Comox Valley REGIONAL DISTRICT

Staff Report

DATE: July 11, 2019

FILE: 5600-03/BCOB

TO: Chair and Director
Black Creek/Oyster Bay Services Committee

FROM: James Warren
Acting Chief Administrative Officer

Supported by James Warren
Acting Chief Administrative Officer

J. Warren

RE: **Black Creek/Oyster Bay Water Local Service Area- New Water Supply Well Project Update**

Purpose
To update the Black Creek/Oyster Bay (BCOB) Services Committee regarding the new water supply well project.

Recommendation from the Acting Chief Administrative Officer:
This report is provided for information.

Executive Summary
The BCOB Water System treats and distributes water from two different water sources to properties north of the Oyster River in Electoral Area D of the Strathcona Regional District (SRD) and south of the Oyster River in Puntledge – Black Creek (Electoral Area C) of the Comox Valley Regional District (CVRD). The first water source is ground water wells (two in the Oyster River Nature Park (the Park)) and the second is an infiltration gallery in the Oyster River. Historically, the river infiltration gallery has been the only source used in the summer, with the ground water wells reserved for the winter when the river water quality is compromised and community water consumption is lower.

Over the past several years the river infiltration gallery has proved unreliable, with 2014, 2015 and 2016 being particularly bad years. In March 2017 the CVRD received approximately $540,000 from the Clean Water and Wastewater Fund, or 83 per cent of the total estimated cost, to install a new production well in the Park to complement the two existing wells. Due to challenges obtaining SRD support for the project, the final deadline for spending the grant money of March 2020 is fast approaching.

Efforts to secure SRD support through development of a formal access agreement for CVRD to access the Park, and more recently a Memorandum of Understanding to define the terms of SRD support for the project, have not been successful.

At their last meeting, the BCOB Services Committee passed a motion to send a letter to the Ministry of Municipal Affairs and Housing asking for help in resolving the ambiguity in the letters patent regarding the BCOB Water System.

On June 19, 2019 CVRD Chief Administrative Officer (CAO), Russell Dyson, sent a letter to the SRD CAO, David Leitch, attached as Appendix A, summarizing the CVRD's request. The letter highlighted:

- The need and urgency of the SRD support for the project;

- The significant effort undertaken by the CVRD to satisfy SRD concerns;
- A commitment to continued collaboration on water planning in the aquifer; and
- An appeal to be considered as a delegation to the SRD Board at the earliest opportunity.

As of the date of publishing this report, the SRD has not responded to the letter.

Prepared by:	In concurrence:
K. La Rose	***M. Rutten***
Kris La Rose, P. Eng. Senior Manager of Water/ Wastewater Services	Marc Rutten, P. Eng. General Manager of Engineering Services

Stakeholder Distribution (Upon Agenda Publication)

Strathcona Regional District	✓

Attachments: Appendix A – "Letter from CVRD CAO to SRD CAO"

Appendix A

Office of the Chief Administrative Officer

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Comox Valley REGIONAL DISTRICT

File: 5600-01/BCOB

June 19, 2019

Sent via email only: dleitch@srd.ca

David Leitch
Chief Administrative Officer
Strathcona Regional District
#301-990 Cedar Street
Campbell River, B.C. V9W 7Z8

Dear David:

Re: Production Well in Oyster River Nature Park for the BCOB Water Service

Our request
I wish to confirm whether the Strathcona Regional District (SRD) will provide a letter of support for the Comox Valley Regional District (CVRD) to drill the production well proposed for the Black Creek Oyster Bay (BCOB) water service within the Oyster River Nature Park (ORNP). As you can appreciate this request is time sensitive.

The BCOB Water System relies on a supply intake on the bed of the Oyster River for summer time flows. Since 2014, water from the river intake is sharply reduced and at times summer demands cannot be met. In early 2017 the CVRD received a grant from the Clean Water Wastewater Fund for a 30 centimeter production well to augment the summer demand. As stated in our 2017 grant application, we seek support from the SRD and have been working toward this since receiving the grant. It was appreciated that you supported the drilling of the test well as part of this project. However, this grant funding is set to expire in March 2020. The deadline for starting the production well in time to meet the grant deadline is now upon us, and we are urgently requesting approval to proceed with drilling the well, to avoid losing the grant funding.

Water supply volume study
Attached is the study completed by Gilles Wending of GW Solutions. It concludes the ORNP aquifer is hydraulically connected to the Oyster River, and also that environmental flow needs of the river must be maintained. While there may be just enough water to satisfy the combined BCOB and a portion of the remainder of Electoral Area D in a good year with conservation measures in place, reduced water volumes would exist due to drought in approximately one out of every four years. Further to that the local projected effects of climate change are for even dryer summers.

Environmental conditions and available volume
In April 2019 CVRD staff met with Ministry of Forest, Lands, Natural Resource Operations and Rural Development (FLNRORD) to discuss the GW Solution findings, and gain further clarity about how withdrawal might be applied in this situation. FLNRORD staff informed us that the lower reaches of the Oyster River are considered critical cutthroat trout habitat; the cumulative total of the existing water licenses on the Oyster River is more than the actual total late summer river flow, i.e. if all existing licenses were maxed out, the river would run dry; and that any increased withdrawal of water that will result in a reduction in fish habitat is not desirable and is not likely to be supported.

It is clear that upon completion of this well our license capacity will not increase from the current allocation and in fact, in time, we may be subject to water constraints in response to conditions beyond our control. Based on the current licenced capacity, that will not change following installation of the new well; there is not enough licenced water for both the BCOB and Northern Area D systems combined. Nonetheless the CVRD is committed to continuing to work with the SRD on water supply issues, in the meantime the well is required to help us manage the supply of water for the BCOB.

Proposed Memorandum of Understanding – rights and obligations

Together we have tried to develop a Memorandum of Understanding (MOU) for the purpose of clarifying the interests of CVRD and SRD. The MOU seeks your support for the well and identifies the issues to work on in collaboration. You have proposed complex matters for the MOU concerning allocation of water rights, access to BCOB infrastructure, and curtailing development potential within the service area. These matters are important and can be considered by the two parties but would fetter the discretion of either party if determined in an MOU. The intent of the MOU is to confirm your acceptance for the well and set out the issues that require further consideration by the appropriate decision makers.

Committed to partnering

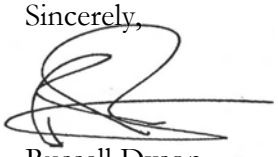
In support of your acceptance for this well the CVRD has implemented various practices and procedures to ensure information sharing on our end.

- We have and continue to fund the required study work to better understand the aquifer.
- We secured provincial funding to help fund this work and have proposed collaboration when working with the consultants to ensure that your questions are answered.

I trust that this demonstrates to the SRD our commitment to collaborate and work together.

I am providing you with this letter and background information understanding that this matter of approval to drill a new production well for the BCOB water service is to be decided by the SRD Board. I request that the materials be shared with your Board and that we be considered as a delegation at the earliest opportunity. As mentioned previously I am committed to include GW Solutions in this presentation to share the results of their work and answer any questions of your Directors.

Sincerely,



Russell Dyson
Chief Administrative Officer

Enclosure: Report - Gilles Wending of GW Solutions

cc: Chair Bob Wells, Comox Valley Regional District
Chair Michele Babchuk, Strathcona Regional District
Chair Edwin Grieve, Black Creek – Oyster Bay Services Committee

GW SOLUTIONS
ASSESSMENT & PROTECTION OF GROUNDWATER

May 18, 2018
Project No.15-16

Comox Valley Regional District
600 Comox Rd.
Courtenay, B.C.
V9N 3P6

(Via email)

Attention: Mike Herschmiller, Manager of Water Services,
Kristian La Rose, Senior Manager of Water and Wastewater Services

Re: Groundwater availability assessment within the Oyster River Nature Park and interactions with the Oyster River

GW Solutions Inc. (GW Solutions) is pleased to present the following letter-report summarizing our findings regarding the potential for additional groundwater withdrawal within the Oyster River Nature Park (the Park), long-term sustainability of the well field and degree of connection between the aquifer and the Oyster River.

The Oyster River at Oyster River Nature Park on October 3, 2017

1 BACKGROUND

The Comox Valley Regional District (CVRD) has previously expressed interest in securing an additional groundwater supply to service the Black Creek Oyster Bay (BCOB) water system to meet future demand and not to have to rely on its surface water source. As part as this process, the CVRD mandated GW Solutions to estimate the potential for additional groundwater withdrawal within the Park, the long-term sustainability of the well field and the degree of connection between the aquifer and the Oyster River.

2 SCOPE

GW Solutions completed the following tasks:

- Reviewing available information within the Park;
- Providing potential location for additional production wells;
- Estimating the long-term sustainability of the aquifer within the area of the Park (taking into account climate change);
- Assessing interactions between groundwater and the Oyster River;
- Documenting the status of the Oyster River regarding the Environmental Flow Needs and allocations; and
- Reporting (this report).

3 GROUNDWATER LEVELS AND RECHARGE

The BCOB system water production is approximately 335,000 m^3 yearly (38.2 m^3/h - based on data from year 2014). The future yearly consumption could be up to 500,000 m^3 (57 m^3/h). Although the available data set is short (3 years), the groundwater levels have been stable over the years (Figure 1), which means the aquifer is not being mined. Aquifer 412, where the wells are installed, is moderately large (3.2 km^2) and directly replenished by precipitation.

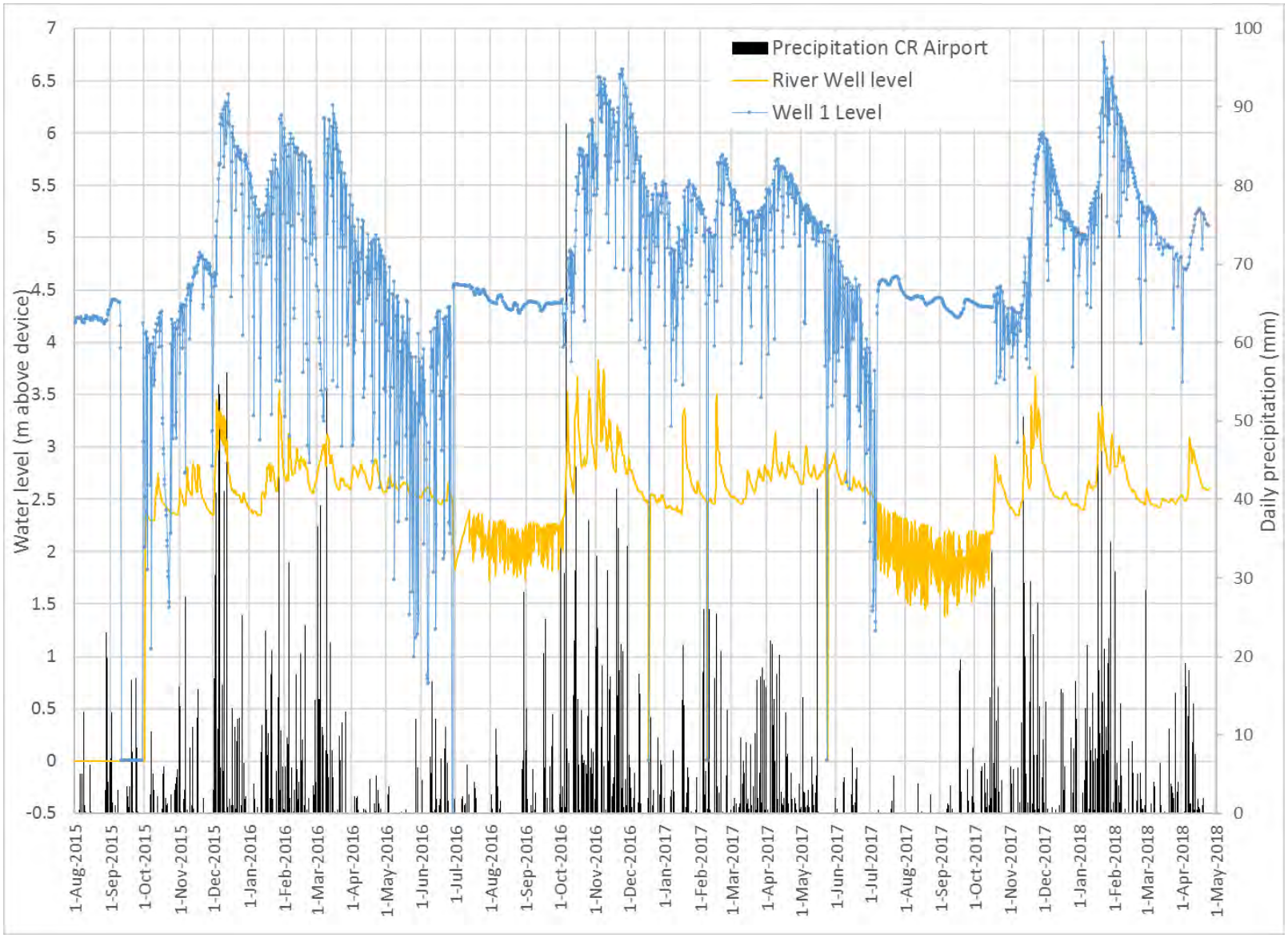


Figure 1. Groundwater level at Well#1, at the River station and precipitation

4 POTENTIAL ADDITION OF PRODUCTION WELLS

Yields provided in this section refer to summer well yields because they correspond to the time of larger water demand.

4.1 Within the Oyster River Nature Park

The aquifer located under the Park (Aquifer 412) is very productive, mostly due to the high permeability of the soil composed of alluvial sand and gravel. However, potential for additional production wells within the Park is constrained by:

- The **limited thickness of the saturated permeable sediments** in some parts of the Park (Figure 2).
- The **limited size of the available land** as production wells cannot be too close to each other without negatively interfering. We estimate **well interference** to be to the order of one hundred meters.
- The **limited physical access to the Park,** for construction and maintenance.
- The **impact to the Oyster river**, that is connected with the aquifer and therefore likely to be affected by additional pumping (see Section 6).
- The **proximity of the Oyster river and the old channel,** that poses a threat of bacteriological contamination and turbidity.

Figure 2 shows the location of existing production and test wells, as well as potential additional well locations. However, they present at least one or more of the above constraints:

Star No.1 (Figure 2): limiting factor is the drilling rig access, which is not possible without tree clearing.

Star No.2 (Figure 2): limiting factor is the proximity to the Oyster River.

Star No.3 (Figure 2): limiting factors are the proximity to the Oyster River and the parking lot and road (potential source of contamination).

These locations may provide a yield of between 20 and 40 m^3/h based on presently available information. These estimates could be confirmed following the completion of test wells, pumping tests, GARP analyses, etc.

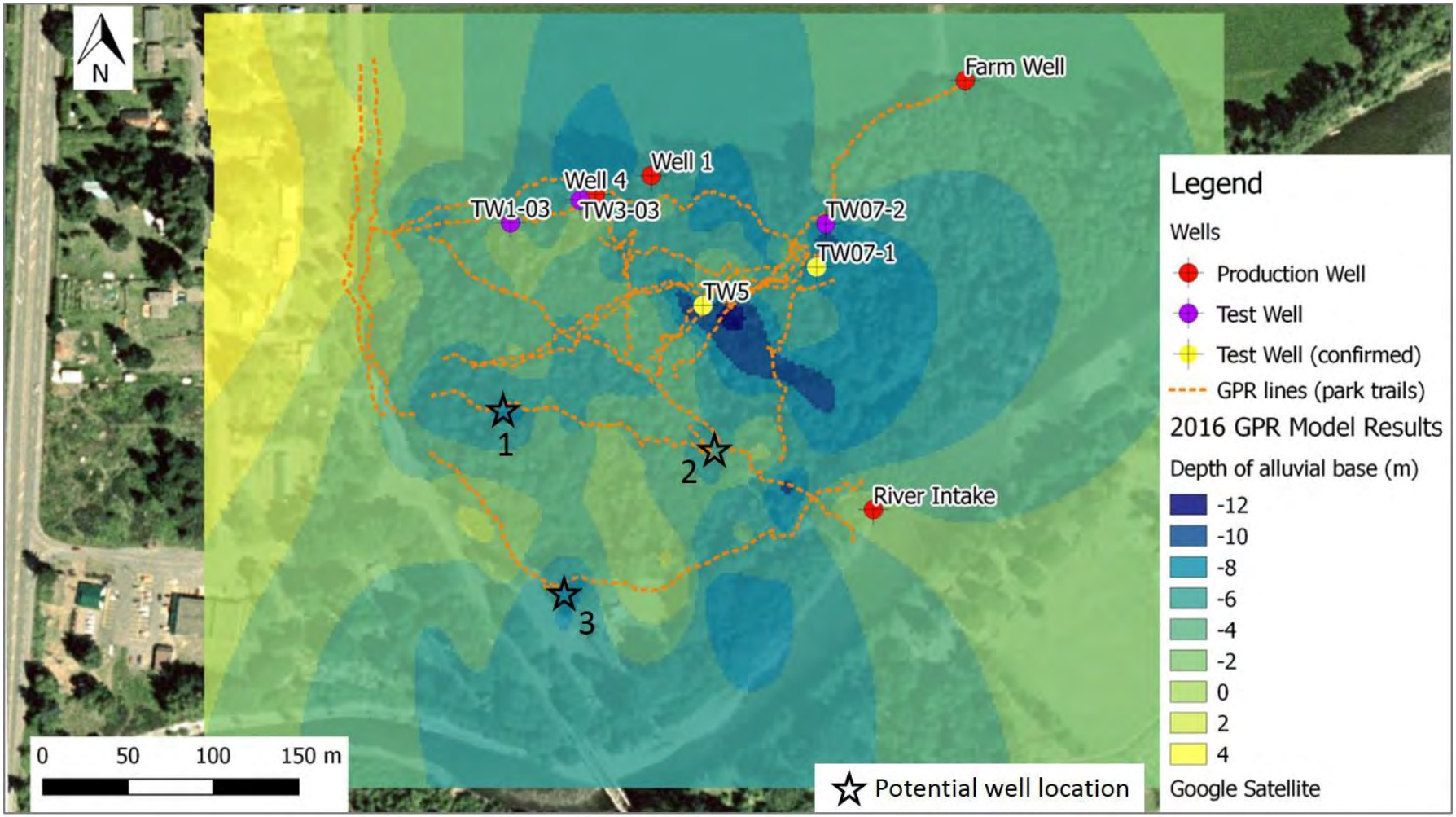


Figure 2. Location of existing wells and potential production wells within the Oyster River Park

4.2 Estimated Yield of the Farm Well (or UBC Well)

According to recent rehabilitation work on the Farm Well by Red Williams and considering the thickness of permeable deposits (11.5 m), it is estimated that this well (WTN 73705) could produce around 40 m^3/h (176 USgpm). Consequently, it would be a valuable asset for the CVRD.

However, the following points should be investigated prior to considering this well as a potential addition to the system:

- A site visit should be undertaken to verify if the well construction is in compliance with the Groundwater Protection Regulation. Indeed, the well was built in 1969, and may require upgrade (e.g., surface seal - see well log in Appendix 2).

- A water sample should be taken and analysed for general water quality and pesticides due to its location on agricultural land.

4.3 Total Estimated Available Yield

Table 1 shows the estimated yield for the existing production well and hypothetic future production wells. A total yield of around 260 m^3/h (1145 USgpm) could be reached. This number has to be considered with caution as more field work is required to confirm assumptions and actual yield and feasibility (see Sections 4.1, 4.2). For comparison, the current maximum summer demand (measured) is approximately 83 m^3/h. With approved new connections, it will soon reach 125 m^3/h.

Table 1. Estimated well yields

Well	Yield (m^3/h)
Well#1	50
Near TW07-1	56
Near TW5	38
Farm well	40
Other production wells within park (3 x 25)	75
Total	259

5 CLIMATE CHANGE

We used the ClimateBC[1] software to simulate the prediction for precipitation in years 2025 and 2055 at the Oyster River Park (downstream of the Oyster River watershed) and at the upstream part of the Oyster River watershed. The results are shown in Figure 3 and indicate the mean annual precipitation (MAP) and the mean annual summer precipitation (MSP - May to September) for the past period 1981 to 2010, and for years 2025 and 2055.

By 2025, the mean annual precipitation will be fairly the same as of today with only a small increase of 3%, but the mean annual summer precipitation will be decreased by approximately 15%. By 2055 the mean annual precipitation will have increase by 5% as of today, and the mean annual summer precipitation will have decreased by 20%. It means summers will be drier, but winters will receive 25% more rain. Consequently, more water will be stored in Aquifer 412 during winter and made available for summer. These percentages are similar for the upstream portion of the Oyster River watershed (Figure 3b). Consequently, depending on the degree of the contribution of groundwater to the Oyster River, summer flows in the Oyster River might be reduced.

[1] Wang, T, Hamann, A, Spittlehouse, DL, Carroll, C, 2016. Locally Downscaled and Spatially Customizable Climate Data for Historical and Future Periods for North America.

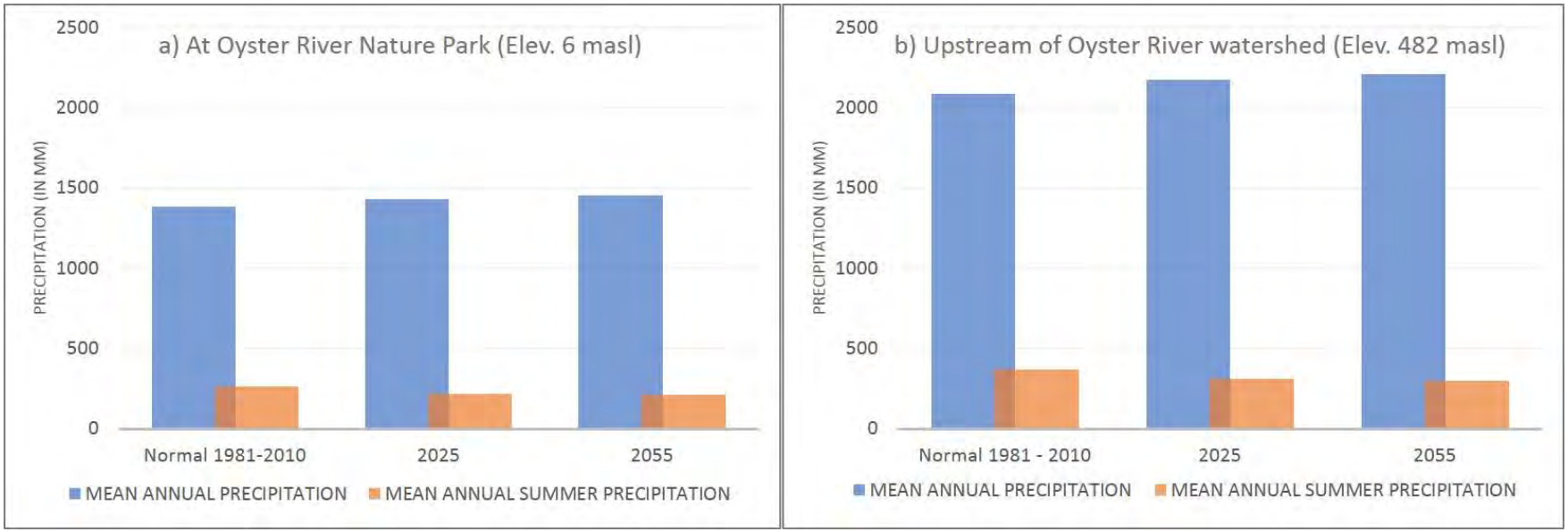


Figure 3. Mean annual precipitation and mean annual summer precipitation at a) the Oyster River Nature Park and b) upstream of the Oyster River watershed using ClimateBC V5.5 model CanESM (masl = meter above sea level).

6 GROUNDWATER – SURFACE WATER CONNECTION AND ENVIRONMENTAL FLOW NEEDS

The existing and future potential wells in the Oyster River Park produce water from the alluvial sands and gravels of Aquifer 412 that are in hydraulic connection with the Oyster River (Figure 4). Due to limited information on flow paths in this area and as a conservative measure, we consider that all the water extracted from the wells is water that is taken from or not made available for the Oyster River (i.e., if the water was not extracted by the wells, it would end up in the Oyster River).

The Environmental Flow Needs (EFN) of a stream is defined by the BC Ministry of Environment as the volume and timing of water flow required for the proper functioning of the aquatic ecosystem. The EFN have not been specifically defined for the Oyster River (pers. Communication with Water Authorization Officer, March 2018). The EFN policy from the BC Ministry of Environment defines a framework for assessing the risk to the EFN and identifying where adaptive management measures could be taken (Appendix 3) before granting new water licenses. We have completed a preliminary EFN evaluation using this framework.

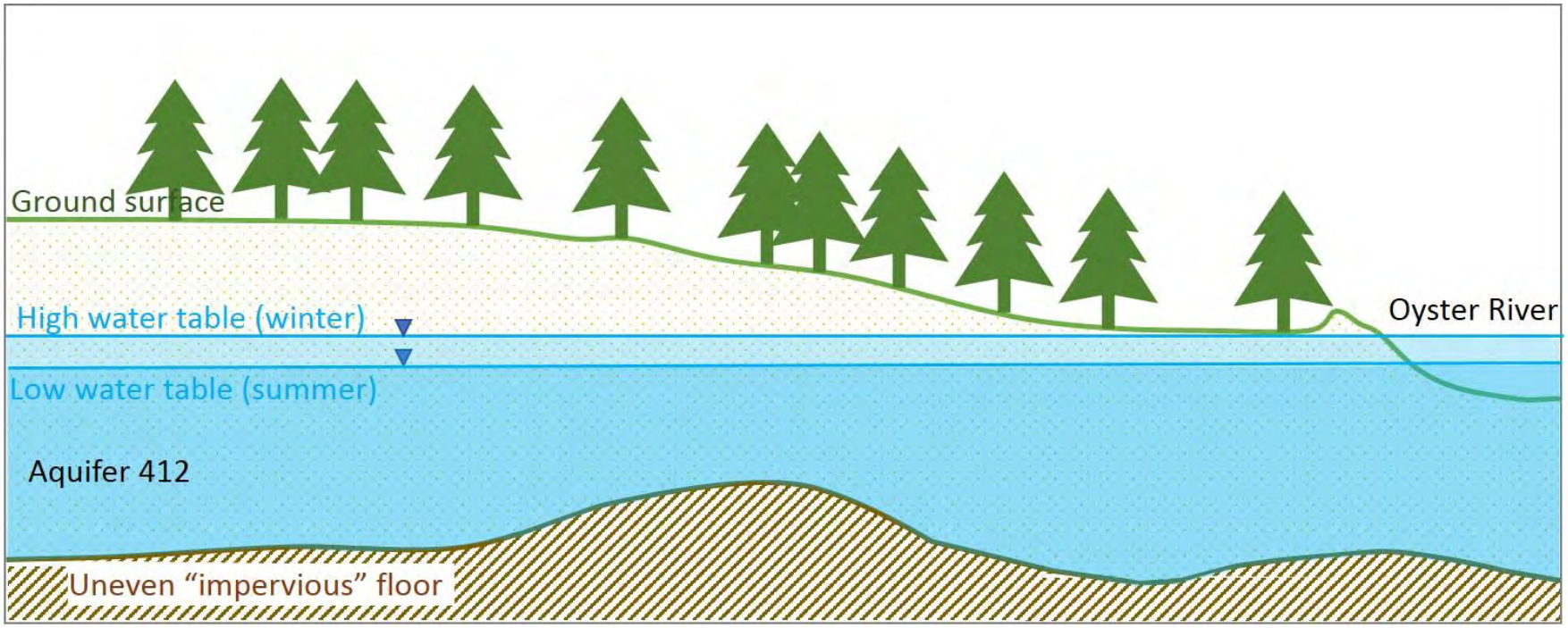


Figure 4. Conceptual cross-section of hydrogeological conditions at the Oyster River Nature Park (not to scale, looking East, hydraulic gradient not shown)

We have interpreted data from the river gauging station 08HD011 located 10 km upstream of the Park (Figure 5). It presents a complete record of flows from 1981 to 2016 (36 years). Our analysis considered a year to year hydrologic variability instead of an average analysis over the full period of record (to account for drier years). Figure 6 shows the calculated minimum monthly mean flow and Mean Annual Discharge (MAD) for each year, as well as the corresponding percentage. The monthly flows as a percentage of the MAD are used in the EFN policy for characterizing flow sensitivity. We have considered for each year the monthly flow of the driest month (i.e., the minimum monthly flow) in order to consider the worst conditions. We found that the Oyster River classified from low to high sensitive stream during the summer depending on the years (Figure 6 and Table 2).

The determination of the flow sensitivity allows the regulators to determine the appropriate level of adaptive management measures to implement when granting new water licenses, depending on stream size and withdrawal amount. Considering a projected withdrawal amount of 260 m^3/h (0.072 m^3/s or 1145 USgpm) in summer time, we found that **Risk Management**

Level 2 would have been necessary about one year over four during the driest months (Table 2). Risk Management Level 2 may include habitat impact assessment and restrictions of withdrawal during low flow periods at the discretion of the water officer (see complete list of possible assessments and mitigation measures on Appendix 3 page 12).

The threshold value which would require at least one time Risk Management Level 2 was obtained for a water demand starting at 131 m^3/h.

Assumptions and limitations:

The data from the river station 08HD011 is located 10 km upstream of the Park and as such, it does not reflect the exact flow conditions at the river at the right of the Oyster River Park. The following items provide either a water input or output to the Oyster River:

1. Water input (Figure 5):
    a. The Little Oyster River, which is gaged under station 08HD023, and provide a yearly average flow input of 1.2 m^3/s. A complete data set of monthly mean flow is available for years 2011 to 2016.
    b. Two unnamed small tributaries, which are not monitored, although they likely provide a small input.
    c. Runoff and groundwater contribution, which are presently unknown.
2. Water withdrawals:
    a. Surface water licenses downstream of station 08HD011 which totals 30 millions m^3/year or on average approximately 1 m^3/s. However, the timing of usage varies monthly but is unknown.
    b. Groundwater wells which may be connected to the Oyster River. These are located in the portion of aquifers 412 and 410 that is within the watershed. Volume extracted is unknown.

These above described contributors were not considered in our analysis because not all of them were known and we don't know how they compensate. GW Solutions is currently developping a water budget model (detailed numerical model) for Vancouver Island watersheds. The model could be applied to the Oyster River watershed and may provide additional information for the EFN assessment.

In addition, the existing EFN policy is an interim document that will be revised in the next few years. Therefore, the present procedure used herein may have to be revised to reflect changes in the EFN policy.

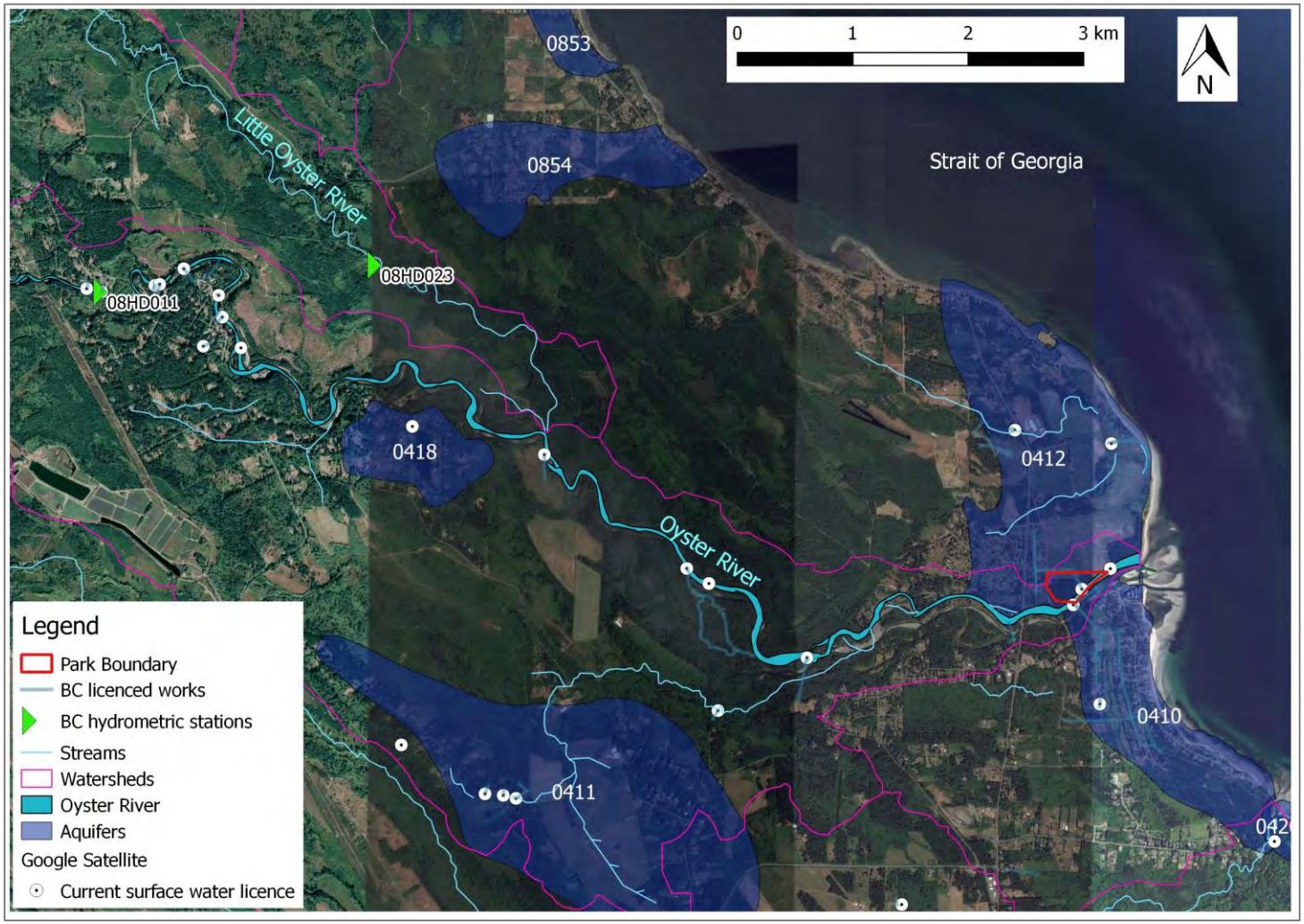


Figure 5. Location of aquifers, hydrometric stations and surface water licences

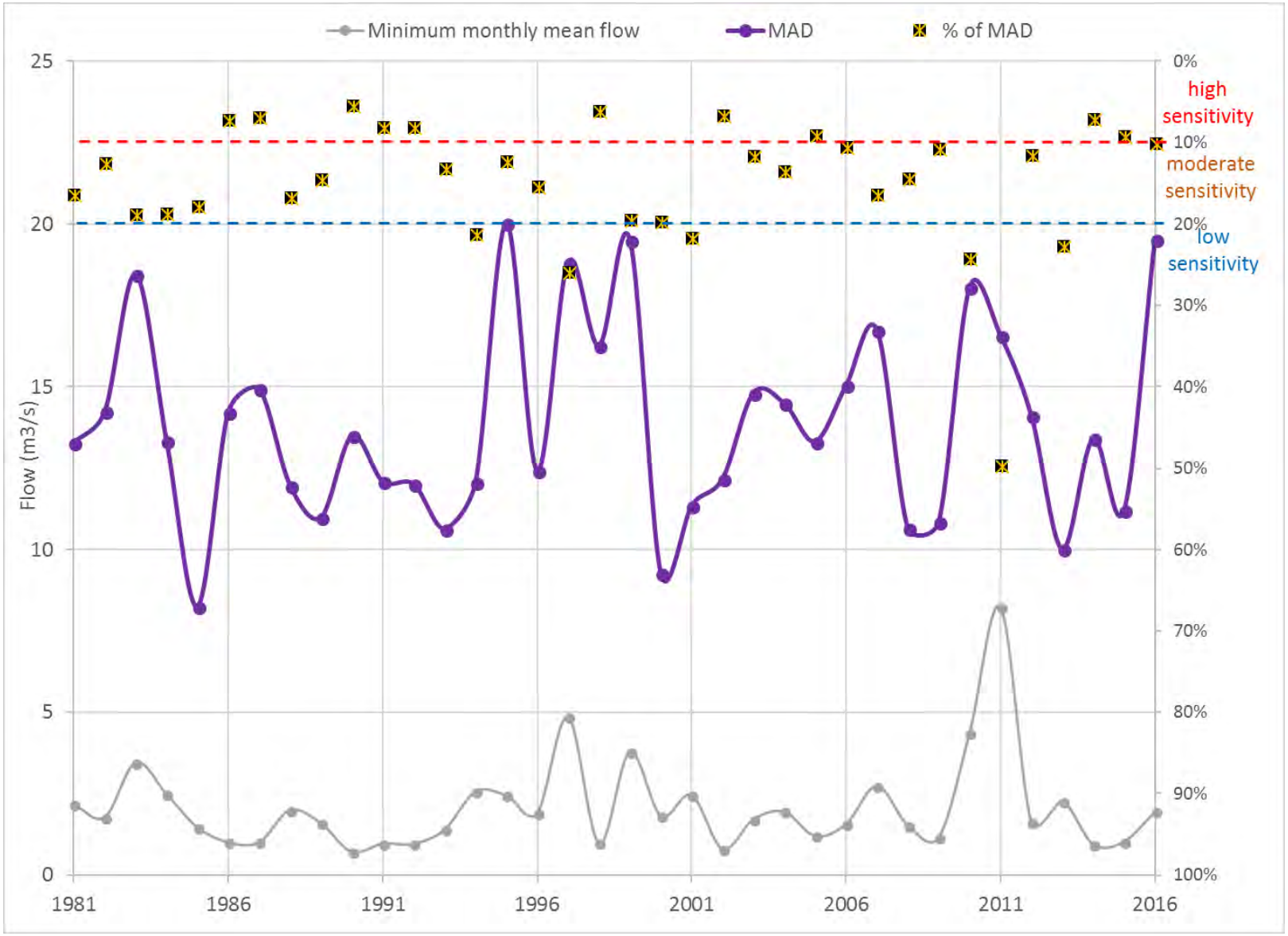


Figure 6. Minimum monthly mean flow, mean annual discharge and % of MAD in Oyster River per year (Station 08HD011)

Table 2. Risk management levels regarding the EFN of the Oyster River, considering the driest month of the year and different water demand

Year	Driest month	Flow Sensitivity driest month	Stream size < or ≥ 1 m3/s	Risk management level		
				Confirmed demand (125 m3/h)	Threshold value (131 m3/h)	Future demand (260 m3/h)
1981	August	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1982	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1983	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1984	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1985	August	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1986	September	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 2
1987	October	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 2
1988	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1989	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1990	September	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 2	Risk Mgmt 2
1991	October	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 2
1992	September	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 2
1993	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1994	September	Low Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1995	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1996	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1997	August	Low Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
1998	September	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 2
1999	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2000	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2001	September	Low Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2002	October	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 2
2003	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2004	August	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2005	September	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 2
2006	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2007	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2008	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2009	August	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2010	September	Low Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2011	August	Low Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2012	September	Moderate Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2013	August	Low Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1
2014	August	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 2
2015	July	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 2
2016	August	High Sensitivity	medium-large stream	Risk Mgmt 1	Risk Mgmt 1	Risk Mgmt 1

7 CONCLUSIONS

Based on our assessment of available information, we have formed the following conclusions:

1. There are potential opportunities for additional production wells within the Oyster River Nature Park with an estimated total production of approximately 260 m^3/h. This will have to be confirmed with additional field work, including drilling test wells.

2. The farm well appears to be a potential asset for the CVRD providing a well inspection is performed to confirm compliance with the Groundwater Protection Regulation.

3. Aquifer 412 and the Oyster River are hydraulically connected. Therefore, EFNs will have to be met. In order to preserve the EFNs of streams, the Ministry of Environment has implemented a policy that classifies streams according to their flow sensitivity and defines Risk Management Levels (1, 2 or 3) with associated adaptive management measures. This applies to new water licences applications only (including amendments). Under increased demand (260 m^3/h) Risk Management Level 2 would be implemented for some years during summer time, including assessment and mitigation measures such as fish habitat assessment and/or restrictions of withdrawal during low flow periods, etc. We estimate the threshold demand that would not require implementation of Risk Management Level 2 at approximately 130 m^3/h.

4. Climate change predictions indicate that by 2055, the Oyster River watershed will receive 25% more rain in winter but 20% less rain in summer. The impact of climate change may result in larger amplitudes of the fluctuation of the water table in Aquifer 412, with lower levels observed in the summer. Unfortunately, it is presently difficult to quantify the consequences it may have on the wells production capacity.

8 RECOMMENDATIONS

We make the following recommendations:

1. Proceed with completion of the production well near TW07-1 and assessing whether its addition to the water system allows to meet current demand. This would allow not to rely on the river intake (infiltration gallery) anymore.

2. Undertaking a topographic survey of the well heads and river bottom, in order to get a better definition of hydraulic gradients, flow direction and capture zone.

3. Plan, in coordination with the provincial regulator, the collection of data required to make informed decisions within a 20 to 30 years timeframe. This should particularly apply to a) a better definition of the EFNs along the section of the Oyster River at the right of the well field and downstream of it, b) the monitoring of the aquifer near the well field, and c) the characterisation of the groundwater regime interacting with the Oyster River near the well field.

4. Continue planning, taking into account the long–term water demand (e.g., 2050 demand), the acquisition, completion and use of wells, and risk management measures.

9 STUDY LIMITATIONS

This document was prepared for the exclusive use of the CVRD. The inferences concerning the data, site and receiving environment conditions contained in this document are based on information obtained during investigations conducted at the site by GW Solutions and others, and are based solely on the condition of the site at the time of the site studies. Soil, surface water and groundwater conditions may vary with location, depth, time, sampling methodology, analytical techniques and other factors.

In evaluating the subject study area and water quality data, GW Solutions has relied in good faith on information provided. The factual data, interpretations and recommendations pertain to a specific project as described in this document, based on the information obtained during the assessment by GW Solutions on the dates cited in the document, and are not applicable to any other project or site location. GW Solutions accepts no responsibility for any deficiency or inaccuracy contained in this document as a result of reliance on the aforementioned information.

The findings and conclusions documented in this document have been prepared for the specific application to this project, and have been developed in a manner consistent with that level of care normally exercised by hydrogeologists currently practicing under similar conditions in the jurisdiction.

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If new information is discovered during future work, including excavations, sampling, soil boring, predictive geochemistry or other investigations, GW Solutions should be requested to re-evaluate the conclusions of this document and to provide amendments, as required, prior to any reliance upon the information presented herein. The validity of this document is affected by any change of site conditions, purpose, development plans or significant delay from the date of this document in initiating or completing the project.

The produced graphs, images, and maps, have been generated to visualize results and assist in presenting information in a spatial and temporal context. The conclusions and recommendations presented in this document are based on the review of information available at the time the work was completed, and within the time and budget limitations of the scope of work.

The CVRD may rely on the information contained in this memorandum subject to the above limitations.

10 CLOSURE

Conclusions and recommendations presented herein are based on available information at the time of the study. The work has been carried out in accordance with generally accepted engineering practice. No other warranty is made, either expressed or implied. Engineering judgement has been applied in producing this letter-report.

This letter report was prepared by personnel with professional experience in the fields covered. Reference should be made to the General Conditions and Limitations attached in Appendix 1.

GW Solutions was pleased to produce this document. If you have any questions, please contact me.

Yours truly,

GW Solutions Inc.

DRAFT

Prepared by: Dr. Sandra RICHARD,
Ph.D. in hydrogeology

Reviewed by: Gilles WENDLING, Ph.D., P.Eng.
President

APPENDIX 1

GW SOLUTIONS INC. GENERAL CONDITIONS AND LIMITATIONS

This report incorporates and is subject to these "General Conditions and Limitations".

1.0 USE OF REPORT

This report pertains to a specific area, a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment. This report and the assessments and recommendations contained in it are intended for the sole use of GW SOLUTIONS's client. GW SOLUTIONS does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than GW SOLUTIONS's client unless otherwise authorized in writing by GW SOLUTIONS. Any unauthorized use of the report is at the sole risk of the user. This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of GW SOLUTIONS. Additional copies of the report, if required, may be obtained upon request.

2.0 LIMITATIONS OF REPORT

This report is based solely on the conditions which existed within the study area or on site at the time of GW SOLUTIONS's investigation. The client, and any other parties using this report with the express written consent of the client and GW SOLUTIONS, acknowledge that conditions affecting the environmental assessment of the site can vary with time and that the conclusions and recommendations set out in this report are time sensitive. The client, and any other party using this report with the express written consent of the client and GW SOLUTIONS, also acknowledge that the conclusions and recommendations set out in this report are based on limited observations and testing on the area or subject site and that conditions may vary across the site which, in turn, could affect the conclusions and recommendations made. The client acknowledges that GW SOLUTIONS is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the client.

2.1 INFORMATION PROVIDED TO GW SOLUTIONS BY OTHERS

During the performance of the work and the preparation of this report, GW SOLUTIONS may have relied on information provided by persons other than the client. While GW SOLUTIONS endeavours to verify the accuracy of such information when instructed to do so by the client, GW SOLUTIONS accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

3.0 LIMITATION OF LIABILITY

The client recognizes that property containing contaminants and hazardous wastes creates a high risk of claims brought by third parties arising out of the presence of those materials. In consideration of these risks, and in consideration of GW SOLUTIONS providing the services requested, the client agrees that GW SOLUTIONS's liability to the client, with respect to any issues relating to contaminants or other hazardous wastes located on the subject site shall be limited as follows:

(1) With respect to any claims brought against GW SOLUTIONS by the client arising out of the provision or failure to provide services hereunder shall be limited to the amount of fees paid by the client to GW SOLUTIONS under this Agreement, whether the action is based on breach of contract or tort;

(2) With respect to claims brought by third parties arising out of the presence of contaminants or hazardous wastes on the subject site, the client agrees to indemnify, defend and hold harmless GW SOLUTIONS from and against any and all claim or claims, action or actions, demands, damages, penalties, fines, losses, costs and expenses of every nature and kind whatsoever, including solicitor-client costs, arising or alleged to arise either in whole or part out of services provided by GW SOLUTIONS, whether the claim be brought against GW SOLUTIONS for breach of contract or tort.

4.0 JOB SITE SAFETY

GW SOLUTIONS is only responsible for the activities of its employees on the job site and is not responsible for the supervision

of any other persons whatsoever. The presence of GW SOLUTIONS personnel on site shall not be construed in any way to relieve the client or any other persons on site from their responsibility for job site safety.

5.0 DISCLOSURE OF INFORMATION BY CLIENT

The client agrees to fully cooperate with GW SOLUTIONS with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The client acknowledges that in order for GW SOLUTIONS to properly provide the service, GW SOLUTIONS is relying upon the full disclosure and accuracy of any such information.

6.0 STANDARD OF CARE

Services performed by GW SOLUTIONS for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

7.0 EMERGENCY PROCEDURES

The client undertakes to inform GW SOLUTIONS of all hazardous conditions, or possible hazardous conditions which are known to it. The client recognizes that the activities of GW SOLUTIONS may uncover previously unknown hazardous materials or conditions and that such discovery may result in the necessity to undertake emergency procedures to protect GW SOLUTIONS employees, other persons and the environment. These

procedures may involve additional costs outside of any budgets previously agreed upon. The client agrees to pay GW SOLUTIONS for any expenses incurred as a result of such discoveries and to compensate GW SOLUTIONS through payment of additional fees and expenses for time spent by GW SOLUTIONS to deal with the consequences of such discoveries.

8.0 NOTIFICATION OF AUTHORITIES

The client acknowledges that in certain instances the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by GW SOLUTIONS in its reasonably exercised discretion.

9.0 OWNERSHIP OF INSTRUMENTS OF SERVICE

The client acknowledges that all reports, plans, and data generated by GW SOLUTIONS during the performance of the work and other documents prepared by GW SOLUTIONS are considered its professional work product and shall remain the copyright property of GW SOLUTIONS.

10.0 ALTERNATE REPORT FORMAT

Where GW SOLUTIONS submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed GW SOLUTIONS's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by GW SOLUTIONS shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by GW SOLUTIONS shall be deemed to be the overall original for the Project. The Client agrees that both electronic file and hard copy versions of GW SOLUTIONS's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except GW SOLUTIONS. The Client warrants that GW SOLUTIONS's instruments of professional service will be used only and exactly as submitted by GW SOLUTIONS. The Client recognizes and agrees that electronic files submitted by GW SOLUTIONS have been prepared and submitted using specific software and hardware systems. GW SOLUTIONS makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

APPENDIX 2

WELL LOG FARM WELL (WTN 73705)

Report 1 - Detailed Well Record

Well Tag Number: 73705	Construction Date: 1969-01-09 00:00:00
Owner: UNIVERSITY OF BC	Driller:
	Well Identification Plate Number:
Address:	Plate Attached By:
	Where Plate Attached:
Area:	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 0 (Driller's Estimate)
COMOX Land District	Development Method:
District Lot: Plan: Lot:	Pump Test Info Flag: N
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block:	Artesian Pressure (ft):
Quarter:	Static Level: 12 feet
Island:	
BCGS Number (NAD 83): 092F085324 Well: 21	WATER QUALITY:
	Character:
Class of Well:	Colour:
Subclass of Well:	Odour:
Orientation of Well:	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: N
Well Use:	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method: Drilled	Water Utility:
Diameter: 0.0 inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:
Well Depth: 40 feet	
Elevation: 0 feet (ASL)	SURFACE SEAL:

Final Casing Stick Up: inches	Flag: N
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: N	Depth (ft):
File Info Flag: N	Thickness (in):
Sieve Info Flag: N	
Screen Info Flag: N	WELL CLOSURE INFORMATION:
	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
CASING 0.0 TO 26.0,1.0 TO 25.0, STAINLESS STEEL,

LITHOLOGY INFORMATION:

From 0 to 10 Ft. BROWN SILT & SAND
From 10 to 34 Ft. SAND & GRAVEL
From 38 to 40 Ft. TILL
From 35 to 38 Ft. GRAVEL 7 SAND RUSTY 35-37
From 34 to 35 Ft. SILT WITH SAND CLAY

- Return to Main
- Return to Search Options
- Return to Search Criteria

APPENDIX 3

EFN POLICY (2016)

Ministry of Forests, Lands and Natural Resource Operations
Ministry of Environment

NAME OF POLICY:	Environmental Flow Needs Policy
APPLICATION:	This policy applies to all applications for a water licence or a use approval for short-term water use administered by MOE or FLNRO, applications for water licences administered by the Oil and Gas Commission (OGC), and to certain amendments to existing authorizations.
ISSUANCE:	Executive Director, Water Protection and Sustainability Branch MOE and Director, Water Management Branch, MFLNRO
IMPLEMENTATION:	Staff of MOE, MFLNRO and the OGC
REFERENCES:	*Water Sustainability Act* (Ch. 15, S.B.C. 2014) *Water Sustainability Regulation* (B.C. Reg. 36/2016)
BRIEFING NOTE:	Policy and Legislation Committee, February 16, 2016
RELATIONSHIP TO PREVIOUS POLICY:	The changes update the 1st version of the policy as a result of the *Water Sustainability Act*.
POLICY AMENDMENT:	Any formal request for an amendment to this policy is to be directed in writing to the Executive Director, Water Protection and Sustainability Branch, Ministry of Environment

Glen Davidson
Director
Water Management Branch
Ministry of Forests, Lands and Natural Resource Operations

16/06/23
Date

Lynn Kriwoken
Executive Director
Water Protection and Sustainability Branch
Ministry of Environment

16.06.28
Date

APPROVED AMENDMENTS:		
Effective date	Briefing Note /Approval	Summary of Changes:
March 1, 2014	January 2014	New policy
June 15, 2015	June 15, 2015	Administrative changes, additional detail for greater clarity
February 29, 2016	February 16, 2016	Administrative changes to align the policy with the *Water Sustainability Act* and its regulations.

TABLE OF CONTENTS

1. POLICY STATEMENT

In situations where a water allocation decision will significantly impact on environmental flow needs, the comptroller or water manager may refuse the application or specify conditions for water use.

This policy describes a coarse screen for assessing the risk to environmental flow needs (EFN) in the review of applications for a water licence or a use approval for short-term water use where the origin of water is a river or creek or an aquifer reasonably likely to be hydraulically connected to a river or creek. The policy is not a method for determining environmental flows but rather a framework for assessing risk and identifying where cautionary measures could be taken or additional analysis may be needed, including developing site-specific environmental flow needs thresholds.

This policy applies to amendments to licences and approvals if there will be additional impacts on fish and fish habitat (e.g., if a change of works puts a point of diversion in a different part of stream or the amendment will result in changes to the volume or timing of flow).

This policy can be used where there is limited site-specific hydrological or biological data; however, the tradeoff for its simplicity is a conservative estimate of cumulative withdrawal thresholds that would have minimal impact on EFNs.

Additional objectives of the policy include:

- Apply a consistent and transparent approach across the province;
- Avoid fish-flow conflicts;
- Be scientifically-defensible;
- Apply an ecosystem perspective; and
- Level of effort and analysis should reflect risk with more efficient reviews for lower risk decisions.

Incremental or empirical methods (e.g., detailed assessments) are appropriate for project-specific reviews requiring assessment of different flow management alternatives, such as for adjudicating higher risk projects. Where detailed assessments or studies exist, they would override the recommendations in this policy.

This policy is derived from methods currently used in B.C. and other jurisdictions, scientific literature, and expert opinion and is based on the following principles:

- Key aspects of the natural hydrograph should be maintained by restricting hydrologic alterations to within a percentage-based range around natural or historic flow variability (DFO, 2013);
- Smaller streams are more sensitive to withdrawals than larger streams;
- Climate change is affecting streamflow hydrographs;
- Use of mean annual discharge for characterizing flow sensitivity has a precedence in B.C. (e.g., BC Modified Tennant method, described in Hatfield *et al.* 2003) and is supported by B.C.-specific studies;

- Hydrology information using natural or "naturalized" flows is used as a proxy for biological performance because historic flows are typically easier to measure or synthesize than ecological metrics like fish abundance; and
- Statistical means can mask year-to-year variability while percentile flows can provide a more complete picture of the range in hydrological variability.

2. DEFINITIONS

"environmental flow needs", in relation to a stream, means the volume and timing of water flow required for the proper functioning of the aquatic ecosystem of the stream (*Water Sustainability Act*, Section 1)

Additional relevant definitions under Section 1 [*definitions*] of the *Water Sustainability Act* are as follows: **aquifer**, **applicant**, **authorization**, **groundwater, stream.**

3. LEGISLATION

Section 15 of the *Water Sustainability Act* requires that a decision maker must consider the environmental flow needs of a stream or an aquifer that is reasonably likely to be hydraulically connected when making a decision on an application, unless a specified decision is exempt under the Water Sustainability Regulation.

Section 14 of the *Water Sustainability Act* provides the comptroller and the water manager with powers respecting an application for a water licence. These include but are not limited to the following:

- Refuse an application;
- Require additional plans or other information; or
- Issue one or more conditional or final licences on the terms the comptroller or the water manager considers proper.

Section 14 allows the decision maker to issue to an applicant, an authorization "subject to the prescribed terms and conditions and on the terms and conditions the decision maker considers advisable".

Section 9 of the *Water Sustainability Act* allows for approval of a water licence for the diversion and use of water.

Section 10 of the *Water Sustainability Act* allows for approval of the short term use of water under a use approval.

Section 16 of the Water Sustainability Regulation provides for exempted applications where EFN does not need to be considered. While these applications may be exempt from the consideration, the decision maker has the discretion to consider EFN on any application he or she feels it is relevant to, including exempted applications.

3.1 Groundwater

In many parts of the province, groundwater discharges contribute a high percentage of base flow in streams. Groundwater extractions from aquifers that are hydraulically connected to a stream can significantly diminish streamflow, particularly in small streams during critical low flow periods. The *Water Sustainability Act* applies the consideration for EFN to aquifers that are reasonably likely to be hydraulically connected to a stream.

3.2 Lakes

Although included in the *Water Sustainability Act* definition of a stream, lakes have different aquatic health needs than streams, which are a function of lake volume, shoal area, geomorphology, upstream/downstream connectivity and other factors. Due to these differences, this policy is not applied to lake withdrawals.

4. REASON FOR POLICY

This policy will help allocation decision makers to better consider the risks to EFNs from withdrawals, and to help ensure consistent and satisfactory water allocation decisions..

A risk-based approach can improve efficiencies in the decision-making process, help manage public expectations, and aid users in understanding the rationale for restrictions that protect stream health. In higher risk streams, statutory decision-makers may require that applicants provide additional information or may specify terms and conditions in the licence to limit withdrawals during flow sensitive periods.

5. POLICY APPLICATION

The policy's decision-support tools are intended for use by statutory decision-makers and resource staff prior to a water allocation or amendment decision. The tools complement existing practices for gathering information on water availability, such as a background scan for water restrictions and water development plan requirements. This policy does not limit the discretion of the decision-maker to ask for additional relevant information from the applicant.

The tools provide a coarse filter for a desktop review. There are provincial guidelines available if a more detailed assessment of EFNs is required, such as for water power projects (Hatfield *et al.* 2007; Lewis *et al.* 2004).

The decision-support tools include an interim environmental risk management framework ("the framework" in **Appendix A)** and sample risk management measures in Appendix B. These are described in more detail in Section 6 "Procedures".

The procedures described in this policy apply to withdrawals from rivers and creeks..

6. PROCEDURES

6.1 Environmental Risk Management Framework

The framework is applied to the stream of interest using supply and demand information to characterize the environmental risk management level as 1, 2, or 3. The quantitative thresholds used in the framework in **Appendix A** have been developed for the province; there may be modifications to address regional hydrological and ecological sensitivities.

Fish presence or absence should be demonstrated using existing standards conducted by qualified individuals or regional expertise, and all streams should be considered fish-bearing by default. A description of the risk factors can be found in **Appendix A** along with the environmental risk management framework.

6.2 Risk Management Measures

Risk management measures are used to assess or mitigate potential effects of withdrawals from a stream. The measures are associated with risk levels 1, 2, 3 or special considerations and are intended to guide where more caution may be needed in reviewing an application or making a decision. Statutory decision-makers may require these measures be completed by the applicant or licensee.

Appendix B describes sample risk management measures from which statutory decision-makers has discretion to select the most appropriate measures before a decision is made, could be completed by regional staff to inform a decision, or could be a condition of the licence or approval.

Risk Management Level 1
A stream, or specific flow periods, deemed to be at Risk Management Level 1 from withdrawals means that there is sufficient natural water availability for the proposed withdrawal period and that cumulative water withdrawals are below the specified threshold described in the Environmental Risk Management Framework (Appendix A, Figure 1). This withdrawal threshold can range from 5 to 15% of the natural or naturalized flow, with the more conservative threshold for streams or flow periods that are naturally flow sensitive. While "Level 1" does not mean "no risk", supplementary information is likely not needed, unless species or habitat-specific sensitivities are identified.

Risk Management Level 2
A stream, or specific flow periods, deemed to be at Risk Management Level 2 from withdrawals means that the aquatic environment is flow-limited for the proposed withdrawal period; or that cumulative water withdrawals are greater than a specified threshold of concern, which ranges from 5 to 20% of the natural or naturalized flow. Supplementary information may be requested from the applicant, or the approval or licence may include terms and conditions to minimize potential impacts to environmental flow needs.

Risk Management Level 3

A stream, or specific flow periods, deemed to be at Risk Management Level 3 from withdrawals means that the aquatic environment may be very flow-limited for the proposed period of withdrawal; or that cumulative water withdrawals are greater than a specified threshold of concern, which ranges from 5% for the most flow sensitive to greater than 20% cumulative withdrawals in a low sensitivity scenario. More rigorous review of the potential risk and/or comprehensive approval/licence terms and conditions are likely.

Special Consideration
The presence of sensitive species or habitats may require "special consideration" or species-specific information which would be taken into consideration with the risk management level.

These may include but are not limited to:

- Species designated "threatened" or "endangered" under B.C. *Wildlife Act* or Federal *Species at Risk Act (*see *BC Conservation Data Centre* for most updated list)*;*
- Sensitive stream designation under the *Water Sustainability Act* and Water Sustainability Regulation;
- *Wildlife Management Areas* with flow related objectives;
- Site-specific report (e.g., Cross-Linked Information Resources or CLIR) identifying species or aquatic habitat with flow related concerns; and
- Regionally important fish species that may include red or blue-listed species and populations that are considered vulnerable in B.C. because they are rare and (or) have limited distributions.

If there are sensitive species or habitats present, additional information may be considered, such as a regional fish periodicity chart that provides minimum flow recommendations for life phases of species of significance (Lewis *et. al.* 2004).

6.3 Adaptive Management

The field of environmental flow needs is an emerging science with large uncertainties in flow alteration and ecosystem response. Over time, an adaptive management approach with monitoring and site-specific detailed studies will build our body of knowledge and potentially lead to refinements in the policy. Adaptive management is particularly important with climate change projections for shifts in streamflow hydrographs and increasing variability.

7. REFERENCES

DFO. 2013. Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada. DFO Can. Sci. Advis. Rep. 2013/017.

Hatfield, T. 2012. BC Ministry of Environment Winter Flows Project. Final Report. Consultant's report prepared for the Ministry of Environment, British Columbia by Ecofish Research Ltd., April 2012.

Hatfield, T., A. Lewis, D. Ohlson and M. Bradford. 2003. Development of instream flow thresholds as guidelines for reviewing proposed water uses. Report prepared for British

Columbia Ministry of Sustainable Resource Management, and British Columbia Ministry of Water, Land, and Air Protection, Victoria, BC.

Hatfield, T., A. Lewis, and S. Babakaiff. 2007. Guidelines for the collection and analysis of fish and fish habitat data for the purpose of assessing impacts from small hydropower projects in British Columbia.

Lewis, A., T. Hatfield, B. Chilibeck, and C. Roberts. 2004. Assessment methods for aquatic habitat and instream flow characteristics in support of applications to dam, divert, or extract water from streams in British Columbia. Prepared for Ministry of Water, Land & Air Protection and Ministry of Sustainable Resource Management.

Appendix A. Environmental Risk Management Framework

Figure 1 provides a schematic of the interim environmental risk management framework. The components of the framework are described below. Regional modifications of the framework are anticipated in the coming years to reflect the hydrological and ecological variability in the province.

Flow sensitivity
On a month by month basis, streams are classified into different categories of flow sensitivity based on daily or monthly natural flows as a percentage of long term mean annual discharge (MAD). Where natural or naturalized monthly flows are greater than 20% MAD, flow sensitivity is considered to be low. Flow sensitivity is moderate for flows between 10-20% and is highly sensitive for flows less than 10% MAD.

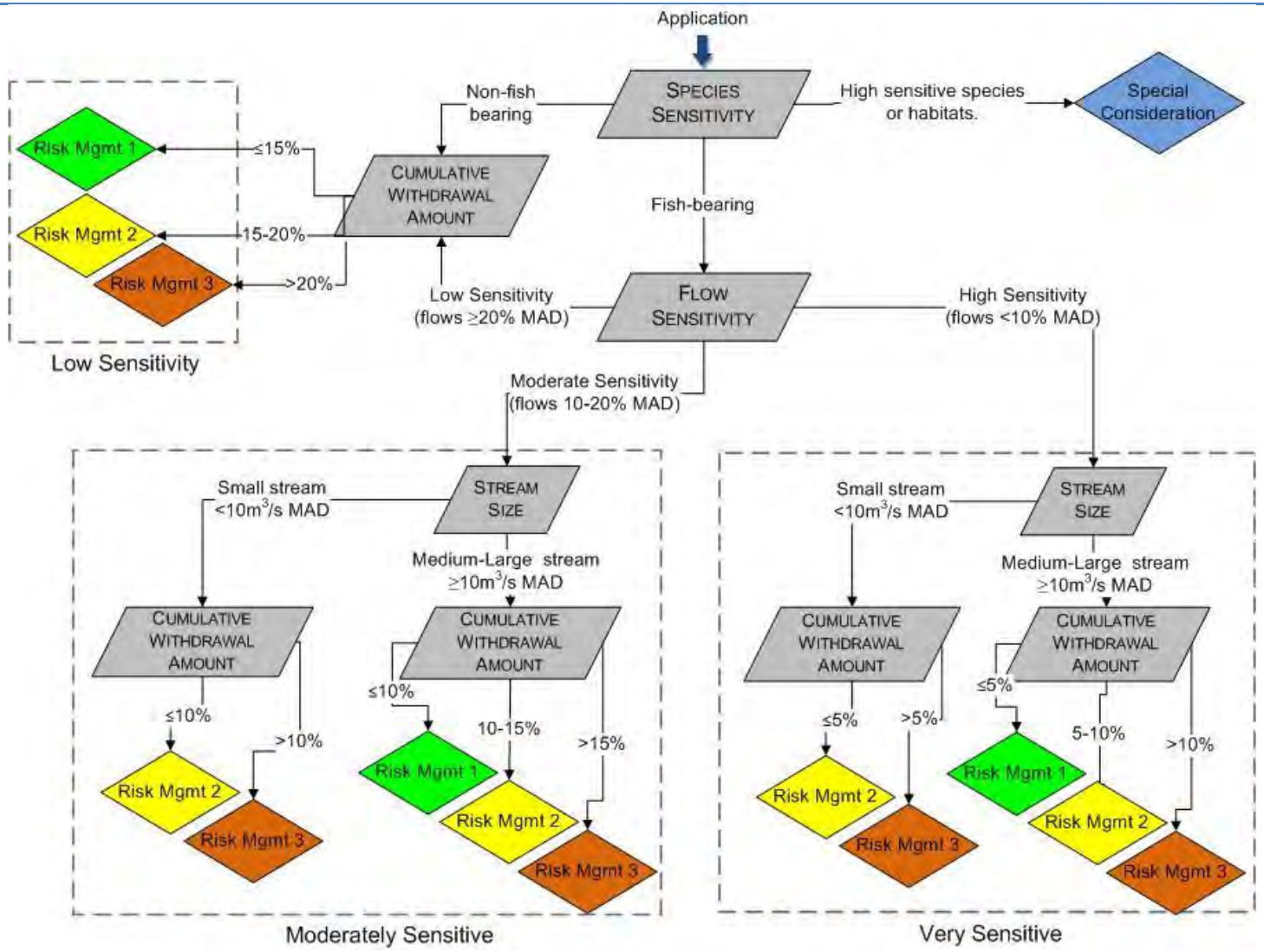
Stream size
The risk framework distinguishes small streams from medium to large streams. A more conservative threshold of $10m^3/s$ MAD is applied to streams that experience ice-covered periods, which is considered to be a more ecologically sensitive period than open water conditions (Hatfield 2012). Outside of winter low flow conditions, a threshold of $1m^3/s$ may be used to define small streams.

Cumulative withdrawals
Cumulative withdrawals include existing water rights and proposed withdrawals to assess risk based on the combined effect of multiple withdrawals. While averaged weekly or monthly withdrawal volumes are more likely to be available, instantaneous demand or peak daily demand, where available, should be taken into consideration in flow sensitive scenarios.

Hydrologic variability
Monthly mean flows are commonly used to characterize the volume and timing of flows; however, monthly mean flow masks year-to-year hydrologic variability. For example, the monthly mean flow may vary considerably from year to year.

Climate change projections suggest variable shifts in water supply (and demand) throughout the province. Incorporating hydrologic variability into allocation decisions increases the ability to adapt to these projected changes.

Figure 1. Environmental Risk Management Framework



Appendix B. Risk Management Measures

These measures may be required of applicants or licensees (as a licence condition) or may be implemented by government.

Level 1

Measures to assess or mitigate potential effects on low sensitivity flow periods:

1 Assess veracity of information and ensure appropriate methods are used, (e.g., RISC, //www.for.gov.bc.ca/hts/risc/index.html)
2 Consider downstream users and species/habitats

Level 2

Measures to assess or mitigate potential effects on moderate sensitivity flow periods:

In addition to Level 1 measures:

1 Establish adequate baseline hydrological data before withdrawals
2 Prepare reconnaissance-level fish and fish habitat impact assessment (e.g., Section 4.1.10.1 in Lewis et al. 2004)
3 Issue seasonal licence, or restrictions during low flow periods
4 Development of off-stream storage
5 Inclusion of a daily maximum or inst. withdrawal e.g., greater consideration of instantaneous demand over averages
6 Limit pump intake size
7 Monitor and report water use during higher risk flow periods, e.g., install flow gauge
8 Monitor low flows and limit withdrawals when flows drop below a certain level
9 Ministry staff to conduct audit of basin use/beneficial use review
10 Refuse application to withdraw water

Level 3

Measures to assess or mitigate potential effects on highly sensitive flow periods:

In addition to Level 2 measures:

1 Issue limited licence term, allowing for review and potential adjustment (e.g., 5 years)
2 Prepare detailed habitat assessment (e.g., Lewis *et al.* 2004; Hatfield *et al.* 2007)

Special Considerations (e.g., sensitive species, cultural sensitivities, etc)

Measures to assess or mitigate potential effects on streams/periods with high value species or habitats:

In addition to Level 1 and 2 measures:

1 Apply regional fish periodicity chart (e.g., Lewis *et al.* 2004)

Risk management measures may differ for short-term approvals vs. licences and may vary in relation to withdrawal amounts