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Cowichan Lake Shoreline Assessment

Property Impacts

Appendix G Final Report – Revision 1
November 15, 2022
KWL Project No. 2212.078

COWICHAN RIVER WATER SUPPLY

Prepared for:
Cowichan Valley Regional District

CVRD

Contents

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Executive Summary

Eight potential impacts resulting from the proposed raised weir were assessed for each of the 846 properties around the lake. The impact indicator, description, and results are summarized in the following table.

Summary of Potential Shoreline Impacts

Impact	Description	Findings
Flooding	Potential change in flood risk to primary residences.	Raising the weir would result in a relatively small increase in flood lake levels. Modelling indicates that the mean annual flood lake level could increase by about 0.1 m (4 inches) while flood levels up to the 50-year return period could increase by no more than 0.05 m (2 inches). Higher peak lake levels (greater than the 50-year flood) are not expected to have any change.
Inundation	Will the raised weir result in additional water being stored within the property boundary?	Approximately half of the shoreline properties (414) have some portion of the lot area with ground elevations below that of the proposed weir crest such that water stored by the proposed raised weir will cover a portion of these lots.
Estimated Change in Natural Boundary	Estimated horizontal change in natural boundary along lake frontage.	The projections of changes in the natural boundary indicate 708 properties (84% of properties) could have a change of less than 3 m due to the proposed raised weir. There are 13 properties (2% of the properties) where the horizontal shift in the natural boundary is estimated to be between 10 m to 22 m.
Impact to Shoreline Structures	Does the natural boundary change at or above shoreline structures?	Eleven of the existing shoreline protection structures (retaining walls, etc,) are within the protected horizontal shift in the location of the natural boundary and could have some impact as a result of proposed raised weir. Further site-specific assessments would be required to assess the vulnerability of structures to projected shoreline and lake level changes.
Potential Changes in Vegetation	Potential change in shoreline and riparian vegetation based on water exposure and vegetation sensitivity.	673 of the shoreline properties (79%) have shoreline vegetation that is considered to have low vulnerability to changes as a result of the proposed raised weir. There are 13 properties where vegetation is considered to be highly vulnerable to changes as a result of the proposed raised weir.
Riparian Access	Potential loss of access to the lake from the property.	No properties are expected to lose riparian access.
Dock Access	Additional days when docks are inaccessible due to high lake levels over the entire year.	About half of the properties with docks (277 of 521) would have more than a 10% reduction in the average number of days the dock is accessible over the year as a result of changes in water levels due to the proposed raised weir.
Beach Use	Additional days when the beach would be less than 3 m wide during the recreational season.	About 42% of properties (356 properties) are expected to see a 10% or greater reduction in beach use days during the recreational season (April1 to end of Oct) as a result of the proposed raised weir.

Should the weir not be raised, all the shoreline properties will have some impact in years when storage is depleted, and lake levels drop below the lowest observed lake levels. Modelling indicates that by the 2080s, lake levels will drop below lowest observed lake levels about ten times more often with the existing weir than the proposed raised weir.

1. Introduction

Kerr Wood Leidal Associates Ltd. (KWL) was retained by the Cowichan Valley Regional District (CVRD) to undertake a shoreline assessment for Cowichan Lake as part of the Cowichan River Water Supply Project. The Shoreline Assessment aims to better understand potential shoreline impacts of the proposed raising of the Cowichan Lake Weir to increase lake storage. A series of technical memoranda and reports have been prepared throughout the study, including:

- Appendix A: Project Approach and Methodology (KWL Technical Memorandum)
- Appendix B: Mapping, Field Work, Shoreline Characterization (KWL Technical Memorandum)
- Appendix C: 2020 Present Natural Boundary for Cowichan Lake (Bazett Land Surveying Technical Memorandum)
- Appendix D: Cowichan Lake Inflow and Water Level Analysis (KWL Report)
- Appendix E: Cowichan Lake Wave Energy Assessment (KWL Report)
- Appendix F: Change in Natural Boundary (KWL Report)
- **Appendix G: Property Impacts (KWL Report)**

The purpose of Appendix G is to describe identified potential shoreline impacts, how they potential impacts were quantified and discuss any general observations of impacts around the shoreline of Cowichan Lake. This work builds on previous project phases which have established baseline shoreline conditions, estimated changes to environmental conditions due to weir upgrades and climate change and projected how those changes will affect key metrics such as the natural boundary and flooding frequency. Revision 1 of this report reflects changes in the lake level frequency resulting from update to the lake level-discharge relationship (rating curve) for the existing weir and proposed raised weir. The impacts analysis presented in this report is based on final rating curve provided in the Final Cowichan Lake Weir Design report (Stantec, 2021).

This report can be used in parallel with the online mapping tool located on the Cowichan River Water Supply Project Website https://cowichanlakeweir.ca.

2. Background and Methods

2.1 Impact Indices

The proposed raising of the Cowichan Lake Weir[1] will cause changes in the lake level regime and the location of the natural boundary to varying degrees around the lake. To understand how these changes could impact shoreline properties, a set of property impact indicators and measures has been developed. Eight potential shoreline impacts were identified as follows:

1. Flooding (increase peak lake levels);
2. Inundation (increase in the horizontal extent of flooding);
3. Change in natural boundary location;
4. Impact to shoreline protection structures;
5. Impact to shoreline and riparian vegetation;
6. Riparian access,
7. Dock access, and
8. Beach use.

In addition to these potential impacts on shoreline properties as a result of the proposed raised weir, there are also potential impacts should the weir not be raised, namely the frequency that storage in Cowichan Lake is depleted and the lake level drops below historical low levels. This measure provides an indication of the potential impacts to property resulting from climate change.

The eight identified potential impact categories were developed from a review of the Cowichan Water Use Plan, discussions with CVRD staff and feedback from the Cowichan Lake Shoreline Assessment Steering Committee[2].

Estimated shoreline impacts were assessed and summarized for each property around the lake. These property-by-property impacts summaries have been made available through the project online mapping tool. Table 2-1 shows an example property impacts table with a discussion on indices and legend for results. The impacts tables are intended to provide accessible information for property owners, project partners, and regulators to better understand the relative impacts of estimated lake level and natural boundary changes.

[1] Details of the design of the proposed raised weir is included in the Cowichan Lake Weir Final Design report prepared by Stantec dated December 9, 2021.

[2] Details on the Cowichan Lake Shoreline Asessment steering committee can be found in the Cowichan Lake Shoreline Assessment report.

Table 2-1: Sample Impacts Table – Impacts of Raised Weir Only

Property Address:		**1234 XX Street**				
Potential Impact		**Index**	**Existing Weir**	**Proposed Weir**	**Difference Between Existing & Proposed Weir**	**Legend**
Flooding	Will the proposed raised weir increase the probability of flooding at the primary residence?[1]	Change in return period or annual exceedance probability of flooding at the primary residence. (Number in brackets provides the average number of times a flood is expected to be exceeded over any given 50-year period)	20-year Return Period Flood 5% AEP (2.5 floods occurs on average over 50 years)	18-year Return Period Flood 5.5% AEP (2.8 floods occur on average over 50 years)	0.5% increase in AEP	**Grey N/A** – Above Flood Level (including freeboard) shown on Provincial Floodplain Map
Inundation	Will raised weir result in additional water being stored within the property title boundary?	Is any portion of the ground elevation within the property title boundary below the proposed weir crest elevation?	n/a	n/a	Y	**Blue** – No **Orange** – Yes
Change of Natural Boundary		What is the average Horizontal Distance between PNB & EFNB?	n/a	n/a	4 m	**Grey** – < 0.5 m **Blue** – 0.5 m to 2 m **Green** – 2 to 5 m **Yellow** – 5 to 10 m **Orange** >10m
Shoreline Protection Structures (e.g., retaining walls)		Is shoreline structure located between PNB & EFNB? If yes, it may be susceptible to erosion depending on its foundation and construction.	n/a	n/a	Y	**Blue** – No **Orange** – Yes
Changes in Shoreline/Riparian Vegetation		What is the vulnerability of vegetation to change in water level & wave energy? If high, vegetation type may change (ie: to more water tolerant species.	n/a	n/a	Low	**Blue** – Low **Yellow** – Moderate **Orange** – High
Riparian Access	Potential loss of lake access.	Would the EFNB location result in having to access lake across neighbouring private property? [2]	n/a	n/a	No	**Blue** – No **Orange** – Yes
Dock Access	Change in access to docks over the entire year (Total 365 days)	What is the change in days when lake level is below the dock access elevation?	104 days	79 days	20% fewer days	**Grey** – N/A – No Dock **Blue** – <10% fewer days **Orange** – >10% fewer days
Beach Use	Change in useable beach days during recreational season (Total 214 Days)	What is the change in days when beach usable (more than 3 m wide)?	104 days	79 days	20% fewer days	**Blue** – <10% fewer days **Orange** – >10% fewer days

Notes: PNB = Present Natural Boundary EFNB = Estimated Future Natural Boundary Recreation season = April 1 to end of Oct AEP = Annual Exceedance Probability:
1. Flooding considered to occur when lake level exceeds the lowest ground elevation at of the primary residence (ie: foundation level)
2. Neighbouring property does not include the lake bottom property owned by Mosaic Forest Management.

2.2 Quantifying Impacts

Each of the above potential impacts resulting from operation of the proposed raised weir were quantified at each property around the lake based on predicted changes in lake level, and the estimated change in natural boundary as determined by comparing the present natural boundary (PNB) to the estimated future natural boundary (EFNB).

Some of the indices used to quantify property impacts are measured across the parcel area, while others are measured along the representative property transect (shown on the online mapping tool). Each transect was manually drawn from the primary residence past the shoreline and is intended to be representative of the shoreline topography of the lot; however, there are also changes in topography along the lots (beyond the transect area), especially for larger parcels.

At each property, the results of the shoreline impacts assessment are based on where the property boundary, primary residence, shoreline structures, shoreline vegetation, and beach lies relative to changes in lake level and natural boundary location. It is difficult to quantify the actual impacts as that would be dependent on site-specific information for each property on the sensitivity of the shoreline property to the change.

For example, the location of existing shoreline protection structures, such as retaining walls and riprap, was compared with the locations of the present natural boundary (PNB) and the EFNB. If the structure was in an area of change, it was concluded that the structure would be subjected to additional exposure to lake levels and possible wave action. Without site-specific information on the structure and its design, construction, and current condition, the impact to the structure could not be assessed. If it had a faulty foundation, it may be susceptible to erosion. If the structure was well built and in good condition, no impact would occur. Therefore, the Impacts Tables summarize the locations of lake level and natural boundary change relative to the property, residence, structure, vegetation, etc., the actual impacts, or magnitude of impacts, were not speculated. The intent of this study is to understand the overall degree of potential impacts and highlight properties or areas with a higher likelihood of concern.

2.3 Shoreline Properties

In order to understand the magnitude of potential impacts, an understanding of the total number of Shoreline properties and their character is important. A review of the cadastral mapping indicates there are a total of 846 land parcels around the shoreline of Cowichan Lake including the islands. However, not all these parcels have primary residences, docks, or shoreline structures (e.g., retaining walls or riprap). Aerial photography was used to identify locations of residences, docks, and structures. A summary of the total number of properties, primary residences, structures, and docks is shown in Table 2-2. Some properties have more than one shoreline structure associated with the parcel.

Table 2-2: Total number and characteristics of shoreline properties

Characteristic	Total Number
Parcels	846
Parcels with primary residences	592
Parcels with shoreline structures (Total number of shoreline structures)	89 (97)
Parcels with docks	521

A summary of each of the eight potential impact categories identified in Section 2.1 is provided in the following subsections for properties around the lake, including how the impacts were assessed.

To understand the overall Cowichan Lake potential impacts across all the properties and the spatial extent of potential impacts, summary tables and maps for each impact type are shown at the end of the report. The impacts tables and overall lake summary tables provide screening tools to identify where lake level and natural boundary changes intersect with property assets.

2.4 Flooding

Raising the weir will result in a relatively small increase in the lake level during times of flood. For lake levels above the mean annual flood (MAF) level of 164.2 m CVGD2013, the proposed raised weir is designed to maintain the current relationship between the lake level and river flow. However, below the MAF level, the flow constriction will increase with the proposed raised weir. This will result in higher lake levels during winter baseflow periods and peak lake levels below the average annual flood level. This results in approximately a 0.1 m increase in the mean annual flood level with the proposed raised weir.

Higher lake levels during winter baseflow periods with the proposed raised weir can translate to slightly higher peak lake levels (less than 0.05 m) during moderate storm events above the mean annual flood. There is no change expected in the extreme (100-year and 200-year return period floods) as a result of the proposed raised weir. The peak lake levels calculation is described in more detail in *Appendix D – Cowichan Lake Inflow and Water Level Analysis Report*.

Flooding impacts were quantified by comparing the flood lake levels for various return periods to the lowest ground elevation at the primary residence on each property. In other words, primary residences are considered to have some degree of flooding when the lake level reaches the foundation regardless of the lowest minimum floor elevation. Ground elevations at the properties were based on the topographic DEM prepared for the study using LiDAR data (see *Appendix A* for more details). Flood levels for the lake were calculated for the mean annual flood, 10-year, 20-year, 50-year, 200-year return periods for both the existing weir and proposed raised weir conditions. Several indicators have been developed to communicate how flooding could change as a result of the weir raising, including:

1. The change in the peak lake level elevation (or water depth) for a flood having a specific frequency of occurring for the proposed raised weir compared to the existing weir.
2. The change of the return period of the lake level being exceeded.
3. The change in the probability of the lake level being exceeded at least once over any given 50-year period.
4. The change in the number of times on average the lake level would be exceeded over any given 50-year period.

A summary of the values is shown in Table 2-3.

Table 2-3: Comparison of Flood Metrics for a Range of Lake Levels

Return Period	Mean Annual Flood	20-year	50-year	100-year	200-year
Change in Peak Lake Level for Specified Return Period	+0.1 m	<0.05 m	<0.05	0.00m	0.00 m
Return Period Peak Lake Level Exceeded – Existing Weir	~ 2-year	20-year	50-year	100-year	200-year
– Proposed Raised Weir	1.9-year	18-year	47-year	100-year	200-year
Probability of Peak Lake Level Exceeded at Least Once in 30-years – Existing Weir	100%	79%	45%	26%	14%
– Proposed Raised Weir	100%	82%	47%	26%	14%
Change in Probability Peak Lake Level Exceeded Once in 30 year	0%	3%	2%	0%	0%
Average Number of Times Peak Lake Level Exceeded over 50 year – Existing Weir	~ 25	2.5	1	0.5	0.25
– Proposed Raised Weir	28	2.7	1.1	0.5	0.25

2.5 Inundation

The proposed raised weir would increase the amount of water storage at Cowichan Lake. The upgraded weir would have the ability to regulate lake levels up to the proposed raised weir crest (El. 163.35 m). In some cases, regulating lake levels at the proposed raised weir crest would result in water being stored on lands within the legal boundaries of lakefront properties. The *inundation impact* indicates whether a change in lake level arising from the proposed raised weir will increase the horizontal extent of flooding within parcel boundary.

A property will have additional inundation if a portion of the property area lies between the existing and proposed raised weir crest elevations (See Example 1 in Figure 2-1). A property will have new inundation if the property is above the existing weir crest elevation, but a portion of the property area lies below the proposed raised weir crest elevation. A comparison of the two conditions is shown in Figure 2-1.

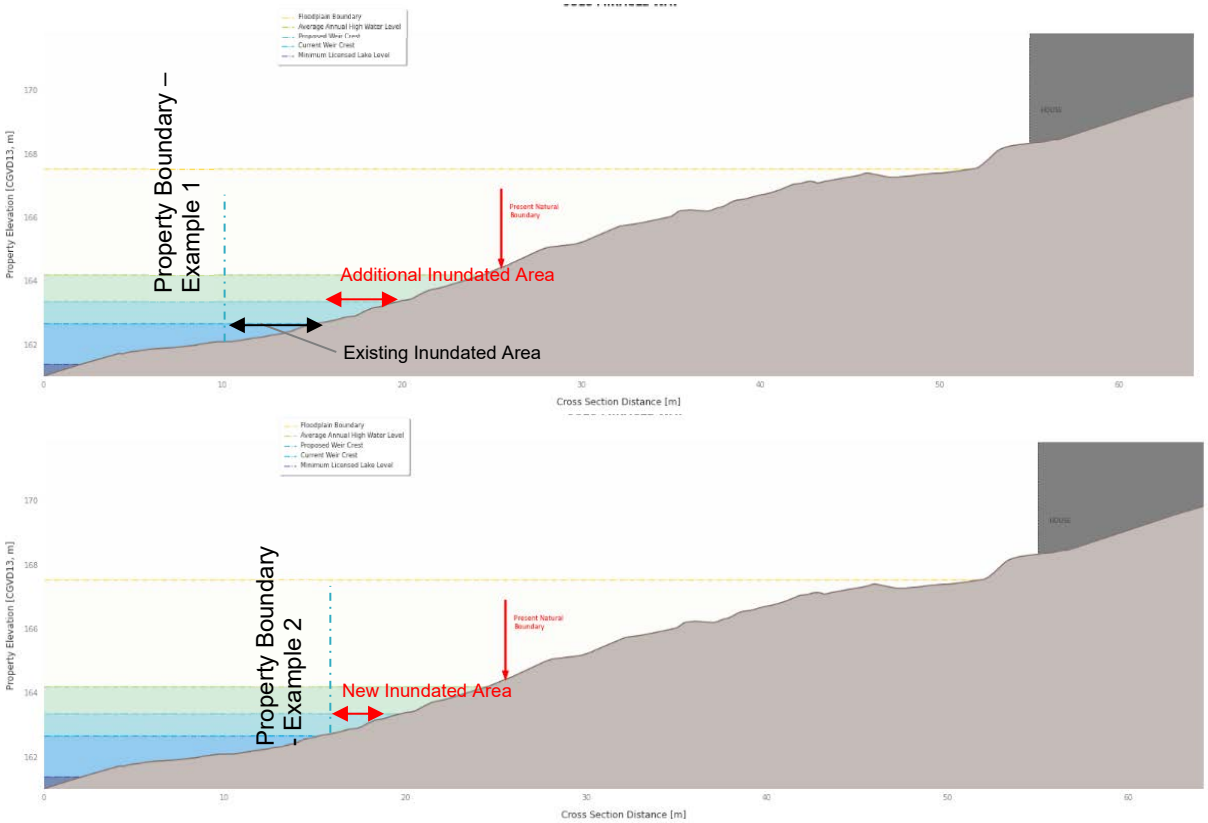

Figure 2-1: Example of Additional Inundated Area and New Inundated Area

2.6 Estimated Change in Natural Boundary

The change in lake level due to the proposed raised weir is expected to cause a change in the natural boundary at most locations around the lake (see *Appendix F: Change in Natural Boundary*). The *natural boundary impact* was quantified in terms of the estimated horizontal translation. Based on mapping precision, a change in the natural boundary is considered detectable if the horizontal distance between the PNB and EFNB is greater than 0.5 m.

The estimated change in the natural boundary is intended to be indicative of the magnitude of the potential for change in the character of the shoreline and riparian area.

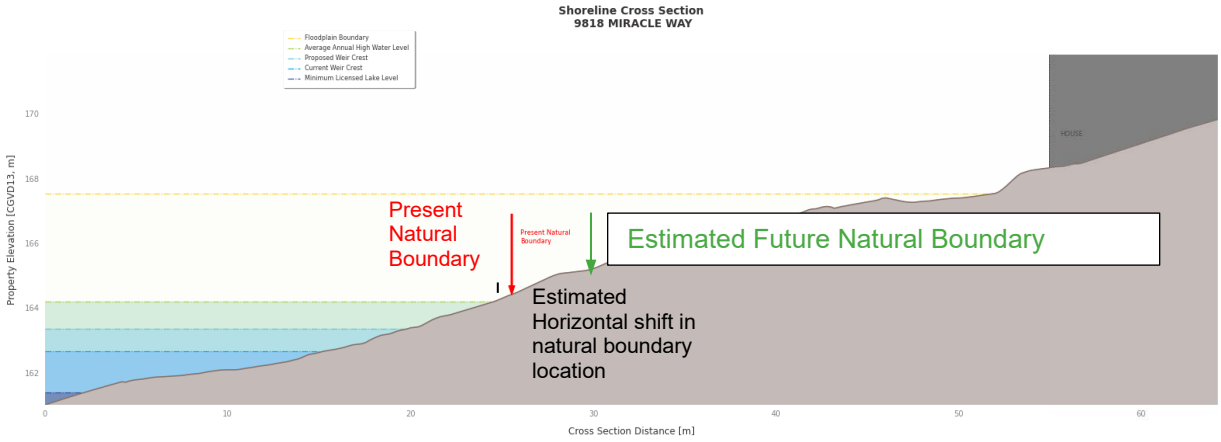

Figure 2-2: Example Transect Showing Estimated Horizontal Shift in EFNB

2.7 Impact to Shoreline Protection Structures

The effectiveness of shoreline structures such as retaining walls, and revetments, etc. are potentially impacted by changes in lake level and/or natural boundary location as a result of the proposed raised weir. The *impact to shoreline structures* was assessed by comparing the EFNB line and the location of structures, and conclusions drawn as follows:

- If the EFNB was below the structure, it was designated to be 'unlikely' the structure would be impacted.
- If the structure was between the PNB and EFNB, it was assumed 'likely' the structure would be impacted as the character of the shoreline is likely to change in this region with the proposed raised weir.
- If the structure was below the PNB, it was assumed that potential impacts are possible but would only be on account of change of lake level frequency as the character of the shoreline below the PNB has already been established by the past lake level and wave energy regime and is not likely to change significantly with raised weir.

Each shoreline structure location was mapped using the air photography and shoreline photography available in the online mapping tool. The location of the structure was then compared to the location of the PNB and EFNB to assess the potential for impact as discussed above.

2.8 Potential Changes in Vegetation

The change in lake level regime associate with the proposed raised weir may impact the distribution of plant species on the shoreline. The impact to shoreline vegetation was considered for both shoreline vegetation below the PNB and for riparian vegetation above the PNB. This was based on the vulnerability of vegetation to change calculated as:

Vulnerability = Exposure + Sensitivity

Where:

Exposure is the plant/shrub/tree location relative to water inundation and wave action, therefore the change in lake level frequency and the natural boundary location from the PNB to the EFNB.

Sensitivity is how well the vegetation can or cannot tolerate water and wave action, and can it naturally adapt to the change.

For this assessment, the vulnerability provides in indication of potential impact without human interventions. For instance, reducing the sensitivity of riparian vegetation to the change in exposure by planting shoreline vegetation to help dissipate wave energy.

Exposure: For shoreline vegetation, exposure is the change in lake level frequency, while for riparian vegetation, exposure is the result of both changes in lake level frequency and wave energy as indicated by the EFNB. The level of exposure for vegetation at each property was determined based on the magnitude of the change in either lake level frequency between the PNB and existing weir crest elevation, for shoreline vegetation, or the horizontal distance between the PNB and EFNB for riparian vegetation. They have been selected based on professional judgement and are intended to provide an indication of the relative exposure of vegetation to change.

Sensitivity: The sensitivity of vegetation to duration of water inundation and erosion force was assessed based on general knowledge of plant species and the professional judgement of a Registered Professional Biologist as a relative measure of sensitivity. Vegetation community classes and subclasses with their ranked low, moderate, high sensitivity level are summarized in Table 2-4.

Table 2-4: Vegetation Class Sensitivities

Vegetation Class	SubClass	Sensitivity to Change in:	
		Inundation Duration (WL Frequency)	Erosive Power (NB Change)
Forested	Mixed Evergreen/Deciduous	High	Low
	Deciduous	Moderate	Low
Shrubland/ Herbaceous	Perennial/Annual Graminoids (grasses)	High	High
	Shrubland	Moderate	Moderate
	Hydromorphic Rooted Vegetation (marshland)	Low	Low
	Sedges (aquatic vegetation)	Moderate	High
Sparse Vegetation	Forested	High	Moderate
	Shrubland	Moderate	Moderate
Developed	Lawn (no trees)	High	High
	Lawn (with trees)	High	Moderate
	Hard landscaping (pavement, patio, etc.)	Low	Moderate
Unvegetated	Exposed sediments	Low	High
Notes: High	Moderate	Low	

Vulnerability

The vulnerability of shoreline or riparian vegetation to change in lake level frequency and wave energy is quantified by combining the exposure score and sensitivity score for each vegetation class segment around the shoreline as follows.

Vulnerability = (Exposure + Sensitivity)/2

The average shoreline and riparian vegetation vulnerability scores for each property is then calculated as the average of the vulnerability scores along the shoreline frontage of the property. Average vegetation vulnerability scores are shown in Table 2-5.

Table 2-5: Vulnerability Ranking

Average Vulnerability Score	Ranking Vulnerability to Change
1 to 1.66	Low
1.66 and 2.33	Moderate
2.33 to 3	High

The vulnerability for each property is reported on the impacts table as the average of the shoreline and riparian vegetation scores.

2.9 Riparian Access

Access to the lake from shoreline properties is considered a riparian right. The change in lake level regime associated with the proposed raised weir upgrade has the potential to impact this right. A qualitative review was conducted by viewing the EFNB line relative to the property lines along the

frontage of the lake. If a property that currently has direct access to the lake across the PNB would be required to cross a neighbouring property to gain access to the lake under the EFNB condition; this property was flagged as 'Yes' impacted. The review indicated that all properties would maintain riparian access at some location along the property line and no properties were flagged as impacted.

2.10 Dock Access

Docks have been installed at many properties around the lake. Changes in the lake level regime could potentially change the amount of time a dock is inaccessible due to high lake levels. This impact was measured by the change in the number of days over the entire year when lake level is at or above dock access elevation. Based on feedback from the steering committee, a reduction of more than 10% in the days of dock access over the year was considered significant for the purposes of defining a potential impact in the property impact tables.

2.11 Beach Use

During the Cowichan Water Use Plan process, enjoyment of beaches was identified as an important value (Compas, 2018). To quantify this, the enjoyment of a beach was considered to be reduced when the width (perpendicular to shoreline) of beach from the natural boundary to the water edge was less than 3 m. This impact was measured by the change in the number of days when beach width is less than 3 m between the PNB and the water's edge during the recreational season from April 1 to end of October. Based on feedback from the steering committee, a reduction of more than 10% in the days of beach access over the recreational season was considered significant for the purposes of defining a potential impact in the property impact tables.

3. Discussion of Impacts

The following discussion presents general trends and observations of impacts around the Cowichan Lake shoreline. It is intended to provide general direction on what types of shoreline properties may experience larger impacts as a result of the operation of the proposed raised weir. The influence of projected climate change is also discussed.

Detailed discussion of the impacts on each individual property is not possible within this report; however, property impact tables are available through the property view tool in the project mapping website.

3.1 Flooding

The flooding analysis, as described in Section 2.4, indicates that the proposed raised weir is likely to result in three changes to peak lake levels on Cowichan Lake:

1. For frequently occurring floods (once every two years on average), the average high water mark lake level (mean annual peak water level) would increase by about 0.1 m with the proposed raised weir. This means that for those properties with residences at lower elevation which currently flood during more frequent floods, the flood depths could be greater (up to 0.1 m (or 4 inches) deeper). Floods having a frequency between the 2-year flood and the 20-year flood are expected to have peak water levels that are between 0.05 m to 0.1 m (2 inches to 4 inches) higher with the operation of the proposed raised weir.
2. The peak lake level for moderate floods up to the 50-year return period would increase by less than 0.05 m. Modelled changes in peak water level of less than 0.5 m are within the uncertainty of the models. Therefore, the models indicate no measurable impact to peak water levels for floods between the 20-year to 50-year return period.
3. The frequency analysis indicates that peak lake level for extreme floods having frequency greater than the 50-year return period have no change in peak water level as a result of the operation of the proposed weir.

Table 3-1 summarizes the distribution of the number of properties with various levels of change in magnitude of the potential for flooding as a result of the weir. The spatial distribution of the potential for flooding around the lake is shown in Figure 3-1.

Table 3-1: Projected Flood Differences Between Existing and Raised Weir

Scenario	Frequency of Flood Event				
	Mean Annual Flood	Return Period Flood			
		20-year	50-year	100-year	200-year
Peak Lake Level Existing Weir[1]	164.2 m	165.3	165.5	165.7	165.9
Change in Peak Lake Level with Proposed Raised Weir	+0.1 m	<0.05 m	<0.05 m	0.0 m	0.0 m
Total number of properties where the primary residence could be flooded[2,3]					
Existing Weir	25	127	153	175	203
Proposed Raised Weir	31	127	153	175	203
Change in Number of Properties	6	0	0	0	0

Notes:
1. Elevation in metres above CGVD2013.
2. Primary residence considered to be flooded when the peak flood lake level is at or above the minimum ground elevation (i.e., touching the foundation) at the primary residence.
3. The number of properties shown is cumulative and includes the number of properties from lower/more frequent flood events.

Climate change projections indicate that fall and winter storms are likely to be more intense in the future, resulting in higher precipitation and more runoff into Cowichan Lake. In addition, higher winter temperatures will result in more precipitation falling as rain at higher elevation rather than as snow. This combination is likely to increase peak flows into Cowichan Lake and thus higher peak lake levels.

An increase of 10% in the storm inflow volume into Cowichan Lake, results in peak lake levels that are 0.3 m higher while an increase of 30% in the storm inflow volume to Cowichan Lake, results in peak lake levels that are 0.5 m higher. These increases in peak lake levels are projected to occur whether or not the proposed raised weir is implemented. Therefore, there are likely to be relatively larger changes in peak lake levels on Cowichan Lake as a result of climate change than as a result of the proposed raised weir.

Cowichan Lake Shoreline Assessment

Property Impacts Tables

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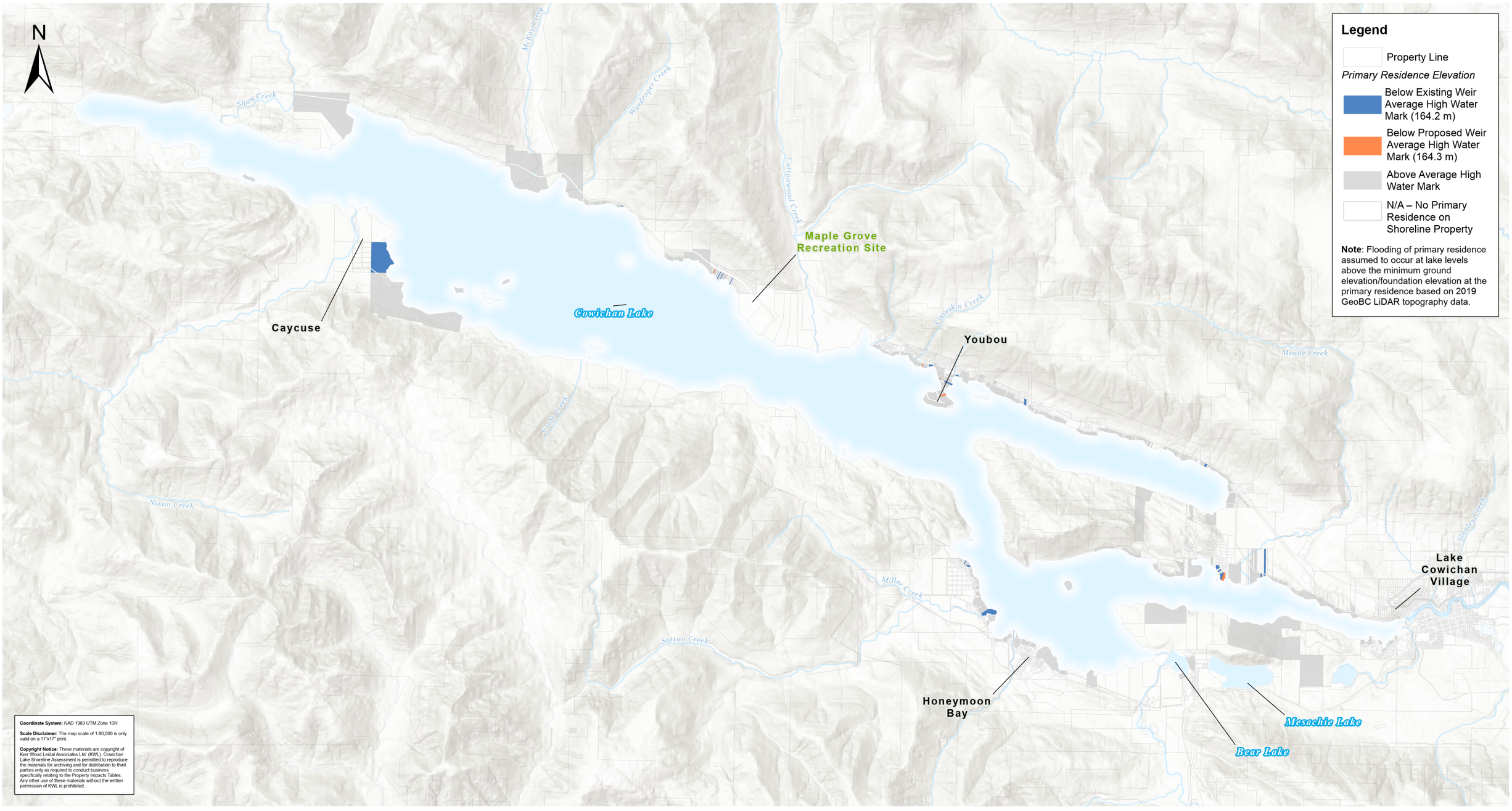

Legend

- Property Line

Primary Residence Elevation

- Below Existing Weir Average High Water Mark (164.2 m)
- Below Proposed Weir Average High Water Mark (164.3 m)
- Above Average High Water Mark
- N/A – No Primary Residence on Shoreline Property

Note: Flooding of primary residence assumed to occur at lake levels above the minimum ground elevation/foundation elevation at the primary residence based on 2019 GeoBC LiDAR topography data.

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:80,000 is only valid on a 11"x17" print.

Project No. 2212-078

Date November 2022

Scale 1:80,000

0 1 2 km

Properties with Potential Flooding Impacts

Figure 3-1

3.2 Inundation

The *inundation impact* indicates whether additional water will be stored on a property with the proposed raised weir, such that the horizontal extent of lake inundation on the property will increase.

As discussed previously in Section 3.2, there are three cases to consider for inundation of parcels.

1.) The proposed raised weir crest elevation is lower than the lowest ground elevation within the parcel boundary such that the proposed raised weir results in no inundation of the parcel. There are 432 properties (51% of all shoreline properties) where the proposed raised weir crest is below the parcel boundary resulting in no storage of water within the parcel.

2.) A portion of the area of the parcel lies below the proposed raised weir but the entire parcel is above the existing weir resulting in new inundation area within the parcel. There 126 parcels (15% of all shoreline properties) where water would be stored over a portion of the parcel area for the proposed raised weir but not for the existing weir.

3.) A portion of the area of the parcel lies below both the existing weir and the proposed raised weir resulting in additional inundated area within the parcel. There are 288 parcels (34% of all shoreline properties) where the area of water being stored within the parcel boundary for the existing weir increases with the proposed raised weir.

Of the 126 properties with new inundation below the proposed raised weir crest, 17 of the properties have an inundated area more than 5% of the total parcel area. The largest new area of inundation above the existing weir crest is 18% of the total parcel area.

For the 288 properties with additional inundated area, 76 have additional inundated area within the parcel more than 5% of the total parcel area. The largest additional inundated area above the existing weir crest is 69% of the total parcel area.

The largest portion of a property parcel that is partially inundated below the crest of the proposed raised weir is 80% of the total parcel area (includes both area below the existing weir and the proposed raised weir). There is also one parcel that is entirely below the existing weir crest elevation and thus is completely inundated when water levels are at the existing weir crest and the proposed raised weir crest elevations.

The spatial distribution of the partially inundated properties shown in Figure 3-2.

3.3 Estimated Change in Natural Boundary

The change in the natural boundary, measured as the horizontal distance between the PNB and the EFNB, is a function of the estimated vertical change in the elevation of the PNB and the slope of the ground between the PNB and EFNB. The number of properties with change in natural boundary is shown in Table 3-2.

Table 3-2: Number of Properties with Change in Natural Boundary Location

Horizontal Distance between PNB and EFNB	< 3 m	3 m to 5 m	5 m to 10 m	>10 m
# of Properties	708	66	59	13
Note: Natural Boundary shifts up to 0.39 m vertically and up to 32 m horizontally.				

Given the variation in the vertical change in elevation between the PNB and the EFNB and the variation in topography around the lake, there are no significant spatial trends in the horizontal distance between the PNB and EFNB around the Cowichan Lake shoreline (see Figure 3-3). However, there are a few areas that have clusters of properties with larger horizontal distance between the PNB and the EFNB greater than 3 m including

- The eastern end of the south arm near the Town of Lake Cowichan, including a couple of properties in the Point Ideal neighbourhood.
- Marble Bay and properties to the East of Marble Bay along Peri Road, Nantree Road and Marble Bay Road.
- Properties on the East Side of Sa-Seen-Os Point in Youbou.
- Properties along North Shore Road and Cowan Road to the west of Cotton Wood Creek and East of Maple Grove Recreation Site.
- Near the mouth of Nixon Creek in Caycuse.
- Five properties to the east of Gordon Bay Provincial Park on Gordon Bay Road.
- Properties within the estuary / alluvial fan of the Robertson River.
- Properties along Bear Lake.
- Many of the islands.

The ranges of horizontal distance between the PNB and EFNB shown along the lake shoreline in Figure 3-3 are based on the average along the shoreline fronting the parcel. Only the average value for each parcel has been assigned for each parcel. For larger parcels, there might be significant range of distances between the PNB and EFNB that are not shown in the figure.

Cowichan Lake Shoreline Assessment
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0 1 2 km

Properties with Potential Inundation impacts

Figure 3-2

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0 1 2 km

Estimated Change in Natural Boundary Location

Figure 3-3

3.4 Impact to Shoreline Protection Structures

The location of shoreline structures (retaining walls, riprap, etc.) was mapped using aerial photography and the shoreline photos. The majority of the existing shoreline structures are unlikely to be impacted due to the proposed raised weir as the structures are above the EFNB. However, there are 11 structures that are located between the PNB and the EFNB and are therefore likely to have some potential impact as a result of changes in shoreline due to the proposed raised weir. Further site-specific information will be required to assess to what extent structures are vulnerable to the projected shoreline changes due to the proposed raised weir. A summary of the number of structures is included in Table 3-3 and the spatial distribution is shown in Figure 3-4.

Table 3-3: Number of Shoreline Structures with Potential Impact from Raised Weir

	Potential Impact to Structure Likely (Structure between PNB and EFNC)	Impact to Structure Unlikely
# of Structures	11	86

3.5 Potential Changes in Vegetation

Combining the sensitivity of different shoreline vegetation classes with the change of exposure of vegetation to water and wave action, quantified as the distance between the PNB and the EFNB, provides an indication of the vulnerability of vegetation to changes resulting from the proposed raised weir. The results are summarized in Table 3-4. The spatial distribution of vegetation vulnerability is shown in Figure 3-5. The vegetation vulnerability classifications shown in Figure 3-5 are based on the spatially weighted average vegetation classification for the property and this single value is shown in the figure along the entire shoreline fronting the parcel. For larger parcels, there might be several vegetation classification segments along the shoreline but only one classification is shown in the figure.

Table 3-4: Distribution of o\the Number of Properties with Various Levels of Vulnerability of Changes to Vegetation Due to Proposed Raised Weir

Vulnerability of Vegetation to Changes Due to Proposed Raised Weir	Low	Moderate	High
# of Properties	673	160	13

The shoreline vegetation at 673 of the properties (79%) is expected to have a low vulnerability to changes in shoreline character and water level as a result of the proposed raised weir. There are 13 properties with highly vulnerable vegetation to changes resulting from the proposed raised weir. These properties are primarily in areas with shallow slopes as well as a number of the islands within Cowichan Lake.

3.6 Riparian Access

As the EFNB is upslope from the PNB, there are no properties where the change in the location of the natural boundary results in having to access the lake across neighbouring private property.

Cowichan Lake Shoreline Assessment
Property Impacts Tables

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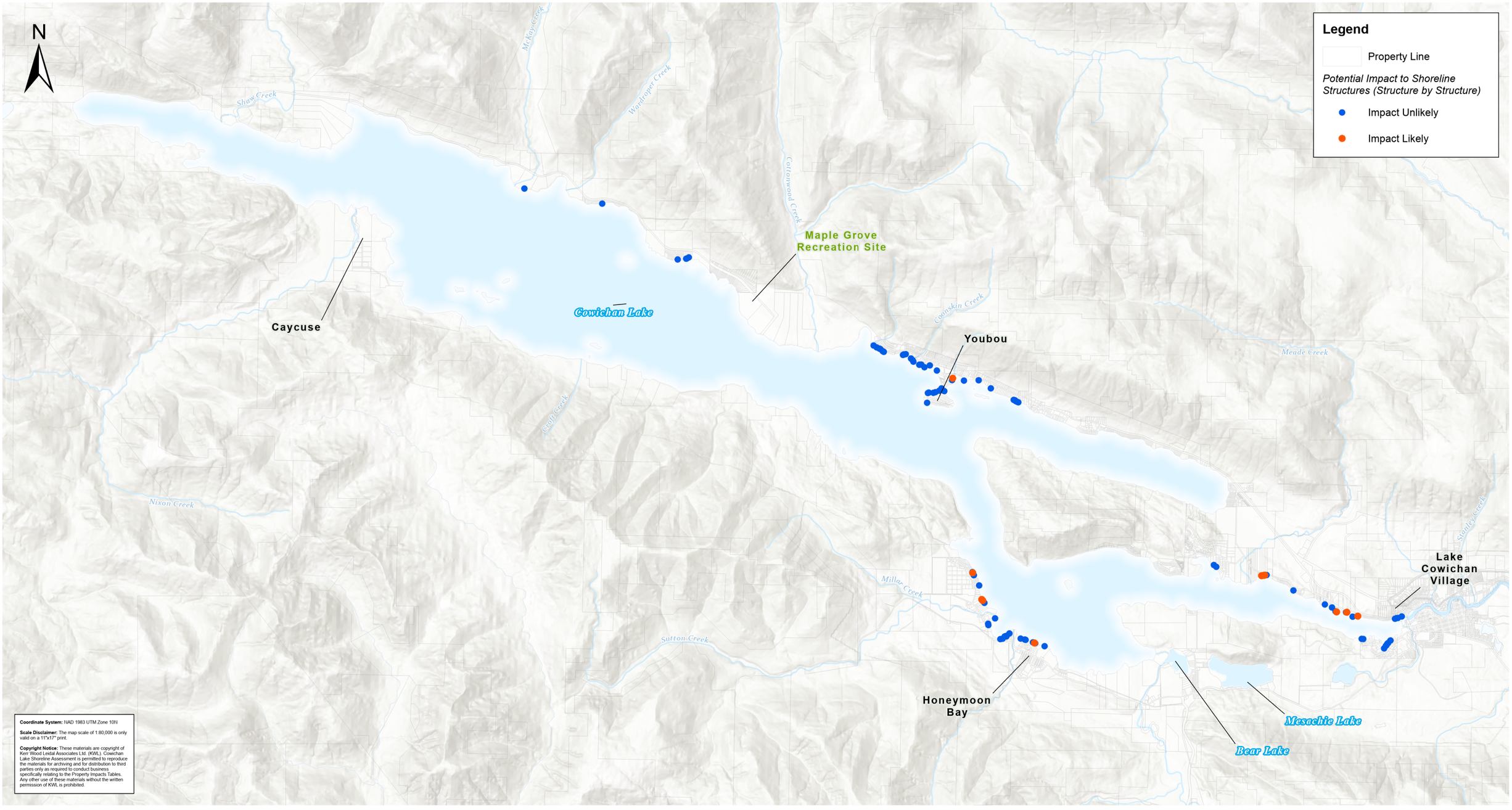

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Properties with Potential Impacts to Shoreline Structures

Figure 3-4

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Vulnerability of Shoreline Vegetation to Change

Figure 3-5

3.7 Dock Access

There are generally two types of docks along the shoreline of Cowichan Lake. Docks which have fixed permanent access point with an overhead gangway to floating platform (see Figure 3-6), or docks made up of floats which sit on the beach (floating access) when water levels are low.

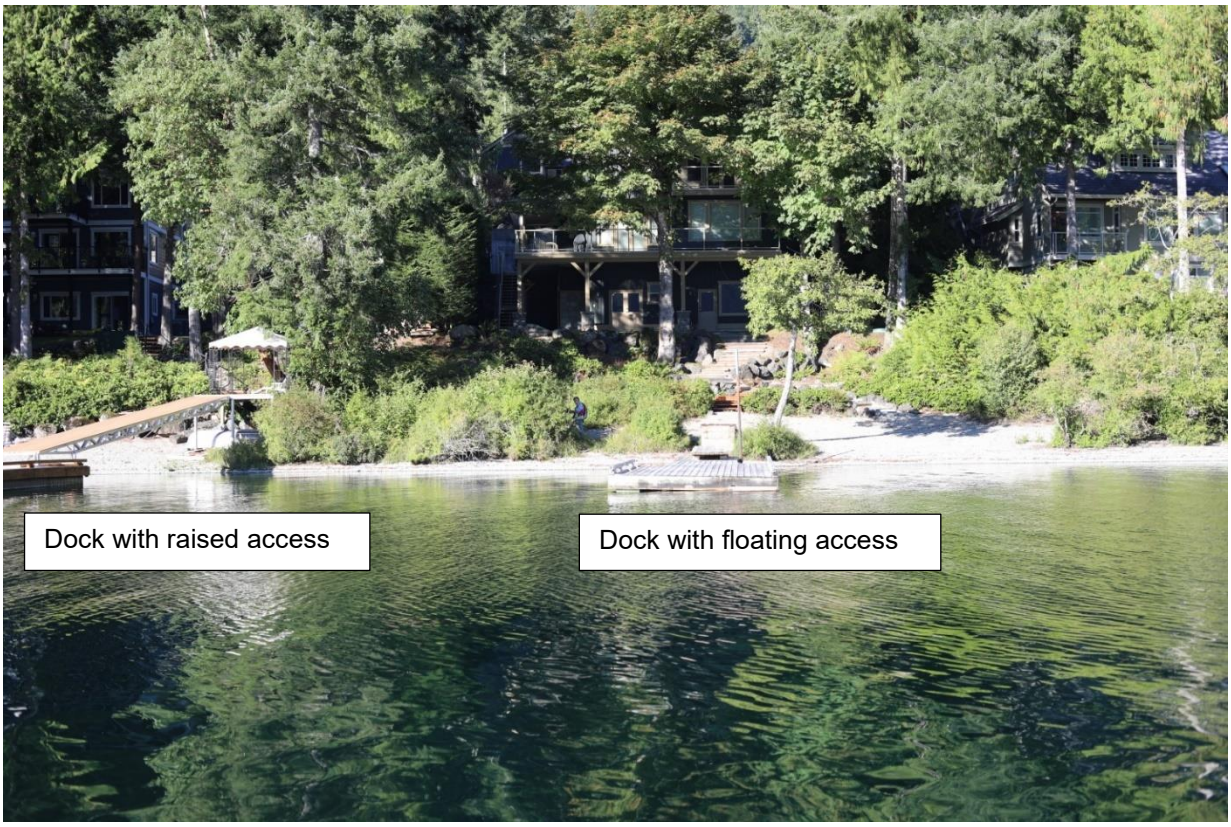

Figure 3-6: Example of Type of Dock Access

The impact on dock access depends on the elevation of the access point to the dock and how that relates to the frequency that water levels are above or below this elevation. Table 3-5 shows the distribution of dock access elevations around the lake.

For properties where the dock access is above the mean annual flood level (164.2 m) there is no change in dock access. For properties where the dock access elevation lies between the mean annual flood elevation and the proposed raised weir crest elevation, there is some reduction in the number of days of access. Properties with dock access between the existing weir crest and the proposed raised weir crest, are anticipated to have the largest reduction in number of days of access. For those properties where dock access is below the existing weir crest, which are mostly floating docks, there is some reduction in the number of days of access.

Both the total number of days of access to dock for the existing weir (when water level is below the dock access point elevation) and the change in days of of access to docks for the proposed weir is shown in Table 3-6.

A value of more than 10% reduction from the number of days of dock access over the year was considered to be significant for the purposes of defining a potential impact to dock access in the property impact tables. There about half of the properties (277 of the 521 properties) with docks that would have more than a 10% change in dock access as a result of changes in water level with the proposed raised weir. The location of properties with more or less than a 10% reduction in the number of days of access to docks shown in Figure 3-7.

Most of the reduction in dock access with the proposed raised weir would occur in March as a result of the earlier start of the control period and in spring (April to June) when lake levels are maintained near the crest of the proposed raised weir.

Table 3-5: Distribution of dock access points elevations.

Elevation of access to dock	Higher than mean annual high water (> 164.2 m)	Between mean annual high water (164.2 m) and proposed weir crest (163.35 m)	Between existing weir crest (162.65m) and proposed weir crest (163.35 m)	Below existing weir crest (162.65 m)
# of Properties	138	103	118	162

Table 3-6: Distribution of the Number of Properties with Changes to Dock Access Due to Proposed Raised Weir

With Existing Weir	**Number of days WL lower than dock access point**	<30 days	30 to 90 days	90 to 180 days	>180 days
	# of Properties	52	62	48	359
With Proposed Raised Weir	**Reduction in # of days WL higher than dock**	<1 day	1 to 10 days	10 to 30 days	>30 days
	# of Properties	154	147	72	148
Note: 521 of the 846 shoreline properties have a dock.					

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Properties with Potential Impacts to Dock Access

Figure 3-7

3.8 Beach Use

As part of the Cowichan WUP, full enjoyment of lakeshore beach was considered when the beach is more than 3 m wide. Therefore, the measure of the impact to beach use considers the change in the number of days the beach is more than 3 m wide (below the PNB). The change is considered to be significant if there is more than a 10% reduction in the number of days of beach use during the recreational season from April 1 to end of Oct. Based on this measure, there are about 356 properties (about 42% of all shoreline properties) which are projected to have a reduction of beach use days during the recreational season of more than 10%. The spatial distribution of these properties around the lake are shown in Figure 3-8. It should be noted that there are 167 properties where the reduction in beach access days is projected to be more than 40% of the current beach access days. The maximum reduction in beach access days with the proposed raised weir is 47% of current beach access days.

The properties with more than 10% reduction in beach use tend to be properties with steep shorelines where the beach is already narrow and the number of days the beach is currently wider than 3 m is relatively small. Therefore, a relatively small number of days in reduction of beach use results in a relatively high percentage of change compared to other properties. Alternatively, the properties with reduction of more than 10% also tend to be those with a larger number of days of reduction in beach use. These properties are located within the largest range of lake levels change in water level frequency, between the proposed raised weir crest and the existing weir crest.

Cowichan Lake Shoreline Assessment
Property Impacts Tables

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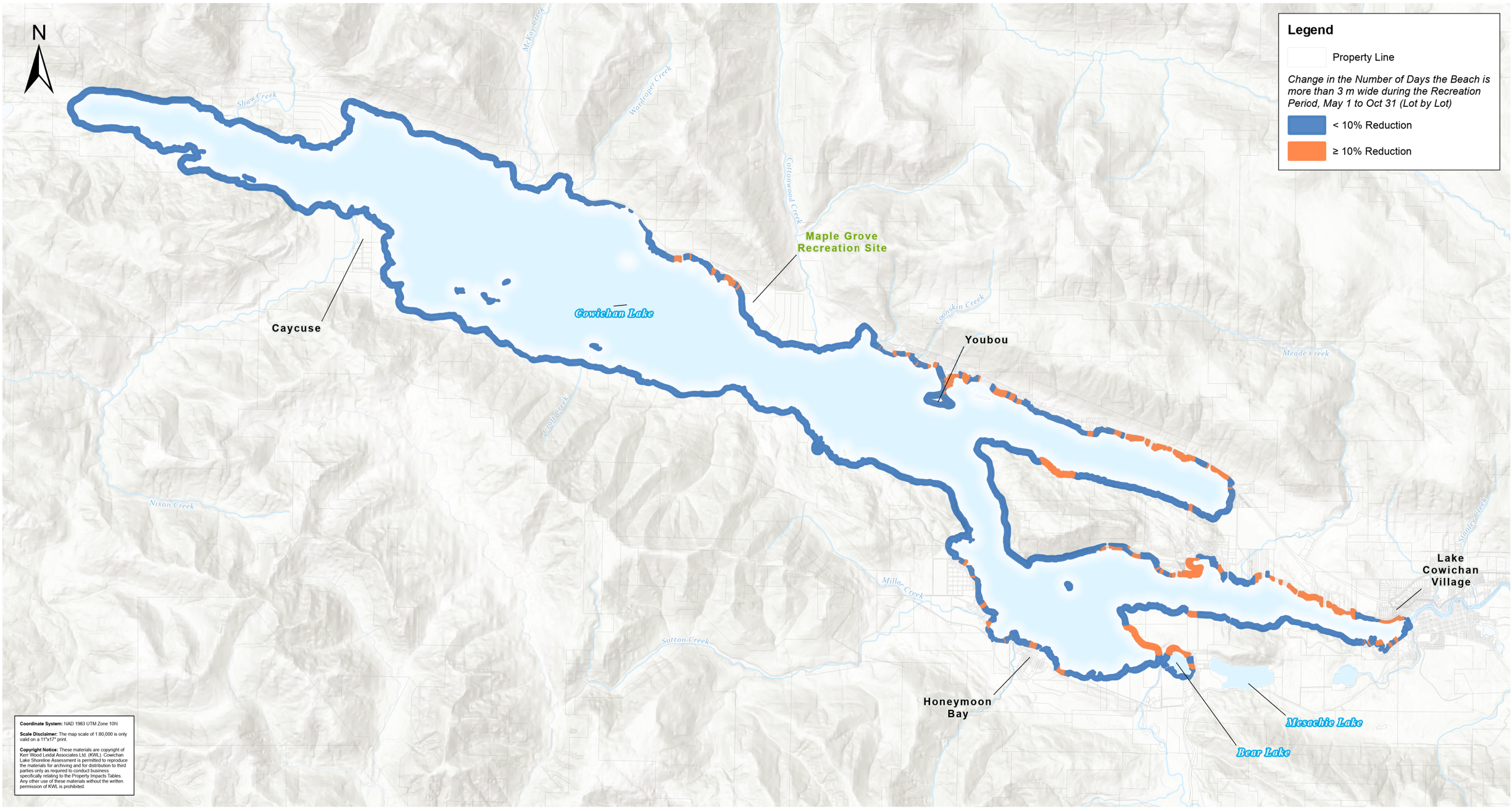

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Properties with Potential Impacts to Beach Use

Figure 3-8

4. Future Impacts with Climate Change

The potential impacts to lakefront properties outlined in Section 3 are based environmental changes associated with the proposed raised weir alone, climate change projections are not included. This approach provides the most direct assessment of impacts resulting from the immediate potential impacts of the proposed raised weir. However, climate change will modify these impacts over time.

Climate change is projected decrease in spring and summer inflows Cowichan Lake in the future. As a result, lake levels in the same period will also be lower in future compared to historic conditions. This means that over time, the amount of change in the frequency of lake levels will reduce back towards current conditions with the existing weir. As a result, those potential property impacts driven by changes in lake level frequency are projected to decrease over time compared to current conditions.

For projected changes in lower lake levels, including dock access and beach access, the duration access is available in future will increase with climate change as lake levels will tend to be lower more frequently than with current climate.

Peak lake levels during times of flood are projected to increase in future as a result of higher intensity winter rainfall events. The influence of the proposed raised weir on peak lake levels reduces as the peak lake levels increase. As such, the impact of the proposed raised weir to peak flood lake is likely to reduce in future.

Property impacts related to the change in the natural boundary location such as natural boundary change, impact to shoreline structures and vegetation impacts could also see future reduction in the potential impacts. However, it is assumed that most of these impacts will occur over a relatively short timeframe immediately after construction of the weir and will take time to recover, if at all, as a result of lower lake levels in future.

Inundation is not projected to change with climate change. As this impact is related to fixed crest elevation of the proposed raised weir and the EFNB, which does not change with projected future climate change.

Finally, impacts as a result of lake levels dropping below historical low water levels such as navigation to docks and exposure of sediments, are expected to increase for both the existing weir and proposed raised weir conditions. However, the frequency that lake levels are projected to drop below historical low water levels by the 2080s, is about three times larger for existing weir condition than for the proposed raised weir.

5. Limitations

The property impacts identified and quantified are intended to provide an indication of the potential for the proposed raised weir to result in impacts to shoreline properties. However, this analysis is based on analysis of mapping that was ground truthed with limited field data. Therefore, the impacts should be considered to be indicative and are intended to provide relative potential impacts between properties for purposes of identifying areas at greater risk of having impacts. This information can then be used to help guide development of adaptive management plan and monitoring of shoreline properties.

6. References

Compas. (2018). *Public Advisory Group Summary Report - Cowichan Water Use Plan.* Prepared for Cowichan Valley Regional District. Compas Resources Ltd.

Stantec. (2021). *Cowichan Lake Weir Design Final Report.* Preapred for Cowichan Valley Regional District. Report dated December 9, 2021: Stantec Ltd.

7. Report Submission

Prepared by:

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EGBC Permit to Practice:
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2022-11-17

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Statement of Limitations

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Revision History

Revision #	Date	Status	Revision	Author
1	November 15, 2022	REVISED	Includes updated modelled lake levels using final rating curves for existing and proposed raised weir	CS
0	June 2, 2022	FINAL		CS

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