Climate-Informed Water Supply Planning and Communication Approaches in the Regional District of Nanaimo

Appendix 1: Best Practices for Climate-Informed Water Supply Planning

January 2023

Acknowledgements

The Regional District of Nanaimo, Econics, Kerr Wood Leidal, and Waterline Resources gratefully acknowledge the participation of the water service provider and municipal staff who helped with development of these best practices by providing information and reviewing results. It would not have been possible to complete this work without their invaluable input. The following organizations participated:

- Bowser Waterworks District
- Deep Bay Improvement District
- French Creek Water System (EPCOR)
- District of Lantzville
- Little Qualicum Waterworks District
- North Cedar Waterworks District
- City of Nanaimo
- City of Parksville
- Town of Qualicum Beach
- Qualicum Bay-Horne Lake Improvement District
- Snaw-Naw-As Nation

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About This Resource

This document is intended to document and collate information to support operators and managers of water systems (‘water service providers’) with planning and managing resilient water supplies for the long-term. It identifies a set of best practices to help achieve climate-informed supply planning. They are organized into the four categories pictured below.

The best practices identified in this document are generally accepted practices in the water utility industry. They are used by professionals in relevant fields (e.g., hydrology, hydrogeology, civil engineering, utility management, public administration) and/or common utility practices with evidence of success. They have been developed through a combination of desktop research and consultation with technical experts.

To ensure this resource is applicable to a range of water service providers, ‘good practice adaptations’ are identified above the relevant best practice tasks. These consist of less onerous or data-intensive approaches that may be more attainable for small water systems or utilities with less capacity.

Resources to support the implementation of the ‘best’ and ‘good’ practices are included in a resource section at the end of this document, organized by the tasks they correspond with. The resources consist of technical standards and methodologies, guidance resources, and in some cases notable examples of resources or templates produced by water utilities or water sector associations. Where possible, the resources identified are freely and publicly available. To the extent possible, resources are oriented to the specific environmental and regulatory context in British Columbia and the Regional District of Nanaimo.

Limitations

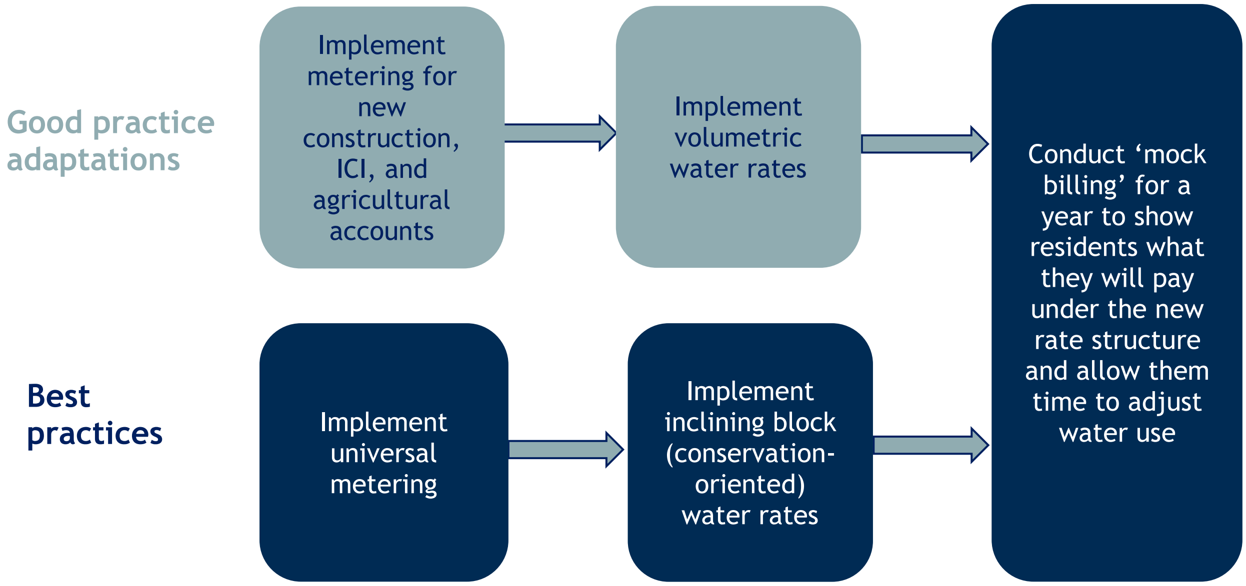
This resource is intended to serve as guidance only. While it originated as a Regional District of Nanaimo project, it was developed in partnership with several water service providers in the region and should not be interpreted as a directive from another level of government. Water service providers have full autonomy over their water supply planning and practices and as such are free to adopt these practices, or others, as they deem appropriate.

Notwithstanding this, one limitation of water service providers undertaking climate-informed supply planning individually is that it does not address the cumulative impacts of water use by multiple service providers and private water users. This highlights the importance regional coordination and provincial action to understand and address cumulative impacts is advised. The existing regional Drinking Water and Watershed Protection service and the Technical Advisory Committee that guides it are promising vehicles to facilitate this.

How to Interpret the Diagrams in this Resource

- This resource is comprised of 17 steps across the four themes outlined in the diagram above. With one exception (as noted in the grey explanatory box for step 1.3b), the steps are intended to be completed in the sequence presented.
- Each page contains a different step. The outcomes or rationale for each step are described in the grey box at the top of each page labeled with the heading 'why?'.
- Each step has a series of 1-6 tasks associated with it. Each task is identified in a separate navy-coloured text box. In cases where the tasks must be done sequentially, there are horizontal arrows to indicate the appropriate sequencing. When there are no horizontal arrows, there is no particular order in which the tasks need to be performed.
- If there are 'good practice adaptations' identified for particular tasks, they are located in light blue text boxes directly above the navy 'best practice' tasks they replace.
- In some cases, a 'good practice' adaptation can replace multiple 'best practice' tasks. This is indicated by the length of the light blue 'good practice' adaptation text box. In other cases, the 'good practice' adaptation replaces only one 'best practice' task.
- To illustrate, a fictional example is presented in a diagram below. It indicates the following:
  - there are 3 tasks associated with the best practice to "charge water users by volume"
  - the arrows indicate that the tasks are sequential
  - for two of the 'best practices' (implement universal metering and implement inclining block water rates), there are 'good practice adaptations' that are lower-barrier approaches located immediately above them in the light blue boxes
  - there is no 'good practice adaptation for the last best practice (conduct 'mock billing'…etc.,), meaning this task is to be completed by both those who implement volumetric water rates (the 'good practice adaptation') as well as those who implement inclining block rates (the 'best practice').

Example of best practice diagram for 'charge water users by volume':



Disclaimer

These best practices focus on water supply planning. While this resource includes practices relevant to water system or utility management, this document should not be considered a comprehensive guide or resource for these broader disciplines.

The information in this report is for general information purposes only. It is not intended to provide legal advice or opinions of any kind. No one should act, or refrain from acting, based solely upon the materials provided here, any hypertexted links, or other general information without first seeking appropriate legal or other professional advice.

1.0 Understand Supply

Step 1.1a (Groundwater): Determine long-term sustainable capacity for supply wells

Why?

Location-specific (or down-scaled) impacts of climate change on groundwater are less understood and predictable than impacts on surface water. ***The best way to detect and prepare for those impacts is to monitor conditions in the groundwater source itself. Monitoring how well levels change over time*** *in response to water use* ***provides insight into how sustainable the rate of use is,*** *and how a groundwater source may withstand increased water demand and/or climate change impacts.*

Good practice adaptation

Use analytical methods (Excel or Aqtesolv) recommended by the Province (see Province of BC, 1999) for assessing the long-term sustainable yield of water supply wells using operational data or by completing a constant rate pump test (based on maintaining 70% of the available head in the well or the groundwater level above sea level).

Best practices

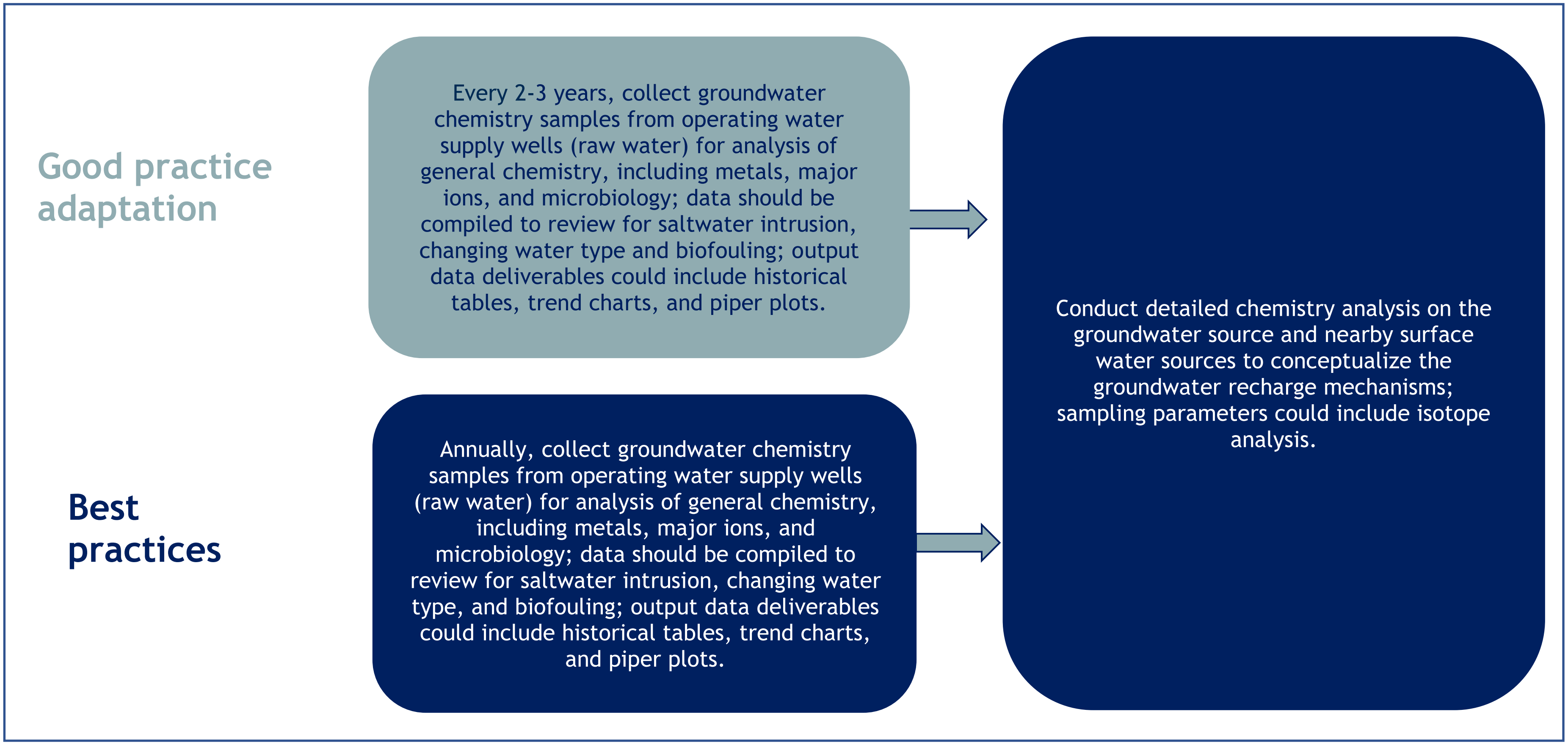
On an annual or semi-annual basis, complete groundwater level trend analysis from long-term performance monitoring data collected from water supply wells.

Using the long-term water level data, develop a numerical groundwater flow model to help forecast changes in the timing and magnitude of groundwater fluctuations based on climate change scenarios.

Step 1.2a (Groundwater): Detect changing conditions from groundwater chemistry

Why?

Location-specific (or down-scaled) impacts of climate change on groundwater are less understood and predictable than impacts on surface water. ***The best way to detect and prepare for those impacts is to monitor conditions in the groundwater source itself****. Ongoing monitoring of groundwater quality can enable stressors and threats to be identified early so appropriate management responses can be identified and implemented.* ***Gradual or rapid changes in groundwater quality can be indicative of stressors*** *from over-use (e.g., saline intrusion into coastal aquifers), changes in land-based activity impacting water quality or recharge dynamics, or simply changes to well dynamics and well efficiency not related to aquifer conditions.*



Good practice adaptation

Every 2-3 years, collect groundwater chemistry samples from operating water supply wells (raw water) for analysis of general chemistry, including metals, major ions, and microbiology; data should be compiled to review for saltwater intrusion, changing water type and biofouling; output data deliverables could include historical tables, trend charts, and piper plots.

Best practices

Annually, collect groundwater chemistry samples from operating water supply wells (raw water) for analysis of general chemistry, including metals, major ions, and microbiology; data should be compiled to review for saltwater intrusion, changing water type, and biofouling; output data deliverables could include historical tables, trend charts, and piper plots.

Conduct detailed chemistry analysis on the groundwater source and nearby surface water sources to conceptualize the groundwater recharge mechanisms; sampling parameters could include isotope analysis.

Step 1.1b (Surface water): Collect data and information on water availability and climate

Why? ***Collecting existing publicly-available information*** *and ongoing data* ***about the watershed*** *supplying the water source provides insight into its condition and a* ***baseline for monitoring trends and forecasting changes****. The 'practices' below are not sequential tasks; rather they identify the range of data types that are valuable for understanding the status of a watershed.*

Good practice adaptations	Collect past hydrological studies in the region of the water supply including provincial water allocation plans and the RDN Phase 1 water supply study.	Collect representative monthly average river flow data from representative watersheds near the water supply watershed and collect monthly bulk water withdrawal data.	Collect available monthly temperature and precipitation records from representative climate station(s) near supply watershed and the RDN Phase 1 water supply study.	Collect climate index values (average and range of projected changes from ensemble of global climate models) for projected monthly changes in temperature and precipitation.	Collect mapping data (max scale 1:10,000) of watershed including boundaries air photos, topography, watercourses, land cover, location of water supply infrastructure (reservoirs, points of withdrawal), climate/ hydrometric stations.
Best practices	Collect river flow, reservoir water level, and bulk water withdrawal data from the water supply watershed; a minimum of one year of data is required but several years of data is preferred if available. Use existing data and supplement with field sampling where necessary.	Use statistical hydrology techniques to understand natural flow dynamics by removing the influence of regulation on flows (e.g., dams) and withdrawals, if required.	Collect good quality daily climate data (temperature, precipitation, snowpack) in the water supply watershed, including gridded historical climate data sets (i.e., PNWNAmet dataset).	Select and collect downscaled global circulation model outputs (daily temperature and precipitation) representative of Vancouver Island Region.	

Step 1.2b (Surface Water): Assess the amount and timing of current and future water availability

Why? *The climate and hydrological data described in step 1.1 provide data inputs for modeling used in this step to* ***understand existing flows for a surface water source*** *and how they may be impacted by anticipated climate change impacts.*

Good practice adaptation

Determine what flows are for a design drought year:

- use available unregulated hydrometric data to estimate annual (water year) flow volumes for design drought conditions (10-year drought, 25-year drought, 100-year drought) and distribution of monthly average flow within water supply watershed;
- use monthly average temperature and precipitation data from climate change projections and trend analysis of observed flows; use professional judgement to estimate how changes in climate could impact monthly average flows (note: at time of writing, Pacific Climate Impacts Consortium are developing projections of change in flows for coastal watersheds in BC which will be useful in making estimates of change in flows within RDN);
- quantify monthly average flows for design drought conditions for historical and future climate periods.

Best practices

Conduct continuous simulation of watershed processes to project long-term (to 2100) daily flows:

- develop a hydrological model to simulate the amount and timing of how water travels through the watershed;
- incorporate interaction of shallow ground water and surface water into modelling framework, if required;
- calibrate and verify the model by comparing results using historical climate data to observed river flow data;
- run the hydrological model using historical climate data and projected future climate data to develop long term (100-years) daily time series of simulated unregulated surface water flows in water supply watershed for both historical and future climate periods.

Step 1.3b (Surface Water): Assess how much storage capacity is available to supplement natural flows

Why? *Water storage devices (e.g., tanks that provide balancing storage or dams that augment available supply) can help supplement the water available through natural flow regimes.* ***Quantifying the amount of storage available*** *is important to help* ***determine the adequacy*** *of existing supply and storage to* ***meet future needs****. Steps 2.1, 2.2, and 2.3 must be completed prior to this step.*

Good practice adaptation

Design a drought water balance:

- collect community water demands for historical and projected future conditions;
- collaborate with other water users in watershed (e.g., industrial, agricultural, other water service providers) to understand overall watershed water demands;
- confirm or develop environmental flow needs within the watershed to support ecological function
- carry out monthly water balance comparing average monthly flow with water demand and EFN across range of design drought conditions;
- calculate the amount of storage needed, if any, to support water withdrawals and EFN and compare with available storage;
- confirm if sufficient winter inflow is available to refill storage, including accounting for future climate impacts;
- evaluate the impacts of community drought management/water conservation on demands and water yield;
- use results of storage assessment to confirm reliability of watershed yield and storage to support demands.

Best practice

Conduct a continuous reservoir operation simulation to take into account storage, flows, and other water uses:

- collect data for water supply storage reservoirs (water level storage relationship, spillway water level discharge relationship, etc.);
- collect community water demands for historical and projected future development and use conditions;
- confirm or develop environmental flow needs within the watershed to support ecological function;
- collaborate with other water users in watershed to understand overall watershed water demands, including industrial and agricultural users as well as other water service providers;
- develop continuous reservoir simulation model using modeled daily flows and projected water demands as inputs;
- assess potential for watershed and current storage to support demands across range of drought conditions;
- evaluate impacts of community drought management/water conservation (demand side management) on demands and water yield;
- collaborate with other water users in watershed to understand competing demands for water; carry out a trade-off/structured decision-making process/water sustainability planning to optimize water availability across competing interests, if required.

2.0 Forecast Demand

Step 2.1: Measure water production and consumption

Why? ***To forecast what will happen with water demand in the future, it is important to understand current water use and trends****. This is achieved by gathering information from meters about how much water is produced from existing water sources, and where it is being used (e.g., which sectors). There is no particular sequence for these tasks.*

Best practices

Measure water production with master meters at all water sources and/or treatment facilities; record results daily.

Regularly calibrate or validate water master meters at sources and/or treatment facilities.

Good practice adaptation

Read meters at least quarterly; charge customers based on the volume of water they consume.

Use advanced metering infrastructure to gather water-use data remotely in real time; charge customers based on the volume of water they consume.

Replace meters as required as part of an ongoing asset renewal program.

Implement “smart” water metering that enables more frequent and granular data capture (e.g., Advanced Metering Infrastructure (meter reading via radio transmitters); home-based water monitoring technology; zone metering/district metered areas that monitor flow and pressure within the distribution system stations).

Step 2.2: Assess historic bulk water production trends

Why? ***Understanding current and historic water production****, which is everything pumped from the water source,* ***is critical for forecasting future water needs****. Unlike consumption data, it captures non-revenue water from leaks and other losses.*

Good practice adaptation

Calculate the following metrics of water production from all water sources: average day demand (ADD), maximum day demand (MDD), total monthly production, base demand (average daily demand for November - March), and seasonal demand (ADD - base demand). Update metrics at least annually and compare with benchmarks for 5 years to identify trends.

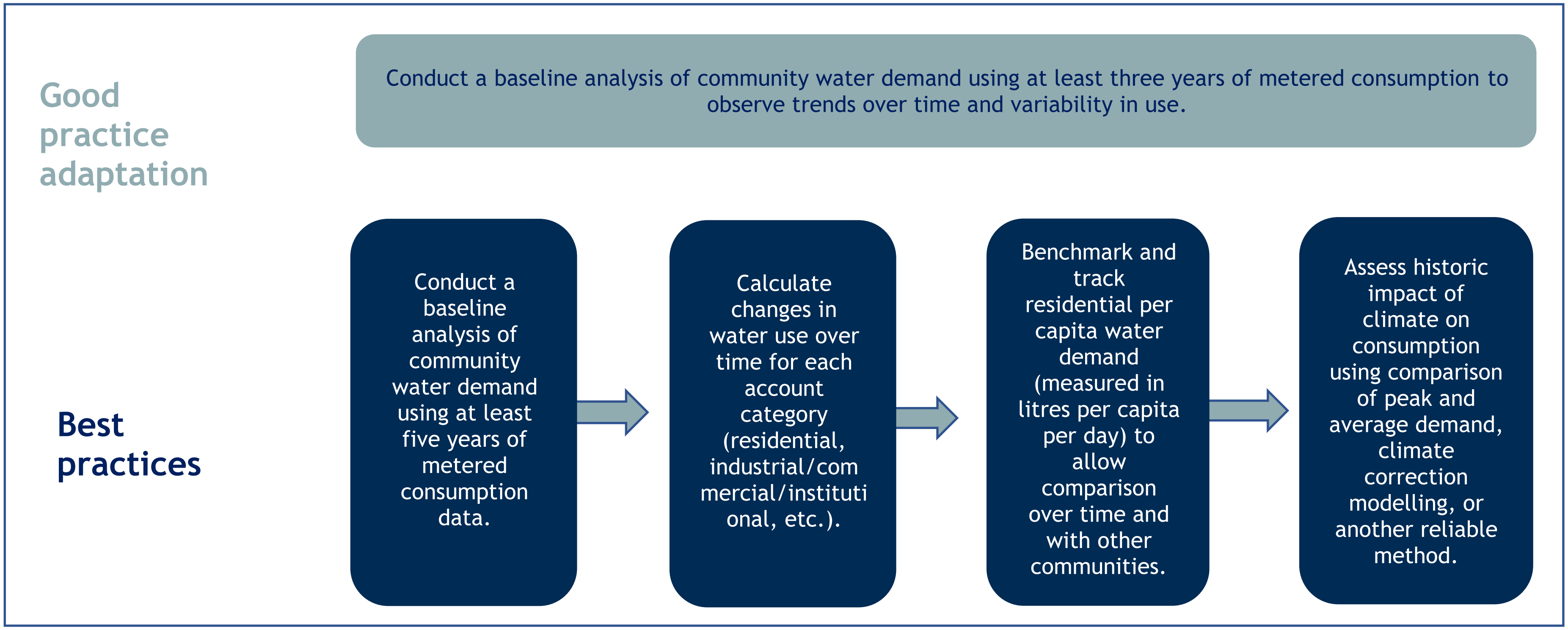
Best practices

Calculate the following metrics of water production from all water sources: average day production (ADD), maximum day production (MDD), total monthly production, base demand (average daily demand for November - March), and seasonal demand (ADD - base demand). Update metrics at least monthly and compare with benchmarks for 5 years to identify trends and support timely decisions related to conservation measures (e.g., watering restrictions) when pressures arise.

Track climate data (precipitation, air temperature, etc.) daily at a consistent location in the service area to identify correlations with water production trends.

Step 2.3: Assess current and past customer water consumption

Why? ***Understanding how much water is used*** *daily, monthly, and annually facilitates planning to ensure existing supplies and infrastructure are adequate and* ***allow for more targeted conservation measures*** *to be designed and monitored (e.g., those targeting specific sectors or users). The arrows indicate that the best practice tasks below should be completed*



Good practice adaptation

Conduct a baseline analysis of community water demand using at least three years of metered consumption to observe trends over time and variability in use.

Best practices

Conduct a baseline analysis of community water demand using at least five years of metered consumption data.

Calculate changes in water use over time for each account category (residential, industrial/commercial/institutional, etc.).

Benchmark and track residential per capita water demand (measured in litres per capita per day) to allow comparison over time and with other communities.

Assess historic impact of climate on consumption using comparison of peak and average demand, climate correction modelling, or another reliable method.

Step 2.4: Assess and manage non-revenue water and system loss

Why? *Significant volumes of water (e.g., 20-40%) are often lost to leakage in water utilities.* ***Quantifying how much is lost****, identifying where the losses are occurring, and beginning to address the leakage can be an* ***important strategy to manage limited supplies of water and/or offset pressures from increased demand or climate impacts on supply****.*

Good practice adaptations

Benchmark and track non-revenue water (NRW = Total Volume of Treated Water - Total Volume of Sold Water) → Implement a proactive leak detection and repair program using acoustic leak detection equipment or other current technology.

Best practices

Complete a water audit based on the approach in the American Water Works Association (AWWA) Manual M36. → Develop and implement comprehensive water loss control program based on the approach in AWWA Manual M36.

Step 2.5: Estimate future changes in the size of the service population

Why?

*An **understanding of how the service population is likely to change is required to plan for water supply needs in the future**. Accurate service population numbers also allow per capita water production and/or consumption to be calculated, providing a basis for monitoring improvements in water efficiency and evaluating the effectiveness of conservation measures.*

Good practice adaptation

Extrapolate the historical rate of growth for the service population (measured over at least 5 years) to the next 30 years.

Best practices

Account for any anticipated changes in the boundaries of the service area, or in land-use policies and regulations that may impact water demand (e.g., permitting secondary dwellings).

→

Estimate high and baseline population growth scenarios to determine the sensitivity of water demand forecasts to population growth. Extrapolate the 0.73% (baseline) and 1.16% (high) growth projections from RDN's 2020 Regional Housing Needs Report out 30 years (or based on more local or updated regional growth projections as they become available).

Step 2.6: Forecast future water demand

Why? *With the forecasted future service population (step 2.5) and an understanding of historical water demand, **future water needs can be forecasted to help ensure supplies are adequate to meet needs over time**. For both the best practices and the good practice adaptations below, all tasks are sequential (as indicated by the arrows).*

Good practice adaptations

- Estimate future water production and community demand using *A Community Guide for Evaluating Future Urban Water Demand* or another authoritative source; develop a 10-year demand forecast.
- Revise the forecast every five years with updated water use and service population data.
- Account for anticipated climate change and drought impacts by conducting scenario analysis (e.g., high, medium, low) that includes conservative scenarios and higher per capita consumption.

Best practices

- Develop 20-year demand forecasts by each account category (residential, industrial/ commercial/ institutional, etc.)
- Develop at least three demand scenarios (low, medium, high) with sensitivity analysis (e.g., 20% higher or lower demand ranges).
- Revise forecasts every three years with updated water use and service population data. dataset).
- Account for anticipated climate change and drought impacts in demand forecast by benchmarking against per capita consumption in historical hot/dry years or undertaking more refined "climate correction" modelling (see Joly et. al. (2014).
- Review levels of service relative to the desired frequency of outdoor watering restrictions to estimate how often escalated restrictions (e.g., watering bans) will be used to manage seasonal demand (e.g., 1 in 5 years, 1 in 10 years etc.). This is an iterative, ongoing process.

3.0 Plan and Manage for Resilience

Step 3.1: Use adaptive and risk-based planning practices

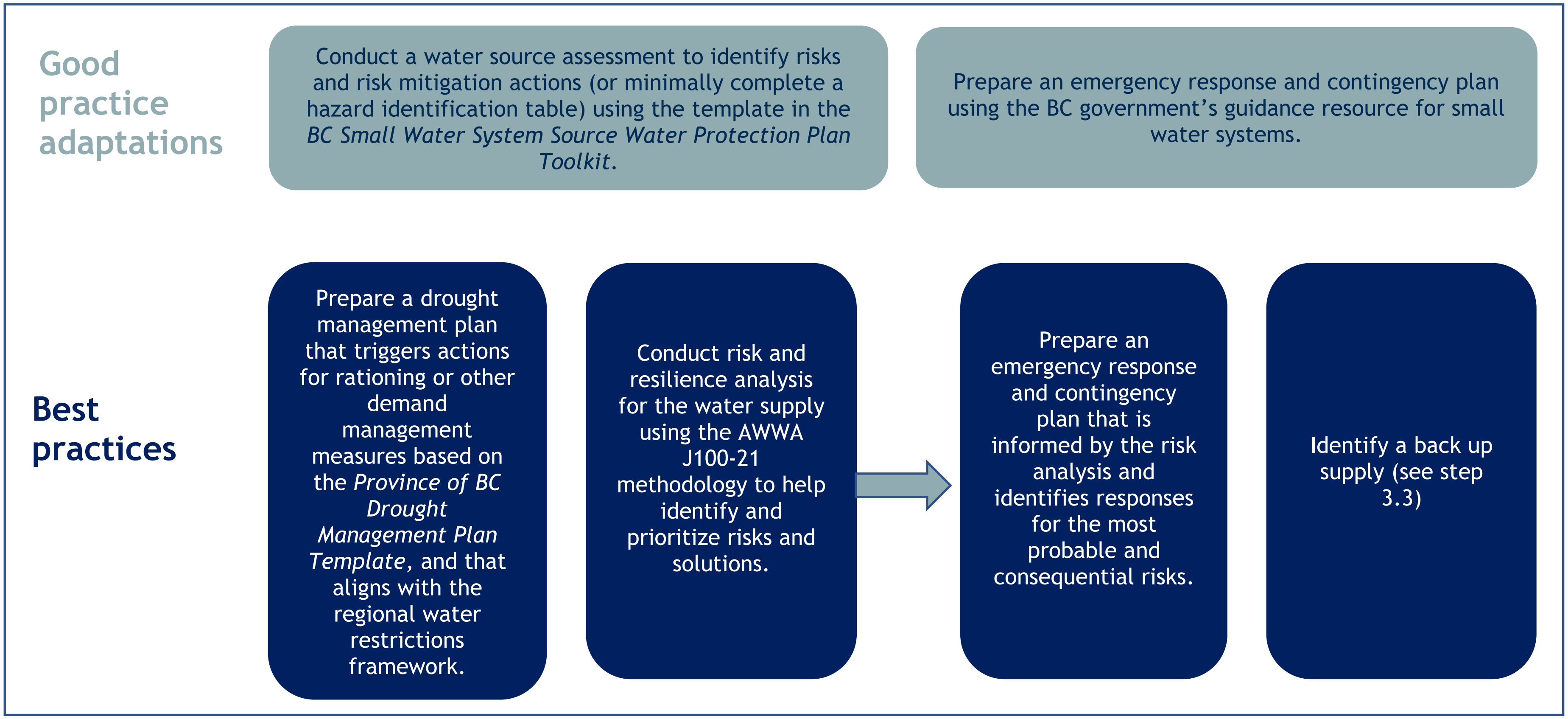
Why? ***Planning for multiple scenarios*** *and regularly verifying or adjusting assumptions and forecasts* ***will increase preparedness*** *to respond to a range of anticipated and unanticipated events. In general,* ***longer planning timeframes are better*** *to provide adequate time to plan for and save up funding for significant infrastructure upgrades that may be required. There is no particular sequence in which any of these tasks should be performed.*

Good practice adaptations	Plan to a horizon of 20-30 years.	Use population growth (see s. 3.5) and demand forecasts (see s. 3.6) to ensure preparedness for reaching supply capacity; evaluate and adjust assumptions every 5 years.	Maintain up-to-date asset inventories, identify critical assets, conduct condition assessments for critical supply infrastructure that does not have system redundancies, and construct/build redundancies for critical supply infrastructure.
Best practices	Plan to a horizon of 40-50 years to adequately forecast renewal cycles for major infrastructure and plan capital projects accordingly.	Use both high and baseline scenarios for population growth (see s. 3.5) and demand forecasts (see s. 3.6) to inform planning and ensure preparedness for reaching supply capacity; evaluate and adjust assumptions every 2-3 years.	

Step 3.2: Plan for drought and emergencies

Why?

Evaluating the vulnerabilities of water systems to drought and other emergencies is a critical step toward increasing resilience to climate change impacts. *Systematically prioritizing solutions to fix and mitigate risk based on those with the greatest consequence and likelihood will help ensure limited resources are directed to the projects that best protect public health. The only two inter-dependent tasks are linked with an arrow, but all should be completed to ensure adequate emergency plans are in place and supported by necessary capital investments.*



Good practice adaptations

Conduct a water source assessment to identify risks and risk mitigation actions (or minimally complete a hazard identification table) using the template in the *BC Small Water System Source Water Protection Plan Toolkit.*

Prepare an emergency response and contingency plan using the BC government's guidance resource for small water systems.

Best practices

Prepare a drought management plan that triggers actions for rationing or other demand management measures based on the *Province of BC Drought Management Plan Template*, and that aligns with the regional water restrictions framework.

Conduct risk and resilience analysis for the water supply using the AWWA J100-21 methodology to help identify and prioritize risks and solutions.

→

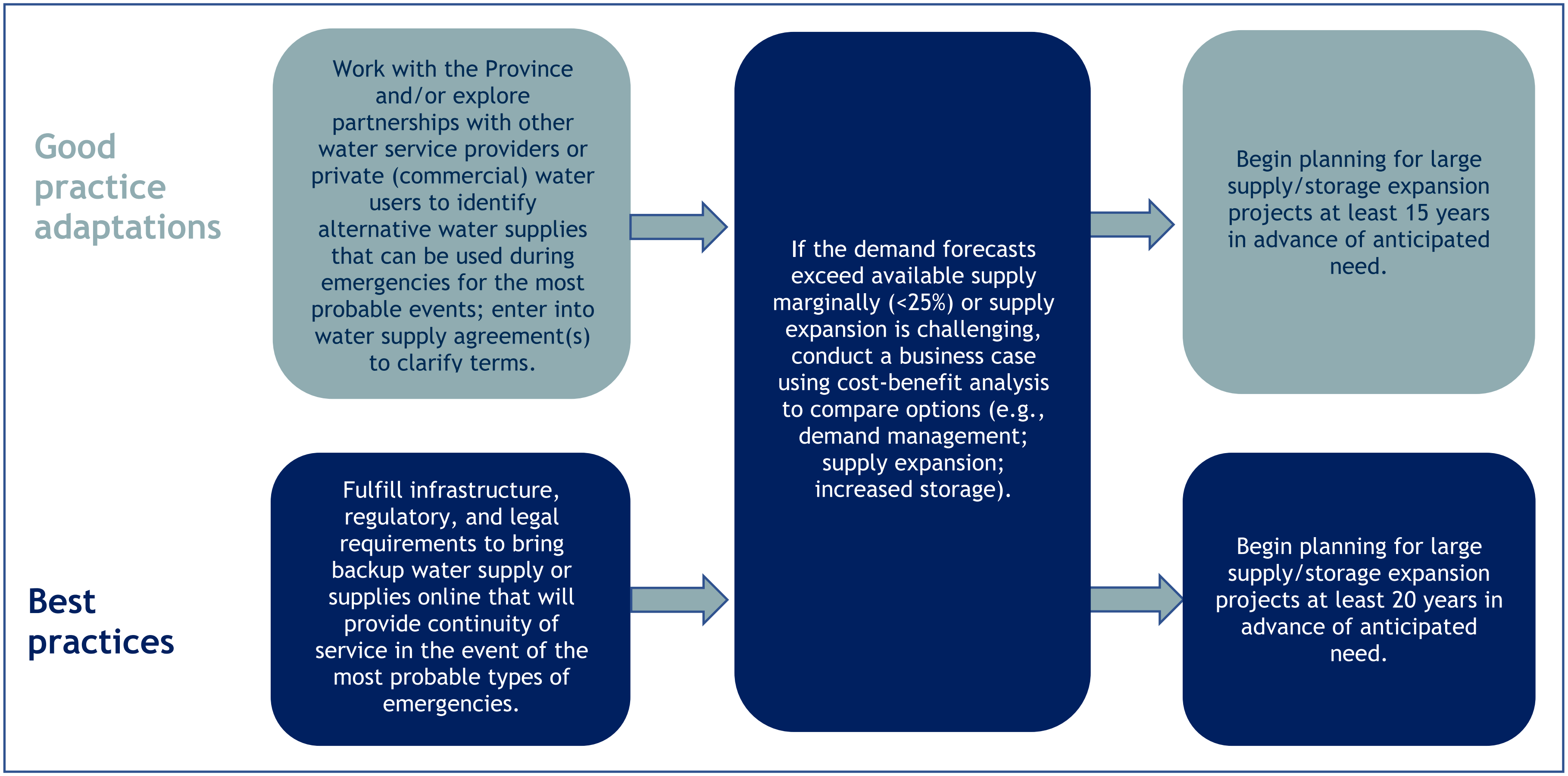
Prepare an emergency response and contingency plan that is informed by the risk analysis and identifies responses for the most probable and consequential risks.

Identify a back up supply (see step 3.3)

Step 3.3: Explore alternative supply and/or storage options

Why?

Having contingency plans to bring on alternate or backup water supplies is a critical element of resiliency *to climate change and other unanticipated future events. Equally important is having a long-range view of future supply enhancement needs to enable sufficient time to explore options and alternatives, to undergo detailed design, and to build up reserves, if desired, to avoid large rate hikes or over-reliance on debt financing. The arrows indicate that these steps are sequential.*



Good practice adaptations

Work with the Province and/or explore partnerships with other water service providers or private (commercial) water users to identify alternative water supplies that can be used during emergencies for the most probable events; enter into water supply agreement(s) to clarify terms.

If the demand forecasts exceed available supply marginally (<25%) or supply expansion is challenging, conduct a business case using cost-benefit analysis to compare options (e.g., demand management; supply expansion; increased storage).

Begin planning for large supply/storage expansion projects at least 15 years in advance of anticipated need.

Best practices

Fulfill infrastructure, regulatory, and legal requirements to bring backup water supply or supplies online that will provide continuity of service in the event of the most probable types of emergencies.

Begin planning for large supply/storage expansion projects at least 20 years in advance of anticipated need.

Step 3.4: Promote water use efficiency by residents and customers

Why?

Improving the efficiency of water use can help utilities withstand future anticipated events *(e.g., growth in water demand or a reduction in supply)* ***and unanticipated pressures*** *(e.g., emergency events). There is research that suggests building public support for effective utility management practices and the associated financial requirements can be achieved by enhancing understanding of water supplies, management challenges, and methods of conservation. These tasks are not sequential or inter-dependent, meaning there is value in doing some, even if all are not completed.*

Good practice adaptations

Use RDN's Team WaterSmart brand and resources to promote water conversation among water users through passive channels like a website, annual general meetings, and billing mailouts.

Implement and promote seasonal watering restrictions by adopting the regional framework schedule to improve regional consistency and effectiveness.

Best practices

Develop and implement a comprehensive water use efficiency plan based on the principles in *The Water Conservation Guide for British Columbia* or other authoritative source.

Use RDN's Team WaterSmart brand and resources to encourage water conversation among target users identified through the efficiency plan.

4.0 Communicate with Residents and Customers

Step 4.1: Increase awareness of the water supply, its value, constraints, and risks among users and decision makers

Why? ***Helping water users understand where their water comes from and the characteristics of the supply is the first step toward fostering appreciation for it, an awareness of constraints, and influencing behaviour*** *(whether a willingness to conserve, to engage with and support the water utility, or to pay necessary fees for effective management of the water system). This is consistent with community-based social marketing research These tasks are not sequential or inter-dependent, meaning there is value in doing one of them,*

Good practice adaptations

Publish accessible and non-technical information about the water supply(ies) online and in print format (e.g., for community events or distribution with utility bills) with location, map, watershed/aquifer, water quality characteristics, adequacy of volume, supply-related challenges, and information about the multiple uses and values of water.

Distribute links to RDN's Drinking Water and Watershed Protection educational Video Series through digital communications to water users or utility bill inserts.

Best practices

Develop accessible and non-technical summary information about the water supply that is published through multiple channels including website content, a 3-5 page backgrounder, social media and traditional media articles, and short videos. Include details about location, map, watershed/aquifer, water quality characteristics, adequacy of volume, supply-related challenges, and information about the multiple uses and values of water.

Engage RDN to deliver their school-based watershed education programming at schools within the service area, adapting them to be specific to the local water supply.

Step 4.2: Make information about water supply status that is easy to understand and publicly available

Why? ***Making all technical information related to the status of the water supply and system available to the public is an important step for transparency and open governance.*** *Making it available in formats that are non-technical and engaging can help water users learn about operational challenges and how to contribute to effective long-term supply management. The tasks below are not sequential or inter-dependent, meaning there is value in doing some, even if all are not completed.*

Good practice adaptations

Publish data and reports required for regulatory compliance in an easy-to locate section on the service provider website.

On an annual basis, publicly publish a summary of total and monthly water production that also identifies available water supply (licensed amount or safe yield, if available). Summarize conclusions to make it easy for water users to interpret the use and supply status.

Best practices

Publish data and reports required for regulatory compliance in an easy-to-locate section on the service provider website; present results annually at public meetings (e.g., Council or Board annual general meetings).

Make all technical reports related to supply planning publicly available along with easy-to-understand summary materials (e.g., executive summaries, decision notes, slide decks).

On a weekly or monthly basis, publicly publish a summary of water demand that includes comparators with past results and available water supply.

Issue a quarterly or annual billing insert with information and infographics to raise awareness of water-use trends, supply capacity and planning, anticipated climate impacts, and conservation tips.

Resources

1.0 Understand Supply (Part A): Groundwater

1.1a Determine the long-term sustainable well capacity for supply wells

- Province of British Columbia. (2020). *Guidance for Technical Assessment in Support of An Application for Groundwater Use in British Columbia.* WSS 2020-01. Prov. B.C. Retrieved from https://a100.gov.bc.ca/pub/acat/documents/r50847/GW_TAG_Aug2020_1605220217068_5216198940.pdf
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- BC Groundwater Association. (2017). Groundwater Protection Regulation Handbook. Retrieved from https://www.bcgwa.org/wp-content/uploads/2017-GWPR-Handbook_BCGWA_v1.pdf

1.2a Detect changing conditions from groundwater chemistry sampling

- Province of British Columbia. (2016). *Best Practices for Prevention of Saltwater Intrusion. Retrieved* from https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-wells/saltwaterintrusion_factsheet_flnro_web.pdf

- Province of British Columbia. (2013). *B.C. Field sampling Manual*. Retrieved from https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual

- Consult with a Qualified Professional (QP) registered with the Professional Association of Engineers, Geoscientist of British Columbia (EGBC). Find registered members: https://www.egbc.ca/app/Registrant-Directory

1.0 Understand Supply (Part B): Surface Water

1.1b Collect data and information on water availability and climate

- Government of Canada. (2022). *Canadian Climate Data and Scenarios*. Retrieved from https://climate-scenarios.canada.ca/index.php?page=main
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3.3 Explore alternative supply and/or storage options

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3.4 Promote water use efficiency by residents and customers

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