POND MANAGEMENT STRATEGIES

Seniors Resource and Recreation Centre
Brydon Lagoon
Sendall Gardens

CITY OF LANGLEY

Submitted to:
City of Langley
Engineering Department
20399 Douglas Crescent
Langley, BC V3A 4B3

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FIGURES

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Acknowledgements

The Project Team would like to thank the City of Langley and the following individuals for their input, advice, and contribution to this Management Strategy:

City of Langley Council	Mayor Peter Fassbender and Councillors Jack Arnold, Dave Hall, Teri James, Gayle Martin, Ted Schaffer, and Rosemary Wallace.
City of Langley Staff	Gary Vlieg, Mike Thomas, Len Walters, Pete Jokisch, and Troy Wilson.

Project Team

Dillon Consulting Limited	Chris Dane, Alex Taylor, Paul Donahue, Nathan Gregory, James Walker, Enrico Barbon, Stephanie Braig, Eric Hertzman, and Katy Lepine.

Part A:
Introduction

1.0 The City of Langley

The City of Langley (the City) is located in the eastern portion of Metro Vancouver, nestled between the City of Surrey to the west and the Township of Langley to the south, east and north. Incorporated in 1955, the City's population has since grown from approximately 2,000 to over 25,000 people today.

The City's Engineering, Parks and Environmental Department is responsible for administration of engineering, public works services, parks, and environment, including the design, construction and maintenance of roads, water, sanitary sewer, drainage, and parks services.

Among the many components of the municipal drainage system, the City is also responsible for maintenance and operation of Brydon Lagoon, Sendall Gardens Pond, and the Langley Seniors Recreation & Resource Centre Pond. All three of the ponds are considered to be Environmental Sensitive Areas and the City aims to protect these areas to ensure the protection of habitat for fish, waterfowl and other wildlife.

Until now, the City has not had a formal strategy or policies in place to effectively manage these three Ponds, and their relationships to the surrounding parkland.

The regional context of the three ponds is shown on Figure 1 on the following page.

2.0 Project Goal and Objectives

To better manage and support the operations and maintenance of these three ponds and their surroundings, a number of steps needed to be undertaken. The project goal was to:

Determine the potential opportunities, costs, and benefits to maintain and / or enhance the existing facilities.

In following this goal, and to ensure each pond is managed according to a vision for its long-term future, the Project Objectives were to:

- Gather information on the current status and context of each pond;
- Explore new tools and best practices that could be used in the their management;
- Create a future vision of how each pond can integrate into the community, ensuring its functional operation within the context of the City's storm water management system, current and future parks and environmental planning frameworks, and best engineering and environmental practices;
- Outline feasible and cost effective strategies and implementation programs for better and safe management of each pond over time; and
- Provide phased and long-term operation and maintenance requirements for the Engineering, Parks and Environment Departments.

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Pond Management Strategies

Location of Ponds

Figure 1

- Major Roads
- Arterial Roads
- Collector Roads
- Local Roads
- City Boundary

0 125 250 500 Meters

SCALE 1:11,500

Map Drawing Information
Data from City of Langley

Map Created by: Eric Hertzman
Map Checked by: Jim Walker
Map Projection: NAD83 UTM Zone 10N

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FILE LOCATION: G:\GIS\126077 City of Langley Ponds\Figure 1 Location of Ponds (Regional Context).mxd

3.0 Project Methodology

Based on the project goals and objectives, the following steps, broken into two phases, were taken to develop these three Strategies. Each task is further explained below.

Phase	Tasks
Phase 1 – Functional Evaluation & Background Review	Task 1: Project Initiation & Information Sharing Meeting
	Task 2: Review of Background Information
	Task 3: Functional Evaluation
Phase 2 – Management Strategy Development	Task 1: Visioning Session
	Task 2: Draft Management Strategy
	Task 3: Staff Workshop; Management Strategy Refinement and Finalization
	Task 4: Council Presentation

3.1 Phase 1 – Functional Evaluation & Background Review

3.1.1 Task 1: Project Initiation & Information Sharing Meeting

The Project Team began the project with a meeting with City staff to review and confirm the project scope, timelines, roles, deliverables, budget and the contract. The background of each pond was discussed, including the history and current function, past and ongoing maintenance issues, community interest/sensitivity, levels of service and O&M Prioritization. Lastly, background information for each pond was discussed, including topographic surveys and GIS / digital data.

3.1.2 Task 2: Review of Background Information

Following the initiation meeting, the Project Team compiled and reviewed available background information to identify historical issues and potential future opportunities.

3.1.3 Task 3: Functional Evaluation

Once the background review had been completed, the Project Team conducted field investigations as the first step to develop a functional evaluation for each pond that provided a comprehensive assessment of the status and considerations in three areas ("buckets"):

1. Engineering,
2. Natural Environment, and
3. Human Environment.

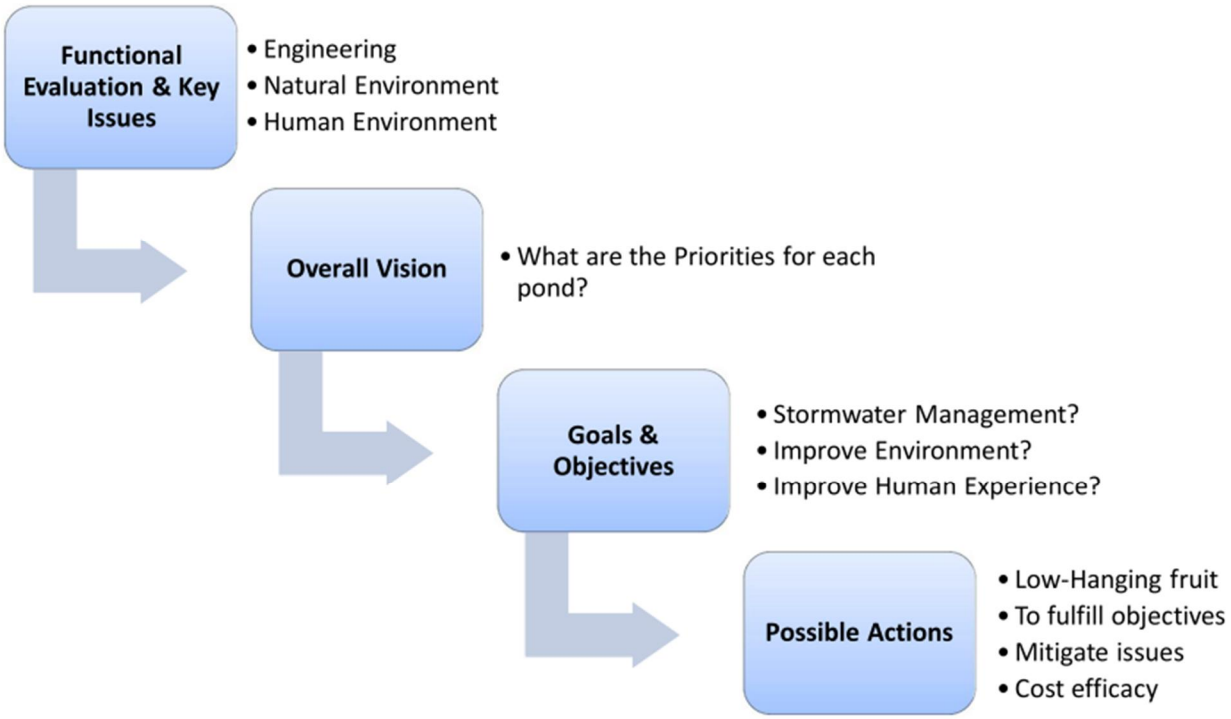
The functional evaluation also summarized issues and opportunities, which were used to create goals and objectives for each pond, and a preliminary list of potential actions for each pond. Once the majority of the Functional Evaluation had been completed, the Project Team made a presentation to the Parks and Environment Advisory Committee (PEAC) on May 5, 2012.

3.2 Phase 2 – Management Strategy Development

3.2.1 Task 1: Visioning Session

For this project, a visioning framework was applied to form and evaluate the many components of the strategy, as shown in Figure 2 below.

Figure 2: The Visioning Framework



Subsequent to the completion of the functional evaluation, a visioning session was held on June 12, 2012 with City staff to review the results and brainstorm / discuss ideas for the overall vision, goals and objectives and potential actions to be considered for future management of each pond.

The Project Team also made a presentation to the Parks and Environment Advisory Committee (PEAC) on September 6, 2012, to present the results of the Visioning Session.

3.2.2 Task 2: Draft Management Strategy

Following the Visioning Session, the Project Team finalized the functional evaluations, assessed the suggested options, and identified short-term and long-term improvement strategies for each pond, with particular attention to issues and opportunities in each of the three 'buckets' (Engineering, Natural Environment and Human Environment).

The main components draft management strategy for each pond include:

Evaluation Matrix

Based on the discussions of the future vision for each pond, all potential actions that were discussed were placed in an "Evaluation Matrix", which allowed the Project Team to identify which options achieved the determined goals and objectives, including the priority levels that were applied to the three "buckets". Actions that met the objectives of a bucket were given a positive rating; actions that did not meet/impact the objectives of a bucket were given a neutral rating; and actions that had a negative impact on the objectives of a bucket were given a negative rating. Based on this evaluation, some potential actions that had a negative or neutral impact on the overall objectives for a pond were eliminated.

Once each action was evaluated against the objectives and negative actions were eliminated, cost ranges and timeframes were determined for the remainder of the actions, for discussion. The evaluation matrix for each pond is included in these Strategies; however, these were used only for the process of relative evaluation and subsequent elimination.

Implementation Plan

Once the management strategies had been drafted, discussed and revised, an implementation plan was designed for each, showing each recommended action, its estimated capital and operation cost, and its recommended timeline.

3.2.3 Task 3: Staff Workshop; Management Strategy Refinement and Finalization

On October 23, 2012, the Project Team held a workshop with City staff to present the management strategies, and review the draft implementation for each pond. Based on the discussion, the Concepts and implementation Plans were revised.

3.2.4 Task 4: Council Presentation

In December 2012, the Project Team, along with Engineering, Parks and Environmental Department staff, made a joint presentation to City Council, to review and accept the management strategies for information.

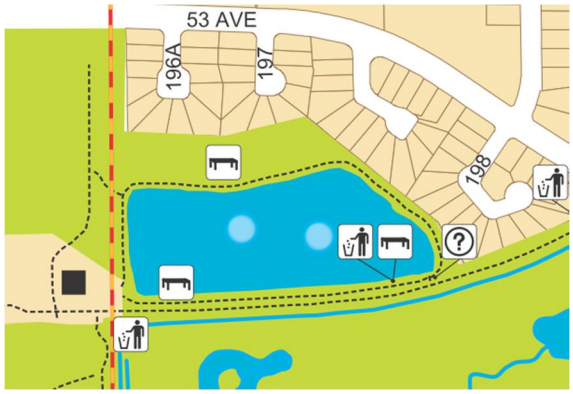
4.0 Assumptions

For the purpose of the project, it was assumed that the development of the management strategies was based on a technical analysis of the opportunities and constraints. The Project Team involved the City's Parks and Environmental Advisory Committee (through two presentations), but beyond that the City is responsible for any public and stakeholder engagement once the management strategies were finalized.

Part B:
Brydon Lagoon

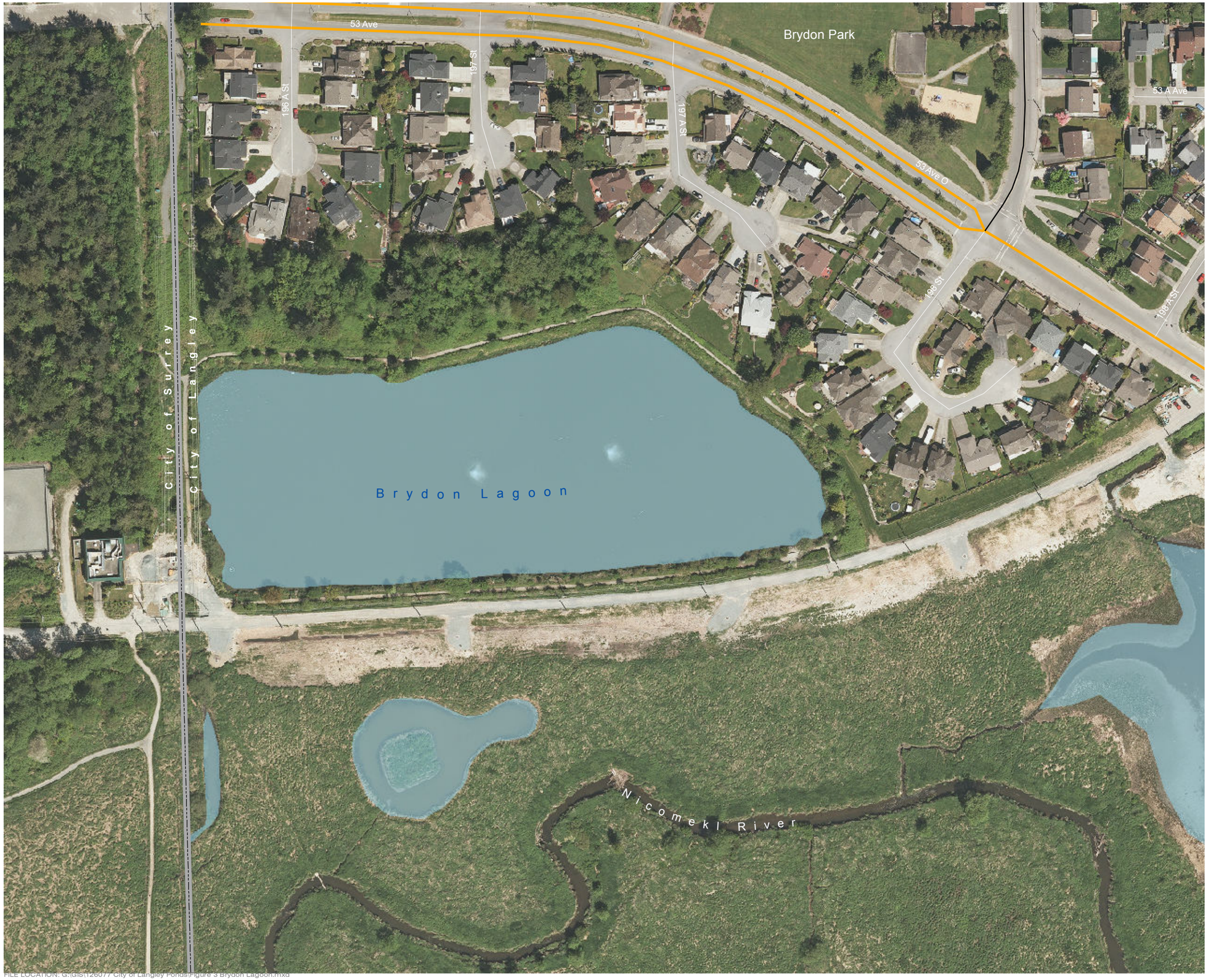
1.0 Introduction

Brydon Lagoon is located in the west end of the City, at 198th Street and 53rd Avenue in the Nicomekl Neighbourhood (adjacent to the Nicomekl River floodplain). Originally constructed in 1963, the lagoon operated as a primary sewage treatment facility until 1975. In 1985, the City designated the lagoon and adjacent 2.5 acres of greenspace to the north as a nature park. Brydon Lagoon receives drainage from a small residential catchment area to the north between 196th and 198th Streets and discharges to the Nicomekl River floodplain through a wood stave culvert (through the dike).



Brydon Lagoon features a perimeter pedestrian pathway, wildlife viewing/feeding areas, aeration fountains, and is very popular with dog walkers and local area naturalists. According to the City's classification mapping, the lagoon is considered Class B habitat (*i.e.,* considered non fish-bearing), however, it does support several species of waterfowl, amphibians, and other wildlife. The lagoon features a perimeter pedestrian pathway and wildlife viewing areas and is very popular with dog walkers and local area naturalists.

The local context of Brydon Lagoon is shown on Figure 3 on the following page.



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Pond Management Strategies

Brydon Lagoon Location Plan
Figure 3

- Major Roads
- Arterial Roads
- Collector Roads
- Local Roads
- City Boundary
- Ponds

0 15 30 60 Meters

SCALE 1:1,750

Map Drawing Information
Data from City of Langley, Some data partially modified by Dillon Consulting

Map Created by: Eric Hertzman
Map Checked by: Jim Walker
Map Projection: NAD83 UTM Zone 10N

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FILE LOCATION: G:\GIS\126077 City of Langley Ponds\Figure 3 Brydon Lagoon.mxd

2.0 Where are we now? Current Pond Status

Section 2.0 includes the summary of the functional evaluation that was completed for Brydon Lagoon. It was done by considering three main components:

1. Engineering,
2. The Natural Environment, and
3. The Human Environment.

2.1 Engineering Assessment

A comprehensive assessment of the Brydon Lagoon was undertaken that consisted of a thorough examination of available background information, together with field reconnaissance to confirm the physical characteristics and current function of the pond as well as the surrounding site features (*i.e.,* trails, topography, drainage features, etc.). The results of the assessment were compiled and evaluated to identify existing issues, constraints and improvement opportunities.

Sources of background information reviewed as part of the assessment include the following:

i) City of Langley GIS database, including topographic/digital elevation mapping, storm sewer system details, watercourse classifications, and land use data;

ii) 2010 ortho-imagery provided the City of Langley;

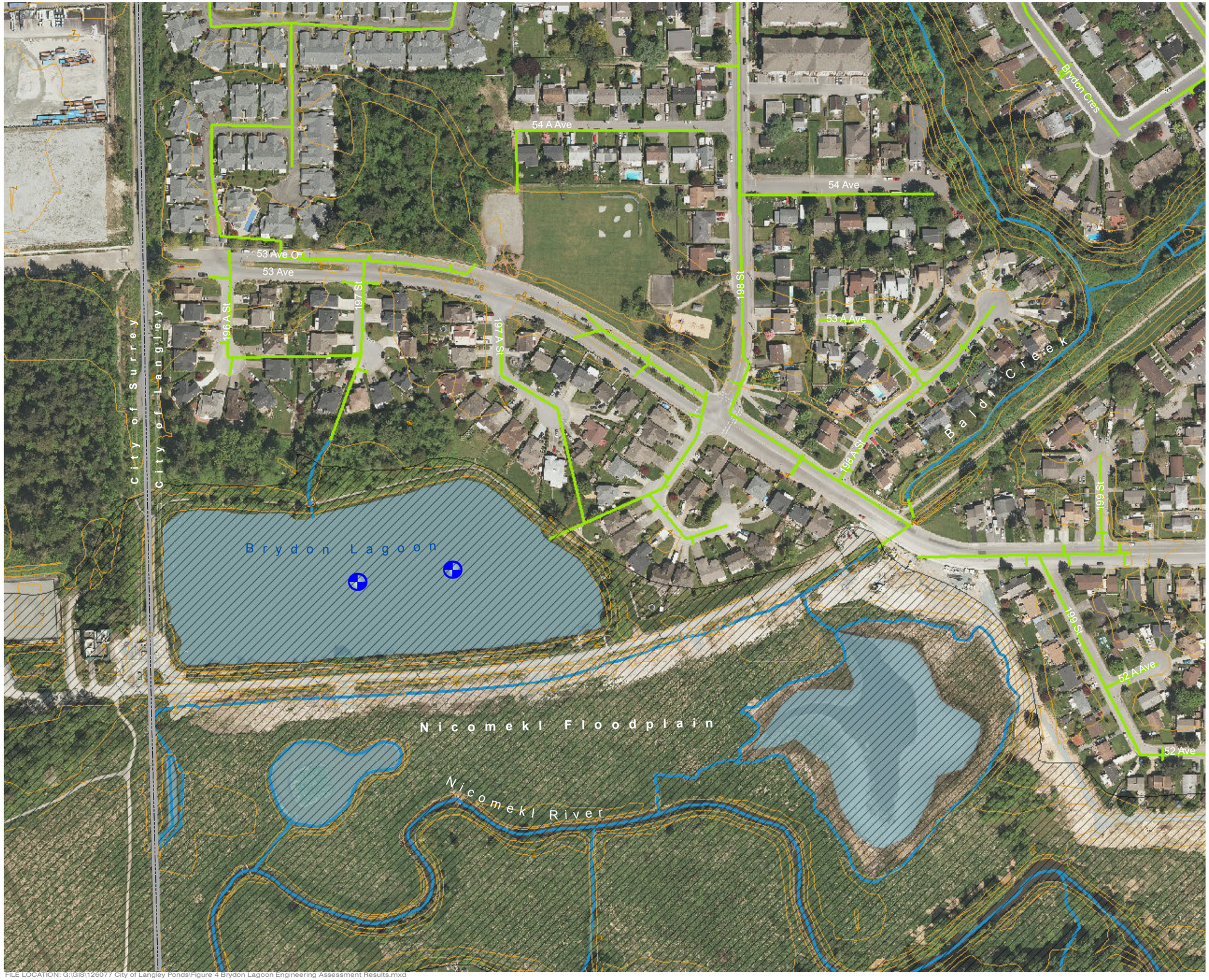
iii) Draft Stormwater Drainage System Assessment, UMA Engineering Ltd. (2005);

iv) Langley Sewage Pump Station Influent Connection Plan & Profile Drawing, Greater Vancouver Sewerage and Drainage District (1975); and

v) Soil Map of the Lower Fraser Valley, Soil Survey Branch, BC Department of Agriculture (1938).

Information regarding the facility layout, purpose/function, physical characteristics, subsurface conditions, watershed hydrology and hydraulic characteristics of the lagoon is summarized below. In addition, a description of the maintenance activities undertaken by Park Operations staff is also provided.

Some results of the Engineering Assessment can be seen on Figure 4 on the following page.



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Pond Management Strategies

Brydon Lagoon
Existing Drainage Features

Figure 4

- Aeration Fountains
- Storm Sewer System
- Watercourses
- Contour (1m)
- City Boundary
- Nicomekl Floodplain
- Ponds

0 15 30 60 Meters

SCALE 1:2,500

N W E S

Map Drawing Information
Data from City of Langley, Some data partially modified by Dillon Consulting. Floodplains from BC Provincial Government GeoBC.

Map Created by: Eric Hertzman
Map Checked by: Jim Walker
Map Projection: NAD83 UTM Zone 10N

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FILE LOCATION: G:\GIS\126077 City of Langley Ponds\Figure 4 Brydon Lagoon Engineering Assessment Results.mxd

2.1.1 Facility Layout

The Brydon Lagoon consists of a large, rectangular shaped pond that is located along the western limits of the City within the Nicomekl flood plain, near the intersection of 53 Avenue and 198 Street (refer to Figure 4). The pond is surrounded by a gravel pathway along its perimeter, and bound to the north and east by an environmentally sensitive wooded area and residential development, to the south by the Nicomekl River, and to the west by the City of Surrey. The pond and pathway system covers an area of approximately 3.5 ha.

Brydon Lagoon currently receives stormwater runoff through two storm sewer outfalls along its northern and eastern perimeter, as well as a small culvert that drains a portion of the wooded area to the north of the pond. Outflows are discharged through a single outlet near the southwestern corner of the pond to the Nicomekl River.

2.1.2 Purpose and Function

As noted, Brydon Lagoon was originally constructed as a primary sewage treatment facility in 1963, which was in operation until 1975. At that time, the lagoon was decommissioned and converted to a stormwater management pond, which was subsequently designated as a wildlife sanctuary and public green space in 1985.

To facilitate the conversion, the pre-existing sanitary system outfall was diverted by extending the 450 mm diameter sewer along the perimeter of the lagoon (east, north and west) to the nearby GVSDD/Metro Vancouver pump station. Following the sanitary sewer modifications, improvements to the municipal drainage system were completed to direct runoff to the pond from its contributing northern catchment area.

In response to ongoing issues with the occurrence of algal blooms during the summer months, the City installed two aeration fountains within the centre of the pond in 2003 for the purpose of water quality enhancement by increasing dissolved oxygen levels and improving circulation.

2.1.3 Physical Characteristics

A summary of the dimensional attributes of the Brydon Lagoon is presented in Table 1, which are based on available background information and field investigations. A bathymetric survey of the pond was conducted by Dillon field staff on May 2, 2012 to confirm its geometric characteristics as well as to determine the average depth of accumulated sediment.

Table 1: Brydon Lagoon – Dimensional Attributes

Attribute	Value
Length (m)	300
Width (m)	100
Depth (m)	1.25
Area (m^2)	27,500
Volume (m^3)	23,000

Note: All dimensions are approximate.

Further to the above, the physical characteristics of the Brydon Lagoon include:

- The lagoon was constructed through excavation into the native clay to create a large, shallow depression for the purpose of primary sewage treatment.
- As shown on Figure 4, side slopes below that water level near the lagoon perimeter are relatively gradual, varying from approximately 15H:1V along the western edge to 65H:1V along the eastern edge. Above the water level, the slopes are as steep as 2H:1V in some locations, but are generally more gradual where access to the water's edge is possible.
- The storm sewer outfalls that discharge into the lagoon include a 675 mm diameter concrete pipe along the eastern edge (former sanitary sewer inlet location) and a 900 mm diameter concrete pipe that discharges to a short channel which conveys flows to a culvert beneath the perimeter pathway and headwall along the northern edge (refer to Figure 4).
- Outflows from the lagoon discharge through a wood stave culvert (approximately 20m in length) beneath the perimeter pathway along the southern shoreline and adjacent Nicomekl trail to a channel that flows into the Nicomekl River – the structure was observed to have experienced significant deterioration, however, a complete assessment of the size and condition was not possible due to site constraints.
- The concrete overflow structure used during the previous operation of the lagoon as a sewage treatment facility is located in the southwest corner of the pond, however, it is understood that these works have been abandoned.
- The aeration system includes two fountains in the centre of the lagoon, which are mounted to floats that are anchored to the base of the lagoon. The aeration fountains are operated by a timer from 8:30 a.m. to 7:30 p.m. daily between May 1 and September 30.
- The pathway consists of a narrow gravel trail (average width of approximately 1.2 m) around the perimeter of the lagoon.

2.1.4 Subsurface Conditions

Sediment and soil characterization for the base of the Brydon Lagoon was conducted July 19, 2012 by Rocky Mountain Soil Sampling Inc. under the supervision of a Dillon professional geoscientist. The investigations involved the drilling of five boreholes to establish the representative stratigraphy to an approximate depth of 2.4 m below the pond bottom using a direct-push drill rig mounted on a raft. Multiple samples were collected at each borehole, which were subjected to field tests and submitted for laboratory analysis of specific parameters. In addition, vertical probing was undertaken at ten locations to determine the thickness of accumulated sediment at the base of the pond.

The results of the investigations are summarized as follows:

i) Available evidence indicates that the silty clay of the pond bottom consists of native material, similar to that commonly present elsewhere in the City and Township of Langley, and which was not placed as an engineered or installed "liner" during the construction of the original sewage lagoon. The silty clay is dense and plastic, with density increasing to the maximum depth of drilling (about 3.7 m below the pond bottom).

ii) Observations during and following drilling suggest that there has been relatively little net deposition of soft (unconsolidated) organic sediment on the lagoon bottom since it ceased to be used for sewage treatment in 1975. Observed sediment thickness ranged from approximately 25 mm along the north side of the pond to as much as 300 mm along the south side. Below this, in two boreholes, soils generally consisted of silty clay with trace sand. This material was typically bluish gray or brown-grey, plastic and dense. At two other borehole locations, a layer of brown to dark brown organic material was encountered, more dense and cohesive than the sediments but less than the clay, and containing some material interpreted to be woody debris or similar.

iii) Two borehole samples were subjected to grain size analysis, and the results indicated that the "clay" soils observed were best described as silty clay with trace sand, while the "organic" soils found included an approximately equal amount of sand and silt sized particles, with some clay and trace gravel.

iv) Four samples were submitted to Maxxam Analytics for analysis of extractable petroleum hydrocarbons and metals to be compared to the standards set out in the BC *Contaminated Sites Regulation* for parkland land use. The results indicated that arsenic (As) and chromium (Cr) were detected in two samples at levels that exceeded the respective standard, and extractable petroleum hydrocarbons in the "heavy" range (C19-C32) were detected in two samples but did not exceed the applicable standard. However, there is little or no evidence that the silty clay and organic soils are contaminated with metals originating in urban runoff, as is apparently the case for the overlying soft organic material.

A description of the methodology followed for the subsurface investigations, together with a location plan, a summary of the analytical results, and the corresponding findings and recommendations, are provided in the letter report presented in Appendix A.

2.1.5 Watershed Hydrology

The catchment area that contributes surface runoff to the Brydon Lagoon is approximately 25 ha, which is generally bounded by the BC Hydro corridor/City of Surrey to the west, 56 Avenue to the north, 168 Street to the east and the Nicomekl River to the south.

Current hydrologic characteristics for the contributing watershed area are summarized here.

- Topographic relief is low/moderate with highest elevation at approximately 12 mASL and the elevation of the lagoon perimeter at 3 mASL, at an average slope of about 2%.
- Land use is predominately residential with some open space (parkland, BC Hydro ROW, nature reserve, etc.).
- Available mapping indicates that native surficial soils in the watershed predominately consist of clay loam over dense clay, which correlates with the results of the subsurface investigations noted above.
- The Drainage system consists of a storm sewer network along with ditches and swales that convey surface runoff to the lagoon via two outfalls.

2.1.6 Lagoon Hydraulic Characteristics

In addition to direct precipitation, inflows to Brydon Lagoon are discharged through two storm sewer system outfalls, as shown on Figure 4, as well as a culvert beneath the pathway along the northern perimeter of the lagoon that conveys flows from a small wooded area. Given the predominately urbanized land use characteristics and clayey subsurface conditions, it is not expected that there are significant groundwater contributions to the pond.

As noted, outflows from the lagoon are discharged via a wood stave culvert under the perimeter pathway and through the adjacent dyke to the Nicomekl River flood plain. The rate of infiltration though the base of the lagoon is expected to be minor by comparison due to the dense native clay subsurface characteristics. However, given the large surface area of the lagoon, together with extended periods of hot, dry weather during the summer months, evaporation could represent a notable component of the lagoon's water balance.

2.1.7 Maintenance Activities

Based on correspondence with City Parks Operations staff, the following maintenance activities are conducted at Brydon Lagoon:

- Vegetation control of pathways around pond – trimming of brush in spring and fall, as well as the addition of rock/gravel dust to trails every 2-3 years.
- Servicing of aeration fountains, including the re-anchoring of the mooring cables and replacement of the motors (last completed in summer of 2012).

2.2 Natural Environment Assessment

The study area is located within and adjacent to the Nicomekl River floodplain. This shallow pond receives the majority of its stormwater runoff through two storm sewer outfalls at the northern and eastern perimeters. A culvert under the perimeter pathway also drains a small wooded area to the north. Outflows are through one outlet at the southwestern corner which flows into the Nicomekl River floodplain. The Nicomekl River is a low-gradient system that originates in the Township of Langley and flows down a shallow plateau to the lowland areas and then out to Mud Bay, which is part of the larger Boundary Bay ecosystem. This 33 km long river drains an area of 175.2 km^2 and has a mean annual flow of 3.47m^3/s (Fisheries and Oceans Canada, 1999). The area surrounding the ponds provide walking and nature viewing opportunities.

2.2.1 Ecological Assessment Parameters

Dillon's ecological field team conducted a biophysical baseline assessment of Brydon Lagoon ecology and the surrounding areas that may be influenced by the future maintenance, operation or redevelopment of the pond. The following parameters were assessed:

- Terrestrial environment (vegetation and wildlife);
- Aquatic environment and fish habitat (including water/sediment quality);
- Invasive species;
- Potential presence of species at risk; and
- Riparian area management/improvement.

2.2.2 Terrestrial Environment

Vegetation

The study area is situated within the Coastal Western Hemlock zone, which occurs at low to middle elevations west of the Coast Mountains. The vegetation within the study area has been previously disturbed, due to human-related activities, and consists primarily of reed canary grass, Himalayan blackberry and several invasive shrub species. Young and mature trees also exist around the lagoon, which include red alder (*Alnus rubra*) and conifer species such as western red cedar (*Thuja plicata).* The field assessment identified 9 native species and 6 non-native species. No rare plant species were observed near Brydon Lagoon.

Vegetation types observed during the initial site assessment are listed in Table 2.

Table 2: Brydon Lagoon – Observed Vegetation in the Vicinity

Category	Species	Native/Invasive
Tree	Western redcedar (*Thuja plicata*)	Native
	Western yew (*Taxus brevifolia*)	Native
	Red alder (*Alnus rubra*)	Native
	Douglas-fir (*Pseudotsuga menziesii*)	Native
Shrub	Himalayan blackberry (*Rubus discolor*)	Invasive
	Common juniper (*Juniperus communis*)	Native
	Pacific rhododendron (*Rhododendron macrophyllum*)	Native
	Evergreen blackberry (*Rubus laciniatus*)	Invasive
	Indian plum (*Osmaronia cerasiformis*)	Native
	Salmonberry (*Rubus spectabilis*)	Native
	English holly (*Ilex aquifolium*)	Invasive
	Rose (*Rosa* sp.)	Native
Herb	Creeping buttercup (*Ranunculus repens*)	Invasive
	Reed canary grass (*Phalaris arundinacea*)	Invasive
	Common tansy (*Tanacetum vulgare*)	Invasive

Reed canary grass and Himalayan blackberry are the dominant species present around the perimeter of the pond with other species represented in smaller numbers. Reed canary grass has been noted by the Langley Field Naturalists and by Dillon's site assessment to be intruding into the pond from the edges, suggesting ongoing infilling.

Wildlife

The area immediately surrounding the pond provides some valuable wildlife habitat for a variety of species. The overall habitat value of the pond itself is moderate, due to the limited complexity (lacking significant large woody debris and wildlife trees), the potential disturbance by people and dogs, and the proximity of residential buildings; however, large tree stands and forest cover are present within the project area which contribute to the overall habitat value for waterfowl and bird species.

Anecdotal information collected from the Langley Field Naturalists indicates that mink, otter, squirrel, coyote, raccoon, black-tailed deer, and beaver inhabit the lagoon area, in addition to several species of reptiles and amphibians. Waterfowl have been observed within the area, including green-winged teal, American widgeon, geese, mallards and American coots. The surrounding wetland habitats of the Nicomekl floodplain are also known to support a variety of amphibian species.

During the site assessment various wildlife species were identified, which included mallards, green-winged teal, American widgeon, American coot, northern shoveler and red-eared slider turtles. Anecdotal information from the Langley Field Naturalists indicates that the pond is utilized by up to 50 species of waterfowl as well as passerines and other bird species (sparrows, swallows, kingfishers, etc.).

Based on a background literature review of the Nicomekl floodplain, the Ministry of Environment considers this area a major flyway for migratory waterfowl moving between Boundary Bay and the agricultural lands of the Serpentine and Nicomekl River floodplains. The area surrounding the ponds are also considered habitat for red-tailed hawks, northern harriers, and other raptors including bald eagle, osprey, and peregrine falcon. Passerines are also considered to potentially inhabit the hedgerows and thickets of the area surrounding the project area. The general area surrounding the project site could also potentially provide habitat for a number of mammals including beaver, muskrat, river otter, mink, short-tailed weasel, and Townsend's vole.

There is an old outlet structure from the pond near the southwest corner consisting of a rectangular concrete tube. The structure acts as a trap for terrestrial aquatic rodents as several decomposing animals were observed at the bottom. The species could not be identified but were likely either beaver or muskrat.

2.2.3 Aquatic Environment and Fish Habitat

Brydon Lagoon is currently unclassified according to the adjacent Township of Langley's watercourse classification system. However, given the documented presence of fish year-round and the potential for reasonable access enhancement, the channel should be given a "Class A – Red" designation. The lagoon discharges via a wood stave culvert (approximately 20 m in length) to a channel that flows into the Nicomekl River. The river supports several runs of anadromous salmonid species such as coho, chum, chinook, cutthroat trout, steelhead, rainbow trout and Dolly Varden char. Resident fish species include redside shiner, brassy minnow, and yellow perch. However, there is no access from the Nicomekl River into the lagoon. Minnow trapping data for Brydon Lagoon (by the Langley Environmental Partners), for 1999, 2001 and 2002 indicate that several coarse fish species exist within the lagoon, they include the following:

- Banded sunfish;
- Brassy minnow;
- Shiners (minnow);
- Catfish;
- Carp;
- Fathead minnow;
- Black crappy; and
- Pumpkin seed.

These fish species are resident populations that could likely exit the lagoon via the woodstave culvert, but would have no potential for access back into the lagoon as the outfall is currently configured. These species are generally tolerant of poor water quality and it is likely that the pond provides them with moderate quality habitat.

Water Quality

Brydon Lagoon is a shallow body of water, which is bordered by residential areas to the north and east, a power station to the west and the Nicomekl River floodplain to the south.

During Dillon's initial site assessment, the water appeared turbid and to have poor circulation and aeration (despite two aeration fountains within the lagoon). The water quality was relatively poor due to the low dissolved oxygen, poor circulation/drainage and elevated summer water temperatures. Sediments were determined to be high in organic material, the decomposition of which would take up oxygen within the water column.

Water samples were collected at five (5) sites during May 2, 2012; at seven (7) sites during August 28, 2012; and four sites on September 21, 2012. A list of all the sampling sites is listed in Table 3 below.

Table 3: Brydon Lagoon – Sample Site Location and Parameters Sampled

Location and Site:	Site 1 *Southeast corner of pond*	Site 2 *Middle, north shore of pond*	*Site 3 Mid pond, 50 m east of west shore*	Site 4 *20 m south of middle*	Site 5 *50 m east of Site 4*	Site 6 *Middle south shore of pond*	Site 7 *Southwest corner of pond*
Date	Parameters Sampled						
May 2, 2012	total metals, dissolved metals, BTEX/VOC, BOD, and TSS	total metals, dissolved metals, BTEX/VOC, BOD, and TSS	total metals, dissolved metals, BTEX/VOC, BOD, and TSS	total metals, dissolved metals, BTEX/VOC, BOD, and TSS	total metals, dissolved metals, BTEX/VOC, BOD, and TSS		
August 28, 20120	total metals, dissolved metals, BTEX/VOC, BOD, and TSS	total metals, dissolved metals, BTEX/VOC, BOD, and TSS	total metals, dissolved metals, BTEX/VOC, BOD, and TSS	total metals, dissolved metals, BTEX/VOC, BOD, and TSS	total metals, dissolved metals, BTEX/VOC, BOD, and TSS	total metals, dissolved metals, BTEX/VOC, BOD, and TSS	total metals, dissolved metals, BTEX/VOC, BOD, and TSS
September 21, 2012	Total Phosphorous	Total Phosphorous				Total Phosphorous	Total Phosphorous

All sites were sampled for total metals, dissolved metals, BTEX/VOC, biochemical oxygen demand (BOD), and total suspended solids (TSS). Phosphorous was sampled at Sites 1, 2, 6 and 7. The results of the surface water sampling were compared to the BC Water Quality

Guidelines (BC WQG). The reported results indicate there were several exceedances of both chronic and acute standards for several parameters as discussed below.

The water quality results and analytical methods for all sites can be seen in Tables B-1 to B-3 in Appendix B.

Total Metals

All sites had exceedances of cadmium, calcium, copper and silver. Both cadmium and calcium exceeded the acute standards; copper the chronic standard at all sites with Site 1 also exceeding the acute standard on August 28th; and silver the acute and chronic standards on all days and sites with the exception of Site 2 on August 28th where only the chronic standard was exceeded.

Other standards that were exceeded at only some locations and/or specific days include arsenic, iron, lead and zinc.

Standards exceeded for specific total metals are indicated in Table B-4 in Appendix B.

Dissolved Metals

The following dissolved metals exceeded the acute standards of the BC WQG:

- Calcium at all sites and all sample days; and
- Iron at Sites 1, 2, 6, and 7 for August 28th.

Standards exceeded for specific dissolved metals are indicated in Table B-5 in Appendix B.

Nutrients

Phosphorous was the only nutrient which exceeded the recommended guidelines for aquatic life in fresh water. Site 2 had the highest concentrations at 0.839 mg/L; other sites were below 0.5 mg/L.

Run-off of household detergents and fertilizers from the residential areas into the pond system has likely contributed to an overabundance of phosphorus, which has resulted in large annual algal blooms. These blooms deprive the waters of oxygen and result in a reduction of water quality for aquatic life. It should be noted that the accumulated phosphorus is likely a result of historic discharge into the lagoon given that phosphorus is being phased out of household detergents and fertilizers.

BTEX/VPH (Benzene, Toluene, Ethylbenzene, and Xylenes/Volatile Petroleum Hydrocarbons)

There were no exceedances for any of the sampled sites during the May and August sampling dates.

Biochemical Oxygen Demand (BOD)

The BOD is a measure of the oxygen that is used by microorganisms to decompose organic wastes. If there is a large amount of organic wastes in the pond, organisms will use more oxygen and therefore the value of the BOD will be high. Elevated BOD levels were found at Site

1 in August (17 mg/L) and at Site 2 in May (13 mg/L), which suggests that the pond is somewhat polluted with high organic matter present. Sites 1 and 2 are also at the storm water inflow area of the pond, which could be contributing the higher BOD levels.

Total Suspended Solids (TSS)

Total suspended solids are solids in the water column that are able to be trapped in a filter. Elevated concentrations of suspended solids cause a reduction in water clarity and therefore decreased light availability for photosynthesis. TSS was the highest for Sites 1, 2, 6 and 7 for the August sampling period. The total average for all sites for both the May and August sampling periods was 28.9 mg/L.

In Situ Parameters

In-situ (field) parameters measured for all sites were temperature, turbidity, pH, dissolved oxygen and conductivity. Only pH exceeded the BC WQG for Site 1 in August, at a value of 9.17. Dissolved oxygen (DO) was within the Canadian Council of Ministers of the Environment (CCME) guidelines. However, Sites 1 and 2 had readings of 13.3 and 12.2 mg/L respectively which were outside of the expected range for the August sampling period. These readings are likely not typical of normal DO levels. Turbidity was also elevated above the CCME standards at Sites 1 and 2 during the August sampling period.

Sediment Quality

Sediment samples were collected at the same five (5) water quality sites during May 2, 2012. All of the sediment samples were taken from a depth of 0 to 0.5 m below the sediment surface. The water depth at these sample locations was approximately 0.6 to 1 m deep. All sites were sampled for metals and hydrocarbons. Results and analytical methods are provided in Table B-6 in Appendix B.

Metals

The results of the sediment sampling indicate that there are reported exceedances of the Contaminated Sites Regulation (CSR) Schedule 9 Sediment Standards for metals concentrations that include the following:

Mercury exceeded the CSR standard for Sites 1 to 4, and arsenic, cadmium, copper, lead, mercury, and zinc exceeded levels at Site 1.

For the purposes of determining potential disposal options, the sediment samples were also compared to the CSR Schedule 4 and 5 Soil Standards for Industrial Land Use (IL). The reported results indicate that there are the following exceedances:

- copper in all five samples
- arsenic, and cadmium at Site 1;
- chromium at Sites 1, 3 and 5; and
- zinc in Sites 1 and 5.

Hydrocarbons

There were no exceedances of hydrocarbons for any of the sites.

2.2.4 Invasive Species

There are several invasive plant species that exist within the Brydon Lagoon area. The 2012 field investigation identified that reed canary grass, Himalayan blackberry, evergreen blackberry, English holly, creeping buttercup, and common tansy are present within the area. These plants are a concern to the overall habitat value, since they are able to spread quickly which results in the displacement of native plant species. Although Himalayan blackberry is an invasive species within the area, the plant has been able to create a barrier for human and dog access to some areas of the lagoon, reducing riparian damage to these areas.

Instream vegetation is primarily decomposing reed canary grass, the decomposition of which has significantly contributed to the infill of the lagoon, thus resulting in higher water temperatures and a reduction of native plant species.

2.2.5 Rare and Endangered Species

An online search of the Ministry of Environment Conservation Data Centre (CDC) search was done, which did not yield any rare species confirmed within the vicinity of Brydon Lagoon.

The potential presence or absence of plant and animal species listed in Schedule 1 and 2 of the Species-at–Risk Act (SARA) registry was queried. Based on the field assessment and our local knowledge of the area, rare or endangered species that may potentially be within the Study Area and in close proximity to Brydon Lagoon are highlighted in Table 4 on the next page. Their potential to occur is based on current and historic range and habitat availability in the area.

Table 4: Brydon Lagoon – Species at Risk and Potential for Occurrence in Area.

Class	Common Name	Scientific Name	Likelihood of Occurring in Project Area	SARA 1 & 2
Mammals	Mountain beaver	*Aplodontia rufa*	Unlikely	Special concern (Schedule 1)
	Pacific water shrew	*Sorex bendirii*	Low	Endangered (Schedule 1)
Amphibians	Northern red-legged frog	*Rana aurora*	Possible	Special concern (Schedule 1)
	Western toad	*Anaxyrus boreas*	Likely	Special concern (Schedule 1)
	Oregon spotted frog	*Rana pretiosa*	Unlikely	Endangered (Schedule 1)
Birds	Great blue heron	*Ardea Herodias* ssp. *fannini*	Likely	Special concern (Schedule 1)
	Short-eared owl	*Asio flammeus*	Possible	Threatened (Schedule 1)
	Barn owl	*Tyto alba*	Possible	Threatened (Schedule 1)
	Olive-sided flycatcher	*Contopus cooperi*	Unlikely	Threatened (Schedule 1)
	Western screech owl	*Megoscops kennicotti*	Unlikely	Special concern (Schedule 1)
	Peregrine falcon	*Falco peregrinus* ssp. *anatum*	Unlikely	Special concern (Schedule 1)
Reptiles	Northern rubber boa	*Charina bottae*	Unlikely	Special concern (Schedule 1)
	Western painted turtle	*Chrysemys picta* pop. 1	Possible	Endangered (Schedule 1)
Insects	Monarch	*Danaus plexippus*	Unlikely	Special concern (Schedule 1)

Discussion of species with the greatest potential (*i.e.,* species indicated as low, possible or likely in the table) to occur in the study area is provided below:

Pacific Water Shrews prefer moderate to high canopy closure, which usually border marshes with skunk cabbage or streams. They require an abundance of shrubs and coarse woody debris, which are all very limited at Brydon Lagoon. The Dillon site assessment and past anecdotal data did not record any Pacific water shrews at or around the site. Brydon Lagoon does not appear to provide the preferred habitat requirement of this species and, as such, is considered poor habitat. Regardless, there may be suitable habitat in the immediate vicinity of the lagoon in the forested sections to the north.

Northern Red-legged Frogs prefer cool temperature and wetlands with trees. They require a habitat with well-shaded areas and logs/other debris to stay cool and damp. These frogs have not been observed within the Brydon Lagoon; however, with increased presence of shaded

areas and woody debris, these frogs could potentially use the lagoon as a habitat in the future, since they have been observed in other parts of the Nicomekl River floodplain.

Western Toads are usually found in a wide variety of habitats (wet and dry forest types, meadows and fields, clear-cuts and aquatic). Therefore, it is likely that suitable habitat exists for this species, though it has not yet been documented in the area.

Great Blue Herons inhabit eel grass beds, mudflats, agricultural fields, and old-fields (mainly short-grass or mowed), wharves, beaches, irrigation ditches and urban lakes, streams, drainage ditches and backyard ponds, where they forage for fish and a range of amphibian species. These species could potentially be found within the area. Suitable nesting trees are available in the immediate vicinity.

Short-eared owls breed in open country with short vegetation (rangelands, near dry marshes, farmlands and rangelands), and forage over open fields. Since there are some open fields close to Brydon Lagoon, there is a possibility of this species occasionally roosting or flying over the area.

Barn Owls prefer foraging in dense grass fields, marshes and hayfields and require very specific nesting sites (barns, attics and other man-made structures). They prefer Townsend's voles, but also exploit over rodent prey items (mice, rats, etc.). The area is not considered to be ideal habitat for these owls, due to the lack of proper nest sites; however, they could potentially forage within this area.

Western painted turtles are found along the margins and shallows of lakes, ponds, ditches and slow-moving streams. They require a lot of aquatic vegetation with muddy sediment and upland areas with no vegetation for breeding. Since there have been red-eared sliders observed by Dillon staff within the pond, any western painted turtle will be outcompeted by these invasive turtles since both species inhabit the same ecological niche. However, this species can potentially exist within Brydon Lagoon.

2.2.6 Riparian Area Management and Improvement

Riparian areas around Brydon Lagoon vary in composition and species; however, most of the riparian area is composed of reed canary grass, which is considered an invasive species that can inundate water bodies and cause infill of streams and lakes. The riparian area also includes some deciduous tree stands and shrubs, which offer some shaded areas to the pond. Based on aerial photographs and the site assessment visit, the riparian buffer is up to 8m between the pond and the trail leading around the pond. This buffer is fairly limited, which does not give much buffering protection for any runoff that could be occurring from the residential areas or the pathway.

Riparian area improvement would involve reducing the amount of inundation from the reed canary grass, which can be accomplished by planting more trees which produce more shade (non-optimal conditions for the growth of reed canary grass), increasing the habitat diversity for the area.

2.3 Human Environment Assessment

When completing the human environment assessment and proposing goals, objectives and potential actions for Brydon Lagoon, a number of planning and landscape architecture aspects were considered, including

- Relevant land use policy and the Official Community Plan;
- Community use, issues, sensitivities and safety;
- Landscape architecture considerations including grading, trails and seating / viewing opportunities; and
- Connectivity to the City's overall Parks System.

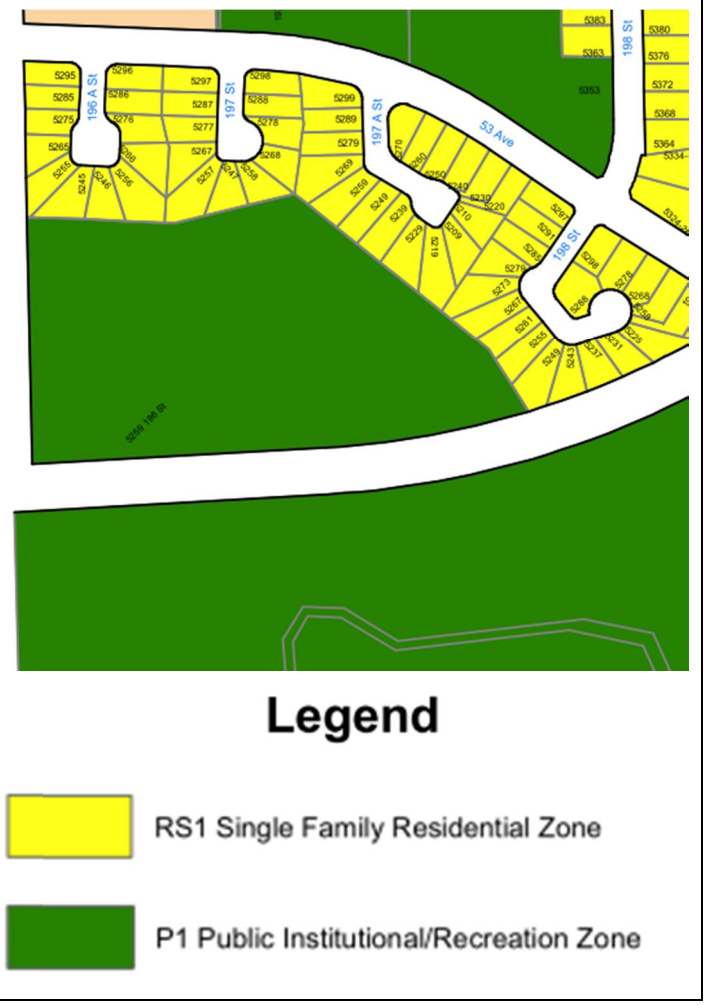
2.3.1 Relevant Land Use Policy and the Official Community Plan

Brydon Lagoon is located on City parkland that is zoned P1 Public Institutional/Recreation Zone. It is surrounded to the north and east by residential land use – zoned as RS1 Single Family Residential Zone, and to the south and west by City Right-of-Ways. Land to the west of the lagoon is within the jurisdiction of the City of Surrey.

The land use context for the Brydon Lagoon is shown in Figure 5 on the next page.

As with all City parkland, the City of Langley Official Community Plan (OCP) recognizes that "parks and recreation play a crucial role in creating quality of life for city residents." City Council adopted a Parks, Recreation and Culture Master Plan Update in 2005 in order "to identify current and future requirements related to the provision of leisure services in the City". The OCP embraces the major recommendations of the PRC Master Plan Update, however, that plan does not include any specific recommendations for Brydon Lagoon.

Figure 5: Brydon Lagoon – Land Use Context



OCP policies that specifically apply to Brydon Lagoon and its surrounding parkland include:

- Policy 8.2.1: Maintain, enhance and expand the open space system shown in the Parks and Open Space Map (Schedule "C").
- Policy 8.2.2: Support and implement the recommendations of the 2005 Parks, Recreation and Culture Master Plan Update, including: (b) Parks & Open Space
  - Acquire parkland in the underserviced Nicomekl and Douglas neighbourhoods;
  - Upgrade individual parks and their facilities in accordance with recommendations;
  - Develop CPTED strategies and bylaw enforcement policies to address crime and safety issues in the park system.
- Policy 8.2.3: Develop and maintain a Nature Trail Network in accordance with the 2005 Nature Trail Network Plan and the Parks and Open Space Map (Schedule "C").

- Policy 8.2.4: Cooperate with GVRD on the development of regional greenways for recreation and wildlife including the Nicomekl River corridor.

Specific to Brydon Lagoon, the OCP Policies for Environmental Protection should also be considered; they include:

- Section 9.1: The Nicomekl Floodplain and the riparian areas associated with its tributary creeks comprise the City's most significant ecological assets.
- Policy 9.2.1: Protect and enhance environmentally sensitive areas and watercourses identified in the Environmentally Sensitive Areas Map (Schedule "D").
- Policy 9.2.5: Encourage storm water management practices both within and outside of the City to mitigate flooding and destruction of habitat and farmland.
- Policy 9.2.6: Storm water management shall be consistent with the GVRD Liquid Waste Management Plan and Integrated Storm Water Management Planning.
- Policy 9.2.7: Pursue habitat enhancement projects in partnership with conservation groups and other government agencies.

Brydon Lagoon is located in the floodplain and wetland component of the City's Environmentally Sensitive Areas (See Figure 6 on following page), and the forest to the north of the lagoon is also identified as an Environmentally Sensitive Area.

2.3.2 Community Use, Issues, Sensitivities and Safety

Brydon Lagoon is used widely by a number of user groups, including residents and the Langley Field Naturalists. The trail is well-used by local residents and forms a component of the City's overall trail system, and the site is popular for wildlife viewing and feeding (grain to ducks). In terms of safety, the lagoon is not fenced; trails are a safe distance from the lagoon - in most parts there is a strip of vegetation between the trail and water's edge.

2.3.3 Landscape Architecture Considerations

Brydon Lagoon is surrounded by a gravel trail, which is limited to pedestrian access only (bikes are restricted). There is one formal access area to the Lagoon / Pond in the southeast that is used for feeding.

2.3.4 Connectivity to the City's overall Parks System

The site is well connected to the surrounding trail system, with trails going to the northwest, southwest and southeast. Figure 7 shows the Lagoon in the context of the City's Park System.

Figure 6: Brydon Lagoon – Environmentally Sensitive Areas Context

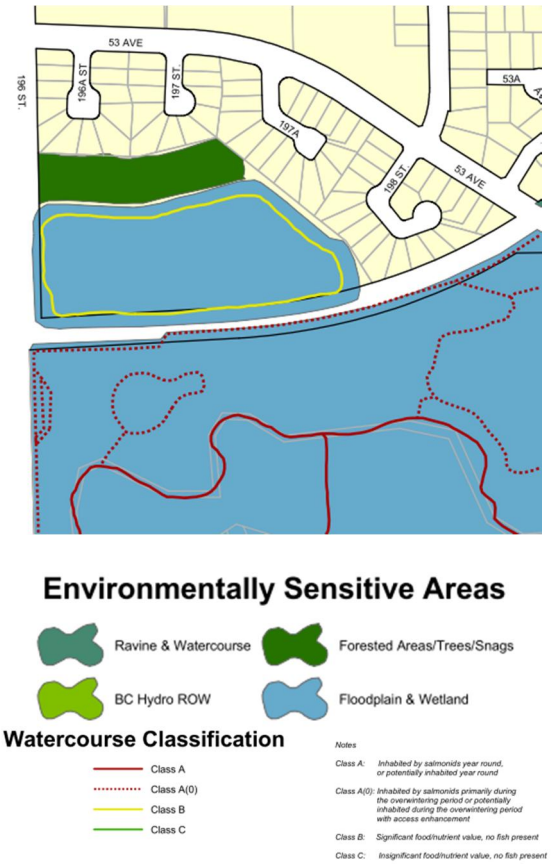


Figure 7: Brydon Lagoon – Parks Context

2.4 Key Issues

During the Functional Evaluation a number of key issues were identified, which are summarized in this section. Issues that can be represented spatially are shown on Figure 8 on the following page, with corresponding photographs.

2.4.1 Engineering

A description of the issues identified as part of the functional evaluation is provided below, which are based on the results of the background review and subsequent field investigations.

i) A significant volume of sediment has accumulated at the base of the pond – based on geo-environmental investigations; the average depth of sediment is approximately 350 – 500 mm and generally consists of organic materials as well as silts and sands contained in runoff discharged from the incoming storm sewers.

ii) The existing wooden outlet culvert to the Nicomekl River has deteriorated and is in need of replacement. Consideration should be given to incorporating improvements that would enhance the hydraulic performance of the pond as well as facilitate the passage of fish to the lagoon.

iii) Issues related to impaired water quality can, in part, be attributed to insufficient runoff from the contributing drainage area, which cannot sustain continuous flows into the lagoon. In the summer months, this leads to stagnation, high temperatures and degraded water quality, including the formation of large algal blooms.

iv) At the time of field investigations, one of the aeration fountains was not in use. Discussions with Parks staff indicate that the pump motors burn out and require replacement every 2-3 years.

v) Localized erosion is occurring along the southern bank of the lagoon, where sleeper slopes exist and aquatic fowl (*i.e.,* ducks, geese, etc.) enter and exit the water.

vi) In its current configuration, the lagoon provides limited benefits with respect to stormwater management (*i.e.,* water quality enhancement, flood control, etc.).

2.4.2 Natural Environment

Riparian Vegetation

- Invasive species include Himalayan blackberry, reed canary grass and other species. These have the potential to displace native species.
- Himalayan blackberry acts as a barrier to human and dog access.
- Lack of overhanging vegetation allows for the proliferation of reed canary grass.
- Lack of shading vegetation on south side can result in higher summer water temperatures.

1 Aeration Fountains

2 Abandoned Overflow Structure

3 Invasive Vegetation along Shoreline

4 Existing Outlet Culvert to Nicomekl River

5 Evidence of Algae Growth

6 Site Entrance

CITY OF LANGLEY

CITY OF LANGLEY
Pond Management Strategies

Brydon Lagoon
Key Issues
Figure 8

1 Picture Location, Direction, and Id Number

Aeration Fountains

Bathymetric Contours

0 12.5 25 50 Meters

SCALE 1:1,250

N W E S

Map Drawing Information:
Data from City of Langley, Dillon Created

Map Created by: Eric Hertzman
Map Checked by: Jim Walker
Map Projection: NAD83 UTM Zone 10N

DILLON CONSULTING

PROJECT: 12-6077

STATUS: FINAL

DATE: (3/11/2013)

FILE LOCATION: G:\GIS\126077 City of Langley Ponds\Figure 8 Brydon Lagoon Key Issues Summary.mxd

Instream Vegetation

- Decomposing reed canary grass appears to be a significant source of pond infill.
- Decomposing reed canary grass also results in higher water temperatures (*i.e.,* decreased water quality).
- Reduced presence of native species.

Fish Habitat

- Site conditions limit potential fish habitat value.
- No access from Nicomekl River.

Terrestrial Habitat

- Limited complexity; lacking LWD and wildlife trees (*i.e.,* snags).
- Potential disturbance by people and dogs.
- Despite limitations still provides good habitat for waterfowl and other bird species.
- Old outlet structure acts as a trap for wildlife.

Water & Sediment Quality

- Improved water quality would provide better fish habitat.
- Excavation of sediment to deepen pond would improve habitat. However, sediment is contaminated and must be dealt with as waste under the *Environmental Management Act.*
- Pathogens are potential health risk.

2.4.3 Human Environment

Based on the assessment of the human environment, the only concern is the appearance of minor vandalism. In an effort to become more natural the area around the lagoon does not have “eyes on the street”.

3.0 Where do we want to be? Future Vision

3.1 Pond Goals and Objectives

Based on the results of the functional evaluation and the visioning workshop held with City staff, the following goals were created for Brydon Lagoon:

GOAL 1: Maintain the current stormwater management functions of the Lagoon;

GOAL 2: Improve the natural environment aspects of the site; and

GOAL 3: Improve the human environment of the site.

With respect to the three "buckets" that had been identified through the functional evaluation, their relative priority for Brydon Lagoon was determined to be as follows:

Discussion Area	Priority Level
1. Engineering / Stormwater Management	LOW
2. Natural Environment / Ecology	HIGH
3. Human Environment	HIGH

3.1.1 Water Resources Engineering Objectives

Three objectives relating to the water resources engineering functions of the lagoon were determined:

1. Improve water quality within lagoon and flows discharged to Nicomekl River.
2. Improve hydraulic performance.
3. Reduce future maintenance requirements.

3.1.2 Natural Environment Objectives

Eight objectives relating to the natural environment functions of the lagoon were determined:

1. Enhance riparian vegetation and increase species composition and variety (*i.e.,* more diversity and abundance).
2. Eliminate invasive species and enhance native aquatic species.
3. Improve fish habitat value.
4. Create access from the Nicomekl River. Note, precludes urban fishery.
5. Improve bird nesting potential.
6. Create more terrestrial habitat.
7. Improve water quality.
8. Manage pathogen potential and perceived health risk.
9. Cap or block old outlet structure at southwest corner.

3.1.3 Human Environment Objectives

Lastly, seven objectives relating to the human environment functions of the lagoon were determined:

1. Improve connectivity and trails.
2. Improve popularity and potential for use.
3. Provide visual interest.
4. Increase public ownership of the site.
5. Improve safety.
6. Improve public treatment of site.
7. Reduce wear and tear on the park.

3.2 Actions and Evaluation

For Brydon Lagoon, a list of potential actions was created during the visioning session. Those potential actions were evaluated according to the objectives for each bucket, and their relative priority, to create a refined list of options. This evaluation can be seen in Table 5 on the following page.

Table 5: Brydon Lagoon - Evaluation Matrix

	Buckets:												Timing			
	Engineering		Natural Environment		Human Environment											
	Low Priority	1	High Priority	3	High Priority	3										
Action:	Meet objectives? – Improve Water Quality – Reduce future maintenance – Improve Hydraulic Performance	Score	Meet objectives? – Enhance riparian vegetation and habitat – Increase aquatic and terrestrial species composition and variety – Eliminate invasive species – Improve habitat value – Improve water quality	Score	Meet objectives? – Improve safety, trails, popularity and education – Reduce wear and tear on the park – Increase community ownership of the park	Score	Subtotal:	Relative Score High = 100 Medium = 50 Low = 0		Cost: Low = $0-$20k (200) Medium = $25k - $75k (100) High = $75k + (0)		Total:		1-3 Years	3-5 years	5 - 10 years
1 Keep / maintain aeration fountains	Yes - improve water quality	2	Yes - Improve water quality	2	Yes - improve water quality	1	11	High	100	Low ($<10k)	200	311	Short-term			
2 Incorporate CPTED design elements	N/A	0	N/A	0	Yes - improve safety	2	6	Medium	50	Low ($20k)	200	256	Short-term			
3 Improve / repair outlet structure	Yes - needs to be done	2	Yes - would improve water flow	1	N/A	0	5	Medium	50	Low ($20k)	200	255	Short-term			
4 Plant trees along south to shade water	Yes - improve water quality and shade out reed canary grass	1	Yes - create more habitat & improve water quality	2	Yes - improve water quality & improve visual variety	2	13	High	100	Medium ($15-$50k)	100	213	Short-term			
5 Develop interpretive signage	N/A	0	N/A	0	yes, improve enjoyment & Environmental education	1	3	Low	0	Low ($10k)	200	203	Short-term			
6 Leave / maintain current trails	N/A	0	N/A	0	Yes - maintains existing human use	1	3	Low	0	Low ($5k)	200	203	Short-term			
7 Replace invasive (Reed canary grass) with native species (cattails)	Would reduce infilling	2	Yes - improve water quality and habitat	2	N/A	0	8	Medium	50	Medium ($50k+)	100	158	Mid-term			
8 Construct baffles to increase flow path of stormwater inflows	Yes - water quality & Sediment benefits	1	Yes - increase water quality	1	Yes - increase water quality	1	7	Medium	50	Medium ($25k)	100	157	Mid-term			
9 Provide pre-treatment of storm sewer outflows (e.g. forebays, oil-grit separators)	Yes - Improves water quality	1	Yes - improve water quality	1	Yes - increase water quality	1	7	Medium	50	Medium ($50k)	100	157	Mid-term			
10 Divert runoff from adjacent catchment areas - provides more volume	Yes - some sub-watershed scale benefits	1	Yes - may improve water quality	1	Yes - increase water quality	1	7	Medium	50	Medium ($75k)	100	157	Mid-term			
11 Create habitat link (Construct fish way/ladder)	N/A	0	Yes - Potential fish habitat banking	1	Could create a fishery, although limited	1	6	Medium	50	Medium ($25-$50k)	100	156	Mid-term			
12 Redesign the trails to meander around the lagoon	N/A	0	May have impact, but likely neutral	0	Yes - increase usability of trails	2	6	Medium	50	Medium ($50k)	100	156	Mid-term			
13 Develop boardwalk and viewing platforms	N/A	0	May have impact, but could also focus access and benefit habitat	0	Yes - improve human experience	2	6	Medium	50	Medium ($75k)	100	156	Mid-term			
14 Create formal (cement, etc) surface access for public	N/A - but may create a maintenance issue	0	Localized habitat impact, but would likely focus access	0	Yes - Significantly improve experience for kids	2	6	Medium	50	Medium ($25-$50k)	100	156	Mid-term			
15 Stock with fish	N/A	0	No siginificant habitat benefit	0	Could create a fishery	2	6	Medium	50	Medium ($50-$70k)	100	156	Mid to Long-term			
16 Create settling ponds / wetlands	Yes - improve water quality	1	Yes - Improve water quality & increase habitat complexity	2	Yes - create visual variety and improve human experience	2	13	High	100	High ($150K+)	0	113	Mid to Long-term			
17 Deepen Lagoon in some areas	Yes - Removes sediment to increase stormwater function Improves Water Quality	1	Yes - Makes it more habitable for fish through improvement water quality	2	Yes - Increase water quality making it better for human contact	1	10	High	100	High ($150k+)	0	110	Mid to Long-term			
18 Modify configuration of pond	N/A	0	Yes - could improve habitat complexity	1	Could create visual variety	2	9	High	100	High ($50-$150k+)	0	109	Mid to Long-term			
19 Make shallower at the edges	No - reduces water quality and more vegetative growth	-2	Yes - improves species, benefits to habitat, BUT, has the potential to worsen water quality	1	Make it slightly safer	1	4	Low	0	Medium ($25k-$50k)	100	104	Mid-term			
20 Create trails in the northern portion of the site	N/A	0	Negative impact on habitat	-1	Yes - increase usability of trails	2	3	Low	0	Medium ($50-$100k)	100	103	Long-term			
21 Widen current trails	N/A	0	Minor removal of vegetation	-1	Yes - improve experience	2	3	Low	0	Medium ($25k)	100	103	Mid-term			
22 Direct groundwater to lagoon	No - would detract from objectives	-2	Yes - increase water quality, but may require oxygenation	0	Yes - increase water quality	1	1	Low	0	Medium ($25k)	100	101	Mid-term			
23 Limit access for people and dogs	N/A	0	Yes - improve habitat	1	No - inhibit Human use	-2	-3			Low ($10k)						
24 Completely infill pond	No - would remove stormwater function	-2	No - would remove fairly valuable habitat	-2	Could be positive or negative	0	-8			High ($750k+)						
							6.5	Average								

4.0 Implementation Plan

The key to the implementation of a strategy such as this involves the identification and prioritization of actions, in such a way that roles, responsibilities, and costs are clear. This section provides the Action Plan for Brydon Lagoon, suggests further studies and detailed plans that are required in the future, implementation considerations, and a recommended timeframe to complete the various projects.

4.1 Action Plan

The Action Plan presented in Table 6 provides a summary of the various projects that are recommended to address the pond goals and objectives outlined in Section 3.1. The plan includes a combination of undertakings along with the associated timeframe, responsible City department, level of importance (requirement vs. enhancement), required studies/next steps, and an estimate of capital and operations and maintenance costs.

The elements of the Action Plan were developed based on the following understanding and assumptions:

i) The summary of work included in the status quo section (*i.e.*, no capital improvements) is based on information provided by Parks Operations staff;

ii) Where possible, construction activities will be carried out by Engineering and/or Parks Operations staff, with labour rates estimated at $50/hour per;

iii) Annual operations and maintenance (O&M) activities will be carried out by Engineering/Parks operations staff; and

iv) Estimated costs are based on 2013 dollar values and include a 20% engineering allowance as well as a 15% contingency.

Table 6. Action Plan and Cost Breakdown for Brydon Lagoon (Human Use Concept)

Project Objective	Implementation Details					Estimate of Costs [1]							
	Summary of Work	Timeframe [2]	Responsibility	Importance	Required Studies/ Next Steps	Units	Quantity	Unit Rate	Capital Cost (A)	Engineering & Contingency [3] (B)	Total (A+B)	Annual O&M [4]	Notes
Status Quo (i.e., No Capital Improvements)	- Vegetation control along perimeter pathway.	Ongoing	Parks	Requirement	N/A	-	-	-	-	$0	$0	$5,000	Vegetation pruning and brush removal - O&M costs estimated at 25 hrs x $200/hr for 4 person Parks Operations crew.
	- Aeration fountain maintenance.	Ongoing	Parks	Requirement	N/A	Ea	2	$750	$1,500	$0	$1,500	$1,000	Motor replacement approximately every 3 years - cost based on 1 hp single phase motor for each aeration fountain, plus annualized 10 hrs x $100/hr for 2 person Parks Operations crew.
	- Perimeter pathway maintenance.	Ongoing	Parks	Requirement	N/A	m^2	1,200	$10	$12,000	$0	$12,000	$4,000	Addition of granular every 3 years (assumed 100 mm depth) - O&M cost based on annualized labour and materials.
								Sub-total	$13,500	$0	$13,500	$10,000	Estimated costs to maintain 'Status Quo'.
1. Improve Public Safety & Security	- Install additional signage, lighting, etc. to improve safety and prevent vandalism.	Short-term	Parks	Enhancement	N/A	LS	1	$8,000	$8,000	$2,800	$10,800	$500	City could consider limiting public use to daytime hours. O&M costs for routine maintenance.
2. Improve Hydraulic Performance	- Replace existing wooden outlet culvert with new structure c/w headwalls and safety railing.	Long-term	Engineering	Requirement	Condition assessment & functional eng. design	LS	1	$50,000	$50,000	$17,500	$67,500	$250	Assumed to be concrete box culvert (approx. 25 m long @ $1000/m x2 for installation). O&M effort required to inspect proposed structure, remove blockages, etc.
	- Equip proposed culvert with elements necessary to facilitate fish passage (e.g., baffles, outlet channel improvements, etc.).	Long-term	Engineering	Enhancement	Functional engineering design	LS	1	$25,000	$25,000	$8,750	$33,750	$250	Cost represents additional value over and above estimated cost to replace existing culvert noted above.
3. Improve Water Quality / Reduce Future Maintenance	- Construct sediment forbay at each inflow location, consisting of excavated sediment sump and berm constructed with spoil material overlain with geo-textile and rip-rap.	Long-term	Engineering	Enhancement	Functional engineering design	Ea	2	$15,000	$30,000	$10,500	$40,500	$3,000	O&M activities based on annualized cost to remove and dispose of accumulated sediment, including labour & equipment (to be carried out on a minimum frequency of 5 years).
	- Stabilize southern bank of lagoon through regrading and bio-engineering techniques to protect the area from continued erosion.	Short-term	Engineering	Enhancement	Functional engineering design	LS	1	$7,500	$7,500	$2,625	$10,125	$500	Potential approaches to stabilize the bank could include landscaping or bio-engineering techniques, such as the planting of deep-rooted, water tolerant vegetation, live stakes (i.e., willow), and/or the installation of fiber rolls. Further protection could be provided by the placement of large stones.
4. Enhance Pathway Network	- Widen perimeter gravel pathway to 2 m.	Short-term	Parks	Enhancement	Functional engineering design	m^2	640	$25	$16,000	$5,600	$21,600	$500	Estimated cost to widen gravel pathway by average of 0.8 m for 800 m length, including labour and materials for vegetation removal, excavation, base prep. and placement/compaction of granular. Annualized O&M cost for the addition of 100 mm of granular material on widened portion only.
	- Construct viewing platform.	Long-term	Engineering	Enhancement		m^2	50	$500	$25,000	$8,750	$33,750	$1,000	Proposed viewing platform to consist of wooden structure (approx. 2m wide) constructed on piles driven into base of lagoon.
								Sub-total	$161,500	$56,525	$218,025	$6,000	Total costs for proposed improvement works.
								TOTAL	$175,000	$56,525	$231,525	$16,000	ESTIMATED TOTAL COSTS

Notes:

1. Estimated costs are based on 2013 dollars and are exclusive of applicable taxes.
2. Engineering and contingency allowances are 20% and 15%, respectively (except where noted).
3. Average labour rates assumed to be $50/hr for Parks Operations staff.
4. Timeframe defined as: short-term (0-5 years) and long-term (>5 years).

4.2 Description of Proposed Improvement Works

A description of each of the proposed improvement works that comprise the Action Plan for the Brydon Lagoon is provided below.

1. Improve Public Safety & Security

It is proposed that additional signage and lighting are installed to improve safety, reduce vandalism, and offer educational information related to the function and ecologic features of the lagoon. It is expected that the locations and other details would be determined through discussions between the Parks and Engineering departments and in consultation with the public. At a minimum, additional signage and lighting should be provided at the lagoon entrance.

2. Improve Hydraulic Performance

As noted in Section 2.4, the existing wooden culvert structure that conveys lagoon outflows to the Nicomekl River has experienced significant deterioration and reached the end of its service life. It is proposed that the structure is replaced with a concrete box culvert complete with headwalls at the inlet/outlet and safety handrails. Given the potential spawning and overwintering habitat available with the lagoon, consideration should be given to equipping the proposed culvert with baffles or otherwise to facilitate the passage of fish.

3. Improve Water Quality/Reduce Future Maintenance

The proposed water quality controls at the lagoon inlets (i.e., storm sewer outfalls) consist of a forebay at each location to promote the settlement of suspended sediment within a confined area, which will facilitate maintenance. To create the forebays, a semi-circular berm would be constructed using earthen materials overlain with rip-rap stone. It is recommended that a sediment sump is also established by excavating material from the base of the lagoon within the forebay area.

Future maintenance requirements will involve a periodic removal of accumulated sediment at each forebay at a frequency of approximately 3-5 years. Depending on the size and configuration of the proposed forebays, sediment clean-out can be conducted using an excavator or vacuum truck.

In addition, a portion of the bank along the southern edge of the lagoon has experienced erosion due to its steep slope and lack of vegetation that appears to be, at least in part, the result of birds entering and exiting the water. To address this issue, it is proposed that the slope is stabilized through the addition of material to provide a more gradual slope, together with measures that will protect the area from continued erosion. Potential approaches to stabilize the bank could include landscaping or bio-engineering techniques, such as the planting of deep-rooted, water tolerant vegetation, live stakes (i.e., willow), and/or the installation of fiber rolls. Further protection could be provided by the placement of large stones.

4. Pathway Network Enhancements

The proposed upgrades to the perimeter pathway involve widening the existing gravel trail to 2 m from the current average width of approximately 1.2 m. The improvement works would include cutting back vegetation, where necessary, followed by the placement and compaction of additional granular material.

Further to the proposed pathway improvements, interactive opportunities for park users could be provided through the construction of a viewing platform. The proposed platform would consist of a wooden structure and could include seating areas.

It is expected that maintenance of the pathway under the proposed configuration would continue to involve the placement of additional granular material every 2-3 years, together with vegetation management (i.e., pruning and removal) twice per year or as needed.

4.3 Further Studies or Detailed Plans

This section highlights additional studies or detailed plans that may be required but are outside of the scope of the Management Strategy.

Additional Studies/Plans	Responsibility	Cost Estimate
Integrated Stormwater/Watershed Management Plan for the Upper Nicomekl River watershed.	City of Langley/ Township of Langley/ City of Surrey	$400,000
Water Quality Monitoring Program	City of Langley	$30,000

4.4 Implementation Considerations

4.4.1 Funding and Funding Options

Stormwater Management Levy or Utility – a specific levy or utility could be established to fund proposed SWM infrastructure within the Study Area. These funds could be collected in the form of a levy added to municipal property taxes, based on the contributing imperviousness and land use of individual properties, or could consist of a separate utility applied to property taxes.

Provincial or Federal Infrastructure Funding – the provincial and federal governments currently provide infrastructure funding that could be applicable to the proposed pond improvements. These include, but may not be limited to the Infrastructure Canada Program, the Canadian Strategic Infrastructure Program, the Canada/BC Infrastructure Program, the Canada-BC Municipal Infrastructure Fund, the Community Recreation Program, the Infrastructure Planning Grant Program, and others that provide funding for projects for urban and sustainable development initiatives.

4.4.2 Approval Process

Any redevelopment of Brydon Lagoon or change in its configuration will require review by the environmental regulatory agencies. Fisheries and Oceans Canada will review any proposed alteration under Section 35 of the *Fisheries Act* (as the law is currently applied). The provincial Ministry of Forests, Lands and Natural Resource Operations will review under Section 9 of the *Water Act* and/or Section 7 of the Water Regulation. The expected review process and the specific requirements of any approval documents will depend on the nature and extent of the proposed alterations.