Foreshore Integrated Management Planning
Database Management

Prepared For:
Living Lakes Canada and Project Partners

Prepared By:
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Living Lakes Canada (LLC) is part of a global network of over 120 non-governmental organizations that facilitates collaboration in education, monitoring, restoration and policy development initiatives for the long-term protection of Canada's lakes, rivers, wetlands and watersheds. LLC has a mandate to help Canadians understand, adapt, and mitigate the impacts of climate change on water quality and quantity, biodiversity and healthy human communities through grassroots water stewardship activities. LLC helps bridge the gap between science and action to foster and normalize citizen- based water stewardship. Declines in lakeshore conditions are occurring globally, and LLC funded this shoreline mapping project through DFO's Canada Nature Fund for Aquatic Species at Risk Program to help aid better long term lakeshore planning in the Kootenay region of British Columbia (BC).

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The results contained in this report are based upon data collected during a single season inventory. Biological and lake systems respond differently both in space and time. For this reason, the assumptions contained within the text are based upon field results, previously published material on the subject, and airphoto interpretation. The material in this report attempts to account for some of the variability between years and in space by using safe assumptions and a conservative approach. Data in this assessment was not analyzed statistically and no inferences about statistical significance are made if the word significant is used. Use of or reliance upon biological conclusions made in this report are the responsibility of the party using the information. Neither Ecoscape Environmental Consultants Ltd., the authors of this report or Living Lakes Canada (or project partners) are liable for accidental mistakes, omissions, or errors made in preparation of this report because best attempts were made to verify the accuracy and completeness of data collected, analyzed, and presented.

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Post 2020 FIMP Methods Update	Pre 2020 FIMHP Methods Update (only if changed)	Acronym
CDC		Conservation Data Center
DFO		Fisheries and Oceans Canada
CMN		Community Mapping Network
EKILMP		East Kootenay Integrated Lake Management Partnership
FDG	SMG	Foreshore Guidance Document / Shoreline Management Documents
FHSI	AHI	Foreshore Habitat Sensitivity Index / Aquatic Habitat Index
FHSI Category		Foreshore Habitat Sensitivity Index Category
FHSI Criteria or Criterion		Foreshore Habitat Sensitivity Index Criteria
FHSI Ecological Rank		Foreshore Habitat Sensitivity Index Ecological Rank or output
FIM		Foreshore Inventory and Mapping
FIMP	SHIM	Foreshore Integrated Management Planning / Sensitive Habitat Inventory and Mapping
FNLRORD		Provincial Ministry of Forests, Lands, Natural Resource Operations and Rural Development'
GIS		Geographic Information Systems
GPS		Geographic Positioning System
HWM		High Water Mark
LLC		Living Lakes Canada
TEK		Traditional Ecological Knowledge
ZOS		Zone of Sensitivity

TABLE OF CONTENTS

TABLES

1.0 INTRODUCTION

Living Lakes Canada (LLC) is part of a global network of over 120 non-governmental organizations that share the mission to enhance the protection, restoration and rehabilitation of lakes, rivers, wetlands and watersheds throughout the world. Living Lakes Canada fosters citizen-based water stewardship and has a mandate to help Canadians understand the intimate connections between water quantity, water quality, land-use, climate change, biodiversity, and healthy human communities.

Foreshore Integrated Management Planning (FIMP) is intended to help governments, landowners, and nonprofit organizations understand lake foreshore habitat values and the potential ecological risks from proposed shore altering activities. The resulting information is used to help make decisions regarding foreshore development and conservation. The methods are standardized to provide a consistent framework for shoreline development reviews. One of the many benefits of the standardized process is that if data from previous surveys are available, the rate of loss of natural shoreline can be determined. Understanding rates of loss is important to better manage the shoreline. The methods have been developed to provide an overview, recognizing that budgets available are finite. These data are thus primarily intended to aid land use planning, and they may not identify site specific habitats of importance. Detailed assessments and planning are an integral process and must be incorporated as necessitated by development proposals, conservation planning, etc.

1.1 Objectives

The key objective of a template for data management for FIM datasets are to ensure better conformance and data standards for use of data in long term monitoring of lakeshore conditions. A primary objective is to standardize lake mapping such that data from many lakes can be used in analyses easily. In collecting and managing data in this way, better land use decisions for lakeshores can be made if important data trends can be identified.

The objectives are:

1. Provide a framework for managing of the FIM database;
2. Provide a framework for managing the FHSI database;
3. Provide a framework for managing identified Zones of Sensitivity;
4. Provide a written summary of mathematical summaries that should be completed as part of database review and proofing;
5. Provide an R Script and analysis that can be used for reviewing the database, which is compared directly with the standardized FIM data dictionary (**Error! Reference source not found.**); and,
6. Provide a summary of how GIS data should be managed and provided so that it can be easily integrated into a larger FIM database.

1.2 Report Terminology

For this report, the following is important to note to aid in interpreting the report. This document is intended technical in nature and assumes the reader is familiar with FIM, the FHIS, ZOS and their methodology (see Schleppe et al 2020 for FIM methods and Schleppe et al. 2019 for a summary of previous FIM database versions to aid with cross reference to this report).

1) All database columns referred to in the text will be displayed in italicized *CAPS LOCK* to identify the specific data attribute and to differentiate between referral to the FIM, FHSI, or ZOS databases.
2) The FIM data dictionary is found in **Error! Reference source not found.**. This is also available as a table in Excel for reference, with all other tables in this report.
3) The FIM Segment number is the unique field that links the FIM data sets FHSI.
4) The FIM, FHSI, and ZOS datasets are setup such that each year is an independent feature class in GIS. This increase functionality of the dataset and treats each data collection event as a separate entity.

1.3 Foreshore Inventory and Mapping GIS Database

The FIM, FHSI, and ZOS consist of three, separate spatial datasets. The general structure of each dataset are as follows:

Table 1. FIMP Data Tables

Geodatabase	GIS Feature Class
FIM	Each Year of Survey
FHSI	Each Unique Year an FHSI
ZOS	Fish Wildlife Herptile Waterfowl Ecosystem Rare Occurrences
Additional FIM or Lake Data Collected	***These data are not managed.***

The FIM database has a specific format for each attribute field contained in the FIM data dictionary. Appendix A contains the FIM data dictionary. This report relies upon field attributes in that dictionary to define scripts used to undertake quality assurance, control, and data conformance.

The FHSI database is intended to only contain the results of the FHSI. The data dictionary for the FHSI database is as follows:

SEGMENT_NUM	FHSI_SCORE	FHSI_RANK	FHSI_COMM

1) *SEGMENT_NUM* refers to the FIM segment number and is the unique identifier to join to the FIM dataset for analysis as required.
2) *FHSI_SCORE* is the resultant score that was determined using the FHSI. This number should range between 0 and 1.
3) *FHSI_RANK* is the Foreshore Ecological Sensitivity Rank and should equal Very High, High, Moderate, Low, or Very Low
4) *FHSI_COMM* is intended to contain any specific comments for a segment as it relates to the FHSI

The ZOS database is intended to only contain the results of the ZOS. For each ZOS, a Layer file to support the Feature Classes is needed for display across all platforms and view portals. Label is the description for each type of ZOS GIS Feature Class. The data dictionary for the FHSI database is as follows in Excel format:

ZOS_FI_LAB	COMMENTS	SOURCE

1) For each ZOS, the label to identify different point, line, or polygon features needs to be created. For example, *ZOS_FI_LAB* could be used for ZOS in the Fisheries Category. This label field should generally be consistent with map outputs.
2) For each ZOS, a comments field should be created. There is no specific labelling database column format provided as there could be numerous different ZOS categories, or point/line/polygon features. The column label should attempt to the backwards compatible with shapefiles, and should be descriptive of the ZOS. For instance, ZOS*_FI_COM* shown above could be used for all Fish as an example.
3) *SOURCE* is intended to be a text field to track the source of the data. As many datasets may be used to generate or spatially identify a ZOS, the source of the data should be tracked here.

2.0 DATABASE REVIEW PROCEDURE

This analysis will develop an export file in Excel of all possible errors identified in the FIM, FHSI, and ZOS databases created.

2.1 Data Preparation

Prior to running the R analysis on any of the datasets, a manual review of field collected data should occur to ensure the data is consistent and conforms to the FIM data dictionary (**Error! Reference source not found.**) as much as possible. This analysis is intended to be used in an iterative process, using an Excel export of the spatial FIM dataset.

The following is required to complete this analysis:

1) R Software Version XX. *It is noted here that this script checks for appropriate R packages, but minor revisions may be necessary to ensure that version conflicts are other small programmatic problems do not exist.*
2) Microsoft Excel. Exports from the analysis are generally given as a PASS or FAIL result, and checks that FAIL are highlighted red in the Excel for easy reference. Warnings are highlighted orange.
3) A copy of the FIM data dictionary to be used in this analysis. *This file should not be amended because the scripts rely upon the information in it to conduct the analysis and modifications may cause unexpected results.*
4) Many of these same scripts can be manually created in Excel if the user does not wish to use R to review the dataset. However, some of these scripts may be very complicated to generate in Excel and a user may wish to just manually review the intent versus trying to program Excel accordingly.

2.2 R Analysis for FIM

The following is a step-by-step procedure that is undertaken using the R analysis. The description below is intended to provide the reader with an understanding of the programmatic checks completed. This script will read a Lake's FIM database and validate some of the fields against the data dictionary and according to some basic validation criteria. When running the script, the user is prompted to enter the name of the lake (ex.: Windermere) and to select the Excel file containing the FIM database. If the column names are valid, the script runs the remaining validations, otherwise, the user will need to correct the issues and re-run the script to perform the remaining validations. Validation results are displayed in-line (on the RMarkdown Script or Notebook) or in the console. The summarized results are outputted to an Excel file in a folder named: "QAQC_Output" created in the same folder where this script is stored.

1) **FIM Variable Names Validation –** This analysis confirms FIM database variable names (column headings) match the FIM data dictionary (**Error! Reference source not found.**). This script completes the following tasks:
    a. Imports the FIM Data dictionary file, to act as a comparison for the FIM field data collected.
    b. Confirms the FIM data dictionary matches the FIM field attributes (i.e., a database length comparison)
    c. Completes a pairwise comparison for FIM data field in the dictionary and the FIM field database. *This comparison does not check the FIM database order. It is noted that the FIM database order should be maintained for easy review in Excel or other programs, but this is not required by the R analysis.*
    d. The result of this analysis is a message rendered to the console screen indicating if all the required dictionary variables are present in the FIM database. If the match is not complete, the user is required to perform the name changes in the database before proceeding with the remaining checks.
2) **Percent Natural / Percent Disturbed Check**

a. *PNPD* – This check for missing data, negative numbers and sums the FIM *DISTURBED* and *NATURAL* field data to confirm the sum equals 100% or not. *PNPD* field exported to Excel returns a PASS or FAIL.
b. *LOI* – The *LEV_OF_IMP* FIM field attribute is based upon *DISTURBED* and *NATURAL* percentages. This check confirms that the disturbance categories in the *LEV_OF_IMP* match one of High (>50%), Medium (10-50%), Low (<10%), or None based upon the data collected. This analysis outputs PASS or FAIL if the amount DISTURBED does not correspond with the LEV_OF_IMP category.

3) Shoreline Modifiers Check

a. *SHOREMOD* – This field checks the different segment modifiers by checking the FIM data fields for information in *PERRAIL_MO, PERROAD_MO, MARINAS*. To correct this field, some user interpretation is needed to ensure the predominant modifier is identified in cases where more than one may be present. The following are the different outputs for this analysis in the *SHOREMOD* field of the Excel output:
    i. 'FAIL – Empty' occurs when there is data in either *PERRAIL_MO, PERROAD_MO, MARINAS* but there is no shore modifier identified.
    ii. 'FAIL – Check Category' occurs when the Category value does not correspond with any of the valid categories (Log Yard, Small Marina (6 - 20 slips), Large Marina (> 20 slips), Railway, Roadway, None, Other).
    iii. 'Warn - Check Modifier' when SHORE_MODI indicates either "Log Yard" or any size of Marinas and the other modifiers are also present.
    iv. 'FAIL - Check modifier' occurs from numerous outputs, including:
        1. SHORE_MODI states None, and values are present for either *PERRAIL_MO, PERROAD_MO, MARINAS*
        2. *SHORE_MODI* states Roadway but PERRAIL_MO is bigger than PERROAD_MO, or vice versa, indicating Railway while PERROAD_MO is bigger than PERRAIL_MO.
    v. 'FAIL - Check MARINAS' occurs when the SHORE_MODI category is either Small Marina (6 - 20 slips) or Large Marina (> 20 slips) but the *MARINA* field has a value of 0.
    vi. When there is no shore modifier with the biggest percentage, the script will output a FAIL and the assessor will have to establish the dominant category.

4) Shore Type Check

a. *ST100* – This analysis checks if the *CLIFF_BLUF, ROCKY, GRAVEL_STYPE, SAND_STYPE, STREAM_MOU, WETLAND, STYP_OTHER* Shore type columns sum to 100% or 100 in the data field. This analysis outs PASS, FAIL.

b. STCAT – This analysis checks that the *SHORE_TYPE* column matches the predominant Shore type in FIM field data for the percentages in the *CLIFF_BLUF, ROCKY, GRAVEL_STYPE, SAND_STYPE, STREAM_MOU, WETLAND, STYP_OTHER*. The output in column is PASS or FAIL. When there is no shore type with the biggest percentage, the script will output a FAIL and the assessor will have to establish the dominant category.

5) Land Use Check

a. *LU100* - This analysis checks if the *AGRICULTUR, COMMERCIAL, CONSERVATN, FORESTRY, INDUSTRIAL, INSTITUTIO, MULTI_FAMI, NATURAL_AR, PARK, RURAL, SINGLE_FAM, TRANSPORTN, URBAN_PARK, UTIL_CORR* Land use columns sum to 100% or 100 in the data field. This analysis outs PASS, FAIL.

b. LUCAT - This analysis checks if the *LAND_USE* category correspond with the dominant of A*GRICULTUR, COMMERCIAL, CONSERVATN, FORESTRY, INDUSTRIAL, INSTITUTIO, MULTI_FAMI, NATURAL_AR, PARK, RURAL, SINGLE_FAM, TRANSPORTN, URBAN_PARK, UTIL_CORR* Land use columns. This analysis outs PASS, FAIL. When there is no Land Use category with the biggest percentage, the script will output a FAIL and the assessor will have to establish the dominant category.

6) Substrates Check

a. Foreshore

i. *FORSUB* – Checks that foreshore substrates fields FOR_MARL, FOR_MUD, FOR_ORGAN, FOR_FINES, FOR_SAND, FOR_GRAVEL, FOR_COBBLE, FOR_BOULD, FOR_BEDRCK. sum to 100%.

ii. *FOR_GRV_CHK* – This checks that if *FOR_GR_FIN* and FOR_GR_COA data are included, they are collected correctly. These fields are each relative to the segment length and the sum of *FOR_GRAVEL_FIN* and *FOR_GRAVEL_COA* must equal *FOR_GRAVEL*.

iii. *FOR_COB_CHK* - This checks that the *FOR_CO_FIN* and *FOR_CO_COA* are entered correctly. These fields are each relative to the segment length and the sum of *FOR_COBBLE_FIN* and *FOR_COBBLE_COA* must equal *FOR_COBBLE*.

b. Littoral

i. *LITSUB* – Checks that foreshore substrates fields sum to 100%. LIT_MARL, LIT_MUD, LIT_ORGAN, LIT_FINES, LIT_SAND, LIT_GRAVEL, LIT_GR_FIN, LIT_GR_COA, LIT_COBBLE, LIT_CO_FIN, LIT_CO_COA, LIT_BOULD, LIT_BEDRCK.

ii. *LIT_GRV_CHK* – This checks that if *LIT_GR_FIN* and LIT_GR_COA data are included, they are collected correctly. These fields are each relative to the segment length and the sum of *LIT_GR_FIN* and *LIT_GR_COA* must equal *LIT_GRAVEL*.

iii. *LIT_COB_CHK* - This checks that the *LIT_CO_FIN* and *LIT_CO_COA* are entered correctly. . These fields are each relative to the segment

length and the sum of *LIT_CO_FIN* and *LIT_CO_COA* must equal *LIT_COBBLE*.

7) Vegetation Band 1

a. *B1CHECK*- This analysis confirms that each of these fields is populated with data: *B1_CLASS, B1_STAGE, B1SHRUB_CO, B1TREE_COV, B1_DISTRIB, B1_BANDWID.*
b. *B1_CLASS_CHK*– This analysis check that the values in *B1_CLASS* equal one of the valid categories: Coniferous Forest, Broadleaf Forest, Mixed Forest, Shrubs, Herbs/Grasses, Exposed Soil, Landscape/Lawn, Natural Wetland, Disturbed Wetland, Row Crops, Unvegetated. The output is PASS or FAIL.
c. *B1_STAGE_CHK* – This analysis checks that the values in *B1_STAGE* to be one of the following: Sparse, Grass/Herb, Low Shrubs (< 2m), Tall Shrubs (2m - 10m), Pole/Sapling, Young Forest, Mature Forest, Old Forest. It also checks B1_STAGE is in accordance with B1_CLASS (e.g., Forest Class – Forest Stage). The results of this analysis are PASS, FAIL or WARN.
d. *B1SHRUB_CO_CHK* This analysis checks that *B1SHRUB_CO* is one of the following: None, Sparse (< 10%), Moderate (10% - 50%), Abundant (> 50%). The results of this output are PASS or FAIL.
e. *B1TREE_COV_CHK* – This analysis checks that *B1TREE_COV* is one of the following: None, Sparse (< 10%), Moderate (10% - 50%), Abundant (> 50%). The results of this output are PASS or FAIL.
f. *B1_DISTRIB_CHK* – The analysis confirms that the *B1_DISTRIB* field is one of either Patchy or Continuous. The results of this output are PASS or FAIL.
g. *B1_BANDWID_CHK – B1_BANDWID Field must be greater than 0. Output is PASS if B1_BANDWID > 0, FAIL if B1_BANDWID < 0, or NA, and XX if B1_BANDWID > 50, where XX is stated value in FIM DB.*

8) Vegetation Band 2. Vegetation Band 2 fields are only checked if *B2_BANDWID* > 0.

a. *B2CHECK*- This analysis confirms that each of these fields is populated with data: *B2_CLASS, B2_STAGE, B2SHRUB_CO, B2TREE_COV, B2_DISTRIB* (noting aforementioned conditions for Vegetation Band 2).
b. *B2_CLASS_CHK* – This analysis checks that B2_CLASS values equal one of: Coniferous Forest, Broadleaf Forest, Mixed Forest, Shrubs, Herbs/Grasses, Exposed Soil, Landscape/Lawn, Natural Wetland, Disturbed Wetland, Row Crops, Unvegetated. The results of this analysis are PASS or FAIL.
c. *B2_STAGE_CHK* – This analysis checks that the values in *B2_STAGE* to be one of the following: Sparse, Grass/Herb, Low Shrubs (< 2m), Tall Shrubs (2m - 10m), Pole/Sapling, Young Forest, Mature Forest, Old Forest. It also checks *B2_STAGE* is in accordance with *B1_CLASS* (e.g., Forest Class – Forest Stage). The results of this analysis are PASS, FAIL or WARN.

d. *B2SHRUB_CO_CHK* This analysis checks that *B2SHRUB_CO* is one of the following: None, Sparse (< 10%), Moderate (10% - 50%), Abundant (> 50%). The results of this output are PASS or FAIL.
e. *B2TREE_COV_CHK* – This analysis confirms that *B2TREE_COV* is one of the following: None, Sparse (< 10%), Moderate (10% - 50%), Abundant (> 50%). The results of this output are PASS or FAIL.
f. *B2_DISTRIB_CHK* – The analysis confirms that the *B2_DISTRIB* field is one of either Patchy or Continuous. The results of this output are PASS or FAIL.
g. *B2_BANDWID_CHK* – This analysis confirms that the *B2_BANDWID* is greater than 0. This analysis outputs a PASS, NO BAND2, FAIL – Missing, or FAIL – Negative.

9) Littoral Zone Checks

a. *LITTORAL_Z_CHK* –This column depends on LITT_WIDTH, therefore, the check combines both columns. The output of the analysis is either:
   i. "FAIL – Missing Data" when *LITTORAL_Z* is empty.
   ii. FAIL – Missing Width, when LITT_WIDTH is empty.
   iii. 'FAIL WIDTH' when *WIDTH_LITT* is negative.
   iv. FAIL -ZONE when LITTORAL_Z and LITT_WIDTH do not match Narrow (< 10m), Medium (10 - 50m), Wide (> 50m) correctly.
   v. PASS, When the values match the categories and ranges.

10) Aquatic Vegetation Checks

a. OVERHANG_V_CHK – This analysis checks to determine if the *OVERHANG_V* > 100 or <0. The results of this analysis are PASS or FAIL if missing or number does not range between 0 and 100.
b. *AQUATIC_VE_CHK* - Checks the dominant category match and their ranges correspond. This analysis outputs:
   i. 'Fail – Missing Data' if any of *AQUATIC_VE, SUBMERGE_V, EMERGENT_V, or FLOATING_V* contain no values.
   ii. 'FAIL SUBMERGE_V' if *SUBMERGE_V* > 100 or < 0.
   iii. 'FAIL EMERGENT_V' if *EMERGENT_V* > 100 or < 0.
   iv. 'FAIL FLOATING_V' if *FLOATING_V* > 100 or < 0.
   v. 'FAIL – AQUATIC_VE not MAX' if AQUATIC_VE does not correspond with the dominant category value.

2.3 R Analysis of FHSI Database

The following is a step-by-step procedure that should be undertaken manually or using the Excel or R for the analysis of the FHSI datasets. The description below is intended to provide the reader with an understanding of the programmatic checks completed. The R script does not attend to this function, as it is simple and easy to undertake manually.

1) *FHSI_WEIGHT_SCORE_CHK* – This analysis confirms that each segment has an *FHSI_WEIGHT_SCORE* that ranges from 0 to 1. The output from this analysis is a PASS or FAIL.
2) FHSI_RANK – This analysis confirms that for each segment the *FHSI_RANK* is one of either Very High, High, Moderate, Low or Very Low.

3.0 REFERENCES

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