a forthcoming report to Council.

The expected completion date for the feasibility study is early 2018. Staff will provide a further project update at that time.

If you require additional information on this matter, please do not hesitate to contact me directly at 604-276-4099.

Alexander Kurnicki
Research Planner 2

pc: SMT
Serena Lusk, Interim Director, Parks and Recreation
Jamie Esko, Manager, Parks Planning, Design and Construction

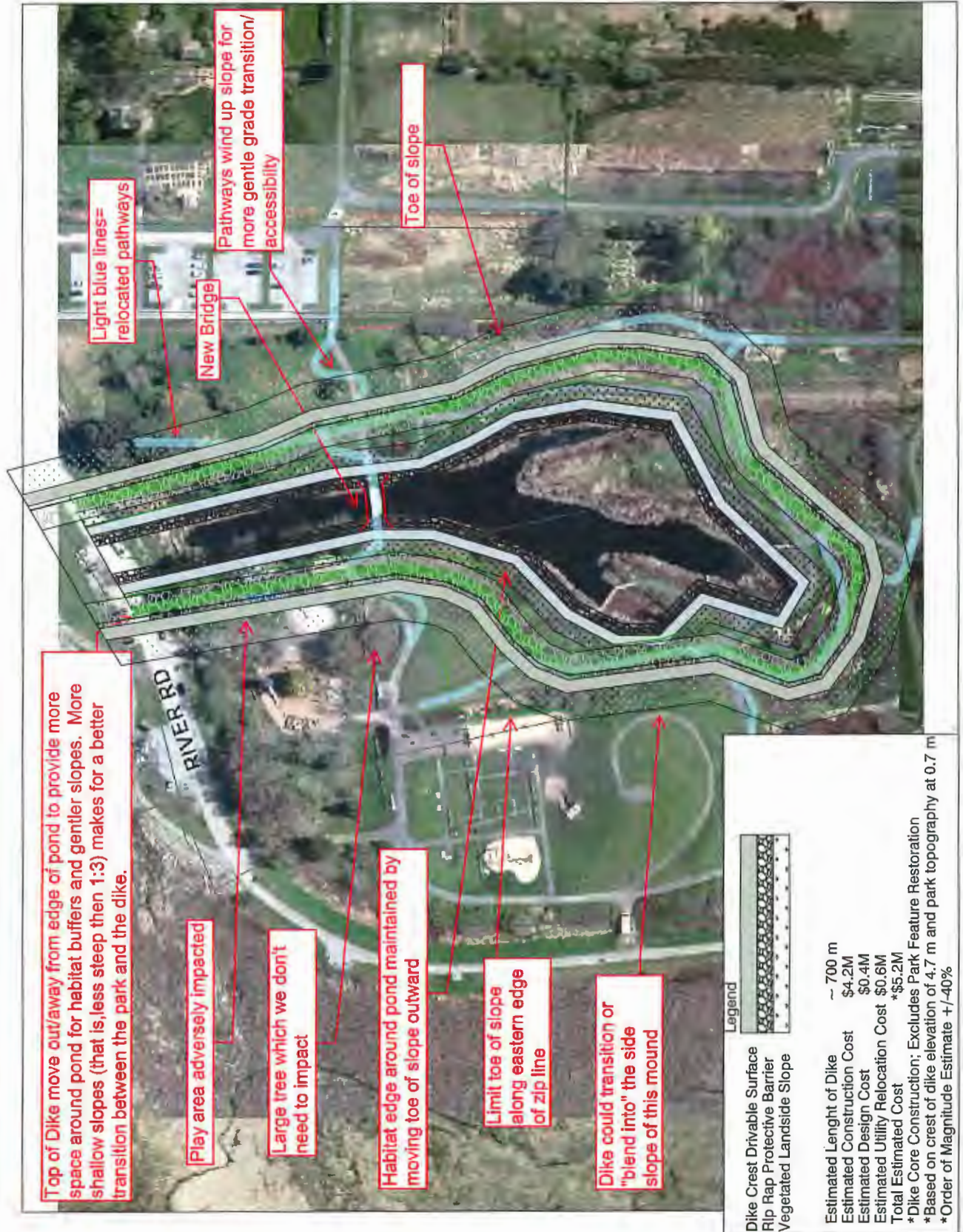


Figure 8: Secondary Dike Alignment through Terra Nova



4.2 AREA SPECIFIC ADAPTATIONS

For the purposes of the master plan, an area specific adaptation is a structural adaptation that can achieve the target 4.7 m crest height, with consideration for a future increase to 5.5 m. This section outlines the preferred area specific adaptation measures for each of the thirteen design areas.

The recommended approaches to area specific adaptations includes: widen footprint to land or water side; raise in place / constrained dike; permanent floodwall; demountable floodwall.

Widen Footprint to Land or Water Side

Dikes are the most common form of structural flood protection. Lulu Island is currently protected by a perimeter ring dike, with floodwalls or alternative protections at some sites. In the Study Area, improvements to the existing dike should be pursued wherever possible.

Grauer Property Monitoring Report – 2016



Figure 1. Location and boundary of the Grauer property in Richmond, BC.

**Terra Nova Park
Richmond, BC**

Feasibility Review: Tidally Influenced Slough at Terra Nova Park



PREPARED FOR:

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PGL File: 831-01.05

February 2018



solve and simplify

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Appendix 2	Site Photographs	body of Attachment 6

1.0 INTRODUCTION

PGL Environmental Consultants (PGL) is pleased to provide you with a feasibility assessment of plans to breach the Terra Nova dyke to create a tidally influenced slough to support juvenile salmonid species.

2.0 BACKGROUND

In 2004, the City of Richmond (the City) developed a master plan for the Terra Nova Rural Park, which is roughly defined by the north half of the Terra Nova Park area. This plan included creating a functional estuarine slough with an outlet to the Middle Arm of the Fraser River. The primary objective of the slough feature was to maximize biodiversity and offer opportunities to support fish and amphibians, including salmonids where feasible. It was intended that the City would also pursue educational interpretation as a secondary objective.

The City retained PWL Partnership Landscape Architects Inc. (PWL) to develop a concept plan to upgrade the overall park. Kerr Wood Leidal Associates (KWL) was subcontracted to prepare the engineering drawings for the slough and design the dyke breach flood structure. PGL was also retained as a subconsultant to provide input on environmental aspects of the design and implementation and to explore regulatory expectations and approval requirements.

The City constructed the slough channel in 2007. However, for several reasons, the installation of the outlet structure and subsequent dyke breach was never implemented. As such, the slough has functioned as a freshwater habitat ecosystem for the ten years since its construction.

2.1 Wildlife Enhancement/Management Strategy

In 2010, The City retained PGL to prepare a wildlife habitat enhancement/management strategy for the Terra Nova Rural Park and Terra Nova Natural Area, collectively referred to as the Park. This project involved a thorough review of historical data and designs, a review of current conditions, and field surveys to fill data gaps.

Based on the work completed, PGL identified a water feature which it labelled and referred to as "Aquatic Habitat Management Unit 01" (AHMU-01). The study concluded that there was moderate to good ecological diversity associated with AHMU-01: a variety of plants and bird species were observed in and around the feature and healthy populations of Threespine Stickleback (*Gasterosteus aculeatus*) and several amphibian species had established themselves in AHMU-01.

It was noted at the time, that portions of the riparian habitat were at risk from invasive plant populations and PGL recommended and prepared a restoration plan to avoid destabilization of the slough ecosystem by invasive species. A final copy of the strategy report was submitted to the City in 2014 and is attached to this report as Appendix 1. PGL is unaware if any parts of the restoration plan were implemented.

3.0 CURRENT SCOPE OF WORK

City staff have been directed by Council to review the ecological value and function of the freshwater slough (AHMU-01) as-is, relative to the value and function of a salt-water and tidally influenced slough.

PGL has been retained to assist staff in developing a report. The scope of PGL's report included a site visit to assess current habitat function, followed by provision of an opinion on the feasibility or rationale of creating a tidally influenced slough and potential salmon rearing habitat vs. enhancing existing habitats at nearby locations. This report represents that opinion.

4.0 SITE VISIT

PGL conducted a site visit with KWL and City representatives on February 7, 2018. In attendance were: Alex Kurnicki (City of Richmond); Andrew Szojka (KWL Calgary); Kimberly Armour (City of Richmond); Kevin Fraser (City of Richmond); and Bruce Nidle (PGL).

4.1 Site Conditions and Observations

During the site visit, PGL senior fisheries biologist, Bruce Nidle, made the following observations:

- The slough water level was up to the level of the boardwalk and had flooded some grassy areas (Photograph 1);
- A beaver lodge was present in the middle of the slough (Photograph 2). Beavers had felled most small trees adjacent to the slough;
- A variety of waterfowl species were in and adjacent to the slough;
- Eagles and hawks were perching in trees adjacent to the slough;
- Vegetation around the perimeter of the slough consisted of common cattail (*Typha latifolia*) and the non-native reed canarygrass (*Phalaris arundinacea*) (Photograph 3);
- Riparian vegetation consisted of invasive, non-native Himalayan blackberry (*Rubus armeniacus*) and an assortment of native shrubs and small trees including hardhack (*Spirea douglasii*), red-osier dogwood (*Cornus stolonifera*) and paper birch (*Betula papyrifera*) (Photograph 4);
- The grass areas had been mown to create lawns in many locations; and
- Suggestions from the previous PGL 2014 report—notably invasive species management protocols—had not been incorporated into the park.

It should be noted that fish and water quality sampling have not been undertaken since the PGL 2014 report.

5.0 DISCUSSION

The Terra Nova Wildlife Habitat Enhancement Strategy (PGL 2014) described Aquatic Habitat Management Units (AHMUs) for the aquatic features at the Site. Recapping that report, a water feature identified as AHMU-01 is present in the north half of the park. It is not connected to any of the perimeter ditches on the site.

It is this feature that was considered in 2007 for connection to the Fraser River via a flood-control box to create a brackish, tidally refreshed slough, but the connection was not established. As a result, AHMU-01 has been isolated from both brackish tidal flow and other freshwater sources. Hydrologically speaking, therefore, it has been functioning as a freshwater "pond" rather than a "slough" for the past decade.

It is this pond that is again under consideration for connection to the estuary.

5.1 Present Pond Conditions

AHMU-01 provides habitat for several amphibian species (unidentified) and for Threespine stickleback, a small coarse freshwater fish species.

Vegetation surrounding AHMU-01 includes common cattail, hardhack, non-native reed canarygrass, invasive non-native Himalayan blackberry, and other shrubs and trees. Manicured lawns are also present. The riparian habitat values currently are low. Non-native and invasive species are pervasive, limiting diversity and wildlife habitat functionality. The upland habitat is further impacted by frequent mowing and use by the public.

The existing habitat at AHMU-01 is suitable for some wildlife, but fish habitat is limited due to the isolated nature of the watercourse. Waterfowl use of AHMU-01 has been observed, and the bench of land between the middle- and east-fingers of the pond has been identified as a potential Killdeer (*Charadrius vociferus*) nesting location. A small Great Blue Heron colony at the park (PGL 2007) may also use this pond as a source of food.

American beaver (*Castor canadensis*) activity at the AHMU-01 pond has resulted in lost trees and the development of a beaver lodge within the pond.

Amphibian presence has been noted; however, species have not been confirmed. Literature suggests that native amphibians that may use the pond include Northwestern salamander (*Ambystoma gracile*), Pacific chorus frog (*Pseudacris regilla*), western toad (*Anaxyrus boreas*), and northern red-legged frog (*Rana aurora*) are not likely to be associated with AHMU-01 as there is a lack of forested upland habitat in close proximity to the pond.

Given the presence of invasive American bullfrog (*Lithobates catesbeianus*) in the south half of the park at AHMU-02 and the lack of upland forest vegetation around the AHMU-01 pond, it is possible that American bullfrog are present in AHMU-01. This species is a voracious predator of native amphibians (BC MoELP 2018a). Non-native green frogs (*Lithobates clamitans*) may also be present in the pond because they, like American bullfrogs, also require permanent waterbodies for tadpole development. While green frogs are not as aggressive as American bullfrogs, they are competitors for resources with our native amphibians (BC MOELP 2018b) and the presence of either species may be compromising the health and survival of native amphibians in the pond.

5.2 Potential Project Benefits

Breaching the dyke would result in the conversion of approximately 7,000m² of freshwater aquatic habitat and riparian habitat to estuarine marsh habitat (PGL 2007).

At present, there is no access for fish in or out of the pond. Tidally influenced sloughs may provide habitat for a greater number of fish species than are currently residing in the pond. A tidal connection to the estuary would allow fish species such as out-migrating juvenile Pink Salmon (*Oncorhynchus gorbuscha*), juvenile Chinook Salmon (*Oncorhynchus tshawytscha*), and juvenile Coho Salmon (*Oncorhynchus kisutch*) to find shelter on their way out to the ocean. Other fish species including Starry Flounder (*Platichthys stellatus*), Prickly Sculpin (*Cottus asper*), Staghorn Sculpin (*Leptocottus armatus*), Peamouth Chub (*Mylocheilus caurinus*), Northern Pikeminnow (*Ptychocheilus oregonensis*), Redside Shiner (*Richardsonius balteatus*), and Largescale Sucker (*Catostomus macrocheilus*) might also use a tidally influenced slough.

The resident Threespine Stickleback can withstand brackish conditions and would, therefore, not be displaced.

Conversion to an estuarine slough could provide a small but productive habitat for a variety of species, but it would require that significant additional and ongoing work, such as clearing and managing invasive plants, planting appropriate marsh vegetation, and conversion of the bench between the middle- and east-fingers of the pond/slough for Killdeer nesting habitat be required.

Habitat values might be further increased with the addition of a second tidal entrance/exit point. While the technical details of this approach are unclear, a connection to channels currently existing to the south, such as the Grauer tidal wetland channels, would allow increased opportunities for fish access and species diversity, potential benefits for water quality with increased flushing, and a more estuarine habitat.

5.3 Project Challenges

Several drawbacks or difficulties are associated with converting the pond to a tidally influenced estuarine habitat.

- With only one entrance and one exit point for the slough, complete flushing of the waterbody is extremely unlikely. While this isn't necessarily a concern for fish, it does mean that any debris or contaminants washed into the slough may not flush back out. This may also lead to sediment deposition, requiring regular – likely annual – maintenance in the form of dredging to keep water depths in the slough adequate for fish habitat.
- During low water periods of the tidal cycle, decreased water volume in the converted pond may be prone to solar warming, particularly if the conversion is not coupled with riparian plantings that provide adequate overwater shading. High water temperatures can be lethal to fish, particularly salmonids and, while current water temperature regimes in the pond are unknown, it is quite possible that the shallow depth and low volume would result in temperatures dangerous to salmonids.
- Developing estuarine habitat would eliminate amphibian habitat. Amphibians require freshwater for egg laying and tadpole/larvae development. This would prevent future development of the habitat for native amphibians.

- Salt water conditions can make beavers ill but they will tolerate it. They will not, however, tolerate fluctuating water levels associated with the conversion to a tidally influenced system. They can be expected to work to block the flow of water, potentially constructing dams in front of the tide gate(s). While trapping of the beaver(s) and relocating them to another habitat prior to flood gate operation can be considered, it will not prevent them from returning or new beavers from entering the area and attempting to dam the system into a permanent water feature.

The flow-through design option (connecting the slough to the tidal wetland channels to the south to create one point of entry and one point of exit) presents its own set of challenges:

- If the south end of the channel is open on incoming tides, potential for an increased saline environment exists. Fluctuating salinity levels will influence the species that inhabit the slough. Some species may not tolerate a high salinity environment, limiting the use of the slough as year-round or rearing habitat;
- Increased flow may increase sediment inflow and deposition and/or deposition of log debris and detritus. This may result in the potential for debris and detritus to block either or both tidal gates. The former will require regular clearing and dredging to maintain suitable water depths, the latter will require regular tidal gate inspection to prevent blockages that could either starve the slough of water (if located at the inlet) or lead to internal flooding (if the blockage is located at the outlet); and
- Significant modelling and engineering challenges in developing a tidally influenced slough also exist that are beyond the scope of this report.
 - To create a flow-through design where water flows in one end, and exits the other, the north entrance point would have to open on an incoming tide, while the south exit would open on the outgoing tide. Significant hydrological modelling would be required to determine the best approach to allow water to flow through the Site rather than stagnate or move convergently on the centre of the channel.

5.4 Project Permitting Requirements and Environmental Considerations

Breaching of the dike and installation of a flood control structure would require significant time and effort to be spent to secure permits under the following pieces of legislation:

- **The federal *Fisheries Act*:** While it is anticipated the project could result in a net benefit to fish, the project will nevertheless require that a Request for Review be made pursuant to the legislation. The application cannot be made without detailed (engineered) design drawings, hydrological modelling to prove the concept, a calculus of habitat types lost and gained, detailed planting plans, a construction management plan, and a plan for ongoing performance monitoring. Once submitted to Fisheries and Oceans Canada, a request for review may take up to six months;
- **The provincial *Water Sustainability Act*:** This piece of legislation requires a Notification or Change Approval for any changes to surface or subsurface water resources and includes temporary dewatering for construction and any types of work that affect water flows. While the application process is relatively straightforward, it may take between five to eight months to secure provincial approval; and

- **The provincial *Dyke Maintenance Act*:** Any alteration to the provincial dyke system must receive approval from the provincial Inspector of Dykes. Given increasing concerns regarding increased flooding resulting from climate change, the Inspector will require that breaching the dyke be coupled with increasing dyke freeboard or providing other protection mechanisms to prevent flooding within the new slough feature from affecting infrastructure.

Richmond may also require its own works be subject to a Phase 1 Environmental Site Investigation to ensure that works will not remobilize historical contaminants present within the park; it will also need so ensure design compliance with its own *Ecological Network Management Strategy*.

6.0 OPINION

It is our opinion that the loss of freshwater habitat coupled with the uncertainty of a successful conversion to a brackish slough suggests that retention of the existing habitat features is a more ecologically appropriate option for the slough. It is our further opinion that significant improvements to the function of the freshwater system can be achieved at a fraction of the cost of the conversion to a tidally influenced slough.

7.0 RECOMMENDATIONS

In light of our opinion in Section 6.0, we would recommend that the City consider the following projects to enhance the freshwater system present at Terra Nova Park.

7.1 Collecting Information to Guide Enhancement Efforts

- **Water sampling:** Water quality sampling should be undertaken during each season to determine the ecological conditions in the pond. Baseline water quality information can help guide planning processes for future habitat enhancement work.
- **Amphibian surveys:** Understanding the species present can inform future remediation work to improve habitat. Invasive species control may be necessary to promote healthy native amphibian populations.

7.2 Enhancement Works

- **Building vernal features:** Native amphibian species would benefit from the creation of a vernal feature at the Park. Vernal features essentially create areas without sufficient year-round standing water needed by the invasive American Bullfrog and Green Frog to breed, yet would create suitable breeding habitat for native amphibians such as Pacific Chorus Frog, Northern Red-Legged Frog and Western Toad. This vernal habitat should be situated adjacent upland forest habitat to provide ideal year-round conditions for all life stages. *A Guide to Creating Vernal Ponds* (Biebighauser 2002) is a valuable resource for vernal pond construction.
- **Fencing to protect trees:** Wire fencing around the base of trees will limit the damage caused by beavers and will preserve the mature trees around the pond. Conifer species are also less desirable for beavers to harvest, and may be planted to replace the damaged trees if ecologically appropriate for the location.
- **Managing invasive species:** Developing and implementing an Invasive Plant Management Plan to remove and maintain invasive plants coupled with replanting of native plant species will stabilize the system, exclude recolonization by non-native species, and allow for the continued development of a robust native ecosystem. Suitable marsh species such as sedges and rushes should be planted in shallow marsh zones.

- Installing bird nesting boxes and perching poles: Boxes for a variety of species, including swallows, Wood Ducks (*Aix sponsa*), and owls will increase species diversity in the area. Coordination with qualified biologists to develop a nest box plan with appropriate box design and installation locations is recommended. Perching poles for raptors along the perimeter of Old Field habitat is also recommended.
- Encouraging the redevelopment of Old Field habitat: The PGL 2014 report recommends that regular mowing in a number of locations (referred to as Old Field Habitat Management units in the 2014 report) be replaced with a five-year mowing/plowing rotation, with re-seeding using the appropriate seed mix. Old Field habitat is important for the production of small mammals such as voles, mice and shrews that are hunted by raptors, including diurnal owls and Great Blue Herons.
- Installing bat boxes: Inclusion of bat habitat will increase the ecological diversity of the Site and help control insect populations.
- Enforcing dog leash and cleanup bylaws: Education and enforcement will help reduce wildlife disturbance and fecal contamination.
- Establishing a Killdeer nesting beach: Recommendations and details are available in the PGL 2014 report.

8.0 LIMITATIONS

PGL prepared this report for our client and its agents exclusively. PGL accepts no responsibility for any damages that may be suffered by third parties as a result of decisions or actions based on this report.

The findings and conclusions are site-specific and were developed in a manner consistent with that level of care and skill normally exercised by environmental professionals currently practicing under similar conditions in the area. Changing assessment techniques, regulations, and site conditions means that environmental investigations and their conclusions can quickly become dated, so this report is for use now. The report should not be used after that without PGL review/approval.

The project has been conducted according to our instructions and work program. Additional conditions, and limitations on our liability are set forth in our work program/contract. No warranty, expressed or implied, is made.

9.0 CLOSURE

We trust that this meets your needs. If you have any questions or require clarification, please contact Katharine Scotton or Bruce Nidle at 604-235-8021 and 604-895-7609, respectively.

10.0 REFERENCES

BC Ministry of Environment, Lands and Parks. 2018a. BC Frogwatch Factsheet 7: Bullfrog *Rana catesbeiana*. Available at: <http://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=667>. Accessed February 2018.

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Respectfully submitted,

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Appendix 2
Site Photographs



Photograph 1:

**Looking north from south end
of slough, with high water
levels evident, February 7,
2018**



Photograph 2:

**Beaver lodge in the middle of
the slough, February 7, 2018**



Photograph 3:

**Looking south from dike
toward slough, with reed
canarygrass prominent,
February 7, 2018**



Photograph 4:

**Typical riparian vegetation
around the perimeter of the
slough, February 7, 2018**