

Guidance for Technical Assessment Requirements in Support of an Application for Groundwater Use in British Columbia

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1. REGULATORY FRAMEWORK AND PURPOSE OF DOCUMENT

The *Water Sustainability Act* (WSA) and the Water Sustainability Regulation (WSR) provide a means to allocate the diversion and use of groundwater¹ for a water use purpose in British Columbia (BC), through the issuance of a licence (if use exceeds 24 months) or use approval (if use does not exceed 24 months). All non-domestic groundwater uses require an authorization. Diversion and use of groundwater for domestic purposes is generally excluded from requiring an authorization; the right to divert and use groundwater for domestic purposes is deemed in Section 22 (8) of the WSA. Unrecorded water can be diverted and used in accordance with the WSR for:

- Diverting and using water from a stream or from an aquifer for the industrial purpose of drilling, altering, developing, rehabilitating, or decommissioning a well (Part 4 of the WSR); and,
- Diverting and using deep groundwater in northeast BC for oil and gas purposes (Part 5 of the WSR).

A person wishing to establish a new non-domestic groundwater supply may be required by the statutory decision maker (SDM) to have a technical assessment completed by a professional with competency in hydrogeology. A technical assessment typically involves compiling and interpreting available information (desktop component), and where necessary, interpreting data collected at and surrounding the site (field-based component). The level of detail of the technical assessment required by the SDM will depend on a number of location-specific factors (see Section 3).

This document provides guidance to the applicant and the professional acting on behalf of the applicant about the requirements of a technical assessment to support their application for an authorization to divert and use groundwater. The guidance provided in this document assumes that the reader has some technical familiarity with respect to groundwater.

The document provides guidance to determine:

- If a technical assessment is or may be required, through use of a self-screening tool; and,
- If a technical assessment is required, what is the appropriate level of detail likely required to support the application (i.e., if a desktop study is sufficient or if a field based study is required).

The guidance is intended to promote greater consistency in technical assessments and more timely decisions on applications for proposed groundwater use.

The proposed groundwater use may also be subject to additional requirements under other enactments (e.g., *Drinking Water Protection Act*, *Oil and Gas Activities Act*, *Environmental Assessment Act*, *Water Utilities Act*, etc.). It is the applicant's responsibility to ensure any additional requirements under the WSA or under other enactments are satisfactorily met, including obtaining any necessary permit(s) or certificate(s) (e.g., permit over Crown land (WSA s. 24), operating permit for water supply systems, Environmental Assessment Certificate). Furthermore, assessment of groundwater at risk of containing pathogens under the *Drinking Water Protection Act*, may also need to be done for a proposed water supply system seeking a licence under the WSA.

¹ Terms underlined and italicised are defined terms under the *Water Sustainability Act* or regulations.

2. OBJECTIVES OF A TECHNICAL ASSESSMENT

A technical assessment is necessary for groundwater diversions as the impacts of well pumping are highly dependent on site-specific conditions. Drawdown from pumping can lower groundwater levels significantly around the pumping well, and the depth and extent of drawdown depends on, for example, local geology, aquifer type, pumping rate, and sources of recharge. A technical assessment can also identify major uncertainties and unknowns governing water availability and potential impacts that would inform a SDM's decision and be considered when exercising their discretion to include appropriate terms and conditions in an authorization.

The objectives of a technical assessment are to provide sufficient information to support the application and to better inform the SDM during the decision making process. The technical assessment is intended to satisfactorily estimate or characterize the following:

- 1) the adequacy of the well's capacity to supply water for the intended water use purpose;
- 2) the potential impacts to existing groundwater users with rights (including domestic groundwater users with deemed rights);
- 3) the likelihood the well is hydraulically connected to streams (in this document, reference to "stream" reflects its broad definition in the WSA) and, if hydraulically connected, the potential impacts on environmental flow needs (EFN) and on surface water users with rights; and,
- 4) any other relevant issues.

3. PRELIMINARY SELF-SCREENING TOOL – GUIDANCE ON THE NEED FOR A TECHNICAL ASSESSMENT

The complexity of the application will inform the level of information required by the SDM to make a decision on the application. The preliminary self-screening tool is meant to inform the need for a technical assessment based on a limited number of factors and is not meant to be a comprehensive analysis of all risks associated with a groundwater diversion. Preliminary self-screening of an application for an authorization for groundwater use can be done to infer whether a technical assessment is likely required, and if required, determine whether a field component is required.

The self-screening tool relies on use of publically available information and mapping tools such as iMAPBC or BC Water Resources Atlas. The self-screening tool can be used by the applicant to determine if it is necessary to hire a professional to complete a technical assessment. Since the self-screening tool was designed to be used by the public, and not solely by professionals, the self-screening tool makes use of key location-specific factors as surrogates for complex hydrological systems. The main factors for consideration in the self-screening tool are:

- The proposed quantity of water to be diverted and used;
- The type of aquifer that water will be diverted from (i.e., unconsolidated aquifer or bedrock aquifer); and
- The potential for impacts to other users (domestic wells and licensed diversions), inferred from proximity.

Although there are other hydrogeologic factors that affect risk of the proposed diversion on other water users and uses, the above three factors are fundamentally important in revealing the potential complexity of the application and require little interpretation. Despite the results of the self-screening tool, the SDM may require additional subsequent information related to site-specific concerns and/or questions related to the proposed use or quantity.

The factors for the preliminary self-screening tool are briefly discussed below, and the criteria considered for each of these factors are outlined in a preliminary self-screening tool in Table 1.

3.1 Proposed Quantity of Water Use

Well pumping lowers (or draws down) the groundwater level around the pumping well. As the quantity of water pumped increases, both the amount of drawdown and the area affected by drawdown increases. Well pumping can potentially increase the risk of impacts to other water users and uses (i.e., EFNs in streams where the aquifer is hydraulically connected). In the preliminary self-screening tool (Table 1), points are assigned based on the proposed quantity of water use.

3.2 The Type of Aquifer

The areal extent of the drawdown (also referred to as radius of influence or cone of depression) not only depends on the quantity of water pumped but also on the characteristics of the aquifer. Drawdown is generally more predictable for unconsolidated aquifers than for fractured bedrock aquifers (much more difficult to characterize fractured bedrock). General assumptions on the productivity of the supply and the predictability of impacts can be inferred based on the type of the aquifer water will be diverted from. In the preliminary self-screening tool (Table 1), points are assigned based on the type of aquifer that is the source of the proposed groundwater supply.

3.3 Potential for impacts to domestic well users and licensed diversions

The potential for existing domestic wells and other licensed users to be impacted (via well interference and stream depletion) as a result of pumping is the final consideration in the preliminary self-screening tool. In the preliminary self-screening tool (Table 1), points are assigned corresponding to the likelihood of impacting another user, as inferred by the proximity of other users (within 1 Km).

Table 1 Preliminary self-screening tool.

Proposed quantity of water use ¹	Type of aquifer	Existence of other users ² within a 1 Km distance of the proposed <u>point of diversion</u>
≤ 10 m ³ /day (0 Points)	Unconsolidated sand and gravel (0 Points)	None (0 Points)
> 10 m ³ /day but not exceeding 100 m ³ /day (1 Point)	Bedrock (1 Point)	Present (1 Point)
>100 m ³ /day (2 points)	-	-
Points:	Points:	Points:
<u>TOTAL POINTS:</u>		

NOTES: 1: Average daily use

2: Domestic wells and licensed stream water or groundwater diversions

Assign points for each column in Table 1 and then add the points from each column to arrive at the total points. The total points from the self-screening tool (Table 1) are used to determine the need for a technical assessment in Table 2 below.

Table 2 Self-screening tool results.

Total Points from Table 1	Guidance on the need for a technical assessment
0 Points	A technical assessment is not necessary, unless required by the SDM.
1-2 Points	Desktop technical assessment is sufficient, unless specific field-based testing is required by the SDM
> 2 Points	Desktop technical assessment and field-based testing is necessary as part of the technical assessment.

This self-screening tool does not in any way restrict or limit the discretion of the SDM in requesting further subsequent information, such as flow sensitivity of a stream or potential flowing artesian conditions, to support the application. If there is uncertainty related to the need for a technical assessment or the level of assessment required in Table 2, the SDM should be contacted prior to preparing a technical assessment. If a technical assessment is completed to support an application, it must be completed by a professional with competency in hydrogeology and a report by the professional should be submitted to the SDM.

4. TECHNICAL ASSESSMENT REQUIREMENTS

The preliminary self-screening tool presented in Section 3 helps to inform when a technical assessment may be required, and when a technical assessment should include a field-based component. Technical assessments will address the following.

- Whether the well is capable of supplying the quantity of water for the proposed use and how the proposed quantity may affect the remaining availability of groundwater supply from the aquifer based on the hydrogeologist professional judgement, local experience, and/or analysis of the data collected.
- The potential impacts the proposed diversion and use are expected to have on other groundwater users with rights (including domestic groundwater users with deemed rights).
- Whether the source aquifer is hydraulically connected to a stream(s) and whether there are associated potential impacts to EFN or surface water rights holders.
- Whether there are any other relevant issues (e.g., flowing artesian conditions, issues with the well or other works, aquifer supply limits, water quality).

The following sections provide guidance on procedures for conducting a technical assessment. Appendix A provides some additional reference materials related to the design, implementation, and completion of technical assessments. In all cases, a technical assessment should be carried out subject to professional judgement, incorporating site-specific information.

4.1 Assessing Adequacy of Supply

Desktop technical assessments will typically be based on synthesizing and summarizing available data (e.g., iMAPBC or BC Water Resources Atlas, WELLS database, eLicensing, geological mapping).

In a field based component of the technical assessment, a *pumping test* is a common and effective tool to assess well capacity, well interference, and aquifer yield characteristics. A pumping test is necessary to characterize how pumping will drawdown groundwater levels over time and to determine site specific aquifer parameters (i.e., transmissivity and storativity). Section 32 of the Groundwater Protection Regulation (GWPR) requires that a pumping test carried out as part of an application for an authorization or by *order* of a SDM must be designed, performed or directly supervised, and interpreted by a professional with competency in hydrogeology.

The following are key aspects of a pumping test but details on specific procedures can be referenced in *Guide to Conducting Well Pumping Tests* (Ministry of Environment, 2010). While this guidance document does not prescribe the details of pumping testing procedures, unless there is a defensible reason to not do so, as determined by the profession responsible for the study, the following are expected.

- Conduct the pumping test for a sufficient period of time to characterize pumping response. Constant rate pumping tests for wells drilled into unconsolidated, confined aquifers should be carried out for a *minimum* of 24 hours. Unconsolidated, unconfined aquifers, pumping tests should be carried out for a minimum of 48 hours to characterize any “delayed yield” effect. For fractured bedrock, the minimum duration should be 72 hours of pumping. Although the pumping test times are recommended minimum times, large groundwater diversions may require longer pumping tests and this would be at the discretion of the professional responsible for the study. This total minimum time does not include any step-rate portion of a pumping test (which may be used prior to the constant rate test to select the pumping rate).
- Conduct the pumping test during a period of the year when precipitation events do not affect drawdown of the groundwater level during the test. Some aquifers are sensitive to seasonal groundwater elevation fluctuations and/or precipitation events (e.g. shallow unconfined aquifers, fractured bedrock) because these aquifers are often very responsive to precipitation events. Precipitation events affecting the pumping test may lead to well capacity being over-estimated and impacts being under-estimated and may not be accepted by the SDM as adequate.
- Conduct the constant rate pumping test at a rate that is generally not less than the maximum pumping rate anticipated during operation.
- Conduct the constant rate pumping test (not including step-drawdown tests), in a manner where the pumping rate is controlled so that it does not vary by more than $\pm 5\%$ during the test.
- Measure the water levels in the pumping well and any observation wells over the course of the pumping test and recovery test at a frequency and accuracy to adequately support the interpretations presented in the technical assessment.
- If a water sample is collected for chemical and biological analysis during the pumping test, collect the sample when water chemistry conditions have stabilized, typically near the end of the pumping test.
- If the well is within 1 kilometre of coastal environments, monitor the salt water content (e.g., specific conductance) during the pumping test. This practice is important to detect any obvious increase in salinity that might indicate intrusion of sea water into the aquifer. Depending on the aquifer type, wells located further than 1 kilometre from the coastal environments may need to be monitored for sea water intrusion. It is the responsibility of the professional conducting the technical assessment to include this component of the pumping test, if required.
- Collect water level data (recovery measurements) for at least the same length of time as the pumping test or until the well has recovered to within 90% of the pre-test *static water levels*, whichever comes first.

4.1.1 Observation Wells

Where feasible or required, drawdown is to be monitored in an observation well(s) or another water supply well drilled into the same aquifer and at a suggested distance of 15 to 150 metres from the pumping well. The distance should be determined by the professional and is typically informed by the aquifer type (e.g. confined, unconfined), quantity pumped, and known areas of concerns.

An observation well(s) is especially important in the following cases:

- The proposed pumping rate is large, where potential impacts can be large, and
- The proposed pumping is from a fractured bedrock aquifer, where drawdown is hard to predict without empirical measurements from the pumping test.

At least 1 (one) well must be monitored for pumping tests for proposed diversions of $\geq 100 \text{ m}^3/\text{day}$ and for proposed diversions from fractured bedrock aquifers, unless there is a defensible reason to not do so.

The professional should consider whether it is necessary to monitor wells drilled into other subsurface units during the pumping test, if there is concern that the aquifer is hydraulically connected to another aquifer or aquifer(s).

4.2 Assessing Likelihood of Hydraulic Connection to Streams and Other Aquifers

The technical assessment must also address the likelihood of hydraulic connection between water in the aquifer and any streams. Diverting groundwater from an aquifer that is hydraulically connected to a stream can reduce flows and water levels of the stream. This can reduce the available amount of water in the streams for future allocation, affect existing water rights or harm aquatic ecosystems if streamflow falls below the critical environmental flow threshold for EFNs.

Guidance for assessing the likelihood of hydraulic connection can be found in: *Determining the Likelihood of Hydraulic Connection, Guidance for Determining the Effect of Diversion of Groundwater on Specific Streams* (Wei et al, 2016). *An Assessment of Modeling Tools for Estimating Effects of Groundwater Pumping on Surface Waters in British Columbia* (Rathfelder, 2016) presents modelling tools to assess stream depletion from well pumping.

4.3 Assessing Potential Impacts on Nearby Groundwater Users

In addition to predicting drawdown in groundwater levels, the assessment of potential impacts on nearby groundwater users requires information about those wells. Data can be tabulated from publically available online databases (WELLS database, eLicensing database) and may be sufficient for a desktop technical assessment. In a field based technical assessment, a field survey is needed to collect information on well location, well depth, etc. to assess impacts on nearby groundwater users.

The radius of the field-verified survey is a minimum of 1 kilometre and may be greater depending on the hydrogeologic conditions, the proposed quantity of groundwater use, and the number of nearby water users. The final radius of the field-verified survey will be based on professional judgement but be no less than the minimum of 1 kilometre.

The following is a list of information required for assessing impacts on nearby groundwater users.

- Plans showing the location of existing licenced and domestic wells within the assessment area relative to the location of the proposed well.
- Information regarding the aquifer properties (e.g., depth, thickness, available drawdown, transmissivity, storativity), pumping rate, etc. to assess drawdown and area of influence due to pumping.
- Information on nearby water wells (can be tabulated):

- Owner's name, if known;
- Legal description;
- GPS location of the well, if known;
- Well tag number, if the well is in the WELLS database;
- Well stickup elevation, top of casing elevation or ground elevation, notation must be clear and method of measuring elevation must be reported together with level of accuracy of the method;
- Well depth, if known;
- Method of drilling the well (e.g., drilled, excavated, driven);
- Water use purpose;
- Pumping rate, if available;
- Daily or annual quantity proposed to be diverted, if available;
- Reported or measured well depth;
- Diameter of the well;
- Reported or measured static water level (to nearest centimetre) and date;
- Aquifer name and aquifer number, if available in iMAPBC or BC Water Resources Atlas;
- Reported screen interval or depth of water-bearing fractures, if available;
- Depth to the top of the aquifer and the total available drawdown, if available;
- Well pump intake depth, if available;
- Specific capacity of the well, if available; and,
- Distance from the proposed well.

Most of the above listed information can be obtained directly from the well construction reports from the WELLS database, well locations from iMAPBC or BC Water Resources Atlas and/or users during the field survey. The information collected from well users during the field survey should be used to confirm or to complete the information in the WELLS database. If the user is absent during the survey, a reasonable effort should be made to obtain the information at a later date.

4.4 Identifying Other Relevant Issues

The desktop review and field based technical assessment may provide information to identify other relevant issues or risks associated with a water authorization application. Relevant issues could include, but are not limited to, issues related to flowing artesian conditions, issues related to the well or other works (e.g., flowing artesian conditions, well or well pit not compliant with GWPR), aquifer supply limits, and poor water quality (e.g., elevated arsenic at concentrations greater than drinking water guideline limit).

The design of the technical assessment should also consider all relevant issues. Issues are typically site specific and may inform the SDM when they are considering terms and conditions for an authorization.

5. TECHNICAL ASSESSMENT REPORT

The results of the technical assessment (desktop and field-based) must be interpreted and reported by a professional with a competency in hydrogeology. The report provides critical information for consideration by the SDM prior to making a decision on the application for an authorization. Raw data (e.g., pumping test data, analytical chemistry results) should be provided in *digital format*. In addition, a checklist of questions for staff reviewing an application is provided in Appendix B "Checklist for Technical Assessment Report".

The technical assessment report (hereafter referred to as “report”) should contain, but is not limited to, the information in the following sections.

5.1 Introduction to the Project

The introduction section of a report presents a description of the site and nature of the project, including the following.

- A clear description of the project, site, and area (including water district and precinct).
- Pertinent background information.
- Location plans showing the following information:
 - Latitude and longitude or UTM including UTM zone;
 - Basic topographic features;
 - Location description of any current and proposed test-production and observation wells, as well as other licensed works; and,
 - The property, described by the site address, legal description, or parcel identifier number (PID), where the well(s) are located.
- A description of the operation, the quantity of water proposed for use, including any proposed variation in timing, rate of diversion, and storage requirements, if applicable.
- The proposed water use purpose(s).
- A description of the appurtenant land, mine, or undertaking.
- If the project is an expansion of an existing project², provide adequate context about how this phase relates to existing project phases, including identifying supplemental licences/sources.

5.2 Physical and Hydrologic Setting

This section presents the physical context and a brief discussion of the climate and hydrology in the area of the proposed diversion. The physical context provides context for subsequent discussion of hydraulic connection of the aquifer to other sources (e.g., streams and other aquifers) and the physical processes that influence groundwater availability in the area.

This section includes the following.

- A description of the physiography of the area.
- A description of the climate of the area and a summary of relevant available climate data (precipitation figures, preferably monthly).
- A description of streams, lakes, springs, and wetlands in the area. Include relevant stream or spring flow data and, where appropriate, include a comparison of long-term stream flow and rainfall data.
- A description of any significant aquatic values (e.g., sensitive stream, protected fish population, fish habitat or protected species, etc.).

5.3 Hydrogeologic Setting

This section describes the hydrogeologic setting for the area of the proposed diversion, including the characteristics of the source aquifer and presents the hydrogeological context. This information provides understanding of the hydraulic connection with other sources (e.g., streams and other aquifers) and the

² This is common for growing communities. For example, a community may have an old water licence on a stream, then over time switch to (or add) a well for all or part of their water supply. As the community continues to grow, additional well(s) may be installed and brought into production, as needed.

physical processes that influence groundwater availability. Where data are available, this will include the following.

- A description of the local geology (e.g., based on soil, surficial geology, and bedrock geology mapping).
- A summary of data on neighbouring wells diverting groundwater (e.g., information from the WELLS database and field survey, if necessary for a field based report) as discussed in Section 4.3.
- A description of the aquifer (e.g., from the Provincial aquifer classification database, from well construction reports in the WELLS database, and information on local hydrogeology from any test drilling).
- Location of all relevant local groundwater discharge (e.g., springs, wetlands, streams, lakes) and recharge zones.
- Available data on groundwater levels to understand groundwater flow direction and fluctuations over time (e.g., from nearby Provincial observation well(s) and/or monitored wells).
- Hydrogeological maps and cross-sections illustrating the hydrogeology and groundwater flow.
- Any available values for the hydraulic properties of the source aquifer (e.g., hydraulic conductivity, transmissivity, and storativity) and a description of where the estimates were obtained and any uncertainty associated with the values.
- Identification of any known issues with the source aquifer or with other sources in the area (e.g., declining water levels, water allocation restrictions, flowing artesian wells).
- Information on any other source(s) potentially hydraulically connected to the source aquifer and relevant attributes (e.g., stream size and flow, supply issues).

5.4 Well Information

This section provides details of the construction of the well and any observation well(s) for the field based component of the technical assessment, including the following information:

- Location of the well(s) (i.e., latitude and longitude coordinates of each well, in decimal degrees with a minimum of six significant decimal places OR UTM coordinates including UTM zone);
- A diagram of the well(s) showing details of casing, screens, and screen assembly;
- Survey elevation of the well(s) including the method of survey and accuracy;
- Lithological details; and
- Water levels (measured from a reference point) and date measured.

5.5 Methodology for Assessing the Adequacy of the Supply

This section presents the professional's assessment of availability of supply. For a desktop only report this section will be limited, based on reported capacity of nearby wells, aquifer lithology, and available studies to derive an estimate. Where a field based report is prepared, a rationale for the pumping test design should be included. The following data should be presented in tabular and graphical form, and raw data should be included as a digital Appendix (data should be provided in international system of units (SI Units)). The minimum data expected is as follows:

- Description of the pumping test design and field procedures for the pumping well and any observation well(s), including:
 - Date of the test;
 - Static water level in the pumping well and observation well(s), if any;
 - Pump type;
 - Depth of the pump;

- Maximum available drawdown (and depth of major water bearing fractures, if applicable);
- Pumping rate(s) of the step and constant rate pumping tests;
- Location where the pumping test water was discharged;
- Method of flow measurement and control;
- Method of water level measurements and water levels/times recorded during the pumping and recovery test;
- Duration of all components of the test (i.e., step-rate test, constant rate pumping test, and recovery test); and
- General observations made during the pumping test (e.g., weather conditions, nearby pumping activities).
- Describe the roles of the personnel/contractors involved with the test, including details related to roles in the test design, supervising the test, analysis, and interpretation of test data.

5.6 Results used for Assessing the Adequacy of the Supply

This section speaks directly to adequacy of the water supply and likely drawdown of water levels as a result of pumping the well during operation. Where a desktop only report is required, estimates from publically available data and/or referenced literature values will be used to support the assessment of the adequacy of the supply. Where a field based assessment is required, the results, analysis and interpretation of the pumping test should be presented in the report. Results of the pumping test should discuss the likelihood of hydraulic connection between the source aquifer and other sources. This section should identify major uncertainties in the interpretation of results.

The following is the minimum analysis expected to assess the adequacy of the supply.

- Analysis of hydraulic properties of the aquifer (e.g., hydraulic conductivity, transmissivity, and storativity (Allen, 1999), and discuss the methodology used to determine the parameters (analytical solutions or numerical models used).
- Where a pumping test was done, calculation of the long-term yield of the pumping well, (i.e., 100-day or modified Moell Q_{20} method – described in Ministry of Environment, 1999 and Maathuis and van der Kamp, 2006, respectively).

Box A – Test-Production Well

Section 12(4) of the WSA allows works (i.e., a test production well) to be constructed for a technical assessment in support of an application for an authorization for groundwater use. Section 6(2) of the WSA allows a person to divert water to test the quality or quantity of water or to conduct a flow test.

The term “test-production well” refers to a well that is drilled to initially explore for and test groundwater. After conducting a pumping test to confirm well capacity, the test well may ultimately be converted to a production well. In a sense, all water supply wells start out as a test-production well. For many projects, the test well and the ultimate production well will be one and the same, only changing to permanent production well once the well is equipped with a permanent well pump and a water licence is obtained to allow diversion and use of water to occur.

For very large projects it can be expensive to drill the production well (e.g., >305 millimetre (mm) (12-inch) diameter well; maximum length of screen) as a test well. Therefore, a test well of smaller diameter (e.g., 203 mm (8-inch) or 254 mm (10-inch) and shorter screen length may be drilled and tested first. The pumping test therefore may be at a lower rate than the ultimate desired quantity. The potential capacity of the well and impacts from production pumping at the higher rate are based on reasonable extrapolation. In most cases, the results of testing would provide the basis for the decision related to the licence application. Once a licence is issued, the licensee would then have the production well drilled (and tested to verify well capacity and impacts), before the well is equipped and put into production.

- Identification of likely boundary conditions inferred from observed pumping response (e.g., connectivity to streams, change in aquifer thickness or aquifer hydraulic conductivity, aquifer limit/boundary, leaky aquifers, delayed yield, aquifer mining effects) and discussion on how they affect the analysis of long-term well capacity.
- Analysis of well interference (either measured directly or based on calculated drawdown from distance drawdown analysis).
- Discussion of assumptions used in the analysis and major uncertainties.
- Discussion related to how the proposed diversion affects the supply of the aquifers. Specifically;
 - The likely main constraints on the supply aquifers (i.e., limited available drawdown or permeability, water budget limit, hydraulically connected to a stream, legal considerations (e.g., *Water Objective*, *Water Sustainability Plan*));
 - Any evidence that limits are being approached (i.e. potential hydraulic connection to streams with a fully recorded restriction, declining groundwater levels); and,
 - Other data from the applicant related to site specific conditions.

5.7 Discussion

In addition to supply, the report should discuss the likelihood of hydraulic connection to specific streams, impacts on other users, and any other relevant issues that relate to the works, land, public safety and environment.

5.7.1 Likelihood of Hydraulic Connection

This section of the report will present and discuss the following:

- The likelihood of hydraulic connection to specific streams including the rational, and if pumping is likely to impact the quantity of water in the streams;
- If the aquifer is likely hydraulically connected, assess the fractional demand on each likely connected stream and how that was determined (Wei et al, 2016);
- Any evidence that there is a likelihood of hydraulic connection to any other aquifer(s); and
- Present the main uncertainties and assumptions associated with the hydraulic connectivity analysis and discuss how they are addressed in the technical assessment or via additional data gathering and monitoring.

5.7.2 Conceptual Model of the Site

This section provides a description of the conceptual model for the well and the source aquifer, including the main processes that govern water availability. The conceptual model is a summary of the professional's understanding of the site hydrogeology, based on their interpretation of available information and results of the technical assessment, and should include a summary of inputs and outputs of water to the aquifer. Relevant uncertainties in the conceptual model should be identified and discussed in this section.

5.7.3 Assessment of Potential Impacts

This section discusses the potential impacts to the aquifer, environment, and/or other water users or uses that may result from the proposed groundwater diversion and use. This section should use aquifer parameters obtained from the pumping test conducted as a part of the technical assessment or from pumping tests conducted in the immediate area or from other referenced information, depending on the complexity of the application. The assessment should consider potential issues such as impacts on well yields, available drawdown, groundwater level changes (in the aquifer or in a hydraulically connected aquifer), and/or on water quality (e.g., likelihood of intrusion of sea water in coastal

aquifers). This section should also present options for mitigating any identified impacts and identify critical data that can be collected to resolve major uncertainties related to the assessment of impacts.

5.7.4 Issues Related to Proposed Works, Land, Public Safety, and Environment

This section of the report presents and discusses any issues related to proposed works, land, public safety, and environment as a result of the diversion and operation of the works. Some issues may include, for example:

- Issues with works and joint works;
- Land access;
- Controlling artesian flow; or
- Known water quality concerns in the site area (e.g., naturally high arsenic, anthropogenic nitrate, saline water intrusion).

5.8 Conclusions and Recommendations

The conclusions and recommendations provide a concise summary of the proposed diversion and any issues identified. The section also offers practical recommendations to help address potential impacts and uncertainties. Where there are concerns related to potential impacts to other water uses and users recommendations should be made related to monitoring and ways to minimize potential impacts. In addition, identify the necessary remedial measures if impact is anticipated.

6. SUMMARY

A technical assessment may be required by the SDM for consideration prior to the SDM making a decision on the application for an authorization to divert and use groundwater. This document provides guidance to the applicant and professional working on their behalf on conducting a technical assessment. In allocating water in a sustainable way, the SDM is responsible for ensuring there is sufficient water available for use and that the potential impacts to existing right holders (including domestic groundwater users) and EFNs have been considered and are acceptable. A technical assessment also helps identify issues related to the proposed groundwater diversion and inform the SDM of the terms and conditions to consider including in an authorization. Appendix B is a Checklist for a Technical Assessment Report; the checklist allows the professional to assess whether he/she has assessed the relevant technical items typically of interest to the SDM.

7. REFERENCES

Allen, D.M., 1999. An assessment of the methodologies used for analyzing hydraulic test data in British Columbia. Queen's Press

Ministry of Environment, 2010. *Guide to Conducting Well Pumping Tests*. Water Stewardship Information Series. ISBN 978-0-7726-7033-5.

Ministry of Environment, Lands and Parks, 1999. *Evaluating Long-term Well Capacity for a Certificate of Public Convenience and Necessity*. Water Management Branch, Groundwater Section, 16 pp. ISBN 0-7726-4019-X.

Maathuis, H. and G. van der Kamp, 2006. *The Q_{20} Concept: Sustainable Well Yield and Sustainable Aquifer Yield*. Saskatchewan Research Council Publication No. 104717-4E06.

Rathfelder, K., 2016. *An Assessment of Modeling Tools for Estimating Effects of Groundwater Pumping on Surface Waters in British Columbia*. Water Science Series No. 2016-09, Ministry of Environment.

Wei, M., K. Rathfelder, J. Turner, 2016. *Determining the Likelihood of Hydraulic Connection, Guidance for the Purpose of Determining the Effect of Diversion of Groundwater on Specific Streams*. Water Science Series No. 2016-03, Ministry of Environment.

APPENDIX A: INFORMATIONAL SOURCES FOR TECHNICAL ASSESSMENTS.

The following references provide guidance on aquifers, pumping test methods, well construction requirements, and key provincial policies.

Aquifers

- [Guide to using the B.C. Aquifer Classification Maps for the Protection and Management of Groundwater.](#)
- [Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater.](#)

Well capacity and pumping tests

- [Guide to Conducting Well Pumping Tests.](#)
- [Evaluating Long-term Well Capacity for a Certificate of Public Convenience and Necessity.](#)
- [An assessment of the methodologies used for analyzing hydraulic test data in British Columbia.](#)

Hydraulic connection, surface-groundwater interaction and stream depletion

- [Streamflow Depletion by Wells—Understanding and Managing the Effects of Groundwater Pumping on Streamflow.](#)
- [Rathfelder, 2016](#)
- [Wei et al, 2016](#)

Regional groundwater level trends

- [Trends in Groundwater Levels in B.C. – Environmental Reporting BC.](#)
- [British Columbia Groundwater Observation Well Network.](#)

Well construction

- [Groundwater Protection Regulation.](#)
- [Flowing Artesian Wells.](#)
- [Best Practices for Dug Wells.](#)

Finding excluded users

- [Guide to finding water well information.](#)

APPENDIX B: CHECKLIST FOR TECHNICAL ASSESSMENT REPORTS

Technical Report Requirements	Satisfactorily Completed? (Y/N/NA)	Additional Notes
1. Introduction of the Project		
Description of the project, site, and study area including locations of current and proposed groundwater diversions.		Including water district and precinct.
Pertinent background information.		
Location map sheet.		Include the following: - Latitude and longitude and UTM zone, - Basic topographic features, - Locations of any current and proposed production and monitoring wells within the study area, - Location description of any current and proposed test-production and monitoring wells, as well as other? licensed works; and, - The property, described by the site address, legal description, or parcel identifier number (PID) where the well(s) are located
A description of the operation, the quantity of water proposed for use, including any proposed variation in timing, rate of diversion, and storage requirements, if applicable.		
The proposed water use purpose(s).		
A description of the appurtenant land mine, or undertaking .		
If the project is an expansion of an existing project, provide adequate context on how this phase related to existing project phases.		Include identifying supplemental licenses/ sources.
2. Physical and Hydrologic Setting		
Description of the physical setting of the area.		Include topography and watershed characteristics.
Location of all relevant local groundwater discharge zones.		
A description of the climate of the area and a summary of relevant available climate data.		Specifically precipitation figures, preferably monthly.
Description of nearby streams, lakes, springs, and wetlands in the area.		Include relevant stream or spring flow data and, where appropriate, include a comparison of long-term stream flow and rainfall data.
A description of any significant aquatic values.		
3. Hydrogeological Setting		
A description of the local geology.		e.g., based on soil, surficial geology, and bedrock geology mapping.

Technical Report Requirements	Satisfactorily Completed? (Y/N/NA)	Additional Notes
A summary of data on neighbouring wells diverting groundwater.		e.g., information from the WELLS database and field survey, if necessary for a field based report.
A description of the aquifer.		e.g., from the Provincial aquifer classification database, from well construction reports in the WELLS database, ECOCAT, and information on local hydrogeology from any test drilling.
Available data on local groundwater levels spatially and as a function of time.		e.g., from nearby Provincial observation well(s) and/or monitored wells.
Hydrogeological maps and cross-sections illustrating the hydrogeology and groundwater flow.		
Any available values for the hydraulic properties of the source aquifer and a description of where the estimates were obtained and any uncertainty associated with the values.		e.g., hydraulic conductivity, transmissivity, and storativity.
Identification of any known issues with the source aquifer or with other sources in the area.		e.g., declining water levels, water allocation restrictions, flowing artesian wells.
Information on any other source(s) potentially hydraulically connected to the source aquifer and relevant attributes.		stream size and flow, supply issues
4. Well Information		
Location of the well(s).		Latitude and longitude coordinates of each well, in decimal degrees with a minimum of six significant decimal places OR UTM coordinates including UTM zone
A detailed diagram of each well.		Include casing, screens, and screen assembly
Survey elevation of the well.		Include the method of survey and accuracy.
Lithological details.		
Water Levels.		From a reference point and the date measured - If the well exists under flowing artesian condition, is the proposed method to control flow reasonable? Has this been verified?
5. Methodology for Assessing the Adequacy of the Supply		
For a desktop only report this section will be limited, based on reported capacity of nearby wells, aquifer lithology, available studies to derive an estimate.		
Description of the pumping tests design and field procedures.		Details should include: - date of the test, - static water level in the pumping and observation

Technical Report Requirements	Satisfactorily Completed? (Y/N/NA)	Additional Notes
		well(s), - depth of the pump, - maximum available drawdown, - pumping rates of the step and constant rate pumping tests, - location where the pumping test water was discharged - method of flow measurement and control - method of water level measurements and water level/ times recorded during the pumping and recovery test, - duration of all components of the test, and - general observations made during the pumping test
Describe the roles of the personnel/contractors involved with the test, including details related to roles in the test design, supervising the test, analysis, and interpretation of test data.		
6. Results used for Assessing the Adequacy of the Supply		
Desktop only report is required, estimates from publically available data and/or referenced literature values will be used to support the assessment of the adequacy of the supply.		
Analysis of hydraulic properties of the aquifer and discuss the methodology used to determine the parameters.		e.g., hydraulic conductivity, transmissivity, and storativity analytical solutions or numerical models used
Where a pumping test was done, calculation of the long-term yield of the pumping well.		i.e., 100-day or modified Moell Q_{20} method – described in Ministry of Environment, 1999 and Maathuis and van der Kamp, 2006, respectively
Identification of likely boundary conditions inferred from observed pumping response and discussion on how they affect the analysis of long-term well capacity.		e.g., connectivity to streams, change in aquifer thickness or aquifer hydraulic conductivity, aquifer limit/boundary, leaky aquifers, delayed yield, aquifer mining effects
Analysis of well interference.		Either measured directly or based on calculated drawdown from distance drawdown analysis
Assumptions used in the analysis and major uncertainties.		

Technical Report Requirements	Satisfactorily Completed? (Y/N/NA)	Additional Notes
Discussion related to how the proposed diversion affects the supply of the aquifers.		The likely main constraints on the supply aquifers (i.e. limited available drawdown or permeability, water budget limit, hydraulically connected to a stream, legal considerations (e.g., Water Objective, Water Sustainability Plan))
		Any evidence that limits are being approached (i.e. potential hydraulic connection to streams with a fully recorded restriction, declining groundwater levels)
		Other data from the applicant related to site specific conditions
7. Discussion		
7.1. Likelihood of Hydraulic Connection		
The likelihood of hydraulic connection to specific streams including the rational, and if pumping is likely to impact the quantity of water in the streams.		Discuss how the assessment was done (e.g. 3D numerical model, Hut VBA routine)
If the aquifer is likely hydraulically connected, assess the apportioned demand on each likely connected stream.		Reference: Determining the Likelihood of Hydraulic Connection, Guidance for the Purpose of Determining the Effect of Apportioning Demand from Diversion of Groundwater on Specific Streams.
Any evidence that there is a likelihood of hydraulic connection to any other aquifer(s).		
Present the main uncertainties and assumptions associated with the hydraulic connectivity analysis and discuss how they are addressed in the technical assessment or via additional data gathering and monitoring.		
7.2. Conceptual Site Model		
Provide a description of the conceptual model for the well and aquifer.		Present and discuss the main processes that govern water availability
7.3. Assessment of Potential Impacts		
Assess the supply and demand of the groundwater resource (i.e. on an aquifer level) and the environment.		Include an assessment of the well capability to provide the quantity of groundwater required in the application on a long-term basis An assessment of how the proposed diversion will likely affect the available drawdown in the well and water availability in the aquifer If connected to another aquifer, assess how the proposed diversion will likely affect the groundwater level and water availability of the connected aquifer Water chemistry analysis for areas where there is a potential for salt water intrusion or mixing of

Technical Report Requirements	Satisfactorily Completed? (Y/N/NA)	Additional Notes
		different qualities of water
Will pumping adversely impact other, licensed and domestic, groundwater users.		Will pumping adversely impact other groundwater users? Discuss proposed monitoring and data requirements to confirm the initial predictions and those necessary to identify likely future adverse effects. Provide hydrographs and historic production information for expansion of ongoing projects or for areas where well interference is known to exist
Discuss potential impacts of the proposed groundwater diversion on connectivity to nearby surface water users and uses.		Specifically if aquifers are hydraulically connected to nearby streams, lakes, and/or springs and if pumping will impact the quantity of water in nearby surface water bodies. - If hydraulically connected, provide an assessment of how the proposed groundwater diversion will affect environmental flow needs, and discuss an adaptive management plan to address this.
7.4. Issues Related to Proposed Works, Land, Public Safety, and Environment		
A description of major works and any joint works.		Potential agreement established between parties
Discuss land access.		Information related to trespassing issues and consent to trespass including any evidence of legal authority to trespass (e.g. easement)
Controlling artesian flow.		
Known water quality concerns in the site area.		e.g., naturally high arsenic, anthropogenic nitrate, saline water intrusion
8. Conclusion and Recommendations		
Summarize the details of the technical assessment for the proposed groundwater license.		
Provide recommendations and/or management approaches regarding the application.		Likely made describing whether the impacts of taking the water as assessed to be acceptable, manageable, or unacceptable. If the impacts are identified as manageable, describe how the taking of the water will be managed to reduce potential future impacts.

NOTE: If data is not available, a detailed explanation should be provided