AGENDA ITEM NO: 7.2

MEETING DATE: July 18, 2023

STAFF REPORT – COVER SHEET

SUBJECT:	Water Conservation Plan Update Report	DATE:	July 7, 2023
DEPARTMENT:	Engineering	PREPARED BY:	Chikezie Nwaoha

1. SUMMARY OF ISSUE:

Amendments to the City's Water Conservation Plan are proposed, including extending the timeline for Stage 2 water restrictions and establishing triggers for Stages 3 to 5.

2. RECOMMENDATION:

Recommendation that the Stage 2 water restrictions in the City's Water Conservation Plan be extended to October 15th and that water conservation triggers based on the Provincial monitoring data for groundwater observation well OW406 be adopted as presented in the staff report dated July 7, 2023.

for Kara Jefford, Director of Engineering

3. FINANCE COMMENTS:

The 2023 Water Conservation Plan contains funding allocated towards planned initiatives through the Water Fund.

Glen Savard, Director of Finance

4. CHIEF ADMINISTRATIVE OFFICER'S RECOMMENDATION/COMMENTS:

Supports recommendation.

Chris Crosman, CAO

STAFF REPORT ON

WATER CONSERVATION PLAN UPDATE REPORT

PREPARED BY:	Luke Yu Sun	DATE:	July 7, 2023
POSITION:	Sr. Engineering Technologist	DEPARTMENT:	Engineering

1. DEFINITION OF ISSUE:

Amendments to the City's Water Conservation Plan are proposed, including extending the timeline for Stage 2 water restrictions and establishing triggers for Stages 3 to 5.

2. FACTORS:

2.1 The City first developed the Water Conservation Plan in 2005 and subsequently updated it in 2008, and 2011, and most recently it was endorsed by Council in 2018 to plan for water conservation initiatives to reduce peak water use.

2.2 Hatfield Consultants was retained to review the Water Conservation Plan and provide trigger points for conservation stages, see attached memo dated July 12, 2023.

2.3 The provincial government describes drought as "a recurrent feature of climate involving a deficiency of precipitation over an extended period of time, resulting in a water shortage." The Provincial Drought Portal displays current drought levels across the province as well as data for groundwater observation wells and river gauges. Currently, the Lower Mainland is at provincial drought level 4 out of 5 and the Ministry of Forests is requesting all water users to conserve water and reduce withdrawals from surface water and groundwater sources. If municipalities and other water users don't voluntarily respond to the Ministry's requests during drought conditions, mandates could be issued.

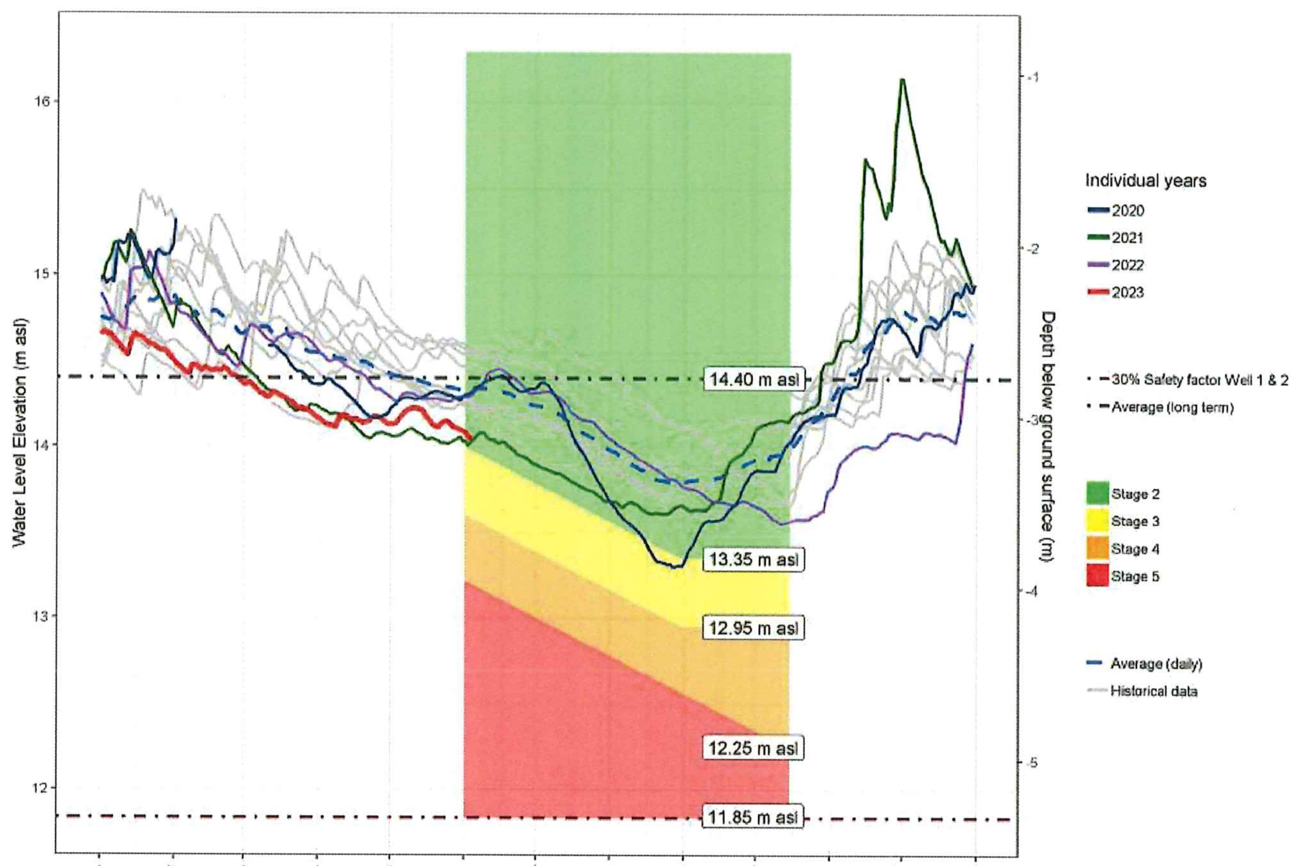
2.4 Historical water consumption and groundwater level data were evaluated by Hatfield Consultants. Chilliwack's water consumption has been relatively consistent in recent years, and changes in groundwater conditions from year-to-year are more related to weather. When the fall/winter season is drier than usual, as was the case in 2022/23, the groundwater levels don't recover as well. Water conservation measures are intended to prevent spikes in consumption due to heat.

2.5 Historical water level observations and typical annual groundwater decline and recovery patterns indicate that groundwater levels generally start declining on June 1st and begin their seasonal recovery around October 15th. Therefore, it is recommended to extend Stage 2 water restrictions until October 15th from the current September 30th end date.

2.6 For higher-level water conservation stages (3 to 5) the triggers are based on provincial well OW406 monitoring data and elevations relative to meters above sea level (m asl), as shown in Figure A3.7 from the Hatfield memo. The extended Environment Canada forecast indicates a 90% chance of a relatively dry and hot summer in the Lower Mainland this year, and groundwater level data for OW406 in early July indicates conditions are entering the threshold for Stage 3.

2.7 These proposed triggers are based on current aquifer conditions and available data and would be evaluated periodically for effectiveness, based on new data as it becomes available and as City water demand increases.

Figure A3.7 Proposed groundwater drought stages and historical water levels at OW406.



3. RECOMMENDATION & SUBSTANTIATION:

Recommendation:

Recommendation that the Stage 2 water restrictions in the City's Water Conservation Plan be extended to October 15th and that water conservation triggers based on the Provincial monitoring data for groundwater observation well OW406 be adopted.

4. ATTACHMENT:

Hatfield Consultants Memo "Proposed Triggers for Water Conservation Plan Stages", July 12, 2023

Hatfield

MEMO

Date: July 12, 2023 Hatfield Ref No.: CHILL10102

From: Hatfield Consultants

To: Chikezie Nwaoha, Ph.D., P.Eng., Manager of Utilities, City of Chilliwack

Subject: Proposed Triggers for Water Conservation Plan Stages

Hatfield Consultants (Hatfield) is pleased to provide the City of Chilliwack (City) with this memo outlining proposed triggers for Water Conservation Plan Stages.

It is understood that the City currently has five stages of water conservation (Appendix A1 – water conservation brochure):

- Stage 1: No water use restrictions from October 1 to May 31 each year.
- Stage 2: Some seasonal lawn watering restrictions are in place annually from June 1 to September 30.
- Stage 3: Precautionary
- Stage 4: Dry conditions
- Stage 5: Very dry conditions

The City also has a current Public and Internal Water Conservation Plan (dated May 24, 2022) which outlines allowed, disallowed and discretionary water uses for each of the water conservation stages (Appendix A2). However, the City lacks a formal mechanism (decision process) to identify when additional water conservation measures may be needed over and above the Stage 2 seasonal lawn watering restrictions. These proposed drought stage triggers are the focus of this memo.

The Sardis Vedder Aquifer (SVA) acts as the City's main water supply. Proposed drought stage triggers are based on Hatfield's analysis of historical groundwater levels and Safe Available Drawdowns (SAD) in the City's groundwater production wells. Drawdown is the decline in water table caused by groundwater extraction/pumping, and the SAD is based on the maximum, total available drawdown in the City's two shallowest wells and a 30% safety factor. Historic groundwater levels, SAD and proposed water conservation stage triggers are shown in Figure 1, further details on the development of these SVA drought triggers are provided in Appendix A3. It is also recommended that the seasonal Stage 2 window be extended from June 1 to October 15. This recommendation is based on analysis of historical groundwater levels and experience from 2022 when unseasonal dry conditions lasted well into October.

The historical groundwater levels shown in Figure 1 also illustrate that Stage 2 drought triggers would have remained in effect in all years, except 2020, during which Stage 3 conservation measures would have been triggered based on the proposed conservation stage triggers. Based on our analysis, it is evident that the abnormal decline in groundwater levels observed in 2020 cannot be attributed to typical climatic conditions or the City's groundwater usage. Instead, it is likely this decline is linked to an extraneous source or event. For further context, the unusual high groundwater levels in late 2021 can be correlated with the atmospheric river events and associated flooding that took place in the area.

It is worth noting that current low groundwater levels in 2023 are close to the proposed Stage 3 (i.e., precautionary) trigger. This reflects poor groundwater level recovery in late 2022 due to the late season drought conditions and additional unusual early season dry conditions that occurred early 2023, including a hot and dry May 2023. It is therefore possible that Stage 3 water restrictions could be triggered in 2023 depending on summer weather conditions, in which it is noted that the extended Environment Canada forecast indicates a 90% chance of a relatively dry and hot summer in the Lower Mainland[1].

It should also be noted that the historical groundwater level ranges coincide with a period of relatively consistent City water demand. It is possible that increasing City groundwater demand (currently expected to double from present levels (about 11 million m^3 per year) to about 20 million m^3 per year by the 2040's) will result in potential and more frequent Stage 3 or Stage 4 restrictions in the future. Proposed triggers are based on current aquifer conditions and available data and should be evaluated periodically for effectiveness, based on new data as it becomes available and as City water demand increases.

We trust that the provided information is sufficient for the City's decision-making purposes. Should you have any questions or comments, please contact the undersigned.

Sincerely

PROFESSIONAL GEOSCIENTIST
PROVINCE OF BRITISH COLUMBIA
Dr. J. BECKERS
#29607

7/12/2023

Jos Beckers, PhD, PGeo
Senior Manager, Groundwater
HATFIELD CONSULTANTS LLP

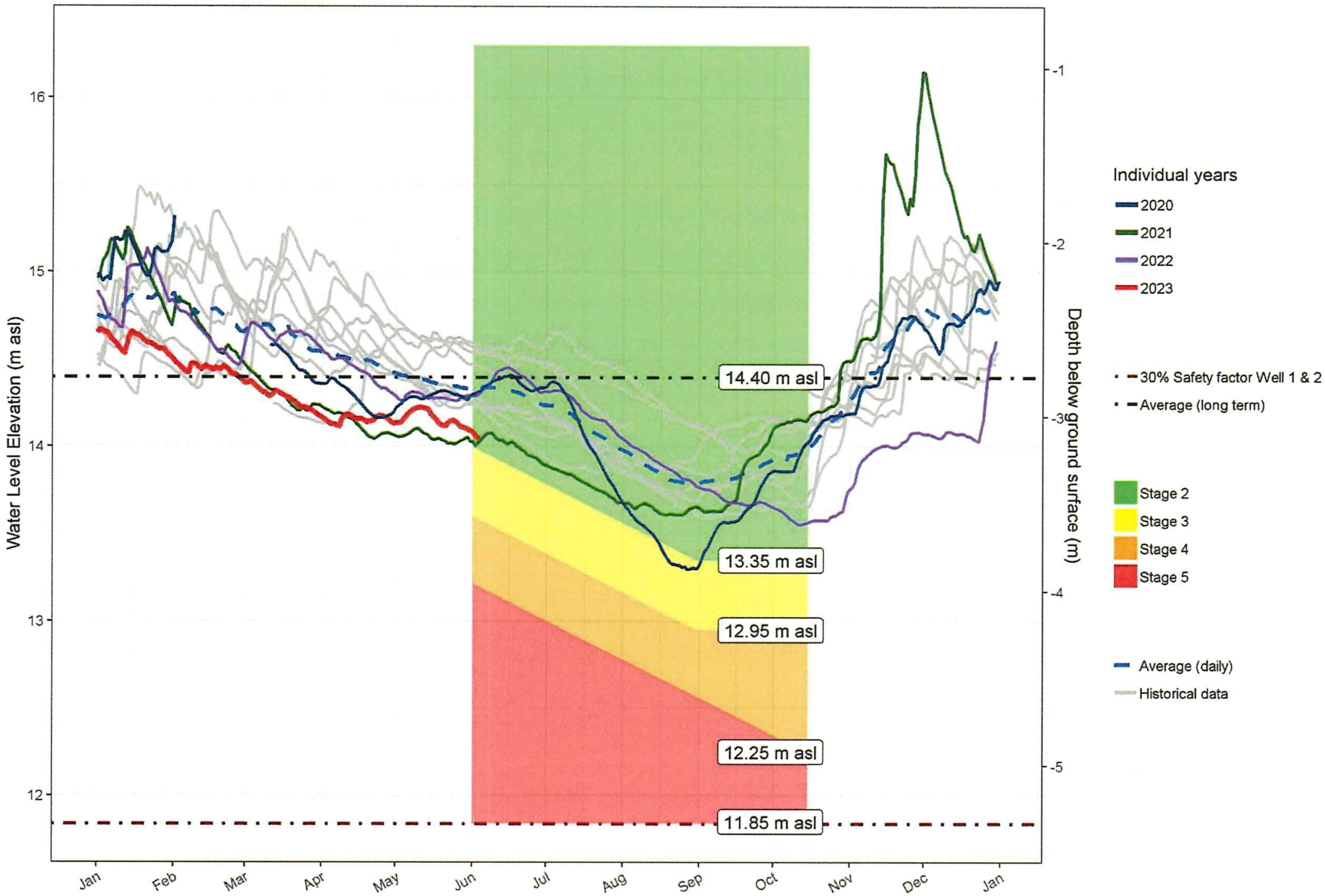
Tim Bennett, MSc, PEng
Director, Water Resources Group
HATFIELD CONSULTANTS LLP

PERMIT NUMBER: 1002914

---

[1] https://www.timescolonist.com/local-news/its-going-to-be-a-hot-hot-summer-in-bc-7096084

Figure 1 Proposed water conservation drought triggers and historical groundwater levels.



APPENDICES

Appendix A1

Water Conservation Card Rack

WATER CONSERVATION IN CHILLIWACK

Our Water Conservation Plan

The City of Chilliwack's water conservation plan is designed to ensure there is an adequate supply of water for non-discretionary uses (like drinking, showering, toilet flushing, doing laundry, and washing dishes) during the summer months when we are more prone to drought conditions. The different stages of the water conservation plan restrict discretionary uses such as lawn watering and filling pools, these different stages are implemented based on weather conditions and the water level in the Sardis-Vedder Aquifer.

There are five stages to the City of Chilliwack's water conservation plan. Annually from June 1 – September 30 the city automatically enters Stage 2 to conserve water early. This helps keep the level of the Sardis-Vedder Aquifer high to minimize the risk of having to move to the next conservation stage later in the summer.

Stages of Water Conservation

STAGE 1 **OCTOBER 1 – MAY 31**

(no restrictions, use of low flow fixtures, rain barrels, etc. encouraged)

STAGE 2 **JUNE 1 -SEPTEMBER 30** (ANNUALLY)

STAGE 3 **PRECAUTIONARY**

STAGE 4 **DRY**

STAGE 5 **VERY DRY**

CITY OF CHILLIWACK

chilliwack.com/water

Scan for more info

Annual Stage 2 Watering Restrictions

Annual Stage 2 watering restrictions are in place June 1 – September 30. Lawn watering is permitted only twice per week, either mornings (between 5 – 8 am) OR evenings (7 – 10 pm), on designated days of the week:

EVEN NUMBERED ADDRESSES
Wednesdays & Saturdays

ODD NUMBERED ADDRESSES
Thursdays & Sundays

GARDENS
As needed
(using handheld spring-loaded hose)

About our Aquifer

The Sardis-Vedder Aquifer is the main source of drinking water for the City of Chilliwack. The Sardis-Vedder Aquifer is also the source of the headwaters for Atchelitz, Chilliwack and Luckakuck Creeks, which is why it is important to conserve as much as we can for people and to protect the environment.

CITY OF
CHILLIWACK

Scan for more info

604.793.2907

waterconservation@chilliwack.com

chilliwack.com/water

Appendix A2

Current Public and Internal Water Conservation Plan

Water Using Activity		2020 - 2022 Current Public and Internal Water Conservation Plan				
	Stage 1	Stage 2 - Normal	Stage 3 - Precautionary	Stage 4 - Dry	Stage 5 - Very Dry (Not posted for Website)	Extreme Heat
1. Lawn Sprinkling	No restrictions, but use of rain barrels, low flow fitting encouraged. (Oct 1 to May 31)	Even addresses – Wednesday & Saturday Odd addresses – Thursday & Sunday 5 - 8am or 7 - 10pm	Even addresses – Wednesday Odd addresses – Thursday 5 - 8am only	Prohibited: All forms of lawn watering using treated drinking water are prohibited.	Prohibited	
2. New Unestablished Lawns		Permits Allowed (1 month) (5-8am or 7-10pm)	Permits Allowed (for 2 weeks) 5-8am only	Prohibited: No new permits issued or renewed. All forms of lawn watering using treated drinking water are prohibited.	Prohibited	
3. Flowers, vegetables, trees and shrubs		Any time of day, watering using a hand-held container, hose with a spring-loaded shutoff nozzle, soaker hose or drip irrigation.	Watering using a hand-held container, or hose with a shut off device or soaker.	Only vegetable gardens with hand-held container or spring-loaded shut off device	At the discretion of the Engineer	
4. Private Pools, Spas and Garden Ponds Filling/Refilling		No restrictions	No restrictions	Prohibited: All filling or topping up of pools, spas, or garden ponds using treated drinking water is prohibited.	Prohibited	
5. Impermeable surface washing		Must use handheld container or a hose with a spring-loaded shutoff nozzle	Washing for aesthetic purposes is prohibited, use of handheld container or hose with shutoff device can be used for painting, or health and safety.	Prohibited: All forms of impermeable surface washing are prohibited unless required to comply with health regulations.	Only for health and safety. At the discretion of the Engineer	
6. Fountains and Water Features		No restrictions	All use of non-recirculkating water features using treated water is prohibited. Recirculating features can be used normally	Prohibited: All use of fountains and water features using treated drinking water is prohibited.	Prohibited	
7. Outdoor Washing vehicles and boats		Must use handheld container or hose equipped with spring-loaded shutoff nozzle. Recommend washing vehicles and boats over grass or gravel.	Must use handheld container or hose equipped with spring-loaded shutoff nozzle. Recommend washing vehicles and boats over grass or gravel.	Prohibited: All forms of impermeable surface washing are prohibited unless required to comply with health regulations.	(Except mirrors and license plates)	
8. Golf Courses		No restrictions	Water tee and green areas normally, fairway watering should be minimized to a maximum of two days per week.	Use of treated drinking water at the discretion of the City, no fairway watering.	At the discretion of the Engineer	
9. Commercial Flower & Vegetable Farms (in urban area)		No restrictions	Limit use to minimal levels	Use of treated drinking water at the discretion of the City, No watering of fairways	At the discretion of the Engineer	
10. Car washes (Business)		No restrictions	No restrictions	Only car washes with recirculation systems allowed	Prohibited	
11. City and School Fields		Sand-based fields daily and soil-based on alternate days between 11pm - 8am	sand-based fields alternate days and soil-based twice a week between 11pm - 8am (water use will be reduced depending on field conditions)	At the discretion of the Engineer	At the discretion of the Engineer	
12. City Passive Lawn Areas		Even addresses – Wednesday & Saturday Odd addresses – Thursday & Sunday 6 - 8am	Prohibited	Prohibited	Prohibited	
13. Hydrant Use Permits		No restrictions	No restrictions	No restrictions	Prohibited	
14. Bulk Fill Stations		No restrictions	No restrictions	No restrictions	Prohibited	
15. Hydrant Flushing		No restrictions	No restrictions	Only for health and safety	Prohibited	
16. Artificial Turf and Tracks		No restrictions	Only for health and safety	Only for health and safety	Prohibited	
17. Water Play Parks		No restrictions	Only with user activated switches	Only with user activated switches	Prohibited	
18. Livestocks Cooling		Max 25 mm connection	Max 25 mm connection	Max 25 mm connection, at the discretion of the City Engineer	Prohibited	

Appendix A3

Technical Derivation and Context for the Proposed Water Conservation Drought Triggers

A3.0 DEVELOPMENT OF THE SVA DROUGHT TRIGGERS

The City currently has a water conservation plan (the Plan) which includes five water conservation stages and associated, increasing levels of water use restriction. However to-date, apart from Stages 1 (no water restrictions) and 2 (basic water restrictions through the summer), the implementation of Stages 3 – 5 (and their associated more stringent restrictions) has been based solely on City staff discretion and judgement.

This Appendix outlines the considerations for and technical derivation of recommended triggers for all water conservation stages. These triggers are intended to provide a simple, transparent and defensible basis for implementation of water conservation measures under the Plan. The potential use of additional triggers focused on the City's permitted groundwater use quantity and protection of sensitive aquatic habitat was also explored but is presently not recommended, as outlined in more detail below.

This analysis builds on previous work by Hatfield to support City groundwater licensing (most recent correspondence in Hatfield 2022c) and assumes familiarity with the aquifer setting (Hatfield 2022a), connected surface water resources such as the Vedder River which acts as a major recharge source for the aquifer and downstream SVA creeks (Atchelitz, Luckakuck, and Chilliwack creeks) which depend on aquifer discharge to maintain flows (Hatfield 2022b).

A3.1 CONTEXT AND BACKGROUND

A3.1.1 Provincial Drought Levels

In British Columbia (BC), drought may be caused by combinations of insufficient snow accumulation, hot and dry weather, or a delay in rainfall. The Provincial Technical Drought Working Group provides drought level updates for each major watershed in the province as conditions warrant, with this information published and updated on the Drought Information Portal[2]. When voluntary conservation measures (e.g., such as the City's water conservation plan) are not sufficient to meet all water rights, or to protect critical environmental flows or the survival of a fish population, the *Water Sustainability Act* (WSA) provides authority for statutory officials, under specified conditions, to regulate water diversion, use (and storage) by users of both stream water and groundwater (i.e., the Province has the authority to regulate the City groundwater use if it deems that conditions warrant this; such as risk to the survival of a fish population).

BC historically categorized drought into four response levels targeted at the water basin and watershed/stream levels (Table A3.1). In 2021 the province updated the provincial drought level scale to a six-level framework to provide more information and transparency on water scarcity conditions and to generally correspond to the north American drought monitor six-level framework. The drought analyses provided below cover both the historical and current definition of drought stages. Drought stages are defined using four core indicators and several supplemental indications to assess drought conditions. Core indicators include two metrics to inform early season forecast (basin snowpack and seasonal runoff volume forecasts) and two metrics that are in use during the June to end of September drought season (last 30-day precipitation and 7-day average streamflow). Supplemental drought indicators include but are not limited to air temperatures and aquifer groundwater (aquifer) levels.

---

[2] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/drought-flooding-dikes-dams/drought-information

Early in the season the drought level represents a forecast of potential dry conditions that could develop throughout the remainder of the year, based on snowpack data and seasonal outlooks, with this information available on the Drought Information Portal web interface. Once the drought season starts, the likelihood and extent of the drought is assessed based on most recent 30-day precipitation (not routinely published on the Drought Information Portal) and 7-day average streamflows (available on the Drought Information Portal). These metrics are relevant to the City groundwater supply as about half the SVA recharge is derived from precipitation while the other half is derived from Vedder River leakage to groundwater (Hatfield 2022a).

As of June 2023, the Province has also started publishing groundwater levels from the Provincial Groundwater Observation Well Network (PGOWN) on the Drought Information Portal.

Table A3.1 Provincial drought levels.

Level	Pre-2021	2021		
		Impacts		General Response Measures
0	NA	No Adverse Impacts	There is sufficient water to meet socio-economic and ecosystem needs	Preparedness
1	Normal	Adverse Impacts Rare	Adverse impacts to socio-economic or ecosystem values are rare	Conservation
2	Dry	Adverse Impacts Unlikely	Adverse impacts to socio-economic or ecosystem values are unlikely	Conservation Local Water restrictions where appropriate
3	Very Dry	Adverse Impacts Possible	Adverse impacts to socio-economic or ecosystem values are possible	Conservation local water restrictions likely
4	Extremely Dry	Adverse Impacts Likely	Adverse impacts to socio-economic or ecosystem values are likely	Conservation and local water restrictions regulatory action possible
5	NA	Adverse Impacts Almost Certain	Adverse impacts to socio-economic or ecosystem values are almost certain	Conservation and local water restrictions Regulatory action likely Possible emergency response

A3.1.2 Vedder River

The Drought Information Portal publishes 7-day average flow conditions for streamflow gauges across BC. Drought levels are based on statistical analysis of recorded flows:

- Drought Level 0: > 30th percentile of historical flows
- Drought Level 1: 21st to 30th percentile
- Drought Level 2: 11th to 20th percentile
- Drought Level 3: 6th to 10th percentile
- Drought Level 4: 2nd to 5th percentile
- Drought Level 5: <2nd percentile

The Water Survey of Canada Vedder River Crossing gauge (08MH001) is one of several monitored stations informing definition Lower Mainland Region drought management levels. Current Vedder River flow conditions are shown in Figure A3.2. Historical conditions and statistical ranges are based on long-term data from 1911-2022. The graph shows that during the extended late season dry period in 2022 flows in the Vedder River dropped to and sometimes below historical ranges while during the early season dry period in May 2023 flows were also near historical minimum ranges before increasing during an earlier than normal freshet (spring snowmelt runoff). Early freshet conditions typically tend to lead to lower than normal late season flow conditions.

A3.1.3 Groundwater Levels

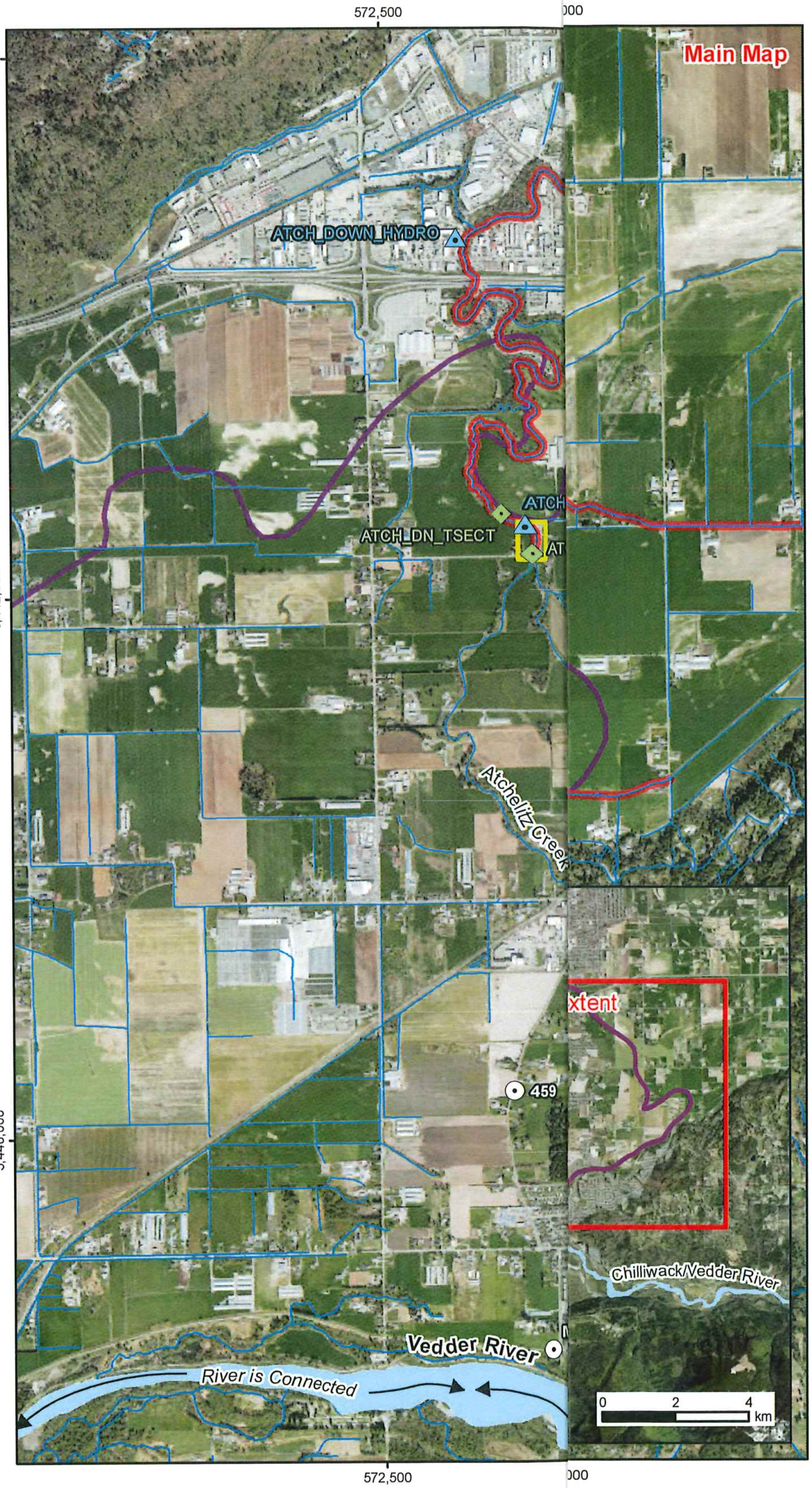
As of June 2023, the British Columbia Drought Information Portal has included information on groundwater conditions using PGOWN data. Currently these data are based on historical statistics for the period of record of observation wells and are not used to interpret potential drought conditions in the aquifer. Rather the statistics indicate relative state of groundwater levels, as follows:

- High: the highest ever measured for the day of year
- Much above normal: greater than the 90th percentile
- Above normal: Between 75th and 90th percentile
- Normal: 25th and 75th percentile
- Below normal: less then 25th percentile
- Much below normal: less then 10th percentile
- Low: lowest ever measured for the day of the year

There are two PGOWN monitoring wells installed in the SVA, observation wells OW459 and OW406 (Figure A3.1). PGOWN monitoring data is available in near real-time. Gullacher et al. (2023) attempted to develop early season and drought season core indicators of groundwater drought. While they included PGOWN wells within the Fraser Valley, they were only able to identify a handful of select wells sensitive to the climate and hydrological predictor variables and SVA wells were not included in the analysis. Nevertheless, data for OW406 been used herein for drought trigger definition and was found to be useful for analysis. Data for OW459 was found to be relatively insensitive to hydroclimatic variability and has not been used. OW406 data[3] is shown in Figure A3.1 and indicates that in late 2022 groundwater levels were lowest ever measured and that current groundwater levels in 2023 are again near or below historical low ranges. It is noted that the data range used in statistics for OW406 is relatively limited (11 years).

[3] http://bcrfc.env.gov.bc.ca/Real-time_Data/Interactive_Q_process/InteractivePlots/groundwater_levels/OW406_dailyWL.html

Figure A3.1 Pumping Well and groundwater m



Legend

- Chilliwack - Vedder River
- Creeks
- Salish Sucker Critical Habitat
- Flow Augmentation Area
- Sardis Vedder Aquifer
- Riparian Habitat Restoration Area

Monitoring Locations

- EFN Transect
- Hydrology Station
- Chilliwack Production Wells
- Chilliwack Monitoring Wells

0 200 400 600 800 m

N

Scale: 1:30,000

Projection: NAD 1983 UTM Zone 10N

Data Sources:

a) Flow augmentation areas, Hatfield 2023.
b) Sardis Vedder Aquifer, BC Groundwater Aquifers, Ministry of Environment and Climate Change, 2020.
c) Riparian habitat restoration areas, LTSA 2016, modified by Hatfield in 2023.
d) Salish Sucker Critical Habitat derived using recovery strategy for the Salish Sucker (Catostomus sp.) in Canada, DFO 2021.
e) Hydrometric Stations, Ministry of Forests, Lands, natural Resource Operations, BC, 2018; Water Survey Canada, 2020.
f) Wells, City of Chilliwack, 2020; Ministry of Environment and Climate Change, 2020.
g) Hydrology, Freshwater Atlas accessed 2019 and modified by Hatfield 2020.
h) Background, 10 cm Orthophoto, 01 May 2021, Esri Online Service.

Hatfield

SVA Groundwater Model For EFN Study

K:\Data\Project\CHILL10102-NV\A_MXD\Report_Maps\GAAMP\CHILL10102_GAAMP_Flo

Figure A3.2 Vedder River Crossing discharge data.

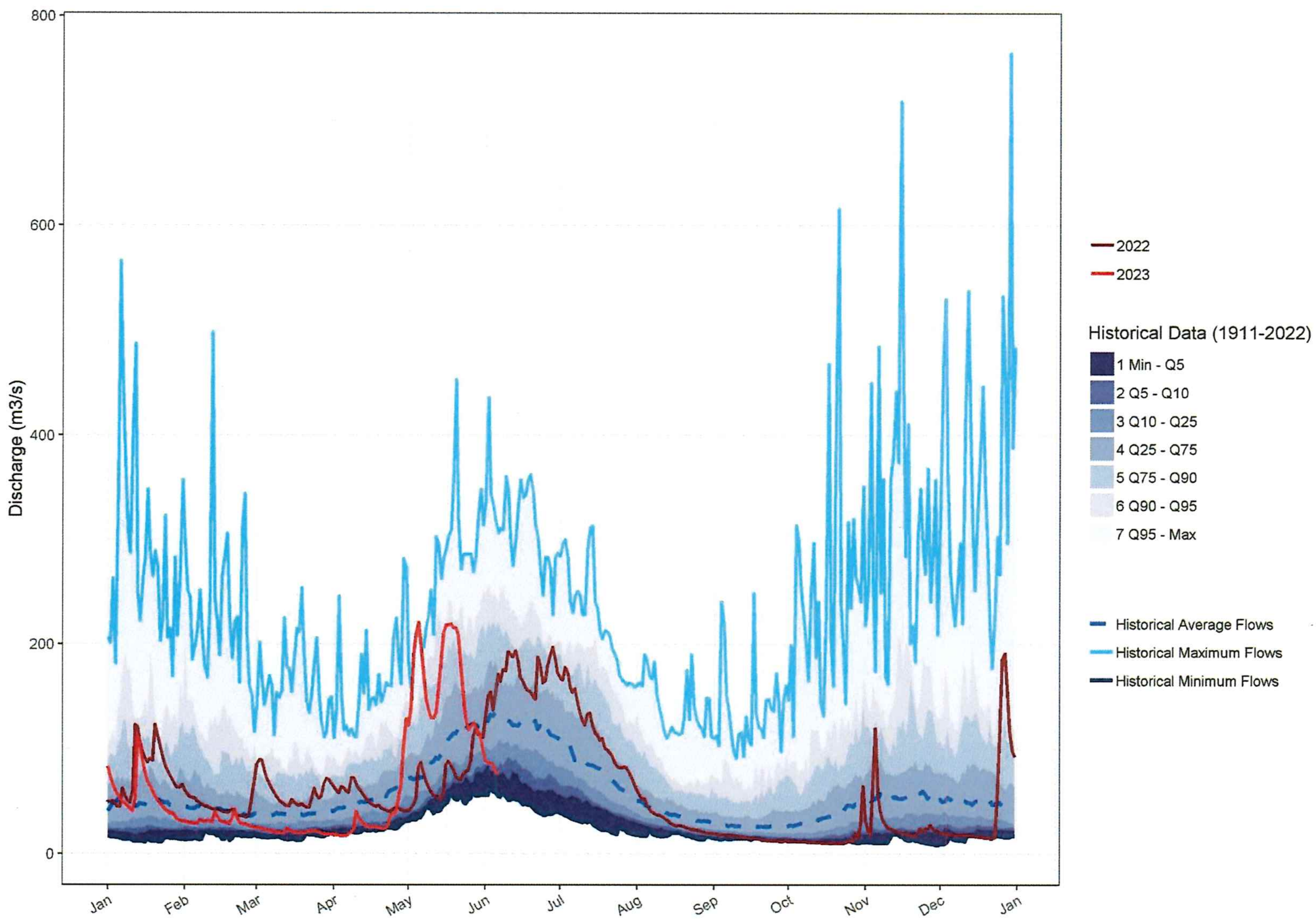
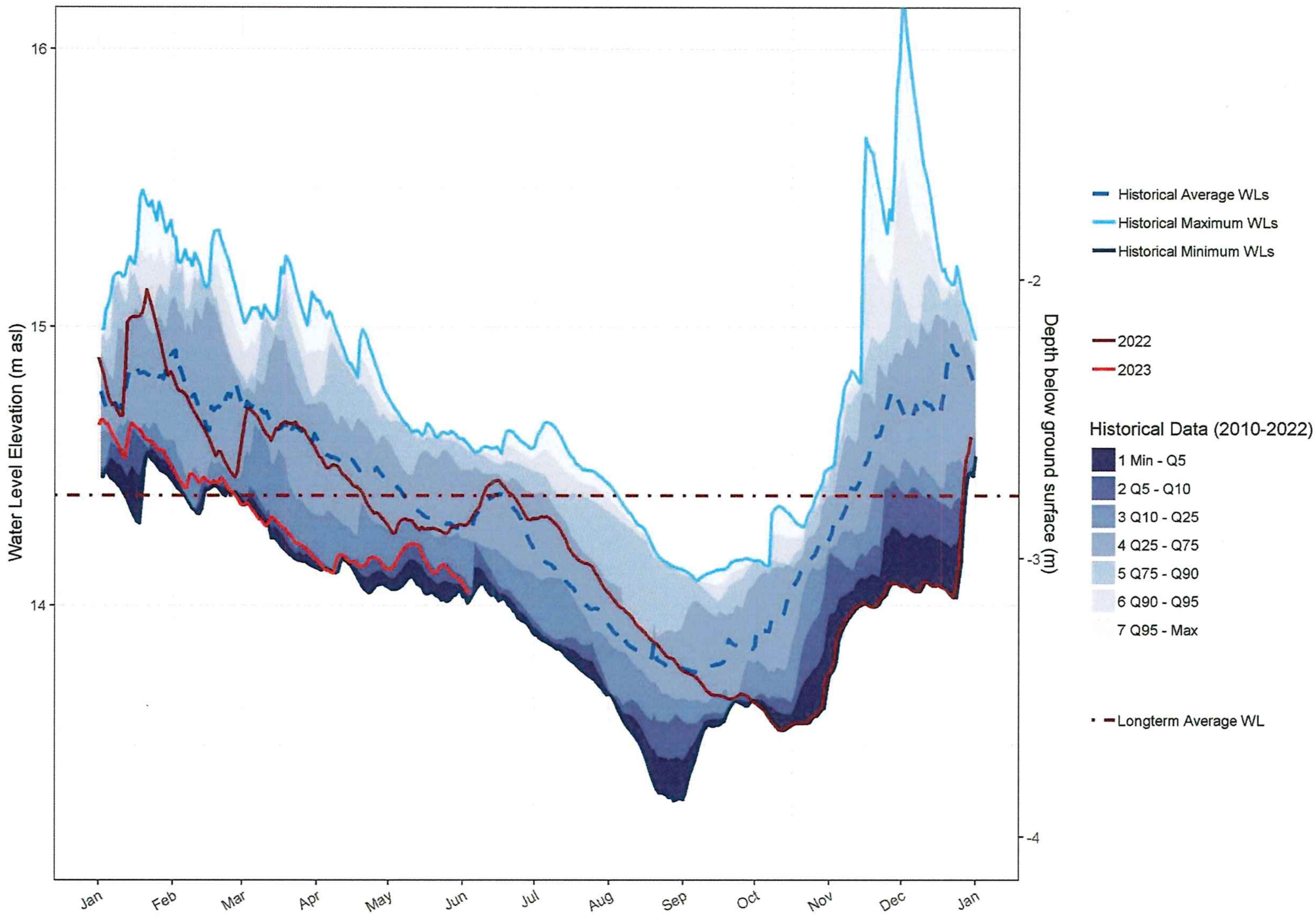


Figure A3.3 Groundwater level data for provincial observation well 406.



A3.1.4 Historical Drought Stages

Historical drought stages for the Lower Fraser are available within the Drought Information Portal since 2015 and displayed in Figure A3.4 along with 30-day precipitation represented at Agassiz climate station (ID: 110010). It is noted that the 30-day precipitation shown in Figure A3.4 does not necessarily reflect Provincial Technical Drought Working Group use of data, which is not precisely defined. They most frequently use a combination of the Agriculture Canada National Agroclimate Risk Report, Agriculture Canada maps of current agroclimate conditions, and the North American Drought Monitor maps (Natasha Cowie, River Forecast Centre, *personal communication*).

The recent worst drought years for the Lower Mainland have been 2015, 2021 and 2022. Figure A3.5 compares drought levels for these years to 7-day average flows on the Vedder River and groundwater levels in the SVA as observed at OW406. Generally, the highest drought levels correspond to the lowest seasonal groundwater levels each year. However, drought conditions in 2015 did not correspond to below average groundwater levels. Groundwater levels in 2021 and 2022 did result in lower-than-normal groundwater levels (on the order of ~20-30 cm below normal). Vedder River streamflows do appear to be close to historical low ranges during historical Level4/5 drought periods for the Lower Mainland Region.

The lowest historical groundwater levels recorded at OW406 were in 2020. However, this year did not have severe drought conditions (Figure A3.6), suggesting some other potential influence on the aquifer or locally near the monitoring well.

Figure A3.4 Historical invocation of provincial drought levels for Lower Fraser Valley.

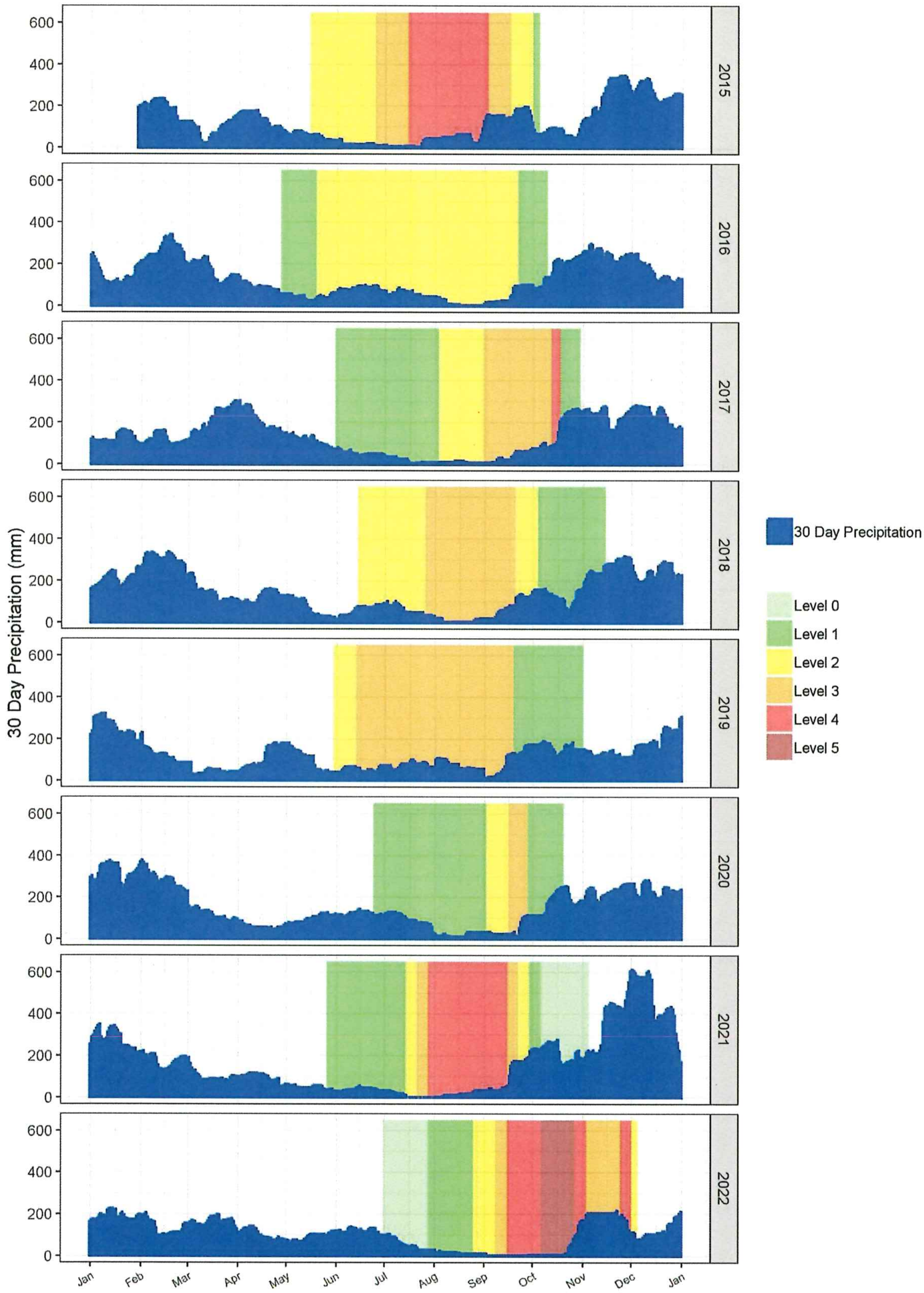


Figure A3.5 Lower Mainland drought levels compared to Vedder River discharge and OW406 groundwater levels for drought years.

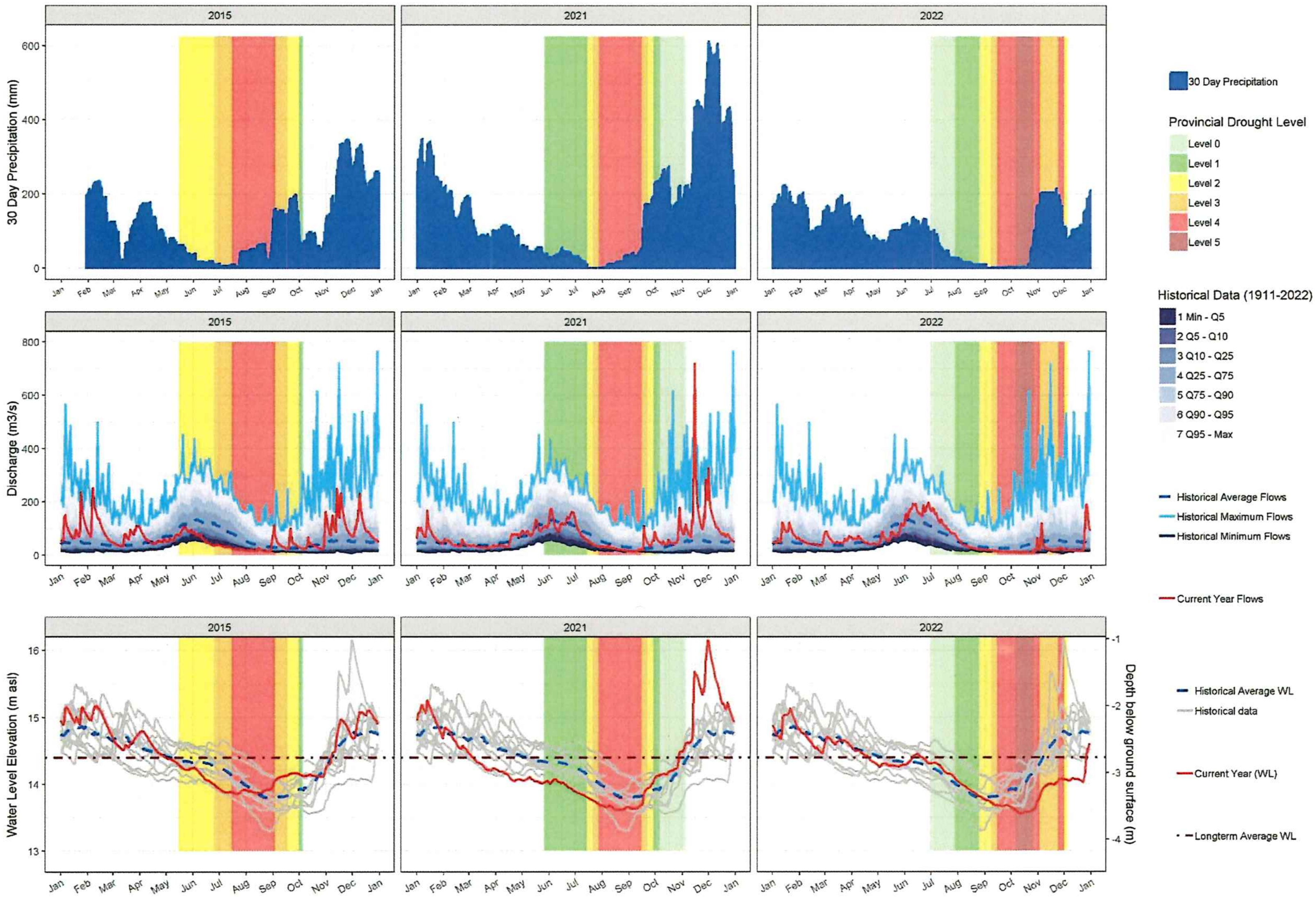
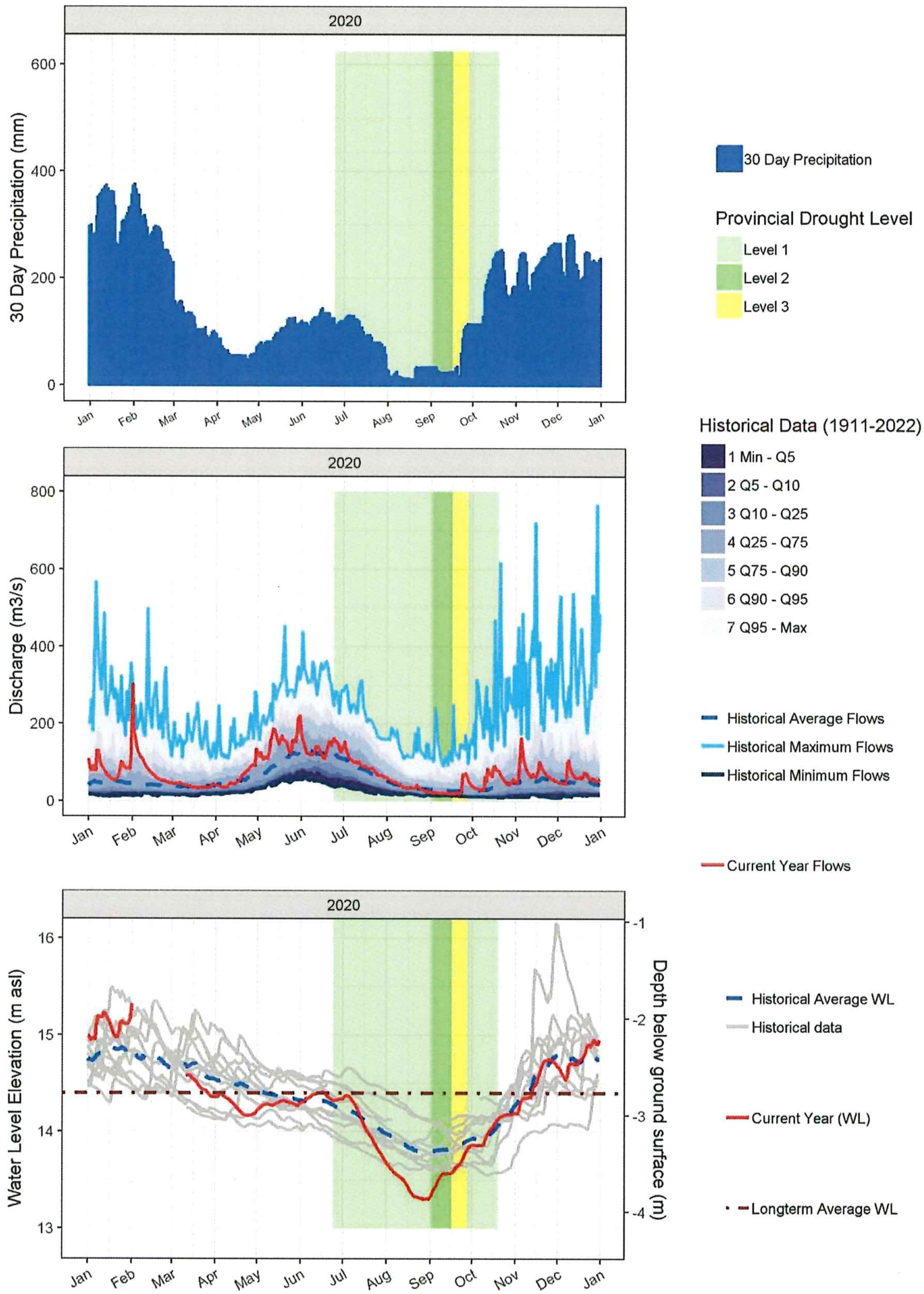


Figure A3.6 Comparing Lower Mainland drought levels to groundwater levels in 2020.



A3.2 POTENTIAL WATER CONSERVATION TRIGGERS

A3.2.1 City Water Conservation Stages and Triggers

Currently there are five stages to Chilliwack's water conservation plan outlined in Table A3.2, Appendix A1 and Appendix A2. Stage 2 water restrictions are implemented annually from June 1 to September 30th to conserve water early in the season. Stages 3-5 are implemented at the discretion of the City but are not based on defined triggers.

Table A3.2 Current City Drought Stages.

Stage		Implementation
1	Normal	October 1 - May 31
2	Normal	June 1 - September 30th
3	Precautionary	At Discretion of City
4	Dry	At Discretion of City
5	Very Dry	At Discretion of City

Hatfield explored the following potential triggers:

- Groundwater levels affecting City groundwater supply
- Water use reaching licensed conditions
- Environmental flow needs (EFN) concerns for the downstream SVA creeks
- EFN concerns and/or drought conditions for the Vedder River

Recommendations around these potential triggers are outlined below.

A3.2.2 Groundwater levels Affecting City Groundwater Supply

Water conservation triggers are proposed below based on historical groundwater level data and the following concepts:

- Safe available drawdown as an accepted measure of sustainable well operation.
- Typical winter groundwater levels in the SVA as an early season indicator.
- Typical wet season groundwater level recovery to prevent aquifer depletion (groundwater mining).
- Typical rates of dry season groundwater level decline.

These metrics are explored below.

A3.2.2.1 Safe Available Drawdown

Safe Available Drawdown (SAD) for unconfined aquifers, such as SVA, is typically defined as 70% of the Total Available Drawdown (TAD) in British Columbia. TAD represents the difference between the average groundwater level in the aquifer and the top of the well screen or top of the pump installed in a production well. In the case of City wells 1&2, which are the shallowest production wells, TAD was determined to be approximately 9.22 m, resulting in an SAD of 3.17 m. TAD was calculated using groundwater model simulated water levels without pumping in the aquifer Hatfield (2022a; Table 4) and considering the top of pump (since pumps are installed above top of well screen in wells 1 and 2).

In Table A3.3, SAD is also calculated for other City production wells. Where the pump elevation was not known, top of screen was used in analysis. The comparison indicates that the use of wells 1 and 2 is conservative given that SAD is (much) lower than for other production wells. Therefore, if SAD were ever to be approached for wells 1 and 2, pumping could theoretically simply be diverted to other production wells to maintain supply (while taking into consideration the maximum pumping capacity of each well).

City groundwater level monitoring data is not yet available in real-time for use in drought analysis. PGOWN monitoring data for OW406 was therefore used instead. Because OW406 is located some distance away from the City production well field, equivalent (hypothetical) SAD conditions at OW406 (SAD_{OW406}) needed to maintain SAD at wells 1 and 2 ($SAD_{W1\&2}$) were calculated as follows:

$$SAD_{OW406} = TAD_{W1\&2} - SF_{W1\&2} - TMD - SFD$$

Where:

- SAD_{OW406} = equivalent safe available drawdown relative to long-term average groundwater level at OW406
- $TAD_{W1\&2}$ = total available drawdown at wells 1 and 2 (static groundwater level minus pump elevation at wells 1 and 2)
- $SF_{W1\&2}$ = 30% of $TAD_{W1\&2}$ (i.e., leaves 70% safe available drawdown at wells 1 and 2)
- TMD = theoretical max drawdown at wells 1 and 2 when pumping at full capacity for 100 days (Theis analysis). The period of 100 days is typically used in BC to simulate extended drought conditions without aquifer recharge.
- SFD = Difference in seasonal groundwater level fluctuation OW406 and the monitoring well nearest to the City production wells (MW92-1).

TMD was calculated using the Cooper and Jacob (1946) modified Theis (1935) solution:

$$s = \frac{2.3Q}{4\pi T} log \frac{2.25Tt}{r^2 S}$$

Where:

- s = drawdown (m); in this case equivalent to TMD
- Q = pumping rate (m^3/day) max theoretical pumping rates (well capacity) for wells 1 and 2 based on AE (2020; Table 4)
- r = radial distance away from pumping well (m) = 0.1 m
- T = transmissivity (m^2/day) taken from Hatfield (2022a) = 12,960 m^2/day
- S = aquifer storativity (dimensionless) taken from (Hatfield 2022a) = 1×10^{-3} m^2/day
- t = time since pumping started (days) taken at 100days

TMD calculations were performed for wells 1 and 2 and for other City production wells (Table A3.3). Higher TMD values reflect lower local aquifer transmissivity while lower TMD values reflect higher transmissivity.

To determine final SAD_{OW406}, an adjustment was made to consider OW406 as representative of seasonal conditions near the City pumping wells. This was done by comparing the closest monitoring well to the City pumping wells (MW92-1), where the typical seasonal fluctuation at the well is on the order of 2.1 m, while the typical seasonal fluctuation at OW406 is 1.4 m. The difference in this seasonal fluctuation (0.7 m) was used to align OW406 with conditions observed at wells 1 and 2 (SFD). The final outcome of this analysis is therefore the 11.85 m asl line shown in Figure A3.7, which maintains 30% safety factor at wells 1 and 2. It is noted that the above calculations are relatively complex because conditions at wells 1 and 2 needed to be transposed to equivalent conditions at OW406. Once the City monitoring data becomes available for real-time analysis, it may be beneficial to update and simplify the existing proposed trigger framework.

Table A3.3 Pumping well completion and safe available drawdown data.

Well Name	Completion Depth (m bgs)	Top of Well Screen (m asl)	Bottom of Well Screen (m asl)	Well Capacity[1] (m³/day)	Pump Elevation (m asl)	Static Water Level[2] (m asl)	Total Available Drawdown (TAD) (m)	30% Safety Factor (SF)[3] (m)	Theoretical Max Drawdown (TMD)[4] (m)	Safe Available Drawdown (SAD) (m)
Well 1	24.4	2.8	-3.3	3,800	8.5	17.72	9.22	2.77	3.29	3.17
Well 2	29.9	7.1	-4.5	16,300	8.9	17.72				
Well 3	33.1	3	-3.4	20,200	2.9	18.37	15.51	4.65	3.50	7.36
Well 6	48.5	-11.4	-22.8	8,600	unknown	17.54	28.94	8.68	3.15	17.11
Well 7	52.1	-20.1	-29.1	10,800	unknown					
Well 8	59.5	-23.1	-35	6,500	unknown	18.70	41.80	12.54	1.05	28.21
Well 9	65.5	-12.1	-40	20,200	unknown	18.00	30.10	9.03	3.50	17.57
Well 10	45.1	-11	-16.1	5,200	unknown	18.89	29.89	8.97	0.84	20.08

[1] Capacity from AE (2020)

[2] Data from Table 4 in Hatfield (2022a).

[3] 30% of Total Available drawdown

[4] Calculated from Cooper and Jacob (1946).

m bgs = Meters below ground surface.

M asl = meters above sea level

A3.2.2.2 Winter Groundwater Levels

Winter groundwater levels provide an important early season indicator of whether relatively low groundwater level conditions may establish in the aquifer during the drought season. This is illustrated by current conditions in the SVA (Figure A3.7), groundwater levels in 2023 have been relatively low largely because of below normal winter groundwater levels at the start of the year. A statistical analysis of winter groundwater levels is therefore provided in Table A3.4.

Table A3.4 Winter groundwater level statistics for OW406.

Statistics	December-February Groundwater Levels (m asl)
Maximum	16.15
95th Percentile	15.23
75th Percentile	15.00
50th Percentile	14.77
25th Percentile	14.54
5th Percentile	14.37
min Percentile	14.03

A3.2.2.3 Seasonal Water Level Recovery

The amount of seasonal groundwater level decline that may occur throughout the year should remain commensurate with expected groundwater level rebound during the wet season in order for the groundwater supply to be long-term sustainable. An aquifer not being able to recover to typical levels could contribute to long-term groundwater decline (groundwater mining). The ability of the aquifer to recover during the wet season was therefore considered. Historical groundwater level recovery data was evaluated and displayed in Table A3.5, considering the difference between the minimum water level in the summer months (June-October) and maximum water level in the winter months (December – February). Average wet season groundwater level recovery is 1.42 m with the lowest recorded recovery being 0.84 m (2018) and the highest 2.54 m (2021). The highest groundwater level recovery corresponds to the 2021 atmospheric rain events.

Table A3.5 Seasonal groundwater level recovery for OW406.

Year	Minimum Water Level Summer Months (June-October; m asl)	Maximum Water Level in following Winter Months (December-February; m asl)	Seasonal Recovery (m)
2010	14.46	15.49	1.03
2011	13.97	15.07	1.10
2012	13.68	15.02	1.34
2013	14.11	15.21	1.10
2014	13.94	15.21	1.27
2015	13.86	15.35	1.49
2016	13.69	15.25	1.56
2017	13.59	15.27	1.67
2018	13.71	14.55	0.84
2019	13.84	15.32	1.48
2020	13.30	15.25	1.95
2021	13.61	16.15	2.54
2022	13.55	14.67	1.12
		Average	**1.42**
		Minimum	**0.84**
		Maximum	**2.54**

A3.2.3 Proposed Groundwater Level Triggers

Historical water level observations and the typical annual groundwater decline and recovery pattern (Figure A3.7) indicate that groundwater levels generally start declining on June 1st and begin their seasonal recovery around October 15th. Therefore, it is recommended to extend the Stage 2 drought management period until October 15th from the current September 30 end date.

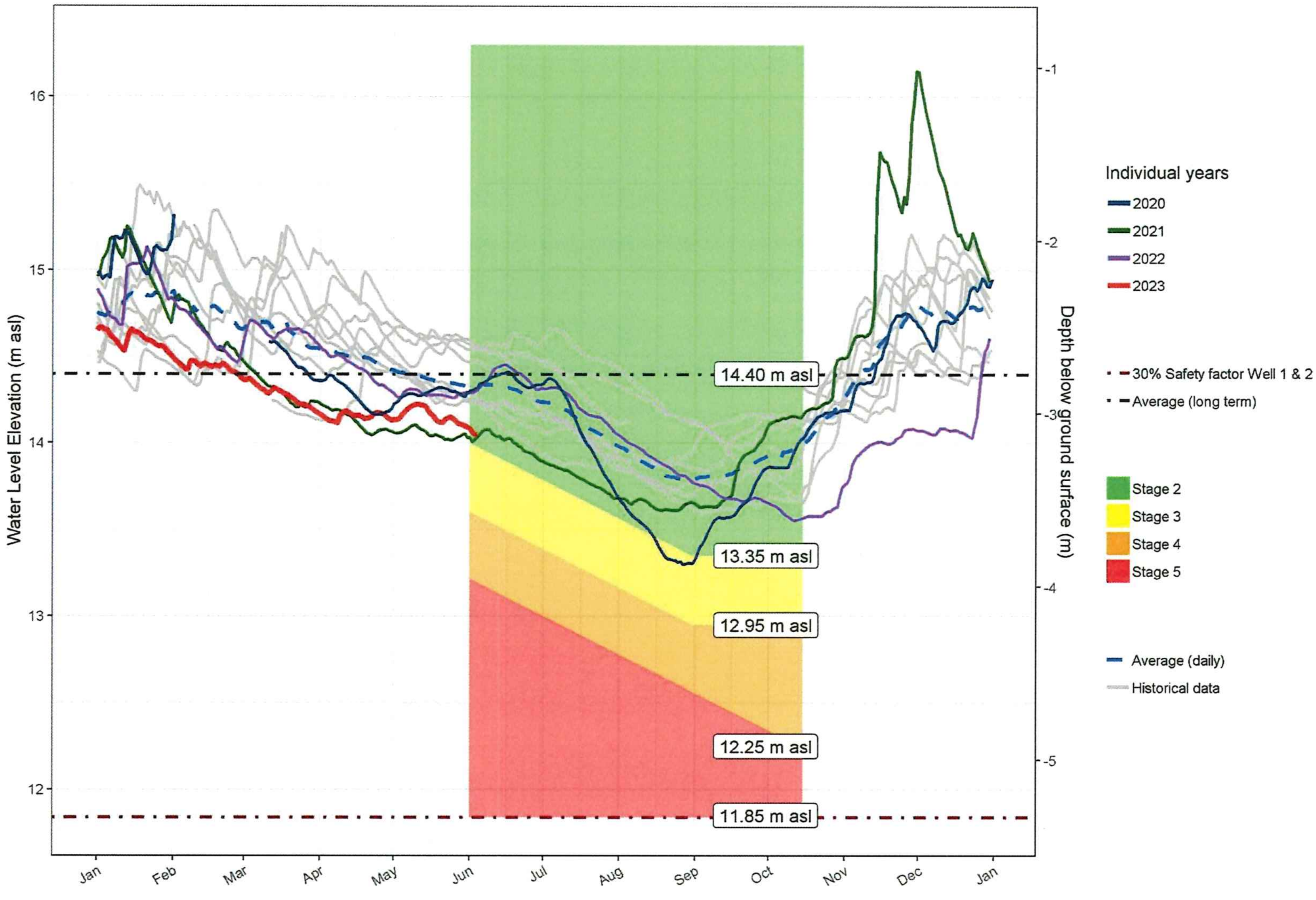
For higher level water conservation stages (Stages 3-5), a focus is placed on not reaching specified triggers by the end of the Stage 2 period (Oct 15th). The rationale for each October 15 trigger stage is provided in Table A3.6, with these triggers also shown in Figure A3.7. The October 15 trigger values are extrapolated backward to start of the seasonal water conservation period (June 1) following the typical slope of groundwater decline, with water levels typically steadying at their lowest levels over the September to mid-October period.

Except for 2020, groundwater levels have therefore remained within the proposed Stage 2 water conservation ranges (i.e., Stage 3 would not have triggered except in 2020). If groundwater levels remain within proposed Stage 2 ranges, water levels should typically be able to recover to near normal levels during the wet period based. If groundwater levels drop to within Stage 3 ranges, water levels may struggle to recover to average winter levels, although they should still recover to levels within the historical range. By Stage 4, water levels will face difficulty in recovering to historical winter ranges. Finally, at Stage 5, water levels will only recover to historical winter levels in a high-water-level recovery year (such as 2021) and are at risk of approaching SAD for wells 1 and 2.

Table A3.6 Proposed water conservation stages based on groundwater triggers.

Stage	Trigger
Stage 1	October 15th – June 1st
Stage 2	June 1st – October 15th
Stage 3	Set based on historical average winter levels (50th percentile) and historical average recovery (1.42 m): 13.35 m asl = 14.77 m asl (50th percentile winter) –1.42 m (average recovery).
Stage 4	Set based on historical lower 5th percentile of winter water levels and average recovery: 12.95 m asl = 14.37 m asl (5th percentile winter) – 1.42 m (average recovery)
Stage 5	Water levels in following winter would only recover based on maximum historical recovery. This October target is 40 cm above 30% drawdown safety factor at shallowest City production wells (Well 1 and Well 2; 11.85 m asl). 12.25 m asl = 14.77 m asl (50th percentile) –2.54 m (maximum recovery)

Figure A3.7 Proposed groundwater drought stages and historical water levels at OW406.



A3.2.4 Water Usage

Cumulative annual City groundwater use relative to licensed amounts was explored as a potential supplementary metric to inform water conservation triggers.

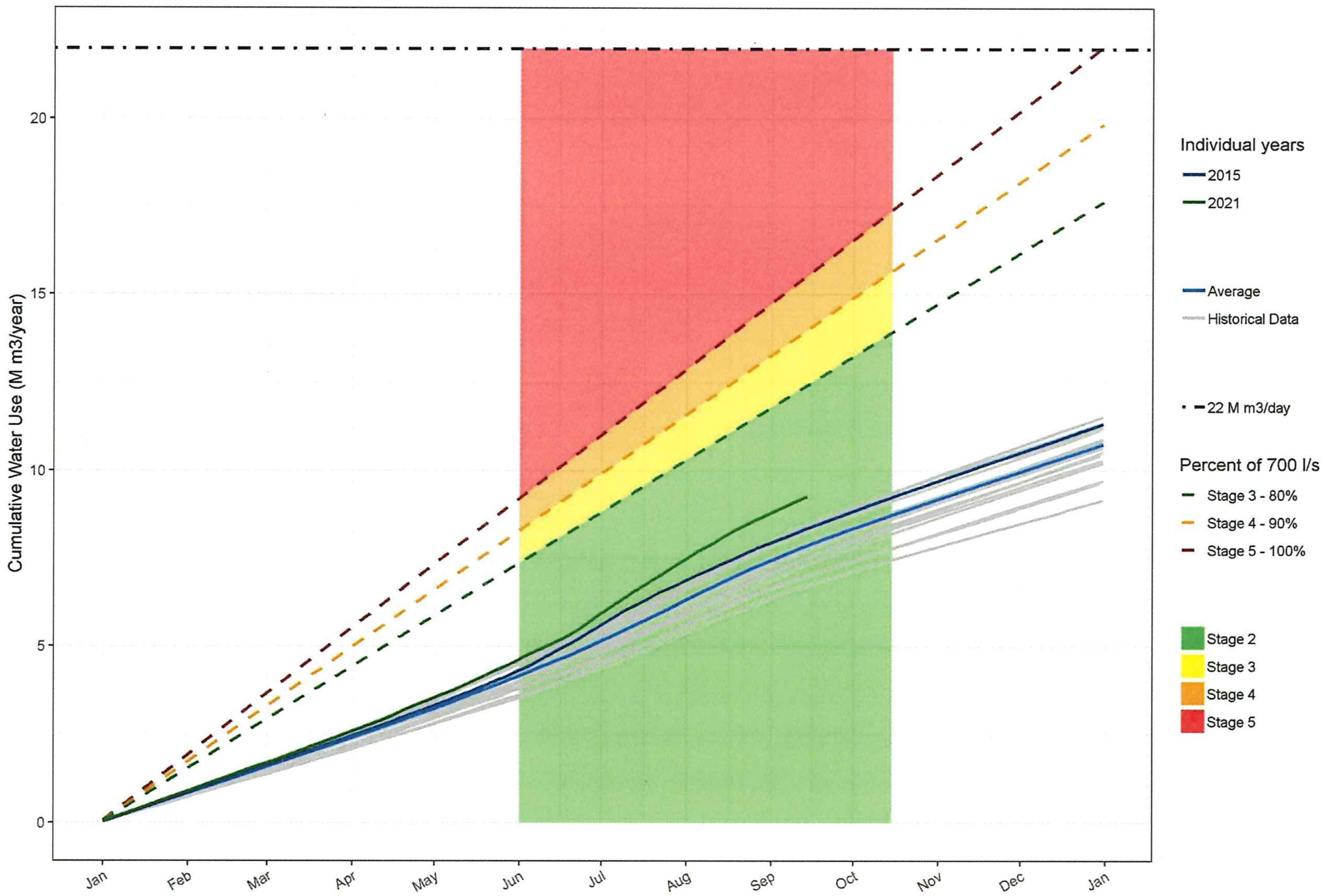
Prior to groundwater licensing requirements introduced in 2016, with the implementation of the *Water Sustainability Act*, the City had previously received an Environmental Assessment Certificate authorizing groundwater pumping at rates up to 600 L/s from the SVA. The City also received a subsequent Order from the Environmental Assessment Office (EAO) in 2009 indicating that no additional assessment was required if average monthly and annual extraction rates did not exceed 700 L/s (i.e., 22 M m^3/year). Following new groundwater licensing requirements in 2016, the City had applied for Provincial groundwater licenses for 22 Mm^3/year (to meet its projected future municipal demand). To date, the City has received groundwater licenses (500637 and 503206) which authorize existing groundwater withdrawal and use of 11 Mm^3/year.

Possible cumulative water use triggers were explored as a percentage of the 700 L/s monthly maximum pumping EAO exemption and associated cumulative annual water use amount (22 M m^3/year). Figure A3.8 shows historical City cumulative groundwater use data with recent Lower Mainland drought years (2015 and 2021) highlighted for emphasis. The data record available for analysis only extended partly into 2021. Despite the limited analysis it is evident that current City water usage is not near levels that would require an adaptive management framework and no triggers are recommended currently. However, it may be necessary to reassess the need for water demand triggers as water usage is projected to substantially increase over the coming decades (AE 2020).

A3.2.5 SVA Creeks

Previous analyses found poor correlation between monitored groundwater levels (OW406) and low flow conditions in the SVA creeks. This may be largely attributable to SVA creek flow conditions being influenced by a range of anthropogenic factors including pumping to prevent Fraser River backwater effects, as documented in Hatfield (2022b). It is also possible that the relatively short-term monitoring record for the SVA creeks factors in the poor correlation with groundwater level data. Therefore, it is presently not possible to establish a drought groundwater level trigger framework to protect aquatic habitat in the SVA creeks. Furthermore, under the currently proposed 22 M m^3/year water license, flow augmentation and other adaptive management measures would be implemented to maintain existing flow conditions in the SVA creeks. These proposed adaptive management measures, which are part of the in-progress Groundwater Adaptive and Aquatic Management Plan (GAAMP), would supersede the need for a separate drought trigger framework if adopted as part of the pending groundwater license application. At present, there are therefore no recommended triggers for protection of the SVA creeks under drought conditions. This may need to be revisited if the pending license application is not approved.

Figure A3.8 City cumulative groundwater usage displaying drought years (2015, 2021) and possible triggers.



A3.2.6 Vedder River Flows

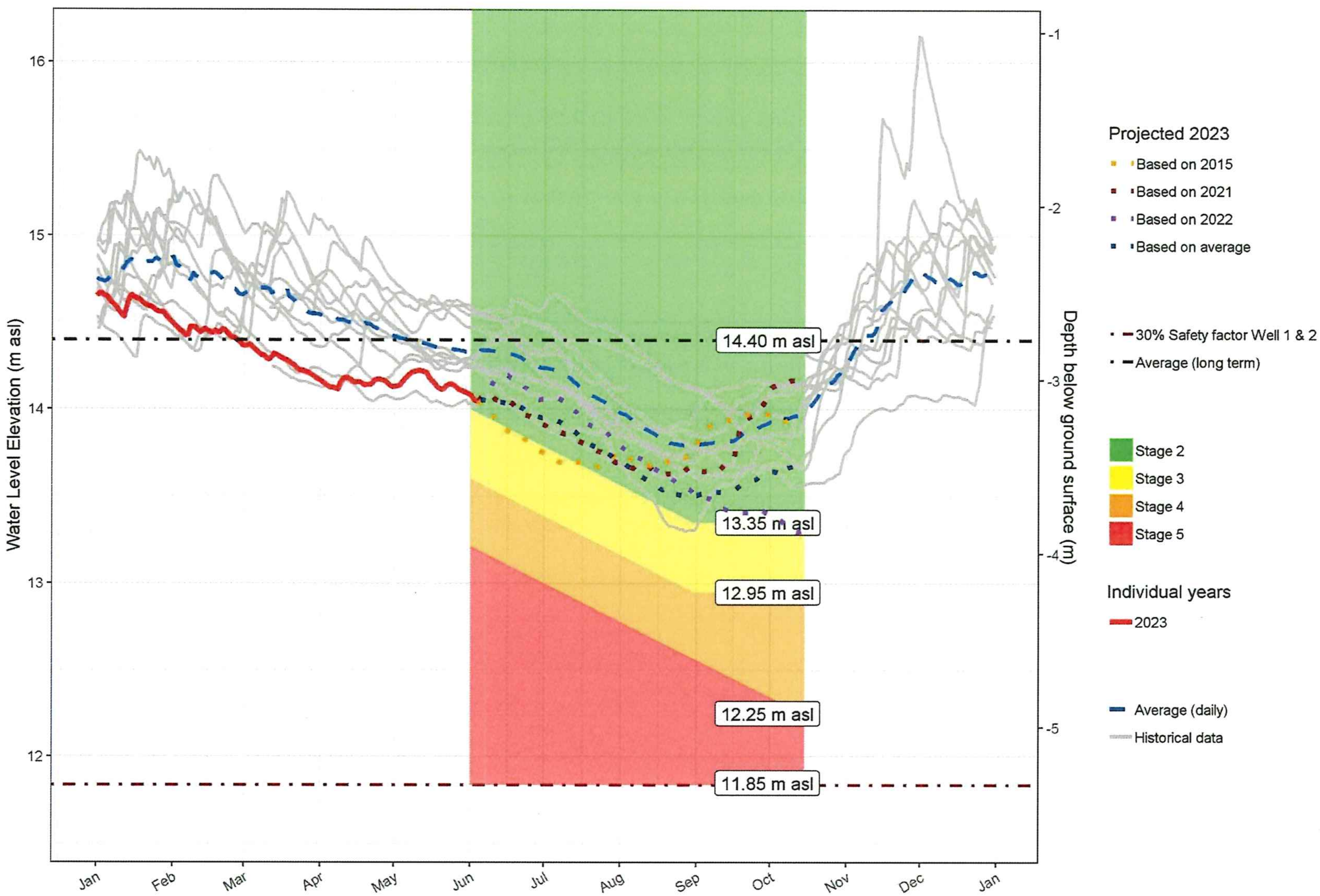
The *Water Sustainability Act* (WSA) provides authority for statutory officials, under specified conditions, to regulate water diversion, use (and storage) by users of both stream water and groundwater (i.e., the Province has the authority to regulate the City groundwater use if it deems that conditions warrant this; such as risk to the survival of a fish population). In this context it is important to note that the Ministry of Forests (MOF) had previously expressed potential concern about possible influence of the proposed increase in City pumping that is part of the pending license application (i.e., to a maximum of 22 M m^3/year). To address this concern, Hatfield (2022c) provided a conservative assessment of the potential impact of City pumping of 22 M m^3/year on Vedder River flows. This analysis indicated that City pumping would represent a maximum of 5% impact under historical low flow conditions and accounting for natural river losses where it is perched above aquifer (i.e., a small impact). This small potential for impact suggests that there is no need for Vedder River drought triggers related to City groundwater use. The Hatfield (2022c) analysis can also be used as argument should the Province seek to regulate Vedder River water use at any point in the future (e.g., under severe drought conditions).

A3.3 2023 GROUNDWATER CONDITIONS

The City requested Hatfield provide projections of potential groundwater levels for the remainder of 2023. Environment Canada has indicated that 2023 could potentially be a hot and dry summer. Projected scenarios are based on previous historical conditions and drought years (Average year, 2015, 2021 and 2022), projecting the remainder of 2023 from June 7th based on historical years. Results are displayed in Figure A3.9. It is noted that 2020 (low anomalous groundwater year), was not used in analysis as it appears to be influenced by factors that deviate from typical climate forcing (Figure A3.6). This anomaly could be attributed to localized use of the aquifer or other factors not captured by historical patterns.

Results indicate that while using the proposed groundwater triggers (Section A3.2.3) the city is most likely to remain in Stage 2 conditions for the remainder of the summer with some chance of reaching Stage 3 conditions. However, these projections present a simplified analysis and actual conditions through the remainder of 2023 may vary.

Figure A3.9 Projected groundwater levels based on seasonal years.



A3.4 SUMMARY AND RECOMMENDATIONS

Key recommendations arising out of the analyses presented herein are outlined below, and include:

- That the seasonal Stage 2 window is extended from June 1 to October 15. This recommendation is based on analysis of historical groundwater levels and experience from 2022 when unseasonal dry conditions lasted well into October.
- That Stage 3 – 5 drought triggers are based on Figure A3.7.

These proposed triggers are based on current aquifer conditions and available data and should be evaluated periodically for effectiveness, based on new data as it becomes available and as City water demand increases.

Once City groundwater level monitoring data becomes readily available for real-time analysis, it may also be beneficial to update and simplify the existing framework rather than rely on PGOWN data.

A3.5 REFERERENCES

[AE] Associated Engineering. 2020. Sardis Wellfield Yield Assessment Technical Memorandum. Prepared for the City of Chilliwack, November 2020.

Gullacher A, Allen DM, Goetz JD. 2023. Indicators of Groundwater Drought in British Columbia. Water Science Series, WSS2023-01. Prov. B.C., Victoria.

Hatfield Consultants LLP. 2022a. Sardis Vedder Aquifer Groundwater Flow Model to Assess Pumping Effects on SVA Creek Flows. Prepared for City of Chilliwack. Version 4. March 2022.

Hatfield Consultants LLP. 2022b. Sardis Vedder Aquifer (SVA) Environmental Flow Assessment and Needs Determination. Prepared for City of Chilliwack. Version 2. March 2022.

Hatfield Consultants LLP. 2022c. Responses to May 19, 2022, BC Ministry of Forests Comments regarding the City of Chilliwack's groundwater license application (Sardis-Vedder Aquifer). Prepared for City of Chilliwack. Version 2. December 2022.

Hatfield Consultants LLP. 2023. Sardis Vedder aquifer groundwater and aquatics adaptive management plan (GAAMP). Prepared for City of Chilliwack. January 2023.