Comox Valley REGIONAL DISTRICT

Staff Report

DATE: September 15, 2022

FILE: 5600-01/Union Bay

TO: Chair and Directors
Electoral Areas Services Committee

Supported by Russell Dyson
Chief Administrative Officer

R. Dyson

FROM: Russell Dyson
Chief Administrative Officer

RE: **Union Bay Water Master Plan**

Purpose

To provide an overview of the Union Bay Water Master Plan.

Recommendation from the Chief Administrative Officer:

THAT the Union Bay Water Local Service Area Water Master Plan, final report dated September 8, 2022 be received;

AND FURTHER THAT in line with the reports principal findings staff utilize existing resources to work towards increasing existing treatment capacity, reducing system leakage and engaging in discussions with Union Bay Estates towards expanding water treatment capacity;

AND FINALLY THAT staff develop an implementation strategy for all recommended actions that includes analysis of timing, water rate implications and costs to be reflected in the 2023-2027 financial plan for the Union Bay Water Local Service Area.

Executive Summary

In October 2021, the Comox Valley Regional District (CVRD) retained Koers and Associates Engineering Ltd. to complete a Water Master Plan for the Union Bay Water Local Service Area. The draft plan was received in spring 2022 and reviewed over the summer by CVRD Engineering Services, Planning and Development Services and Fire Services. The final report is now complete and attached as Appendix A, and includes the following key findings:

- The water system is currently operating well within its annual water license withdrawal limits.
- The new Union Bay water treatment plant is very close to its capacity based on the max day demand experienced during the summer of 2021.
- The water system is currently losing a notably high amount of treated water (41 per cent) to non-revenue water sources (flushing, system leakage, etc.).
- Future development potential within the service area significantly exceeds the Langley Lake water license. Full or even partial future development potential will likely require a combination of reduced demand, increase storage and securing additional water supply sources.
- Several significant upgrades are ultimately required in order to increase system capacity over time, including:
    - Expansion of the water treatment plant and the McKay Rd reservoir
    - Water storage reservoir to service the existing 155m pressure zone
    - Creation of a 125m pressure zone
    - Watermain projects (upgrade of existing mains and installation of new mains)

- Additional hydrological assessment of Langley Lake must be completed to better understand the maximum number of properties that could be serviced based on the current available storage volume and include an assessment of the potential impacts of climate change.

Developing and implementing a strategy and action plan to address all of the report's findings will be completed in stages as part of future work plan and financial plan updates. However, staff feel that some work can progress more quickly and recommend utilizing existing staff resources and funding to immediately action the following:

1. Increase capacity of the current water treatment plant. The report finds that there may be an opportunity to increase the maximum treatment capacity by 10 to 15 per cent during the summer months when raw water quality is typically better in Langley Lake. CVRD staff will work with Island Health and the treatment plant manufacturer to investigate this potential. Any significant required equipment upgrades can then be considered for budget amendment or inclusion in future financial plans.

2. Reduce system leakage and flushing (non-revenue water). The report finds that system leakage and flushing accounts for 41 per cent of water system demand in 2021 and that by eliminating flushing (if possible), non-revenue water demand could be reduced to 34 per cent. CVRD staff will evaluate if chlorine residuals can be maintained through the system, without flushing, now that the water treatment plant is in operation.

3. Initiate discussions with stakeholders on the installation of a second Dissolved Air Flotation (DAF) treatment plant. Expansion of the water treatment plant should be initiated immediately to ensure insufficient water treatment capacity doesn't delay development in the service area. CVRD staff to initiate discussions and develop a plan for installation of a second treatment plant.

Prepared by:	Concurrence:	Concurrence:
C. Leimert	***K. La Rose***	***M. Rutten***
Caley Leimert, EIT Engineering Analyst	Kris La Rose, P.Eng. Senior Manager of Water/Wastewater Services	Marc Rutten, P.Eng. General Manager of Engineering Services

Government and Community Interests Distribution (Upon Agenda Publication)

K'ómoks First Nation	✔
Union Bay Estates	✔
Upper Island Developments	✔

Background/Current Situation

As detailed in the September 29, 2021 staff report titled "Union Bay Water Service Budget Amendment – Water Master Plan," the Comox Valley Regional District retained Koers and Associates Engineering Ltd. to complete a Water Master Plan of the Union Bay Water Local Service Area.

Staff received the completed draft document on March 31, 2022. The document contains significant technical detail and its conclusions and recommendations impact multiple services within the CVRD. Staff representatives from Engineering, Planning and the Fire Services have had several meetings over the last few months reviewing the key findings and recommendations and discussing impacts on the service areas in the future. Engineering Services staff also have had multiple meetings and correspondence with Koers regarding additional water system modeling for fire flows, updated GIS mapping and analysis, and additional hydrology information.

Non-Revenue Water
Non-revenue water is treated water that is not paid for and consists of authorised unbilled use (such as watermain flushing), apparent losses (such as water theft) and real losses (such as system leakage). In 2021, the amount of non-revenue water was notably high at 41 per cent compared with an anticipated range of between 20-30 per cent typical of similar water systems. Addressing this issue is the key recommendation in the Water Master Plan and staff are looking at ways to reduce non-revenue water in the system such as modifying the auto flushing valves.

Water Treatment Plant Capacity
A recent max day demand of 1320m^3/day occurred on July 20, 2020, which exceeded the water treatment plant design capacity of 1,200m^3/day. Staff are actively investigating the possibility to increase the capacity of the water treatment plant by 10-15 per cent by completing system upgrades. Given the length of time required to build the second phase of treatment, it is recommended to initiate planning for the phase 2 expansion of the water treatment plant.

Langley Lake Hydrology and License Capacity
Several reports on the hydrology of Langley Lake have been completed since the 1990s, but many rely on assumptions due to unknown information. Koers has reviewed these reports, available bathymetry and recorded lake levels. Although there are no immediate concerns with the hydrology of Langley Lake, a hydrological study is recommended prior to expansion of the water treatment plant beyond the phase 2 expansion currently planned, to review future development's impact on the lake level and incorporate climate change considerations.

Future Development and Required Infrastructure
The development potential within the Union Bay Water Local Service Area significantly exceeds the existing Langley Lake water license. In order to model what upgrades to the water system are required to service the known potential developments, Koers made assumptions on where and how development would occur up to the water license amount. This modelling scenario is not a commitment of a water license allocation to developers and will need to be revised in future versions of the Water Master Plan as development occurs according to the Official Community Plan and rezoning applications. While the Water Master Plan puts a strong emphasis on water conservation and reducing per connection demand, it's important to note that infill development could increase the per connection demand, further necessitating the importance of revising the Water Master Plan in the future.

By identifying the required infrastructure to service the larger developments (including expansion of the water treatment plant), CVRD staff will be able to negotiate with developers on the appropriate contributions and timing required as development applications are refined.

Upgrading existing levels of service for provision of improved fire flows
The Master Municipal Construction Document (MMCD) Association provides design guidelines that standardise the design and construction of municipal infrastructure in British Columbia that can be adopted by municipalities and local governments. Koers is recommending significant upgrades over time to the existing water system to provide a level of service consistent with the MMCD design guidelines for providing fire flows for the entire Union Bay Water Local Service Area. While these upgrades will occur over time with scheduled replacements, there will be cost implications to

existing service members. There are no legal requirements to provide MMCD design guideline fire flows, but it is considered to be a best practice that Koers is obligated to recommend.

While staff agree committing to MMCD design guidelines for fire flows within the Union Bay settlement node is consistent with the Rural Comox Valley Official Community Plan, staff don't believe that committing rural areas outside the settlement node to such a level of service is advisable. If future infrastructure replacements outside the settlement node are sized to meet the MMCD design guideline fire flows (150LPS) for the three Industrial/Commercial/Institutional (ICI) zoned properties outside of the settlement node, this would drive costly upgrades to the McKay Road Reservoir and associated watermains that would otherwise be not nearly as significant. Staff rather recommend that areas outside the settlement node would still be upgraded where fiscally achievable, but to supply a lesser standard (60-90LPS) that in CVRD staff's opinion is more appropriate with its rural context and would avoid significant costly upgrades benefiting only a few properties.

The CVRD Fire Services has noted some difficulty servicing some larger residential developments that may not always have fire suppression or "sprinkler" systems. Staff reviewed the possibility of enforcing the installation of sprinklers on certain buildings, but under Section 5 of the Building Act, if a matter is addressed by the BC Building Code (such as sprinkler systems) then any local government bylaw for that matter has no legal force. To assist Fire Services, Engineering Services staff intend to eventually upgrade areas outside the settlement node to a standard that will at minimum meet the MMCD Design Criteria for residential properties (60LPS). The few ICI properties outside the settlement node would still have the opportunity to qualify for reduced fire insurance rates with the installation of fire suppression or "sprinkler" systems.

Its worth mentioning that the Water Master Plan only attempts to provide MMCD fire flows for the residential properties (60LPS) in the highest portions of the system (both within and outside of the settlement node) upon the construction of a third reservoir, which is also required to service the upper portions of all major proposed developments with the exception of phase 1 of UBE.

Options

The committee has the following options regarding the future level of service of the Union Bay Water Local Service Area.

1. Direct staff to implement recommendations in the Water Master Plan where possible with existing staff resources and to begin developing detailed financial plan impacts of full adoption to be included within the 2023-2027 financial plan for the Union Bay Water Local Service Area.
2. Direct staff to only implement recommendation in the Water Master Plan where possible with existing staff resources.

For effective use of rate payer revenue, and to continue planning for significant development, Option 1 is recommended.

Financial Factors

Implementing the report's recommendations comes with significant financial consideration for the service. This staff report recommends utilizing existing resources and funding to begin work on some of the more immediate needs, followed by the development of an implementation strategy for all recommended actions, which includes analysis of timing, water rate implications and costs to be reflected in the 2023-2027 financial plan for the Union Bay Water Local Service Area.

Strategic Considerations: Strategic Drivers and Regional Growth Strategy

CVRD Board Strategic Drivers:							
Fiscal Responsibility	✔	Climate Crisis and Environmental Stewardship and Protection	✔	Community Partnerships	✔	Indigenous Relations	✔

The CVRD Board has set four strategic drivers to guide service delivery and the Water Master Plan is in alignment with each of these drivers in the following ways.

Fiscal Responsibility

- Staff recommend to plan for compliance with MMCD design guidelines only within the Union Bay Settlement Node in order to reduce significant upgrades that would only benefit relatively few properties.

Climate Crisis and Environmental Stewardship and Protection

- The initiation of a hydrology study is recommended to better understand the ultimate source water capacity of Langley Lake.

Community Partnerships

- The Water Master Plan incorporates information on Langley Lake forwarded from the Baynes Sound Area Society for Sustainability, Mosaic Forest Management and Union Bay Estates.

Indigenous Relations

- K'ómoks First Nation has an interest in the development of DL7 and has shared their intentions with the CVRD to incorporate into the Water Master Plan.

CVRD Regional Growth Strategy Goals:							
Housing	✔	Ecosystems, Natural Areas and Parks	✔	Local economic development	✔	Transportation	
Infrastructure	✔	Food Systems		Public Health & Safety	✔	Climate Change	✔

Union Bay is one of the three settlement nodes identified by the Regional Growth Strategy (RGS) to accommodate compact forms of development. MG Policy 1B-1 of the RGS states that growth in the settlement nodes shall be accommodated through a balance of new development, intensification and improvements to public infrastructure including the provision of appropriate water services.

By concentrating on reducing non-revenue water sources and staging watermain replacements over time, the Water Master Plan will provide affordable, effective and efficient infrastructure in balance with conserving water and energy resources.

By increasing the number of loops in the water system and increasing the available fire flows, the Water Master Plan supports a high quality of life through the protection and enhancement of community health through improved water quality and public safety through improved fire service capability.

A new watershed assessment of Langley Lake is recommended, which will incorporate climate change considerations and ensure that natural ecosystems are protected in balance with increasing local economic development and housing supply.

Intergovernmental Factors
K'ómoks First Nation has an interest in the development of DL7 and has shared their intentions with the CVRD to incorporate into the Water Master Plan.

Interdepartmental Involvement
Engineering Services is leading this work in consultation with Planning and Development Services and the Fire Services to evaluate the broader impacts of the Union Bay Water Master Plan's key findings and recommendations.

Citizen/Public Relations
Should the committee approve the recommendations within this report, a press release will be issued and a dedicated web page will be created

Attachments: Appendix A – Union Bay Water Master Plan

Appendix A

Union Bay
Water Local Service Area
-
Water Master Plan

FINAL REPORT

September 8, 2022

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September 8th, 2022
File: 2157-02

Comox Valley Regional District
770 Harmston Avenue
Courtenay, B.C.
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Attention: **Mr. Kristian La Rose, P.Eng.**
Senior Manager of Water/Wastewater Services

Re: Comox Valley Regional District
Union Bay Water Local Service Area Water Master Plan - FINAL REPORT -

Koers & Associates Engineering Ltd. is pleased to submit a pdf copy of our report entitled: Union Bay Water Local Service Area Water Master Plan – Final Report. The principal findings of the report are summarized below:

Water Supply Capacity

The Union Bay water system is operating well within its authorized licenced withdrawal limits. Over the past four years, the system's maximum day demand equated to only 16% of the licenced limit and the total annual demand equated to only 27% of the licenced withdrawal limit.

Water Treatment Plant Capacity

The water treatment capacity is operating at or close to its design capacity for one or more days during the dry summer months. Allowance was made during the design and construction of the water treatment plant for future expansion/duplication.

Revenue & Non-Revenue Water

Over the past four years, non-revenue water (water that is used and not paid for) averaged 31% of the total annual demand. For Year 2021, the first complete calendar year of operation of the water treatment plant, it was 41%.

Future Growth & Water Licence Limit

The water system presently services 691 properties and all have a metered connection. There are 256 existing properties that are not yet connected to the water system. If connected, this would increase the number of serviced properties by 37%.

Future development projects could add more than 5,400 service connections to the system. This would increase the number of properties serviced by almost 8 times. While the timeframe for this type of expansion is not known, it is expected to be in the range of the next 50 years or more and would likely be contingent on development of a sewage collection system to service (as a minimum) the properties within the Union Bay Settlement Node Boundary.

…/2

Comox Valley Regional District
Mr. Kris La Rose, P.Eng.

Based on the water systems current total annual demand (202,400 m^3/year) and the authorized licenced annual withdrawal limit (809,205 m^3/year), 1,846 additional service connections could be added to the system. Adding more connections beyond this would require:

- reduction in non-revenue water, 60% reduction in per connection annual demand, increased water treatment capacity, or
- increase in Langley Lake storage, increase in Langley Lake licenced storage and water withdrawal limits, increased water treatment capacity, or
- securing additional water supply source(s), or
- a combination of the above.

Langley Lake Ultimate Service Capacity
The last hydrologic assessment of Langley Lake was carried out in 2009 and included only a preliminary monthly water balance. A new hydrologic study should be carried out to assess the maximum number of properties that could be serviced based on the current available storage volume and include an assessment of the potential impact of climate change.

Water System
Upgrading and expansion works have been identified and include:

- Expansion of the water treatment plant and the McKay Rd reservoir
- Water storage reservoir to service the existing 155 m pressure zone
- Creation of a 125 m pressure zone
- Watermain projects (upgrade of existing mains and installation of new mains)

We have appreciated the opportunity to be of service to the CVRD on this interesting assignment and we would be pleased to assist in the implementation of the recommendations in this report.

Yours truly,

KOERS & ASSOCIATES ENGINEERING LTD.

Chris Holmes, P.Eng.
Project Engineer

Mitch Brook, P.Eng.
Modelling Specialist

Matt Palmer, P.Eng.
Project Manager

Permit to Practice No. 1001658

Enclosure

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES BRITISH COLUMBIA

Union Bay
Water Local Service Area
Water Master Plan

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C Pump Curves
- Pressure Zone 155

C Water Treatment Plant Site Plan

1 INTRODUCTION

1.1 Authorization

The Comox Valley Regional District (CVRD) authorized Koers & Associates Engineering Ltd to prepare a Water Master Plan for the Union Bay Water Local Service Area (WLSA). The study work was to be carried out in accordance with our proposal dated April 30, 2021.

1.2 Study Need

On July 1, 2021, the Union Bay Improvement District was dissolved and operation of the water system was transferred over to the CVRD and became the Union Bay Water Local Service Area. The service area boundary of the water system is shown in **Figure 1** and encompasses approximately 15 km^2.

There are a number of large development projects being proposed for lands within the Union Bay WLSA and the CVRD needs to understand what impact these developments would have on the existing water supply and distribution system.

1.3 Study Objectives

The primary objectives of this Water Master Plan are to:

- Examine historical meter data and compare current system demands to available water supply capacity,
- Review current annual demands, per connection demands and the water system's percentage of non-revenue water, compare them with those of other fully metered water systems on Vancouver Island and if they are considered to be high, assess potential reduction targets.
- Perform water modelling on the existing system and identify upgrading works necessary to meet current design standards,
- Develop future water demands based on a defined level of growth (provided by the CVRD), and compare future demands to the existing Langley Lake licenced withdrawal limits,
- Perform water modelling and identify upgrading works necessary, if any, to accommodate the future development up to the existing licenced withdrawal limits.

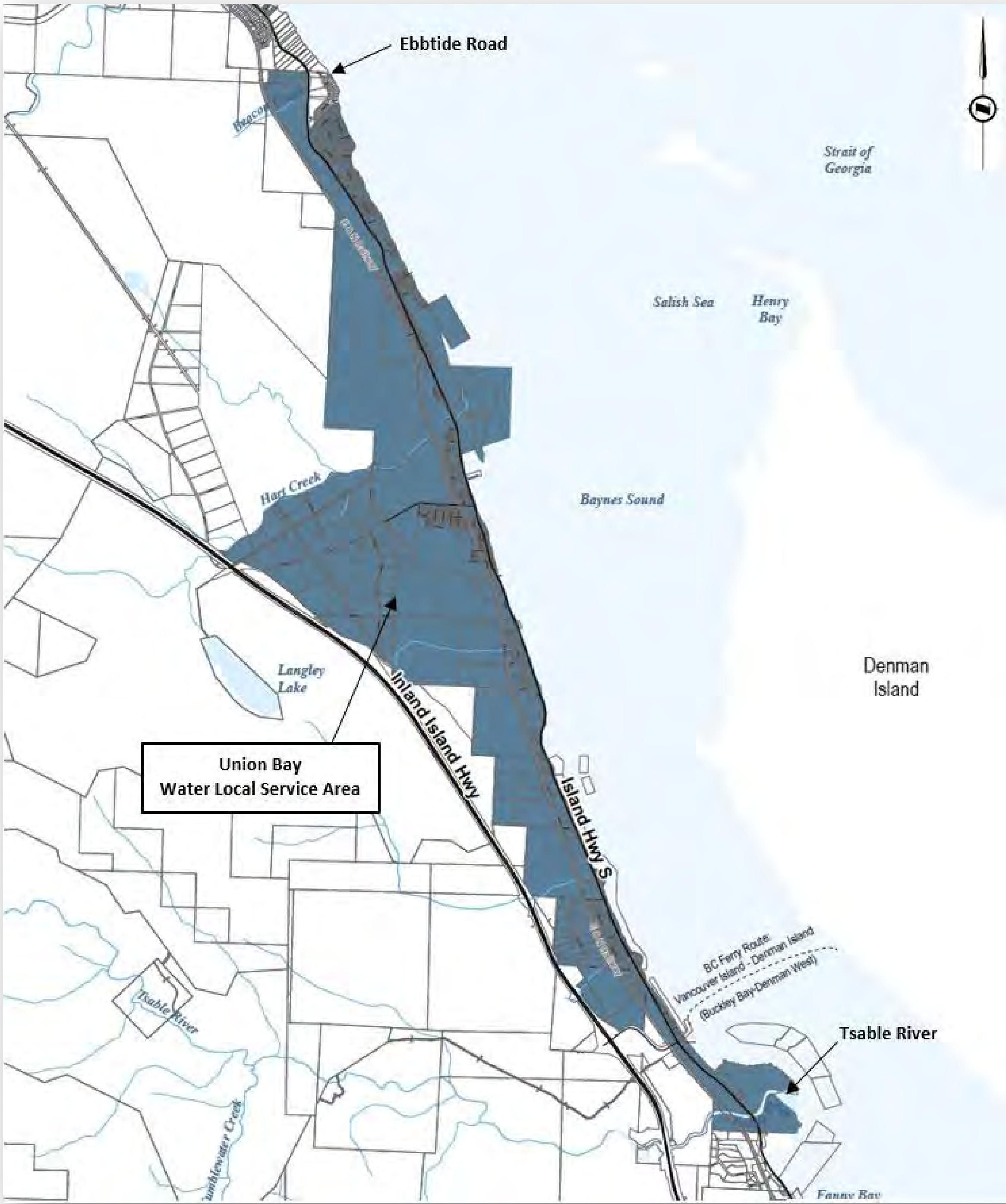


Figure 1 – Union Bay Water Local Service Area Boundary

1.4 Tasks

The tasks carried out during preparation of this Water Master Plan include the following:

1 Water System Overview

i) Overview of the existing surface supply, lake intake, raw water supply main, treatment, treated water storage reservoirs, pressure reducing valves, booster pumps, distribution piping, and pressure zones.

ii) Development of a Schematic Water System Map of the entire system which shows these existing system components as well as the pressure zone boundaries.

2 Current Water Demands

i) Detailed review of the existing bulk and individual water meter records to establish current demands and estimate the level of system leakage occurring within the distribution system at this time.

ii) Review of water treatment plant design capacity against historical peak day production records to estimate the available capacity of the existing water treatment equipment.

iii) Review historical peak day production records and compare to the current water license withdrawal limit.

3 Existing Distribution System Modelling

i) Develop a computer model of the existing water distribution system.

ii) Carry out modelling to calculate system pressures under peak hour demands and available fire flows under maximum day demands.

iii) Calculate the current treated water reservoir storage volume in the distribution system and compare it with the recommended minimum reservoir storage volume.

iv) Available fire flow and peak hour pressure maps will be produced for the entire water system.

v) A schematic plan showing the proposed improvement works will also be provided.

4 Future Growth & Demand Projections

i) Summarize future growth projections associated with infill of existing service areas and the proposed land development projects that are currently under review (Union Bay Estates, Upper Island Developments & District Lot 7).

ii) Estimate future demands attributed to infill within the existing service areas and to the proposed land development projects.

iii) Approximate where future growth will occur and distribute these demands throughout the water system model to estimate this future demand condition.

5 Future Distribution System Modelling at Water Licence Limit

i) Add the future demands to the water distribution system model.

ii) Carry out modeling to calculate system pressures under peak hour demands and available fire flows under maximum day demands.

iii) Carry out an assessment of treated water storage volume capacity compared to the recommended minimum volume when system demands reach the withdrawal limit of the existing water licence.

iv) Available fire flow and peak hour pressure maps will be produced for this future demand condition.

v) A plan showing the proposed improvement works (if needed) will be provided.

1.5 Reference Documents

In the preparation of this report, several published documents were utilized, which are listed in **Table 1**.

Table 1 – Reference Documents

No.	*Document Description*	*Date*	*Author*
Union Bay Water System			
1	*Langley Lake Deep Water Intake Inlet*	*2022 Mar*	*CVRD Staff email*
2	*Union Bay Improvement District Conversion Study, Final Draft*	*2020 Sep*	*Urban Systems*
3	*Union Bay Improvement District, Annual General Meeting, Public Works Report*	*2017 to 2021*	*UBID Public Works Superintendent*
4	*Kensington Union Bay Properties: Water Master Plan, Draft Report*	*2020 Feb 26*	*McElhanney*
5	*Source to Tap, Review of Union Bay Improvement District Water System*	*2019 Winter*	*Sonya Jenssen, MA*
6	*Union Bay Improvement District Then & Now – Union Bay, B.C.*	*2012*	*UBID Administrator*
7	*Langley Lake Storage Volume & Surface Area vs Water Surface Elevation*	*2010 Feb 22*	*McElhanney*
8	*Review of Hydrologic Reports and Preliminary Water Balance for Langley Lake, Union Bay, BC*	*2009 Nov 17*	*Summit Environmental Consultants Ltd.*
9	*Langley Lake Bathymetric Survey*	*2009 Oct 22*	*McElhanney*
10	*Langley Lake Dam Review & Inspection*	*2009 Jul*	*McElhanney*

No.	Document Description	Date	Author
11	*Union Bay Improvement District, Capital Plan Update Report, Draft*	2009 Feb 18	*McElhanney*
12	*Kensington Island Properties, Water Supply Options Report, Union Bay Resort Development*	2006 Jan	*CH2MHILL, EBA, Focus*
13	*Union Bay Resort Development, Kensington Island Properties, CPC Report, Supplemental Technical Summary*	2005 Sep 21	*Focus*
14	*The Unexpected in Dam Safety Failure of Langley Lake Dam, Union Bay (1912)*	n/a	*Marion Houston M.Eng., P.Eng. (Published in Canadian Dam Association Bulletin)*
	Water System Design Standards		
15	*MMCD Design Guidelines, 2014*	2014	*Master Municipal Construction Documents Association*
16	*Water Supply For Public Protection*	1999	*CGI Risk Management Services Fire Underwriters Survey, CGI Group Inc.*
	Proposed Development Plans		
17	*Upper Island Development Ltd. Proposed 18 Lot Subdivision, Lot 1 & 2, Sec. 6 (Proposed Forest Hill Rd & Ridge Rd)*	2021 July	*Charnell Consulting Inc.*
18	*Upper Island Development Ltd. Proposed 113 Lot Subdivision, DL 13*	2020 Oct	*Grant Land Surveying Inc.*
19	*Union Bay Estates, Design Guidelines*	2020 July	*Union Bay Estates*

1.6 Acknowledgements

Koers & Associates Engineering Ltd. acknowledges with thanks the assistance provided by the following CVRD Staff in the preparing of this report:

- Kristian La Rose, P.Eng. Senior Manager of Water/Wastewater Services
- Caley Leimert, EIT Engineering Analyst

2 WATER SYSTEM OVERVIEW

2.1 Water Supply, Langley Lake

The Union Bay water system obtains its water from Langley Lake. The lake is located beyond the top (west) end of McLeod Road on the west side of the Inland Island Hwy.

The lake intake pipe, dam, and raw water supply mains are owned, operated ,and maintained by the CVRD. Portions of this infrastructure are located within privately owned land, consisting of multiple managing stakeholders.

2.1.1 Catchment Area

The watershed catchment area for Langley Lake encompasses ±369 ha as reported by the CVRD from recent Mosaic Forest Management LIDAR data. Most of the catchment is located on the west side along with the highest ground elevation of ±446 m. To the east, the catchment area is much smaller and rises to an elevation of ±190 m. The approximate catchment area is shown in **Figure 2**.

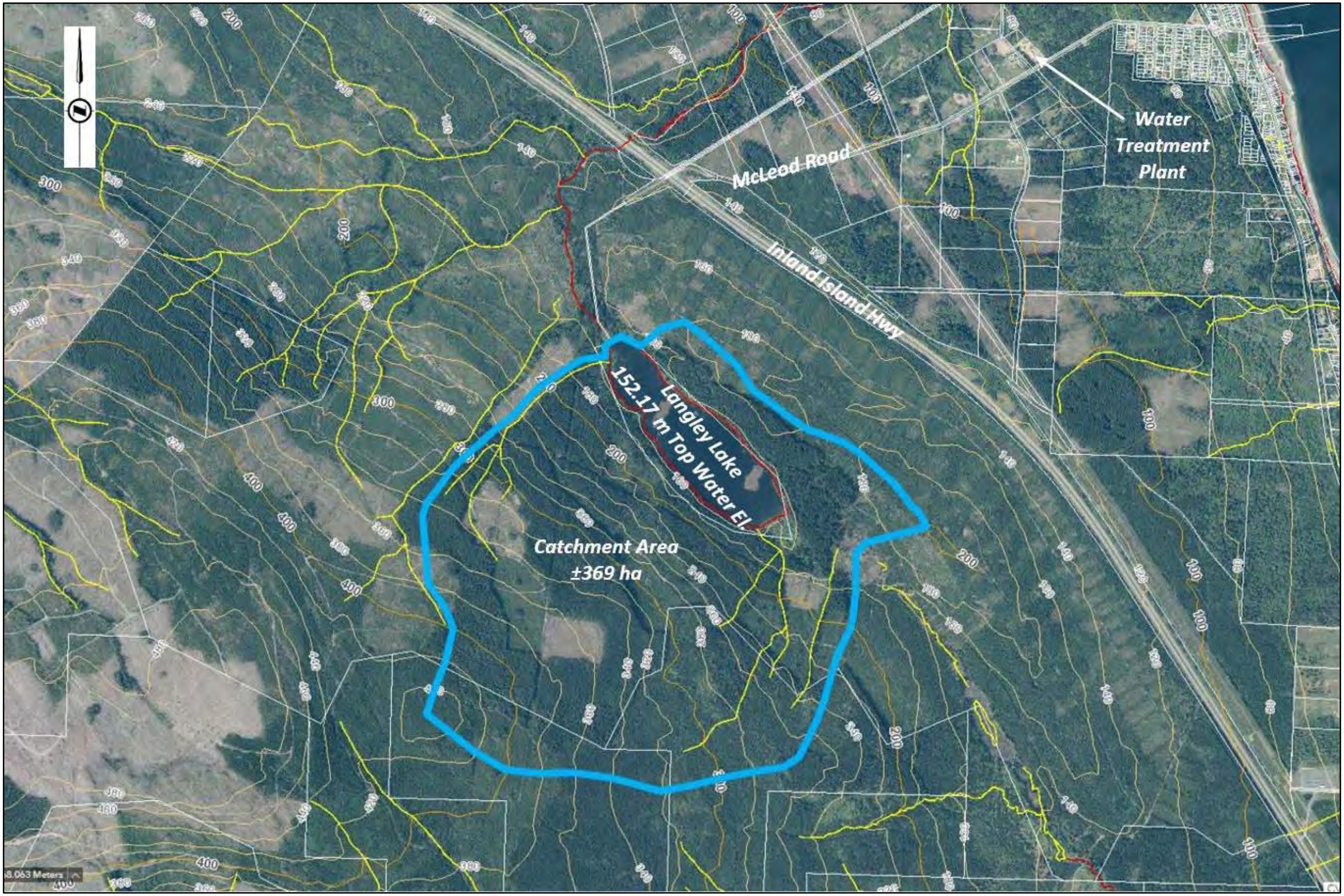
There are several watercourse/creeks that flow into the lake and the lake is also reported to be spring fed. A review of the watershed is not included in the scope of work of this assignment.

2.1.2 Dam

The first dam on Langley Lake was a 6.6 m high earth filled timber crib structure constructed in 1908. A pipeline conveyed water from the lake to the coal washers and screening system at the Union Wharf. In 1912, at 5 pm on February 10th, the dam burst and flooded the town and the colliery yards (coal mining buildings, equipment, etc.). The dam was subsequently replaced and in the 1940's it was reportedly upgraded. When the colliery closed in 1960, the dam along with the water mains servicing the town site were sold to the Union Bay Water Board which had previously been established seven years earlier (1953). The Union Bay Improvement District was incorporated by provincial Letters Patent on March 18, 1960.

In 1976 (45 years ago), the dam was reportedly rebuilt to improve embankment stability and increase its impoundment (storage) capacity. A concrete spillway, approximately 7.6 m (25 ft) wide x 1.2 m deep was added at that time.

Langley Lake Outlet Spillway (Crest El. = 152.17 m)
April 11, 2022



Base Image (2020 Airphoto with contours, legal, and streams) from CVRD iMap

Figure 2 - Langley Lake Catchment Area

2.1.3 Langley Lake Storage Volume

When full, the lake surface is ±1,200 m long and ±260 m wide, with a surface area of more than 310,000 m^2 (31 ha). The lake full level, when the water level reaches the dam spillway, is 152.17 m geodetic. The lake bottom at the deepest point has been estimated at 141.14 m geodetic, resulting in a maximum depth of just over 11 metres. The lake storage volume has been estimated to be 1,015,000 m^3.

Langley Lake from spillway looking southeast
Sep 6, 2022
water level 0.34 m below spillway invert

Gravity Flow Storage Depth & Volume

The lake has a reported operating depth of 2.47 m as calculated by the difference between the dam spillway invert elevation (152.17 m) and the elevation of the invert of the 300 mm dia. submerged intake main (149.7 m) as it transitions out of the lake and is buried on the east bank of the lake. This main exits the lake on the east side approximately 800 m south of the dam.

The 2.47 m of operating depth results in an estimated live storage volume of 629,000 m^3 based on a bathymetric survey completed on October 22, 2009 and partial ground elevation data around the lake between the then surveyed water surface elevation of 151.64 m, and the spillway invert elevation of 152.17 m (see reports in **Appendix B**). The estimated live storage volume does not include any water that may be available by siphoning.

Non-Gravity/Siphon Storage Depth & Volume

The storage depth between the invert of the submerged intake main (149.7 m) and the lake bottom (141.14 m), is 8.56 m and the storage volume is 386,000 m^3, based on the bathymetric survey completed on October 22, 2009 (see reports in **Appendix B**). Accessing this water requires the 300 mm dia. intake main to function as a siphon, which it would do provided there is not air in the main which would break the suction and stop the siphoning of water until the air was removed.

Prior to installation of the 300 mm dia. submerged intake pipe in 1998, water was withdrawn from the lake by the outlet pipe installed through the dam. The 1978 design drawing indicates this outlet to be a ±35 m long, ±450 mm dia. pipe with an invert elevation of ±147.37 m geodetic (±4.8 m below the spillway invert). The total storage volume for this 4.8 m depth is estimated to be 834,000 m^3. This volume is very close to and consistent with the licenced annual storage volume for Langley Lake of 888,100 m^3 which is discussed in **2.2.1 Langley Lake Storage Volume Licence**. It is not known whether the old outlet pipe is still connected and useable.

The calculated gravity flow and non gravity/siphon flow storage volumes and depths of Langley Lake are summarized in **Table 2**.

Table 2 – Langley Lake Storage Volume vs Water Level Elevation

Water Surface Elevation (m)	Submerged Intake		Dam Intake	
	Gravity Flow Storage (6) m^3	Non Gravity / Siphon Flow Storage (6) m^3	Gravity Flow Storage (6) m^3	Non Gravity / Siphon Flow Storge (6) m^3
152.17 (1)	629,000		834,000 (7)	
152	566,000		771,000	
151.5	417,000		622,000	
151	280,000		485,000	
150.5	157,000		362,000	
150 (2)	52,000		257,000	
149.7 (3)	0		205,000	
149		90,000	115,000	
148		165,000	40,000	
147.37 (4)		205,000	0	
147		225,000		20,000
146		275,000		70,000
145		315,000		110,000
144		355,000		150,000
141.14 (5)		386,000		181,000

Notes:

1. 152.17 m: Spillway crest invert elevation: Lake full.
2. 150.0 m: Top of 300 mm dia. submerged intake main where it leaves the lake.
3. 149.7 m: Invert of 300 mm dia. submerged intake main where it leaves the lake.
4. 147.37 m: Invert of ±450 mm dia. pipe through the dam.
5. 141.14 m: Lake bottom.
6. Storage volumes derived from Langley Lake bathymetric survey contours, Oct 22, 2009 and Langley Lake Area – Capacity Curve graph, Feb 22, 2010 (see copies in **Appendix B**).
7. This volume is very close to and consistent with the licenced annual storage volume for Langley Lake of 888,100 m^3.

The **Table 2** data is graphically shown in **Figure 3**.

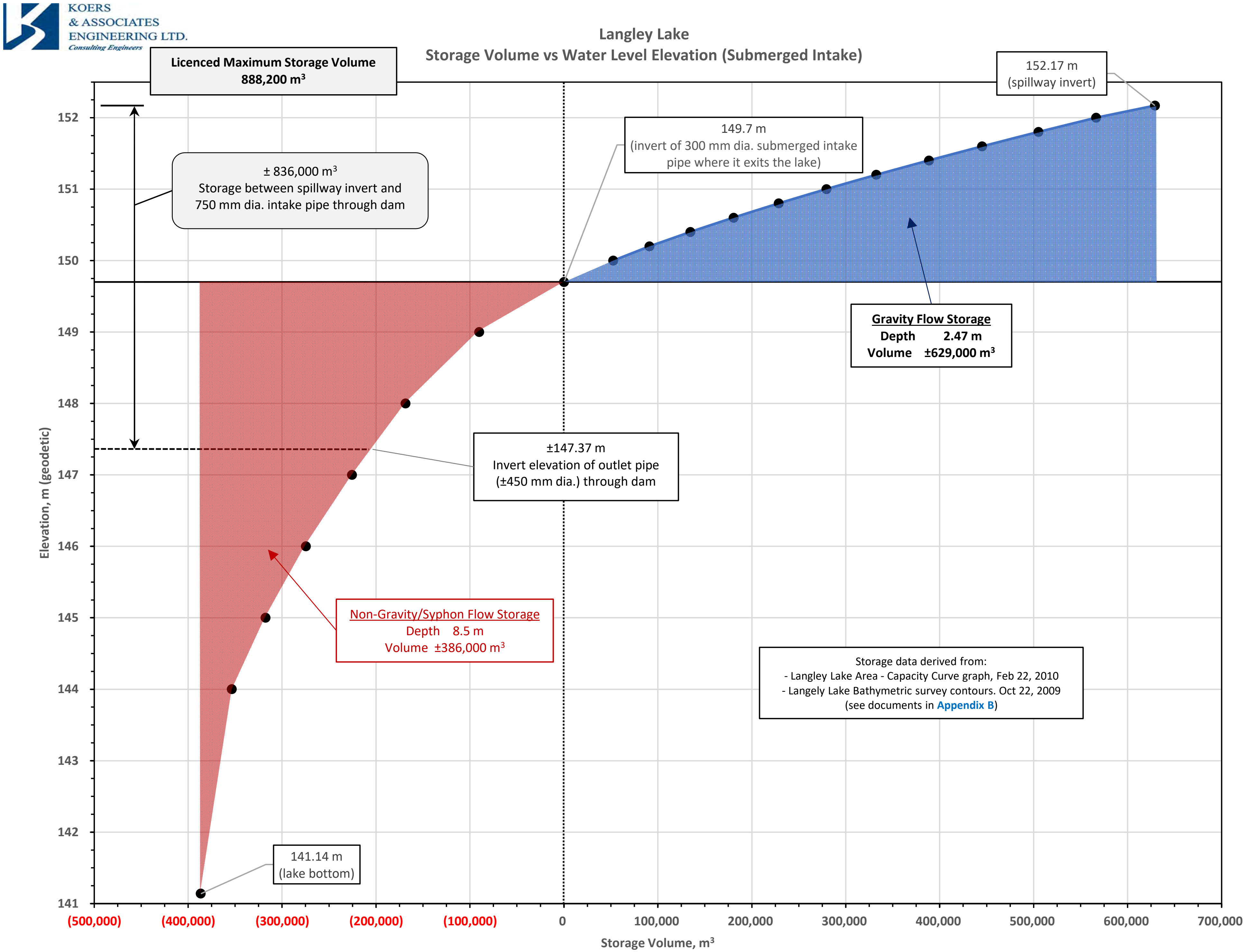

KOERS & ASSOCIATES ENGINEERING LTD.
Consulting Engineers
Langley Lake
Storage Volume vs Water Level Elevation (Submerged Intake)
Licenced Maximum Storage Volume
888,200 m³
152.17 m
(spillway invert)
± 836,000 m³
Storage between spillway invert and
750 mm dia. intake pipe through dam
149.7 m
(invert of 300 mm dia. submerged intake
pipe where it exits the lake)
Gravity Flow Storage
Depth 2.47 m
Volume ±629,000 m³
±147.37 m
Invert elevation of outlet pipe
(±450 mm dia.) through dam
Non-Gravity/Syphon Flow Storage
Depth 8.5 m
Volume ±386,000 m³
Storage data derived from:
- Langley Lake Area - Capacity Curve graph, Feb 22, 2010
- Langely Lake Bathymetric survey contours. Oct 22, 2009
(see documents in Appendix B)
141.14 m
(lake bottom)
Elevation, m (geodetic)
152
151
150
149
148
147
146
145
144
143
142
141
(500,000)
(400,000)
(300,000)
(200,000)
(100,000)
0
100,000
200,000
300,000
400,000
500,000
600,000
700,000
Storage Volume, m³

FIGURE 3

2.1.4 Langley Lake Water Levels

Langley Lake is reported to be full to overflowing beginning sometime in October, with the onset of the fall/winter rains. The lake typically remains full until sometime in April, with the arrival of warmer/drier weather, when the flow out of the lake exceeds the flow entering the lake, resulting in the water level dropping. A review of the manually recorded annual lowest water level for the past six years (2016 – 2021) showed:

- lowest recorded water level elevation (151.50 m) was last year (Sep 8, 2021),
- highest recorded water level elevation (151.83 m) was the previous year (Sep 11, 2020).

The reported maximum annual drawdown level in the lake for the past six years is presented in **Table 3**.

Table 3 – Langley Lake Lowest Annual Water Level, 2016 - 2021

Year	Draw Down below Spillway Crest m	Resulting Water Surface Elevation (m)	Date Recorded	Return to Lake Full Level	
				Date	No. of Days
2016	0.61	151.56	-	-	-
2017	-	-	-	-	-
2018	0.59	151.58	-	-	-
2019	0.58	151.59	Sep 13	Oct 23	40
2020	0.34	151.83	Sep 11	Oct 14	33
2021	0.67	151.50	Sep 8	Oct 15	37

Notes:

1. Year 2016 – 2020 from Union Bay Improvement District Annual General Meeting Public Works Reports.
2. Year 2021 data provided by CVRD staff.
3. Stage 1 water level restrictions are automatically implemented every year from May 1 to September 30.
4. Stage 2 water level restrictions are implemented when the water level elevation drops to 151.53 m (0.64 m below the spillway crest). Stage 2 has not been implemented since universal metering was implemented in 2004 as noted in Union Bay Improvement District Annual General Meeting Public Works Report, April 2019.
5. A water surface elevation of 151.64 m (0.53 m below the spillway crest) was recorded on October 22, 2009 during the bathymetric survey (see **Appendix B**).

2.1.5 Water Supply Main & Lake Intake

1908 to 1998

In 1908, the first supply main and dam was constructed. Sometime in the 1930's it was abandoned and replaced with a pumphouse which withdrew water directly from the Hart/Washer Creek. The pumphouse remained in use until ±1978/79 when a supply main (3,500 m of 200 mm dia. PVC) was installed along McLeod Road from 7th Ave to Langley Lake. The supply main connected the existing outlet pipe through the dam. The design drawing suggests the existing dam outlet pipe to be ±450 mm dia. Its material was not noted on the drawing.

1998 to Present

In 1998, the intake was relocated to a deeper area of the lake. The works consisted of ±600 m of 300 mm dia. PVC main installed along the east side of the lake followed by ±200 m of HPDE piping extending into the centre of the lake. The HDPE pipe lies along the bottom of the lake weighted down by concrete rings. The pipe is reported to end in the deepest part of the lake.

There is a 1m x 1m x 1m box attached to the end of the pipe. The box is perforated with holes which are reported to be dime size. The box is reported to be located just above the bottom of the lake.

In the summer of 2020 shortly after the new water treatment plant came on-line, the basket strainer on the raw water supply in the water treatment plant building was found to contain debris and small fish. The holes in the basket strainer are smaller dia. that the dime sized holes of the submerged intake. It is reported the pipeline and intake were last inspected by a diver on December 4, 2008.

2.2 Water Licences

There are four water licences issued to the CVRD for Langley Lake: two for water storage, and two for water withdrawal. These licences are discussed below.

2.2.1 Langley Lake Storage Volume Licence

There are two water licences issued for the storage of water in Langley Lake, both dating back more than 100 years, to Year 1913; the year before the start of World War I. The licenced maximum storage volume is 888,100 m^3 as noted in **Table 4**.

Table 4 – Langley Lake Licenced Storage Volume

Licence No.	Priority Date	Licenced Maximum Storage Volume m^3/year
C112815	Oct 29, 1913	197,350
C112817	Oct 29, 1913	690,750
	Total:	888,100

Historically, we understand the dam is typically full, with water flowing over the spillway for approximately 7 months of the year (October to April).

2.2.2 Langley Lake Withdrawal Licence

There are two water licences issued for the withdrawal of water from Langley Lake and both are dated the same as the two water storage licences (October 29, 1913). The licences authorize the withdrawal of a maximum of 809,025 m^3/year, which is slightly less than (91% of) the authorized maximum annual storage volume noted in **Table 4**. In addition, the licences limit the maximum amount of water that can be withdrawn from the lake on any day to 8,310 m^3/day.

A summary of the authorized withdrawal limits is presented in **Table 5**.

Table 5 – Licenced Withdrawal Limits, Total Annual and Maximum Day

Licence No.	Priority Date	Licenced Withdrawal Limit	
		Annual m^3/year	Maximum Day m^3/day
C112815	Oct 29, 1913	161,841	1,643
C112817	Oct 29, 1913	647,364	6,667
	Total:	809,205	8,310

2.3 Water Treatment

2.3.1 Raw Water Quality

Langley Lake is reported to be spring fed in addition to the creeks/drainage courses that drain into it from the surrounding watershed (see **Figure 2**). The lake has floating peat islands and the quality of the water changes throughout the year in response to the variation of flow into and out of the lake and the temperature of the water in the lake. The raw water at various times throughout the year has elevated colour, total organic carbon, turbidity, and occasionally elevated iron and manganese.

2.3.2 Water Treatment Process

In the fall of 2018, Union Bay authorized construction of a new water treatment plant and a treated water storage reservoir. They are both located at 490 McLeod Rd and were commissioned in May 2020. The treatment process consists of:

- pH adjustment (caustic soda addition, before and after Dissolved Air Floatation)
- Dissolved Air Floatation (Conventional Treatment)
- Rapid Gravity Media Filtration (sand and anthracite)
- Provision for Ultra Violet disinfection (if required at a later date), and
- Chlorination.

Conventional Treatment processes for reducing turbidity and naturally occurring organic matter typically consists of coagulation, flocculation and sedimentation followed by filtration. For Union Bay, Dissolved Air Floatation (DAF) was selected in place of sedimentation. DAF introduces a cloud a very small bubbles that carry the floc particles to the surface where they are skimmed off. While effective at removing organics, conventional treatment processes including filtration can generate significant water and waste streams that need to be disposed of. Provision for a future ultraviolet (UV) disinfection was incorporated into the design in case future standards change or become more stringent and require additional barriers of treatment.

Water Treatment Plant Building, Exterior

2.3.3 Treatment Equipment Capacity

The existing treatment equipment has a rated design flow capacity of 14 lps (1,210 m^3/day). When the treatment equipment was tendered (April 2017), quotations for three design flows were requested:

- 14 lps – Single Train
- 28 lps – Dual Train (14 lps each)
- 28 lps – Single Train

The 28 lps flow rate was based on an estimated build-out Max Day Demand of 27.3 lps (2,360 m^3/day) that was established at that time.

Shortly after tendering the equipment, UBID staff assembled and analyzed the most recent (2017) water system demand data. The 2017 data showed a reduction in demands compared to previous years records. It was understood that the reduction was due to a concentrated effort to identify and repair significant watermain leaks that were occurring in the distribution system. For Year 2017, the Maximum Day Demand (MDD) was 9.8 lps (850 m^3/day). This was notably lower than the treatment equipment minimum design capacity of 14 lps and lower than other years maximum day demands.

After careful consideration of the previous years maximum day demands and the maximum day demand of 2017, UBID elected to base the selection of the water treatment equipment using the most current data available (Year 2017). In addition, UBID was committed to reducing water demands even further by maintaining a leak reduction and repair program, and UBID staff suspected the existing bulk flow meter at the McLeod Reservoir was reading high, resulting in elevated demand data.

The tender bid for a 14 lps – Single Train treatment system was selected by UBID. Expansion of the treatment capacity would be implemented, if and when needed, to meet future development requirements. Provisions were made in the final design for increasing the water treatment capacity by expansion of the existing building on its west side and the addition of a 2nd treated water storage reservoir in the future.

Water Treatment Plant Building, Interior

2.4 Water Storage Reservoirs

The Union Bay water system has two existing treated water storage reservoirs in the distribution system. These are referred to as the McLeod Road and the McKay Road Reservoirs. The locations of the two reservoirs are shown in **Figure 4** and their physical characteristics are summarized in **Table 6**.

Table 6 – Water Storage Reservoir Characteristics

Reservoir	Year Built	Shape	Type	Dia. (m)	Height (m)	Volume (m^3)	Top Water El. (m)	Floor El. (m)
490 McLeod Rd	2020	Circ	GLBS	13.0	13.0	1,730	92.0	79.0
510 McKay Rd	1995	Rec	RConc	-	3.7	300	74	70.6
Total Storage Volume:						2,030		

Notes:

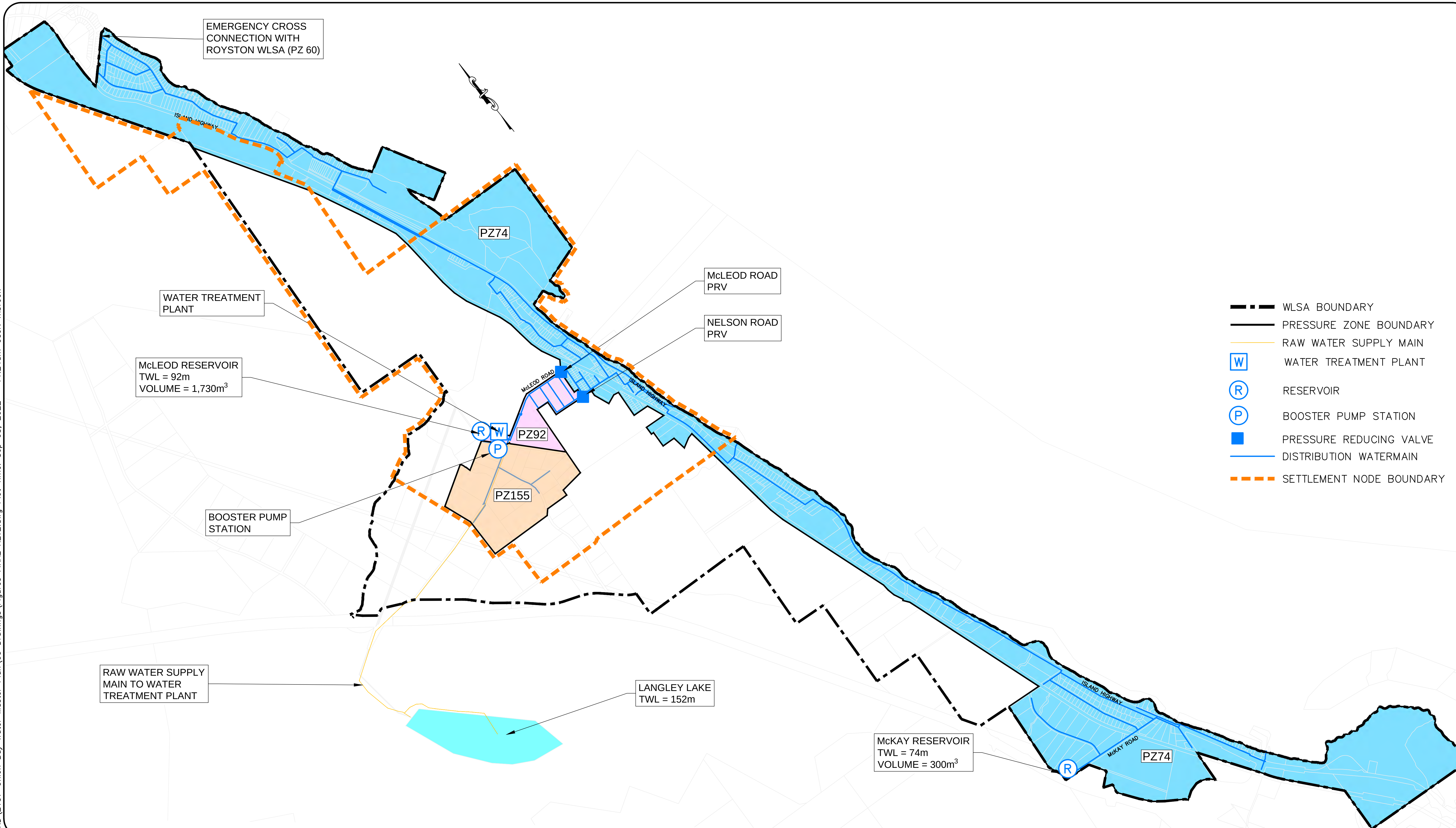
Circ = Circular GLBS = Glass Lined Bolted Steel
Rec = Rectangular RConc = Reinforced Concrete

2.4.1 McLeod Road Reservoir

The McLeod Road treated water reservoir (located at 490 McLeod Road) is a circular glass-lined-bolted-steel reservoir that was constructed in 2020.

The reservoir replaced a partially below ground rectangular reinforced concrete reservoir (located at 451 McLeod Road) that had a Top Water Level (TWL) of approximately 74.0 m. The new reservoir resulted in a higher TWL (92.0 m) and increased system pressure between 5th Street and 8th Street by 175 kPa (25 psi). The old concrete reservoir (located at 451 McLeod Road) was taken offline.

Treated Water Storage Reservoir
490 McLeod Road
Top Water El. = 92 m



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CLIENT: COMOX VALLEY REGIONAL DISTRICT

PROJECT: UNION BAY LOCAL SERVICE AREA WATER MASTER PLAN

TITLE: UNION BAY EXISTING WATER SYSTEM

APPROVED	MP	SCALE	1: 30,000
DATE	SEP 2022	DWG No.	FIGURE 4
PROJECT No.	2157		

File: H:\1014 Comox Valley RD\2157 Union Bay Water Master Plan\03 Drawings\Figures FINAL REV2.dwg Plot Time: Sep 08, 2022 - 11:24am User: mbrook

2.4.2 McKay Road Reservoir

The McKay Road reservoir is a rectangular, reinforced concrete reservoir that is a mostly below ground and located in a Statutory Right-of-Way on private property (510 McKay Rd) at the top (west) end of the McKay Road. The roof and 0.6 m of the sides are above ground and 3.5 m is buried. The reservoir was constructed in Year 1995.

It is understood that the altitude valve at the reservoir is not functioning very well and flows into the reservoir are presently being controlled by a partially opened 25 mm dia. ball valve. The flow entering the reservoir is constricted in an effort to reduce the frequency and duration of the reservoir over filling, resulting in water flowing out the reservoir overflow.

Treated Water Storage Reservoir, 510 McKay Road, Top Water El. = 74 m

2.5 Distribution System

The service area of the Union Bay WLSA (see **Figure 1**) encompasses approximately 15 km^2. It is almost 14 kms long, from the Tsable River in the south to Ebbtide Road in the north, and almost 3 km wide at its widest, from the Inland Island Hwy in the west to the Baynes Sound foreshore in the east.

2.5.1 Watermains

The Union Bay water distribution system consists of approximately 30.3 kms of watermain piping and 691 water service connections. All the water services are metered. The extent of the existing water supply and distribution system infrastructure is shown in **Figure 4**. A breakdown of the piping by material and diameter is presented in **Table 7**.

Table 7 – Pipe Lengths by Material and Diameter

Dia. mm	Pipe Length (m)			Total
	PVC	AC	Other	
300	517	-	-	517
250	1,265	-	-	1,265
200	7,059	9,653	-	16,712
150	1,173	6,221	-	7,394
100	806	1,808	-	2,614
< 100	1,462	-	390	1,852
Total	12,282	17,682	390	30,354

Dia. Mm	Pipe Length as % of Total			Total
	PVC	AC	Other	
300	2 %	-	-	2 %
250	4 %	-	-	4 %
200	23 %	32 %	-	55 %
150	4 %	20 %	-	24 %
100	3%	6 %	-	9 %
< 100	5 %	-	1 %	6 %
Total	41 %	58 %	1 %	100 %

2.5.2 Water System Pressure Zones

There are three pressure zones in the Union Bay water distribution system service area. They are referred to as:

- Boosted Pressure Zone (PZ 155),
- Upper Pressure Zone (PZ 92), and
- Lower Pressure Zone (PZ 74).

The area serviced by each pressure zone is shown in **Figure 4**. A description of each pressure zone is presented below.

Booster Pump Pressure Zone (PZ 155)

Original Booster Pump Station (at McLeod Road Reservoir)

This pressure zone was originally serviced by a booster pump station located adjacent to, and withdrawing water from, the now abandoned McLeod Road reservoir. The station was equipped with two booster pumps (Grundfos, model: CR-4) with one pump operating continuously. The booster pump(s) pumped into a 100 mm diameter watermain on McLeod Road that serviced properties along McLeod Road west of the reservoir, back towards Langley Lake (ending just before Murray Ave) as well as properties along Musgrave Road and Green Ave. A system pressure of 470 kPa (68 psi) was reported at the end of Green Ave.

New Booster Pump Station (at Water Treatment Plant)

With the construction of the water treatment plant and its treated water storage reservoir (and the subsequent decommissioning of the McLeod Road reservoir), the PZ 155 booster pump station was relocated to inside the water treatment plant building.

The booster pump station consists of three Grundfos model CR-5 pumps that are capable of supplying domestic flows. The pumps obtain water from the outlet line of the water treatment plant reservoir and pump into the 100 mm dia. watermain along McLeod Road.

As requested by the then operators of the water system (UBID) when the station was being designed, there is always one pump operating continuously. A system pressure of 550 kPa (80 psi) is reported at the end of Green Ave. This is an 80 kPa (12 psi) increase from the original (previous) booster pump station. Each pump is designed to provide a flow of 4 lps against a total dynamic head of 76 m (745 kPa / 108 psi). A copy of the pump curve is located in **Appendix C**.

Booster Pump Station (PZ 155)
Three Grundfos CR-5 Pumps

The current service area of the booster pump station (PZ 155) is shown in **Figure 4**.

Pressure Zone 155 is capable of servicing properties with a ground elevation up to 120 m geodetic, based on providing a residual pressure of 300 kPa (44 psi) at property line during peak hour demands. The booster pump station is not capable of supplying fire flow demands.

Upper Pressure Zone (PZ 92)

Pressure Zone 92 is fed from and controlled by the water level of the McLeod Road Reservoir. This pressure zone is the newest pressure zone in the distribution system as it did not exist prior to the start-up of the water treatment plant and construction of the McLeod Road Reservoir (top water level of 92 m).

The properties located within PZ 92 were previously serviced by the now abandoned concrete reservoir which had a top water level of 74 m. With the higher water level from the new reservoir, the distribution system mains and the customers within PZ 92 received a pressure increase of approximately 175 kPa (25 psi).

The current service area of this pressure zone is shown in **Figure 4**. It is capable of servicing properties with a ground elevation up to 57 m geodetic, based on providing a minimum residual pressure of 300 kPa (44 psi) at property line during peak hour demands.

Lower Pressure Zone (PZ 74)

The lower pressure zone (PZ 74) is fed from the upper pressure zone (PZ 92) and is created by two PRV stations at the following locations:

- Nelson Street at 4th Street
- McLeod Road at 4th Street

Each pressure reducing valve (PRV) station is housed in an above ground metal kiosk. The Nelson Street PRV station is equipped with a 200 mm dia. main valve and a 75 mm dia. bypass valve; one for low flows and the other for high flows. The McLeod Road PRV station is equipped with a 150 mm dia. main valve c/w integral low flow bypass. The characteristics of each of the four PRVs and their operating downstream pressures are presented in **Table 8**.

Table 8 – Pressure Relief Valve Station Characteristics

PRV Diameters (mm)	PRV Centreline Elevation (m)	Hydraulic Grade Line (m)		Static Pressure (psi)	
		Inlet	Outlet	Inlet	Outlet
McLeod Rd at 4th Street					
Low Flow	26.95	92.0	74.8	92.4	68
150	26.95	92.0	72.0	92.4	64
Nelson St at 4th Street					
75	51.32	92.0	74.6	57.8	33
200	51.32	92.0	71.0	57.8	28

The McLeod Road low flow bypass is set to open first, followed by the Nelson Street 75 mm dia. PRV. During larger demands, the McLeod Road 150 mm dia. PRV will open and would then be followed by the Nelson Street 200 mm dia. PRV.

The current service area of this pressure zone is shown in **Figure 4**. It is capable of servicing properties with a ground elevation up to 39 m geodetic, based on providing a minimum residual pressure of 300 kPa (44 psi) at property line during peak hour demands.

PRV Station – McLeod Rd at 4th St

PRV Station – McLeod Rd at 4th St (150 mm dia. & Low Flow)

PRV Station - Nelson St at 4th St

PRV Station - Nelson St at 4th St (200 mm dia. & 75 mm dia.)

3 CURRENT WATER DEMANDS REVIEW

3.1 Historic Demands

A detailed review of bulk and individual water meter records was carried out to establish historic demands by land-use and to estimate the amount of non-revenue water in the system.

Bulk water metering data spanning the following four year periods was reviewed:

- 2010 through 2013
- 2018 through 2021

There is 1.5 years of daily bulk metering data related to the operation of the water treatment, as it started operating on May 15, 2020.

3.1.1 Total Annual, Average Day & Maximum Day

A review of the available bulk meter records showed:

- The highest recorded total annual demand (286,700 m^3 - Year 2011) was 35% of the licenced annual withdrawal limit (809,000 m^3).
- Demands are highest in the summer months and lowest in the late fall/early winter months.
- Prior to the commissioning of the water treatment plant (May 2020), the highest recorded maximum day demand (2,502 m^3/day - Year 2010) was 30% of the licenced maximum day withdrawal limit (8,310 m^3/day).
- After the commissioning of the new water treatment plant (May 2020), the maximum day demand decreased and the highest recorded demand was in Year 2020 (1,320 m^3/day - July 20); equating to 16% of the licenced withdrawal limit (8,310 m^3/day).

Total annual, average day, and maximum day demands, for each year that was reviewed, are presented in **Table 9** and are shown graphically in **Figure 5**. Daily demands from 2010 through 2013 and 2018 through 2021 are shown in **Figure 6**.

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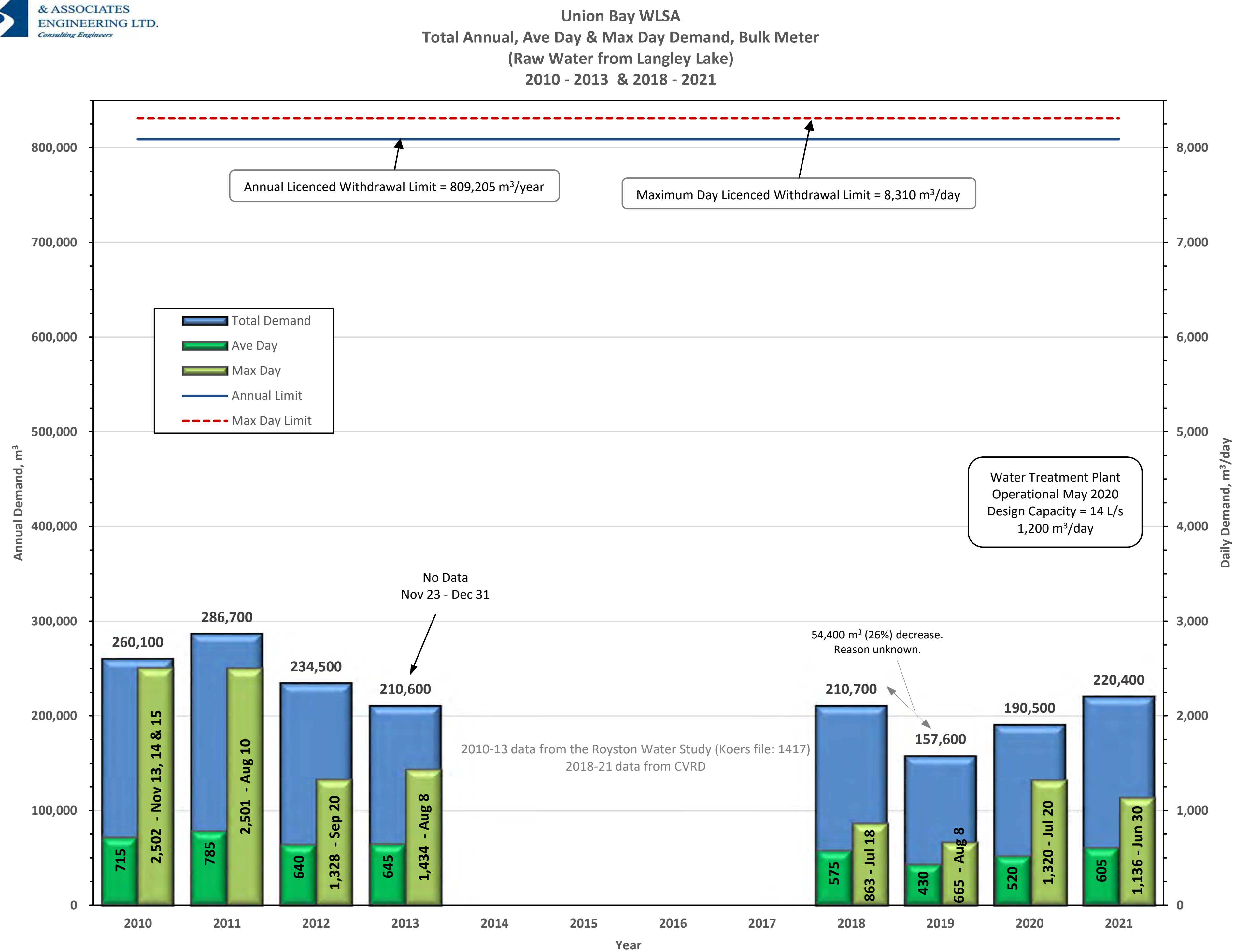

FIGURE 5

Union Bay WLSA
Daily Demand (Raw Water from Langley Lake)
2010 - 2013 & 2019 - 2021

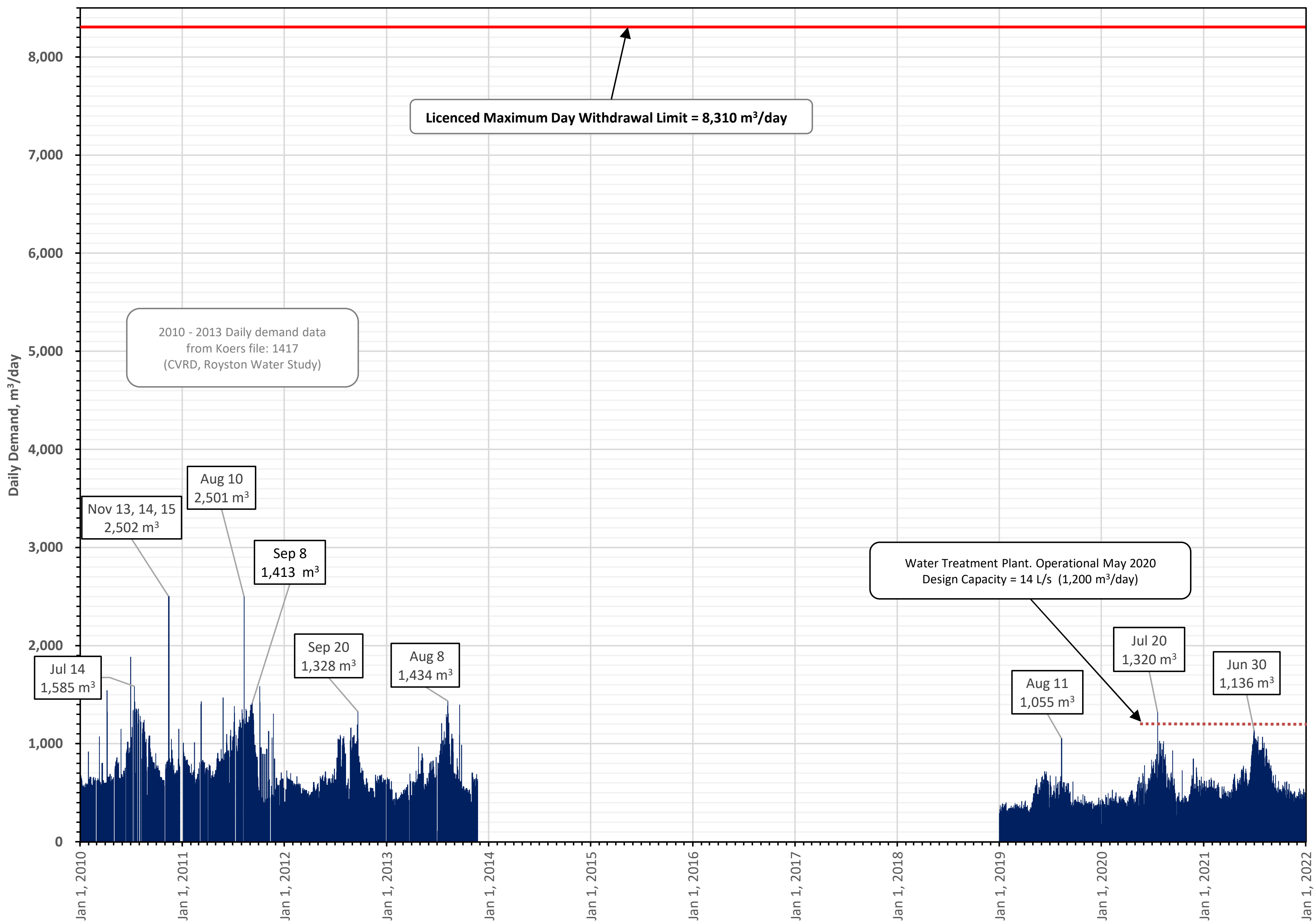

FIGURE 6

Table 9 – Annual, Ave and Max Day Demands, 2010 - 2013, 2018 - 2021

Year	Annual Demand m^3	Average Day m^3/day	Maximum Day		Max Day / Ave Day Ratio
			m^3/day	Date	
2010	260,100	715	2,502	Nov 13, 14, 15	3.51
2011	286,700	785	2,501	Aug 10	3.19
2012	234,500	640	1,328	Sep 20	2.07
2013	210,600	645	1,434	Aug 8	2.22
2018	210,700 (1)	575	863 (1)	Jul 18 (1)	1.50 (1)
2019	157,600 (2)	430	665	Aug 8	1.55
2020	190,500 (3)	520	1,320	Jul 20	2.54
2021	220,400 (3)	605	1,136	Jun 30	1.88
Licenced Withdrawal Limit (Water Licence C61430)					
-	809,000	2,217	8,310	-	-

Notes:

1 Year 2018 total annual and maximum day demand, as reported in the Union Bay Improvement District Annual General Meeting Public Works Report dated April 2019.

2 Year 2019 total annual demand is notably (±1/3rd) lower than the year before and the year after. The reason for this significant decrease could not be determined from the information available.

3 Water Treatment Plant commenced operation in May 2020, including a new bulk water flow meter. Annual demand is the calculated volume of water from Langley Lake. As of May 15, 2020, the Langley Lake volume is based on the difference between the water treatment plant inflow meter and the recycled water/rinse tank meter.

3.1.2 Monthly

The available data showed that the highest demand month was most often July, followed by August (2 times) and once in September and November.

The monthly total and monthly averaged day demands are presented in **Table 10** and graphically shown in **Figure 7** and **Figure 8**.

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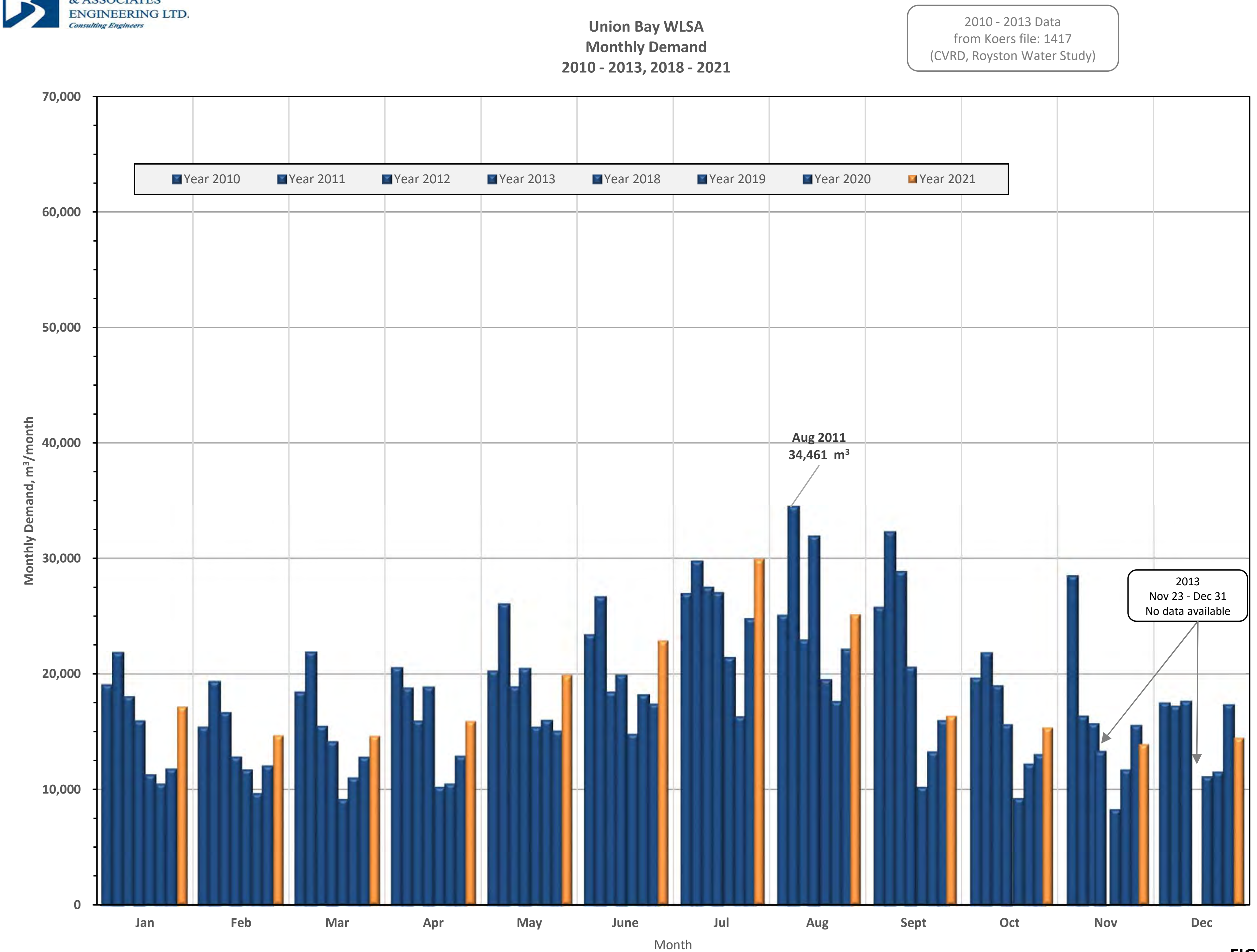
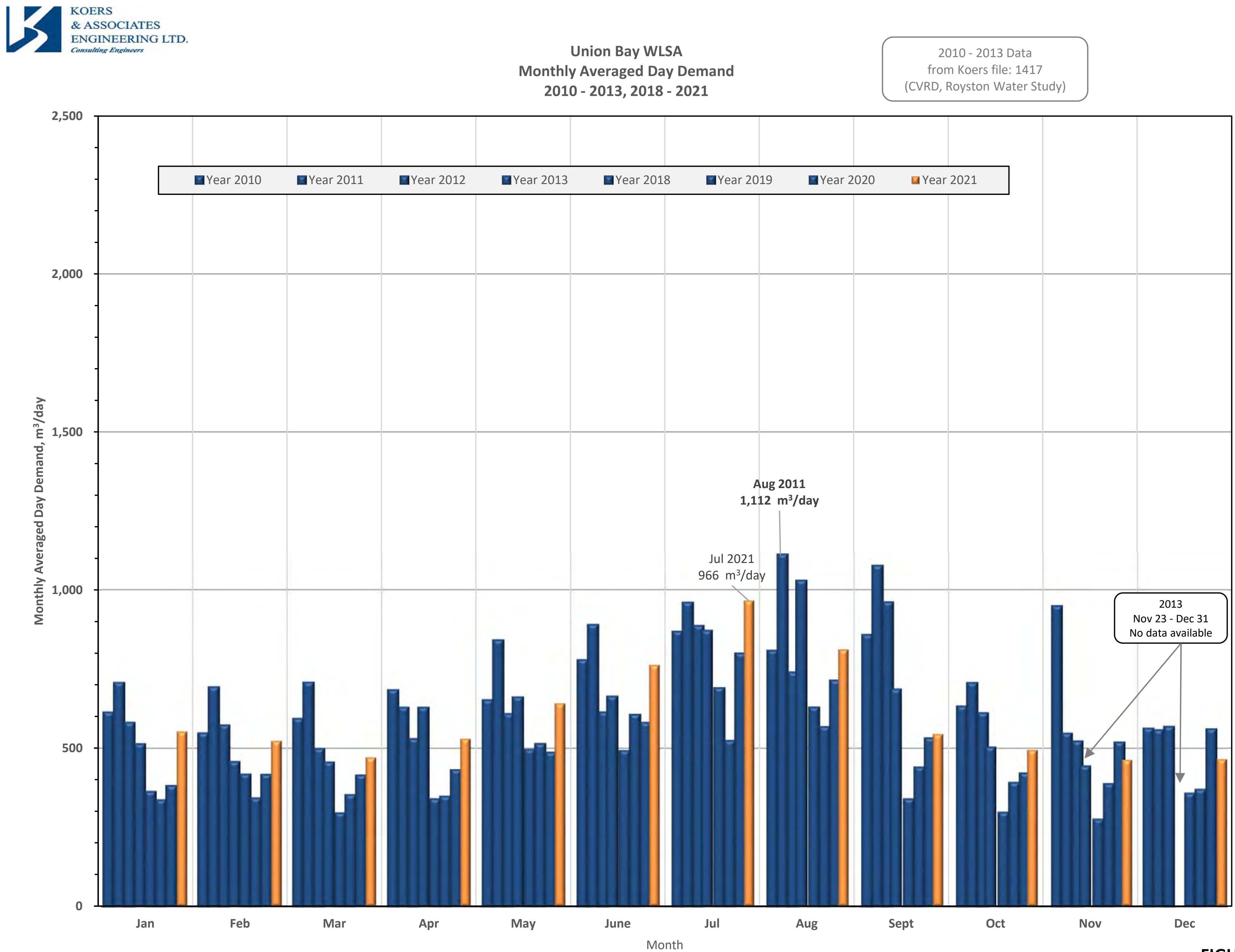


FIGURE 7



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Consulting Engineers
Union Bay WLSA
Monthly Averaged Day Demand
2010 - 2013, 2018 - 2021
2010 - 2013 Data
from Koers file: 1417
(CVRD, Royston Water Study)
Year 2010
Year 2011
Year 2012
Year 2013
Year 2018
Year 2019
Year 2020
Year 2021
Monthly Averaged Day Demand, m^3/day
2,500
2,000
1,500
1,000
500
0
Aug 2011
1,112 m^3/day
Jul 2021
966 m^3/day
2013
Nov 23 - Dec 31
No data available
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
Month

FIGURE 8

Table 10 – Monthly Demands, 2010 - 2013, 2018 - 2021

Month	Monthly Demand (1), m^3							
	2010	2011	2012	2013	2018 (2)	2019	2020 (3)	2021 (3)
Jan	19,000	21,900	18,000	15,900	11,200	10,400	11,800	17,200
Feb	15,400	19,400	16,600	12,800	11,600	9,600	12,000	14,700
Mar	18,400	21,900	15,400	14,100	9,100	10,900	12,800	14,600
Apr	20,500	18,800	15,900	18,900	10,100	10,400	12,900	15,900
May	20,200	26,100	18,900	20,500	15,300	15,900	15,000	19,900
Jun	23,400	26,700	18,400	19,900	14,700	18,200	17,400	22,900
Jul	26,900	29,700	27,500	27,000	21,400	16,200	24,800	29,900
Aug	25,000	34,500	22,900	31,900	19,500	17,600	22,100	25,200
Sep	25,700	32,300	28,800	20,600	10,100	13,200	15,900	16,400
Oct	19,600	21,900	18,900	15,600	9,200	12,100	13,000	15,300
Nov	28,500	16,400	15,700	13,300	8,200	11,600	15,500	13,900
Dec	17,500	17,200	17,600	n/a	11,000	11,500	17,300	14,500
Total	260,100	286,700	234,500	210,600	151,600	157,600	190,500	220,400

Month	Monthly Average Day Demand (4), m^3/day							
	2010	2011	2012	2013	2018	2019	2020 (3)	2021
Jan	615	705	580	515	360	335	380	555
Feb	550	690	570	460	415	345	415	525
Mar	595	705	500	455	295	355	415	470
Apr	685	630	530	630	340	345	430	530
May	655	840	610	660	495	515	485	640
Jun	780	890	615	665	490	605	580	765
Jul	870	960	885	870	690	525	800	965
Aug	810	1,110	740	1,030	630	565	715	810
Sep	860	1,075	960	685	340	440	530	545
Oct	635	705	610	505	295	390	420	495
Nov	950	545	520	445	275	385	515	465
Dec	565	555	570	n/a	355	370	560	605

Notes:

1. Total monthly demand rounded to nearest 100 m^3.
2. Year 2018 total annual demand of 151,600 m^3 is notably lower than the total annual demand of 210,700 m^3 reported in the Union Bay Improvement District Annual General Meeting Public Works Report dated April 2019. The reason for this significant difference could not be determined from the available information.
3. Water Treatment Plant commenced operation in May 2020. Monthly totals from May 2020 to Dec 2021 are the calculated volumes of water from Langley Lake based on the difference between the water treatment plant inflow meter and the recycled water/rinse tank meter readings.
4. Monthly averaged day demand rounded to nearest 10 m^3.
5. Orange shading indicate highest value for that year and blue shading indicates lowest value for that year.

6 **Bold red numbers** indicate **highest value** and **bold blue numbers** indicate **lowest value** of all of the years in each period reviewed.

7 In Year 2010, the notably high demand in November (28,500 m^3) was in response to a total demand of 7,506 m^3 for the three day period of Nov 13 – 15 (Saturday – Monday). This equates to an average daily demand of 2,502 m^3/day compared to the ±750 m^3/day the day before (Nov 12) and the day after (Nov 16). The cause for the more than tripling of the demand over the weekend could not be determined from the information available during the preparation of this Water Master Plan.

8 The Union Bay water system has a three stage water restriction schedule as follows:

- Stage 1 is automatically applied every year from May 1st to September 30th as indicated by the light yellow shading of months May through September in **Table 10**.
- Stage 2 is implemented when the water level in Langley Lake drops to elevation 151.53 m (0.64 m below the spillway crest). Stage 2 has not been implemented since universal metering was implement in 2004.
- Stage 3 is implemented when the water level in Langley Lake drops to elevation 150.95 m (1.22 m below the spillway crest).

The image below (from the CVRD's website), list the water strictions for the three stages.

Union Bay Water System Watering Schedule

Residential lawn and garden watering is permitted during the specified days and hours as follows:

STAGE	STARTS	HOURS	Mon	Tues	Wed	Thu	Fri	Sat	Sun
1	Starting May 1	5-8 am & 7-10 pm	No Watering	Even Address	Odd Address	Even Address	Odd Address	Even Address	Odd Address
2	When Notified	5-8 am & 7-10 pm	No Watering	Even Address	Odd Address	No Watering	No Watering	Even Address	Odd Address
3	When Notified	N/A	No Watering						

3.2 Property Demands

A detailed review of water demands by land-use was carried out using the individual meter reading records. Properties were assigned one of two categories:

- Single Family residential
- Institutional/Commercial/Industrial (I/C/I

Individual water meters are read approximately once every two months. A comparison of total annual demand, number of connections, and annual demand per connection for the past four years (2018 – 2021) is presented in **Table 11**.

Table 11 – Annual Demands by Land-Use, 2018 - 2021

Description	Year			
	2018	2019	2020	2021
Total Annual Demand, m^3 (1)				
Residential	132,100	114,500	119,500	122,900
I/C/I (2)	11,000	8,700	6,900	7,900
Combined Total	143,100	123,200	126,400	130,800
Number of Service Connections				
Residential	655	659	665	673
I/C/I (2)	19	19	19	18
Combined Total	674	678	684	691
Annual Demand Per Connection, m^3/connection (3)				
Residential	200	175	180	185
I/C/I (2)	580	455	365	440
Combined Total	210	180	185	190

Notes:

1. Rounded to nearest 100 m^3.
2. I/C/I = Institutional/Commercial/Industrial. This encompasses all properties that are NOT Residential.
3. Rounded to nearest 5 m^3.

3.2.1 Residential Properties

The following observations are made regarding metered demand for residential properties (**Table 11**) and from a detailed analysis of metered demands for Year 2021 which is graphically shown in **Figure 9**:

- Residential service connections account for 97% of all service connections.
- Residential demand accounts for approximately 94% of the total annual metered demand.
- For Year 2021 (**Figure 9**), the following observations were made:
  i) The average annual demand was 185 m^3/year per connection (total demand divided by the number of metered connections).
  ii) The median annual demand was 145 m^3/year (equal number of meters above and below this demand).
  iii) The combined demand of the 67 highest residential users (10% of the total) accounted for 29% of the total demand of all single family residential properties. These percentages are not unexpected and are consistent with several other similar (primarily residential) universally metered mid-Vancouver Island water systems.

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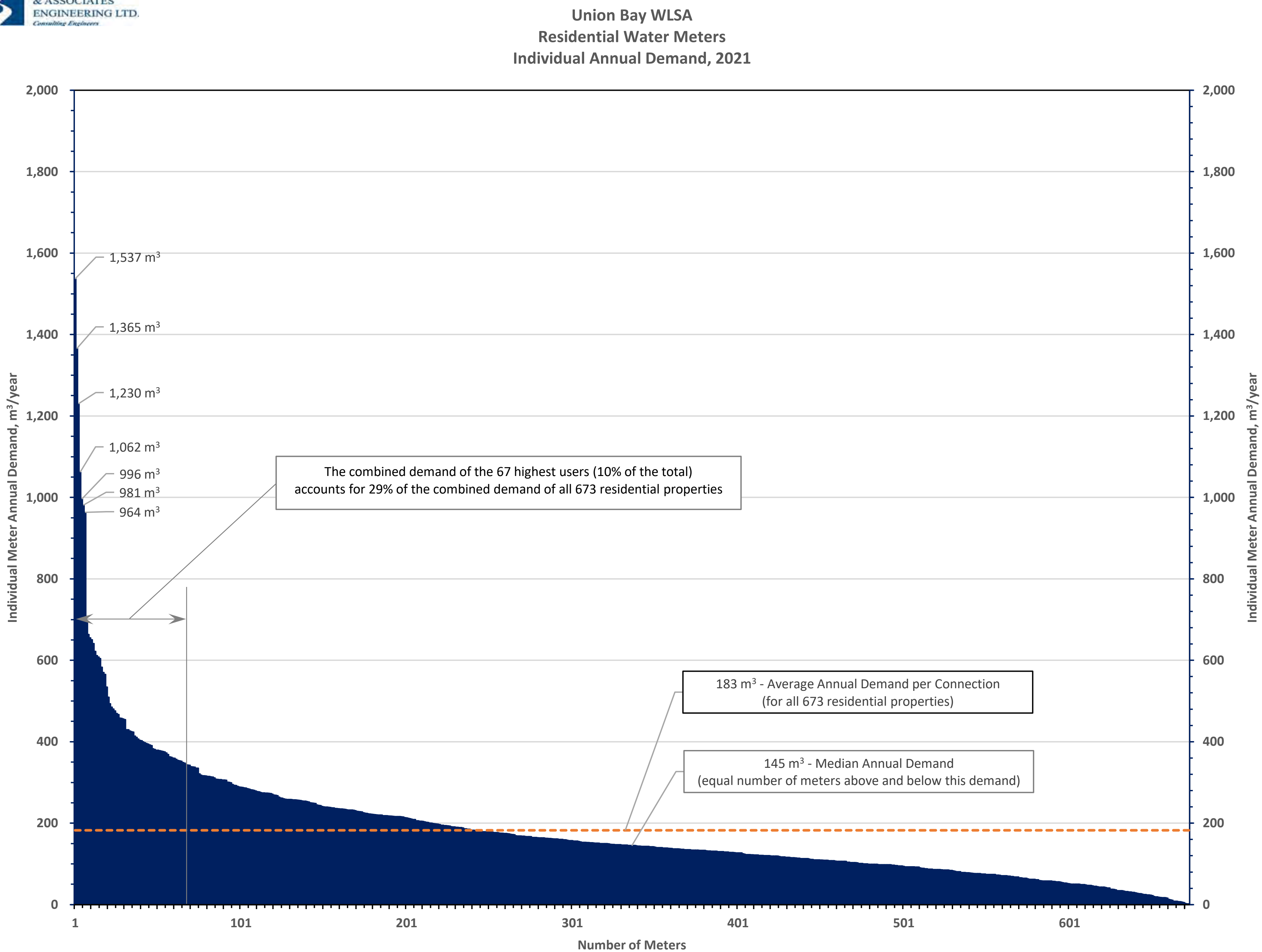


FIGURE 9

3.2.2 I/C/I Properties

The following observations are made regarding metered demand for Institutional / Commercial / Industrial properties (**Table 11**):

- I/C/I service connections account for 3% of all service connections.
- I/C/I demand accounts for approximately 6% of the total annual metered demand.
- From 2018 through 2020, the I/C/I demand decreased each year, totalling 4,100 m^3 (37% decrease) but then increased by 1,000 m^3 in 2021.

3.3 Non-Revenue Water

3.3.1 Definition & Calculation

Water usage in a water system can be divided into two categories, Revenue Water and Non-Revenue Water which are defined as:

- Revenue Water: Water that is metered and paid for
- Non-Revenue Water: Water that is used and not paid for

Non-Revenue water is made up of three components:

- *Authorized Unbilled Use + Apparent Losses + Real Losses*

The water used in each of these three categories can be partitioned into several sub-categories as noted below:

Authorized Unbilled Use

- Water Treatment Plant Process (DAF tank waste, backwash, chlorine analyzer, pH analyzer, etc.)
- Watermain flushing
- Fire department training and fire fighting
- Public boulevard and playfield irrigation
- Sewer main flushing (not applicable for Union Bay)

Apparent Losses

- Water theft
- Metering Inaccuracies

Real Losses

- Leakage on transmission mains and distribution mains
- Leakage on service connection piping located before the customer's meter

For a universally metered water system, the Non-Revenue Water Demand can be calculated using the following equation:

Non-Revenue Water = Bulk Meter – All Individual Meters

3.3.2 Union Bay Non-Revenue Water Annual Amount

For Union Bay, the amount of Non-Revenue Water averaged 31% over the past four years (2018-2021) and ranged from a low of 21% in Year 2019 to a high of 41% in Year 2021.

For 2019, the year prior to the commissioning of the water treatment plant (May 2020), the percentage of Non-Revenue Water (21%) drawn from the Union Bay water system was within the anticipated range of 20% to 30%, which is typical for a water system that is around 50 years old and more than half (58%) comprised of Asbestos Cement watermains.

For 2021, the first complete calendar year of operation of the water treatment plant, the percentage of Non-Revenue Water (41%) was notably high and above the anticipated range of 25% to 35%, when allowing for the increase in Non-Revenue Water attributed to the Dissolved Air Floatation treatment process.

The Non-Revenue calculation for each of the past four years (2018 – 2021) is presented in **Table 12** and graphically shown in **Figure 10**.

Table 12 – Non-Revenue Water, 2018 - 2021

Description	Year			
	2018	2019	2020	2021
Number of Water Service Connections				
Entire System	674	678	684	691
Annual Demand (1) (m^3)				
Entire System Demand	210,700	156,400	190,500	220,400
Individual Metered Demand	143,100	123,200	126,500	130,800
Difference (Non-Revenue Water)	67,600	33,200	64,000	89,600
as % of Entire System	32 %	21 %	34 %	41 %
Per Connection Annual Demand (2) (m^3/connection)				
Entire System Demand	315	230	280	319
Individual Meter Demand	215	180	185	190
Difference (Non-Revenue Water)	100	50	95	129

Notes:

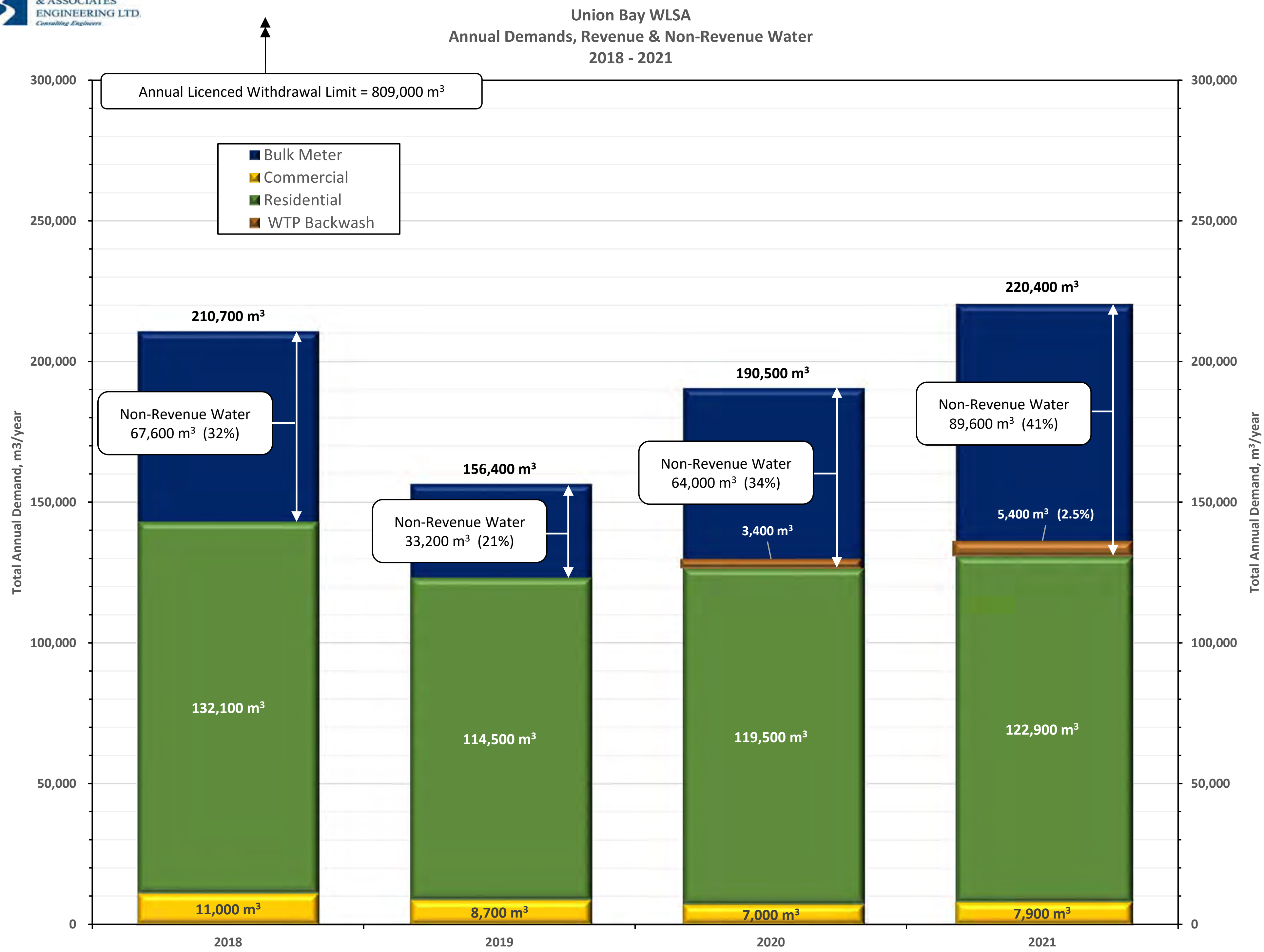
1. Annual demand rounded to nearest 100 m^3.
2. Per Connection Annual Demand rounded to nearest 5 m^3 except for Year 2021 which is rounded to the nearest 1 m^3.

The sources of Non-Revenue Water cannot be definitively established at this time. Section 3.3.2 (below) compares the amount of Non-Revenue Water in the Union Bay water system to other mid-Vancouver Island water systems.

3.3.3 Union Bay and Other Island Water Systems

A review of eleven other universally metered water systems located on the east side of Vancouver Island (in the mid-island area) found the amount of Non-Revenue water ranged from a minimum of 5% to a maximum of 37% of the system's total annual demand. The 5% is on the newest water system and the 37% is on the oldest water system. As water systems age, *Real Losses* (leakage) increase in response to several factors, such as:

- gaskets on old pipe joints hardening and becoming brittle and more susceptible to leakage



Union Bay WLSA
Annual Demands, Revenue & Non-Revenue Water
2018 - 2021
Annual Licenced Withdrawal Limit = 809,000 m³
Bulk Meter
Commercial
Residential
WTP Backwash
Total Annual Demand, m3/year
300,000
250,000
200,000
150,000
100,000
50,000
0
210,700 m³
Non-Revenue Water
67,600 m³ (32%)
132,100 m³
11,000 m³
156,400 m³
Non-Revenue Water
33,200 m³ (21%)
114,500 m³
8,700 m³
190,500 m³
Non-Revenue Water
64,000 m³ (34%)
3,400 m³
119,500 m³
7,000 m³
220,400 m³
Non-Revenue Water
89,600 m³ (41%)
5,400 m³ (2.5%)
122,900 m³
7,900 m³
2018
2019
2020
2021

FIGURE 10

- pipe material weakening, notably at direct tap service connections on AC pipe
- loss of pipe wall strength (on AC pipe this occurs in areas where the pipe comes in contact with aggressive water and/or soils, resulting in cement mortar leaching)
- Inadequate or improper bedding material used when the pipe was installed resulting in rocks or trench rock pressing onto the outside of the pipe wall, causing a localized pressure point, that overtime can create a crack in the pipe wall
- Excessive loading and/or settlement, which disturbs the "settled" state of the water system and causes disruption/movement at pipe joints, service connections, tees, valves, fittings and other appurtenances, resulting in a loss of the integrity of the seal of the gasket at these locations

The percentage of Non-Revenue Water in other Vancouver Island fully metered water systems (as compared to Union Bay) is presented in **Table 13**.

Table 13 – Non-Revenue Water for Other Vancouver Island Metered Systems

Water System	Year	No of Service Connections #	Annual Demand [1] m^3	Non-Revenue Water %	Demand per Connection[2] m^3
Decourcey WSA	2018	5	1,000	10 %	200
Melrose Terrace WSA	2018	28	4,900	21 % [3]	175
Whiskey Creek WSA	2018	124	42,400	35 % [3]	340
Englishman River WSA	2018	151	64,400	5 % [4]	425
French Creek WSA	2018	238	59,000	8 %	250
San Pareil WSA	2018	288	99,100	35 % [5]	345
Union Bay WLSA	**2021**	**691**	**220,400**	**41 % [3]**	**319**
Saltair	2016	803	266,000	27 %	330
Lantzville	2014	885	242,200	22 % [6]	275
BC/OB WLSA	2019	975	356,200	23 % [7]	365
Cumberland	2015	1,616	545,100	37 % [8]	335
Nanoose Bay Peninsula WSA	2018	2,191	725,000	23 % [3]	330

Notes:

1. Total Annual Demand for entire water system rounded to nearest 100 m^3/year.
2. Demand per Connection rounded to nearest 5 m^3/year except for Union Bay WLSA which is rounded to nearest 1 m^3/year.
3. Includes wastewater from the water treatment (filtration system) process.
4. The Englishman River water system is the youngest water system at 18 years old.
   It consists of 12.6 kms of PVC watermain.
5. The San Pareil water system is around 60 years old.
   It consists of 8 kms of watermain of which 6.4 kms (82%) is AC pipe.
6. The District of Lantzville water system is around 50 years old.
   It consists of 27 kms of watermain of which 15 kms (57%) is AC pipe.

7 The BC/OB water system is believed to be around 50 years old.
It consists of 29 kms of watermain of which 28 kms (96%) is AC pipe.

8 The Village of Cumberland water system is the oldest water system. Its water licence is almost 125 years old (Year 1897). The distribution system consists of varying pipe materials, such as CI, DI, AC and PVC.

3.3.4 Known Union Bay Non-Revenue Water Sources

For the Union Bay water system, there are seven known sources of Non-Revenue water. A summary of each over the past four years (2018 – 2021) is presented in **Table 14** along with the associated water loss volume, where it could be estimated.

Table 14 – Known Union Bay Water System Non-Revenue Water Sources (2018 – 2021)

Description	2018	2019	2020	2021
Non-Revenue Volume (m^3)	67,600	33,200	64,000	89,600
Sources				
No. of Leaks Repaired	13	17	21	18
Watermain Automatic Flush (m^3)	15,000 (1)	15,000 (1)	15,000 (1)	15,000 (1)
Watermain Manual Flush	-	May 13-15 (2) ± 100 m^3	Nov 16-18 (3) ± 100 m^3	-
Major Structure Fire	-	Dec 12 (4)	-	-
Pump Upgrade, PZ 155	-	-	In Operation (5)	In Operation (5)
New Reservoir, PZ 92	-	-	Yes (6)	Yes (6)
WTP Backwash Volume (m^3)	-	-	3,400 (7)	5,400
Sources Volume (m^3):	15,000	15,100	18,400	20,400
Remainder Volume (m^3): (Non-Revenue minus Sources)	52,600	18,200	45,600	69,200

Notes:

1 There are seven (7) automatic flushing valves in the water distribution system. One of the flushing valves is turned off while the other six (6) operate once a day. They are reported to flush the following volumes each day.

- Green Ave: 0.75 m^3/day
- Montrose Dr: 3.6 m^3/day
- Spence Rd: off
- Callis Rd: 0.06 m^3/day
- Country Rd: 18.9 m^3/day
- McKay Reservoir: 5.76 m^3/day
- Buckley Bay Rd: 11.52 m^3/day

Combined Total: 40.59 m^3/day

A flushing volume of 15,000 m^3 equates to almost 7% of the Year 2021 total annual demand (220,400 m^3). Flushing valves were installed in the water system prior to construction of the new water treatment plant. They were installed in locations to help maintain chlorine residual in the system, especially at the extremities and on dead-end mains that have low demands. Prior to the construction of the new water treatment plant, maintaining chlorine residual during rainy periods (when the turbidity of the raw water increased significantly) was challenging. This was the impetuous for installation of the automatic flushing valves. With the construction of the water treatment plant, the turbidity and organic carbon levels of the treated water were significantly reduced. As a result, the need for continuing with the same frequency and duration of automatic flushing may no longer be necessary, subject to review of the chlorine residual levels after adjustments are made to operation of the flushing valves.

2 The amount of water used for watermain manual flushing between May 13-15, 2019 could not be conclusively determined from the bulk water meter reading data. A review of the data suggests a cumulative flushing volume of ± 100 m^3, which equates to approximately 16% of the ± 640 m^3 of water contained within the watermains in the distribution system.

3 The amount of water used for watermain manual flushing between Nov 16-18, 2020 could not be conclusively determined from the bulk water meter reading data. There was a recorded demand increase of approximately 32 m^3/day (96 m^3 cumulative total). However, the demands in the days after Nov 18 continued to increase reaching an additional maximum increase of more than 320 m^3 for both Nov 24 and Nov 25, before returning to a demand similar to Nov 15 (before flushing). The estimated manual flushing volume of 96 m^3 equates to approximately 15% of the ± 640 m^3 of water contained within the watermains in the distribution system.

4 A house fire occurred on Mystery Beach Rd in the early evening of Dec 12, 2019. The Union Bay fire chief noted that it did not require a lot of water to extinguish the fire. The amount of water used for fire fighting could not be determined from a review of the bulk water meter readings as there was no discernable increase.

5 With the start-up of the new booster pump station (as previously discussed in Section 2.5.2 Water System Pressure Zones), the system operating pressure in the upper pressure zone increased by 83 kPa (12 psi); equating to an average pressure increase of 12%. This pressure zone (PZ 155) contains 1.2 kms (4%) of the 30 kms of watermain piping that exists in the distribution system. Water loss due to leakage increases as system pressures increase.

6 With the construction of the new McLeod Road Reservoir (top water level of 92 m) a new pressure zone was created. The service area of this new pressure zone (**Figure 4**) contains 2.1 kms (7%) of the 30 kms of watermain piping that exists in the entire distribution system. The system operating pressure in this area increased by 176 kPa (25 psi) as it used to be part of the 74 m pressure zone. This equates to an average pressure increase of 24%. Water loss due to leakage increases as system pressures increase.

7 Filter backwashing became a component of Non-Revenue water with the start-up of the new water treatment plant in May 2020.

3.4 Water Demand Reduction

3.4.1 Non-Revenue Water

While the complete elimination of Non-Revenue water is not possible, reducing it from the 41% in Year 2021 (**Table 13**) to 25% of total system demand is considered a reasonable and realistic target for the Union Bay water system.

The quickest way to lower Non-Revenue water losses will be to reduce or eliminate automatic flushing, provided chlorine residuals can be maintained throughout the system now that the Water Treatment Plan is in operation.

If the 15,000 m^3 of water used by the automatic flushers (**Table 14**) was not required in Year 2021, an additional 50 residential properties could have been serviced and additional revenue generated by its metered usage. This change in water usage would have reduced Non-Revenue water to 34% of the total system demand.

If in Year 2021, Non-Revenue water demand had been 25% and not 41%, an additional 110 properties could have been serviced by the 16% difference, resulting in additional revenue (generated by its metered usage) without any increase in the water treatment plant operating costs.

Annual Leak Detection and Reduction Program

As the Union Bay Water System continues to age, addressing system leakage will become more and more critical in order to reduce Non-Revenue water losses even further.

Initial quantifying of the amount of leakage in the water system can be carried out by monitoring water usage when it is lowest, which typically occurs between 2 am and 5 am each day. Monitoring of the system during the fall and winter months, when outdoor water usage is minimal, will provide the most accurate data. Monitoring could be carried out by reviewing the drop in the water level in the McLeod Road reservoir. The SCADA system can be used to record the water level in 15 minute increments. The water treatment plant should be shut off during the monitoring period, if possible, otherwise any volume added to the reservoir would need to be accounted for. In addition, the McKay Road reservoir should be isolated from the system so that flows into and out of this reservoir are eliminated during the monitoring period.

The total recorded drop in the reservoir water level can be converted into a total volume which can be converted into an hourly demand by dividing the volume by the duration of the monitoring period. This hourly volume can then be extrapolated to a total daily volume by multiplying it by 24 hours to quantify the potential maximum amount of leakage over 24 hours. This total volume for the day can then be divided by the total bulk metered volume to establish its percentage of the total daily demand. Once the results of the reservoir water level monitoring are known, development and implementation of an **Annual Leak Detection and Reduction Program** should be considered for the Union Bay water system. This program would help reduce Non-Revenue water, which in turn will allow the servicing of additional properties and thereby generate additional revenue by its metered usage.

3.4.2 Revenue Water

Reducing Revenue (metered) water demands requires a change in human behaviour.

A reduction in metered demand during the dry summer months (in Year 2021) when the treatment plant was operating near or at its capacity, most notably between June 27 and July 4, when daily demand exceeded 1,000 m^3/day and peaked at 1,136 m^3/day on June 30, would have provided the ability to service additional properties.

Water Conservation Plan

Changing human behavior of water usage during the dry summer months, and year round, will require the development of a **Water Conservation Plan** specifically for the Union Bay water system. The plan would identify water use modification tools which would result in the goal of demand reduction. The plan would assess the potential for reducing both indoor and outdoor water usage.

4 DESIGN CRITERIA

In establishing the servicing capabilities of a water supply and distribution system, three levels of water demands are normally considered, in addition to fire flows. These are:

Average Day Demand	=	Total annual consumption / 365 days
Maximum Day Demand	=	Day with highest demand for the year
Peak Hour Demand	=	Highest flow rate maintained for one hour (generally occurring on maximum day of the year)

4.1 Water Supply

The water supply source(s) must be capable of meeting the maximum day demand. Peak hour demands and fire flow demands are to be covered by the emergency storage that is built into the potable water storage reservoirs.

4.2 Water Storage

Water reservoirs perform three functions:

- storage for fire fighting
- storage for equalization to manage hourly peaks in demand
- storage for emergencies (such as a watermain break)

The storage volume requirements will be calculated using the following, generally accepted, formula from the "Design Guideline Manual, 2014" from the Master Municipal Contract Document (MMCD) Association:

Storage Volume = A + B + C

where:

A = Fire Storage	Fire flow from MMCD Design Manual, Fire duration from Fire Underwriters Survey Guide
B = Equalization (Peaking) Storage	25% of Maximum Day Demands
C = Emergency Storage	25% of [A + B]

The requirement for Emergency Storage (C) can be reduced or eliminated based on several factors, including, water source dependability; reliability of the supply system (e.g. gravity vs pumped, duplication of mains and treatment, standby emergency power); multiple sources; more than one storage reservoir; and reservoir water circulation needs. It is recommended that the full amount of the emergency storage component be included in the Union Bay water storage reservoir volumes.

4.3 Water Distribution System

The water distribution system must be capable of delivering all demands, as well as delivering fire flow demands during maximum day demands, while operating within acceptable pressure ranges.

4.3.1 System Pressures & Watermain Diameters

The adequacy of the distribution system for various demand conditions is judged by the residual pressures available throughout the system and by the maximum velocities in the watermains. The criteria that are typically applied to assess the distribution system are listed in **Table 15**.

Table 15 – Distribution System Design Criteria

Parameter	Value	
Pressures & Velocities		
Under Peak Hour Demand Conditions		
Minimum residual pressure at property line	300 kPa	(44 psi)
Maximum velocity in watermains	2.0 m/s	(6.6 ft/s)
Under Fire Flow Demand Conditions (during Maximum Day Demands)		
Minimum residual pressure at hydrant	150 kPa	(22 psi)
Maximum velocity in watermains	3.5 m/s	(11.5 ft/s)
Minimum residual pressure at property line	35 kPa	(5 psi)
Under Static Conditions		
Maximum service pressure	860 kPa	(125 psi)
Pipe Diameter		
Minimum pipe diameter up to hydrant	150 mm	

4.3.2 Fire Flow Requirements

Fire flow requirements are typically based on guidelines published by MMCD and the “Water Supply for Public Fire Protection” by the Fire Underwriters Survey (FUS).

The FUS fire flow requirements vary depending on building design, floor area, number of stories, construction materials, if a fire sprinkler system is installed, fire break walls, and spacing from adjacent buildings (exposure). The duration for which a fire flow is to be provided increases as the flow increases. For example, a fire flow of 33 L/s (2,000 L/minute) or less is to be sustained for at least 1 hour and a fire flow of 200 L/s (12,000 L/minute) is to be sustained for 2.5 hours, according to FUS. The FUS recommends that a water system be capable of providing the design fire flow during maximum day demands, while maintaining a minimum residual pressure 150 kPa (22 psi) in the watermain.

The application of target fire flows for commercial and industrial applications can vary widely depending on the building’s design, age, size, use, exposures, the materials utilized for construction, and whether a sprinkler system has been installed. Typically, the required flow rates are determined using FUS criteria at the time of design, and if necessary, improvements to the municipal system are undertaken by the developer as required to achieve the desired fire flow.

It is challenging to determine a specific target number for commercial and industrial land uses in existing rural areas, as the fire flow requirements for each facility will vary. For the purposes of this report, we have used the MMCD fire flow guidelines according to land-use and the FUS fire flow durations, as presented below in **Table 16**.

Table 16 – Fire Flow Demand by Land-Use

Land-Use	Recommended Minimum Fire Flow & Duration	
	MMCD Fire Flow (L/s)	FUS Fire Duration (hrs)
Single/Two Family Residential	60	1.5
Multi-Family	90	1.85
Light Industrial	150	2
Commercial	150	2
Institutional	150	2

5 WATER MODEL

5.1 Computer Program

Modelling of the water distribution system was carried out utilizing the computer software program InfoWater Pro by Innovyze. This is a newer water modelling program that has GIS based software. The program's features include; steady state and extended time modelling, fire flow event modelling while evaluating flows and pressures across the entire system, peak hour pressure analyses, optimization of fixed and variable speed pumps and reservoir storage to minimize energy usage and cost, and automated model calibration. Other analyses features include; system leakage, water loss and unaccounted for water, reservoir mixing, and water-age. The modelling results can be presented in tabular and graphical form.

5.2 Water Model Set-up

5.2.1 Water System

Koers' in-house computer model of the Union Bay water system served as the basis for this Water Master Plan. A copy of the CVRD's GIS database of the Union Bay water system was obtained and compared to our in-house model. The in-house model of the water supply and distribution system were spatially updated as warranted. The developed model consists of:

- lengths, diameter and material type of the water supply and distribution mains
- water storage reservoirs
- Pressure relief valves
- fire hydrants

The model is spatially developed, matching the CVRD's composite legal plan and the GIS database of the water system, so that the actual lengths of watermains and distances between services connections reflect "on the ground" conditions.

The model was developed to geodetic datum using digital 1 m contour intervals provided by the CVRD. Elevations of nodal points (pipe intersections, end of mains, and pipe diameter changes) were automatically obtained from the nearest contour interval.

The settings for the Pressure Reducing Valves (inlet and outlet pressures) were provided by the CVRD water department.

5.2.2 Pipe Friction Factors

A Hazen Williams friction factor was entered in the model for varying pipe materials, as listed in **Table 17**.

Table 17 – Pipe Friction Factors

Pipe Material Name	Pipe Material Abbreviation	Friction Factor C (Hazen Williams)
High Density Polyethylene	HDPE	145
Polyvinyl Chloride	PVC	140
Asbestos Cement	AC	130
Ductile Iron	DI	130
Steel with Coating	SC	130
Pre-stressed Concrete	PConc	120
Cast Iron	CI	110

5.2.3 Allocation of Demands

Water demands were distributed evenly throughout the model at nodal points (pipe intersections, end of mains and pipe diameter changes). The maximum day demand was used as the base.

Peak hour demand was modelled by multiplying each individual maximum day demand by one and one half (1.5).

6 EXISTING DISTRIBUTION SYSTEM ANALYSIS

The existing conditions computer model was used to assess the ability of the water distribution system to:

- provide adequate pressure during peak hour demands, and
- deliver adequate fire flow during maximum day demands.

The modelling results are discussed below.

6.1 Peak Hour Pressures

The calculated residual pressures throughout the existing distribution system (during the current peak hour design demand of 19.7 L/s (1.5 times Year 2021 maximum day demand of 1,136 m^3/day) are graphically shown in **Figure 11**. The recommended minimum pressure at property line of 300 kPa (44 psi) are provided throughout the distribution system with the exception of properties close to the two reservoirs as shown in **Figure 11** and described below:

Water Treatment Plant Reservoir (PZ 92)

Around the water treatment plant reservoir (with its top water level of 92 m), properties with plumbing fixtures above ±61 m geodetic experience pressures less than the minimum recommended 300 kPa (44 psi).

McKay Road Reservoir (PZ 74)

Around the McKay Road reservoir (with its top water level of 74 m), properties with plumbing fixtures above ±43 m geodetic experience pressures less than the minimum recommended 300 kPa (44 psi).

6.2 Maximum Day with Design Fire Flow

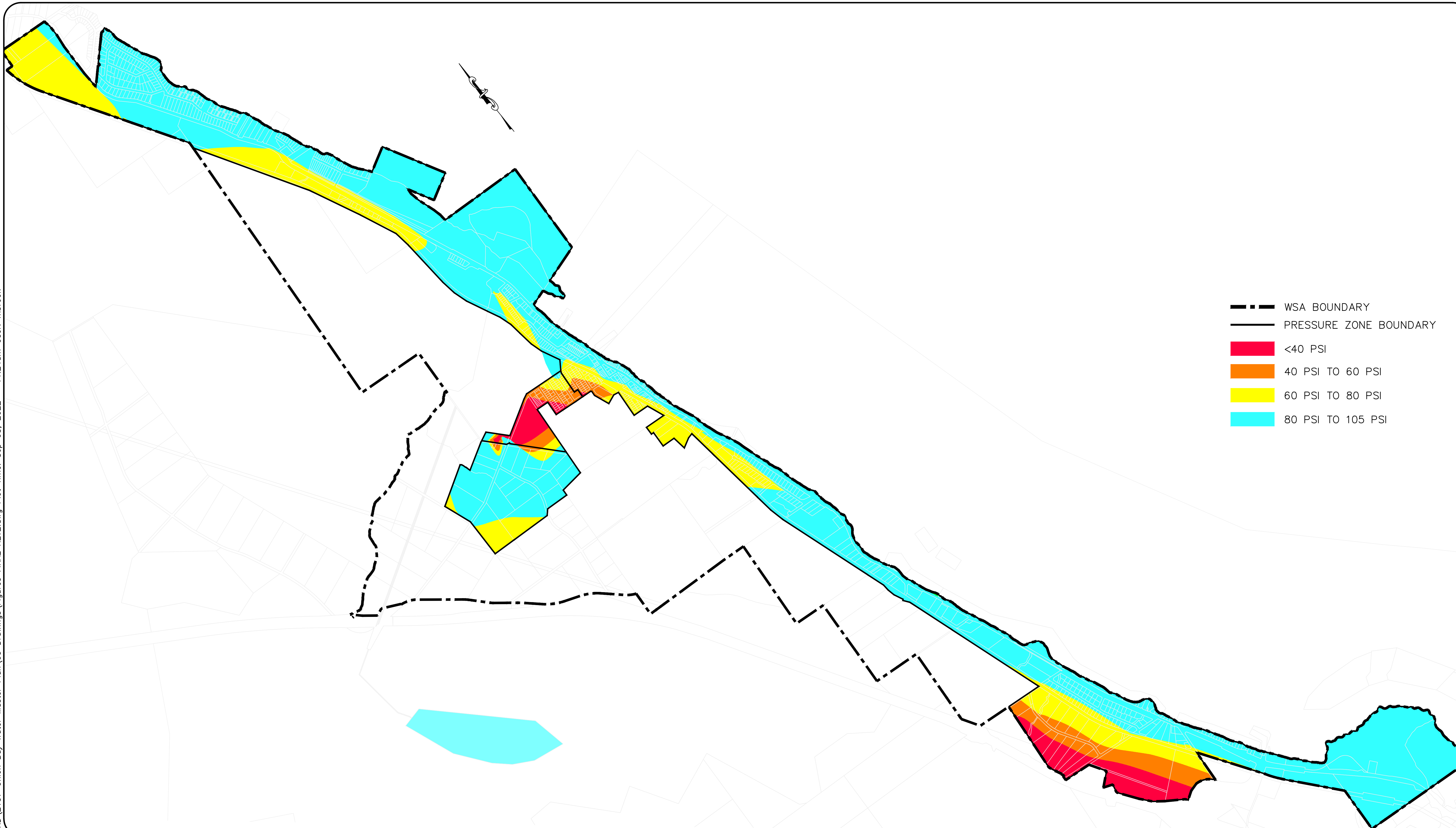
The calculated maximum available fire flows throughout the existing distribution system (during a maximum day demand of 1,136 m^3/day (Year 2021 Maximum Day Demand) are graphically shown in **Figure 12** and are based on allowing a maximum velocity in the watermains of 3.5 m/s (**Table 15**).

6.2.1 PZ 155 Available Fire Flows

Computer modelling results indicate that available fire flows are very limited (less than 60 L/s). There are presently four fire hydrants within PZ155:

- **McLeod Road (Murray Ave to Musgrave Rd)**: There are three hydrants along this section of McLeod Road. They are each connected to the raw water supply main (200 mm dia.) that draws water from Langley Lake. Maximum available fire flow from these hydrants during maximum day demand is less than 45 L/s.

- **Green Ave**: There is one hydrant on Green Ave. It is located along the frontage of #5719 Green Ave and is connected to the distribution main (100 mm dia.) serviced by the booster pump station (see Section 2.5.2 Water System Pressure Zones). The booster pump station



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CLIENT: COMOX VALLEY REGIONAL DISTRICT

PROJECT: UNION BAY LOCAL SERVICE AREA WATER MASTER PLAN

TITLE: EXISTING CONDITIONS RESIDUAL PEAK HOUR PRESSURES

APPROVED	MP	SCALE	1: 30,000
DATE	SEP 2022	DWG No.	FIGURE 11
PROJECT No.	2157		

File: H:\1014 Comox Valley RD\2157 Union Bay Water Master Plan\03 Drawings\Figures FINAL REV2.dwg Plot Time: Sep 08, 2022 - 11:24am User: mbrook

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CLIENT: COMOX VALLEY REGIONAL DISTRICT

PROJECT: UNION BAY LOCAL SERVICE AREA WATER MASTER PLAN

TITLE: EXISTING CONDITIONS AVAILABLE FIRE FLOWS

APPROVED	MP	SCALE	1:30,000
DATE	SEP 2022	DWG No.	FIGURE 12
PROJECT No.	2157		

File: H:\1014 Comox Valley RD\2157 Union Bay Water Master Plan\03 Drawings\Figures FINAL REV2.dwg Plot Time: Sep 08, 2022 – 11:24am User: mbrook

is designed to provide domestic demands only, not fire flows. Computer modelling indicates the available fire flow to the hydrant on Green Ave is less than 30 L/s.

Improving fire flows in PZ 155 will require either the installation of a fire pump or a treated water storage reservoir with a top water level of 155 m. A reservoir (± 25 m in height) could be constructed at the west end of McLeod Road near the Inland Island Hwy. The reservoir would be filled by a booster pump station and a new treated water supply main. In addition, the existing distribution mains (100 mm dia.) within PZ 155 would need to be upgraded. It is noted that the area where this reservoir would be constructed is one of the locations initially proposed for the water treatment plant.

6.2.2 PZ 92 Available Fire Flows

Computer modelling results indicate that along McLeod Road, between Musgrave Road and the old concrete reservoir (a distance of ±280 m), available fire flows are very limited (less than 60 L/s). In addition, there are currently no fire hydrants along this section. The first fire hydrant along McLeod Road that is serviced by PZ 92 is located at Seventh Street. Improvements have been identified for this area and are shown in **Figure 13** and listed in **Table 18**.

6.2.3 PZ 74 Available Fire Flows

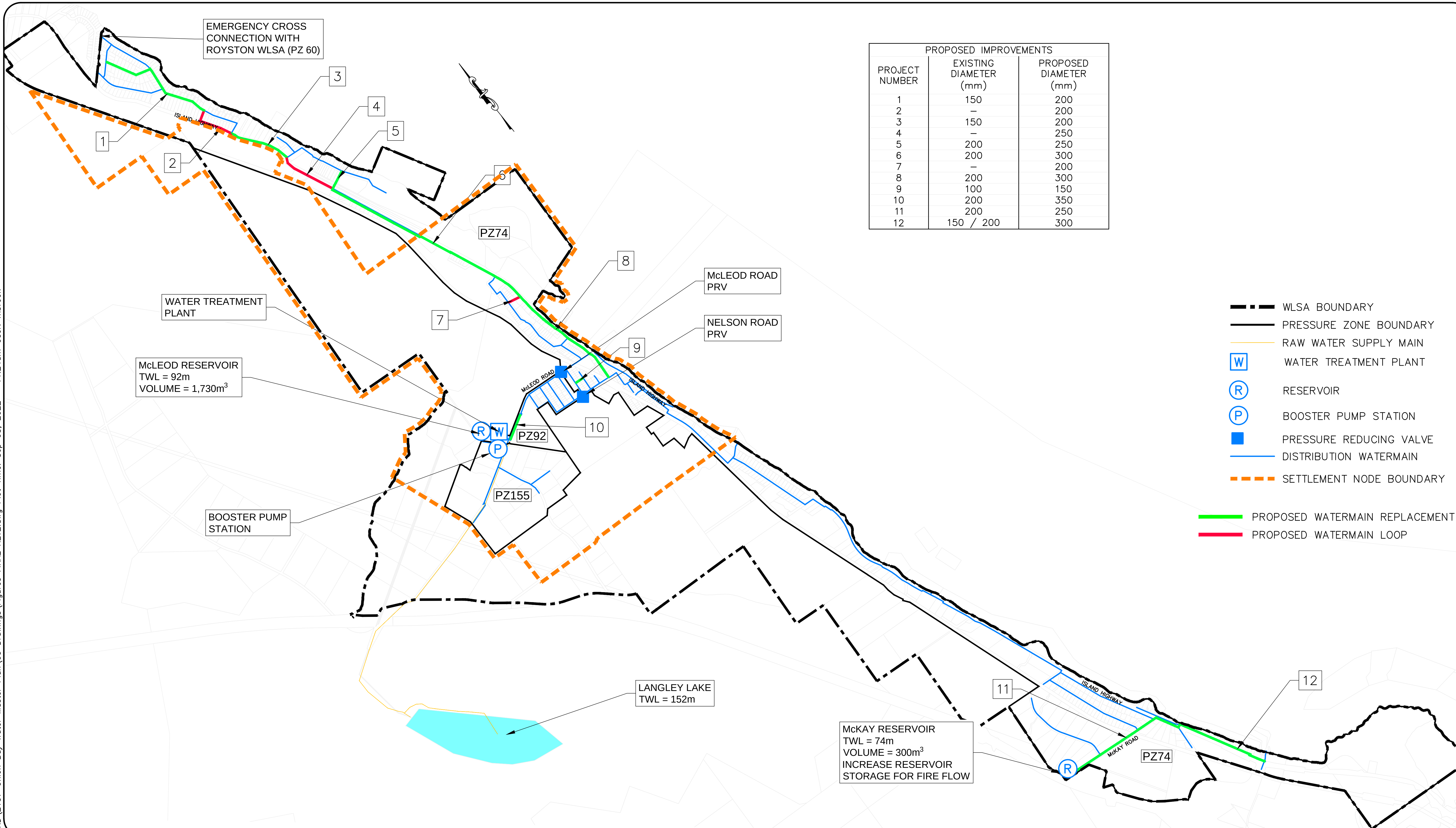
Computer modelling results indicate available fire flows are very limited (less than 60 L/s) in the:

- northern end (north of Glover Rd), and
- southern end (south of Emerton Rd).

Improvements have been identified to increase the available fire flows to these areas. They include replacing existing watermains with larger pipes and looping dead-ended watermains as shown in **Figure 13** and listed in **Table 18**.

6.3 Proposed Improvements

The watermain upgrades that are proposed to improve the fire fighting capabilities of the existing Union Bay water system are listed below in **Table 18** and shown in **Figure 13**.



PROPOSED IMPROVEMENTS

PROJECT NUMBER	EXISTING DIAMETER (mm)	PROPOSED DIAMETER (mm)
1	150	200
2	–	200
3	150	200
4	–	250
5	200	250
6	200	300
7	–	200
8	200	300
9	100	150
10	200	350
11	200	250
12	150 / 200	300

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CLIENT: COMOX VALLEY REGIONAL DISTRICT

PROJECT: UNION BAY LOCAL SERVICE AREA WATER MASTER PLAN

TITLE: PROPOSED WATERMAIN IMPROVEMENTS

APPROVED	MP	SCALE	1:30,000
DATE	SEP 2022	DWG No.	FIGURE 13
PROJECT No.	2157		

File: H:\1014 Comox Valley RD\2157 Union Bay Water Master Plan\03 Drawings\Figures FINAL REV2.dwg Plot Time: Sep 08, 2022 – 11:24am User: mbrook

Table 18 – Proposed Piping Improvements (for Fire Flows), Existing Conditions

Location	Dia. (mm) Existing	Dia. (mm) Proposed	Length (m)
PZ 92			
McLeod Rd, Musgrave Rd - abandoned reservoir	100 AC	350	280
PZ 74			
North of McLeod Rd			
Hwy 19a, McLeod Rd – Russell St	200 AC	300	770
Russell St, Hwy 19a – Tappin St	-	300	110
Hwy 19a, Tappin St – 5277 Washer Rd	200 AC	300	700
Hwy 19a, 5277 Washer Rd – Glover Rd	100 AC	250	1,560
Glover Rd, Hwy 19a – Spence Rd	150 AC	250	175
Hwy 19a, Glover Rd – 90 m south of Dorothy Rd	-	250	500
Hwy 19a, 90 m south of Dorothy Rd – 50 m north of Brolin Rd	150 AC	200	525
Hwy 19a, 50 m north of Brolin Rd – Argyle	-	200	290
Argyle, Hwy 19a – Kilmarnock Dr	-	200	85
Kilmarnock Dr, Argle – Arran Rd	150 AC	200	600
Arran Rd, Kilmarnock Dr – Inverness Rd	150 AC	200	420
South of McLeod Rd			
Hwy 19a/1st St, McLeod Rd – Nelson St	200 AC	250	265
Douglas St, 4th St – 3rd St	100 AC	150	90
McKay Rd, Reservoir – Mystery Beach Rd	200 PVC	250	770
McKay Rd, Mystery Beach Rd – Hwy 19a	200 PVC	250	170
Hwy 19a, McKay Rd – Emerton Rd	200 AC	300	200
Hwy 19a, Emerton Rd – Buckley Bay Rd	150 AC	300	760
		Total:	8,270

The resulting available fire flows after the improvements (**Table 18** and **Figure 13**) are completed are shown in **Figure 14**.

On a smaller water system the size of the Union Bay system, such a magnitude of watermain improvements (27% of the water distribution system mains) will likely have to be carried out over a significant time frame due to the cost of the upgrades. In some areas it may be acceptable to wait until the older piping reaches the end of its operational life, and then replace it with the larger watermains identified above.

The CVRD should share the existing conditions fire flow mapping (**Figure 11**) with the local fire department, so they are aware of the existing fire flow limitations that currently exist throughout

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CLIENT: COMOX VALLEY REGIONAL DISTRICT

PROJECT: UNION BAY WATER SYSTEM WATER MASTER PLAN

TITLE: EXISTING CONDITIONS AVAILABLE FIRE FLOWS AFTER IMPROVEMENTS

APPROVED	MP	SCALE	1:30,000
DATE	SEP 2022	DWG No.	FIGURE 14
PROJECT No.	2157		

File: H:\1014 Comox Valley RD\2157 Union Bay Water Master Plan\03 Drawings\Figures FINAL REV2.dwg Plot Time: Sep 08, 2022 – 11:24am User: mbrook

the distribution system. It would also be advisable to find out if the local fire department can identify specific areas of concern that may cause challenges from the perspective of fire fighting operations. This type of input will help establish which watermain improvements should be targeted as priorities.

6.4 Reservoir Storage Capacity

A comparison of the recommended minimum storage volume requirements to the current storage volume (both reservoirs combined) indicates the total available storage volume is currently more than the recommended minimum, as shown in **Table 19**.

Table 19 – Minimum Reservoir Storage Volume, Existing Conditions

Description			Current Conditions m^3
A	Fire Storage	FUS Guide	1,080 (1)
B	Equalization	25% of Max Day	285 (2)
C	Emergency	25% of [A+B]	340
		Total:	1,705
		Current Available:	2,030 (3)
		+Surplus/-Shortfall:	+325 +16%

Notes:

1. Fire storage volume based on 150 L/s demand for 2 hours.
2. Current Conditions Maximum Day demand = 1,136 m^3/day (June 30, 2021) as shown in **Table 9** and **Figure 6**.
3. See **Table 6**.

While the current storage volume of both reservoirs combined meets the recommended minimum requirement, the fire fighting capabilities in the north and south ends of PZ 74 (along Hyw 19a) are hindered by the diameter of the existing watermains along the Hwy and the limited storage volume of the McKay Road Reservoir.

7 FUTURE GROWTH & DEMAND PROJECTIONS

7.1 Future Growth

There are properties within the Union Bay WLSA that are not yet connected to the water system. There also are properties within the Union Bay WLSA that have the potential to be subdivided under the current zoning. It is projected that more than 5,600 water service connections could be added to the water system based on properties not yet connected (developed and undeveloped) and anticipated development projects.

An overview of the potential increase in number of properties services is presented below.

7.1.1 Developed & Undeveloped Properties

The CVRD identified a total of 256 properties within the Union Bay WLSA that are not yet connected to the water system or are connected to the system but are vacant. They are comprised of:

- 237 Vacant Properties
  - connected to the water system: 216
  - not yet connected to the water system: 21
- 19 Developed Properties

The locations of these properties are shown on **Map 1**.

7.1.2 Potential Development Projects & Areas

The Comox Valley Regional Growth Strategy identifies a Settlement Node for the Union Bay area. A Settlement Node is an area established around an existing community located outside of the municipal boundaries of the Town of Comox, City of Courtenay and Village of Cumberland, that has significant planned capacity to accommodate new growth. The Settlement Node for Union Bay encompasses more than 680 ha.

The extent of the Settlement Node in Union Bay is shown in **Figure 15** along with several large areas encompassing one or more parcels of land that could accommodate significant growth. A brief discussion of these large areas is presented below.

Union Bay Water System

Comox Valley
REGIONAL DISTRICT

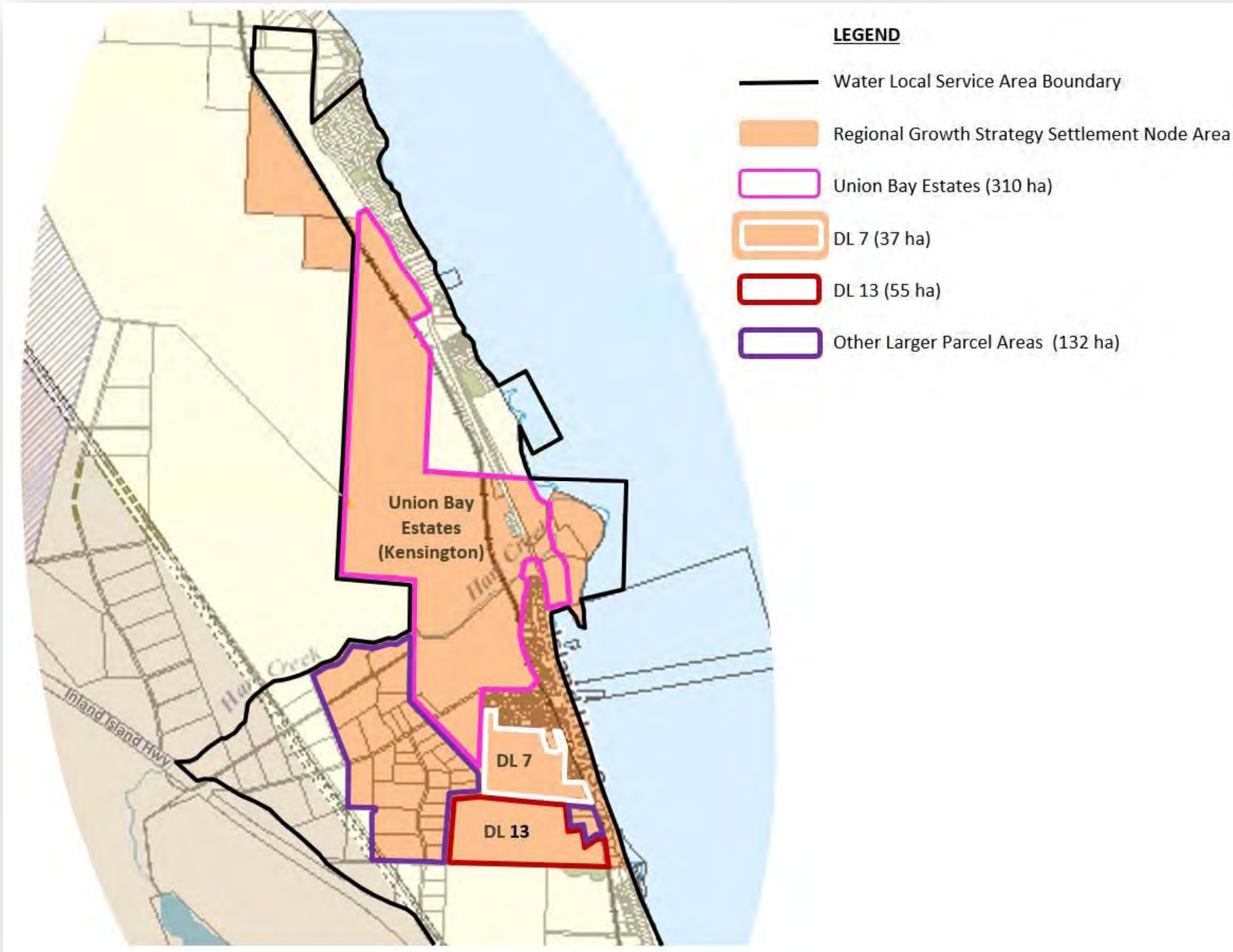

Figure 15 – Large Potential Development Areas within Union Bay Settlement Node

7.1.2.1 Union Bay Estates

Encompassing approximately 310 ha of land, Union Bay Estates (formerly known as Kensington Union Bay Properties, and Kensington Island Properties) is the largest proposed development within the Union Bay Settlement Node. It is located within the Union Bay WLSA boundary as shown in **Figure 15**. The development of this area was first put forward in the early 1990's when the land was being sold by the forestry company, Weyerhauser.

The proposed development envisions the construction of 3,245 dwelling units, comprised of single family and multi-family lots, along with commercial, institutional, and light industrial development including a 200 slip marina. The development is planned to be built in three phases over 30 years, resulting in an anticipated permanent residential population of 7,120. The estimated development horizon and permanent population for the phased development are presented in **Table 20**.

Table 20 – Union Bay Estates Dwelling Units, Population, & Water Demand Projections

Phase	Development Completion Horizon (Year)	No. of Dwelling Units		Total Population Estimate	Water Demand, m³/day	
		Per Phase	Total		Total Ave Day	Total Max Day
1	2030	455	455	1,068	285	560
2	2040	590	1,045	2,146	1,550	1,400
3	2050	2,200	3,245	7,120	2,295	4,385

Notes:

1 Information from: Kensington Union Bay Properties: Water Master Plan, Draft Report, February 26, 2020 by McElhanney (Table 1, Table 5 and Appendix B).

7.1.2.2 District Lot 13

District Lot 13 is an undeveloped 55 ha parcel of land. It is located within the service area boundary of the Union Bay WLSA and the Union Bay Settlement Node as shown in **Figure 15**. The parcel is located to the south of McLeod Road and east of Green Avenue, with access off the east end of Craddock Road.

The current zoning (CR-1) allows for a minimum lot size of 2 ha, which translates to approximately 23 lots. An application was submitted in 2020 to rezone the property to allow for 113 single family residential properties (average lot size of 0.4 ha). For the purposes of this Water Master Plan, the water demand for DL 13 has been based on 113 dwelling units.

7.1.2.3 District Lot 7

District Lot 7 is an undeveloped 37 ha parcel of land. It is located within the service area boundary of the Union Bay WLSA and the Union Bay Settlement Node as shown in **Figure 15**. The parcel is located adjacent to (on the north side of) District Lot 13.

The current zoning (RU-20) has a minimum lot size of 20 ha. It is understood the property is likely to become K'ómoks First Nation (KFN) treaty lands, and that they have development intentions for the property which could include:, a care facility (4 ha with up to 150 units), commercial development (2 ha), and mixed use residential (31 ha with up to 465 units). For the purpose of this Water Master Plan, a water demand for District Lot 7 has been based on the equivalent of 625 dwelling units.

7.1.2.4 Other Large Parcel Areas

In addition to the three areas discussed above, two other areas encompassing larger parcels of land have been identified as shown in **Figure 15**. They encompass more than 132 ha.

The largest one, located along either side of McLeod Road (north of Musgrave Road) is 126 ha in size and encompasses thirty (30) properties. Some of the properties in this area have homes on them. The other one, located at the northeast corner of DL 13, is just under 6 ha in size and encompasses three (3) properties. Two of the properties in this area have homes on them.

There are no known development plans for these two areas. Based on an assumed single-family density of 10 units per ha, up to 1,320 dwelling units could be constructed in these areas.

A summary of the potential number of future water service connections is presented in **Table 21**.

Table 21 – Potential Additional Water Service Connections

Description	No. of Water Services Connections
Existing Properties Not Yet Connected (1)	
Developed	19
Vacant and Undeveloped	237
Subtotal:	256
Development Projects (2)	
Union Bay Estates	3,245 (3)
DL 13	226 (4)
DL 7	625 (5)
Other Large Parcel Areas	1,320 (6)
Subtotal:	5,416
Combined Total:	5,672

Notes:

1 Properties not yet connected provided by CVRD and are shown on **Map 1**.

2 Potential development locations are shown on **Figure 15**.

3 From: Kensington Union Bay Properties: Water Master Plan, Draft Report, February 2020 by McElhanney (see Table 5). The proposed development encompasses a total of 310 ha.

4 From Preliminary Parcel Review and Phasing Concept layout drawing for Lot B, DL 13, Nelson District, Plan VIP60017 dated October 26, 2020 prepared by Grant Land Surveying Inc. The property size is 55 ha.

5 From preliminary information provided by K'ómoks First Nation to the CVRD for Lot 1, DL 7, Nelson District, Plan VIP66762. The property size is 37 ha.

6 Based on an assumed density of 10 dwelling units/ha (Single Family) for the 132 ha.

7.2 Future Demand Projections

Future demands were developed for Average Day, Maximum Day, and Peak Hour based on a per connection design demand and the number of potential service connections.

7.2.1 Per Connection Design Demands

The per connection design demands used for this Water Master Plan are presented in **Table 22** along with an explanation of how they were developed.

Table 22 – Future Per Connection Design Demand

Demand	Per Connection Demand			Design Demand Source
	m^3/yr	m^3/day	L/s	
Annual	319	-	-	Based on the Year 2021 Total Annual Demand of 220,400 $m^3/year$ (**Table 9**) for 691 connections in the water system (**Table 11**).**(1)**
Maximum Day	-	1.64	-	Based on the Year 2021 Maximum Day demand of 1,136 m^3/day (July 20) and a total of 691 water service connections.**(2)**
Peak Hour	-	-	0.029	A typical multiplier of 1.5 was applied to the Maximum Day demand to generate the peak hour design demand.

Notes:

1 Annual demand per connection based on the bulk meter reading and therefore consists of revenue and non-revenue water.

2 Maximum day demand per connection based on the bulk meter reading and therefore consists of revenue and no-revenue water.

7.2.2 Future Demands, Build-Out

The future Annual, Maximum Day, and Peak Hour design demands are presented in **Table 23** and are based on build-out of all of the potential additional water service connections (**Table 21**) and the per connection design demands proposed in **Table 22**.

Table 23 – Future Development Water Demands at Full Build-Out

Description	No. of Service Connections (1)	Total Annual (1, 2) m^3/year	Max Day (1,4) m^3/day	Peak Hour (5, 6) L/s
Current Demand (Year 2021)	691	220,400	1,136	20
Future Development (Build-Out)				
Not Yet Connected	256	80,000	420	7
Settlement Node				
- Union Bay Estates	3,245	1,035,000	5,320	94
- DL 13	226	70,000	370	6
- DL 7	625	200,000	1,025	18
- Other Large Parcel Areas	1,320	420,000	2,165	38
Future Development Total:	5,672	1,805,000	9,300	163
Current & Future Total:	6,363	2,025,400	10,436	183
Water Licence Limit:	-	809,205	8,310	-
Future Surplus / - Shortfall:	-	- 1,216,195	- 2,126	-
(% of Current Licence Limit):	-	150 %	25 %	-

Notes:

1. For Year 2021, number of service connections from **Table 9** and total annual demand, average day demand and maximum day demand from **Table 11**.
2. Future Total Annual demand based on number of connections multiplied by current year annual demand per connection of (**Table 22**) and rounded to the nearest 5,000 m^3.
3. Future Max Day demand based on number of connections multiplied by the maximum day demand per connection (**Table 22**) and rounded to the nearest 5 m^3.
4. Peak hour demands are not recorded by the Union Bay water system. In their absence, the standard multiplier of 1.5 was applied to the Max Day demand to generate the peak hour design demand for both the *Current Conditions* and *Future Development.*

$$\text{Peak Hour} = \frac{\text{Max Day} \times 1.5 \times 1{,}000 \text{ L/m}^3}{86{,}400 \text{ seconds/day}}$$

5. Future Peak Hour demand based on number of connections multiplied by the peak hour demand per connection (**Table 22**) and rounded to the nearest 1 m^3.

The existing water licence limits are not sufficient to meet the projected future demands based on the current (Year 2021) demand per connection, with the largest shortfall being for the annual licenced withdrawal limit. Maximizing the number of properties serviced within the existing water licence limits is discussed in **7.3 Maximizing Number of Properties** Serviced.

To meet the projected future demands (at full build-out) under the existing annual licenced withdrawal limit, the annual demand per connection would need to be reduced to 127 m^3/year per connection (inclusive of Non-Revenue water demand). This equates to a reduction of 60% from the current demands (319 m^3/year per connection).

7.2.3 Future Demands, Water Licence Limit

Based on the current licence withdrawal limits and the current (Year 2021) demands, an additional 1,846 water service connections could be added to the Union Bay water system as shown in **Table 24**.

Table 24 – Future Development Water Demands to Water Licence Limit

Description	No. of Service Connections (1)	Total Annual (2) m^3/year	Max Day (1,3) m^3/day	Peak Hour (4, 5) L/s
Current Demand (Year 2021)	691	220,400	1,136	20
Future Development to Water Licence Limit				
Not Yet Connected	256	81,500	420	7
Settlement Node Development	1,590	507,200	2,610	46
Future Development Total:	1,846	588,700	3,030	53
Current & Future Total:	2,537	809,100	4,166	73
Water Licence Limit:	-	809,205	8,310	-
Future Surplus:	-	105	4,144	-
(% of Current Licence Limit):	-	0.01%	50%	-

Notes:

1. For Year 2021, number of service connections from **Table 9** and total annual demand, average day demand and maximum day demand from **Table 11**.
2. Future Total Annual demand based on number of connections multiplied by current year annual demand per connection (**Table 22**) and rounded to the nearest 100 m^3.
3. Future Max Day demand based on number of connections multiplied by the maximum day demand per connection (**Table 22**) and rounded to the nearest 5 m^3.
4. Peak hour demands are not recorded by the Union Bay water system. In their absence, the standard multiplier of 1.5 was applied to the Max Day demand to generate the peak hour design demand for both the *Current Conditions* and *Future Development.*

$$\text{Peak Hour} = \frac{\text{Max Day} \times 1.5 \times 1{,}000 \text{ L/m}^3}{86{,}400 \text{ seconds/day}}$$

5. Future Peak Hour demand based on number of connections multiplied by the peak hour demand per connection (**Table 22**) and rounded to the nearest 1 m^3.

7.3 Maximizing Number of Properties Serviced

To add service connections to the system beyond the additional 1,846 connections shown in **Table 24**, while staying within the current licenced withdrawal limits, a reduction in both the current (Year 2021) annual average demand per connection and the maximum day demand per connection would be required.

To service the total projected 6,363 service connections (691 existing + 5,672 future) while staying within the current licenced withdrawal limits:

- annual demand per connection would need to be no more than 127 m^3/year per connection (a 60% reduction from Year 2021), and
- maximum day demand per connection would need to be no more than 1.30 m^3/day per connection (a 21% reduction from Year 2021).

Maximizing the number of properties serviced within the existing licenced withdrawal limits requires the development and implementation of an **Annual Leak Detection Program** and a **Water Conservation Plan**, both specific to the Union Bay water system, as previously discussed in **3.4 Water Demand Reduction**.

The number of service connections that could be added to the system, for every 5% reduction in the annual demand per connection, is presented in **Figure 16**.

It is understood that the CVRD is currently extending regional water south to K'ómoks First Nation lands located south of the northernmost portions of the Union Bay water system. The CVRD could review the feasibility of transferring properties in the Kilmarnock Drive area to the Royston Water Local Service Area as a way to service future development within the Union Bay Water Local Service Area. If implemented, the service area boundaries for both the Royston and Union WLSA's would need to be revised.

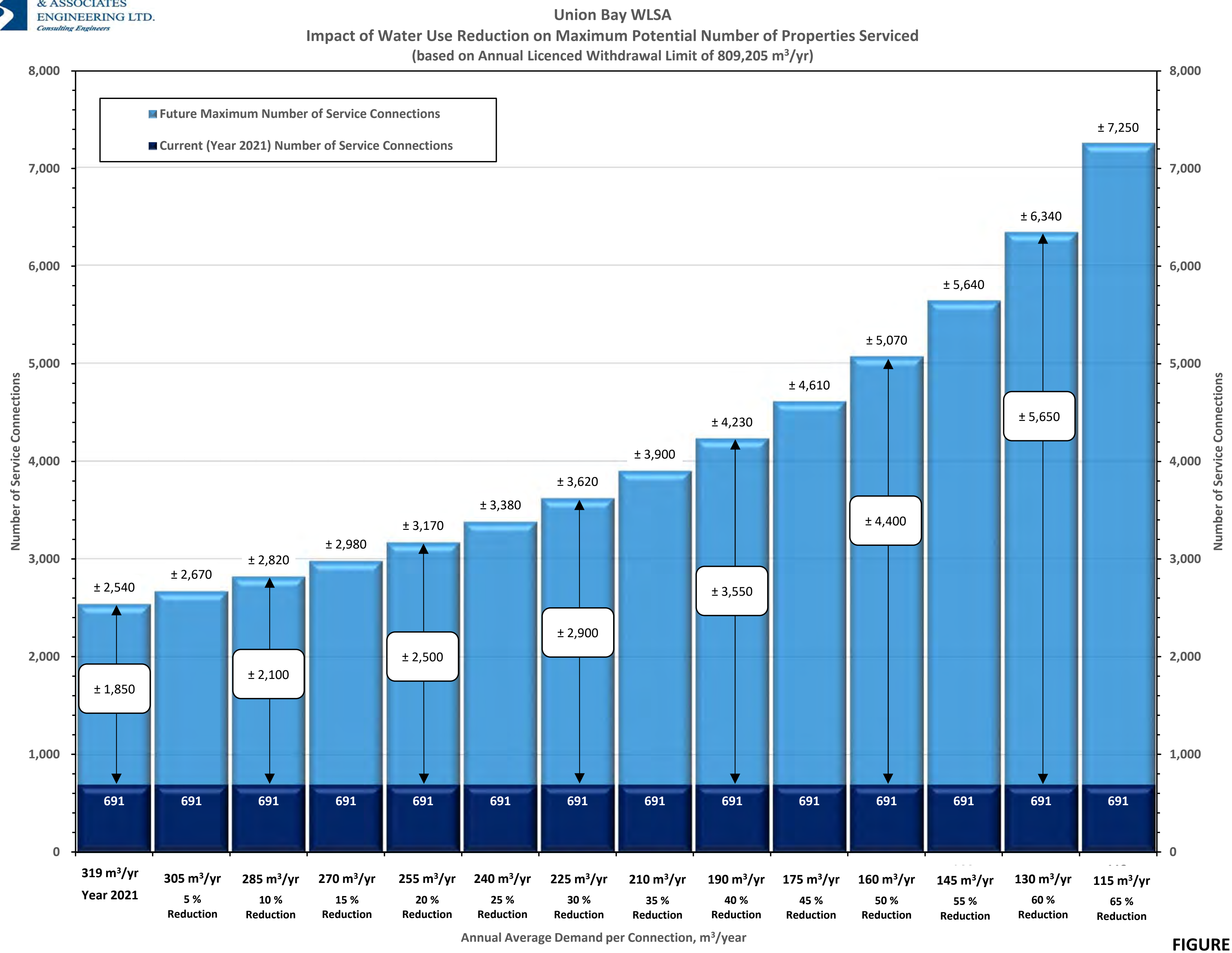
Union Bay WLSA
Impact of Water Use Reduction on Maximum Potential Number of Properties Serviced
(based on Annual Licenced Withdrawal Limit of 809,205 m³/yr)
Future Maximum Number of Service Connections
Current (Year 2021) Number of Service Connections
Number of Service Connections
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
± 2,540
± 2,670
± 2,820
± 2,980
± 3,170
± 3,380
± 3,620
± 3,900
± 4,230
± 4,610
± 5,070
± 5,640
± 6,340
± 7,250
± 1,850
± 2,100
± 2,500
± 2,900
± 3,550
± 4,400
± 5,650
691
319 m³/yr
Year 2021
305 m³/yr
5 %
Reduction
285 m³/yr
10 %
Reduction
270 m³/yr
15 %
Reduction
255 m³/yr
20 %
Reduction
240 m³/yr
25 %
Reduction
225 m³/yr
30 %
Reduction
210 m³/yr
35 %
Reduction
190 m³/yr
40 %
Reduction
175 m³/yr
45 %
Reduction
160 m³/yr
50 %
Reduction
145 m³/yr
55 %
Reduction
130 m³/yr
60 %
Reduction
115 m³/yr
65 %
Reduction
Annual Average Demand per Connection, m³/year

FIGURE 16

8 FUTURE SYSTEM ANALYSIS, WATER LICENCE LIMIT

8.1 Langley Lake Water Supply

During the spring and summer months, when flows into the lake are decreasing and system demand is increasing, the water level in the lake is drawn down. Over the past six years, the annual maximum recorded draw down levels has ranged from a minimum of 0.34 m (Year 2020) to a maximum of 0.67 m (Year 2021) as shown in **Table 3**. These drawdown depths and their relationship to the storage volume of Langley Lake, and the depth at which each of the three water restrictions is implemented, is graphically presented in **Figure 17**.

8.1.1 Historical Drawdown Depth/Volume

In Year 2021, the maximum drawdown of 0.67 m was recorded on September 8 (**Table 3**), equating to a storage volume decrease of 212,250 m^3. The lake returned to full storage on October 23; 37 days later. A summary of the annual maximum draw down, the estimated draw down storage volume, and the bulk meter volume from mid April to mid October (when the lake is typically less than full) is presented in **Table 25**.

Table 25 – Langley Lake Estimated Annual Drawdown Volume, 2016 - 2021

Year	Langley Lake Drawdown		Demand, mid April to mid Oct (3) (m^3)	Difference (Drawdown - Demand) (4) (m^3)	Lake Inflow, mid April to mid Oct (m^3)
	Maximum Distance (1) (m)	Estimated Volume (2) (m^3)			
2016 (5)	0.61	195,300	-	-	n/a (8)
2017 (6)	-	-	-	-	n/a (8)
2018	0.59	189,650	90,650	99,000	n/a (8)
2019	0.58	186,825	92,350	94,475	n/a (8)
2020	0.34 (7)	114,775	108,150	6,625	n/a (8)
2021	0.67	212,250	129,900	82,350	n/a (8)

Notes:

1. Drawdown distance below spillway crest.
2. Estimated volume derived from Langley Lake bathymetric survey contours, Oct 22, 2009 and Langley Lake Area – Capacity Curve graph, Feb 22, 2010 (see copies in **Appendix B**).
3. UBID/CVRD water operational staff indicate that the water level in Langley Lake typically drops below full around the middle of April and returns to full level some time in the middle of October. Demands are based on the raw bulk meter reading.
4. The resulting volume difference would consist of:
   i) Lake Water Surface Evaporation (sun and wind effect)
   ii) Plant Transpiration
   iii) Exfiltration from Lake into Surrounding Ground

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Langley Lake
Water Restriction Implementation Levels & 2016 - 2021 Draw Down Levels

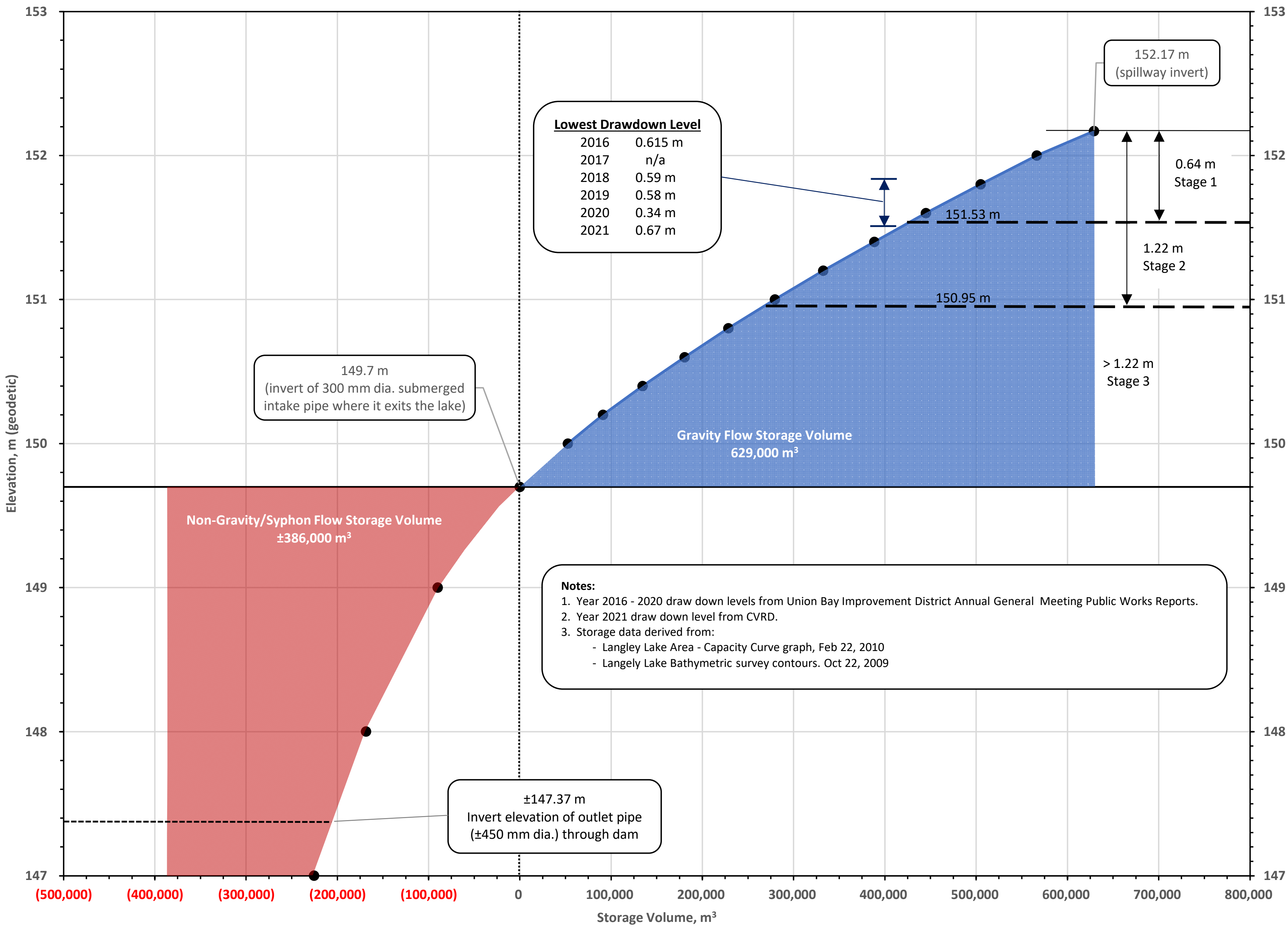


FIGURE 17

iv) Dam Leakage
v) Lake Drawdown Measurements & Bulk Meter Reading Inaccuracies
vi) Leakage in the raw water supply main

5 No bulk meter reading data for Year 2016 and Year 2017.

6 No maximum drawdown for Year 2017.

7 The maximum drawdown reported for Year 2020, and the resulting calculated volume difference, are noticeably lower compared to the other years. It is suspected that this could be due to higher rainfall during late spring and through the summer. The monthly rainfall (recorded at the Comox Airport weather station) for May, June and August were higher compared to the other years with the August total (55 mm) being double that of the next highest year (28 mm, Year 2019).

8 The quantity/cumulative volume of runoff and groundwater entering the lake is not known.

8.1.2 Future Drawdown Depth/Volume

Lower water levels and longer periods of time to restore the lake to full storage volume will occur in response to:

- increases in system demands, with additional development, during the spring and summer months when outflow exceeds inflow from precipitation
- warmer/drier springs and summers resulting in an increase in surface evaporation and potentially transpiration.

The elevation/depth to which the water level in Langley Lake would reach/lower to in the future is controlled by many factors, including but not limited to: system demands; flows into the lake; lake surface evaporation rates; infiltration into surrounding areas; dam leakage; raw water supply main leakage; and transpiration (movement of water through plants and subsequent evaporation).

A preliminary monthly water balance analysis for Langley Lake was carried out in the *Review of Hydrologic Reports and Preliminary Water Balance for Langley Lake, Union Bay, BC,* report dated November 17, 2009 by Summit Environmental Consultants Ltd. The report includes allowances and estimates for monthly inflows (runoff flows into the lake and precipitation on the lake surface) and outflows (lake evaporation, UVID water demands, lake/dam leakage, flow over the spillway, and an outflow correction factor. Limitations of the preliminary water balance include:

- no lake bathymetric survey,
- no water level data,
- estimated catchment of 320 ha,
- assumption that there were no flows over the spillway from May through October (6 months of the year),
- estimated monthly UBID water demand of 11,625 m^3/month from September through April (8 months) and estimated monthly 13,500 m^3/month from May through August (4 months); totalling 147,000 m^3 for the year.

The water balance calculations estimated that the 320 ha catchment would generate a total annual flow into Langley Lake of 2,500,000 m^3 during an average precipitation year and 1,870,000 m^3 during a drought precipitation year. Both are greater than the 1,015,000 m^3 current estimated storage volume of the lake (see **2.1.3 Langley Lake Storage Volume**), suggesting that the lake would be returned to full storage level each year.

During the 6 month period when it was assumed that there would be no flow over the spillway (May through October), the water balance calculations indicate the storage in the lake would be drawn down. For an average precipitation year, the drawdown volume was calculated to be 182,000 m^3. This is similar to the drawdown volumes for Year 2018, and 2019 (see **Table 25**) which has slightly higher total annual demands and notably higher monthly demand during May through August (see Table 10). During a drought year, the drawdown volume was calculated to be 247,000 m^3. This is somewhat greater than the 212,250 m^3 drawdown calculated for Year 2021 which experienced lower than average rainfall from February through August (as recorded at the Environment Canada Comox Airport weather station) as well as extreme and sustained day and night time temperatures during the “heat dome” event from late June to mid July.

The study recommended that a new hydrological assessment and water budget be carried out with the availability of additional information such as: a bathymetric survey, lake water level data, water demand records, rainfall and stream flow data. The study should incorporate water demand increases from future development and calculate the resulting maximum lake drawdown volume and level, the number of days required to return to full storage, and an assessment of the potential impact of climate change.

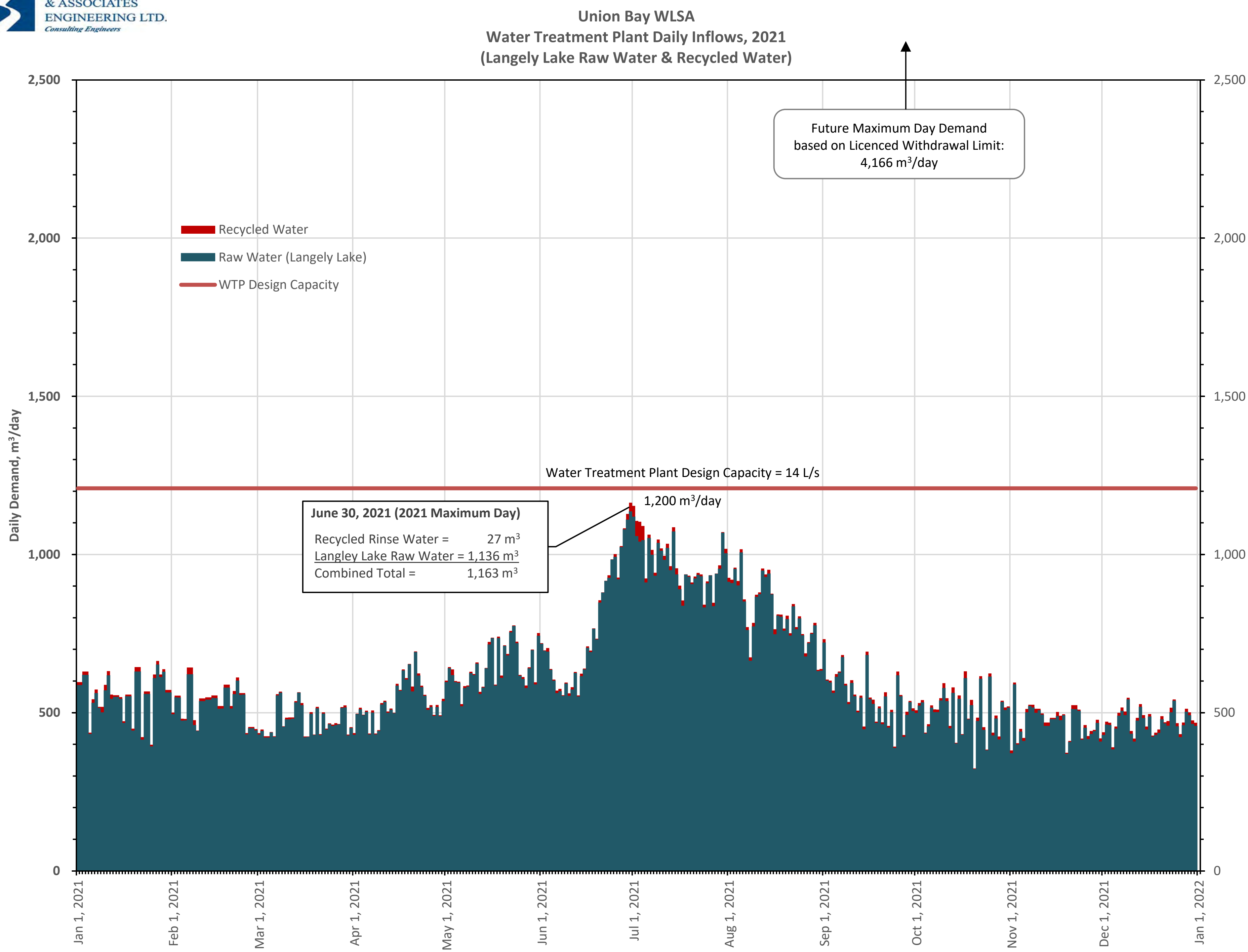
8.2 Langley Lake Supply Main Capacity

Conveyance of the future maximum day design demand of 4,166 m^3/day (48 L/s) through the supply main from Langley Lake to the water treatment plant will require a driving head of 44 m (430 kPa / 63 psi). As there is 71 m of head when the Lake is full (152.2 m geodetic) and 60 m of head when the Lake is empty (141.1 m), the existing supply main is adequate to convey the future maximum day design demand (4,166 m^3/day) at the point the Langley Lake water licence is fully utilized based on the annual volume limit (see **Table 24**).

8.3 Water Treatment Capacity

8.3.1 Existing Conditions (Immediate Term)

In the summer of 2021, the water treatment plant operated very close to its design flow capacity. The maximum flow into the water treatment plant was 1,163 m^3/day (consisting of 1,136 m^3 from Langley Lake and 27 m^3 of recycled rinse water) compared to the treatment plant design capacity of 1,200 m^3/day (14 L/s). The Year 2021 daily demands, as compared to the water treatment plant design capacity, are graphically presented in **Figure 18**.



Union Bay WLSA
Water Treatment Plant Daily Inflows, 2021
(Langely Lake Raw Water & Recycled Water)
Future Maximum Day Demand based on Licenced Withdrawal Limit: 4,166 m³/day
Recycled Water
Raw Water (Langely Lake)
WTP Design Capacity
Water Treatment Plant Design Capacity = 14 L/s
1,200 m³/day
June 30, 2021 (2021 Maximum Day)
Recycled Rinse Water = 27 m³
Langley Lake Raw Water = 1,136 m³
Combined Total = 1,163 m³
Daily Demand, m³/day
2,500
2,000
1,500
1,000
500
0
Jan 1, 2021
Feb 1, 2021
Mar 1, 2021
Apr 1, 2021
May 1, 2021
Jun 1, 2021
Jul 1, 2021
Aug 1, 2021
Sep 1, 2021
Oct 1, 2021
Nov 1, 2021
Dec 1, 2021
Jan 1, 2022

FIGURE 18

Treatment Plant Production Increase

The dissolved air floatation (DAF) equipment has been designed for the following flow range:

- Maximum flow: 14 L/s
- Minimum flow: 8 L/s

The Island Health Construction Permit that was obtained for the existing Water Treatment Plant specifies a maximum design flowrate of 14 L/s. That said, there may be an opportunity to increase the maximum treatment capacity of the existing treatment equipment by 10% to 15% (1.5 L/s to 2 L/s) during the summer months when the raw water quality is typically better in Langley Lake. The plant's treatment capacity is limited by incoming raw water quality parameters including turbidity and naturally occurring organics (TOC and DOC). Increasing the treatment flow above 14 L/s will require approval from Island Health. As a minimum, it is anticipated that the following steps will be necessary:

Retain the Services of the Treatment Plant Manufacturer

The water treatment plant manufacturer (AWC Water Solutions) should be consulted to see if they foresee any challenges with increasing the treatment plant capacity by 10% to 15% during the summer months.

Review Control of Treatment Plant Inlet Flow

The rate of flow entering the water treatment plant is controlled by a butterfly valve on the DAF tank inlet. It is understood the operating controls (electronic programming) for this valve may restrict the incoming flow (by throttling the valve) so that it does not exceed 14 L/s. This is likely a safety measure to prevent the plant from operating above its design capacity. The water treatment plant manufacturer (AWC Water Solutions) has indicated that programming changes to the controls could allow additional water to enter the DAF tank. Re-establishing the remote connection between AWC and the plant's control panel would allow AWC to remotely adjust programmed settings to increase the rate of flow of water entering the DAF tank inlet. This remote connection was originally used during start-up and commissioning of the treatment plant.

Review Capacity of Existing Pumps Transferring Treated Water to Reservoir

There are two existing pumps that transfer treated water from the treatment plant to the reservoir. Currently these are set-up to operate one at a time. The capacity of these pumps will have to be reviewed to see if each pump can transfer more than 14 L/s, or whether it will be necessary to modify the controls and operate both pumps at the same time in order to pump the higher flow.

Develop a Water Quality Testing Plan and Submit to Island Health for Approval

It is anticipated that a carefully thought-out water quality testing plan will have to be developed and submitted to Island Health for approval before attempting to increase the capacity of the existing plant. Such a plan will likely involve a series of gradual flow increases (over and above the 14 L/s), and then testing specific water quality parameters in both the raw water entering the plant and the treated water leaving the plant. Careful review of the water quality testing results would be required after each flow increase to ensure the water quality of the treated water is staying within the limits specified under the plant's Operating Permit.

8.3.2 Future Conditions (Longer Term)

Servicing the future maximum day design demand of 4,166 m^3/day (48 L/s) will require expansion of the water treatment plant for the processing of an additional 34 L/s.

Allowance was made during the design and construction of the existing water treatment plant for future expansion/duplication of the:

- water treatment plant building and treatment processes,
- treated water storage reservoir, and
- backwash waste containment pond.

The electrical service was sized to accommodate duplication of the water treatment plant and provisions for future inlet/outlet water tie-ins were included. Expanding the plant to a capacity of 48 L/s will have to be reviewed to see whether the existing electrical service needs to be upgraded.

As can be seen on the original site plan drawing (located in **Appendix D**), approximately half of the property (0.9 ha of the 1.7 ha) has been cleared and graded for the now constructed works and to accommodate the future expansion/duplication works noted above. Additional expansion of the treatment system (Beyond duplication), reservoir storage, and backwash waste containment pond should be possible on the property, if needed.

8.4 Allocation Scenario of Future Demands

As previously discussed in Section 7.2.3 Future Demands, Water Licence Limit, an additional 1,846 water service connections could be added to the system based on the annual licenced withdrawal limit and the current (Year 2021) total annual demand. Additional connections (discussed in Section 7.1.2 Potential Development Projects and Areas) were added to the model as follows:

Properties Not Yet Connected:	256 connections
Union Bay Estates Phase 1:	455 connections
Union Bay Estates Phase 2:	283 connections
DL 7:	625 connections
DL 13:	226 connections
Combined Total:	1,846 connections

This is one of many possible demand allocation scenarios that could be modelled to establish upgrades that are needed within the water system. This particular demand allocation scenario is based on estimated connections associated with proposed developments that the CVRD is currently aware of. The number of connections assigned to DL 7 and DL 13 are based on the proposed development plans which will require an OCP amendment followed by rezoning. The final number of connections permitted would not be known until both processes are completed.

Demands for properties not yet connected were distributed evenly throughout the model at nodal points (pipe intersections, end of mains and pipe diameter changes) by increasing the existing demands by 37%. Demands for the Union Bay Estates (Phases 1 & 2), District Lot 7, and District Lot 13, were added to the model based on the physical location of these developments.

8.5 Future Distribution System & Pressure Zones

A conceptual water distribution system for the proposed developments was added to the computer model based on the available proposed development plans (see **Table 1**). Where no development plans were available (DL 7), a basic network was applied between the existing water system on Nelson Street (north side of DL 7) and the proposed DL 13 development (south side of DL 7). A distribution system for Union Bay Estates, Phase 3 (located north of Hart/Washer Creek and west of the Island Hwy 19A), was not incorporated into the model as demands were not associated with it. Development of Phase 3 is not scheduled to commence until Year 2040 after completion of phase 1 and phase 2 (see **Table 20**).

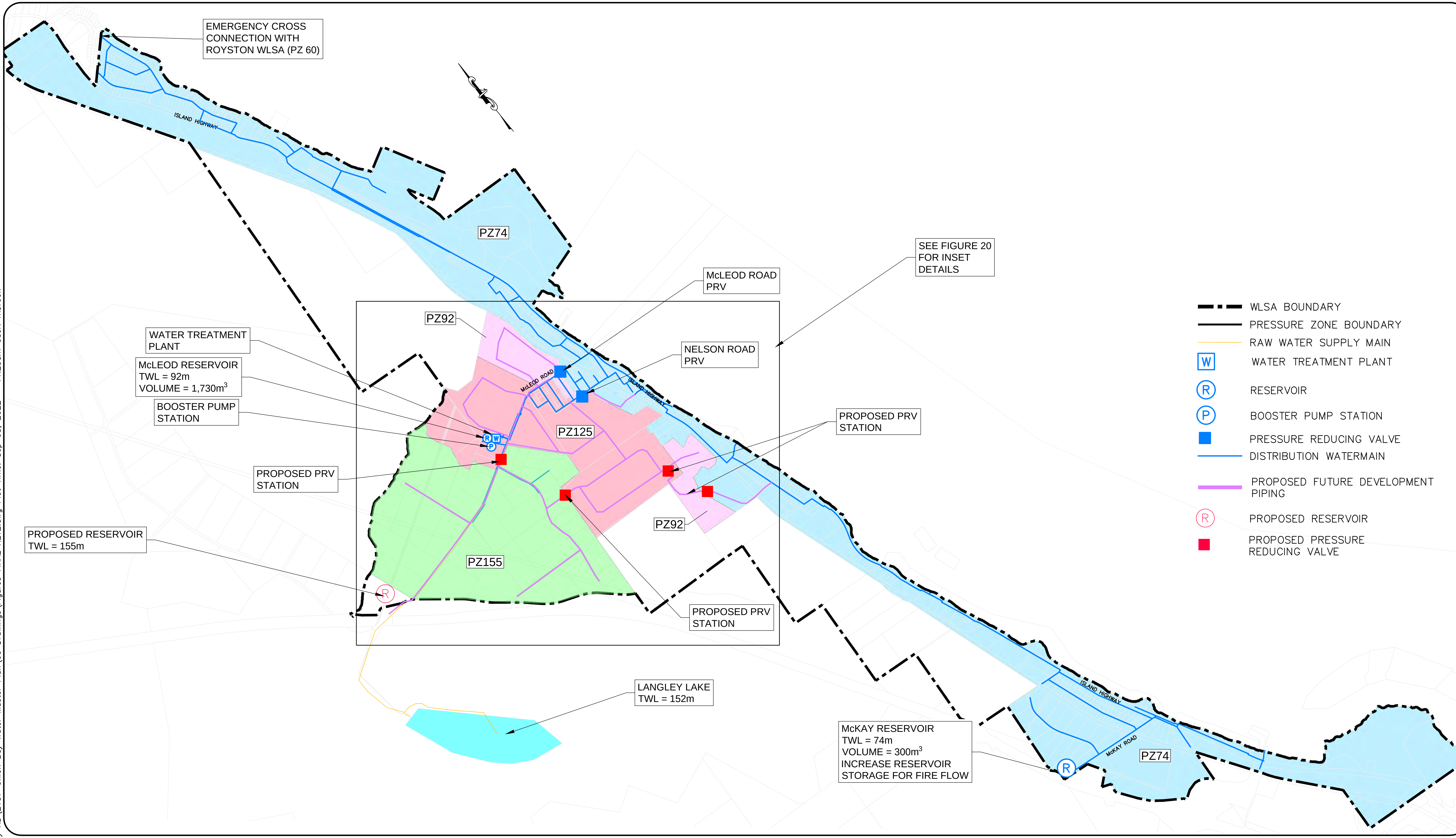
A preliminary layout of the future water distribution system, to service the proposed developments, is shown in **Figure 19** and **Figure 20**. Four pressure zones are proposed including the three existing pressure zones (PZ 74, PZ 94 and PZ 155) and a new pressure zone (PZ 125). These pressure zones have been developed in accordance with the minimum and maximum service pressure design criteria noted in **Table 15**, i.e., minimum 300 kPa (44 psi) and maximum 860 kPa (125 psi). **Figure 21** shows the highest serviceable ground elevation for each pressure zone under static conditions. It is anticipated the servicing of Union Bay Estates phase 3 lands above the 39 m contour will be achieved by a future watermain crossing of Hart Creek from the proposed PZ 125 as shown in **Figure 20**. A brief discussion of the future water distribution system is presented below.

8.5.1 155 m Pressure Zone

To provide fire flows within the 155 m pressure zone, a new water storage reservoir (with a top water level of 155 m) needs to be constructed. The highest point of land in this pressure zone is located at the top (west) end of McLeod Road near the Inland Island Hwy, but even this site will require a very tall reservoir. A new booster pump station connected to a dedicated watermain, from the treatment plant to the reservoir, would be required to fill the reservoir. A new watermain from the reservoir down (east) along McLeod Road would also have to be constructed, with a new watermain branching off along Murray Ave. The existing 100 mm dia. watermain along Green Ave would be upgraded and a new watermain installed off it at Craddock Rd (to the west).

The proposed watermain from the reservoir will need to be sized to convey the design fire flow demand plus maximum day demands. A potential location of the proposed reservoir is shown in **Figure 20** along with the new watermains.

The 155 m pressure zone could service properties below 124 m geodetic (static pressure of 300 kPa / 44 psi) and above 67 m geodetic (static pressure of 860 kPa / 125 psi), though it would be advantageous to try and limit the lowest elevation to between 92 m and 102 m geodetic. This would result in a maximum static pressure between 620 kPa to 540 kPa (90 psi to 80 psi) which would help minimize system leakage (Non-Revenue Water) by way of pressure management.



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CLIENT: COMOX VALLEY REGIONAL DISTRICT

PROJECT: UNION BAY LOCAL SERVICE AREA WATER MASTER PLAN

TITLE: FUTURE CONCEPTUAL WATER SYSTEM

APPROVED	MP	SCALE	1: 30,000
DATE	SEP 2022	DWG No.	FIGURE 19
PROJECT No.	2157		

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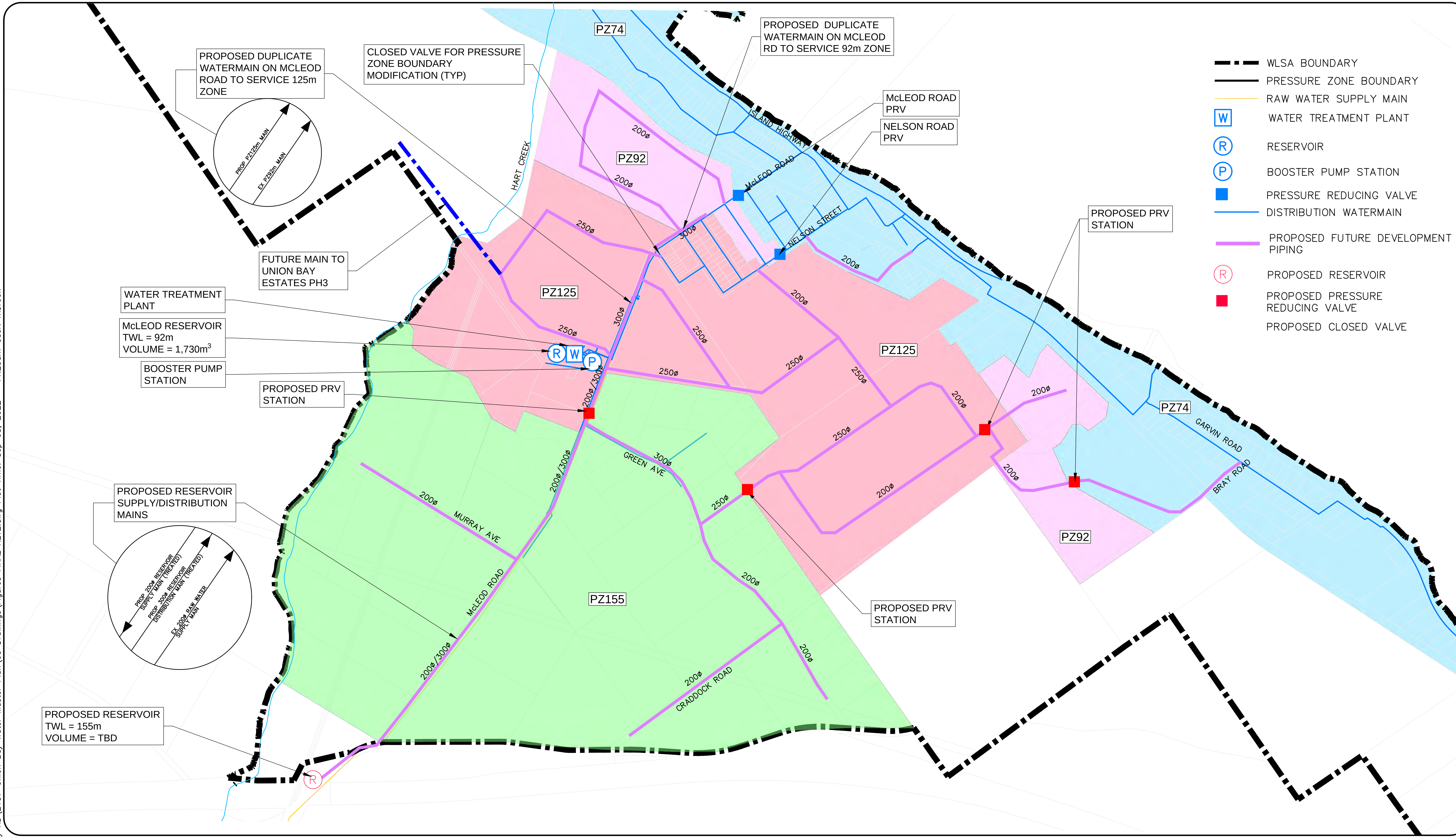

CLIENT COMOX VALLEY REGIONAL DISTRICT

PROJECT UNION BAY LOCAL SERVICE AREA WATER MASTER PLAN

TITLE FUTURE PRESSURE ZONES AND IMPROVEMENTS

APPROVED	MP	SCALE	1:12,500
DATE	SEP 2022	DWG No.	FIGURE 20
PROJECT No.	2157		

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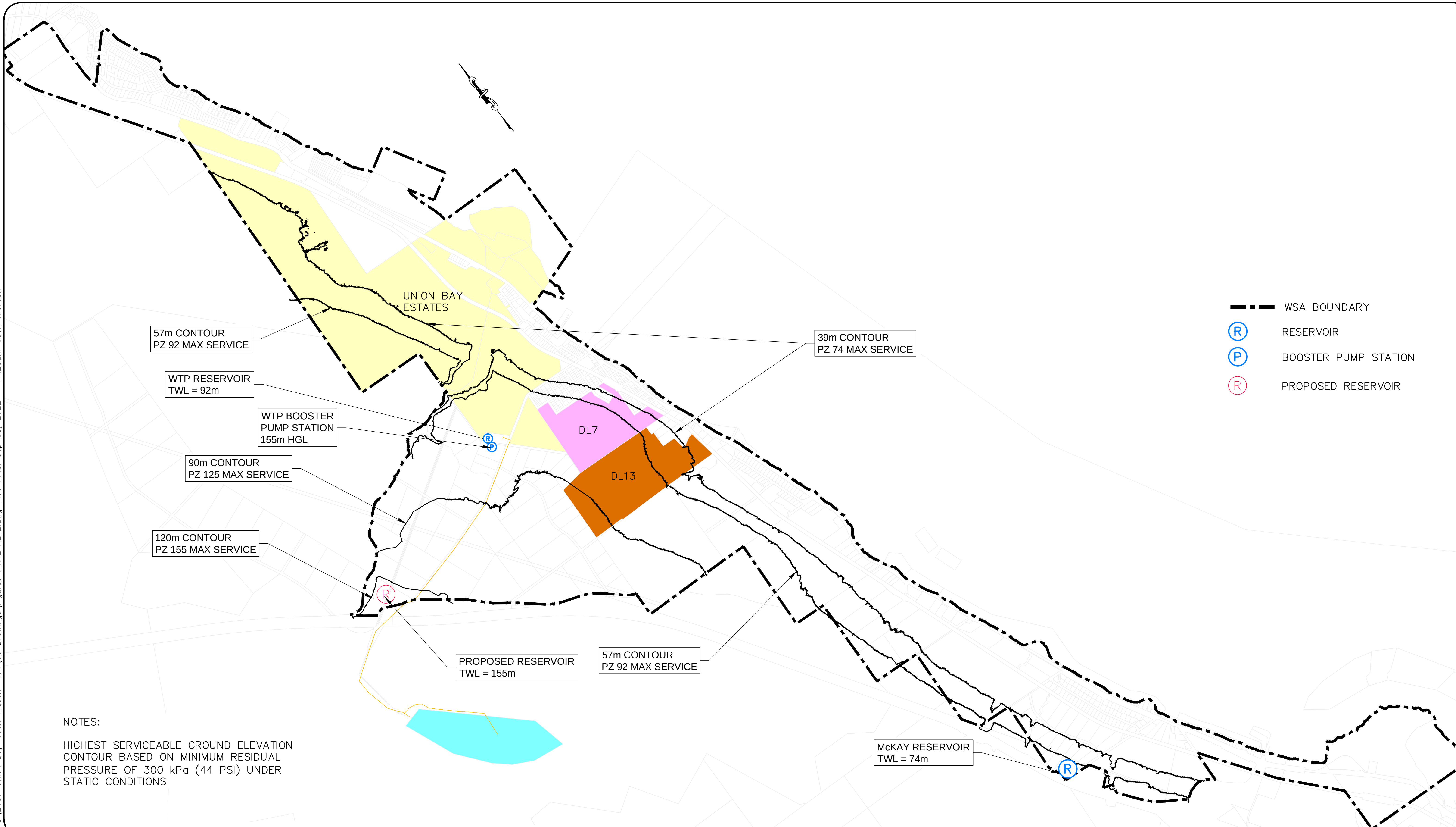

NOTES:

HIGHEST SERVICEABLE GROUND ELEVATION CONTOUR BASED ON MINIMUM RESIDUAL PRESSURE OF 300 kPa (44 PSI) UNDER STATIC CONDITIONS

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CLIENT: COMOX VALLEY REGIONAL DISTRICT

PROJECT: UNION BAY WATER SYSTEM WATER MASTER PLAN

TITLE: HIGHEST SERVICEABLE GROUND ELEVATION CONTOUR FOR PZ 74, PZ 92, PZ 125 & PZ 155

APPROVED	MP	SCALE	1: 30,000
DATE	SEP 2022	DWG No.	FIGURE 21
PROJECT No.	2157		

8.5.2 125 m Pressure Zone

A new pressure zone will be created between the 155 m and the 92 m pressure zones. It would service the existing properties within the 92 m pressure zone that are presently not provided a minimum residual pressure of 300 kPa (44 psi) during peak hour demands (see **Figure 11**).

The 125 m pressure zone would be serviced from the proposed 155 m pressure zone reservoir via Pressure Reducing Valves (PRVs). The service area of the 125 m pressure zone would encompass properties within the proposed Union Bay Estates (Phase 2 and some of Phase 3), District Lot 7 and District Lot 13.

The 125 m pressure zone could also be used to service properties within Phase 1 of Union Bay Estates that are above an elevation of 39 m geodetic; the maximum ground elevation that the 74 m pressure zone can provide a minimum residual pressure of 300 kPa (44 psi) to during peak hour demands. This would require the installation of a watermain across Hart Creek. The potential locations of the proposed PRVs, the watermains in the 125 m pressure zone and a future watermain across Hart Creek are shown in **Figure 20**.

The 125 m pressure zone could service properties below 94 m geodetic (static pressure of 300 kPa / 44 psi) and above 37 m geodetic (static pressure of 860 kPa / 125 psi), though it would be advantageous to try and limit the lowest elevation to between 62 m and 72 m geodetic. This would result in a maximum static pressure between 620 kPa to 540 kPa (90 psi to 80 psi) which would assist in reducing system leakage (Non-Revenue Water) by way of pressure management.

8.5.3 92 m Pressure Zone

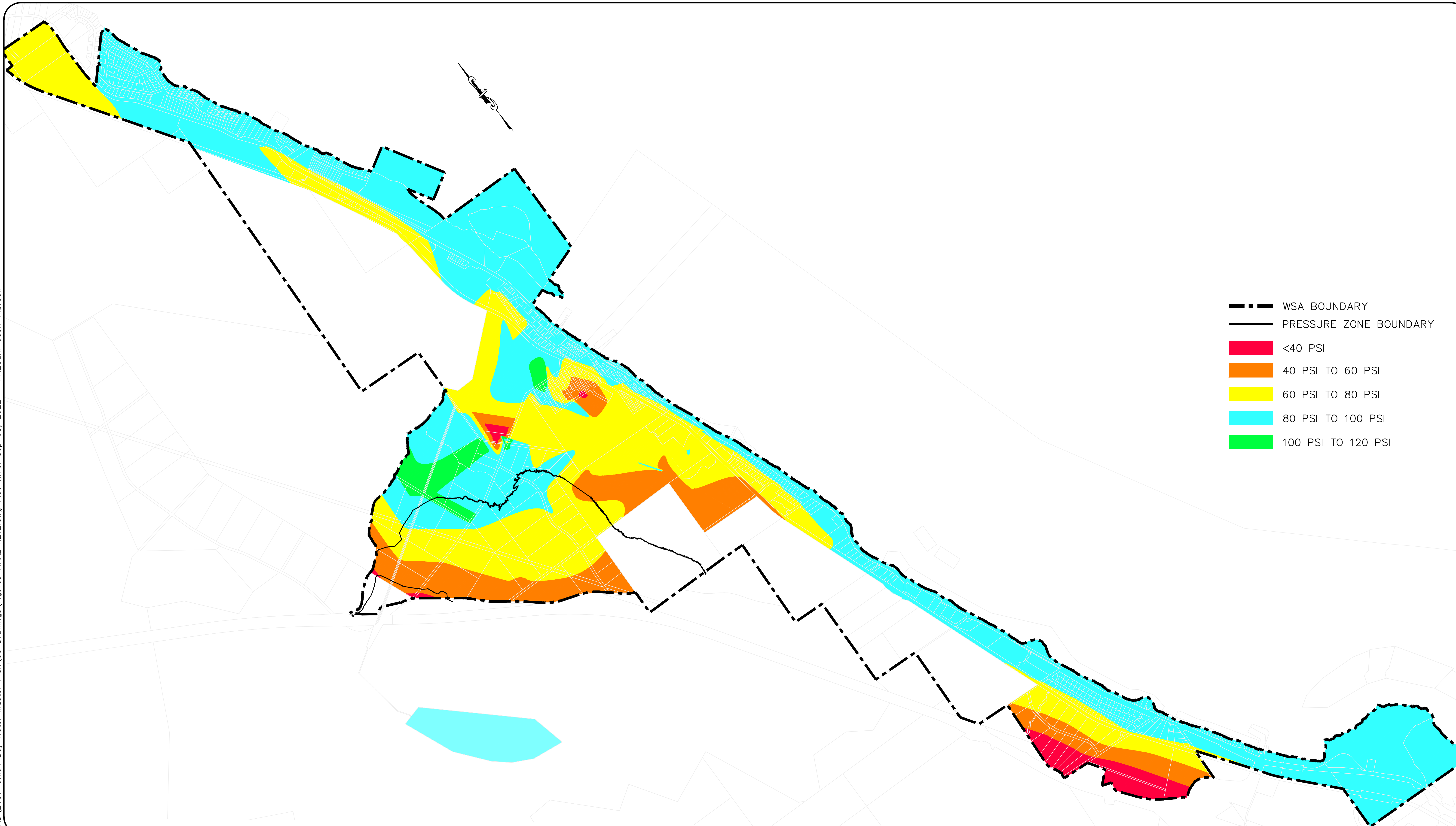
The service area for this existing pressure zone would encompass those properties in Union Bay Estates (Phase 2) and in District Lot 13 that should not be serviced from the 125 m pressure zone in order to avoid high static pressures. This pressure zone would be serviced by the existing McLeod Rd reservoir, with its top water level of 92 m geodetic, and by the 125 m pressure zone through a PRV. The proposed pressure zone service area and PRV are shown in **Figure 20**.

8.5.4 74 m Pressure Zone

The 74 m pressure zone would continue to be serviced from the 92 pressure zone by the two existing PRVs and one new PRV located south of District Lot 13. For the purposes of this study, this new PRV is located along a future extension of Bray Road off Garvin Road. The proposed pressure zone service area and the PRVs are shown in **Figure 20**.

8.6 Peak Hour Pressures

The calculated residual pressures throughout the water distribution system during the future peak hour design demand (73 L/s), are graphically shown in **Figure 22**. These residual pressures are based on the completion of the improvement works shown in **Figure 13** and the future pressure zones and improvements shown in **Figure 20**.



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CLIENT	COMOX VALLEY REGIONAL DISTRICT
PROJECT	UNION BAY LOCAL SERVICE AREA WATER MASTER PLAN

TITLE	FUTURE DEMAND CONDITIONS RESIDUAL PEAK HOUR PRESSURES AFTER IMPROVEMENTS		
APPROVED	MP	SCALE	1:30,000
DATE	SEP 2022	DWG No.	FIGURE 22
PROJECT No.	2157		

8.7 Maximum Day with Design Fire Flow

The calculated maximum available fire flows throughout the water distribution system, during the future maximum day design demand (4,166 m^3/day), are graphically shown in **Figure 23**. These fire flows are based on the completion of the improvement works shown in **Figure 13** and the future pressure zones and improvements shown in **Figure 20**.

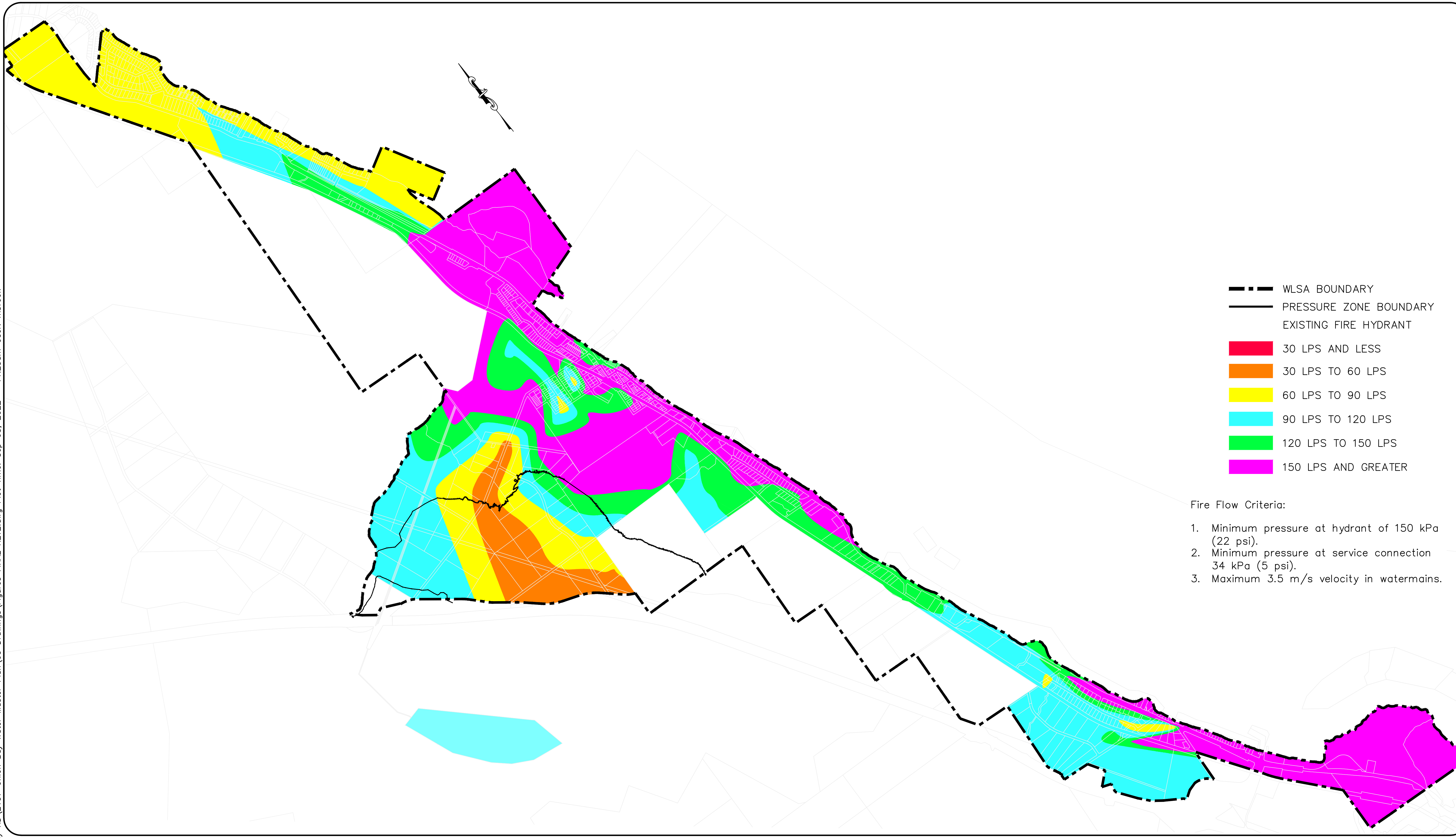
8.8 Future Reservoir Storage

8.8.1 92 m and 74 m Pressure Zones

The two existing reservoirs (McLeod Rd reservoir and McKay Rd reservoir) have a combined storage volume of 2,030 m^3 (**Table 6**). Based on the design fire flow demand of 150 L/s (for a duration of 2 hours), a maximum day demand of 2,176 m^3/day could be serviced from this combined storage volume. This equates to 1,327 service connections, based on the current (Year 2021) maximum day demand of 1.64 m^3/day per connection (**Table 22**). This is an increase of 636 service connections from the existing 691 service connections.

8.8.2 155 m and 125 m Pressure Zones

A new water storage reservoir will be required in the 155 m pressure zone to provide the fire flow storage, the equalization (peaking) storage and the emergency storage needed to support the future developments within the 155 m and 125 m pressure zones. The total storage volume of the reservoir will be dependent on the design fire flow and the maximum day demand within this future service area. If the design fire flow demand was 150 L/s (for a duration of 2 hours) and if the maximum day design demand was 3,030 m^3/day (the maximum day demand of all the future development covered by the existing water licence; see **Table 24**) the total storage volume would be 2,830 m^3. This equates to 1,846 service connections within the 155 m and 125 m pressure zones based on the current (Year 2021) maximum day demand of 1.64 m^3/day per connection (**Table 22**). It is anticipated that some future development will occur in the lower pressure zones and therefore, the proposed reservoir volume can be less than 2,830 m^3.



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CLIENT: COMOX VALLEY REGIONAL DISTRICT

PROJECT: UNION BAY WATER SYSTEM WATER MASTER PLAN

TITLE: FUTURE DEMAND CONDITIONS AVAILABLE FIRE FLOWS AFTER IMPROVEMENTS

APPROVED	MP	SCALE	1: 30,000
DATE	SEP 2022	DWG No.	FIGURE 23
PROJECT No.	2157		

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9 CONCLUSIONS

The following are the principal findings of this study:

9.1 Existing Conditions

Water Licenced Authorized Withdrawal Limit & Historical Demand

1 The Union Bay water system is authorized to withdraw the following daily maximum and total annual volume:

- Maximum Day Withdrawal Limit: 8,310 m^3/day
- Annual Withdrawal Limit: 809,205 m^3/year

2 During the past four years (2018-2021), the historical demands (Maximum Day and Total Annual) have been well below the licenced withdrawal limits. The highest recorded demands were:

- Highest Maximum Day Demand: 1,320 m^3/day, July 20, 2020 (16% of licence)
  For Year 2021, the first complete calendar year of operation of the water treatment plant, the maximum day demand was slightly lower at 1,136 m^3/day (June 30, 2021) which was 14% of the licened withdrawal limit.
- Largest Total Annual Demand: 220,400 m^3/year, Year 2021 (27% of licence)

Langley Lake Authorized Storage Volume & Actual Storage Volume

3 Langley Lake has a calculated total storage volume of 1,015,000 m^3 and a total depth of just over 11 m. The storage volume consists of (see **Figure 3**):

- 629,000 m^3 of gravity flow storage with a depth of 2.47 m (between the dam full elevation and the invert of the 300 mm dia. submerged intake pipe where it exits the lake).
- 386,000 m^3 of non-gravity/siphon flow storage with a depth of 8.56 m (between the invert of the 300 mm dia. submerged intake pipe and the bottom of the lake).

4 The Union Bay water system is authorized to store a maximum of 888,100 m^3/year. This is very similar to the 834,000 m^3 water volume that exists between the top of the spillway (the dam full elevation) and the invert of the ±450 mm dia. intake pipe originally installed through the dam (a depth of 4.8 m) as shown in **Figure 3**.

Langley Lake Drawdown Levels & Volumes

5 In Year 2021, a water level in the lake was drawn down to 0.67 m below the lake's top water level. This equates to an estimated reduction in total storage volume of 212,250 m^3 (34% of the 629,000 m^3 of gravity flow storage in the lake). It required a total of 37 days (from Sep 8 to Oct 15) for the lake to return to full storage (**Table 3**).

Water Treatment Process & Design Treatment Capacity

6 Commissioned in May 2020, the Union Bay water treatment process consists of:

- pH adjustment (caustic soda addition), followed by
- Dissolved Air Floatation, followed by
- Rapid Gravity Media Filtration, followed by
- Chlorination.

7 The treatment process has been designed to accommodate addition of UV disinfection if required in the future.

8 The existing water treatment plant has a design treatment capacity of 14 L/s (1,200 m^3/day).

9 Allowance was made during the design and construction of the existing water treatment plant for future expansion/duplication of the water treatment plant building and treatment processes, treated water storage reservoir, and backwash containment pond (**Appendix D**).

Water Storage

10 There are two treated water storage reservoirs in the distribution system with a combined storage volume of 2,030 m^3:

- The Water Treatment Plant Reservoir has a storage volume of 1,730 m^3. It has a top water level of 92 m geodetic and services Pressure Zone 92 (PZ 92).
- The McKay Rd Reservoir has a storage volume of 300 m^3. It has a top water level of 74 m geodetic and services Pressure Zone 74 (PZ 74).

Water Distribution System

11 The water distribution system consists of more than 30 kms of watermain piping, of which 58% (17.7 kms) is Asbestos Cement material.

12 The majority (55%) of the watermain piping is 200 mm dia., followed by 150 mm dia. at 24%, and 100 mm dia. or less at 15%. The remaining 6% is 250 mm dia. (4%) and 300 mm dia. (2%).

13 Most of the water distribution mains are believed to be around 50 years old.

14 The water distribution system contains three pressure zones:

- Pressure Zone 155 (Booster Pump Station)
- Pressure Zone 92 (McLeod Road Reservoir)
- Pressure Zone 74 (McKay Road Reservoir)

Booster Pump Station (Pressure Zone 155)

15 Pressure Zone 155 (PZ 155) is supplied by the booster pump station located inside the water treatment plant and consists of three Grundfos CR-5 pumps, with one pump operating continuously. The pumps draw water from the water treatment plant reservoir and pump into the 100 mm dia. distribution main along McLeod Road.

16 This pressure zone is capable of servicing properties below 120 m geodetic and above 67 m geodetic. At present, this encompasses properties along McLeod Road west of the reservoir

(back towards Langley Lake) ending just before Murray Ave, as well as properties along Musgrave Rd and Green Ave.

17 The booster pump station is not capable of supplying fire flow demands.

Pressure Zone 92 (McLeod Rd Reservoir)

18 This pressure zone is serviced by the McLeod Road reservoir which has a top water level elevation of 92 m.

19 This pressure zone is capable of servicing properties below an elevation of 57 m geodetic.

Pressure Zone 74 (McKay Rd Reservoir)

20 This pressure zone is fed from Pressure Zone 92 and is created by two PRVs located at:

- Nelson St at 4^{th} St
- McLeod Rd at 4^{th} St

21 This pressure zone contains the McKay Road reservoir, which has a top water level of 74 m geodetic.

22 This pressure zone is capable of servicing properties up to an elevation of 39 m geodetic.

Demands Per Connection, Historical

23 The Union Bay water system is universally metered. In Year 2021, there were 691 water meters. The majority of the meters (97%) are for single family residential properties. The other 3% are for Institutional, Commercial, or Industrial (I/C/I) properties.

24 For Year 2021, the average demand per connection for the water system was 319 m^3/year per connection, based on a total system demand of 220,400 m^3 and 691 connections (**Table 12**). This is similar to other Vancouver Island universally metered water systems (see **Table 13**).

Non-Revenue Water Amount

25 Known non-revenue water sources identified for Year 2021 included watermain repair leaks, watermain automatic flushing valves, watermain manual flushing, water treatment plant backwash, and likely increased system pressures compared to before the construction of the water treatment plant (**Table 14**).

26 As the Union Bay Water System continues to age, addressing system leakage will become more and more critical in order to reduce Non-Revenue water losses as much as possible.

Non-Revenue Water Demand Reduction

27 For 2021, the amount of Non-Revenue Water (Water System Bulk Meter minus Sum of all Individual Meters) was 41% (**Table 12**). This is notably high.

28 If the 15,000 m^3 (equivalent to 7% of total metered property demand) of water used by the automatic flushers (**Table 14**) was not required in Year 2021, an additional 50 residential properties could have been serviced and additional revenue generated by its metered usage.

29 While elimination of Non-Revenue water is not possible, reducing it to 25% of total system demand is considered a reasonable and realistic target for the Union Bay water system.

30 If in Year 2021, Non-Revenue water demand had been 25% and not 41%, an additional 110 properties could have been serviced by the 16% difference, resulting in additional revenue generated by its metered usage, without any increase in the water treatment plant operating costs.

31 Development and Implementation of an **Annual Leak Detection and Reduction Program** will be a key component of reducing Non-Revenue water demand, which in turn will allow the servicing of additional properties and thereby generate additional revenue by its metered usage.

32 The quickest way to lower Non-Revenue water losses will be to reduce or eliminate automatic flushing, provided chlorine residuals can be maintained throughout the system, now that the Water Treatment Plant is in operation.

Revenue Water Demand Reduction

33 Reducing Revenue (metered) water demands requires a change in human behaviour.

34 A reduction in metered demand in Year 2021 (during the dry summer months), when the treatment plant is operated near or at capacity, would have provided the ability to service additional properties. This will require the development of a **Water Conservation Plan** specifically for the Union Bay water system. The plan would identify water use modification tools which would result in the goal of demand reduction during the dry summer months when demand is the highest. The plan would assess the potential for reducing both indoor and outdoor water usage.

System Pressures During Peak Hour Demands, Existing Conditions

35 Computer modelling results indicate that the water system is capable of providing the recommended minimum pressure of 300 kPa (44 psi) at property line throughout the distribution system, with the exception of some properties close to the two reservoirs as shown in **Figure 11**.

Available Fire Flows During Maximum Day Demand, Existing Conditions & Proposed Upgrades

36 As shown in **Figure 12**, computer modelling results indicate that available fire flows are very limited (less than 60 L/s) in many areas including:

- in Pressure Zone 155
- in Pressure Zone 92 between the water treatment plant and the old McLeod Road reservoir site
- in Pressure Zone 74 at the northern end (north of Glover Rd), and

- in Pressure Zone 74 at the southern end (south of Emerton Rd).

37 To improve the fire fighting capabilities of the water system, 8.3 kms of upgrading works consisting of watermain upsizing and looping has been identified (see **Figure 13** and **Table 17**).

38 On a water system the size of the Union Bay system, the upgrading of 8.3 kms (27% of the water distribution system mains) will likely have to be carried out over a significant period of time due to the cost of the upgrades. In some areas it may be acceptable to wait until the older piping reaches the end of its operational life, and then replace it with the proposed larger watermains.

Minimum Reservoir Storage Requirements, Existing Conditions

39 The combined storage volume of the two existing reservoirs (totalling 2,030 m^3) is currently more than the recommended minimum design storage volume of 1,705 m^3 (**Table 19**).

40 The existing reservoirs have adequate storage to service a maximum day demand of 2,176 m^3/day. Based on the current (Year 2021) maximum day demand of 1.64 m^3/day per connection, this equates to a total of 1,327 service connections; an additional 636 connections to the existing (Year 2021) 691 service connections.

9.2 Future Growth & Demands

Future Growth

41 It is projected that more than 5,600 water service connections could be added to the water system based on existing properties not yet connected (developed and undeveloped) and anticipated development projects (**Table 21**).

42 Based on the licenced annual withdrawal limit and the current (Year 2021) annual demand per connection, only an additional 1,846 water service connections could be added to the Union Bay water system (**Table 24**) without exceeding the existing licence. The maximum day demand would increase to 4,166 m^3/day based on the current (Year 2021) maximum day demand per connection (**Table 22**).

Langley Lake Drawdown

43 Increases in system demands will result in lower water levels in Langley Lake and longer recovery times to restore the lake to full storage level.

44 The elevation/depth to which the water level in Langley Lake would drop to in the future is controlled by many factors, including but not limited to: system demands; flows into the lake; lake surface evaporation rates; infiltration into surrounding areas; dam leakage; raw water supply main leakage; and transpiration (movement of water through plants and subsequent evaporation).

45 The preliminary water balance carried out in 2009 was limited by: no lake bathymetric survey; no lake water level data; the assumption there was no flow over the spillway from May through October; not having daily UBID water demands and assumed a constant monthly UBID water

demand from May through August and another constant monthly UBID water demand from September through April; and a smaller catchment area (320 ha) compared to the current estimated catchment area (±369 ha). The study did not include a water balance based on future water demands.

46 The 2009 report recommended a new hydrologic assessment and water balance of Langley Lake be carried out when more complete and additional information was available.

Langley Lake Raw Water Supply Main Capacity

47 The existing raw water supply main from the lake is adequate to convey the future maximum day design demand of 4,166 m^3/day; at which point the Langley Lake water licence would be fully utilized, based on the annual volume limit (**Table 24**).

Water Treatment Capacity, Immediate Term and Longer Term

48 The water treatment plant has been designed for a maximum flow rate of 14 L/s (1,200 m^3/day). In the immediate term, there may be an opportunity to increase the maximum treatment capacity of the DAF equipment by 10% to 15% (1.5 L/s to 2 L/s) during the summer months when demand is the highest and the raw water quality is typically at its best (less organics and turbidity).

49 Any proposed changes within the treatment plant should be discussed with the water treatment plant manufacturer (AWC Water Solutions) before making any adjustments.

50 Adjustments to the control setting (electronic programming) of the butterfly valve on the DAF tank inlet may be required.

51 Adjustments to the operation of the two pumps that transfer treated water to the reservoir may be required.

52 After approval from Island Health has been obtained, water quality testing will need to be conducted during the summer months prior to making any permanent capacity changes in the treatment plant.

53 In the longer term, the servicing of the future maximum day design demand of 4,166 m^3/day (48 L/s) will require a major expansion of the water treatment plant for the processing of an additional 34 L/s.

Future Distribution System and Pressure Zones

54 To provide the recommended minimum pressure of 310 kPa (44 psi), during peak hour demands, to development above 57 m geodetic, a new pressure zone is required. This encompasses most land in District Lot 13, District Lot 7, more than half of Union Bay Estates Phase 2, and some of the existing properties on Seventh Street and Eighth Street. A 125 m pressure zone is proposed.

55 To provide fire flows within the 155 m pressure zone, a new water storage reservoir (with a top water level of 155 m) needs to be constructed. The highest point of land in this pressure zone is located at the top (west) end of McLeod Road near the Inland Island Hwy, but even this site will require a very tall reservoir. A new booster pump station connected to a dedicated watermain, from the treatment plant to the reservoir, would be required to fill the reservoir. A new watermain from the reservoir down (east) along McLeod Road, to supply pressure zone 155 and pressure zone 125, would also have to be constructed.

56 The proposed new water storage reservoir in the 155 m pressure zone would service the development in this pressure zone as well as development in the proposed 125 m pressure zone.

57 The total storage volume of the proposed new reservoir will be dependent on the design fire flow and the maximum day demand within this future service area. If the design fire flow demand was 150 L/s (for a duration of 2 hours) and if the maximum day design demand was 3,030 m^3/day (the maximum day demand of all the future development covered by the existing water licence; see **Table 24**) the total storage volume would be 2,830 m^3. This equates to 1,846 service connections within the 155 m and 125 m pressure zones based on the current (Year 2021) maximum day demand of 1.64 m^3/day per connection (**Table 22**). It is anticipated that some future development will occur in the lower pressure zones and therefore, the proposed reservoir volume can likely be less than 2,830 m^3.

58 A conceptual design of the water system infrastructure to service the future development of Union Bay Estates (Phase 2 and Phase 3), District Lot 7, District Lot 13 and properties in the 155 m pressure zone is presented in **Figure 20**. Union Bay Estates Phase 1 will be serviced from the existing watermain, identified for upgrading, along Hwy 19a as shown in **Figure 13**.

10 RECOMMENDATIONS

Based on the conclusions reached in this study, the following actions are recommended in the following priority:

Water Demand Reduction

1 The use of automatic flushers be reduced and/or eliminated, provided chlorine residuals can be maintained throughout the distribution system.

2 A **Leak Detection and Reduction Program** be developed and implemented annually to manage and reduce Non-Revenue water to 25% of total system demand. This program should be developed after an initial assessment of system leakage is carried out using reservoir level monitoring (between 2 am and 5 am) during the fall and winter months, when outdoor water usage is minimal.

3 A **Water Conservation Plan** be developed to help manage and reduce Revenue water demand.

Water Treatment Capacity

4 Assess if the maximum flow rate of the treatment plant can be increased by 10% to 15% during the summer months by:

(a) Meeting with the water treatment plant manufacture (AWC) and discussing the possibility.

(b) Review with AWC the steps required to increase rate of flow entering the water treatment plant.

(c) Review the ability to increase the capacity of the existing transfer pumps that pump treated water from the water treatment plant to the water storage reservoir.

(d) Develop a water quality testing program and submit it to Island Health for approval.

5 The planned duplication of the water treatment plant building and treatment processes and the expansion of the backwash pond be carried out to provide system redundancy and to accommodate future demand increases.

Langley Lake

6 The ability of the existing submerged intake pipe to siphon water out of the lake (withdrawing water below 149.7 m geodetic) be confirmed and the ability to withdraw water out of the lake utilizing the original 450 mm dia. outlet pipe (installed through the existing dam) be investigated.

7 A hydrological assessment and water budget for Langley Lake be carried out within the next few years and prior to expanding the treatment capacity beyond the planned duplication noted above, which will provide a maximum treatment capacity of 28 lps (2,420 m^3/day). The study should incorporate water demand increases from future development and calculate the resulting maximum lake drawdown volume and level, and the number of days

required to return to full storage. The study should include an assessment of the potential impact climate change may have on the ability of the Langley Lake to meet future demands.

Water Distribution System Upgrades

8 The looping of dead-end watermains and installation of new watermains, as shown in **Figure 13**, be carried out.

9 The order in which/prioritization of the watermain upgrading projects shown in **Figure 13** are carried out should be developed based on several factors, including but not limited to:

- Input from the Union Bay Fire Department following their review of the fire flow mapping (see **Figure 12**)
- Watermains with a history of breaks/leaks
- Remaining service life of watermains
- Timing of proposed developments and their fire flow requirements
- Adequate funding

Water Storage Reservoir & Pressure Zones

10 Land be obtained near the Inland Island Highway for the construction of a new water storage reservoir with a top water level of 155 m geodetic and a storage volume of up to 2,830 m^3. The proposed reservoir would supply a new 155 m and 125 m pressure zone.

11 A new 125 m pressure zone be established to service lands above 57 m geodetic.

12 The 125 m pressure zone be fed from the 155 m pressure zone through PRVs.

Water Master Plan Updating

13 This Water Master Plan should be reviewed and updated at regular intervals, roughly once every five years or more frequently if there are: notable changes in the amount, type or location of future development; adjustments to the service area boundary; significant changes in the per connection design water demands; significant findings from the Langley Lake hydrological assessment and water budget; updating of the Official Community Plan or Local Area Plan.

APPENDIX A

-

WATER STORAGE & WITHDRAWAL LICENCES
Licence No. C112815
Licence No. C112817

BRITISH COLUMBIA

Water Act

CONDITIONAL WATER LICENCE

The owners of the land to which this licence is appurtenant are hereby authorized to divert and use water as follows:

(a) The stream on which the rights are granted is Langley Lake and the reservoir is the lake.

(b) The point of diversion and storage site are located as shown on the attached plan.

(c) The date from which this licence shall have precedence is 29th October, 1913.

(d) The purposes for which this licence is issued are storage and waterworks.

197,400 m^3/yr

(e) The maximum quantity of water which may be held in storage is 160 acre feet per annum, and the maximum quantity of water which may be used for waterworks purpose is 35,600,000 gallons a year, at a rate not to exceed 361,500 gallons a day.

161,841 m^3/yr   1,643 m^3/day (Max Day) = 19 L/s

(f) The period of the year during which the water may be held in storage and used for waterworks purpose is the whole year.

(g) The land upon which the water is to be used and to which this licence is appurtenant the lands within the boundaries of Union Bay Improvement District.

(h) The works authorized to be constructed are dam, intakes, and pipelines, which shall be located approximately as shown on the attached plan.

(i) The intakes shall be adequately screened to prevent debris and fish from entering the works.

(j) The licensee shall make releases of water past the dam authorized under clause (h) hereof, as may from time to time be ordered by the engineer under the Water Act.

(k) The construction of the said works has been completed and the water is being beneficially used. The licensee shall continue to make a regular, beneficial use of water in the manner authorized herein.

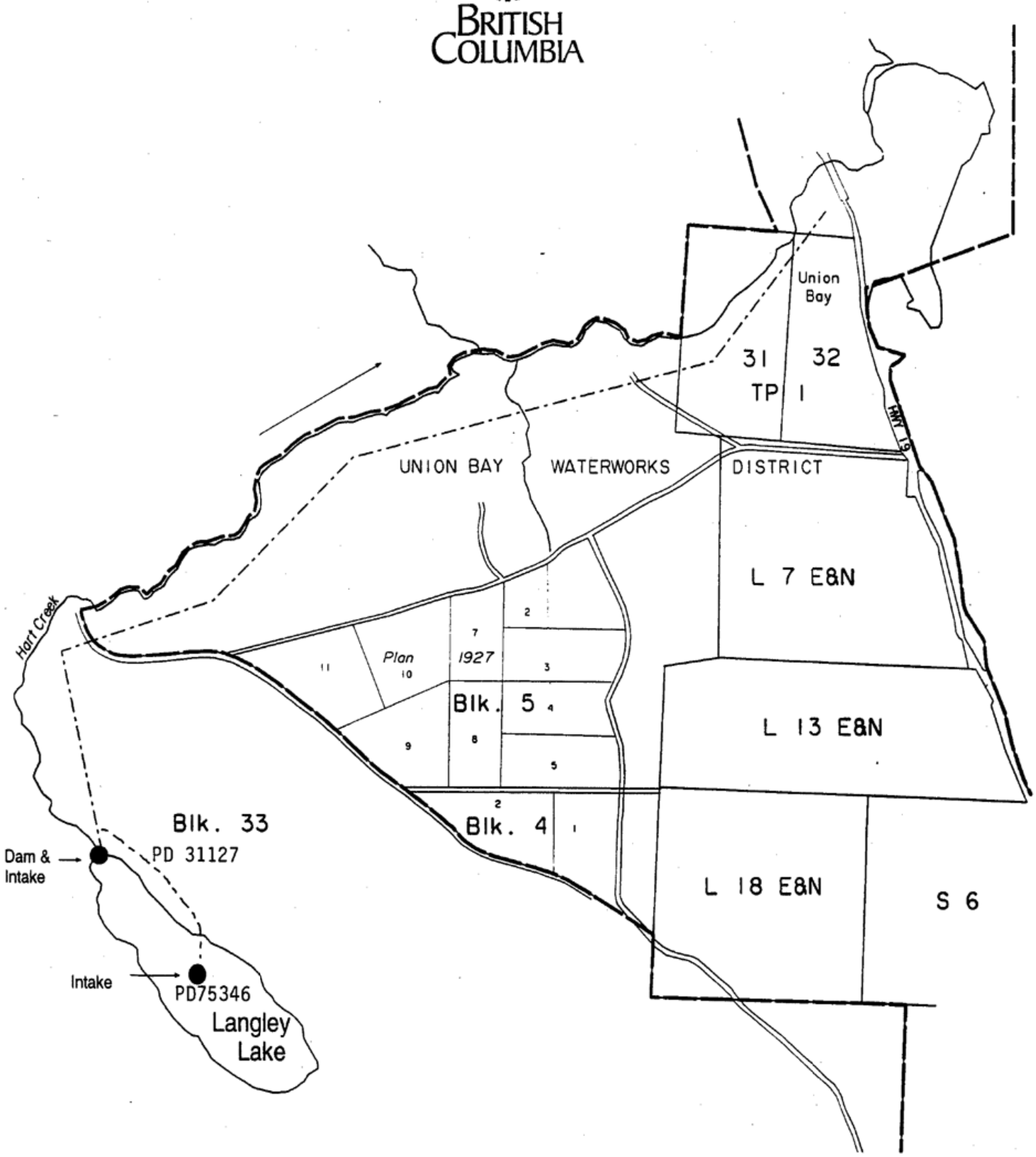
(l) This licence is issued in substitution of Conditional Water Licences 27746 and 27747, under Section 18 of the Water Act 1996, RS Chap 483.

George Bryden

George Bryden
Engineer Under the Water Act

File: 0245746   Date Issued: June 22, 2000   Conditional Licence: 112815

BRITISH COLUMBIA



WATER DISTRICT : Nanaimo
PRECINCT : Courtenay
LAND DISTRICT : Nelson

Signature : George Buyle
Date : June 22, 2000

LEGEND

Scale	: 1:20,000
Point of Diversion	: ●
NTS Map Number	: 92.F.056
Pipe	: ▬ - ▬
Improvement District	: ▬ ▬

CL 112815 for CL 27746 and CL 27747
File: 0245746

BRITISH COLUMBIA

Water Act

CONDITIONAL WATER LICENCE

The owners of the land to which this licence is appurtenant are hereby authorized to divert and use water as follows:

(a) The stream on which the rights are granted is Langley Lake and the reservoir is the lake.

(b) The point of diversion and storage site are located as shown on the attached plan.

(c) The date from which this licence shall have precedence is 29th October, 1913.

(d) The purposes for which this licence is issued are storage and waterworks.

690,753 m^3/yr

(e) The maximum quantity of water which may be held in storage is 560 acre feet per annum, and the maximum quantity of water which may be used for waterworks purpose is 142,400,000 gallons a year, at a rate not to exceed 1,466,500 gallons a day.

647,364 m^3/yr 6,667 m^3/day (Max Day) = 77 L/s

(f) The period of the year during which the water may be held in storage and used for waterworks purpose is the whole year.

(g) The land upon which the water is to be used and to which this licence is appurtenant the lands within the boundaries of Union Bay Improvement District.

(h) The works authorized to be constructed are dam, intakes, and pipelines, which shall be located approximately as shown on the attached plan.

(i) The intakes shall be adequately screened to prevent debris and fish from entering the works.

(j) The licensee shall make releases of water past the dam authorized under clause (h) hereof, as may from time to time be ordered by the engineer under the Water Act.

(k) The construction of the said works has been completed and the water is being beneficially used. The licensee shall continue to make a regular, beneficial use of water in the manner authorized herein.

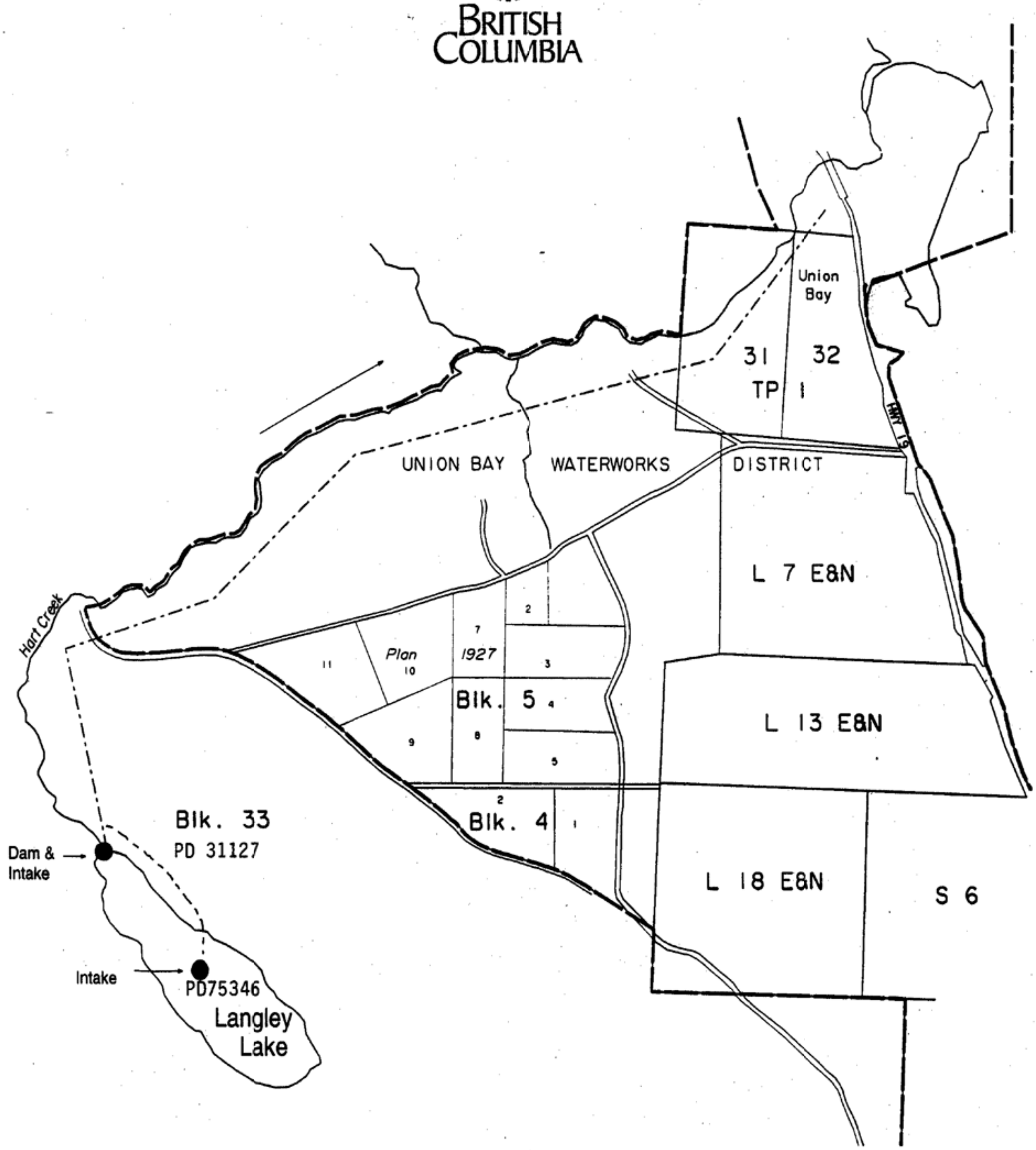
(l) This licence is issued in substitution of Final Water Licences 18000 and 18001, under Section 18 of the Water Act 1996, RS Chap 483.

George Bryden

George Bryden
Engineer Under the Water Act

File: 0265330 Date Issued: June 22, 2000 Conditional Licence: 112817

BRITISH COLUMBIA



WATER DISTRICT	: Nanaimo
PRECINCT	: Courtenay
LAND DISTRICT	: Nelson

LEGEND

Scale	: 1:20,000
Point of Diversion	: ●
NTS Map Number	: 92.F.056
Pipe	: — - —
Improvement District	: — —

Signature : George Ryder

Date : June 22, 2000

CL 112817 for FL 18000 and FL 18001

File: 0265330

APPENDIX B

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LANGLEY LAKE STORAGE VOLUME

Bathymetric Survey Letter Report, Nov 19, 2009

Storage Volume & Surface Area vs Water Surface Elevation, Feb 22, 2010

McElhanney

November 19th, 2009

Union Bay Improvement District
5471 Island Highway
P.O. Box 70
Union Bay, BC V0R 3B0

Attention: Brenda Fisher, Administrator

Dear Madame,

SUPPLEMENTAL REPORT FOR BATHYMETRIC SURVEY OF LANGLEY LAKE.

Further to your request, this letter is intended to summarize the results of our recent survey of Langley Lake as well as to provide some details about the lake's physical characteristics.

The survey of the lake was completed on October 22nd, we forwarded the digital files to you in our email of November 13th, shortly after we finished sorting out the data. The data was reduced using Terramodel Version 10.3 software.

The survey data is in the NAD 83, UTM Zone 10 coordinate system, and has been reduced to contour mapping of two surfaces. One surface is the shoreline and lake bottom, and the other is the shoreline and bottom of the peat layer, which underlies the effective lake bottom. There are several peat 'islands' within the lake that are included in the lake bottom surface. No topography above the existing lake surface was included in our survey.

The contours for both surfaces are provided in the AutoCAD 2004 previously emailed. Also attached to the email were two ASCII coordinate files, one for each surface. Elevations in these files are referred to Geodetic datum.

The water level of the lake was determined to be 151.64 metres Geodetic as of the date of survey. The spillway elevation is 152.17 metres, and the elevation of the top of the round bolt set in the concrete spillway wall is 153.40 metres. The bolt's elevation is intended to provide a site benchmark, and is approximately at the level of the existing dam.

As per your request, we computed the volume of the lake to be 839,000 cubic metres, using the effective lake bottom and a 151.64 metre water level at the date of survey.

The general physical characteristics of the lake, as determined by our survey, are that it is 1200 metres (3940') long, by 350 metres (1150') wide. The shoreline perimeter as of the date of survey was approximately 2700 metres (8860'), and the area of the lake is about 30 hectares (75 acres). This area includes the six peat islands, of which, two are quite sizeable. The maximum depth is 10.5 metres (34.5'), which is located within an elongated bowl, central to the lake.

Once again, thank you for the opportunity to provide this survey. Please don't hesitate to call if you have any questions or concerns.

Yours truly,
McELHANNEY ASSOCIATES

M.R. Kuss, BCLS
Legal Survey Manager

495 Sixth St
Courtenay BC
Canada V9N 6V4

Tel 250 338 5495
Fax 250 338 7700
www.mcelhanney.com/mcsl

LANGLEY LAKE
UNION BAY, BC

LAKE BOTTOM CONTOURS

BATHYMETRIC SURVEY COMPLETED ON OCTOBER 22, 2009

McElhanney Associates
Professional Land Surveyors
495 6th Street
Courtenay, B.C. V9N 6V4
Ph : (250) 338-5495
Fax : (250) 338-7700
File : 05274

LANGLEY LAKE
UNION BAY, BC

PEAT BOTTOM CONTOURS

McElhanney Associates
Professional Land Surveyors
495 6th Street
Courtenay, B.C. V9N 6V4
Ph : (250) 338-5495
Fax : (250) 338-7700
File : 05274

BATHYMETRIC SURVEY COMPLETED ON OCTOBER 22, 2009

McElhanney

February 22, 2010

Our File: 2211-46959-0

Union Bay Improvement District
5471 Island Highway, PO Box 70
Union Bay, BC V0R 3B0

Attention: Ms. Brenda Fisher, Administrator

Dear Madam,

UNION BAY IMPROVEMENT DISTRICT CAPITAL DEVELOPMENT FUNDING

Attached is a copy of an 8.5"x11" Area - Capacity curve for the Langley Lake storage reservoir. As discussed at the recent UBID board meeting, there are a number of assumptions having been made in the derivation of these curves, given the limitations on available survey data.

McElhanney's bathymetric surveys captured lake bottom topography only up to the water surface elevation at the time of survey. In order to ascertain storage volumes and surface areas above this elevation, additional ground survey data was solicited from Bazett Land Surveying, Courtenay. Upon receipt, this data was found to be incomplete. Survey point data was available in the area of the existing dam, spillway and roughly 40% of the lake perimeter, but not around the balance of the lakeshore. Through discussions with Bazett Land Surveying, it was determined the past contours and lake volume calculations as derived for Kensington's calculations of storage [were the lake surface to be raised beyond that currently possible], were prepared, in part, from BC 'TRIM' mapping and physical reconnaissance 'ground truthing'.

In order to determine area/capacities, therefore, McElhanney has derived data points around the lakeshore based on an assumed shoreline slope of 1H:1V beyond areas where surveyed point data was made available to us. At some point in the future and certainly prior to any further future consideration of potential for dam raising, the UBID should consider commissioning ground surveys to complete the perimeter information, up to roughly geodetic elevation 156 metres.

We note the Area-Capacity curve is based on elevations from 150.0 metres to 152.2 metres geodetic. The lower of these represents the minimum allowable lake surface elevation below which water would not flow by gravity into the UBID distribution system. This is the elevation of the top of the pipe leading out of the lake, at the point where the outlet pipe reaches the lakeshore. The higher value (152.2m) is the existing spillway surface elevation.

...continued

495 Sixth St
Courtenay BC
Canada V9N 6V4

Tel 250 338 5495
Fax 250 338 7700
www.mcelhanney.com/mcsl

In the interests of conservatism, corrections for peat 'islands' have been made, as were encountered/identified during the bathymetric survey work. Surface areas as measured, by contrast, do not exclude the peat deposits. As discussed at our recent meeting, the overall percentage volume of storage capacity represented by these peat deposits, between the maximum and minimum elevations noted on the attached curves, is not large. In addition, these deposits are thought to be of very low density and fully saturated with water, as a result of which the overall reduction in storage represented thereby is thought to be insignificant. The total storage indicated is, therefore, somewhat conservative.

For your convenience, we would note the conversion factor from cubic metres of storage to acre-feet of storage is 1,233.5 cubic metres per acre-foot.

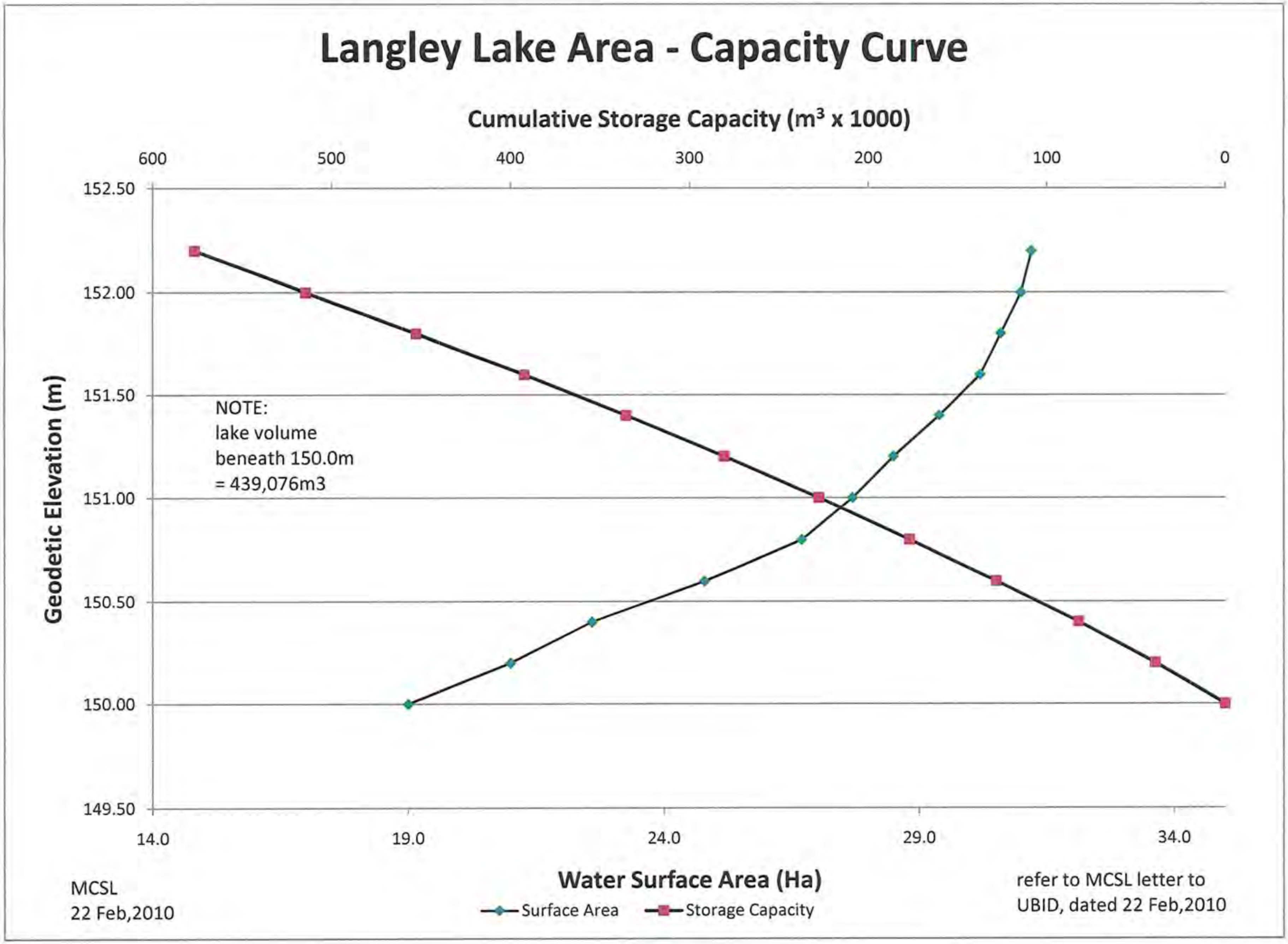
Yours truly,

MCELHANNEY CONSULTING SERVICES LTD.

Ian S. Whitehead, P.Eng.
Regional Manager

ISW:ldg

Enclosure


Langley Lake Area - Capacity Curve
Cumulative Storage Capacity (m^3 x 1000)
600
500
400
300
200
100
0
152.50
152.00
151.50
151.00
150.50
150.00
149.50
Geodetic Elevation (m)
NOTE:
lake volume
beneath 150.0m
= 439,076m3
14.0
19.0
24.0
29.0
34.0
Water Surface Area (Ha)
Surface Area
Storage Capacity
MCSL
22 Feb,2010
refer to MCSL letter to
UBID, dated 22 Feb,2010

APPENDIX C

-

PUMP CURVES
PRESSURE ZONE 155

GRUNDFOS

Submittal Data

PROJECT:	Koers & Associates	UNIT TAG:	________	QUANTITY:	________
	________	TYPE OF SERVICE:	________		________
REPRESENTATIVE:	CWP	SUBMITTED BY:	________	DATE:	________
ENGINEER:	________	APPROVED BY:	________	DATE:	________
CONTRACTOR:	________	ORDER NO.:	________	DATE:	________

Note! Product picture may differ from actual product

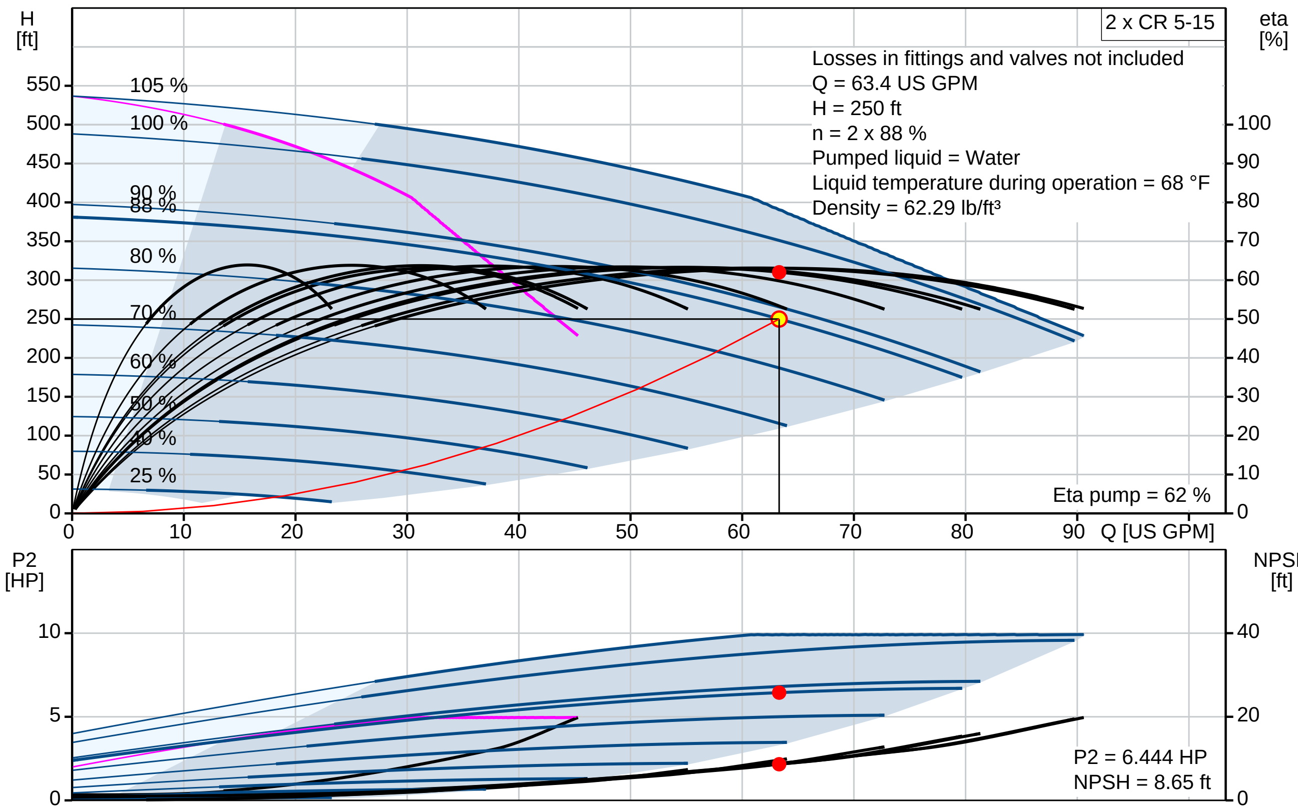
CR 5-15 A-FGJ-A-E-HQQE

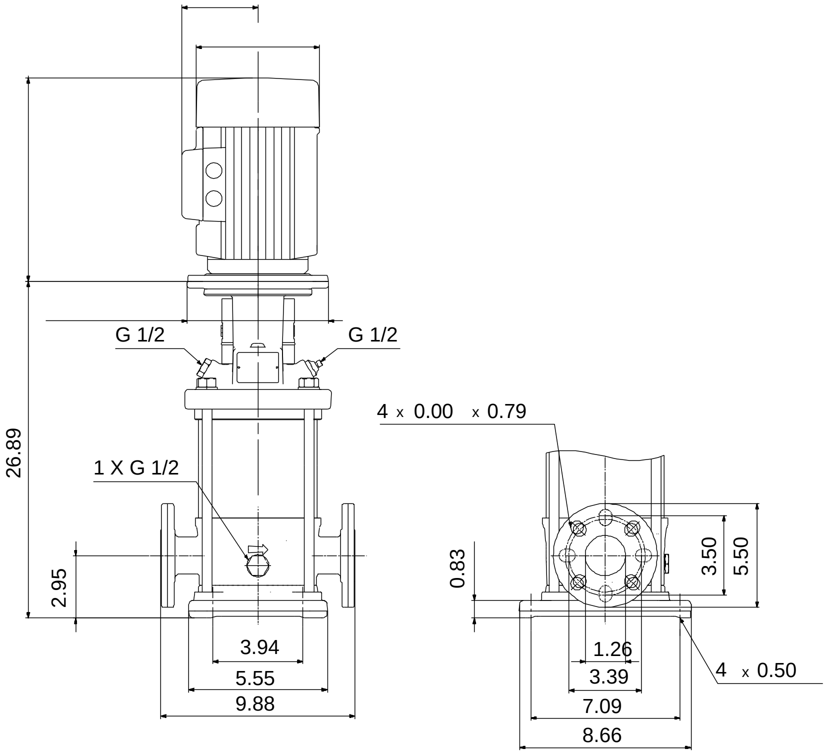
Vertical, multistage centrifugal pump with suction and discharge ports on the same level. The pump head and base are in cast iron. All other wetted parts are in stainless steel (EN 1.4301)

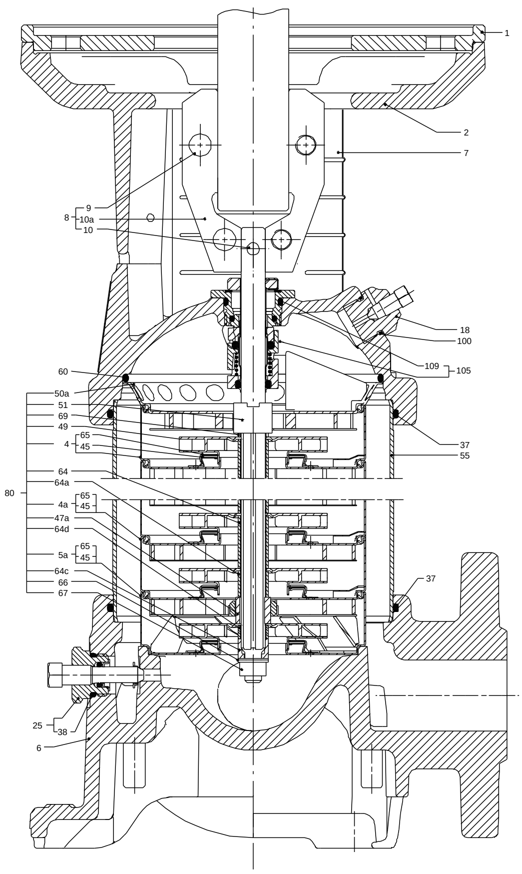
Conditions of Service	
Flow:	63.4 US GPM
Head:	250 ft
Efficiency:	________
Liquid:	Water
Temperature:	68 °F
NPSH required:	8.65 ft
Viscosity:	________
Specific Gravity:	1.000

Pump Data	
Max pressure at stated temp:	363 psi / 250 °F
Liquid temperature range:	-4 .. 248 °F
Approvals:	NSF61
Shaft seal:	HQQE
Product number:	96084244

Motor Data	
Mains frequency:	60 Hz







Materials:

Base:	Cast iron EN 1561 EN-GJL-200 ASTM A48-25B
Impeller:	Stainless steel AISI 304 EN 1.4301
Material code:	A
Code for rubber:	E

GRUNDFOS

Company name: Corix Water Products
Created by:
Phone:

Date: 10/07/2018

Tender Text

Note! Product picture may differ from actual product

Product No.: 96084244
CR 5-15 A-FGJ-A-E-HQQE
Vertical, non-self-priming, multistage, in-line, centrifugal pump for installation in pipe systems and mounting on a foundation.

The pump has the following characteristics:
- Impellers and intermediate chambers are made of
- The shaft seal has assembly length according to EN 12756.
- Power transmission is via cast iron split coupling.

Controls:
Frequency converter: NONE

Liquid:

Pumped liquid:	Water
Liquid temperature range:	-4 .. 248 °F
Liquid temperature during operation:	68 °F
Density:	62.29 lb/ft³

Technical:

Pump speed on which pump data are based:	3461 rpm
Actual calculated flow:	63.4 US GPM
Rated flow:	30.4 US GPM
Resulting head of the pump:	250 ft
Pump orientation:	Vertical
Shaft seal arrangement:	Single
Code for shaft seal:	HQQE
Approvals on nameplate:	NSF61
Curve tolerance:	ISO9906:2012 3B

Materials:

Base:	Cast iron EN 1561 EN-GJL-200 ASTM A48-25B
Impeller:	Stainless steel EN 1.4301 AISI 304
Bearing:	SIC

Installation:

Maximum operating pressure:	363 psi
Max pressure at stated temp:	363 psi / 250 °F
	363 psi / -4 °F
Type of connection:	DIN / ANSI / JIS
Size of inlet connection:	DN 25/32
	1 1/4 inch
Size of outlet connection:	DN 25/32
	1 1/4 inch
Pressure rating for pipe connection:	PN 25
Flange rating inlet:	250 lb
Flange size for motor:	182TC

Electrical data:

Motor standard:	NEMA
Power (P2) required by pump:	5 HP

Others:

Net weight:	61.8 lb
Gross weight:	79.7 lb
Shipping volume:	6.11 ft³
Country of origin:	US
Custom tariff no.:	8413.70.2040

	Company name:	Corix Water Products
	Created by:	
	Phone:	
	Date:	10/07/2018

Position	Qty.	Description
	1	**CR 5-15 A-FGJ-A-E-HQQE**

Note! Product picture may differ from actual product

Product No.: 96084244
Vertical, non-self-priming, multistage, in-line, centrifugal pump for installation in pipe systems and mounting on a foundation.

The pump has the following characteristics:
- Impellers and intermediate chambers are made of
- The shaft seal has assembly length according to EN 12756.
- Power transmission is via cast iron split coupling.

Controls:
Frequency converter: NONE

Liquid:
Pumped liquid: Water
Liquid temperature range: -4 .. 248 °F
Liquid temperature during operation: 68 °F
Density: 62.29 lb/ft³

Technical:
Pump speed on which pump data are based: 3461 rpm
Actual calculated flow: 63.4 US GPM
Rated flow: 30.4 US GPM
Resulting head of the pump: 250 ft
Pump orientation: Vertical
Shaft seal arrangement: Single
Code for shaft seal: HQQE
Approvals on nameplate: NSF61
Curve tolerance: ISO9906:2012 3B

Materials:
Base: Cast iron
EN 1561 EN-GJL-200
ASTM A48-25B
Impeller: Stainless steel
EN 1.4301
AISI 304
Bearing: SIC

Installation:
Maximum operating pressure: 363 psi

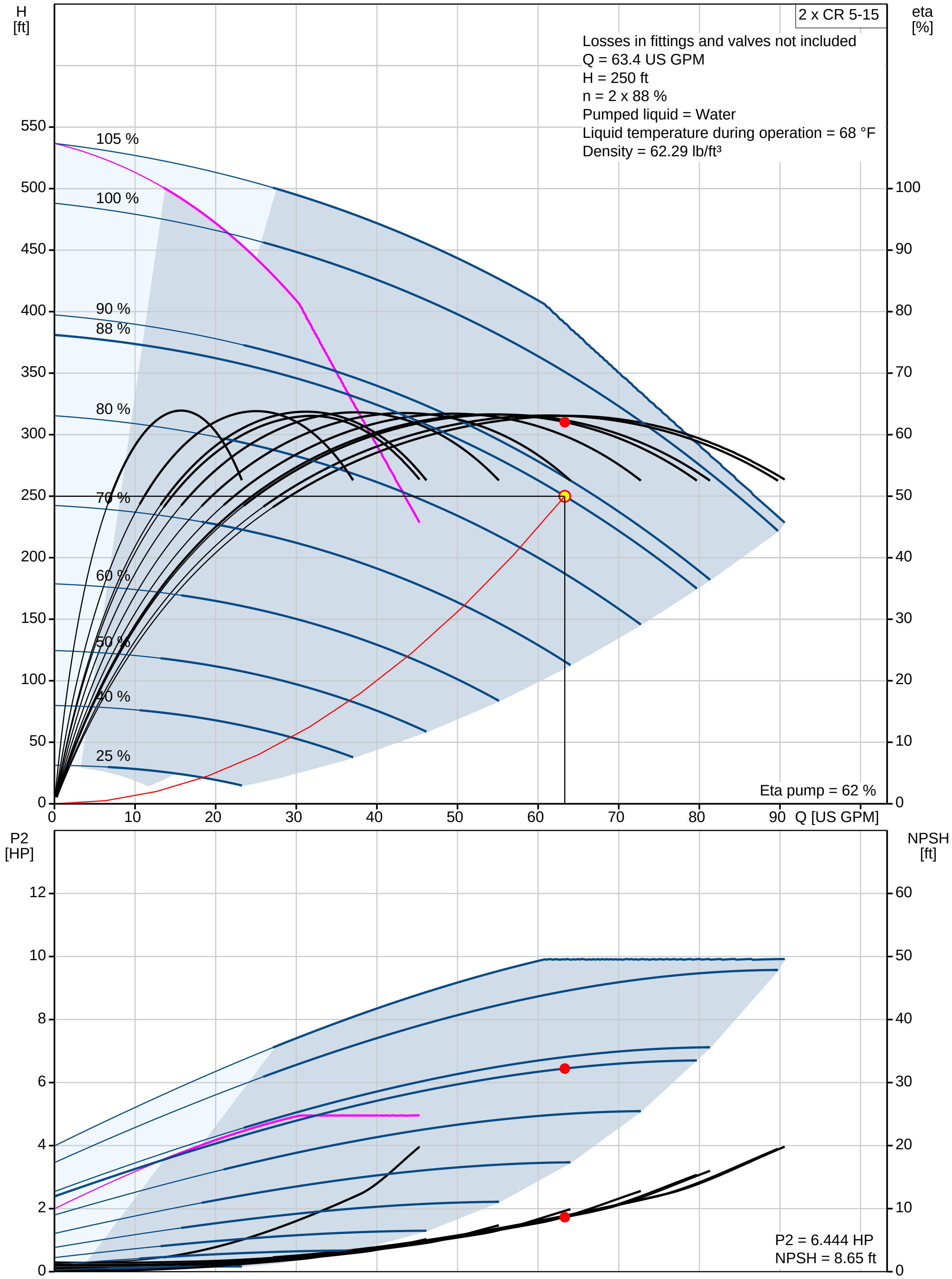
		Company name:	Corix Water Products
		Created by:	
		Phone:	
		Date:	10/07/2018

Position	Qty.	Description	
		Max pressure at stated temp:	363 psi / 250 °F
			363 psi / -4 °F
		Type of connection:	DIN / ANSI / JIS
		Size of inlet connection:	DN 25/32
			1 1/4 inch
		Size of outlet connection:	DN 25/32
			1 1/4 inch
		Pressure rating for pipe connection:	PN 25
		Flange rating inlet:	250 lb
		Flange size for motor:	182TC
		Electrical data:	
		Motor standard:	NEMA
		Power (P2) required by pump:	5 HP
		Others:	
		Net weight:	61.8 lb
		Gross weight:	79.7 lb
		Shipping volume:	6.11 ft^3
		Country of origin:	US
		Custom tariff no.:	8413.70.2040

Company name: Corix Water Products
Created by:
Phone:

Date: 10/07/2018

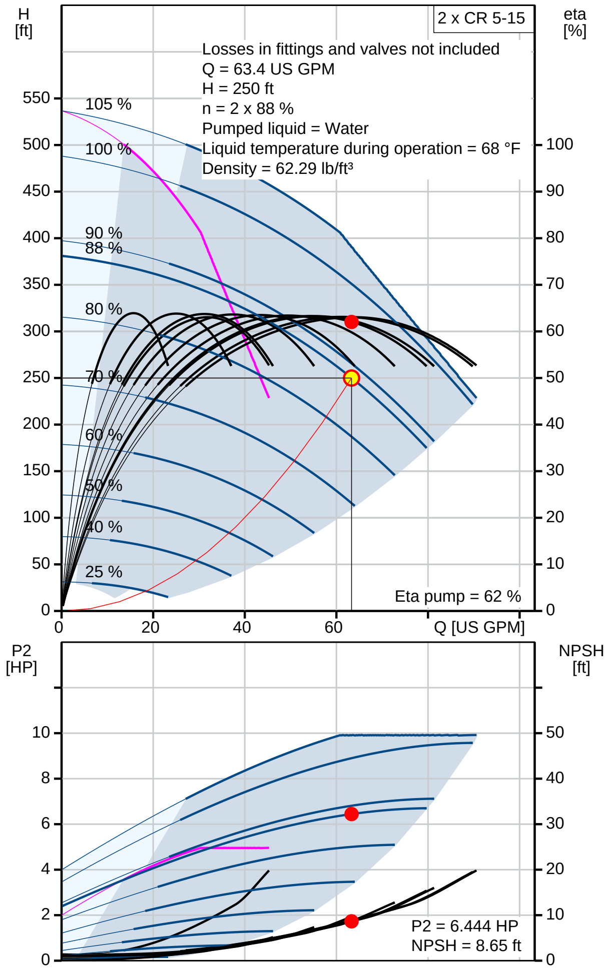
96084244 CR 5-15 A-FGJ-A-E-HQQE 60 Hz



Company name: Corix Water Products
Created by:
Phone:

Date: 10/07/2018

Description	Value
General information:	
Product name:	CR 5-15 A-FGJ-A-E-HQQE
Product No:	96084244
EAN number:	5700395190823
Technical:	
Pump speed on which pump data are based:	3461 rpm
Actual calculated flow:	63.4 US GPM
Rated flow:	30.4 US GPM
Resulting head of the pump:	250 ft
Stages:	15
Impellers:	15
Low NPSH:	N
Pump orientation:	Vertical
Shaft seal arrangement:	Single
Code for shaft seal:	HQQE
Approvals on nameplate:	NSF61
Curve tolerance:	ISO9906:2012 3B
Pump version:	A
Model:	A
Materials:	
Base:	Cast iron
	EN 1561 EN-GJL-200
	ASTM A48-25B
Impeller:	Stainless steel
	EN 1.4301
	AISI 304
Material code:	A
Code for rubber:	E
Bearing:	SIC
Installation:	
Maximum operating pressure:	363 psi
Max pressure at stated temp:	363 psi / 250 °F
	363 psi / -4 °F
Type of connection:	DIN / ANSI / JIS
Connect code:	FGJ
Size of inlet connection:	DN 25/32
	1 1/4 inch
Size of outlet connection:	DN 25/32
	1 1/4 inch
Pressure rating for pipe connection:	PN 25
Flange rating inlet:	250 lb
Flange size for motor:	182TC
Liquid:	
Pumped liquid:	Water
Liquid temperature range:	-4 .. 248 °F
Liquid temperature during operation:	68 °F
Density:	62.29 lb/ft³
Electrical data:	
Motor standard:	NEMA
Power (P2) required by pump:	5 HP
Controls:	
Frequency converter:	NONE
Others:	
Net weight:	61.8 lb
Gross weight:	79.7 lb
Shipping volume:	6.11 ft³
Country of origin:	US



APPENDIX D

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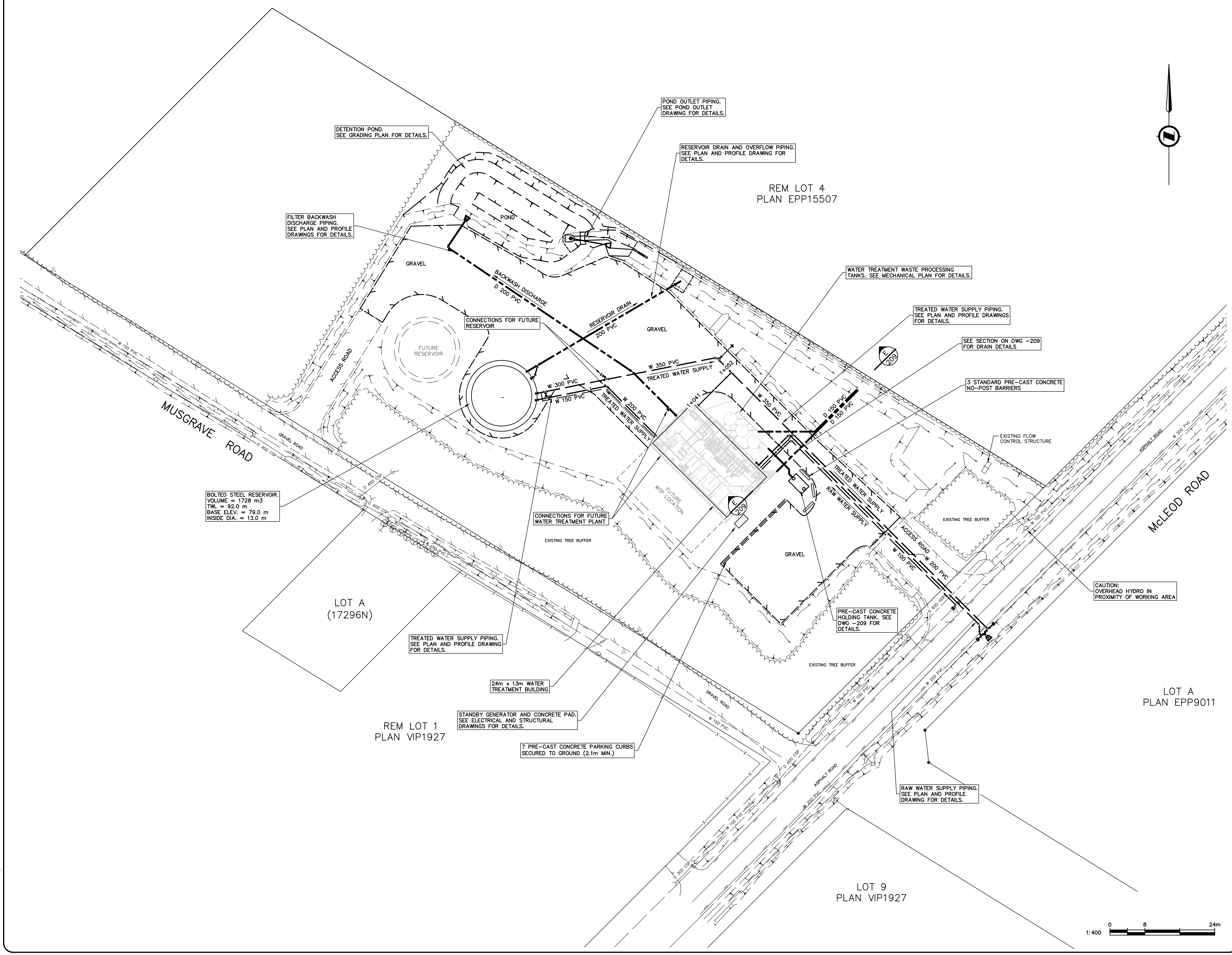
WATER TREATMENT PLANT SITE PLAN
Koers Dwg No. 1595-202, Rev 2.



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Fax: 250-248-5362

RECORD OF REVISIONS

REV	DATE	BY	ENG	DESCRIPTION
1	17DEC18	RC	KD	FOR TENDER
2	13FEB19	CACH	KD	ADDENDUM #1

ISS	DATE	BY	ENG	DESCRIPTION
D	25MAR19	RC	KD	FOR CONSTRUCTION
C	17DEC18	RC	KD	FOR TENDER
B	23NOV18	RC	KD	APPROVAL
A	16NOV18	RC	KD	95% REVIEW

RECORD OF ISSUE

SEAL

PROJECT NO.	1595
DRAWN	RC
DESIGNED	KD/RC
CHECKED	MP
APPROVED	KD
DATE	AUGUST 2018
SCALE	1:400

CLIENT

UNION BAY IMPROVEMENT DISTRICT

PROJECT

LANGLEY LAKE WATER TREATMENT PLANT AND RESERVOIR

TITLE

SITE PLAN

DRAWING No.	REV.	SHEET
1595–202	2	2/28

File: 1595-C2-Sheets.dwg Plot Time: Apr 15, 2019 - 10:00am User: rcave