Upper Columbia Basin

Groundwater Monitoring Program

2020 Data Collection Summary

Living Lakes CANADA

About Living Lakes Canada

Living Lakes Canada is a non-profit society that facilitates collaboration in education, monitoring, restoration and policy development initiatives for the long-term protection of Canada's lakes, rivers, wetlands and watersheds. Our mandate is to help Canadians understand, adapt and mitigate the impacts of climate change to water quality and quantity, biodiversity and healthy human communities through grassroots water stewardship activities. Living Lakes Canada bridges the gap between science and action to foster and normalize citizen- based water stewardship.

For more information on Living Lakes Canada:

- www.livinglakescanada.ca
- info@livinglakescanada.ca
- facebook.com/LivingLakesCanada/
- twitter.com/LivingLakesCA
- instagram.com/livinglakesca
- linkedin.com/company/living-lakes-canada

For more information on the Groundwater Monitoring Program:

- www.livinglakescanada.ca/project/columbia-basin-groundwater-monitoring-program/
- groundwater@livinglakescanada.ca

Data can be downloaded from the BC Real-time Water Data Website and the Columbia Basin Water Hub.

The Living Lakes Canada Upper Columbia Basin Groundwater Monitoring Program acknowledges that the data collected in this Program are from the unceded traditional territories of the Ktunaxa, Lheidli T'enneh, Secwepemc, Sinixt and Syilx Nations who have stewarded these lands for generations.

Acknowledgements

The Living Lakes Canada Columbia Basin Groundwater Program gratefully acknowledges the many individuals and organizations who have contributed to the Program and the well owners who have volunteered their wells to be monitored. To date, Volunteer Observation Wells have been established in collaboration with ʔaq̓am, City of Castlegar, City of Cranbrook, District of Invermere, Kala Geosciences, McDonald Ranch and Lumber, Nature Trust of British Columbia, Playmor Water Utility, Regional District Central Kootenay, Village of Canal Flats, Village of Radium Hot Springs, and private landowners throughout the Columbia Basin. Data were collected by Carol Luttmer (C Waters Services) with assistance from regional technicians, well owners and volunteers. Data were reviewed and this report was written by Carol Luttmer (C Waters Services), Antonio Barroso, P.Eng (GW Solutions) and Mike Wei, P. Eng (Hydro-Geo-Logic).

This Program has been made possible through funding and in-kind support from:

Table of Contents

List of Tables

List of Figures

Appendix A: Water Level Interpretative Graphs……A – i

1 INTRODUCTION

The Living Lakes Canada Upper Columbia Basin Groundwater Monitoring Program facilitates the collection, management, and sharing of groundwater level data from Volunteer Observation Wells in the Upper Columbia Basin (Figure 1). The Upper Columbia Basin is located in southeastern British Columbia and comprises of the Canadian portion of the Columbia River Watershed that is upstream of the Village of Montrose. The Volunteer Observation Wells complement the six active observation wells in the Upper Columbia Basin that are monitored by the Provincial Government as part of the Provincial Groundwater Observation Well Network (PGOWN).

A number of reports have outlined the need to increase our understanding of groundwater systems and collect long-term groundwater data in order to effectively protect and manage groundwater resources (Carver, 2017, 2019; Kohut et.al, 2009; Office of Auditor General, 2010; Rivera et.al, 2003). Several of these reports suggest that partnerships involving communities, water users, and other stakeholders are needed to collect the amount of data necessary for effective management. Living Lakes Canada's Upper Columbia Basin Groundwater Monitoring Program (Program) is facilitating these partnerships and is collecting, managing, and sharing groundwater level data from existing wells in the Upper Columbia Basin.

The Program is unique in that groundwater conditions are monitored in collaboration with communities, using existing wells. Well owners volunteer their wells to be monitored and to share the data. Typically, wells being monitored are not used to withdraw water, so the measured static water levels are representative of aquifer conditions.

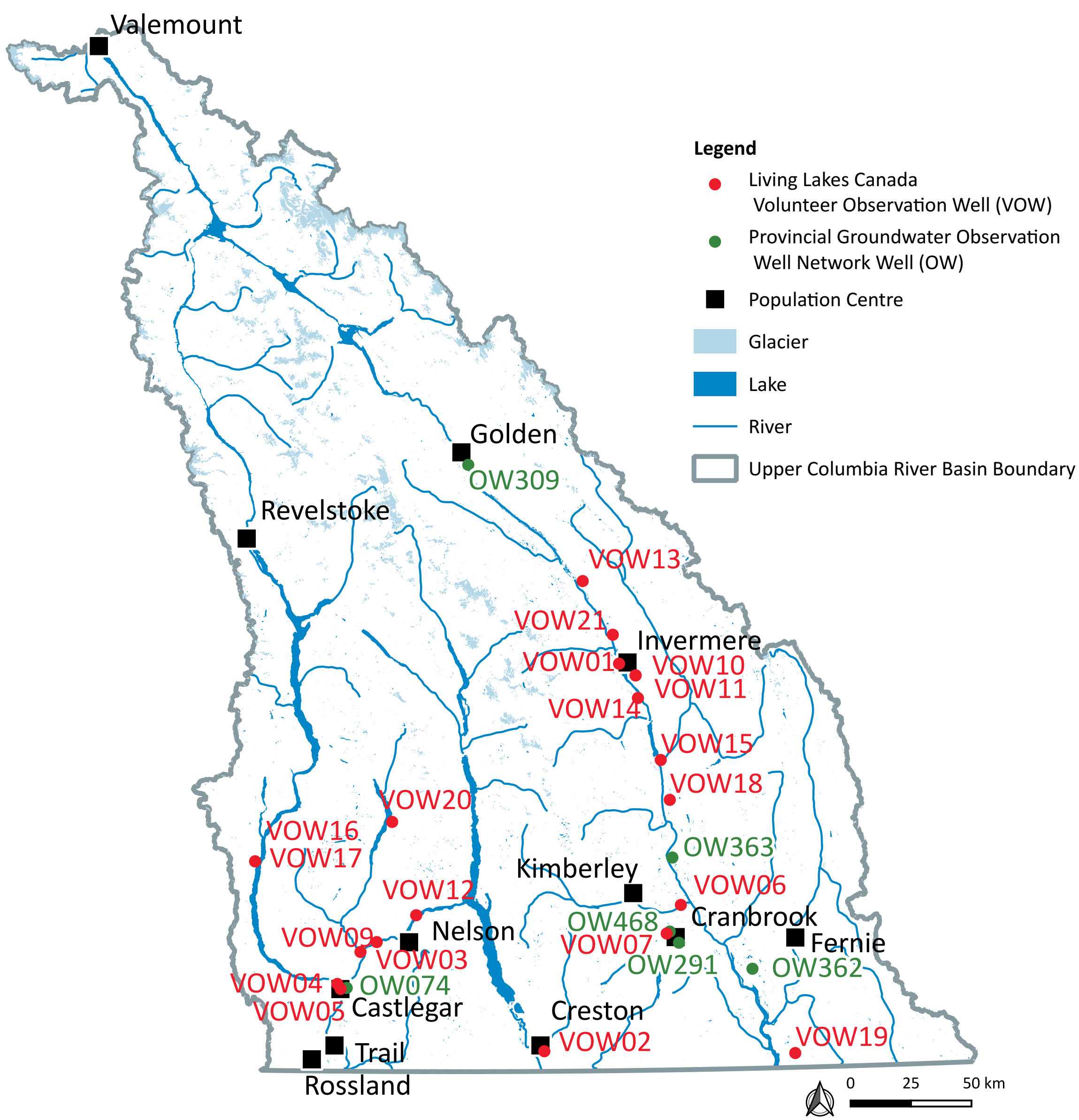


Figure 1: Locations of active LLC and PGOWN observation wells in the Upper Columbia Basin.

1.1 About the Groundwater Monitoring Program

The goal of the Upper Columbia Basin Groundwater Monitoring Program is to increase knowledge about groundwater resources to effectively inform sustainable water management to meet the needs of people and nature. The objectives of the Program are to: collect groundwater level data across a range of geological, topographical, climatic, hydrological, and water use intensity conditions to determine how levels change seasonally and from year to year; increase knowledge and awareness about groundwater by engaging partners and citizens in the collection of data; and share the data publicly so they can be used to support effective management and protection of groundwater resources. To reach these objectives Living Lakes Canada:

- Helps establish Volunteer Observation Wells by securing, installing, and maintaining monitoring equipment;
- Provides training to well owners so they can view the data in real-time and assist with monitoring;
- Collects hourly groundwater level measurements consistent with the Provincial Groundwater Observation Well Network;
- Manages, summarizes, and reports on the data on a regular basis; and
- Provides public access to the data via the BC Real-time Water Data Website and the Columbia Basin Water Hub.

More information about the Program can be found on the Program's webpage.

1.2 Report Purpose

The main purpose of this report is to provide information on the wells and aquifers being monitored and data collection and review methods, as well as a summary of the data collected to date. This information is to support the use of the data which are available publicly on the BC Real-time Water Data Website and the Columbia Basin Water Hub.

This report provides summary graphs of the groundwater levels by year for Volunteer Observation Wells with sufficient data collected to date. It does not provide interpretation of the data. At this time, the focus of the Program is on data collection. Summary statistics and graphs of water levels and comparisons to precipitation were created to assist with a cursory review of the data to support on-going Program development and assist data users with interpretation. These graphs are described in Section 5 and presented in Appendix A.

2 METHODS

2.1 Establishment of Volunteer Observation Wells

Priority areas and existing wells that are suitable for monitoring are identified with community groups, landowners, researchers, consultants, well drillers, First Nations, municipalities, and regional and provincial governments. Living Lakes Canada designs, implements and conducts monitoring in collaboration with well owners who volunteer their wells to be used as Volunteer Observation Wells.

Volunteer Observation Wells have been established in seven aquifers (Provincial Aquifers 487, 505, 508, 511, 514, 524, and 603) that were identified as priorities for monitoring in a report (Kohut et. al, 2009) that recommended where observation wells need be located to help protect, manage and sustain the groundwater resources of British Columbia. Interested parties have helped identify an additional 14 suitable wells for monitoring in 13 other aquifers in order to monitor groundwater levels across a range of geological, topographical, climatic, hydrological, and water use intensity conditions.

2.2 Water Level and Temperature Measurements

Once a Volunteer Observation Well (VOW) is established, site visits are conducted two to four times per year by Living Lakes Canada staff, contractors, and/or the well owners or volunteers to collect manual water level measurements and download the data loggers following protocols outlined in the Upper Columbia Basin Groundwater Monitoring Program Field Manual. At some sites, data are downloaded more frequently based on well owner interest. Field notes are recorded using a standardized monitoring form.

The majority of the Volunteer Observation Wells are equipped with HOBO MX 2001 Bluetooth or HOBO U20 water level loggers. These data loggers determine water levels by continuously collecting the absolute pressure of the water column above a sensor, compensating it for atmospheric pressure, and calibrating it with reference water levels that are collected manually. Data compensation and water level referencing are completed with the HOBOmobile App or HOBOware Pro software, for the Bluetooth and U20 loggers, respectively. For the conversion of pressure to water level, the water density of freshwater is adjusted for water temperature. The atmospheric pressure is measured by a barometric sensor in the airspace at the top of the wellhead. At some sites, other types of pressure transducers and data loggers are installed, if required based on the well and associated infrastructure. Information on the water level logger model and sampling details to date for each Volunteer Observation Well are presented on the water level and temperature graphs in Appendix A.

For most sites, continuous measurements are being collected hourly, consistent with the Provincial Groundwater Observation Well Network. During initial phases of Program development and the establishment of new observations wells, other sampling frequencies were explored. However, all sites are now collecting hourly data, except VOW_15 which is collecting data on five-minute intervals.

Reference water levels (manual measurements) are measured from a marked point at the top of the well casing using water level tapes (sounder tapes). Typically, the continuous water level measurements are calibrated based on the manual water level measurement at the beginning of a monitoring period (typically 3-6 months depending on the number of site visits). At each site visit, the manual water level is compared to the data logger output and the reference water level is updated if the manual and logger water level data differ by more than +/-0.01 meter.

2.3 Data Review and Sharing

Data are imported into Living Lakes Canada's Tableau® database for review, display, and analyses by Living Lakes Canada and its technical advisors. The absolute pressure data are reviewed to ensure pressures being recorded are within the calibrated ranges of the water level sensors. The manual and logger data are reviewed by checking the hydrographs to identify any gross errors, outliers, and pumping effects (for wells which may be pumped periodically).

In addition, manual and logger data are compared to identify potential instrument drift. If the difference between the manual and logger data is greater than the acceptable water level accuracy (Table 1) and no gross errors are identified, offset corrections are applied to the logger data to account for instrument drift. The acceptable water level accuracy is the larger of the maximum error of the data logger (Table 1) and the accuracy of the manual measurements which is inferred to be 0.01 meters. This accounts for human and instrument errors (different technicians, tapes kinking/stretching, rounded measuring mark at the top of casing, difference in times between manual and continuous measurements). If needed, the offset corrections to the logger data are pro-rated linearly based on the manual water level measurements collected at the beginning and end of the monitoring period.

The reviewed data (outlying data points and pumping effects removed, corrections for instrument drift applied if required) are uploaded to the BC Real-time Water Data Website and the Columbia Basin Water Hub. Data are reported at hourly recording intervals in either Pacific Standard Time or Mountain Standard Time based on the time zone in which the well is located.

Table 1: Summary of instrument accuracies

Water Level Measurement Instrument	Water Level Accuracy	Acceptable water level accuracy (m)
Solinst Water Level Tape (imperial)	0.001 ft (increments on tape)	0.01
Heron Water Level Tape (metric)	0.001 m (increments on tape)	0.01
HOBO MX-2001-04 HOBO U20-001-04 (4 m range)	Typical error: ±0.075% FS, 0.3 cm (0.01 ft) water Maximum error: ±0.15% FS, 0.6 cm (0.02 ft) water	0.01
HOBO MX-2001-01 HOBO U20-001-01 (9 m range)	Typical error: ±0.05% FS, 0.5 cm (0.015 ft) water Maximum error: ±0.1% FS, 1.0 cm (0.03 ft) water	0.01
HOBO MX-2001-02 HOB0 U20-001-02 (30 m range)	Typical error: ±0.05% FS, 1.5 cm (0.05 ft) water Maximum error: ±0.1% FS, 3.0 cm (0.1 ft) water	0.03

3 SUMMARY OF VOLUNTEER OBSERVATION WELLS

In 2020, monitoring began in eight new Volunteer Observation Wells, bringing the total number of Volunteer Observation Wells in the Program to 20 (Table 2; Figure 1). Collectively the Living Lakes Canada and Provincial Groundwater Observation Well Network (PGOWN) Programs are monitoring seven of the nine aquifer types that have been mapped in the Upper Columbia Basin by the Province[1] (Table 2). For an explanation of the aquifer types referred to in this report, the reader should refer to Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater by Wei et al (2009).

Approximately half of the wells being monitored in the LLC Program are in confined sand and gravel aquifers of glacial origin, which represents the majority of the provincially mapped aquifers in the Upper Columbia Basin. Neither the PGOWN nor LLC programs are currently monitoring unconsolidated sand and gravel aquifers associated with small streams or deltas (where streams flow into a standing body of water). Few of these aquifers have been mapped as they are generally located in undeveloped areas and mapping has been focused on developed aquifers (i.e., aquifers used for water supply).

Table 3 provides a summary of the Volunteer Observation Wells (VOW) in the Program including location, Well Tag Number, Well plate ID, aquifer type and number, ground elevation, well depth and well screened interval. The Well Tag Number is a record number corresponding to the record for the well in the Groundwater Wells and Aquifers application (GWELLS). The Well ID Plate is the number on the well plate affixed to the well. The aquifer number is the number assigned in GWELLS. The aquifer type is based on the provincial aquifer subtype code descriptions. If a Volunteer Observation Well is not correlated to a provincially mapped aquifer in GWELLS, correlation was determined based on the well lithology, location and understanding of how the aquifer was initially mapped. The aquifer type was determined based on the well record lithology and geologic setting of the VOW site.

[1]The Provincial Aquifer Mapping has mapped 183 aquifers in the Upper Columbia Basin. Information and mapping of these aquifers can be found in the Groundwater Wells and Aquifers application (GWELLS).

Table 2: Number of active LLC and PGOWN groundwater observation wells by aquifer type in the Upper Columbia Basin

Aquifer Type	# of Mapped Aquifers	General Aquifer Characteristics	# of Observation Wells with continuous water level monitoring	
			Provincial Groundwater Observation Well Network	Living Lakes Canada
Unconfined sand & gravel – large river systems	5	Aquifers along major rivers (e.g., Columbia River, Kootenay River) or at the confluence with large rivers. Hydrologic response reflects large watershed area. Hydraulic connection with streams likely.	0	3
Unconfined sand & gravel – medium stream systems	22	Aquifers along medium sized rivers (e.g., Elk River, Salmo River). Hydraulic connection with streams likely.	1	1
Unconfined sand & gravel – small stream systems	4	Aquifers along smaller streams (e.g., Lussier River) in confined valleys with relatively undeveloped floodplains where aquifer thickness and lateral extent are more limited. Hydrologic response reflects local watershed area. Hydraulic connection with streams likely.	0	0
Unconfined sand & gravel – deltas	4	Aquifers associated with deltas where a stream flows into a lake. Hydraulic connection with streams likely.	0	0
Unconfined sand & gravel – alluvial or colluvial fans	15	Aquifers that typically occur at or near the base of mountain slopes, either along the side of valley bottoms, or if formed during the last period of glaciation, raised above the valley bottoms.	0	1
Unconfined sand & gravel – late glacial outwash	13	Aquifers comprising glacio-fluvial outwash or ice contact sand and gravel deposits generally formed near or at the end of the last period of glaciation. Hydraulic connection with streams likely.	2	2

Aquifer Type	# of Mapped Aquifers	General Aquifer Characteristics	# of Observation Wells with continuous water level monitoring	
			Provincial Groundwater Observation Well Network	Living Lakes Canada
Confined sand & gravel – glacial	81	Aquifers comprising confined glacio-fluvial sand and gravel deposits overlain by till or glacio-lacustrine (clay, silt) deposits.	2	11
Fractured sedimentary bedrock	21	Aquifers comprising a major bedrock type underlying the Rocky Mountain part of the Upper Columbia Basin. Less productive than unconsolidated aquifers. Encountering groundwater is dependent on drilling into water-bearing fractures.	1	0
Fractured crystalline bedrock	18	Aquifers comprising of igneous intrusive or metamorphic, meta-sedimentary, meta-volcanic, or volcanic rock. Less productive than unconsolidated aquifers. Encountering groundwater is dependent on drilling into water-bearing fractures.	0	2
Total	183		6	20

Table 3: Summary of Volunteer Observation Wells

Station ID	Location	Well Tag Number	Well Plate ID	Aquifer #	Aquifer Type	Ground elevation (m asl)	Well depth (m bgs)	Screened Interval (m bgs)
VOW_01	Invermere	None	None	603*	Unconfined sand & gravel - medium stream system (1b)	807	8.47	Unknown
VOW_02	Creston	106697	30483	487*	Unconfined sand & gravel - late glacial outwash (4a)	553	24.4	Unknown
VOW_03	Blewett	87879	17715	511	Fractured crystalline bedrock (6b)	599	140.2	No screen (bedrock)
VOW_04	Castlegar	23702	16671	505	Confined sand & gravel – glacial (4b)	441	38.4	27.43 -30.48 & 36.58-37.80
VOW_05	Castlegar	None	None	508*	Unconfined sand & gravel - large river system (1a)	421	14.1	No screen (open at bottom)
VOW_06	ʔaq̓am	None	20279	538*	Unconfined sand & gravel - large river system (1a)	786	10.7	9.45-10.67
VOW_07	Cranbrook	None	None	524*	Confined sand & gravel – glacial (4b)	934	24.2	18.1-24.2
VOW_09	Playmor	32162	None	514*	Confined sand & gravel – glacial (4b)	497	43	41.57-41.73
VOW_10	Windermere	66814	n/a	453	Confined sand & gravel – glacial (4b)	923	47.9	No screen (open at bottom)
VOW_11	Windermere	None	None	453*	Confined sand & gravel – glacial (4b)	938	68.6	No screen (open at bottom)
VOW_12	Duhamel	107254	37927	517*	Confined sand & gravel – glacial (4b)	607	83.2	No screen (open at bottom)
VOW_13	Brisco	101596	None	1039	Confined sand & gravel – glacial (4b)	924	22.4	No screen (open at bottom)
VOW_14	Fairmont/ Invermere	103641	28716	n/a	Confined sand & gravel – glacial (4b)**	841	55.5	54.86-55.5

Station ID	Location	Well Tag Number	Well Plate ID	Aquifer #	Aquifer Type	Ground elevation (m asl)	Well depth (m bgs)	Screened Interval (m bgs)
VOW_15	Canal Flats	90231	10587	816*	Unconfined sand & gravel - large river system (1a)	813	11.73	8.23-11.28
VOW_16	Edgewood	20097	10034	874	Confined sand & gravel – glacial (4b)	466	36	32.7-35.5
VOW_17	Edgewood	83198	10035	873	Unconfined sand & gravel - late glacial outwash (4a)	468	36.9	10.3-11.3
VOW_18	Skookumchuk/ Canal Flats	122171	None	n/a	Confined sand & gravel – glacial (4b)**	864	47.5	No screen (open at bottom)
VOW_19	Grasmere	93220	20269	Possibly 1065***	Confined sand & gravel – glacial (4b)**	944	115.82	No screen (open at bottom)
VOW_20	Silverton	None	None	n/a	Fractured crystalline bedrock (6b)	867	91.4	No screen (bedrock)
VOW_21	Radium Hot Springs	None	None	n/a	Unconfined sand & gravel – alluvial or colluvial fans (3)	833	24.07	14.93-24.07

Notes:
m asl = meters above sea level based on the BC Digital Elevation Model
m bgs = meters below ground surface
*Aquifer correlation completed by Mike Wei (P.Eng).
**Aquifer Type determined by Mike Wei (P.Eng).
*** VOW_19 is located beyond the boundaries of where Aquifer 1065 is currently mapped. However, water levels and lithology data from VOW_19 are consistent with other wells in Aquifer 1065, indicating that the extent of 1065 likely covers a larger area than currently delineated.

4 DATA SUMMARY TO 2020

The water level data collected to date show that the Program is monitoring Volunteer Observation Wells that represent a range of hydrogeologic conditions with mean water levels varying from two to over a hundred meters below ground surface (Table 4). The mean annual water level ranges (the average fluctuation within a year) vary from less than half a meter to over five meters.

The water levels in unconfined aquifers typically represent the level of saturation (e.g. the water table). The water levels in Volunteer Observation Wells 01, 02, 05, 06, and 15 are close to ground surface and the mean annual water level ranges are up to 3.5 meters (Table 4). The water level trends in these unconfined aquifers show peak water levels occurring in the spring and a relatively steep falling limb with lowest water levels occurring in the summer and throughout the fall (Figure 2). These trends are consistent with nival (snowmelt and precipitation) driven recharge mechanisms. In addition, these wells (VOW 01, 02, 05, 06, and 15) are completed in unconfined aquifers that are likely hydraulically connected to streams. Thus, water levels are likely to rise and fall in association with stream water levels. This suggests that these aquifers will be influenced by factors affecting water levels in the streams, including glacier melt if they are glacier fed streams, as well as the local hydrogeological conditions. These wells also show additional peaks in water levels throughout the winter, likely associated with winter precipitation and snow melt, or variable stream conditions such as ice up/break up throughout the winter. These surficial aquifers are likely to respond quickly to changes in the timing and amounts of precipitation that are occurring with changing climate.

Groundwater in confined sand and gravel and bedrock aquifers is commonly under pressure due to the overlying confining layers. Additionally, the water levels in confined aquifers typically show variable ranges suggesting different hydrogeological conditions and recharge-discharge mechanisms. For instance, groundwater levels peak in VOW 04, 10, 11 and 12 in late summer and fall, and show a delayed response compared to unconfined aquifers, which may reflect the time it takes for precipitation and snowmelt to recharge the aquifer (Figure 3). Observation wells VOW 07 and 14 show yearly groundwater fluctuations of less than one meter, with very little discernable seasonal trends, suggesting even slower groundwater recharge to these aquifers. This could be due to the characteristics of the confining layers (e.g. low permeability) or that recharge areas may be located far away from the wells (e.g. kilometers away). More in-depth assessment is required to confirm the causes for the various water level responses observed in these VOWs.

The observation well completed in bedrock (VOW_03) shows peak water levels occurring in early spring (April) and the lowest levels occurring in October and November (Figure 4). Groundwater in bedrock aquifers occurs mainly in fractures and faults. The water level response in bedrock wells is typically dependent on the characteristics of the fractures that the well intersects, which makes characterizing bedrock aquifers a challenge.

Table 4: Data summary for active Volunteer Observation Wells based on data collected to date

Station ID	Start of Record	Mean Annual Water Level (m bgs)	Mean Annual Water Level Range (m)	Data Available for Download
Unconfined Sand and Gravel Aquifers				
VOW_01	2013-10-12	2.09	1.31	Yes
VOW_02	2017-02-03	6.86	1.68	Yes
VOW_05	2017-03-02	7.33	3.50	No
VOW_06	2017-02-28	4.77	2.26	No^
VOW_15	2020-07-16	3.65	n/a	Yes
VOW_21	2020-09-18	21.81	n/a	No*
Confined Sand and Gravel Aquifers				
VOW_04	2016-11-29	16.02#	1.38#	Yes*
VOW_07	2008-07-24	7.60	<1.0	Yes
VOW_09	2019-09-10	30.62	4.77	Yes
VOW_10	2018-10-24	44.72	0.51	Yes
VOW_11	2018-10-24	57.98	0.48	Yes
VOW_12	2019-08-22	73.90	2.26	Yes
VOW_13	2019-09-17	6.11	0.67&	Yes
VOW_14	2020-01-06	28.42	0.22	Yes
VOW_16	2020-09-05	19.66	n/a	No*
VOW_17	2020-10-31	20.21	n/a	No*
VOW_18	2020-07-16	25.31	n/a	Yes
VOW_19	2020-09-19	107.49	n/a	No*

Station ID	Start of Record	Mean Annual Water Level (m bgs)	Mean Annual Water Level Range (m)	Data Available for Download
Bedrock Aquifers				
VOW_03	2016-12-09	33.31	5.48	Yes
VOW_20	2020-07-18	19.42	n/a	Yes

#Insufficient manual water level measurements to validate the data. Sensor may have moved between monitoring periods.

^Data are held by the Community of ʔaq̓am.

&Mean annual water level range may be underestimated because water levels are likely affected by pumping of nearby well in the summer months when garden is being irrigated.

*Data will be published in future, when there are sufficient data and they have been validated.

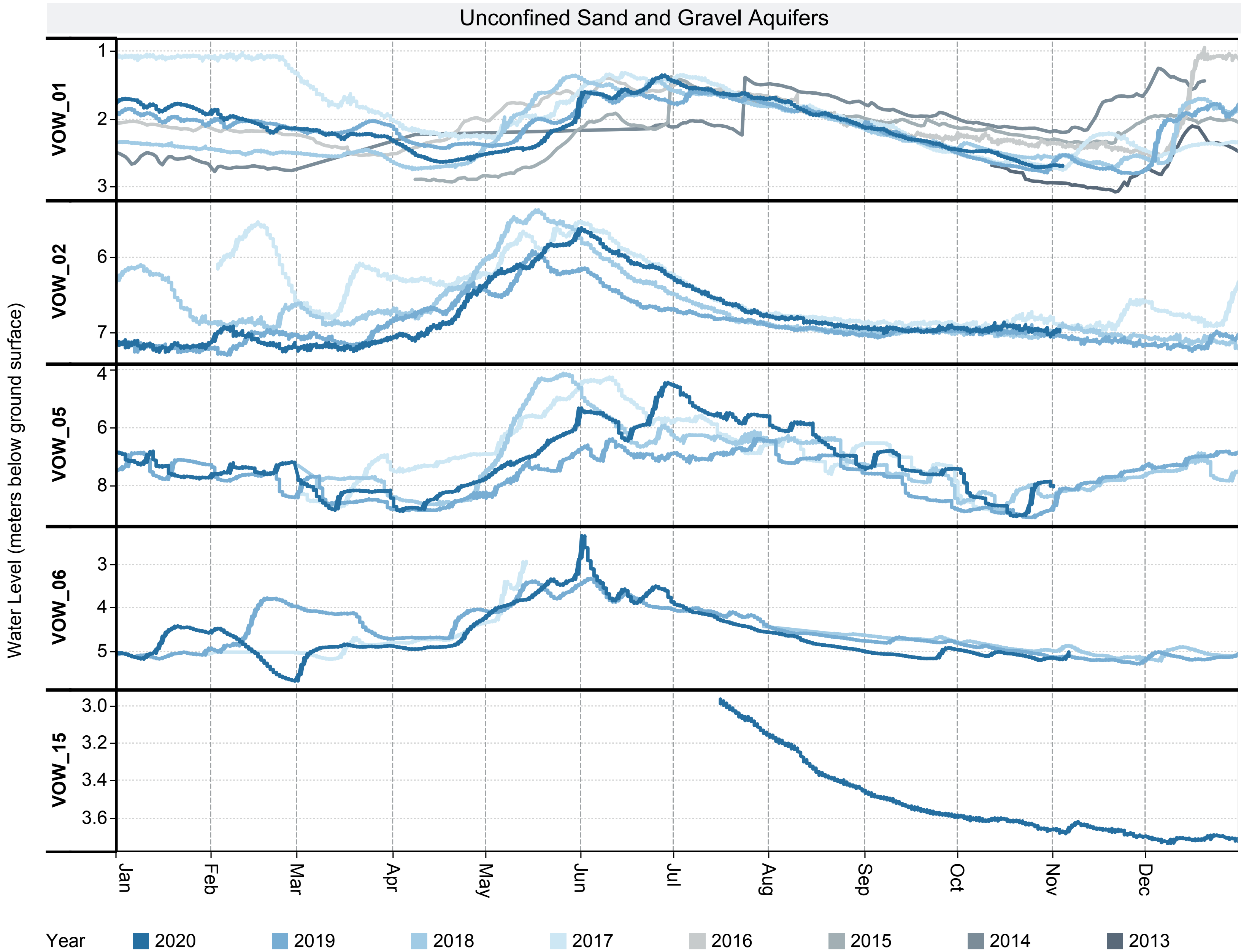


Figure 2: Water level by year in Volunteer Observation Wells in unconfined sand and gravel aquifers.

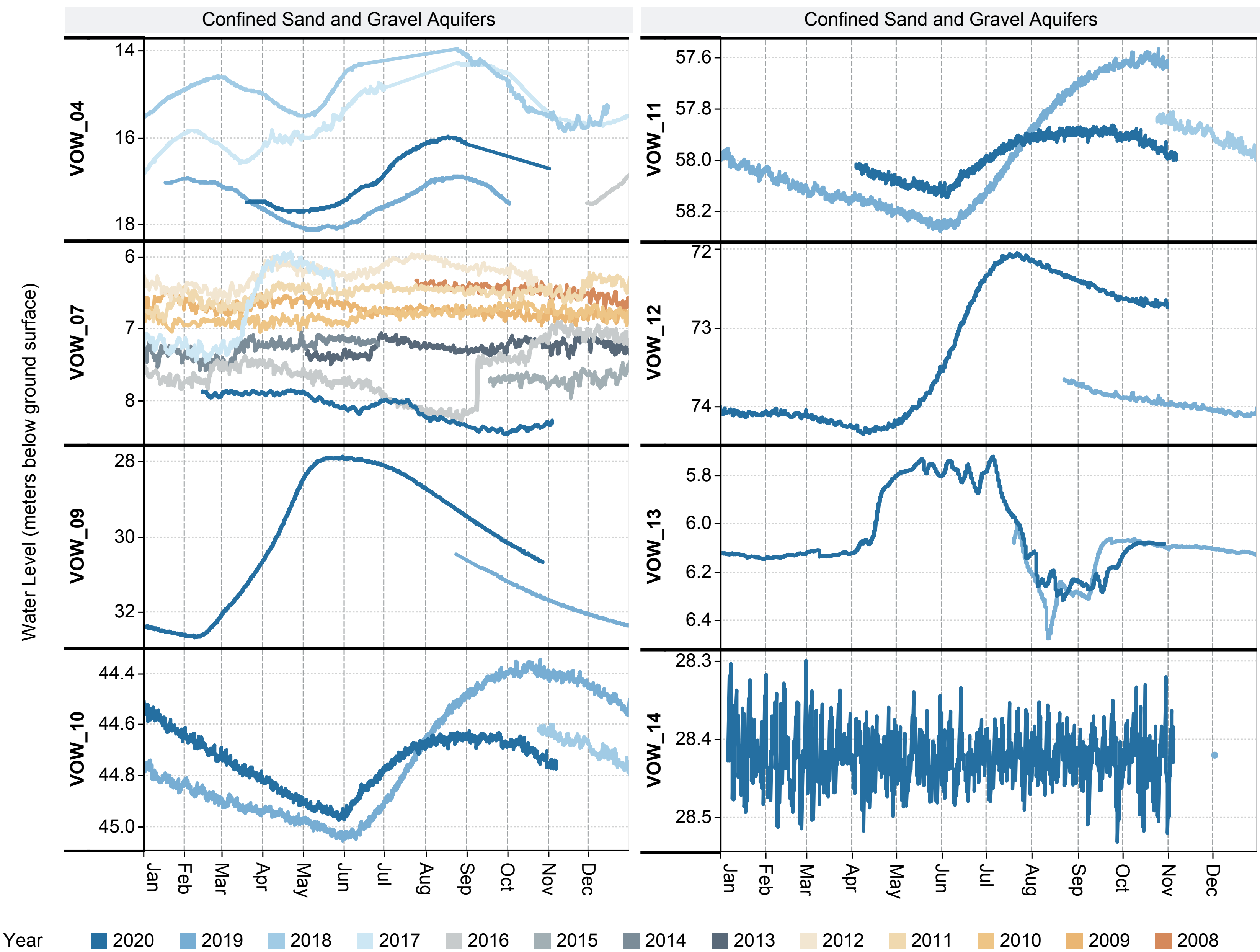


Figure 3: Water level by year in Volunteer Observation Wells in confined sand and gravel aquifers.

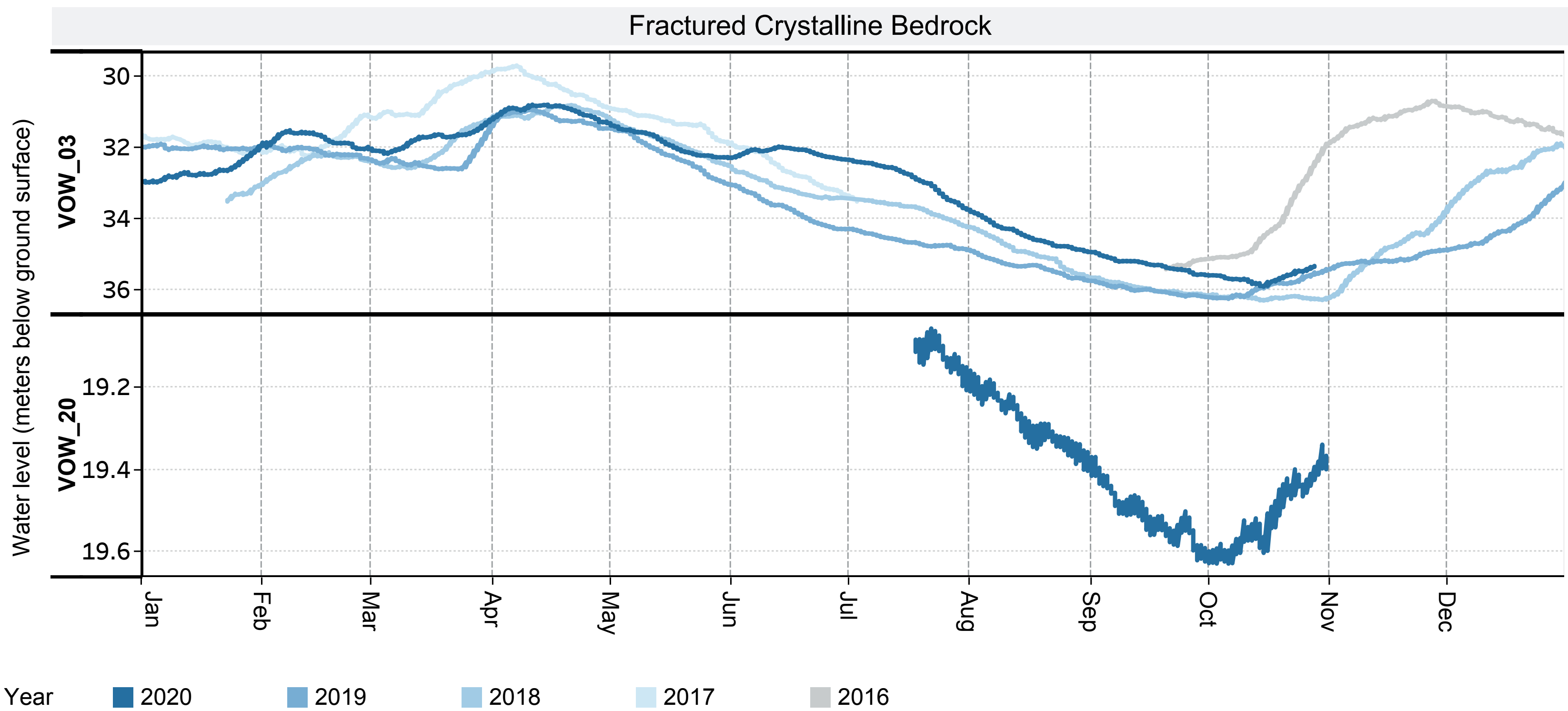


Figure 4: Water level by year in Volunteer Observation Wells in bedrock.

5 WATER LEVEL INTERPRETATIVE GRAPHS

For each Volunteer Observation Well (VOW) with sufficient data collected to-date graphs were created to guide the Program and assist data users with data interpretation. These graphs are presented in Appendix A. They include:

1 - Water Level and Water Temperature:

Time series of the groundwater level and groundwater temperature data collected to-date. The graphs show both the sensor and manual groundwater level measurements. The water temperature is representative of the water temperature in the well at the depth of the sensor.

2 - Water Level and Daily Total Precipitation:

Time series of the groundwater level data and daily total precipitation from nearby Environment and Climate Change Canada Climate Stations[2]. Precipitation is commonly recognized as a main driver for groundwater levels. Climate stations were selected based on proximity to the well and completeness of the precipitation record. For instance, only stations which had less than 20 days of data missing per year were considered.

3 - Water Level & Cumulative Precipitation Departure from Average (CPD):

Time series of the groundwater level at the beginning of each month, cumulative precipitation departure from average (CPD), and monthly total precipitation from nearby climate stations. The cumulative effects of preceding precipitation often affect groundwater levels and trends. The cumulative precipitation departure from average precipitation (CPD) is a derivative of precipitation data (Weber & Stewart, 2004). CPD was calculated by determining the mean monthly precipitation over the monitoring period and summing the cumulative difference between the actual monthly precipitation and the mean monthly precipitation for each month in the monitoring period. The calculated CPD begins at zero at the start of the monitoring period and returns to zero for the last month of the monitoring period. Within the monitoring period, if the CPD is negative it reflects a period of cumulative precipitation deficit within the monitoring period. If the CPD is positive, it reflects a cumulative precipitation surplus within that period.

4 - Water Level by Year:

Hourly water level by year. These graphs summarize the seasonal groundwater variation throughout the year(s).

[2]Data downloaded from: https://climate.weather.gc.ca/historical_data/search_historic_data_e.html

6 CONCLUSIONS

Collectively the data collected to date demonstrate that water level responses in aquifers being monitored are dependent on the varied conditions across the Columbia Basin. In general, the aquifers in the Basin are small and fragmented and the water level response for each aquifer is dependent on the local geology, topography, land cover, water use, and climatic conditions. While trends can be drawn based on aquifer types, and other characteristics, monitoring individual aquifers provides the most accurate site-specific information. Additional analyses are needed to characterize the water level responses in each aquifer and longer data sets (ideally 10+ years) are needed to determine statistical water level trends over time. The data collected to date and summarized here demonstrate that the Program is effectively increasing the availability of groundwater data in the Upper Columbia Basin through community engagement to establish and monitor Volunteer Observations Wells.

7 REPORT CLOSURE

Findings and conclusions presented herein are based on available information at the time. The work has been carried out in accordance with generally accepted engineering practice. No other warranty is made, either expressed or implied. Engineering judgement has been applied in producing the summary herein.

This report was prepared by personnel with professional experience in the fields covered.

We are pleased to produce this data summary. If you have any questions, please contact us via Living Lakes Canada.

Yours truly,

March 10, 2021

Carol Luttmer, BSc (Eng), M.Sc.
C Waters Services

Antonio Barroso, M.Sc, P.Eng
Hydrogeologist, GW Solutions

Mike Wei, P.Eng
Hydro-Geo-Logic

8 REFERENCES

Carver, M. (2017). Water Monitoring and Climate Change in the Upper Columbia Basin: Summary of Current Status and Opportunities. https://ourtrust.org/wp-content/uploads/downloads/WaterMonitoringandClimateChange_FullReport_2017_FINAL_Web-5.pdf

Carver, M. (2019). Water Monitoring and Climate Change in the Upper Columbia Basin - Guidance Information for Planning Monitoring Programs. https://livinglakescanada.ca/wp-content/uploads/2019/03/WMGuidance_Carver_22Feb2019.pdf

Kohut, A., Hodge, W., & Azar, J. (2009). Provincial Observation Well Network Review British Columbia. https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=20489

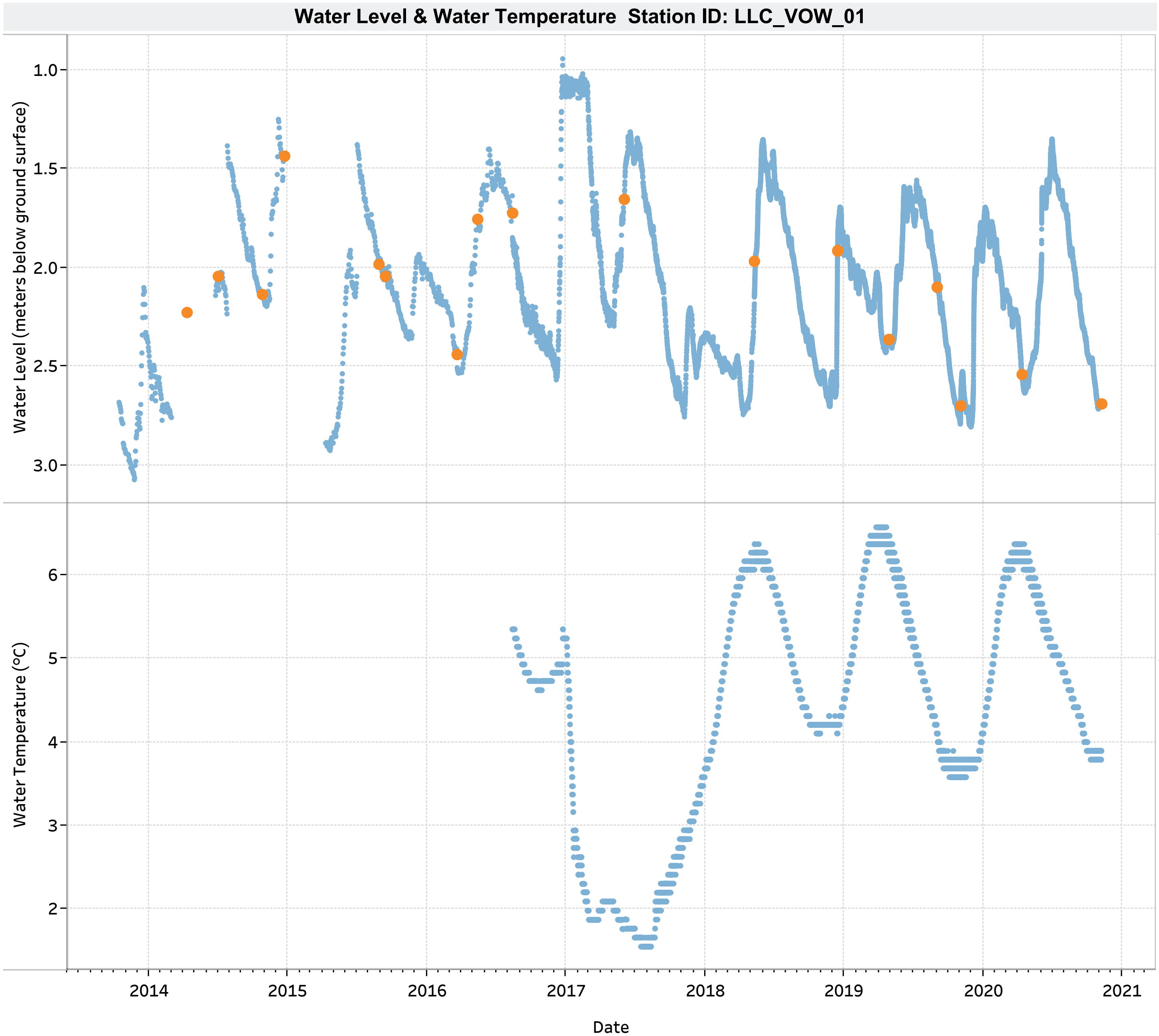
Office of the Auditor General of British Columbia. (2010). An Audit of the Management of Groundwater Resources in British Columbia. Victoria. https://www.bcauditor.com/sites/default/files/publications/2010/report_8/report/OAGBC_Groundwater_Final.pdf

Rivera, A., Crowe, A., Kohut, et al. (2003). *Canadian Framework for Collaboration on Groundwater*. https://doi.org/10.4095/214620

Weber, K., and M. Stewart. (2004). A Critical Analysis of the Cumulative Rainfall Departure Concept. *Ground Water*, Vol. 42, No. 6, 953-938. https://doi.org/10.1111/j.1745-6584.2004.t01-11-.x

Wei, M., D. Allen, A. Kohut, S. Grasby, K. Ronneseth, and B. Turner. (2009). Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. In *Streamline* Watershed Management Bulletin, vol 13, no. 1, p 10-18. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.634.4563&rep=rep1&type=pdf

APPENDIX A: WATER LEVEL INTERPRETATIVE GRAPHS



Station ID
LLC_VOW_01

Measurement Type
Manual data
Logger data

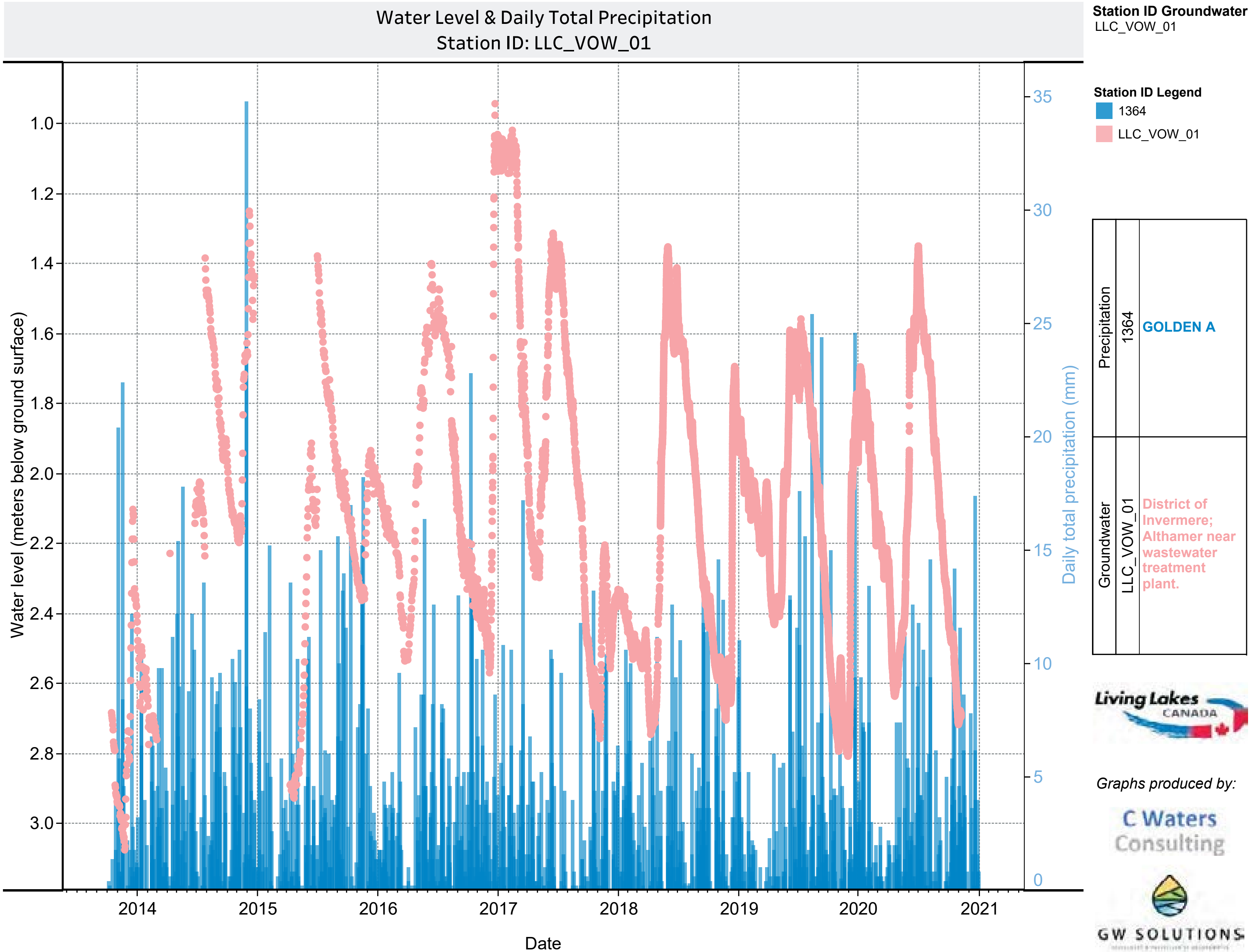
Well depth (mbgs)
8.47 (measured with water level tape)

Depth of Water Level Sensor (mbgs)
5.97

Recording Interval
2013-10-12 to 2016-08-10 - daily; 2016-08-10 to 2018-05-07 - 6 hrs; 2018-05-07 to present - 1 hr

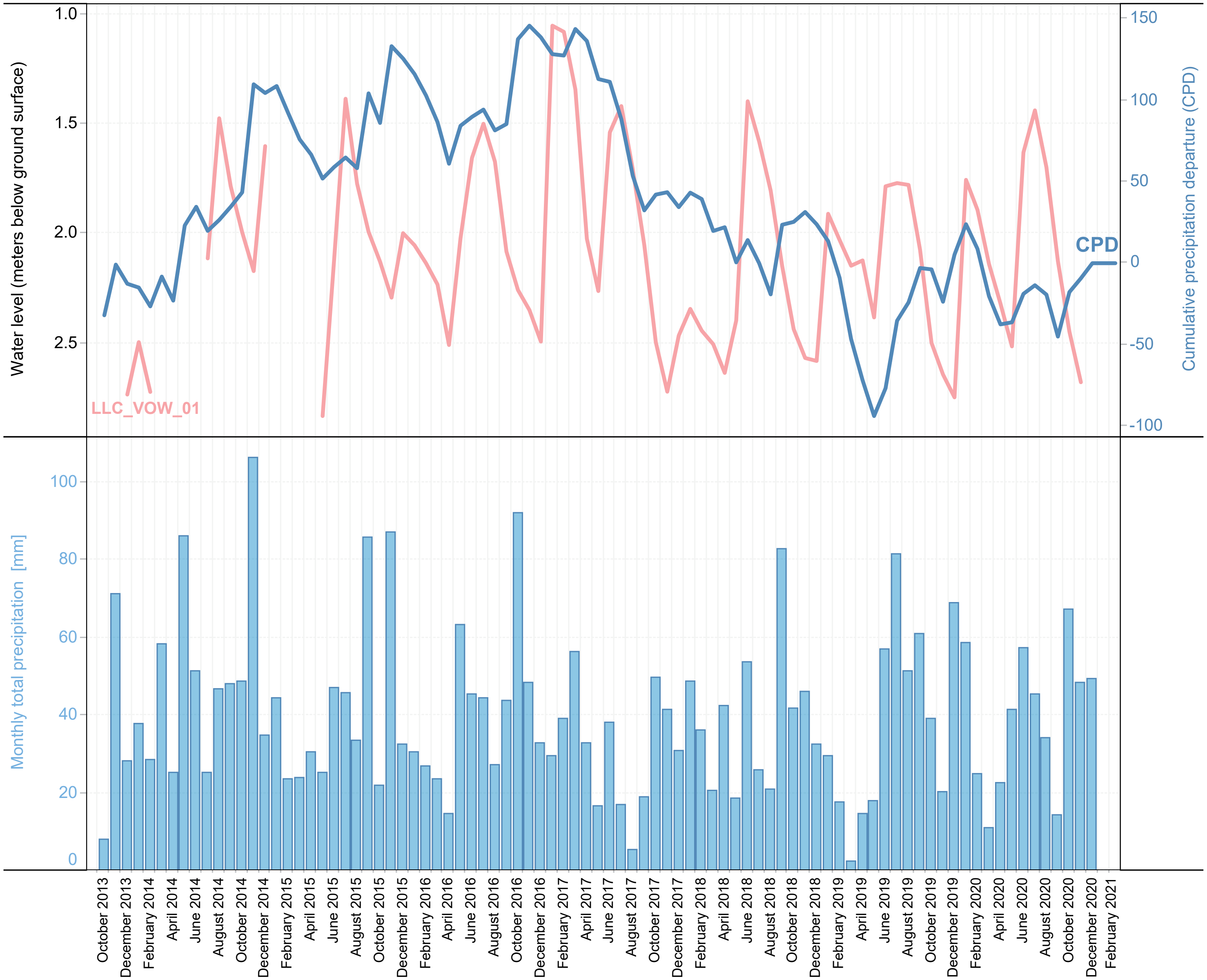
Water Level Sensor
HOBO U20-001-04 (Range 4 m)

Graphs produced by:



Water Level & Daily Total Precipitation
Station ID: LLC_VOW_01
Water level (meters below ground surface)
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Daily total precipitation (mm)
35
30
25
20
15
10
5
0
2014
2015
2016
2017
2018
2019
2020
2021
Date
Station ID Groundwater
LLC_VOW_01
Station ID Legend
1364
LLC_VOW_01
Precipitation
1364
GOLDEN A
Groundwater
LLC_VOW_01
District of Invermere; Althamer near wastewater treatment plant.
Graphs produced by:

Water Level & Cumulative Precipitation Departure from Average (CPD)
Station ID: LLC_VOW_01

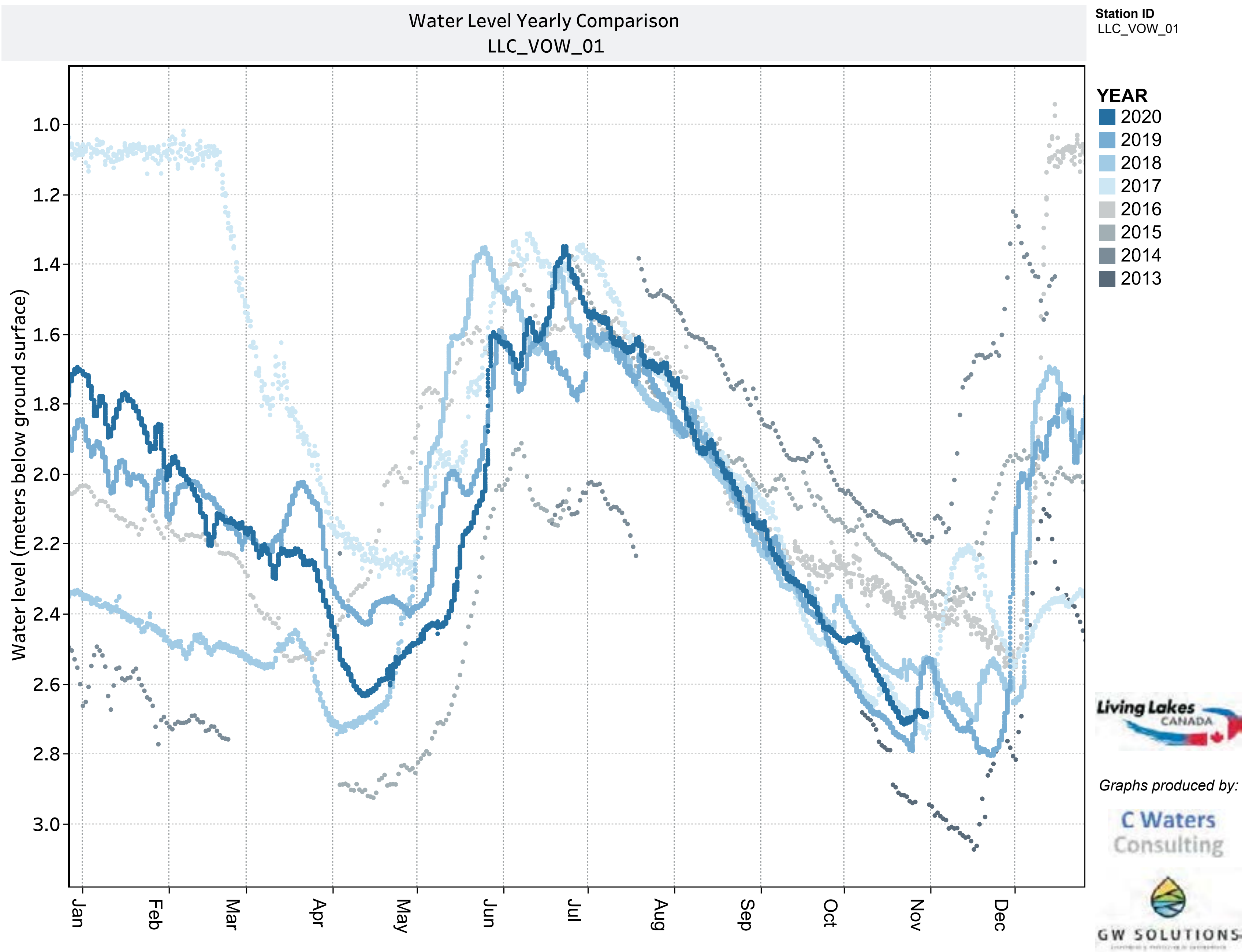


Station ID Groundwater
LLC_VOW_01

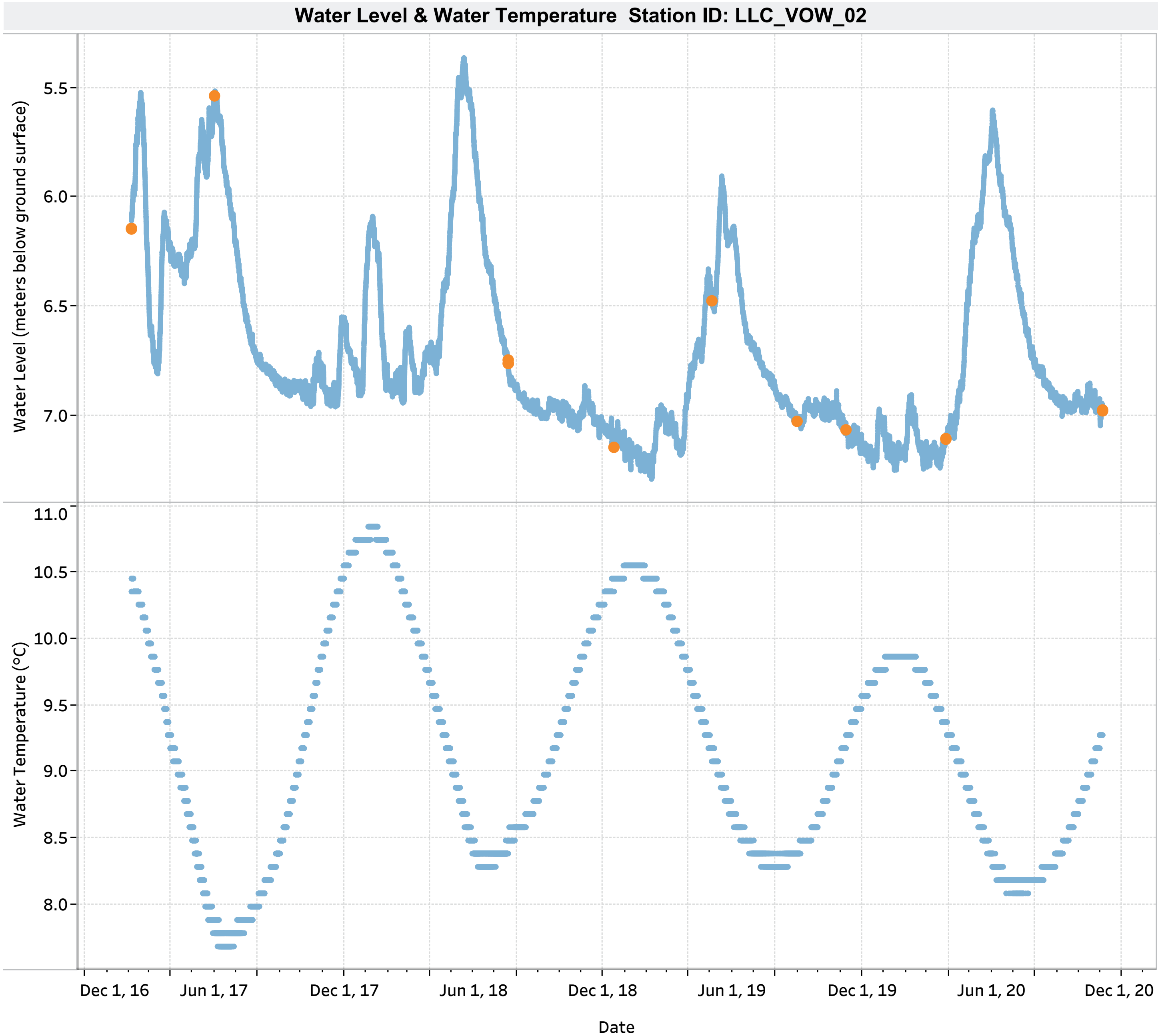
Water level data
Begining of the month

Precipitation	1364	GOLDEN A
Groundwater	LLC_VOW_01	District of Invermere; Althamer near wastewater treatment plant.

Graphs produced by:



Water Level Yearly Comparison
LLC_VOW_01
Station ID
LLC_VOW_01
YEAR
2020
2019
2018
2017
2016
2015
2014
2013
Water level (meters below ground surface)
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Graphs produced by:



Station ID
LLC_VOW_02

Measurement Type
Manual data
Logger data

Well depth (mbgs)
24.4

Depth of Water Level Sensor (mbgs)
10.1 mbgs then lowered to 10.8 mbgs on 2018-07-19.

Recording Interval
2017-02-03 to 2018-07-19 - 30 min; 2018-07-19 to present - 1 hr

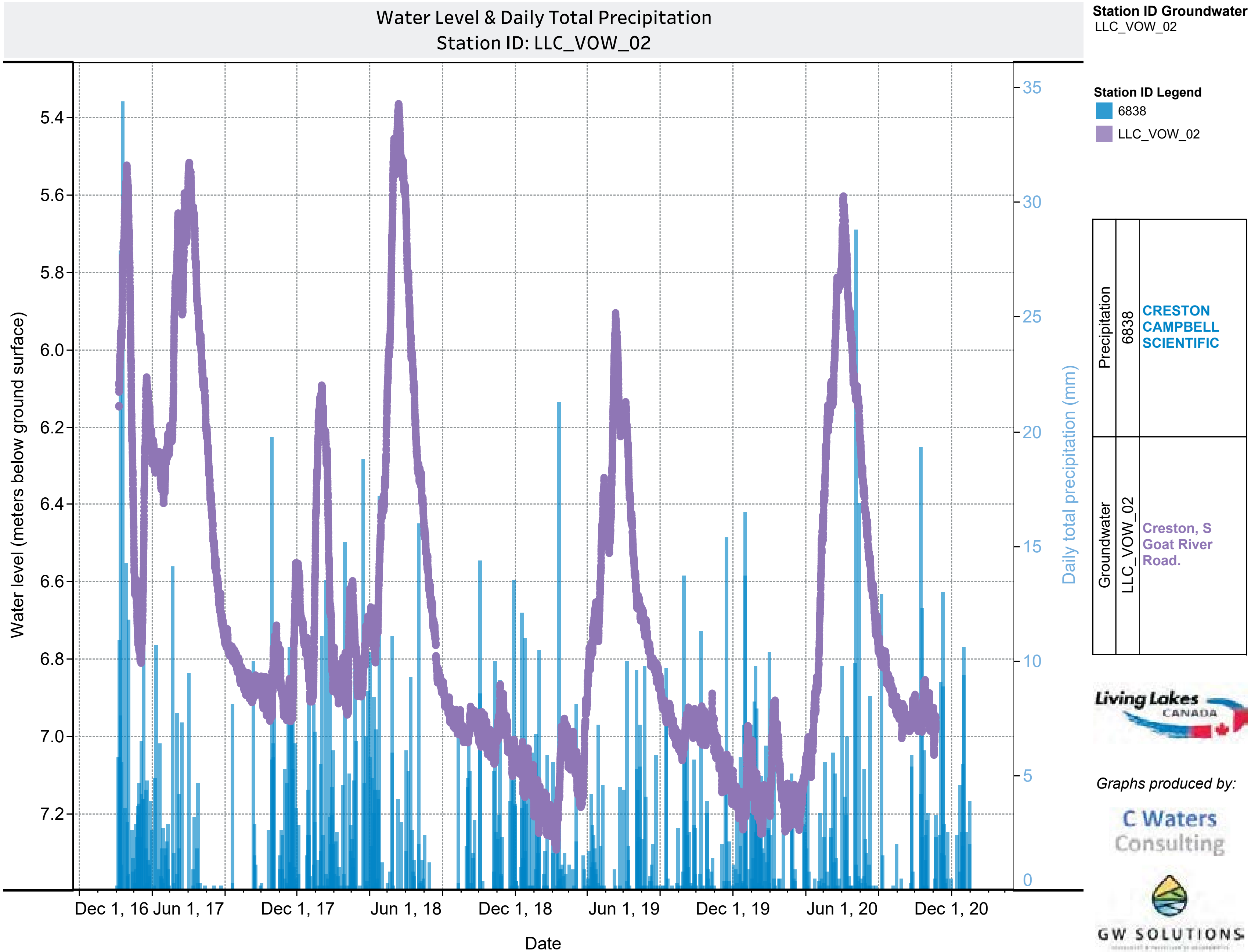
Water Level Sensor
HOBO U20-001-04 (Range 4 m)

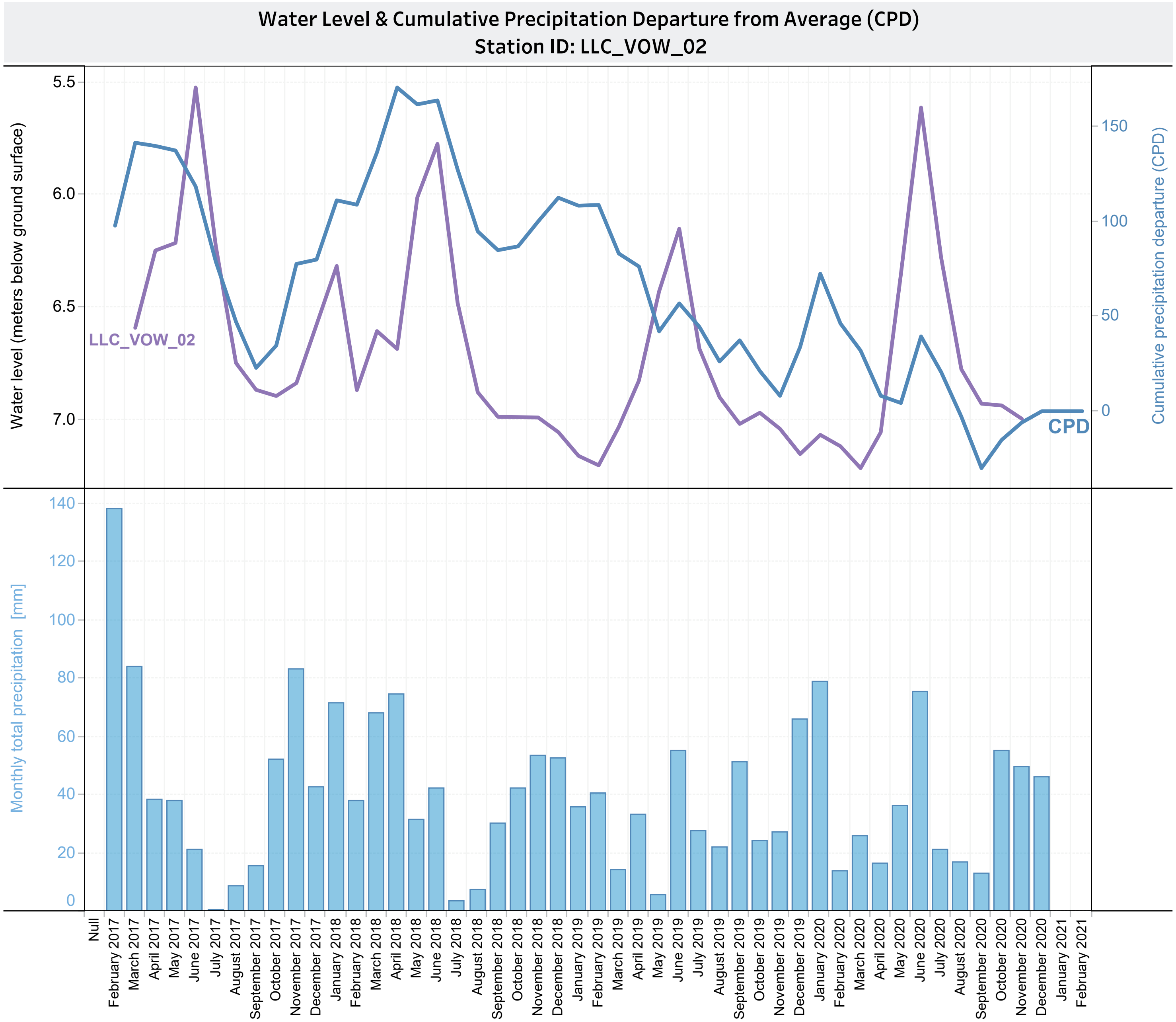
Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS


Water Level & Daily Total Precipitation
Station ID: LLC_VOW_02
Water level (meters below ground surface)
5.4
5.6
5.8
6.0
6.2
6.4
6.6
6.8
7.0
7.2
Daily total precipitation (mm)
35
30
25
20
15
10
5
0
Dec 1, 16
Jun 1, 17
Dec 1, 17
Jun 1, 18
Dec 1, 18
Jun 1, 19
Dec 1, 19
Jun 1, 20
Dec 1, 20
Date
Station ID Groundwater
LLC_VOW_02
Station ID Legend
6838
LLC_VOW_02
Precipitation
6838
CRESTON CAMPBELL SCIENTIFIC
Groundwater
LLC_VOW_02
Creston, S Goat River Road.
Living Lakes CANADA
Graphs produced by:
C Waters Consulting
GW SOLUTIONS



Station ID Groundwater
LLC_VOW_02

Water level data
Begining of the month

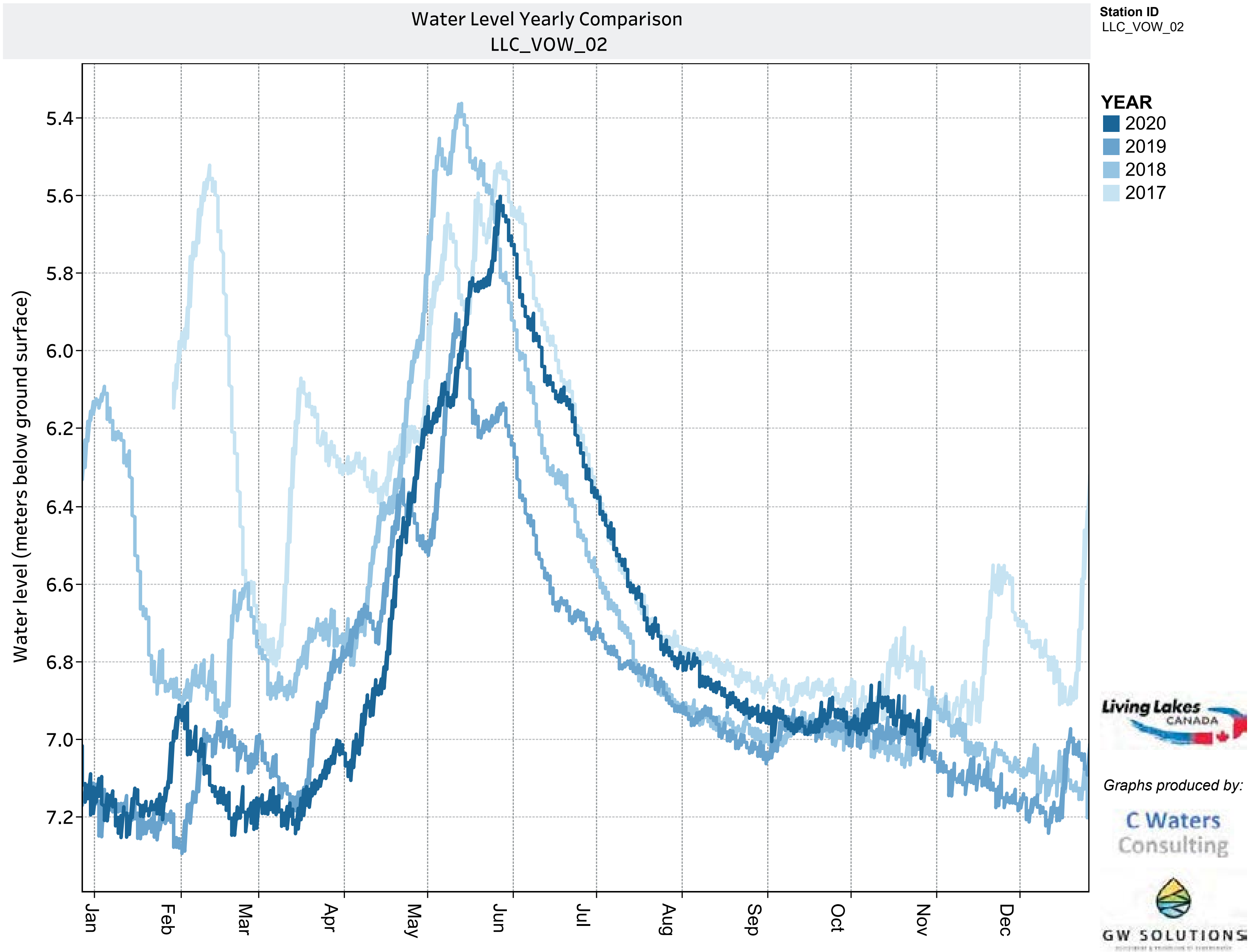
Precipitation	6838	CRESTON CAMPBELL SCIENTIFIC
Groundwater	LLC_VOW_02	Creston, S Goat River Road.

Living Lakes CANADA

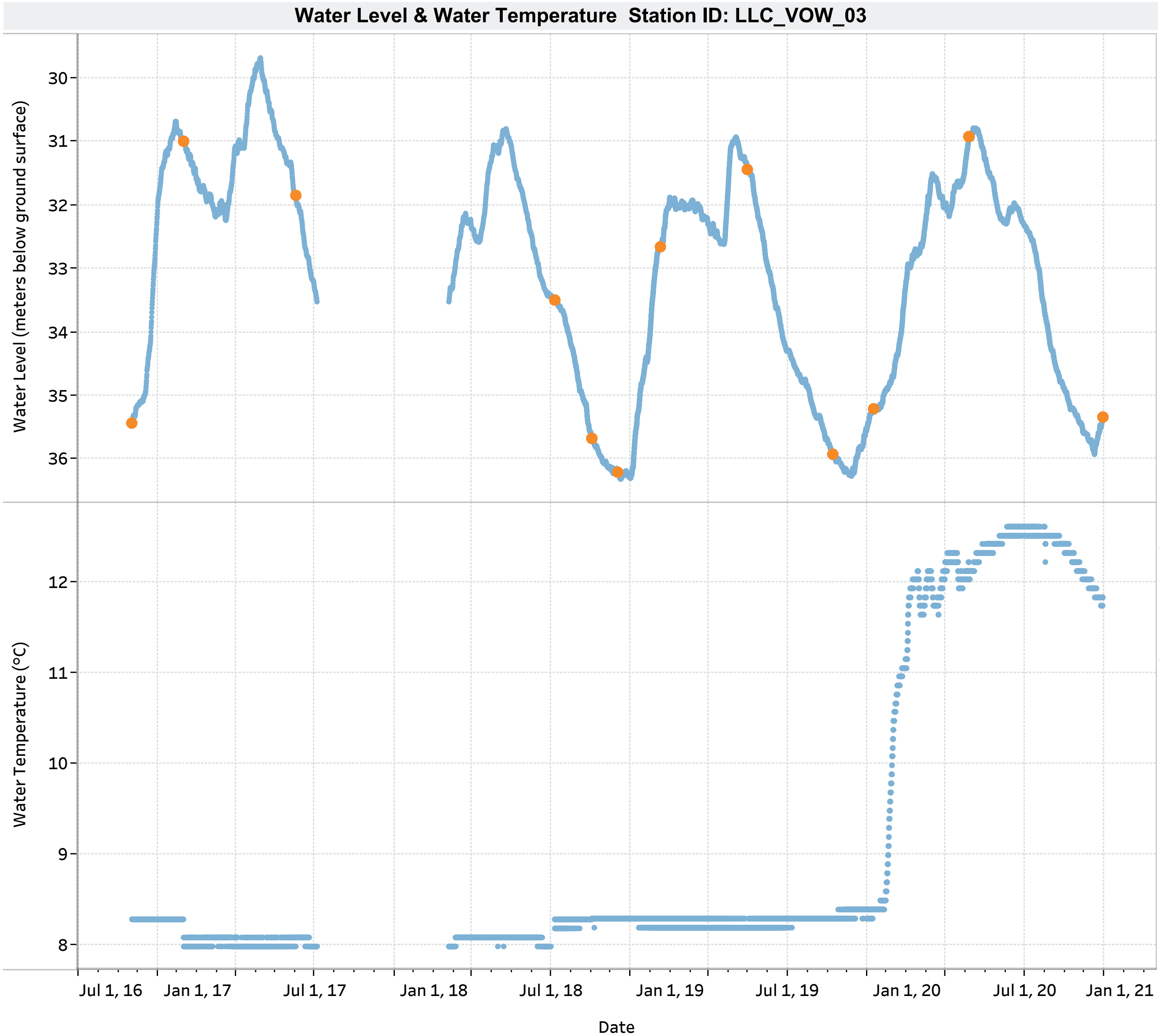
Graphs produced by:

C Waters Consulting

GW SOLUTIONS



Water Level Yearly Comparison
LLC_VOW_02
Water level (meters below ground surface)
5.4
5.6
5.8
6.0
6.2
6.4
6.6
6.8
7.0
7.2
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Station ID
LLC_VOW_02
YEAR
2020
2019
2018
2017
Living Lakes CANADA
Graphs produced by:
C Waters Consulting
GW SOLUTIONS



Station ID
LLC_VOW_03

Measurement Type
Manual data
Logger data

Well depth (mbgs)

140.2

Depth of Water Level Sensor (mbgs)

40 mbgs at installation, raised to 33.5 mbgs on 2016-12-09, lowered to 39.5 mbgs on 2018-07-05.

Recording Interval
2016-09-20 to 2018-06-29 - 6 hrs; 2018-07-05 to 2018-08-31 - 1 hr; 2018-08-31 to 2018-10-11 - 30 min; 2018-10-10 to present- 1 hr

Water Level Sensor

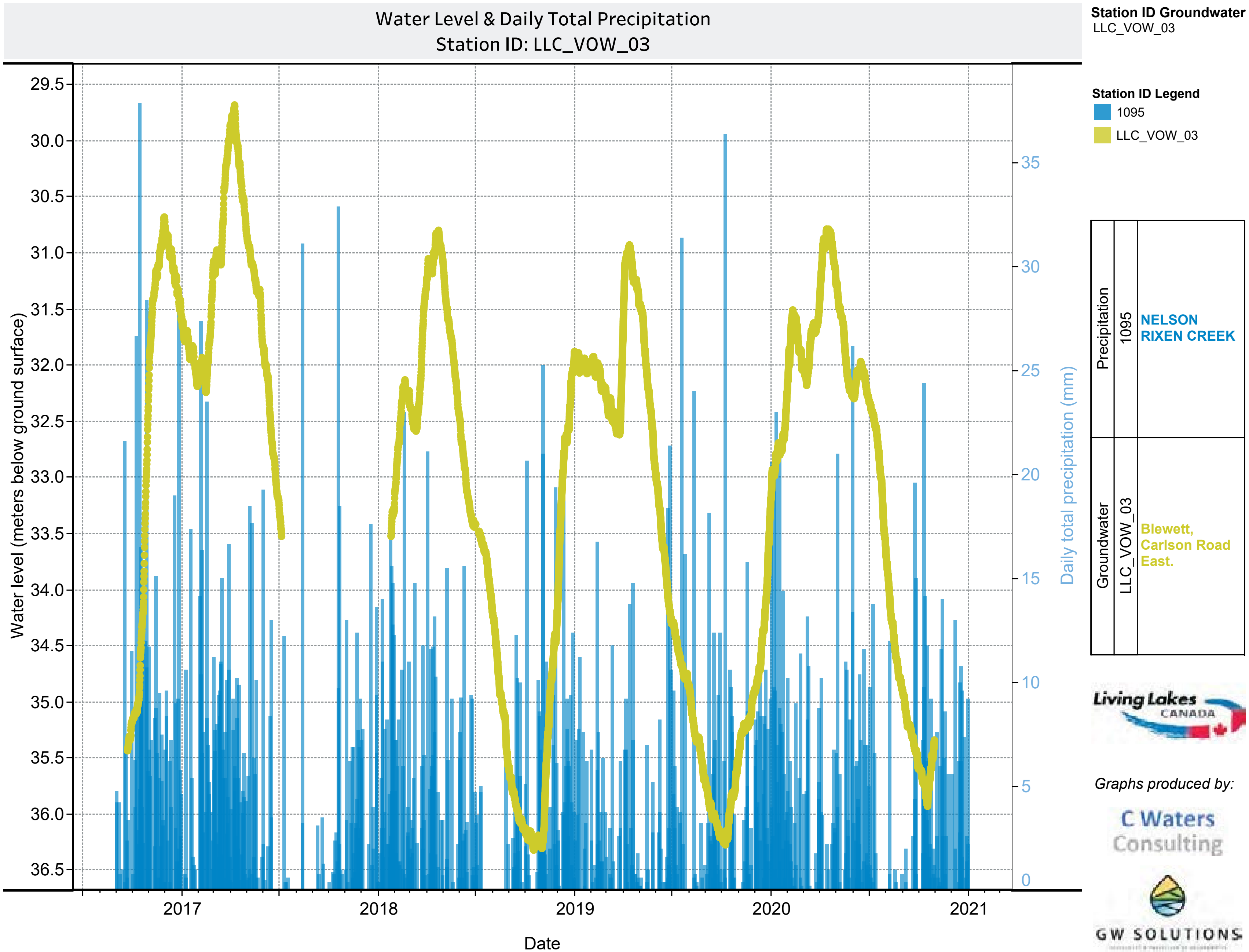
HOBO U20-001-01 (Range 9 m) replaced with HOBO MX2001-01 (Range 9m) on 2018-10-10.

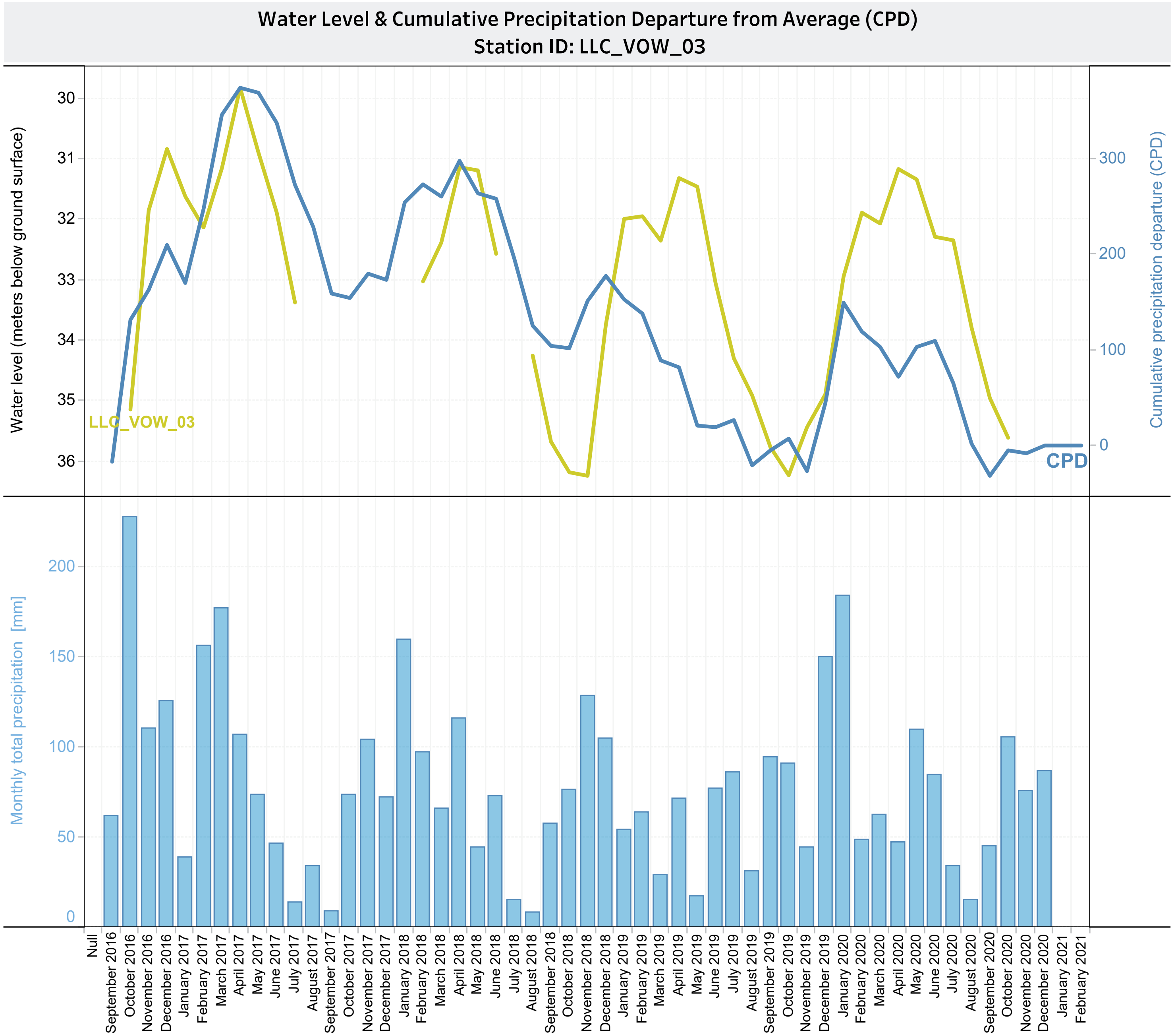
Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS


Water Level & Daily Total Precipitation
Station ID: LLC_VOW_03
Water level (meters below ground surface)
29.5
30.0
30.5
31.0
31.5
32.0
32.5
33.0
33.5
34.0
34.5
35.0
35.5
36.0
36.5
Daily total precipitation (mm)
35
30
25
20
15
10
5
0
2017
2018
2019
2020
2021
Date
Station ID Groundwater
LLC_VOW_03
Station ID Legend
1095
LLC_VOW_03
Precipitation
1095
NELSON RIXEN CREEK
Groundwater
LLC_VOW_03
Blewett, Carlson Road East.
Graphs produced by:

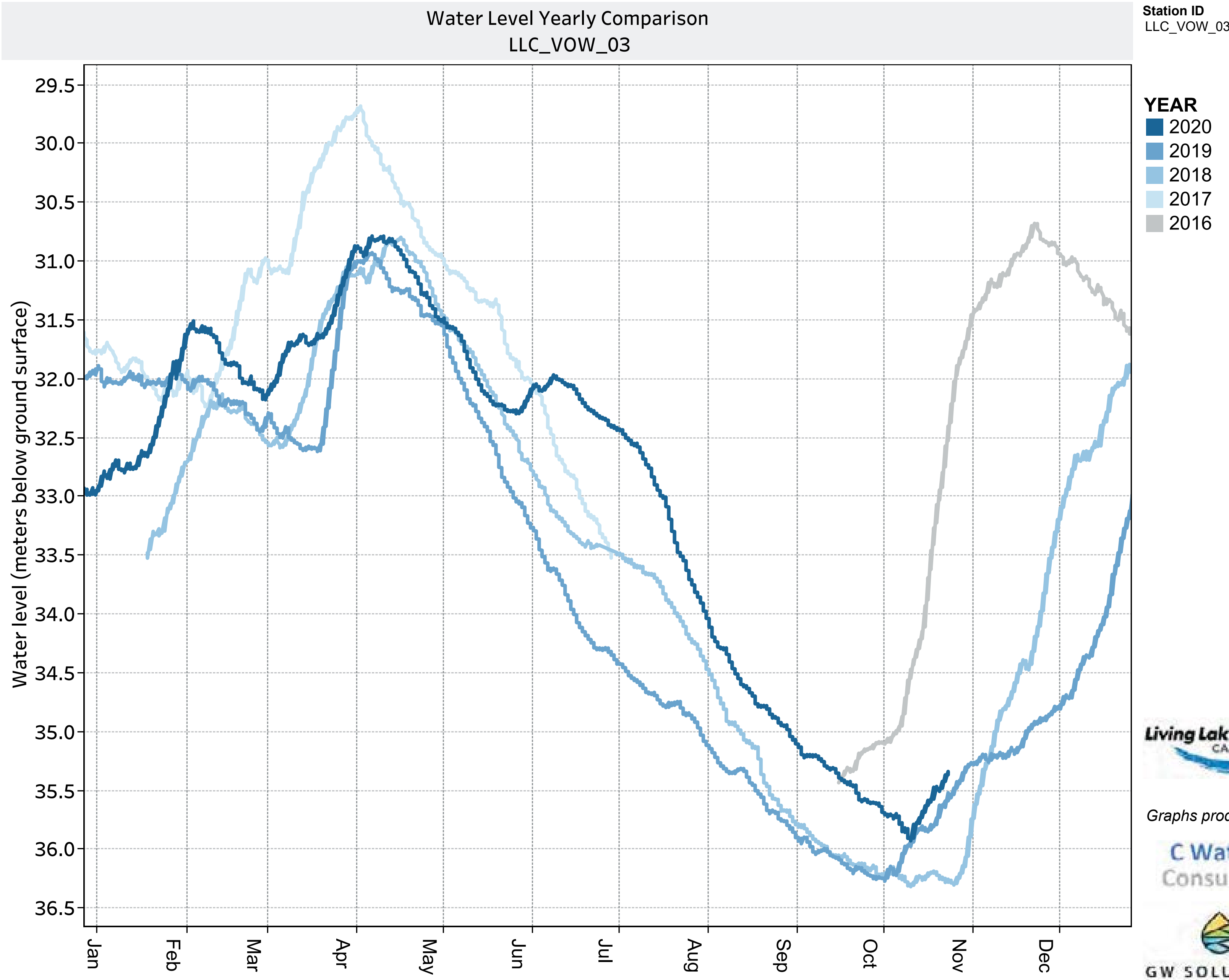


Station ID Groundwater
LLC_VOW_03

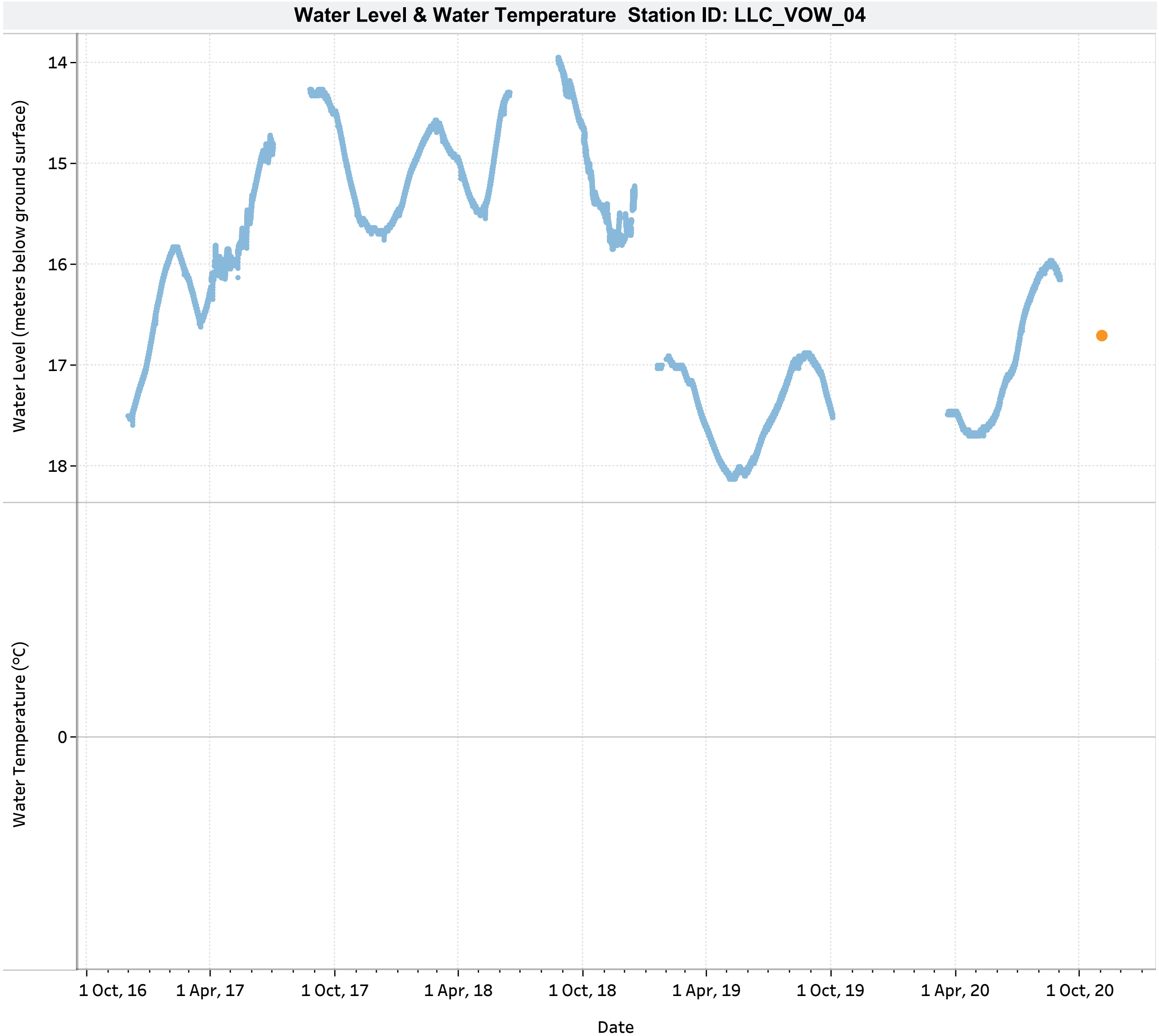
Water level data
Begining of the month

Precipitation	1095	**NELSON RIXEN CREEK**
Groundwater	LLC_VOW_03	**Blewett, Carlson Road East.**

Graphs produced by:



Graphs produced by:



Station ID
LLC_VOW_04

Measurement Type
Manual data
Logger data

Well depth (mbgs)

38.4

Depth of Water Level Sensor (mbgs)

26.1; assummed 29.9 mbgs from 2018-06-14 to 2018-12-15, repositioned to 26.14 mbgs on 2019-04-09

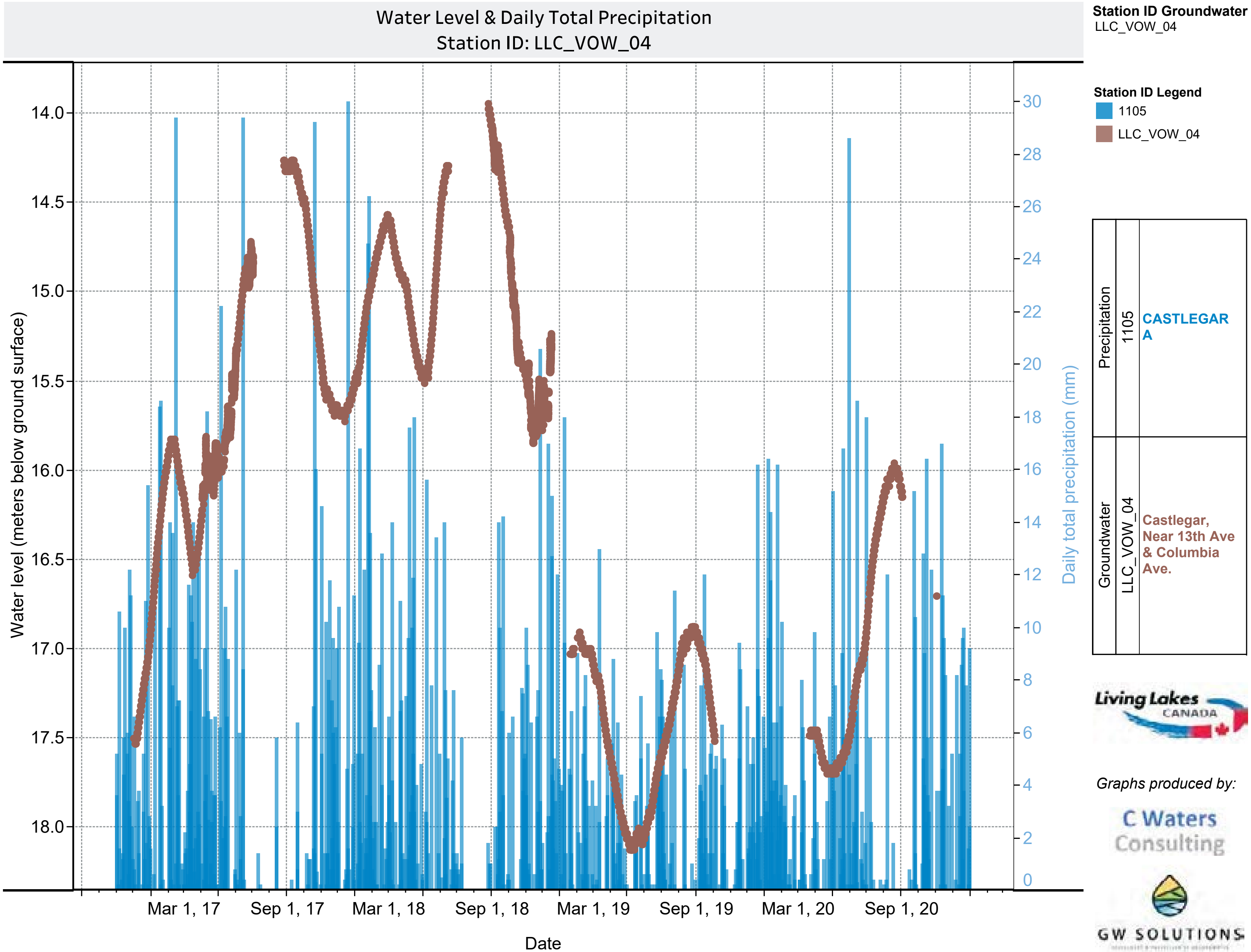
Recording Interval

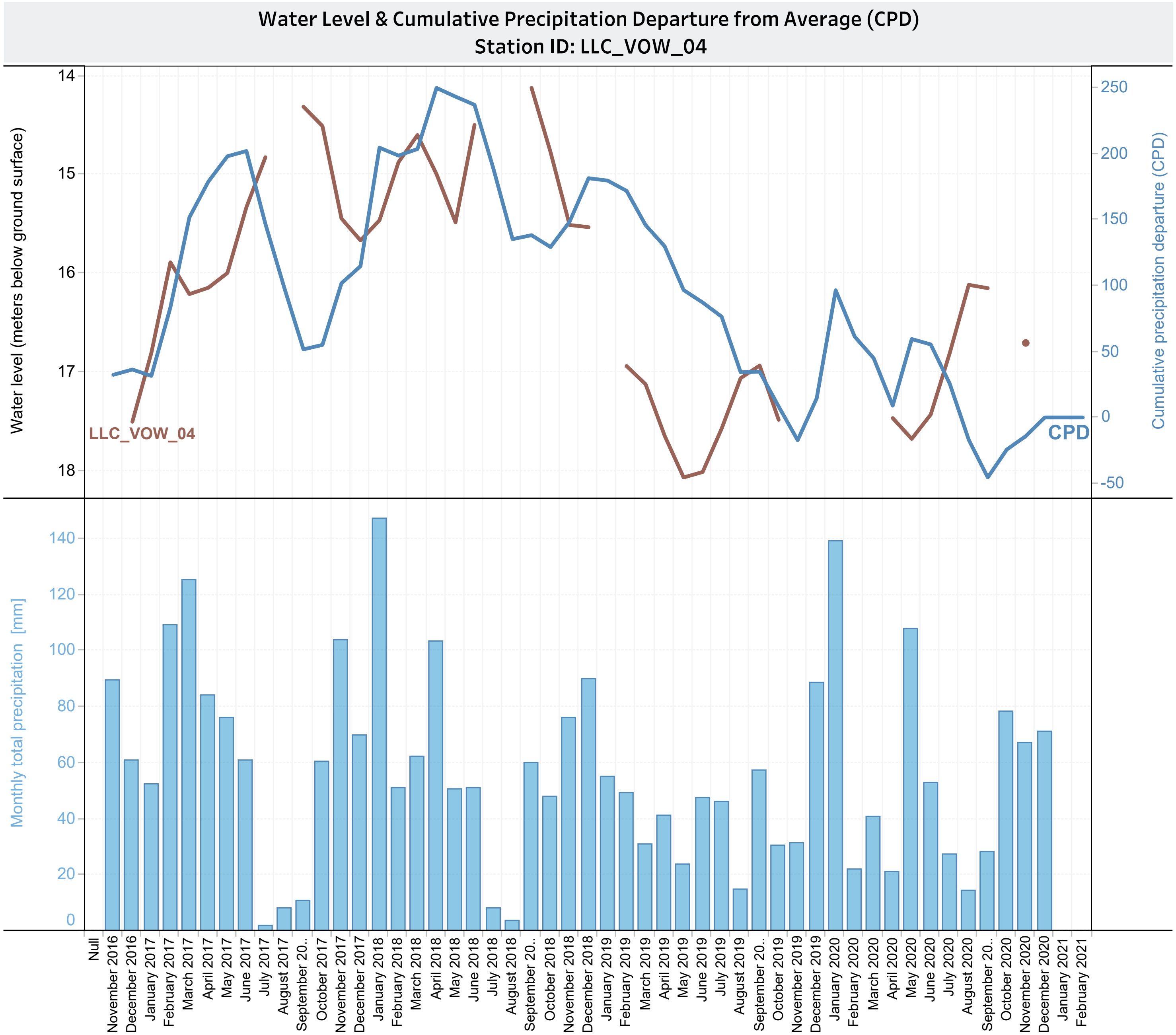
5 min up to 2019-04-09 13:40; 10 min thereafter

Water Level Sensor

Keller Acculevel High Accuracy Submersible Level Transmitter, Range-40 ft. (No temperature sensor)

Graphs produced by:


Water Level & Daily Total Precipitation
Station ID: LLC_VOW_04
Water level (meters below ground surface)
14.0
14.5
15.0
15.5
16.0
16.5
17.0
17.5
18.0
Daily total precipitation (mm)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Mar 1, 17
Sep 1, 17
Mar 1, 18
Sep 1, 18
Mar 1, 19
Sep 1, 19
Mar 1, 20
Sep 1, 20
Date
Station ID Groundwater
LLC_VOW_04
Station ID Legend
1105
LLC_VOW_04
Precipitation
1105
CASTLEGAR A
Groundwater
LLC_VOW_04
Castlegar, Near 13th Ave & Columbia Ave.
Graphs produced by:
C Waters Consulting
GW SOLUTIONS

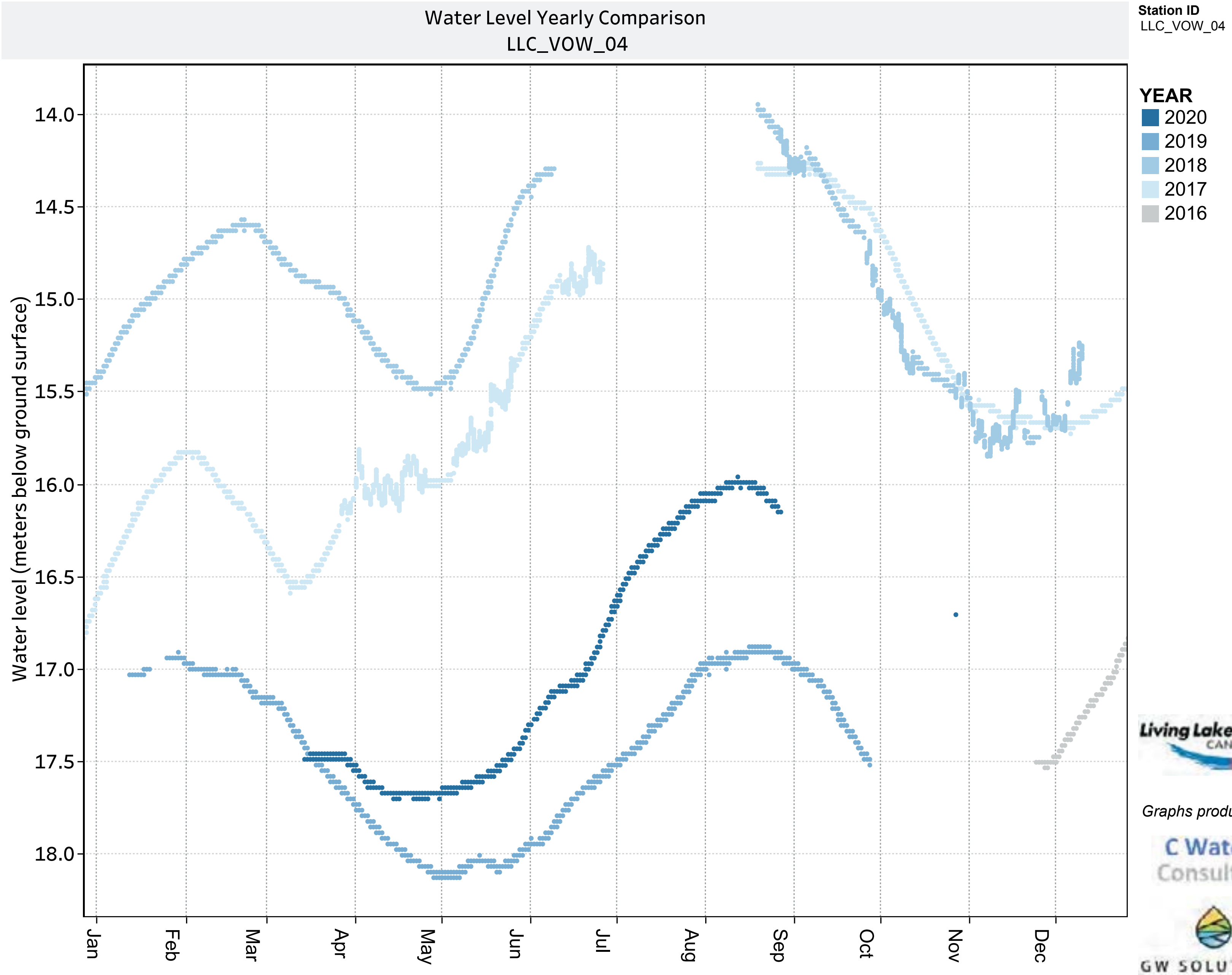


Station ID Groundwater
LLC_VOW_04

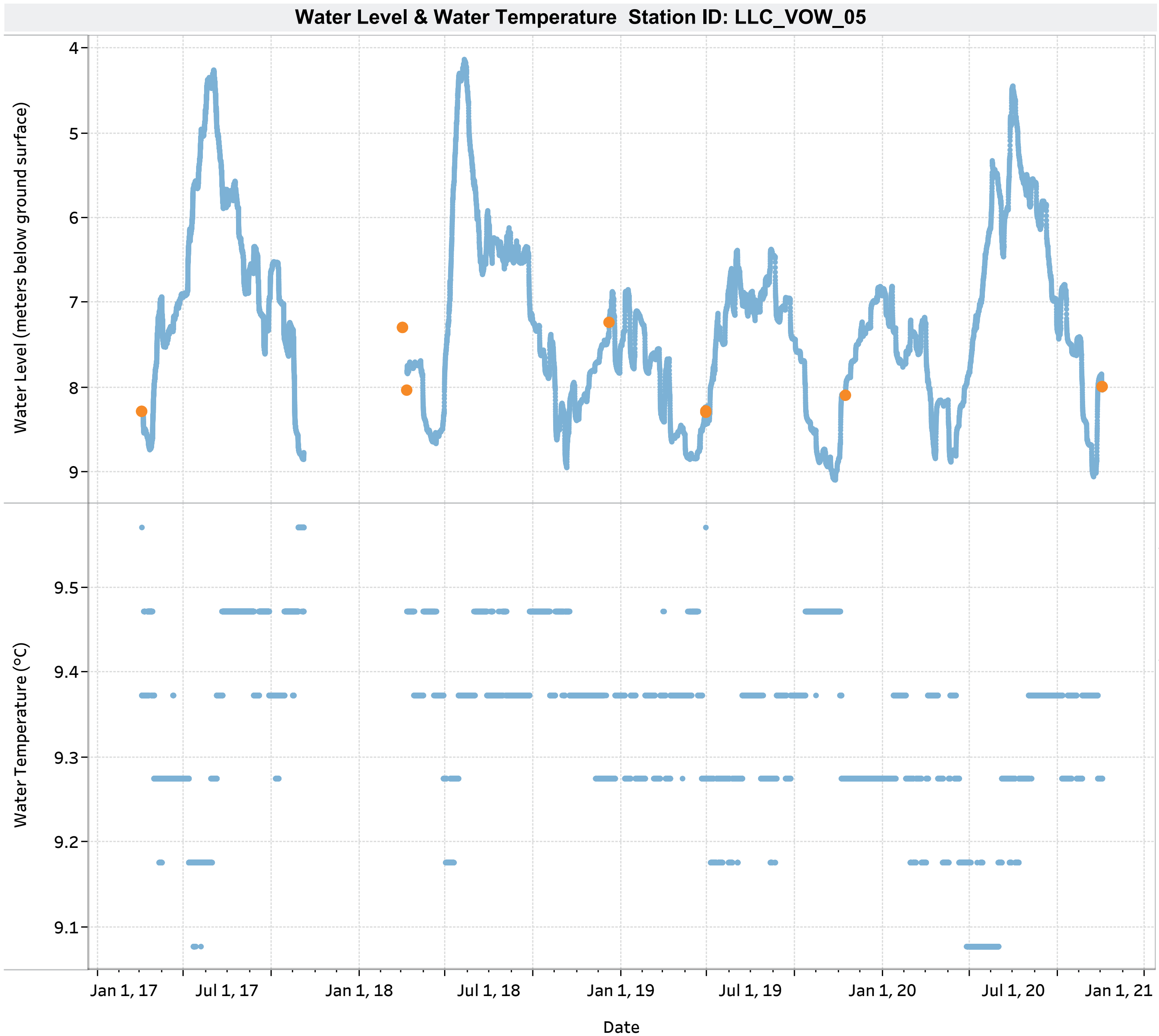
Water level data
Begining of the month

Precipitation	1105	CASTLEGAR A
Groundwater	LLC_VOW_04	Castlegar, Near 13th Ave & Columbia Ave.

Graphs produced by:



Graphs produced by:



Station ID
LLC_VOW_05

Measurement Type
Manual data
Logger data

Well depth (mbgs)
14.1

Depth of Water Level Sensor (mbgs)
12.9

Recording Interval
2017-03-02 to 2017-10-14 - 15 min; 2018-03-07 to present- 1 hr

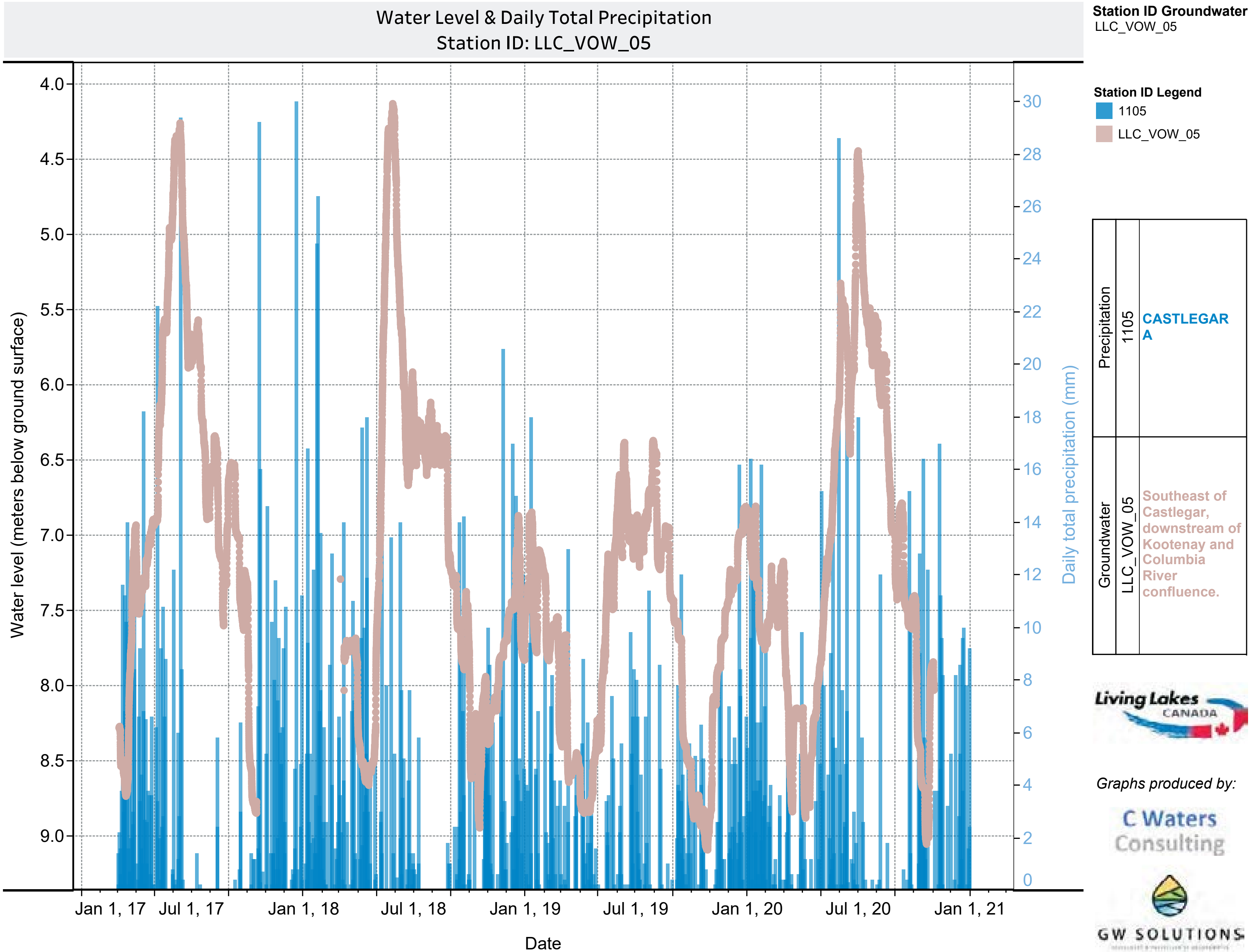
Water Level Sensor
HOB0 U20-001-02 (Range 30 m)

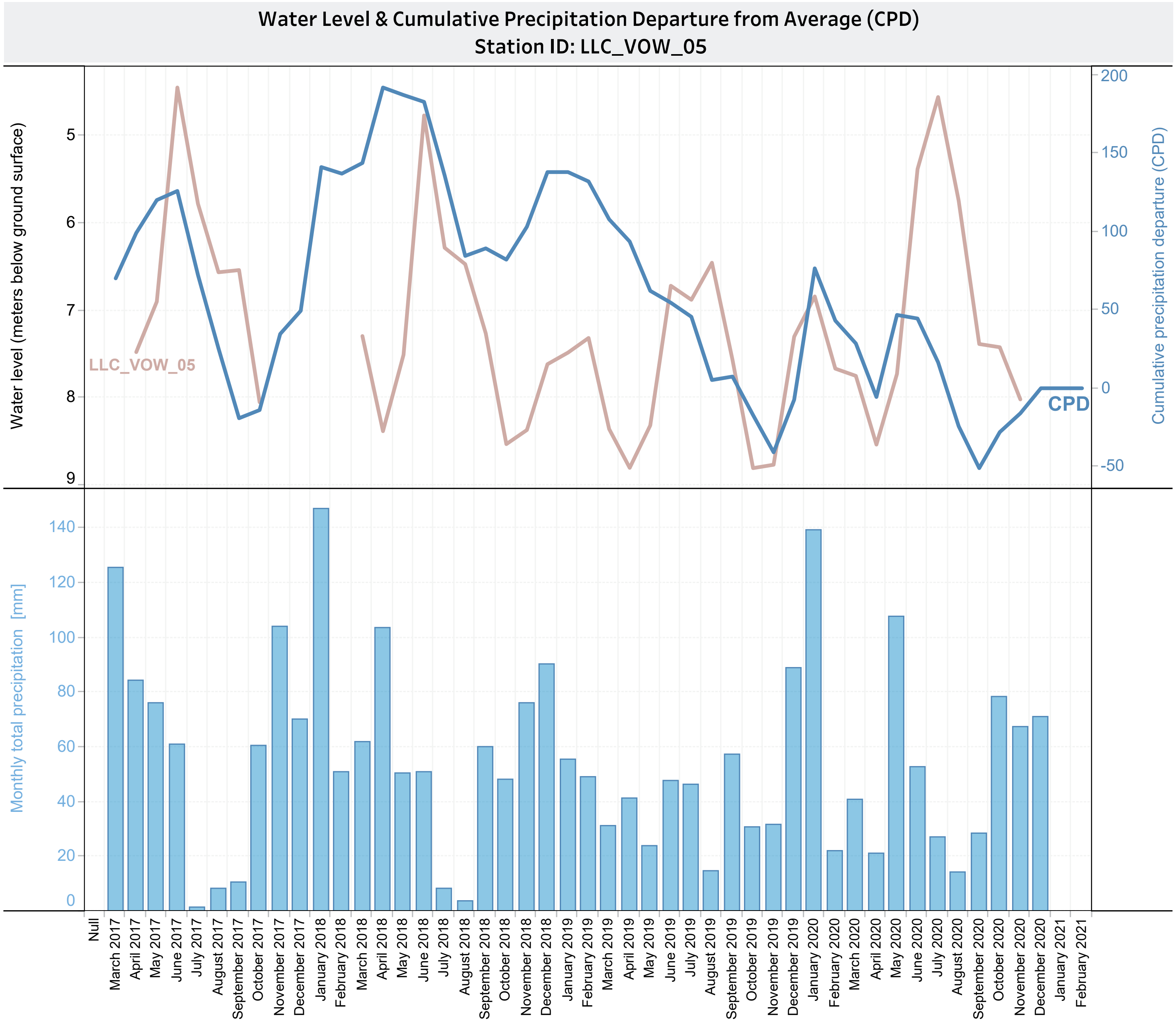
Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS


Water Level & Daily Total Precipitation
Station ID: LLC_VOW_05
Water level (meters below ground surface)
Daily total precipitation (mm)
Date
Jan 1, 17
Jul 1, 17
Jan 1, 18
Jul 1, 18
Jan 1, 19
Jul 1, 19
Jan 1, 20
Jul 1, 20
Jan 1, 21
Station ID Groundwater
LLC_VOW_05
Station ID Legend
1105
LLC_VOW_05
Precipitation
1105
CASTLEGAR A
Groundwater
LLC_VOW_05
Southeast of Castlegar, downstream of Kootenay and Columbia River confluence.
Living Lakes CANADA
Graphs produced by:
C Waters Consulting
GW SOLUTIONS

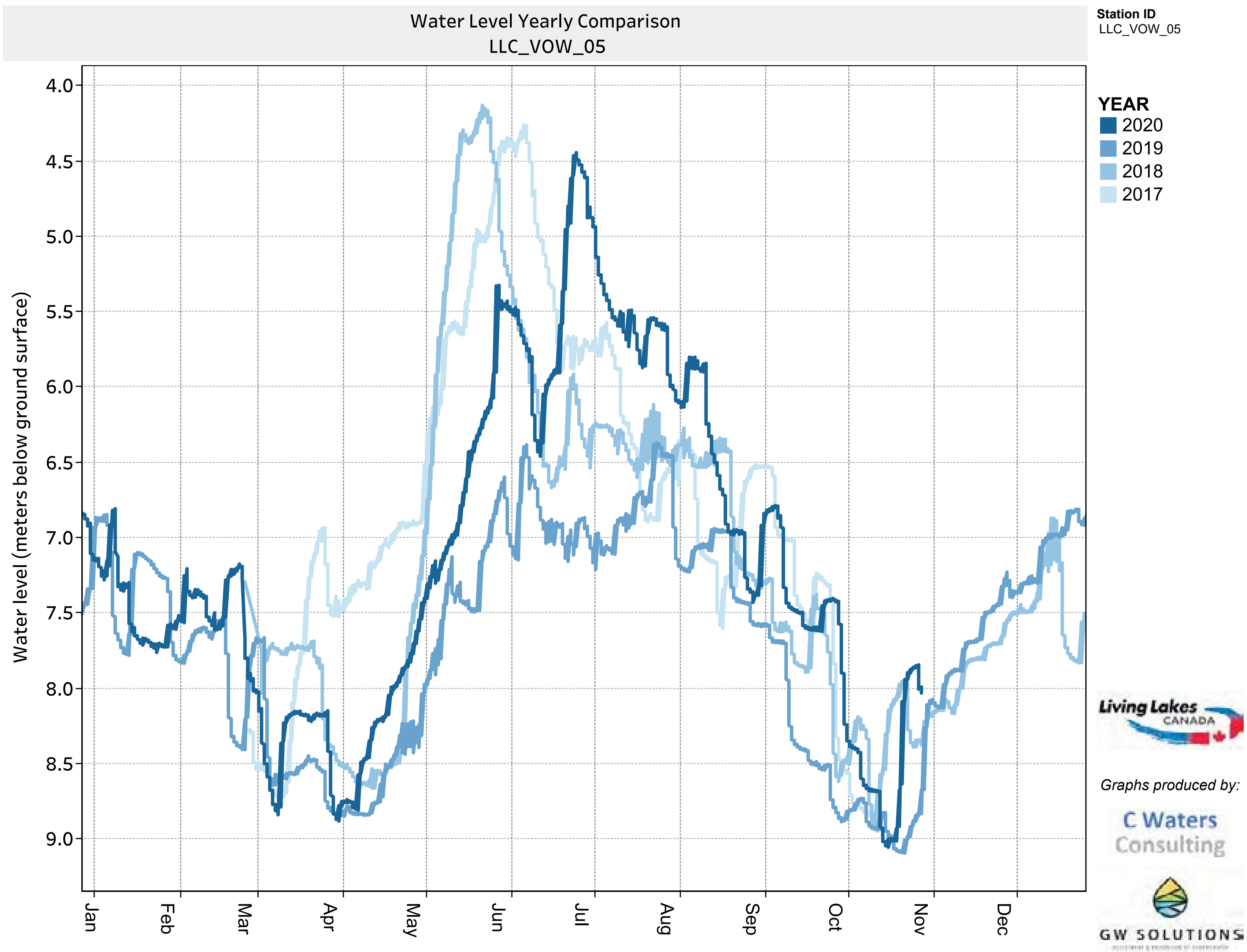


Station ID Groundwater
LLC_VOW_05

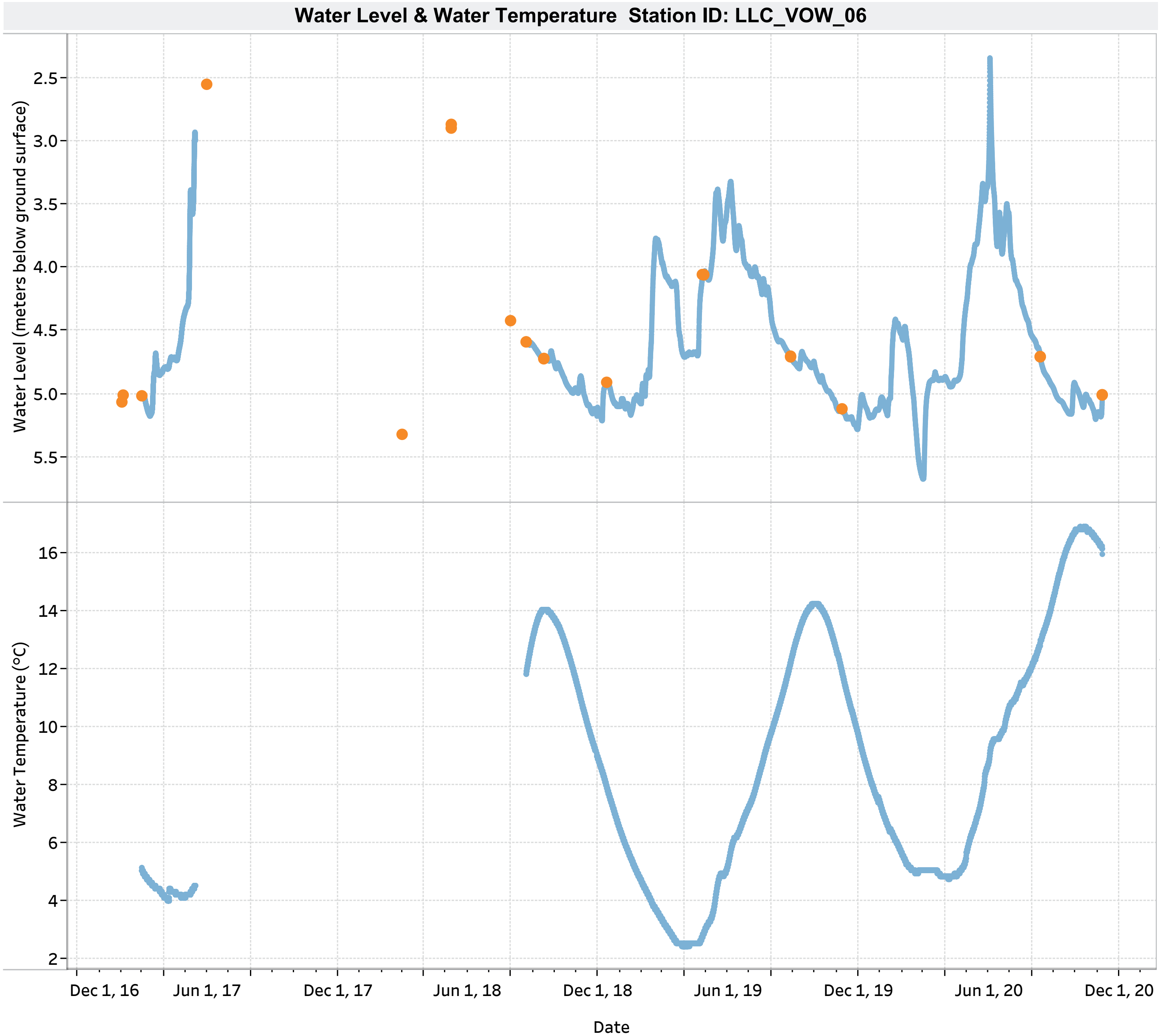
Water level data
Begining of the month

Precipitation	1105	CASTLEGAR A
Groundwater	LLC_VOW_05	Southeast of Castlegar, downstream of Kootenay and Columbia River confluence.

Graphs produced by:



Water Level Yearly Comparison
LLC_VOW_05
Station ID
LLC_VOW_05
YEAR
2020
2019
2018
2017
Water level (meters below ground surface)
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Living Lakes Canada
Graphs produced by:
C Waters Consulting
GW SOLUTIONS



Station ID
LLC_VOW_06

Measurement Type
Manual data
Logger data

Well depth (mbgs)
10.7

Depth of Water Level Sensor (mbgs)
10.9

Recording Interval
2017-02-28 to 2017-05-14- 5 min; 2018-08-21 to present- 1 hr

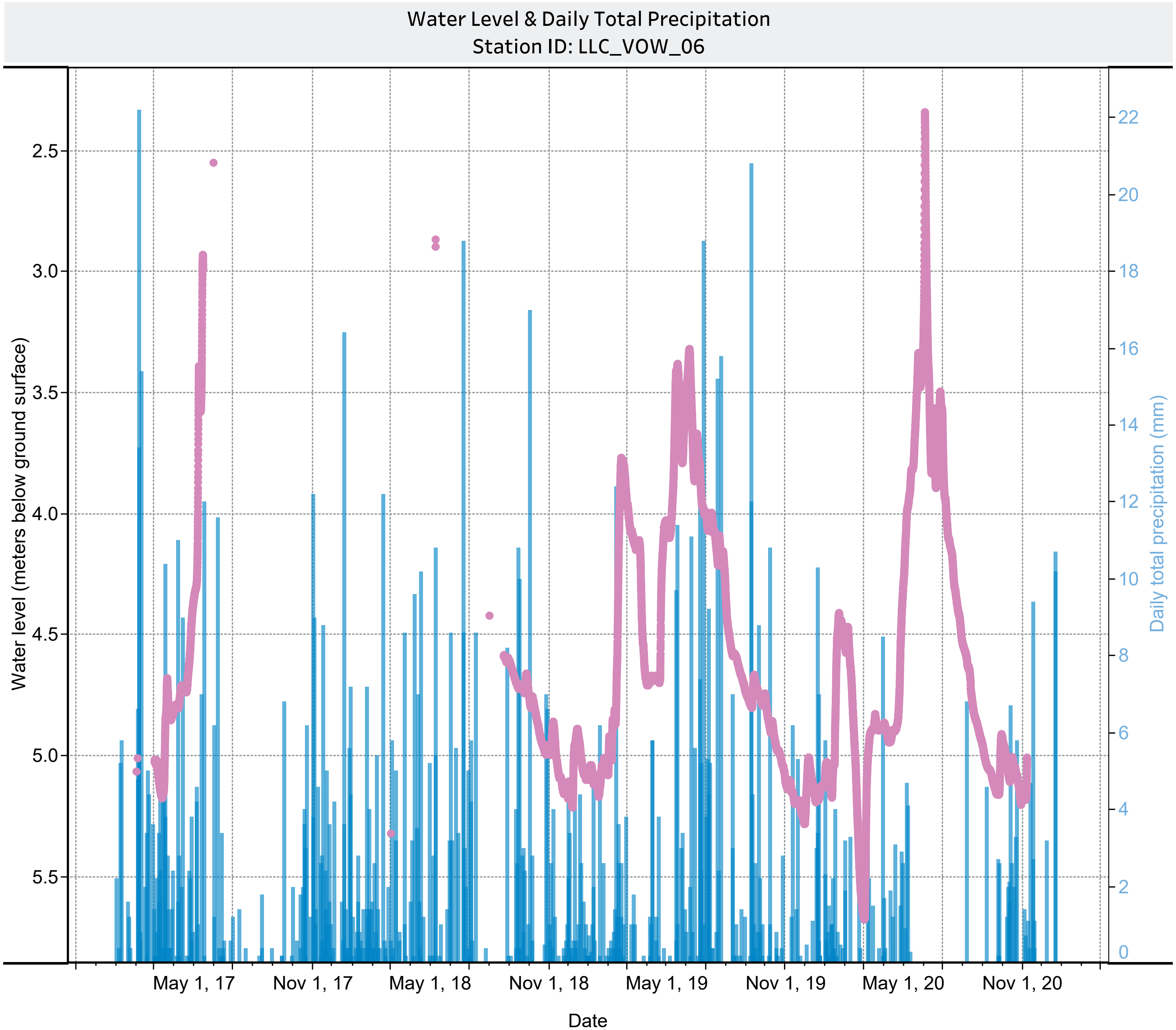
Water Level Sensor
HOBO U20-001-04 (Range 4 m)/ replaced with HOBO MX2001-01 (Range 9 m) on 2018-08-21

Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS

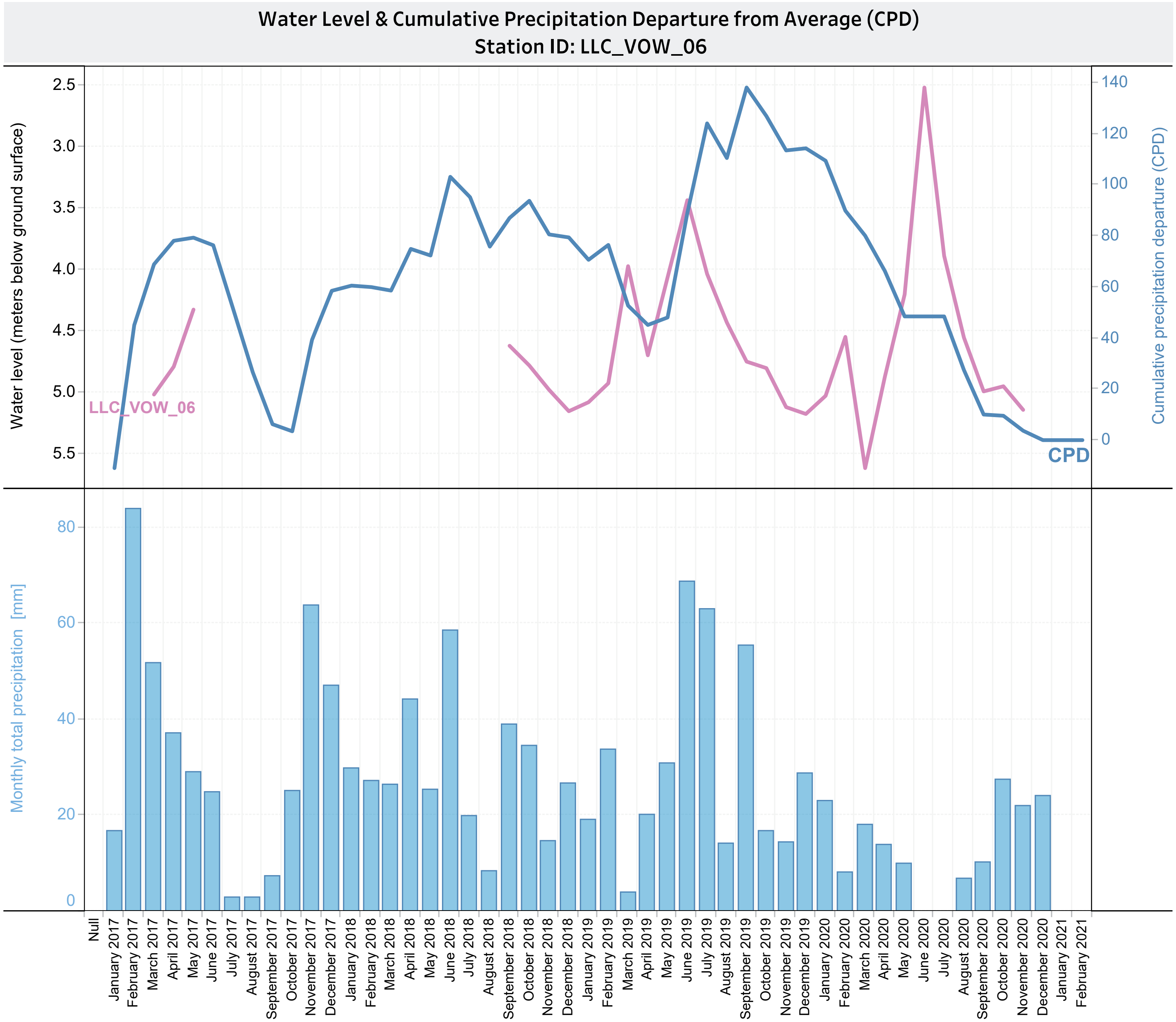


Station ID Groundwater
LLC_VOW_06

Station ID Legend
- 50818
- LLC_VOW_06

Precipitation	50818	CRANBROOK A
Groundwater	LLC_VOW_06	ʔaq̓am Community, North side of St.Mary's River.

Graphs produced by:

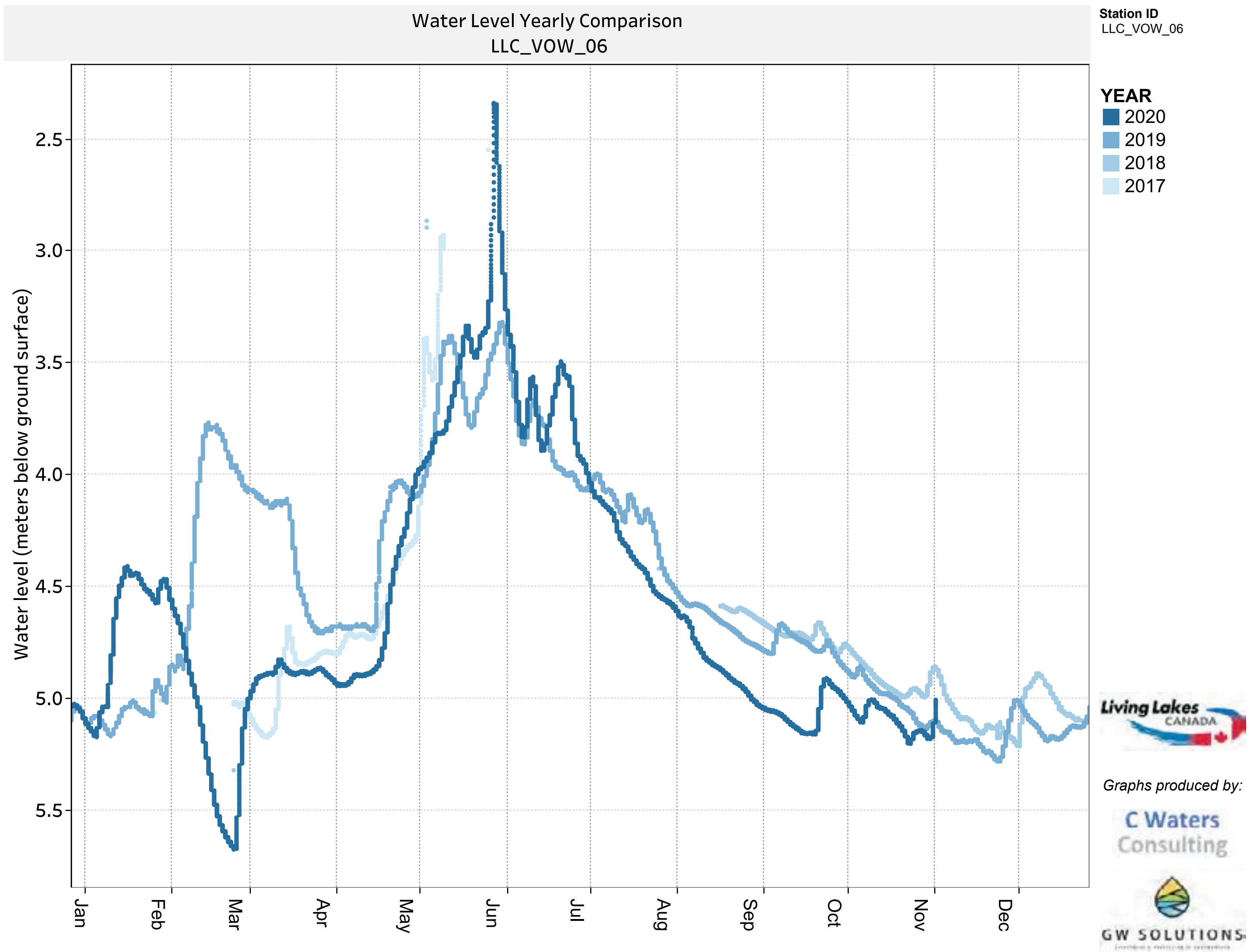


Station ID Groundwater
LLC_VOW_06

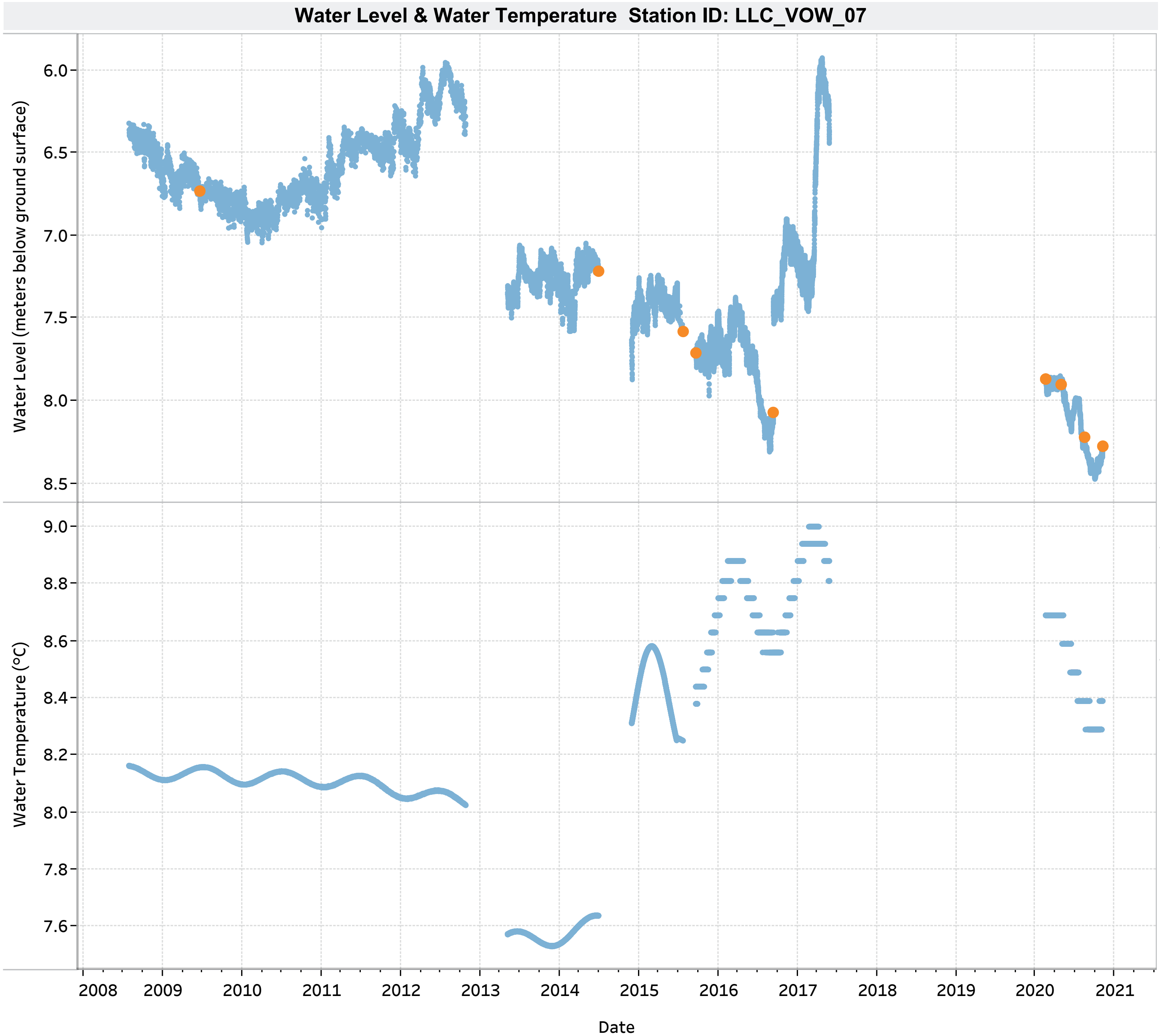
Water level data
Begining of the month

Precipitation	50818	CRANBROOK
Groundwater	LLC_VOW_06	ʔaq̓am Community, North side of St.Mary's River.

Graphs produced by:



Water Level Yearly Comparison
LLC_VOW_06
Station ID
LLC_VOW_06
YEAR
2020
2019
2018
2017
Water level (meters below ground surface)
2.5
3.0
3.5
4.0
4.5
5.0
5.5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Living Lakes CANADA
Graphs produced by:
C Waters Consulting
GW SOLUTIONS



Station ID
LLC_VOW_07

Measurement Type
Manual data
Logger data

Well depth (mbgs)
24.2

Depth of Water Level Sensor (mbgs)
22

Recording Interval
1 hour

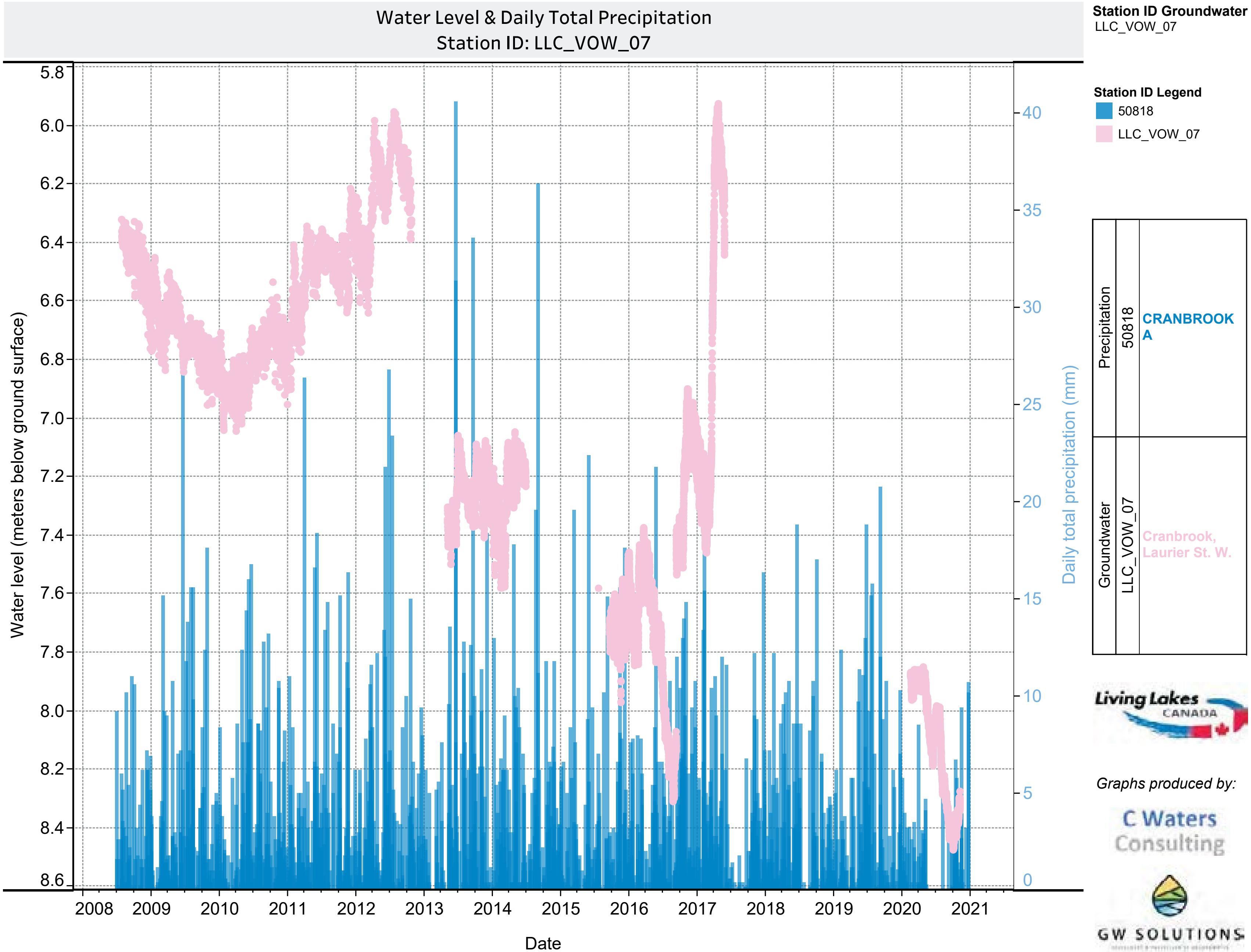
Water Level Sensor
Heron Dipper Module- 2008-07-24 to 2017-05-24; HOBO MX-2001-01 (Range 9 m) 2020-02-14- Current

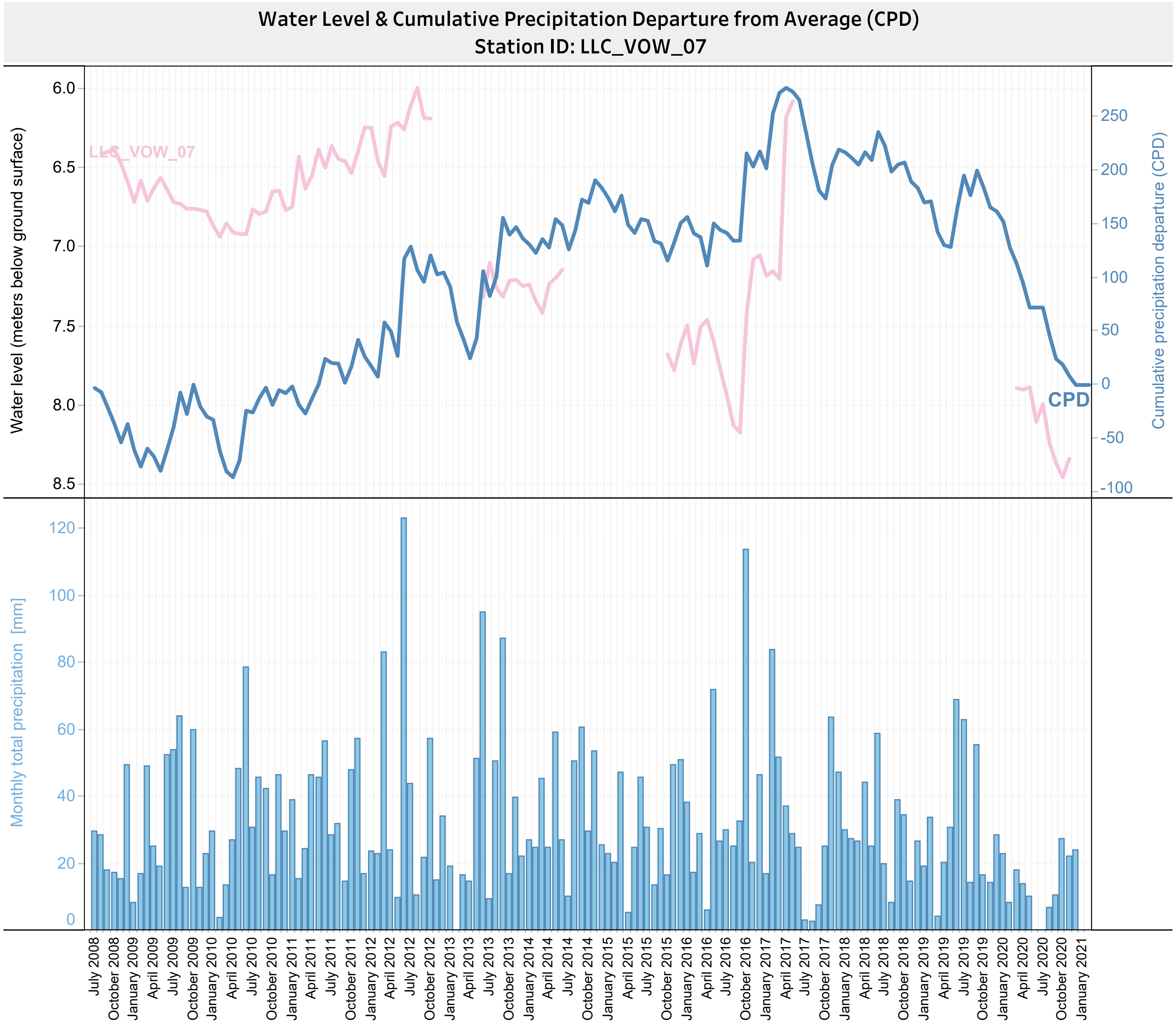
Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS


Water Level & Daily Total Precipitation
Station ID: LLC_VOW_07
Water level (meters below ground surface)
5.8
6.0
6.2
6.4
6.6
6.8
7.0
7.2
7.4
7.6
7.8
8.0
8.2
8.4
8.6
Daily total precipitation (mm)
40
35
30
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Date
Station ID Groundwater
LLC_VOW_07
Station ID Legend
50818
LLC_VOW_07
Precipitation
50818
CRANBROOK A
Groundwater
LLC_VOW_07
Cranbrook, Laurier St. W.
Graphs produced by:
C Waters Consulting
GW SOLUTIONS



Station ID Groundwater
LLC_VOW_07

Water level data
Begining of the month

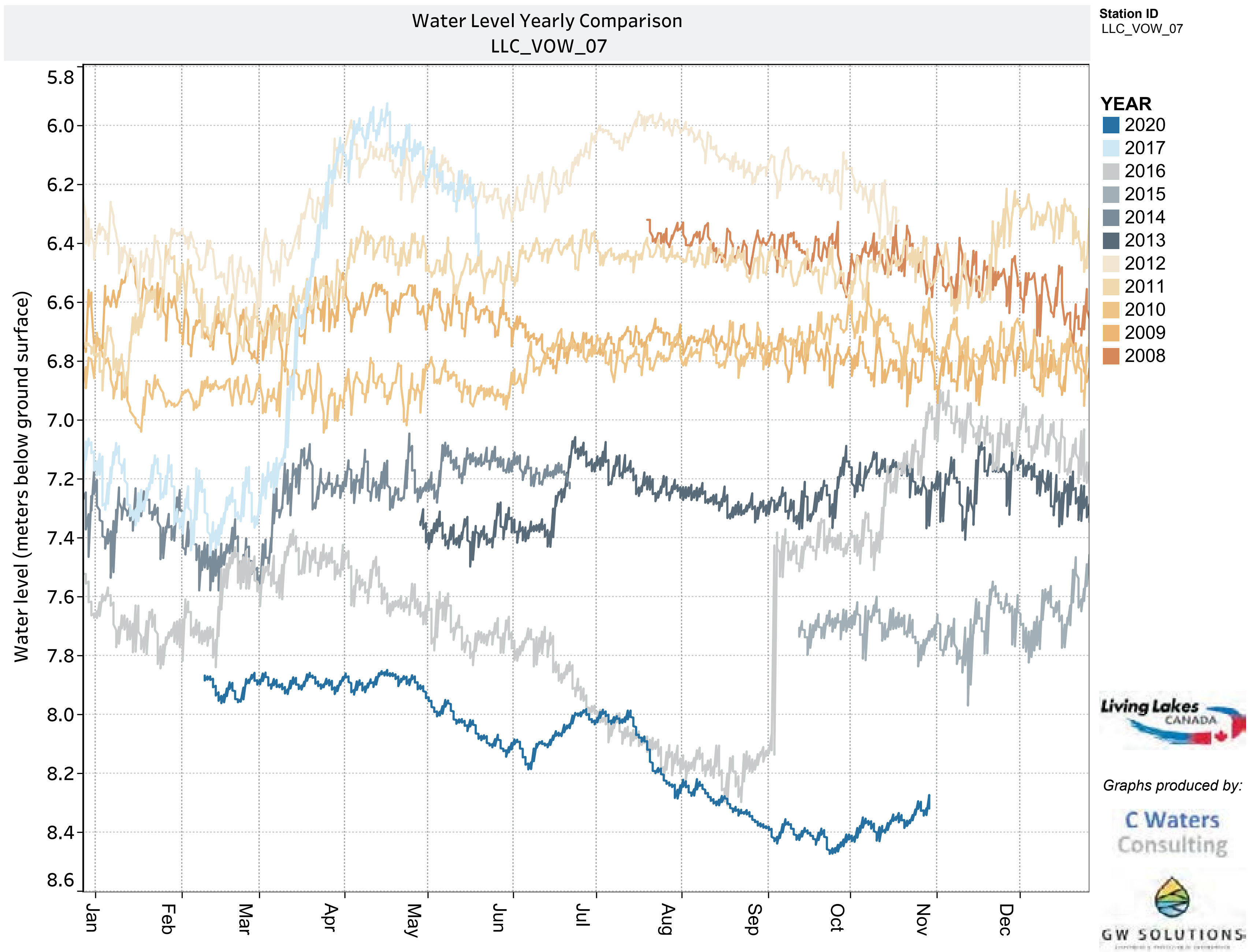
Precipitation	50818	CRANBROOK
Groundwater	LLC_VOW_07	Cranbrook, Laurier St. W.

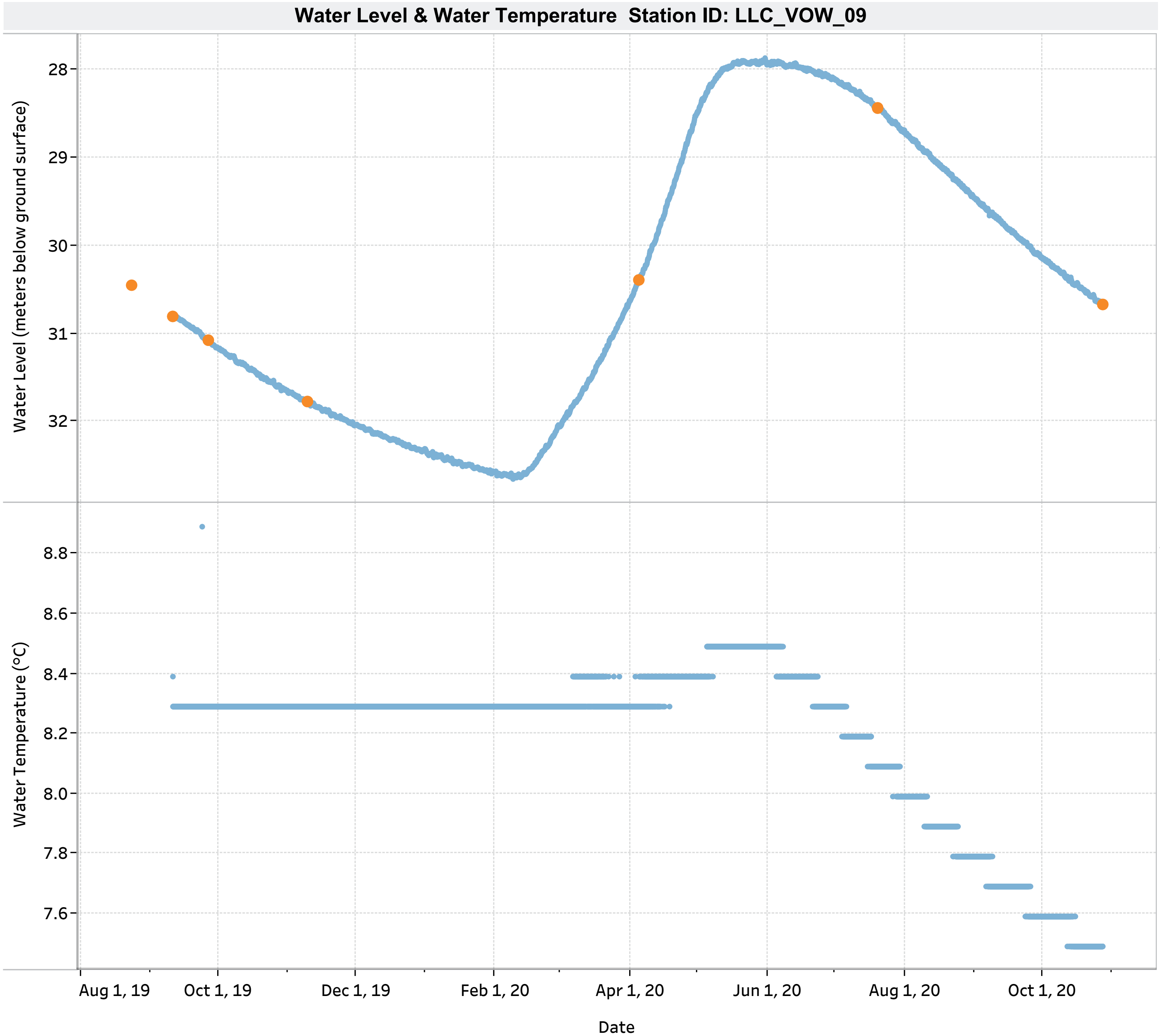
Living Lakes Canada

Graphs produced by:

C Waters Consulting

GW SOLUTIONS


Water Level Yearly Comparison
LLC_VOW_07
Station ID
LLC_VOW_07
YEAR
2020
2017
2016
2015
2014
2013
2012
2011
2010
2009
2008
Water level (meters below ground surface)
5.8
6.0
6.2
6.4
6.6
6.8
7.0
7.2
7.4
7.6
7.8
8.0
8.2
8.4
8.6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Living Lakes CANADA
Graphs produced by:
C Waters Consulting
GW SOLUTIONS



Station ID
LLC_VOW_09

Measurement Type
Manual data
Logger data

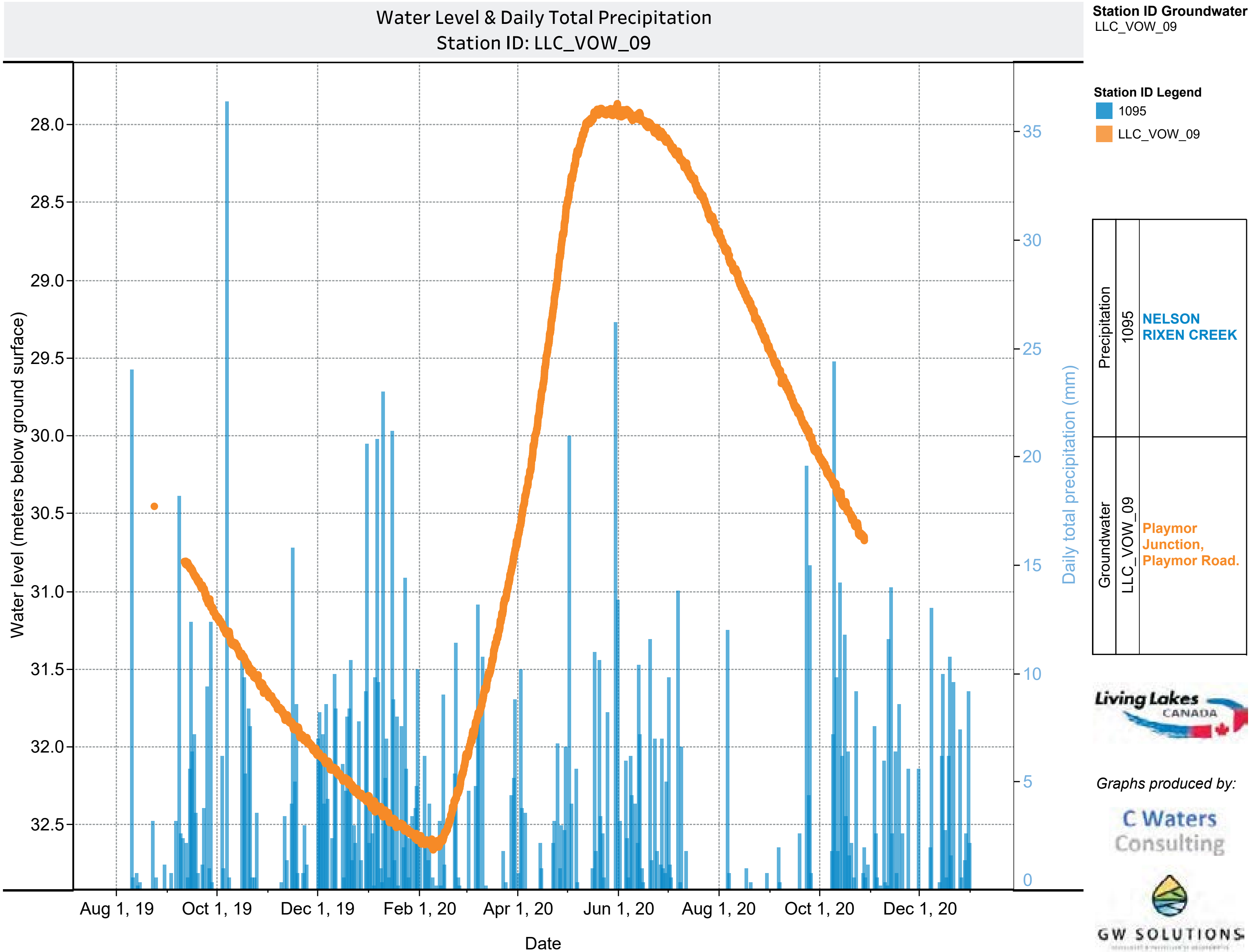
Well depth (mbgs)
43

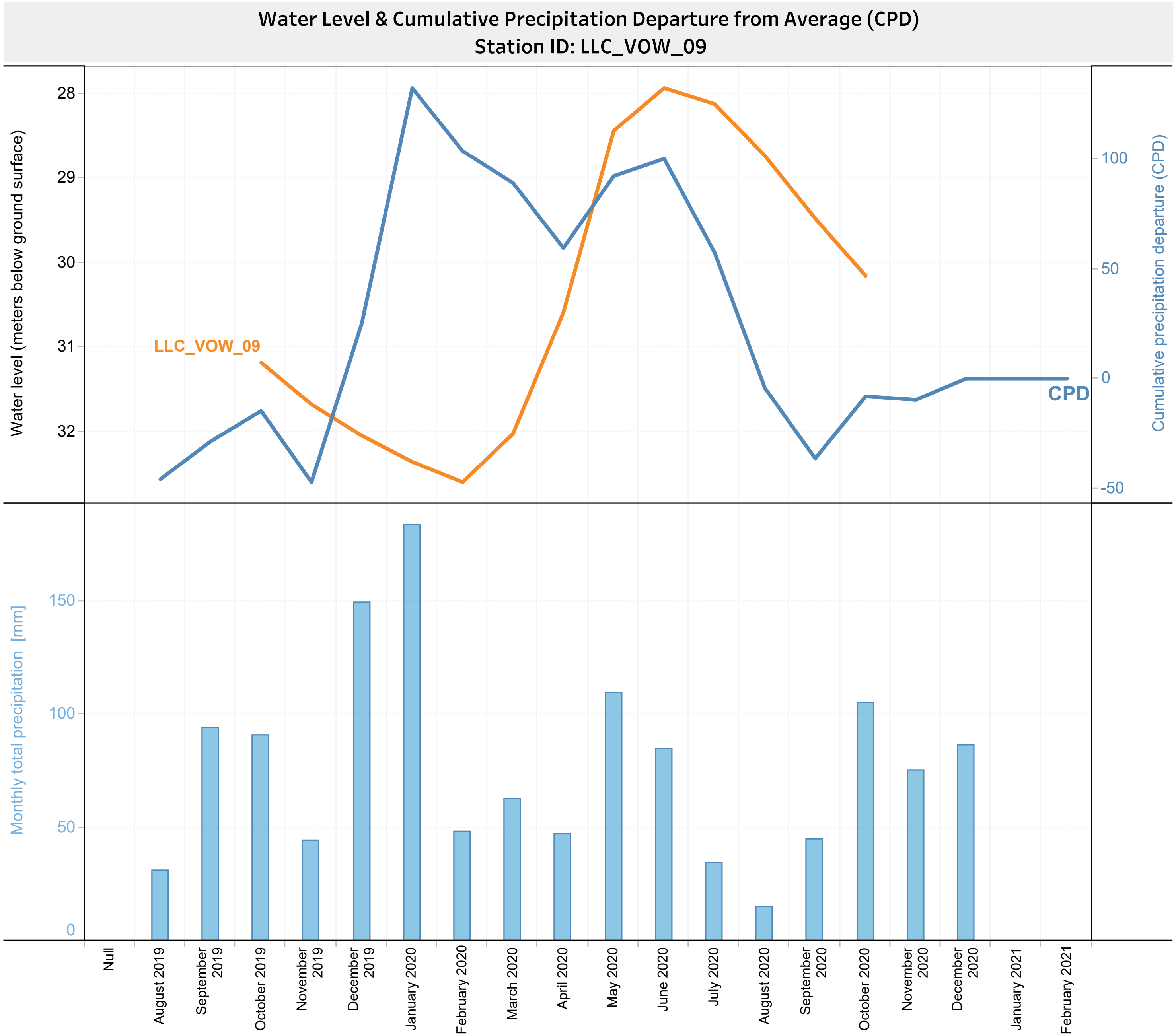
Depth of Water Level Sensor (mbgs)
41.2

Recording Interval
1 hour

Water Level Sensor
HOBO MX2001-02 (Range 30 m)

Graphs produced by:


Water Level & Daily Total Precipitation
Station ID: LLC_VOW_09
Water level (meters below ground surface)
28.0
28.5
29.0
29.5
30.0
30.5
31.0
31.5
32.0
32.5
Daily total precipitation (mm)
35
30
25
20
15
10
5
0
Aug 1, 19
Oct 1, 19
Dec 1, 19
Feb 1, 20
Apr 1, 20
Jun 1, 20
Aug 1, 20
Oct 1, 20
Dec 1, 20
Date
Station ID Groundwater
LLC_VOW_09
Station ID Legend
1095
LLC_VOW_09
Precipitation
1095
NELSON RIXEN CREEK
Groundwater
LLC_VOW_09
Playmor Junction, Playmor Road.
Living Lakes CANADA
Graphs produced by:
C Waters Consulting
GW SOLUTIONS

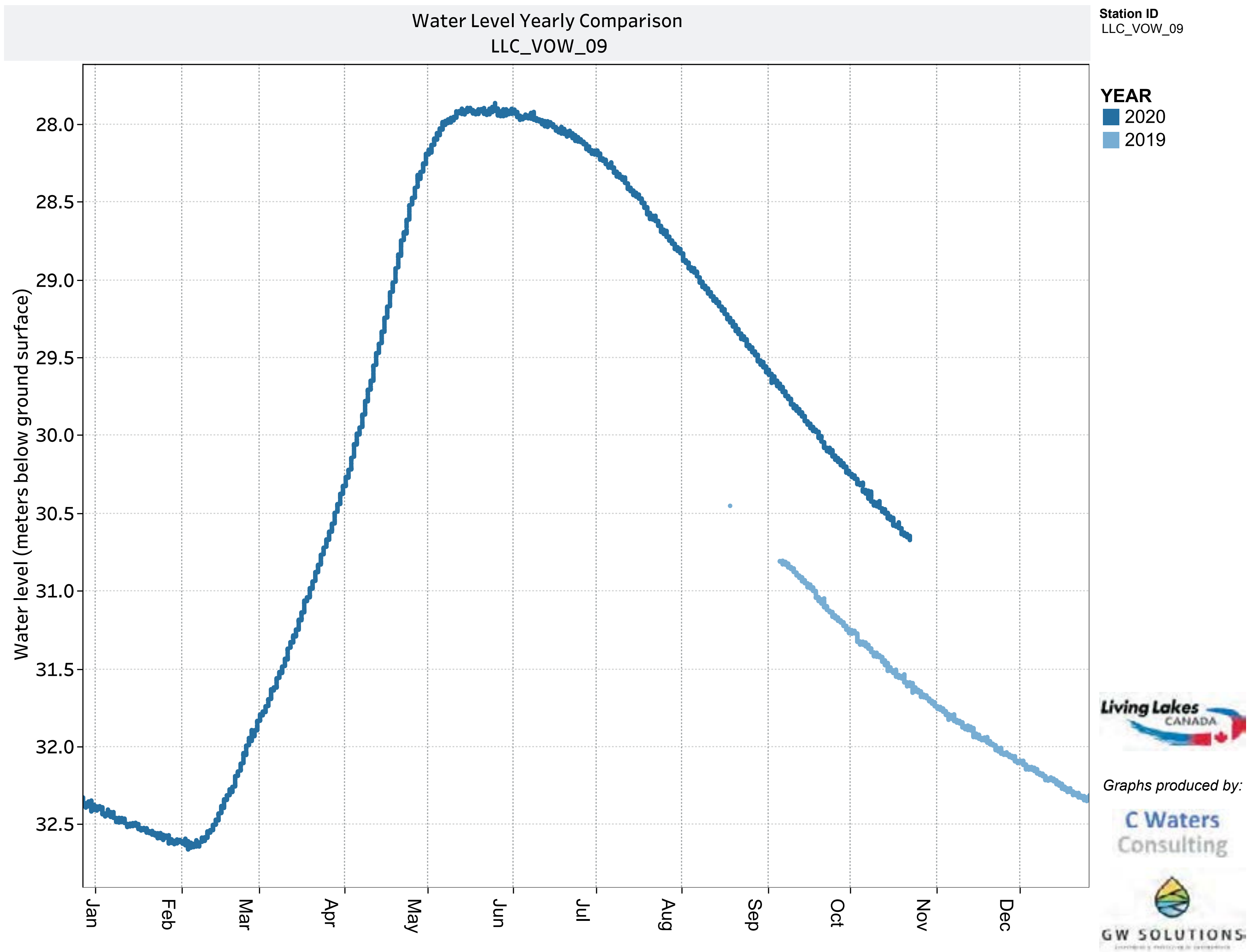


Station ID Groundwater
LLC_VOW_09

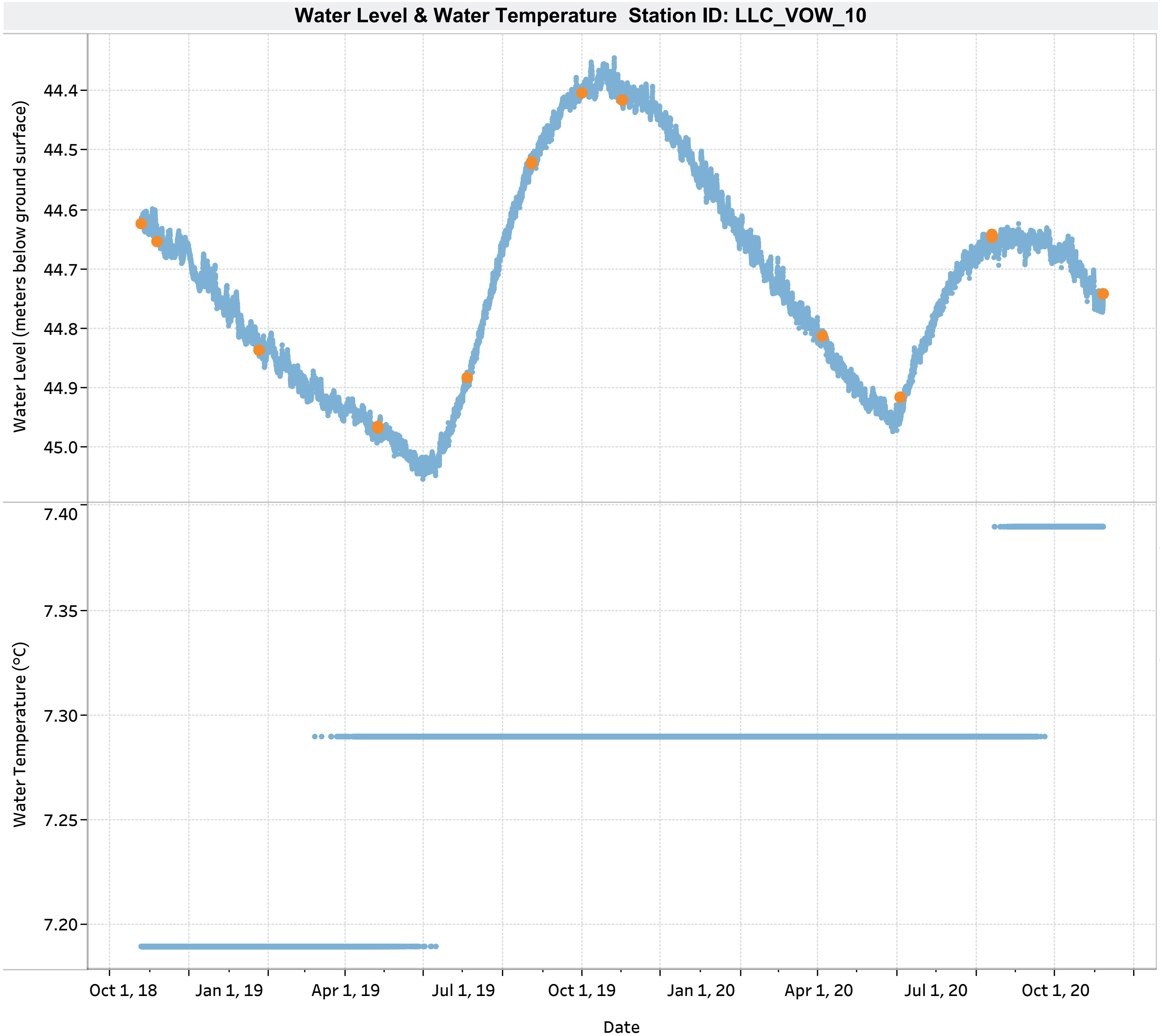
Water level data
Begining of the month

Precipitation	1095	NELSON RIXEN CREEK
Groundwater	LLC_VOW_09	Playmor Junction, Playmor Road.

Graphs produced by:



Water Level Yearly Comparison
LLC_VOW_09
Water level (meters below ground surface)
28.0
28.5
29.0
29.5
30.0
30.5
31.0
31.5
32.0
32.5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Station ID
LLC_VOW_09
YEAR
2020
2019
Graphs produced by:



Station ID
LLC_VOW_10

Measurement Type
- Manual data
- Logger data

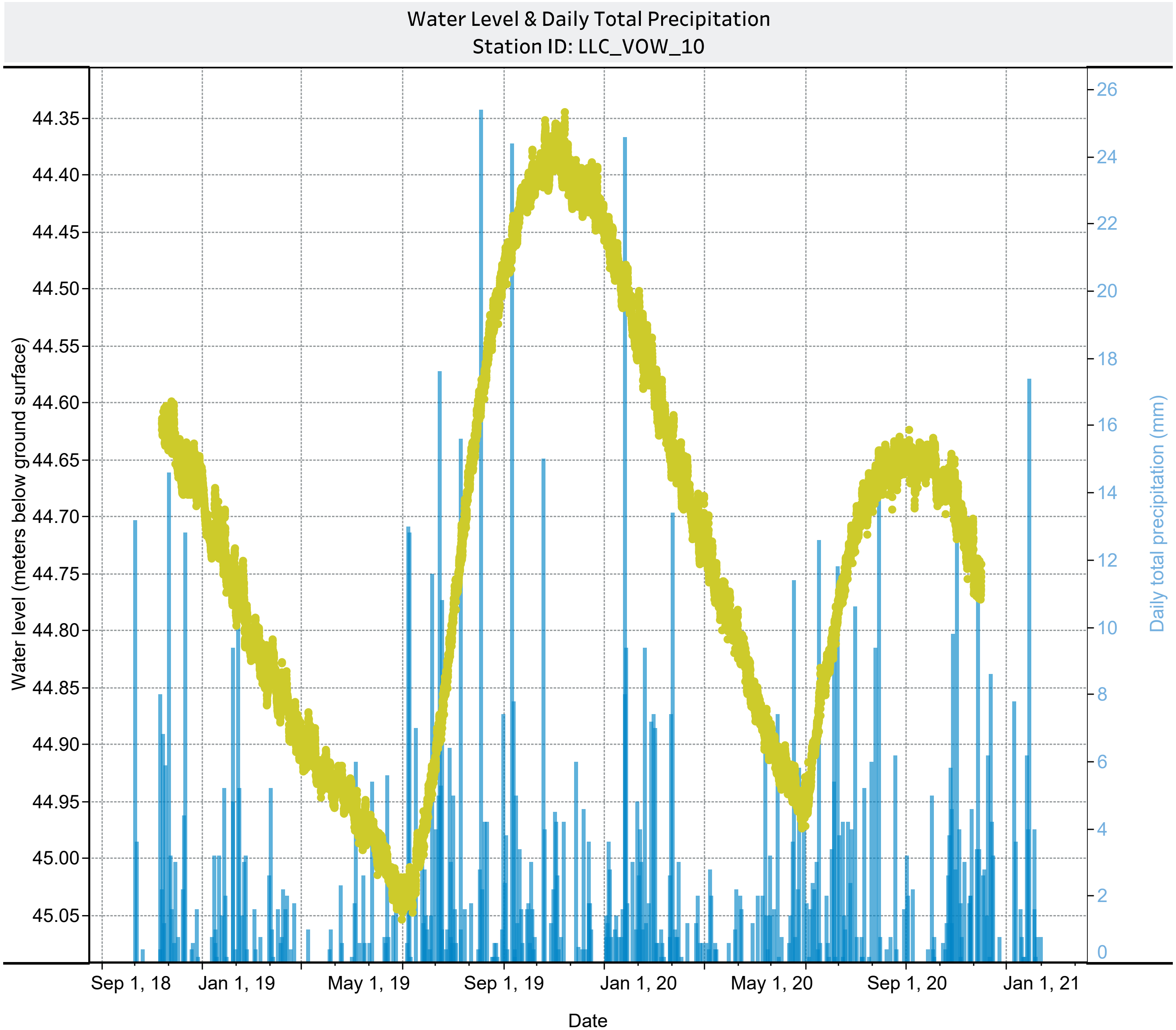
Well depth (mbgs)
47.9

Depth of Water Level Sensor (mbgs)
47.2

Recording Interval
1 hour

Water Level Sensor
HOBO MX2001-02 (Range 30 m)

Graphs produced by:



Station ID Groundwater
LLC_VOW_10

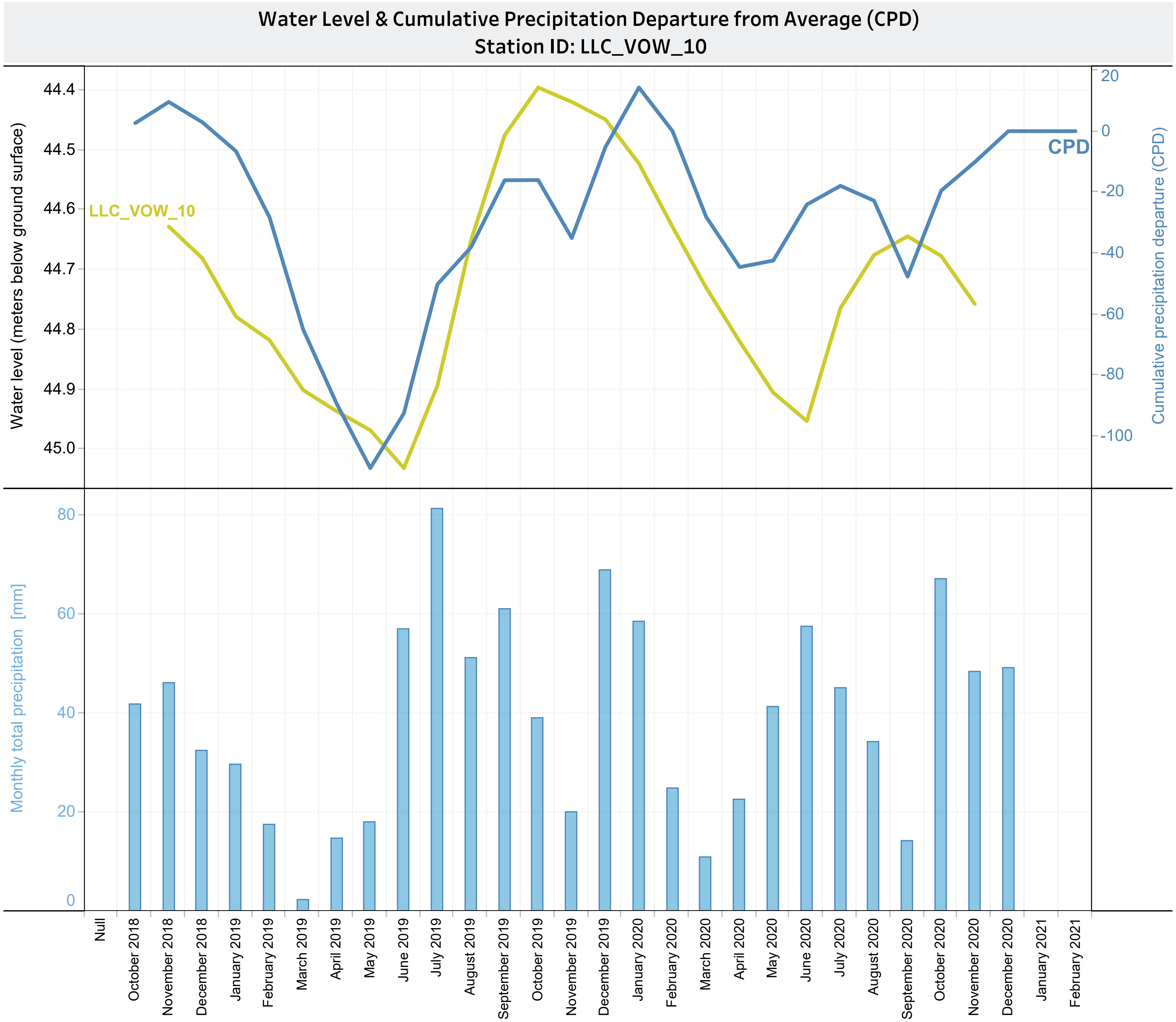
Station ID Legend
- 1364
- LLC_VOW_10

Precipitation	1364	GOLDEN A
Groundwater	LLC_VOW_10	Windermere, Windermere Loop Road -West side of road.

Graphs produced by:

C Waters Consulting

GW SOLUTIONS

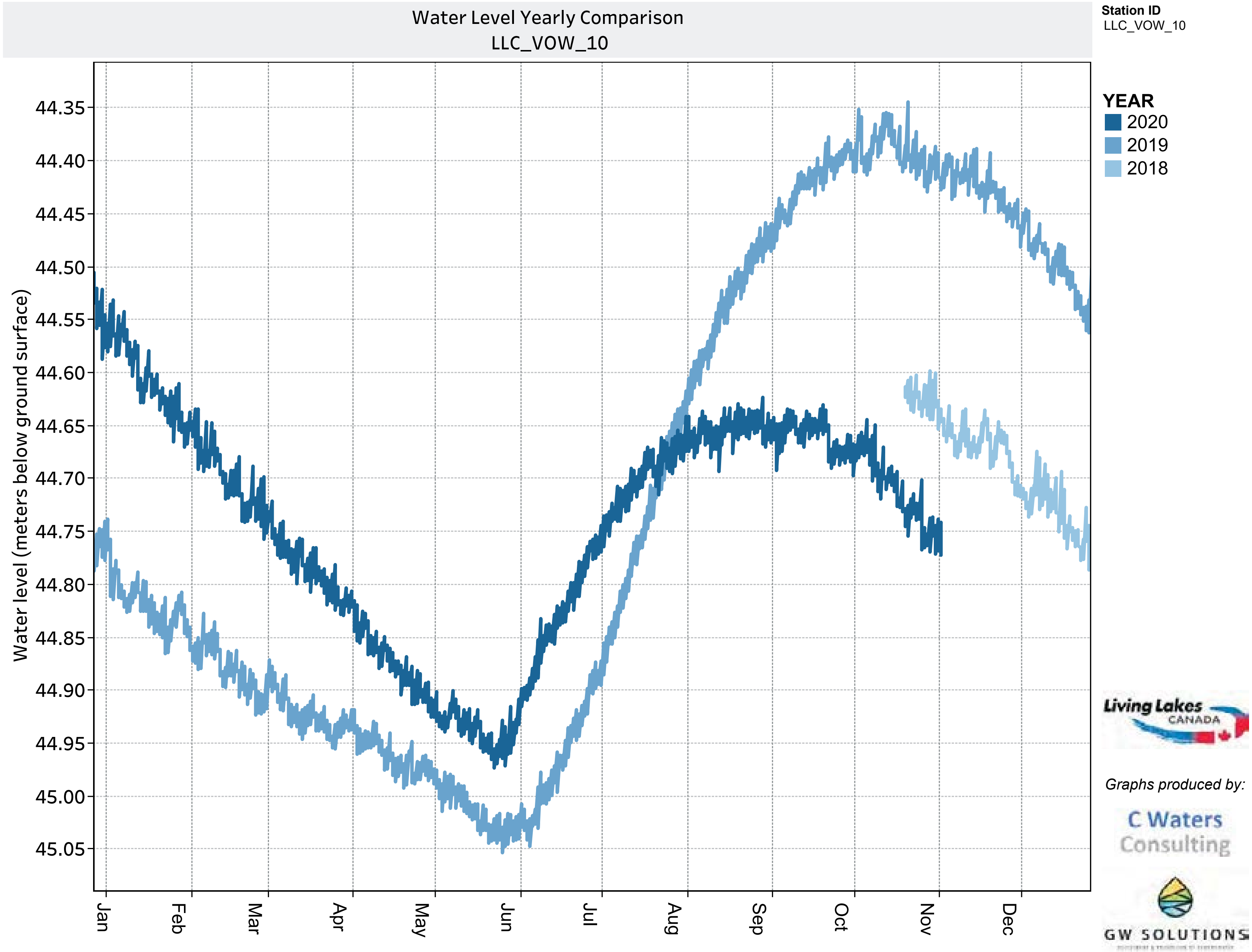


Station ID Groundwater
LLC_VOW_10

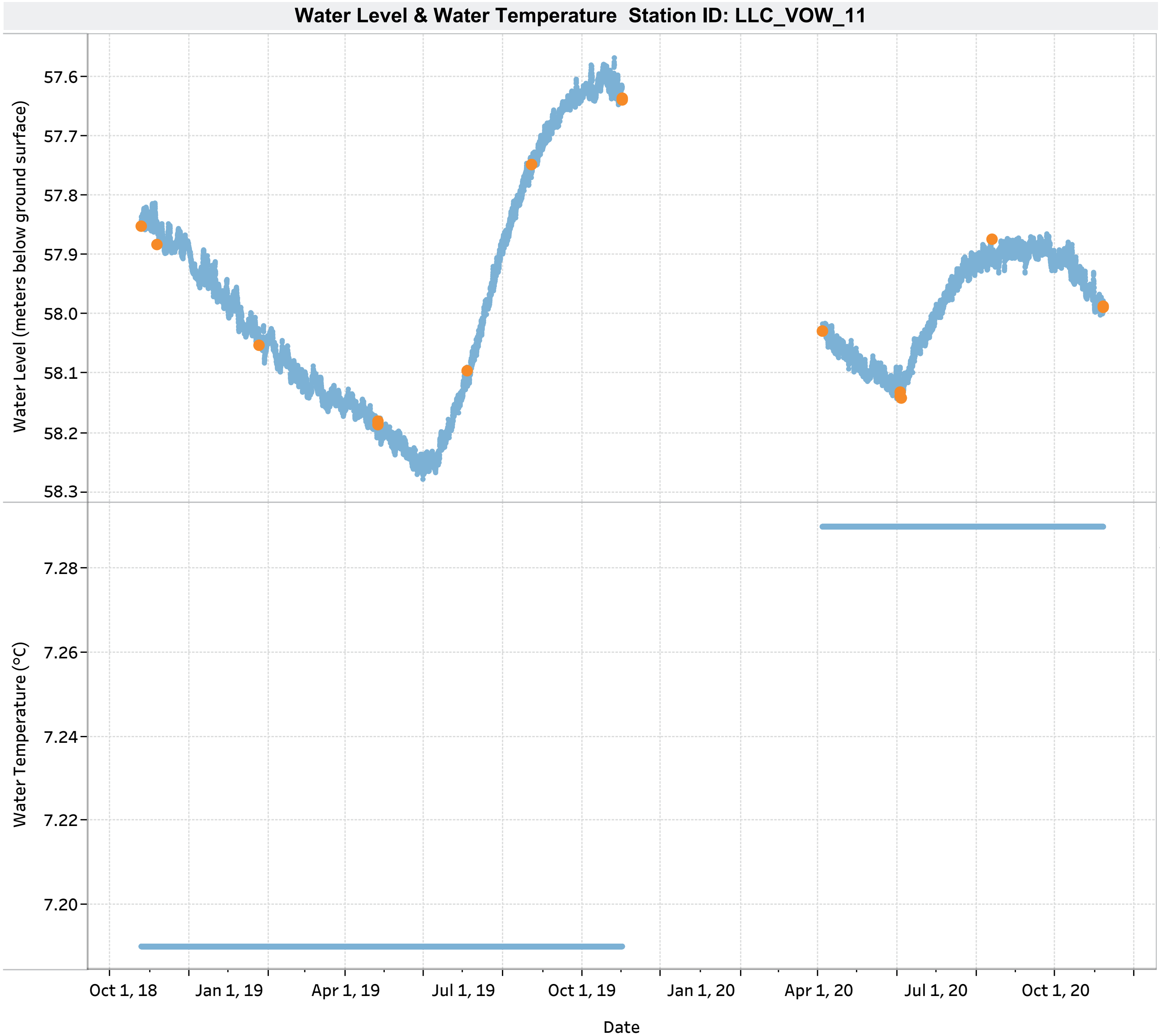
Water level data
Begining of the month

Precipitation	1364	GOLDEN A
Groundwater	LLC_VOW_10	Windermere, Windermere Loop Road -West side of road.

Graphs produced by:



Water Level Yearly Comparison
LLC_VOW_10
Station ID
LLC_VOW_10
YEAR
2020
2019
2018
Water level (meters below ground surface)
44.35
44.40
44.45
44.50
44.55
44.60
44.65
44.70
44.75
44.80
44.85
44.90
44.95
45.00
45.05
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Living Lakes
CANADA
Graphs produced by:
C Waters
Consulting
GW SOLUTIONS



Station ID
LLC_VOW_11

Measurement Type
Manual data
Logger data

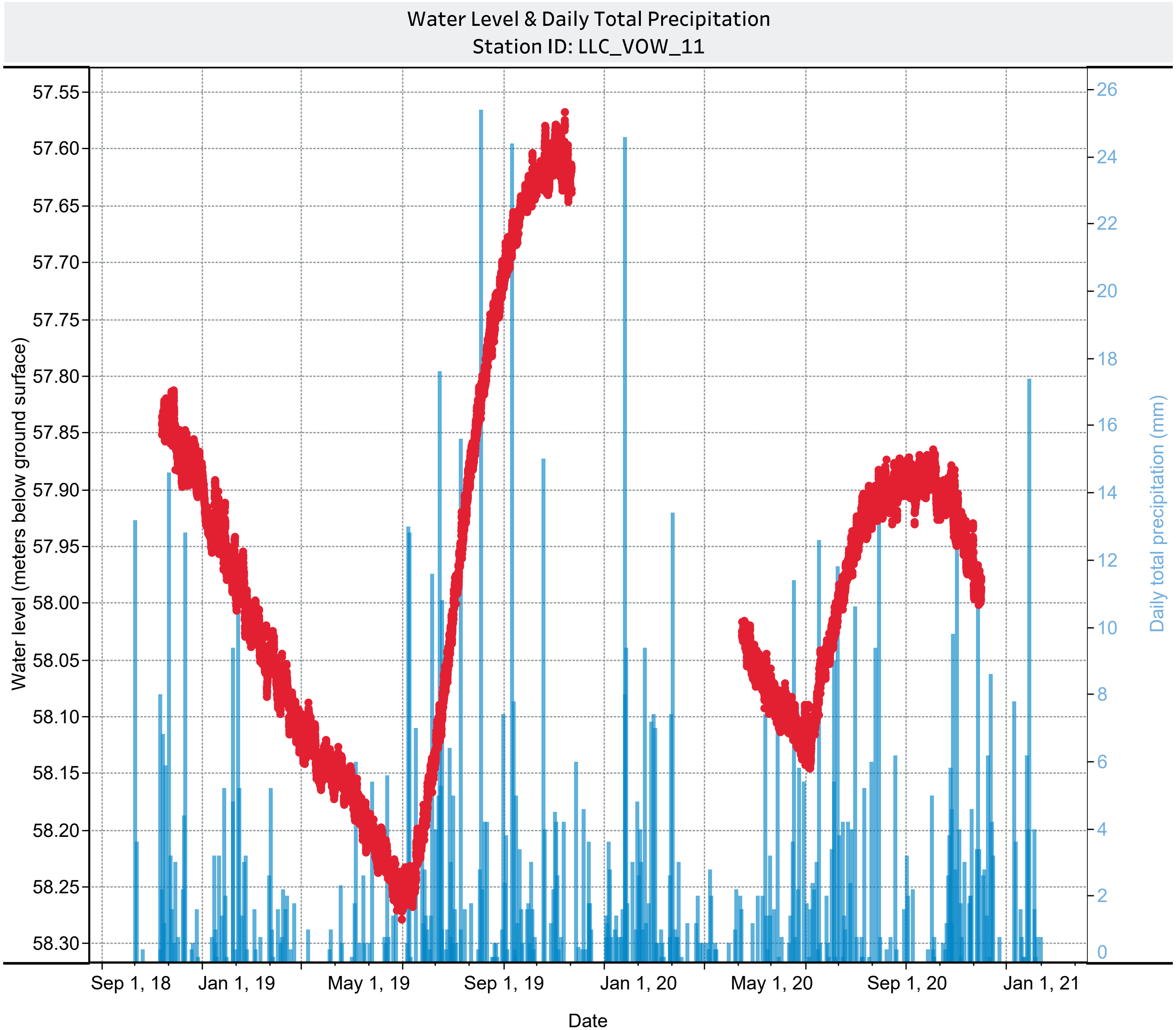
Well depth (mbgs)
68.6 (measured with water level tape; difficult to get ..
Depth of Water Level Sensor (mbgs)
67
Recording Interval
1 hour
Water Level Sensor
HOBO MX2001-02 (Range-30m)

Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS



Station ID Groundwater
LLC_VOW_11

Station ID Legend
1364
LLC_VOW_11

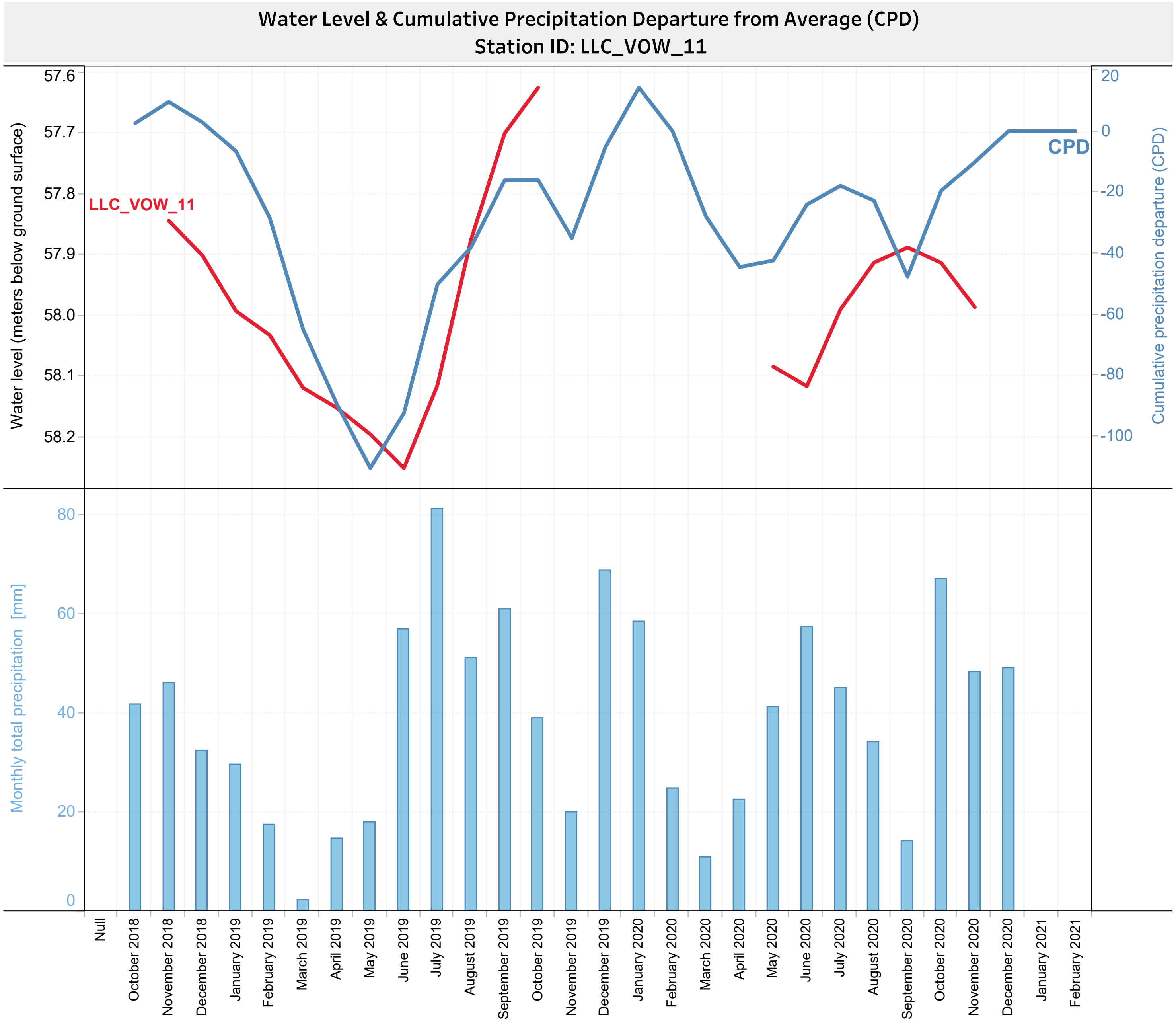
Precipitation	1364	**GOLDEN A**
Groundwater	LLC_VOW_11	**Windermere, Windermere Loop Road - East side of road.**

Living Lakes Canada

Graphs produced by:

C Waters Consulting

GW SOLUTIONS

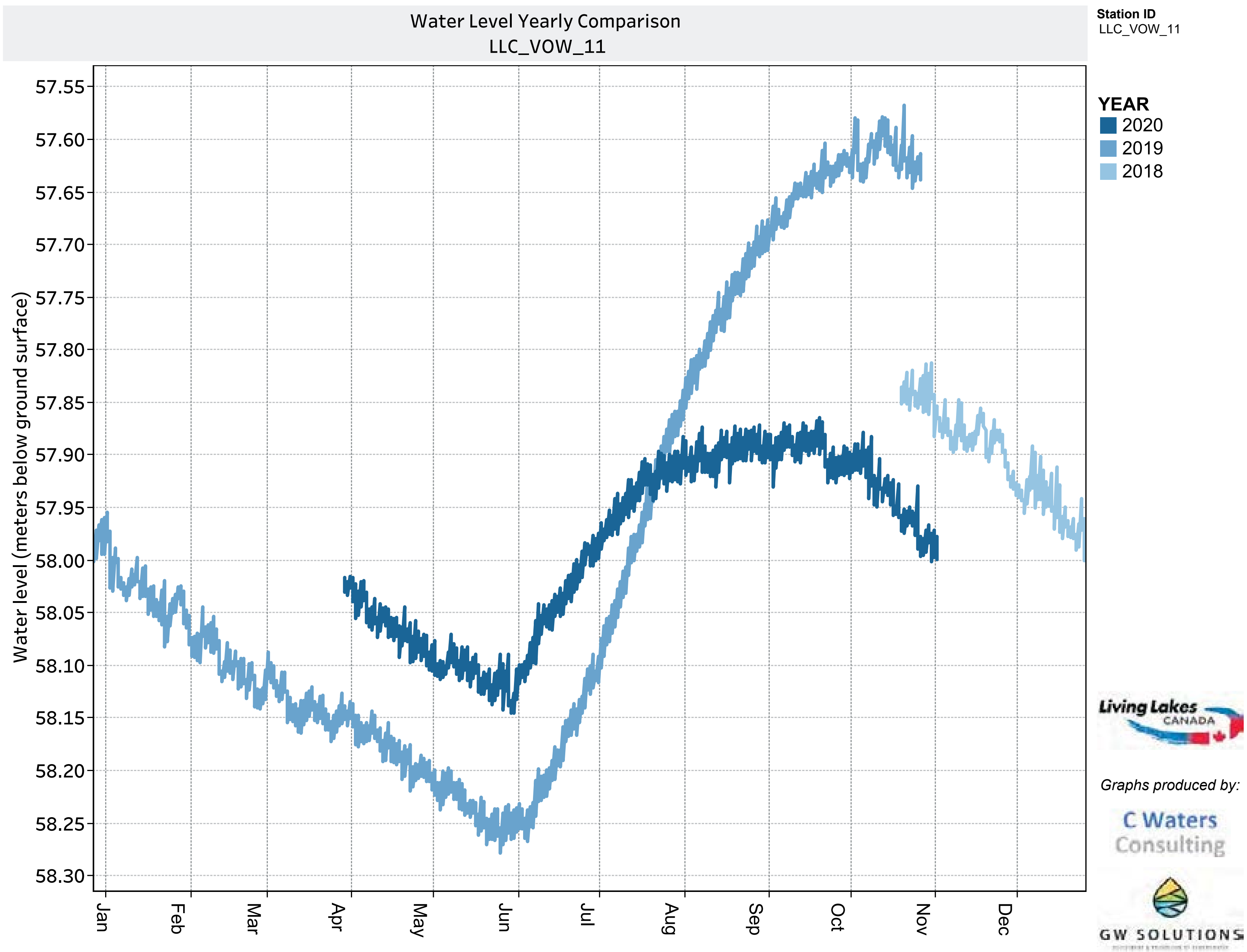


Station ID Groundwater
LLC_VOW_11

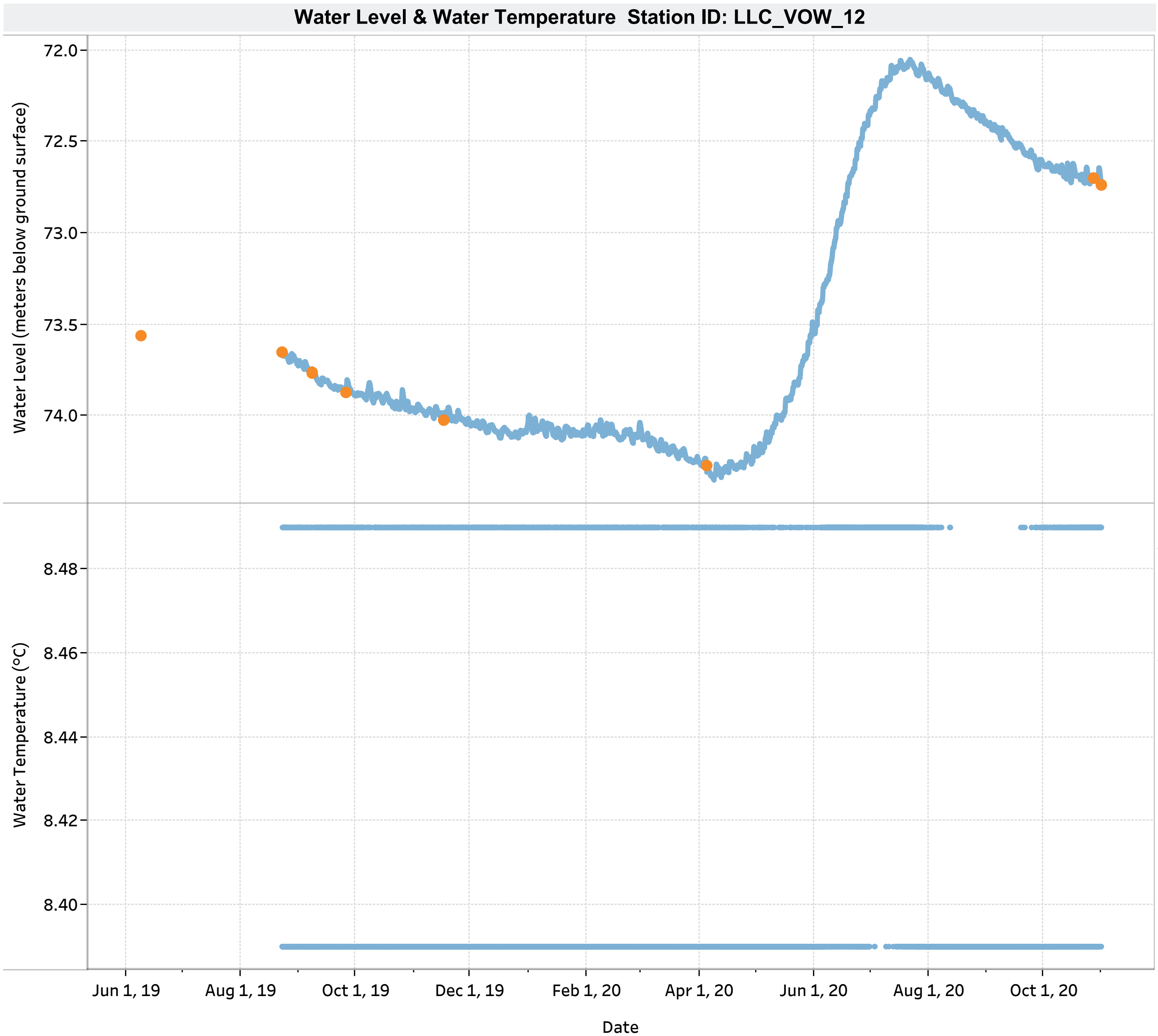
Water level data
Begining of the month

Precipitation	1364	GOLDEN A
Groundwater	LLC_VOW_11	Windermere, Windermere Loop Road - East side of road.

Graphs produced by:



Water Level Yearly Comparison
LLC_VOW_11
Water level (meters below ground surface)
57.55
57.60
57.65
57.70
57.75
57.80
57.85
57.90
57.95
58.00
58.05
58.10
58.15
58.20
58.25
58.30
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Station ID
LLC_VOW_11
YEAR
2020
2019
2018
Living Lakes CANADA
Graphs produced by:
C Waters Consulting
GW SOLUTIONS



Station ID
LLC_VOW_12

Measurement Type
Manual data
Logger data

Well depth (mbgs)
83.2

Depth of Water Level Sensor (mbgs)
80.9

Recording Interval
1 hour

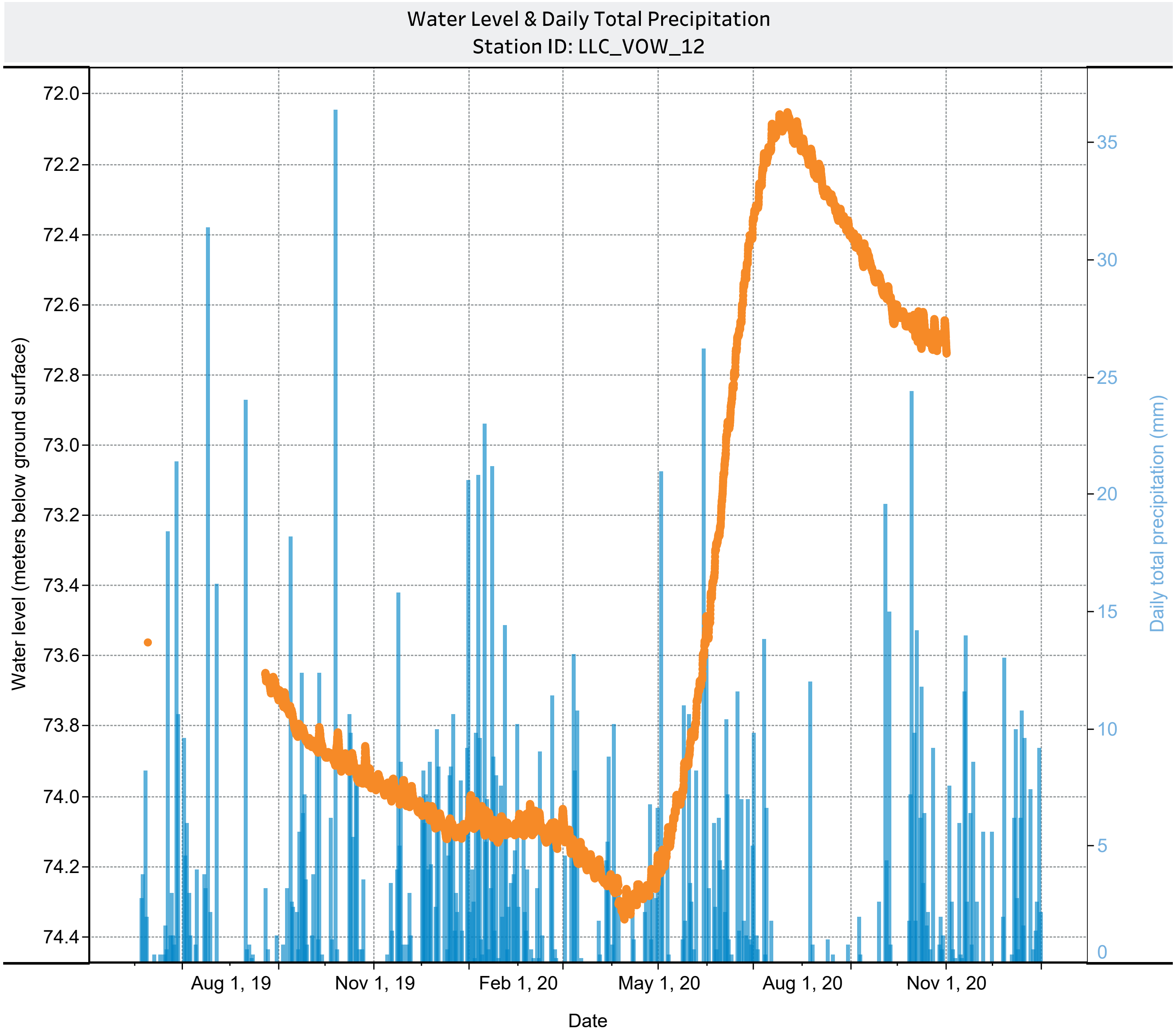
Water Level Sensor
HOBO MX2001-02 (Range-30m)

Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS

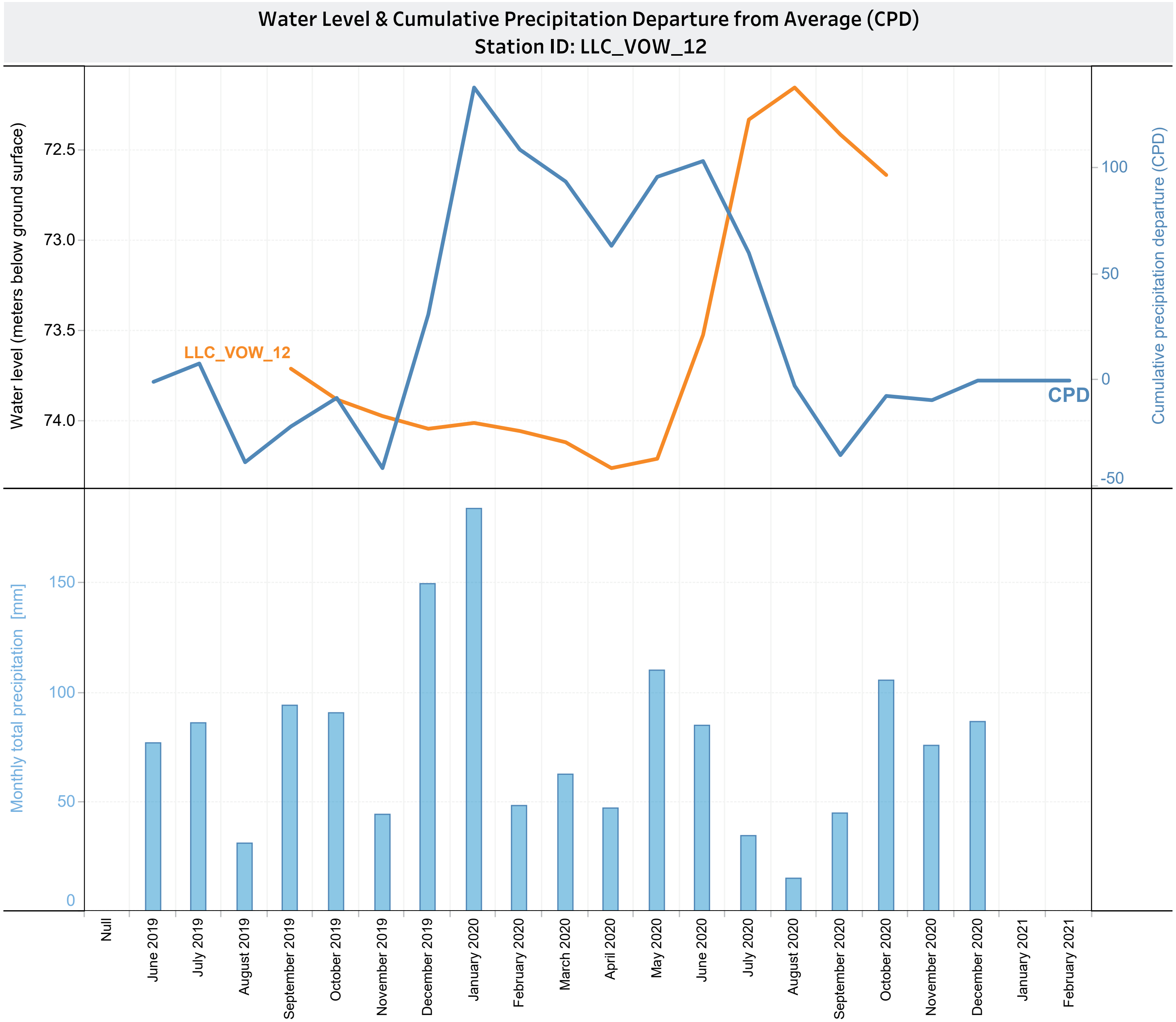


Station ID Groundwater
LLC_VOW_12

Station ID Legend
1095
LLC_VOW_12

Precipitation	1095	**NELSON RIXEN CREEK**
Groundwater	LLC_VOW_12	**Willow Point, Heddle Road. North shore of the West Arm of Kootenay Lake.**

Graphs produced by:



Station ID Groundwater
LLC_VOW_12

Water level data
Begining of the month

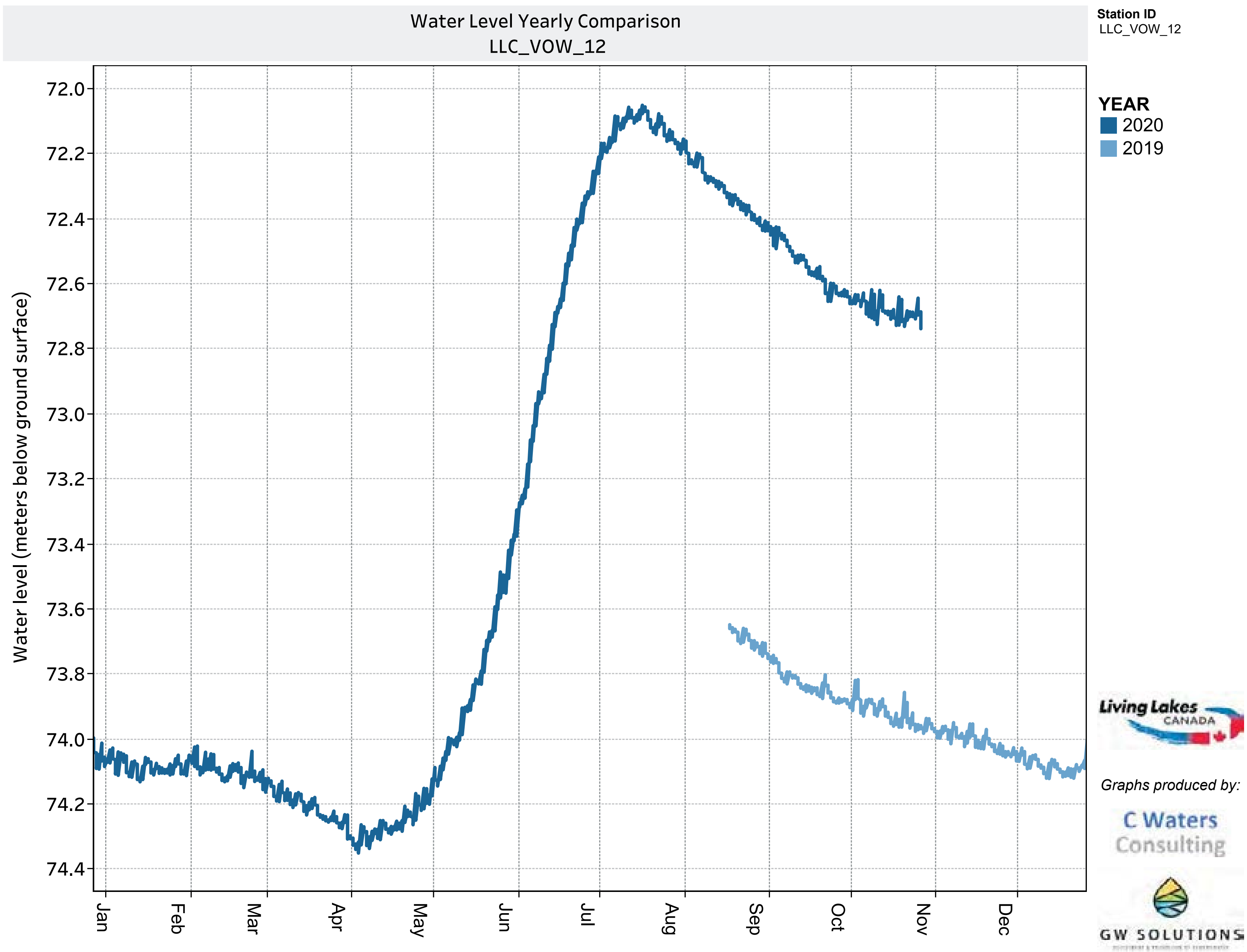
Precipitation	1095	**NELSON RIXEN CREEK**
Groundwater	LLC_VOW_12	**Willow Point, Heddle Road. North shore of the West Arm of Kootenay Lake.**

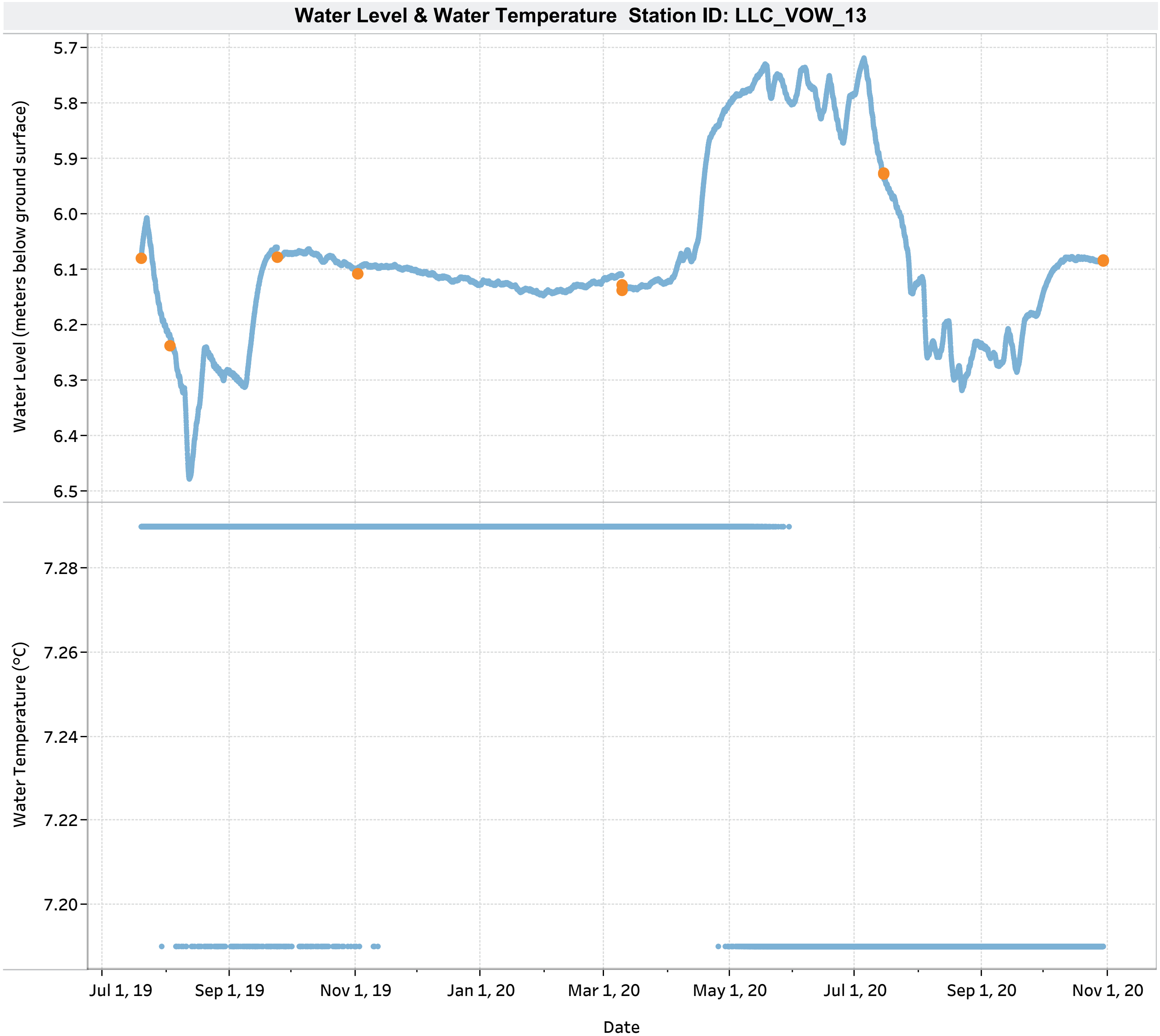
Living Lakes Canada

Graphs produced by:

C Waters Consulting

GW SOLUTIONS


Water Level Yearly Comparison
LLC_VOW_12
Water level (meters below ground surface)
72.0
72.2
72.4
72.6
72.8
73.0
73.2
73.4
73.6
73.8
74.0
74.2
74.4
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Station ID
LLC_VOW_12
YEAR
2020
2019
Living Lakes CANADA
Graphs produced by:
C Waters Consulting
GW SOLUTIONS



Station ID
LLC_VOW_13

Measurement Type
Manual data
Logger data

Well depth (mbgs)
22.4

Depth of Water Level Sensor (mbgs)
15

Recording Interval
1 hour

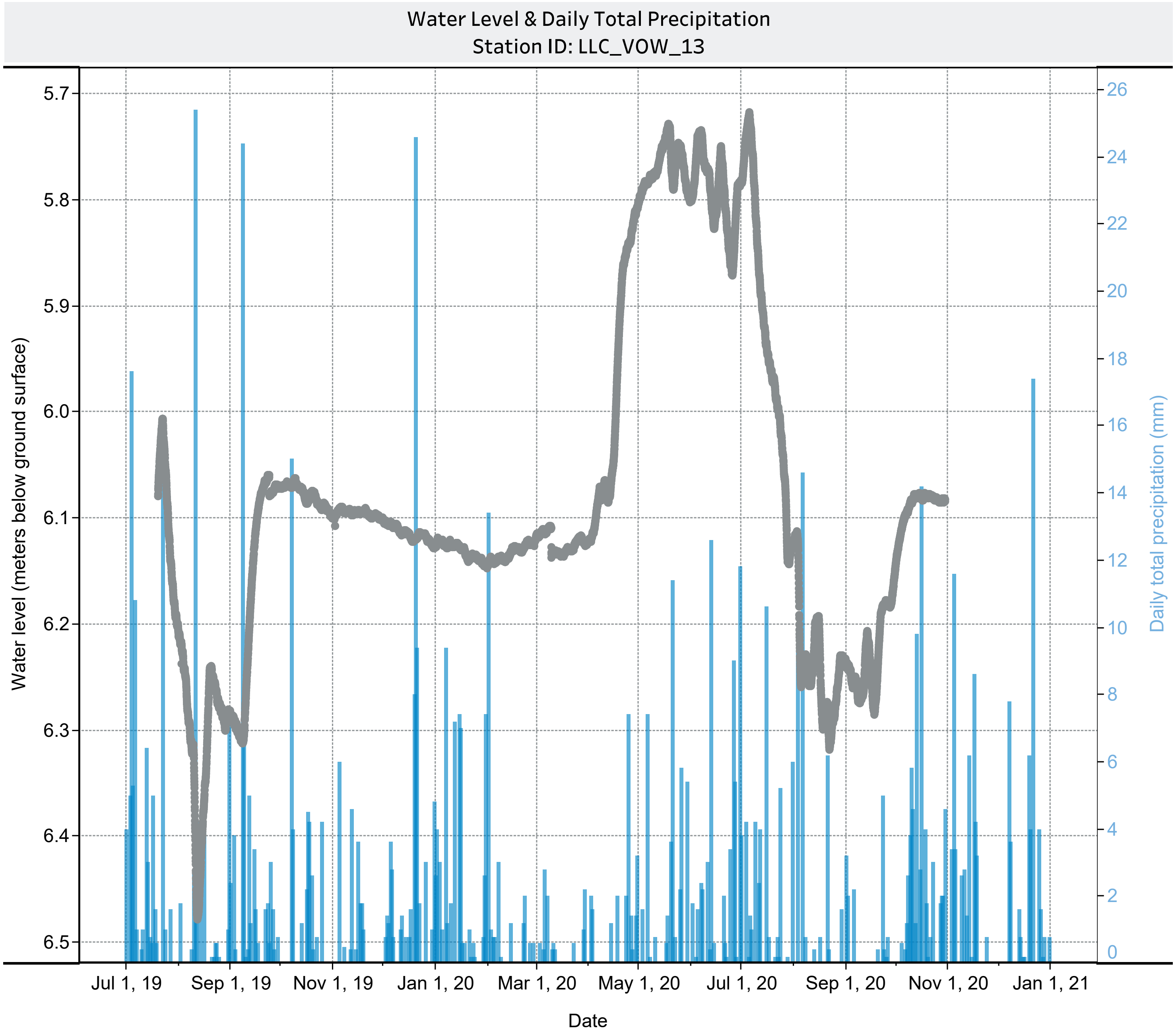
Water Level Sensor
HOBO MX2001-02 (Range 9 m)

Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS



Station ID Groundwater
LLC_VOW_13

Station ID Legend
1364
LLC_VOW_13

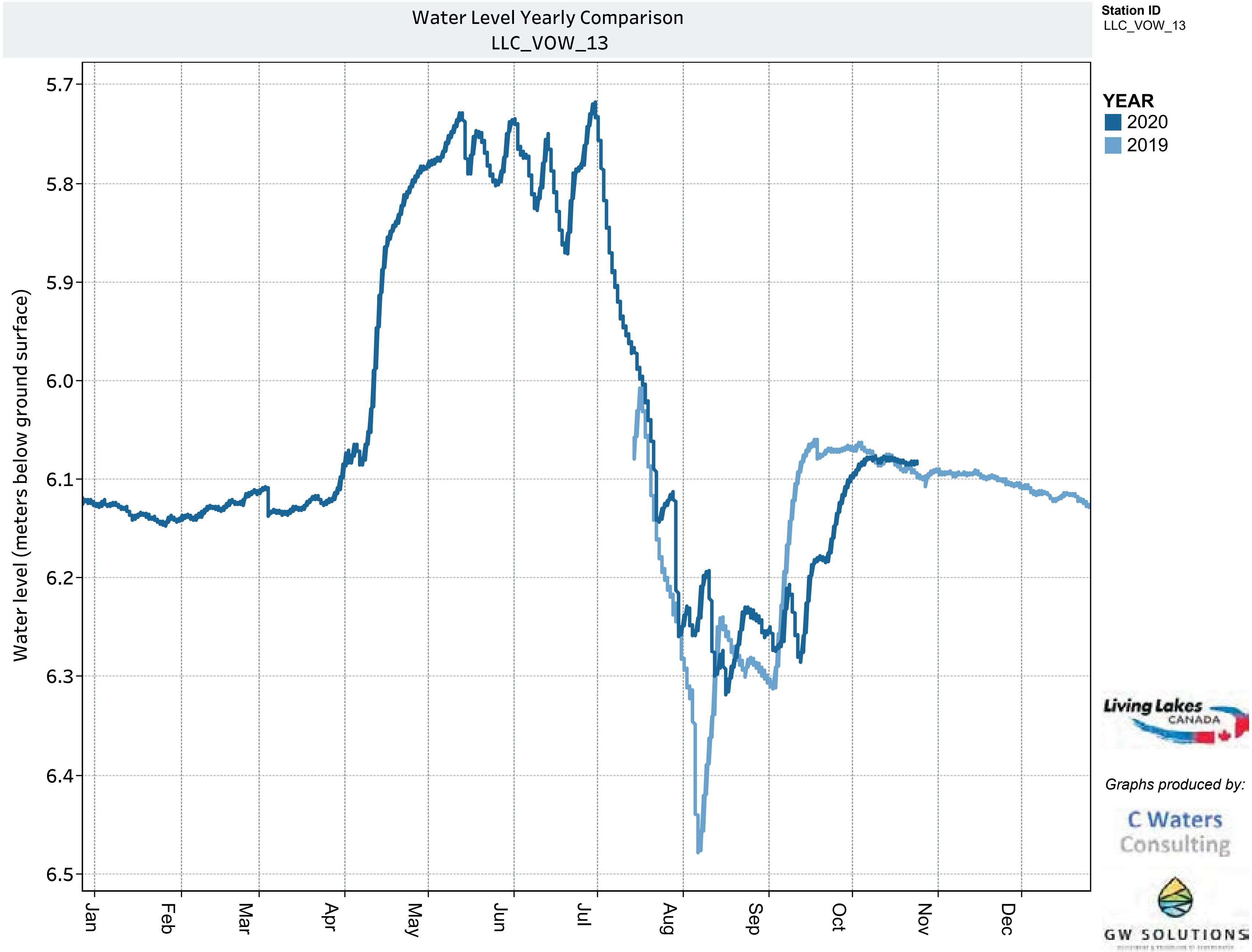
Precipitation	1364	GOLDEN A
Groundwater	LLC_VOW_13	Brisco, Sylvania Road. East side of Columbia Wetlands

Living Lakes Canada

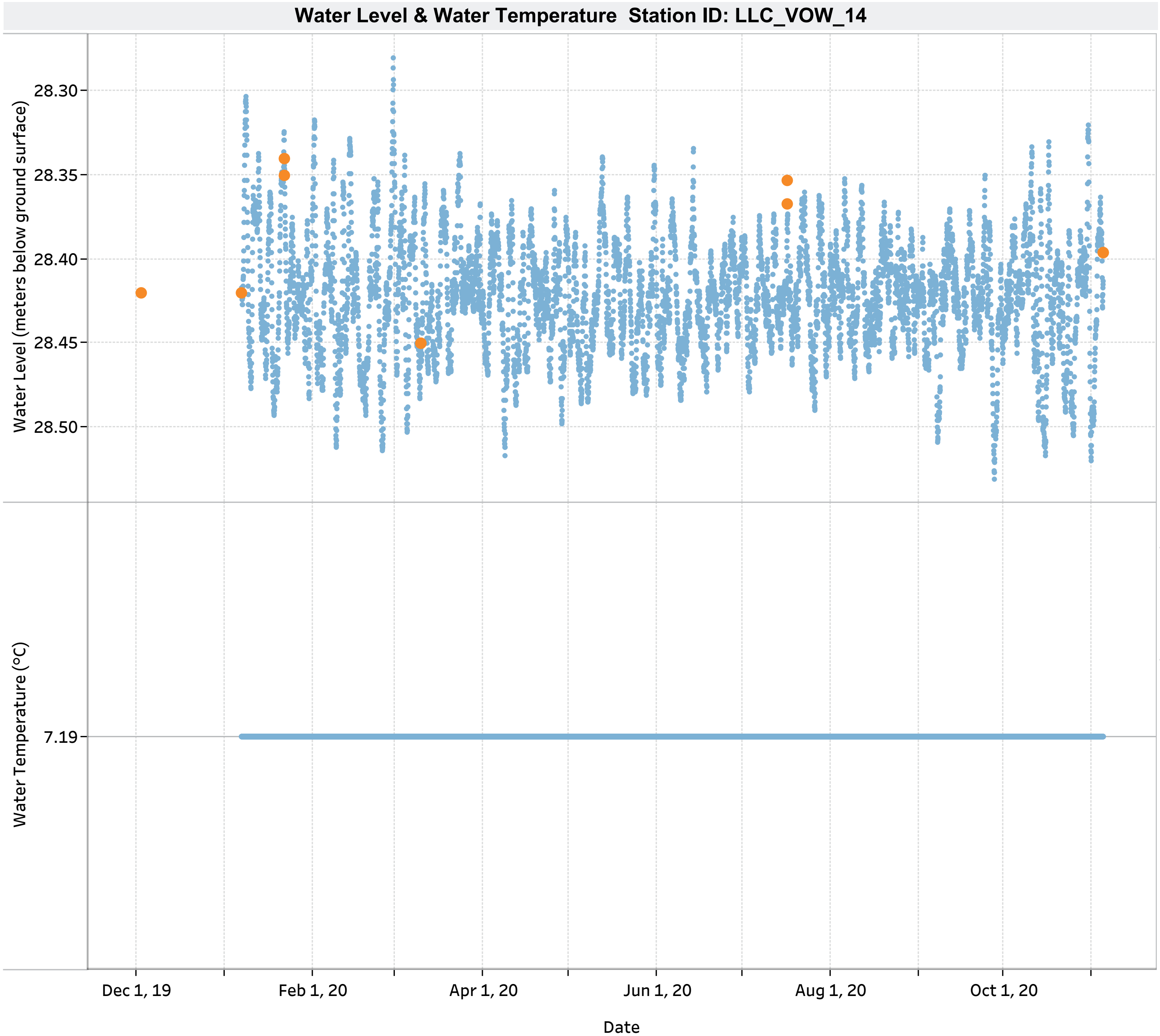
Graphs produced by:

C Waters Consulting

GW SOLUTIONS



Water Level Yearly Comparison
LLC_VOW_13
Station ID
LLC_VOW_13
YEAR
2020
2019
Water level (meters below ground surface)
5.7
5.8
5.9
6.0
6.1
6.2
6.3
6.4
6.5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Graphs produced by:



Station ID
LLC_VOW_14

Measurement Type
Manual data
Logger data

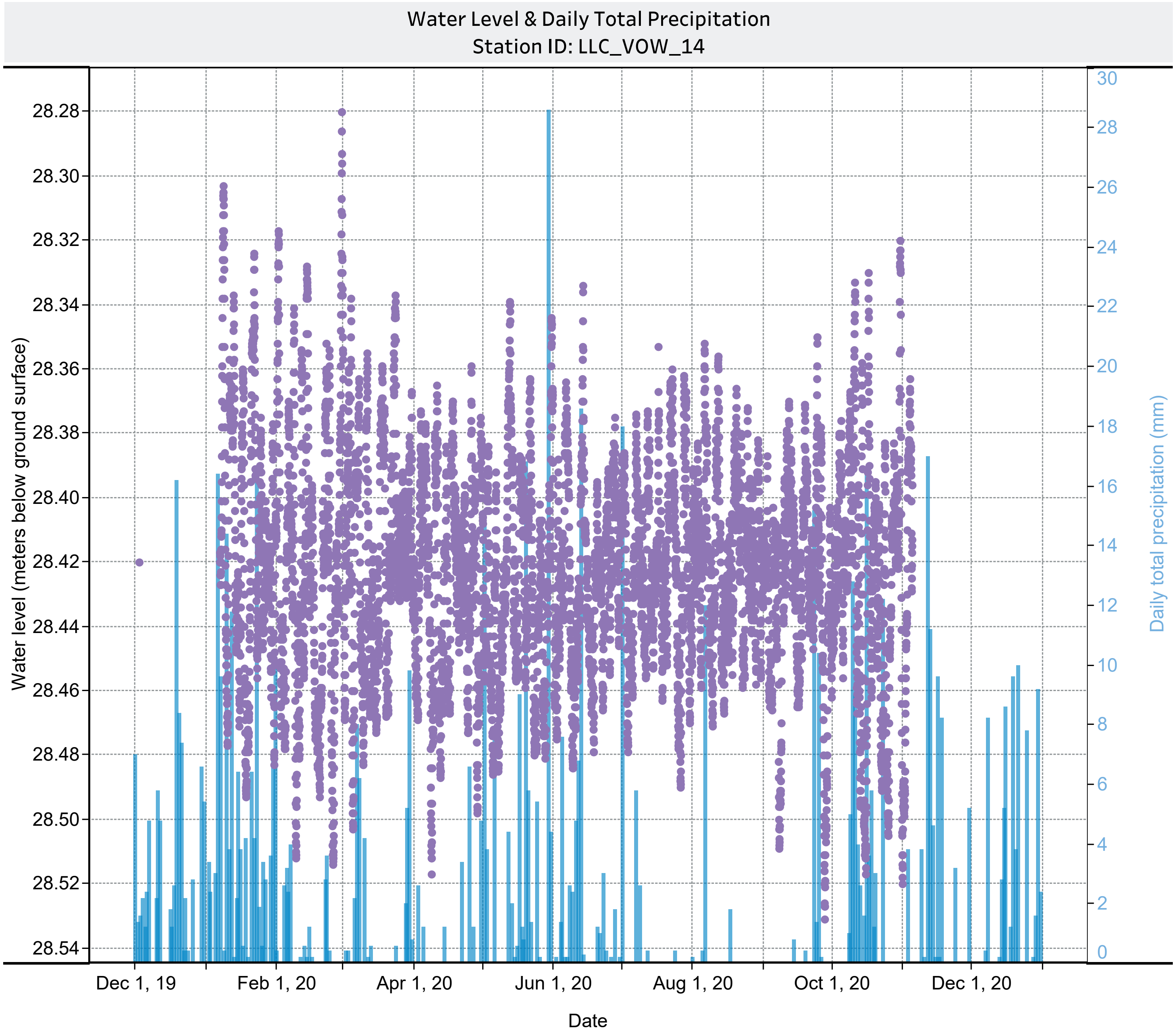
Well depth (mbgs)
55.5

Depth of Water Level Sensor (mbgs)
31

Recording Interval
1 hour

Water Level Sensor
HOBO MX2001-04 (Range 4 m)

Graphs produced by:



Station ID Groundwater
LLC_VOW_14

Station ID Legend
- 1105
- LLC_VOW_14

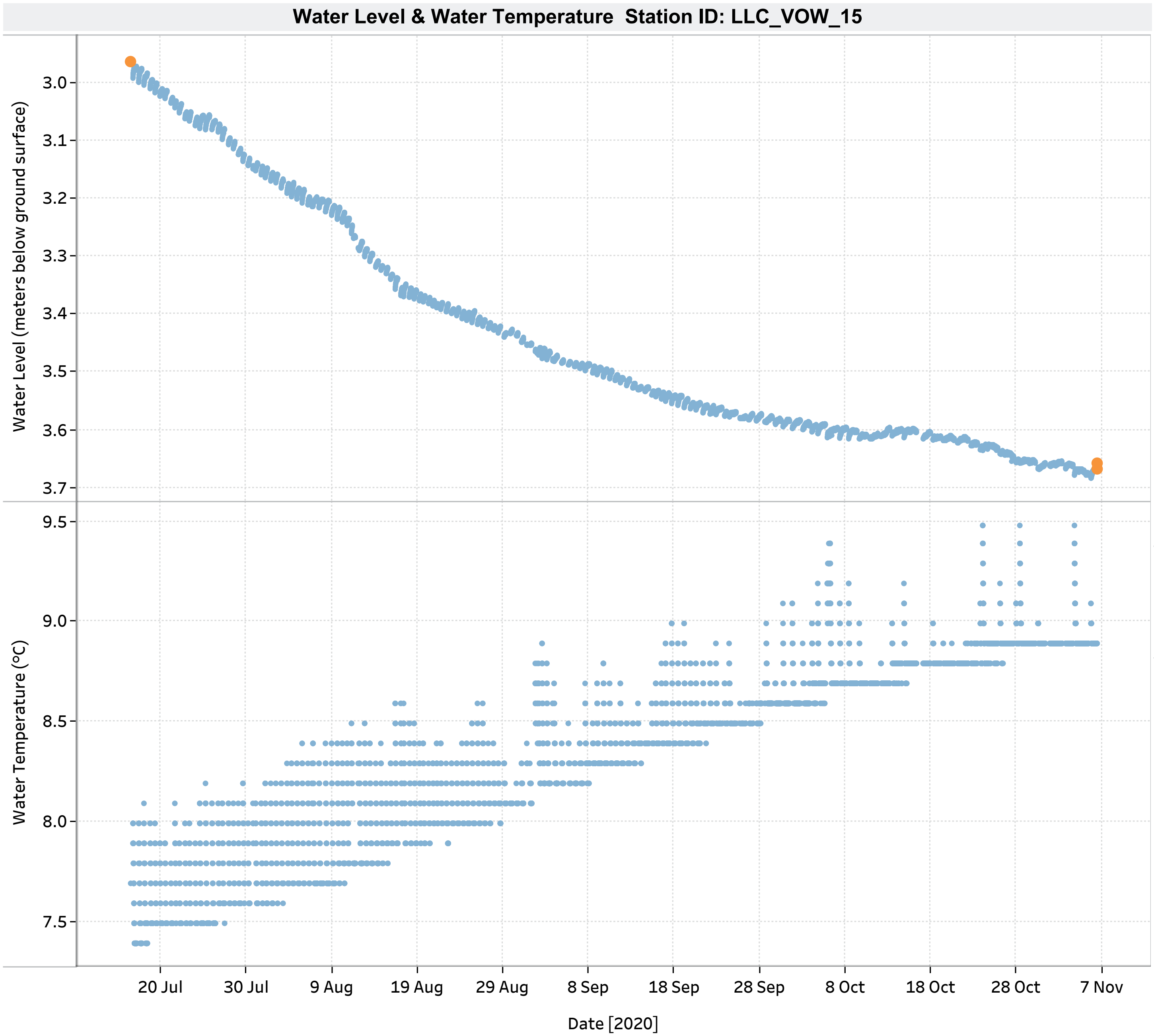
Precipitation	1105	**CASTLEGAR A**
Groundwater	LLC_VOW_14	**North of Fairmont, West of Columbia Wetlands, Westside Road.**

Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS



Station ID
LLC_VOW_15

Measurement Type
Manual data
Logger data

Well depth (mbgs)
11.73

Depth of Water Level Sensor (mbgs)
7.94

Recording Interval
5 min

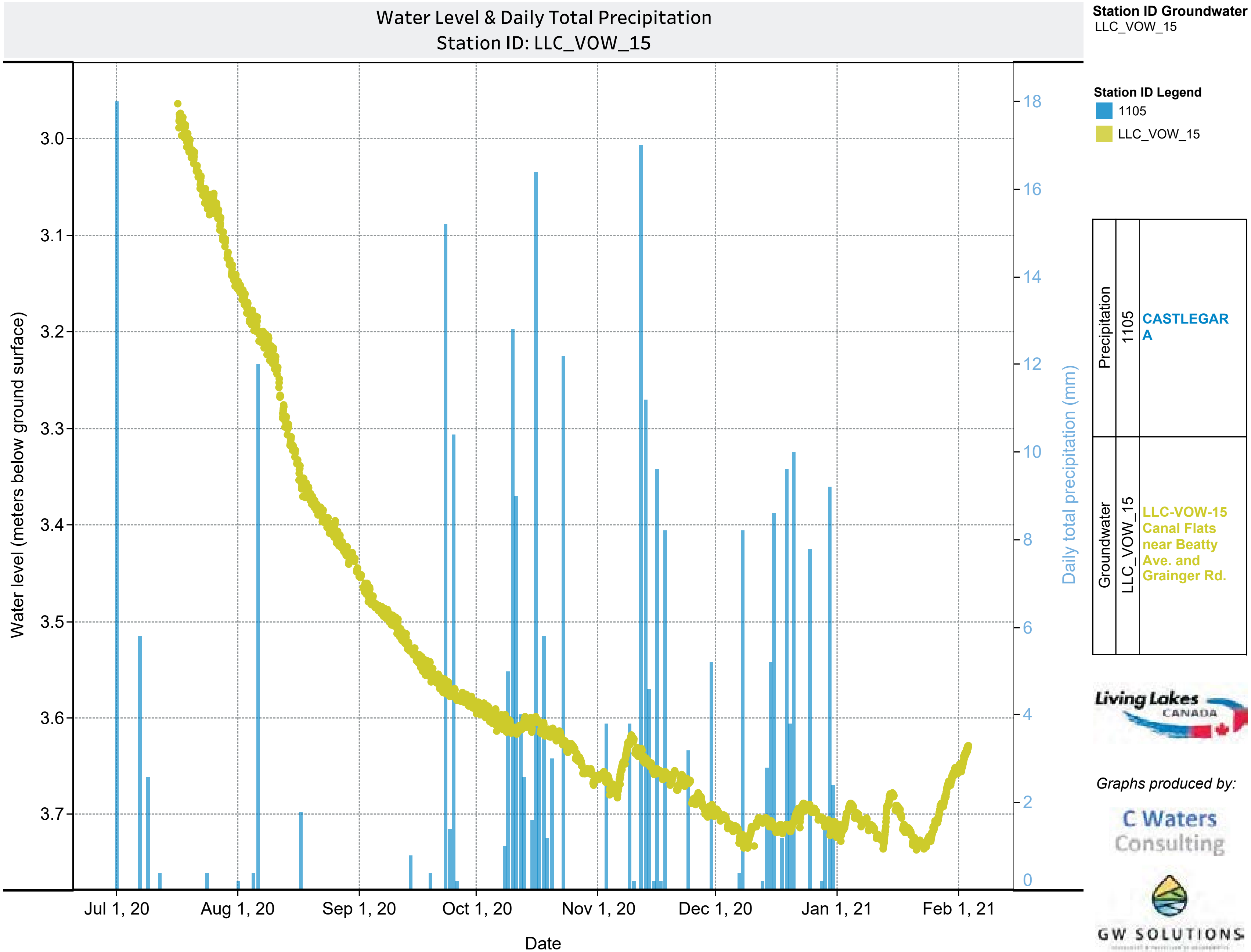
Water Level Sensor
HOBO MX2001-01 (Range 9 m)

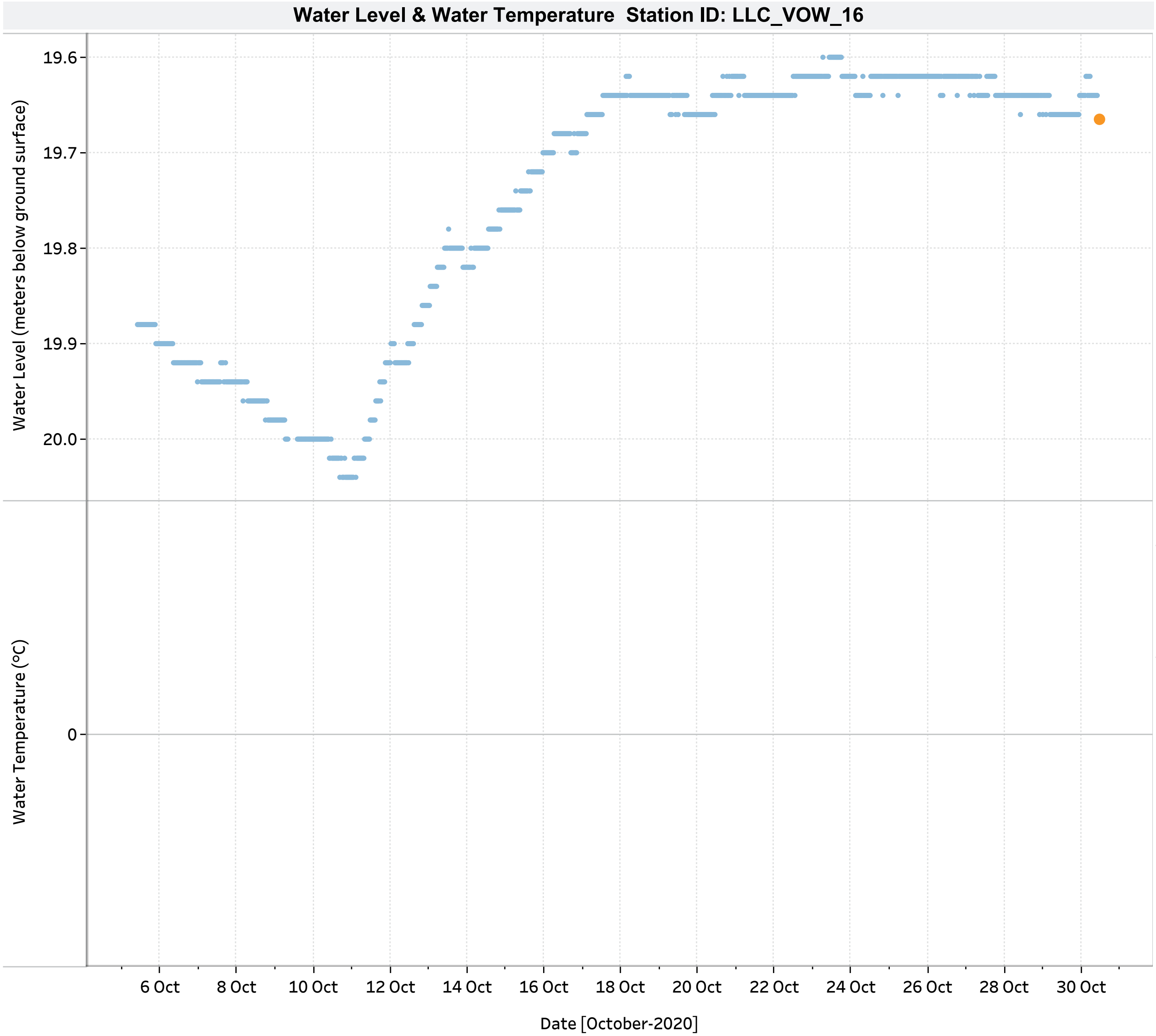
Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS


Water Level & Daily Total Precipitation
Station ID: LLC_VOW_15
Water level (meters below ground surface)
3.0
3.1
3.2
3.3
3.4
3.5
3.6
3.7
Daily total precipitation (mm)
18
16
14
12
10
8
6
4
2
0
Jul 1, 20
Aug 1, 20
Sep 1, 20
Oct 1, 20
Nov 1, 20
Dec 1, 20
Jan 1, 21
Feb 1, 21
Date
Station ID Groundwater
LLC_VOW_15
Station ID Legend
1105
LLC_VOW_15
Precipitation
1105
CASTLEGAR A
Groundwater
LLC_VOW_15
LLC-VOW-15 Canal Flats near Beatty Ave. and Grainger Rd.
Living Lakes CANADA
Graphs produced by:
C Waters Consulting
GW SOLUTIONS



Station ID
LLC_VOW_16

Measurement Type
Manual data
Logger data

Well depth (mbgs)
36

Depth of Water Level Sensor (mbgs)
30.1

Recording Interval
30 min

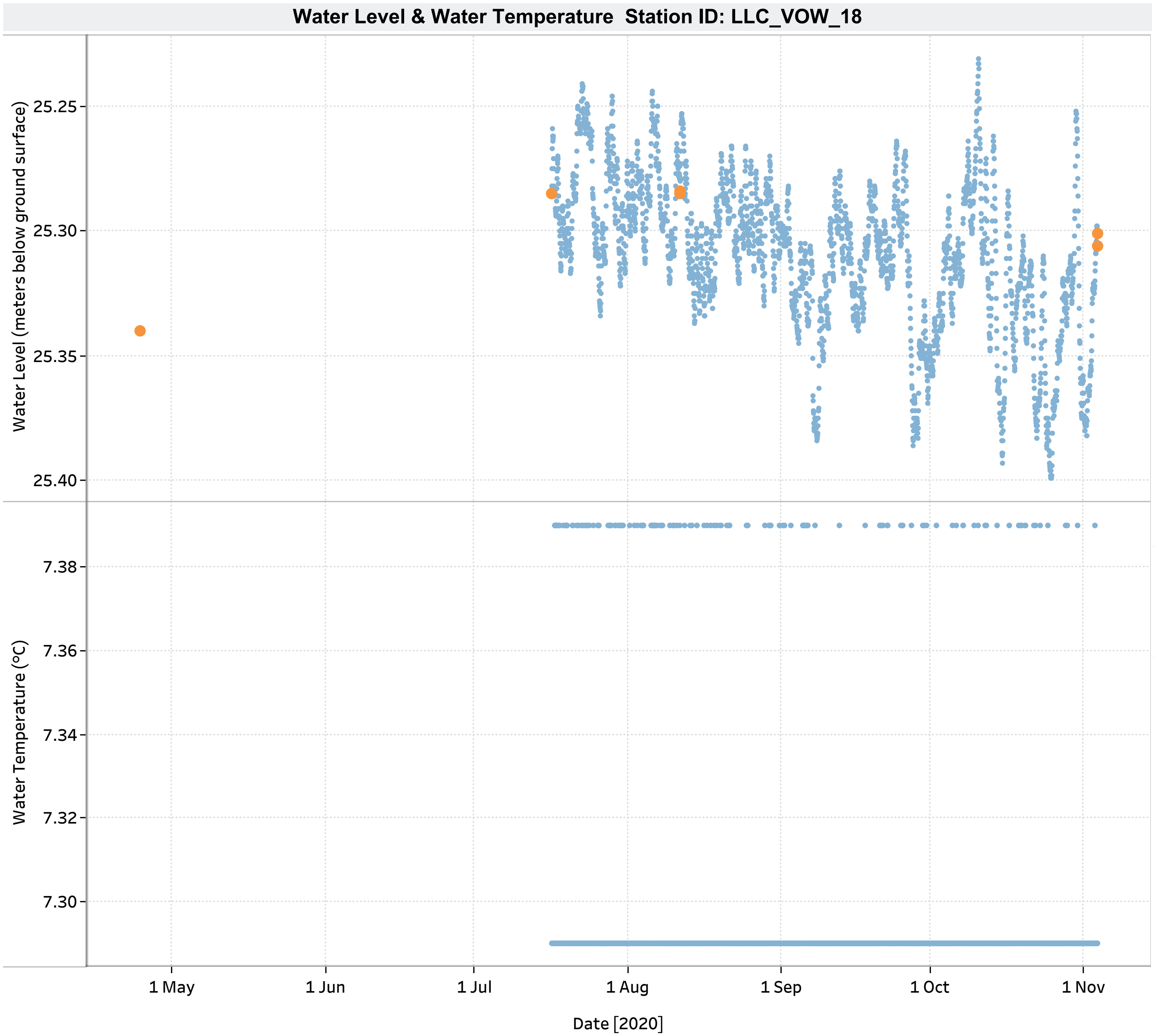
Water Level Sensor
Druck PTX 1230 4-20 mA Pressure Transducer (No temperature sensor)

Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS



Station ID
LLC_VOW_18

Measurement Type
Manual data
Logger data

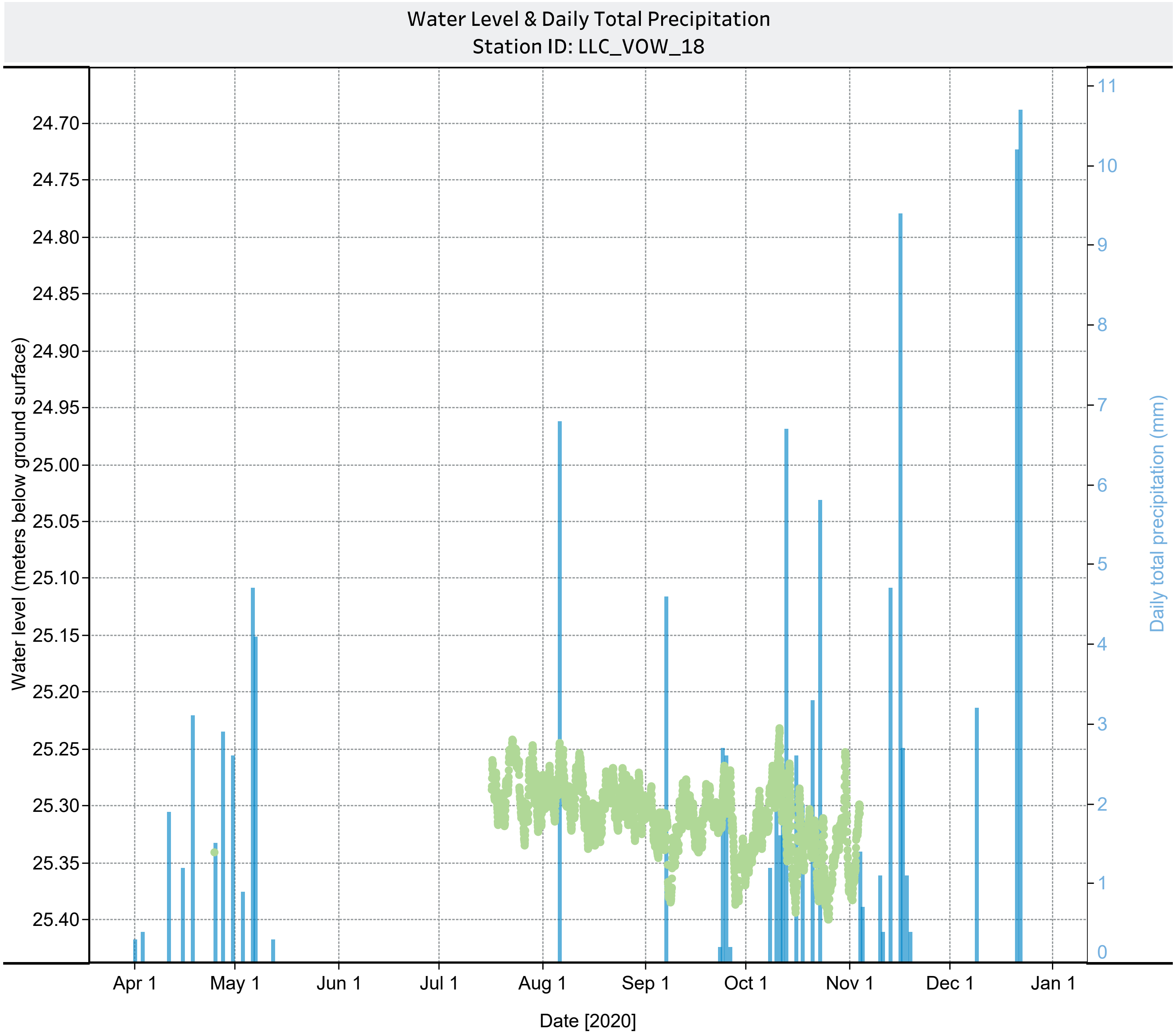
Well depth (mbgs)
47.5

Depth of Water Level Sensor (mbgs)
30.25

Recording Interval
1 hour

Water Level Sensor
HOBO MX2001-01 (Range 9 m)

Graphs produced by:



Station ID Groundwater
LLC_VOW_18

Station ID Legend
- 50818
- LLC_VOW_18

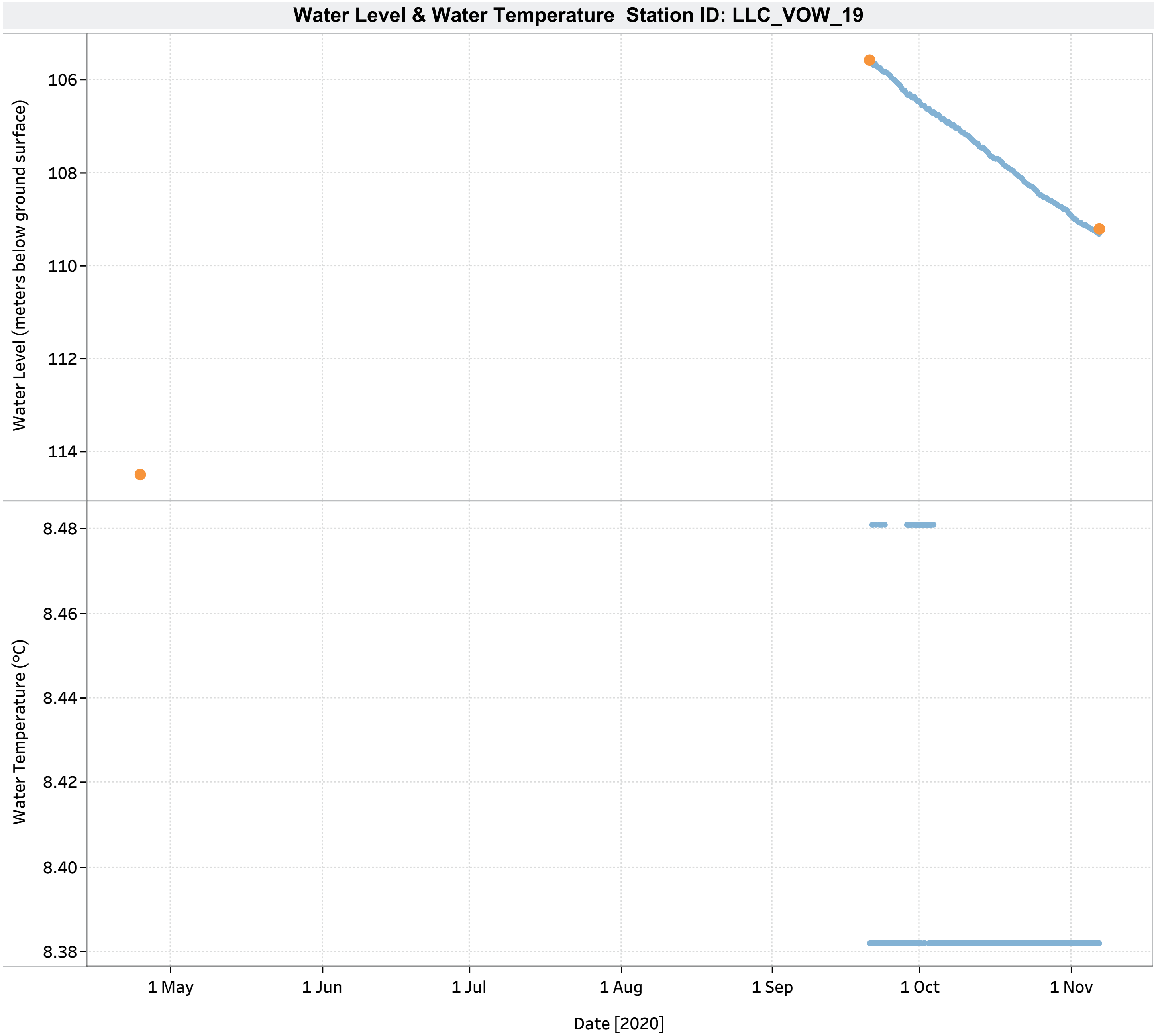
Precipitation	50818	CRANBROOK A
Groundwater	LLC_VOW_18	LLC-VOW-18 Highway 93/95 between Canal Flats and Skookumchuk.

Living Lakes Canada

Graphs produced by:

C Waters Consulting

GW SOLUTIONS



Station ID
LLC_VOW_19

Measurement Type
Manual data
Logger data

Well depth (mbgs)
115.82

Depth of Water Level Sensor (mbgs)
114.9

Recording Interval
1 hour

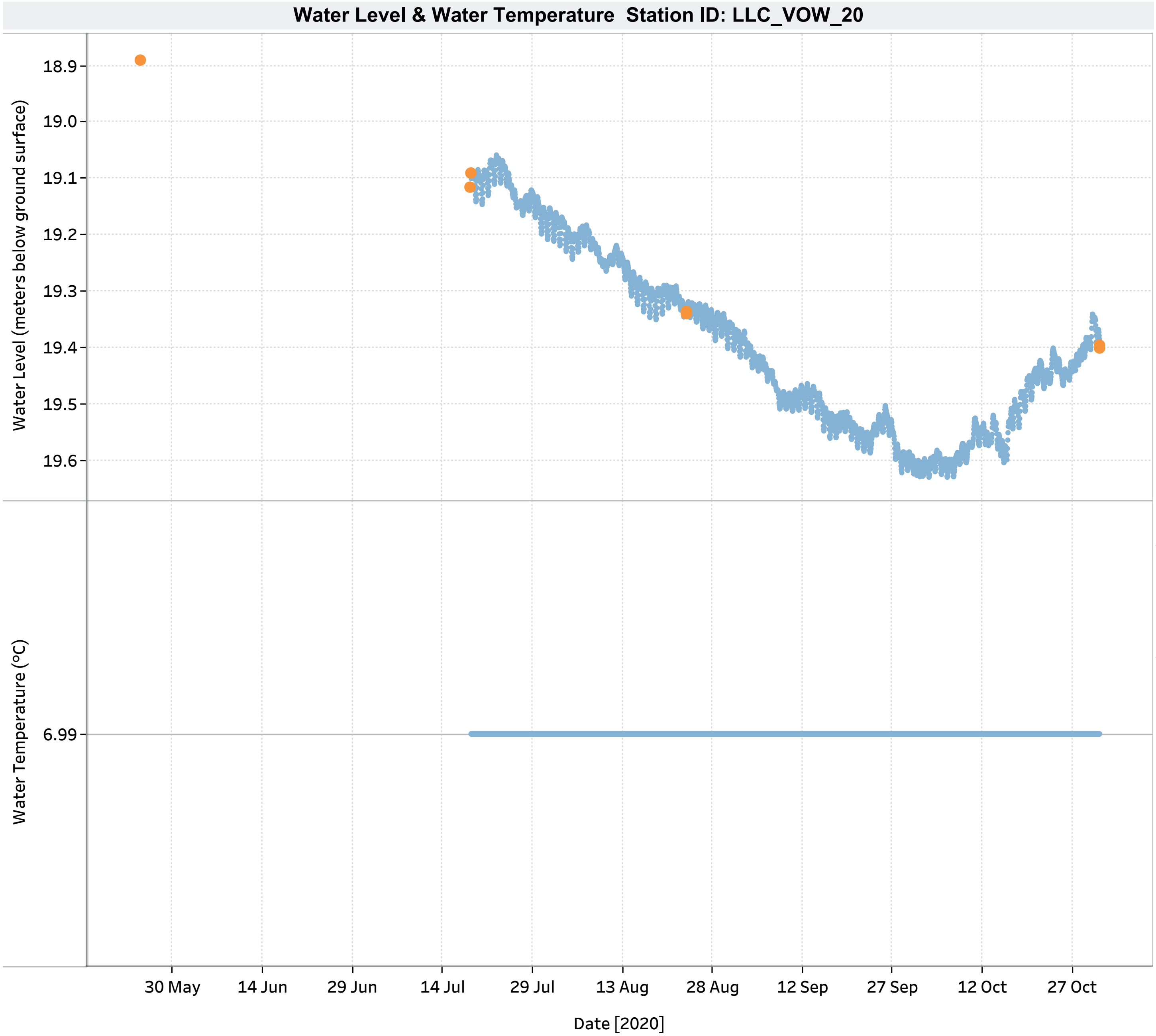
Water Level Sensor
HOBO U20-001-02 (Range 30 m)

Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS



Station ID
LLC_VOW_20

Measurement Type
Manual data
Logger data

Well depth (mbgs)
91.4

Depth of Water Level Sensor (mbgs)
80.3

Recording Interval
1 hour

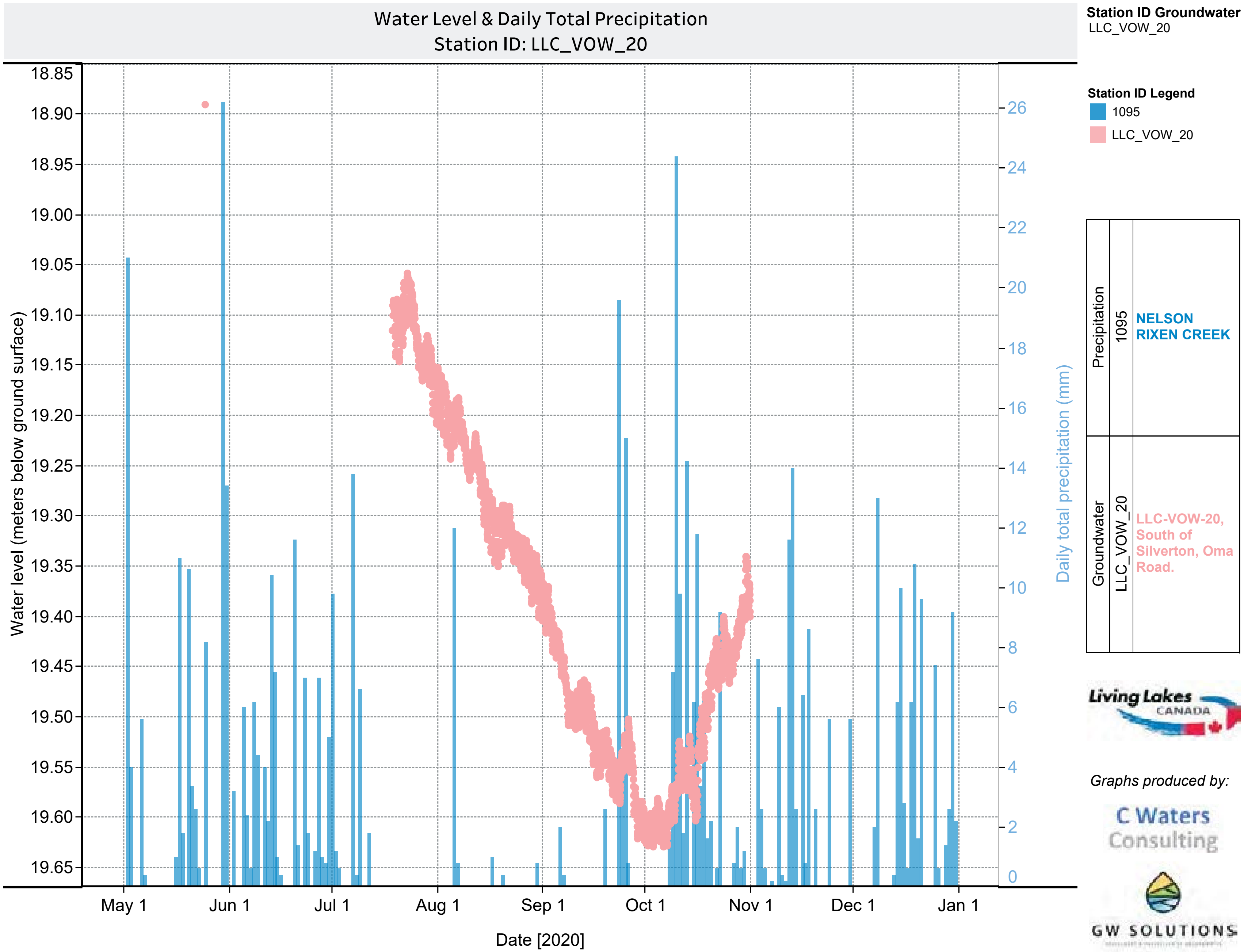
Water Level Sensor
HOBO-MX2001-01-Ti (Range 9 m)

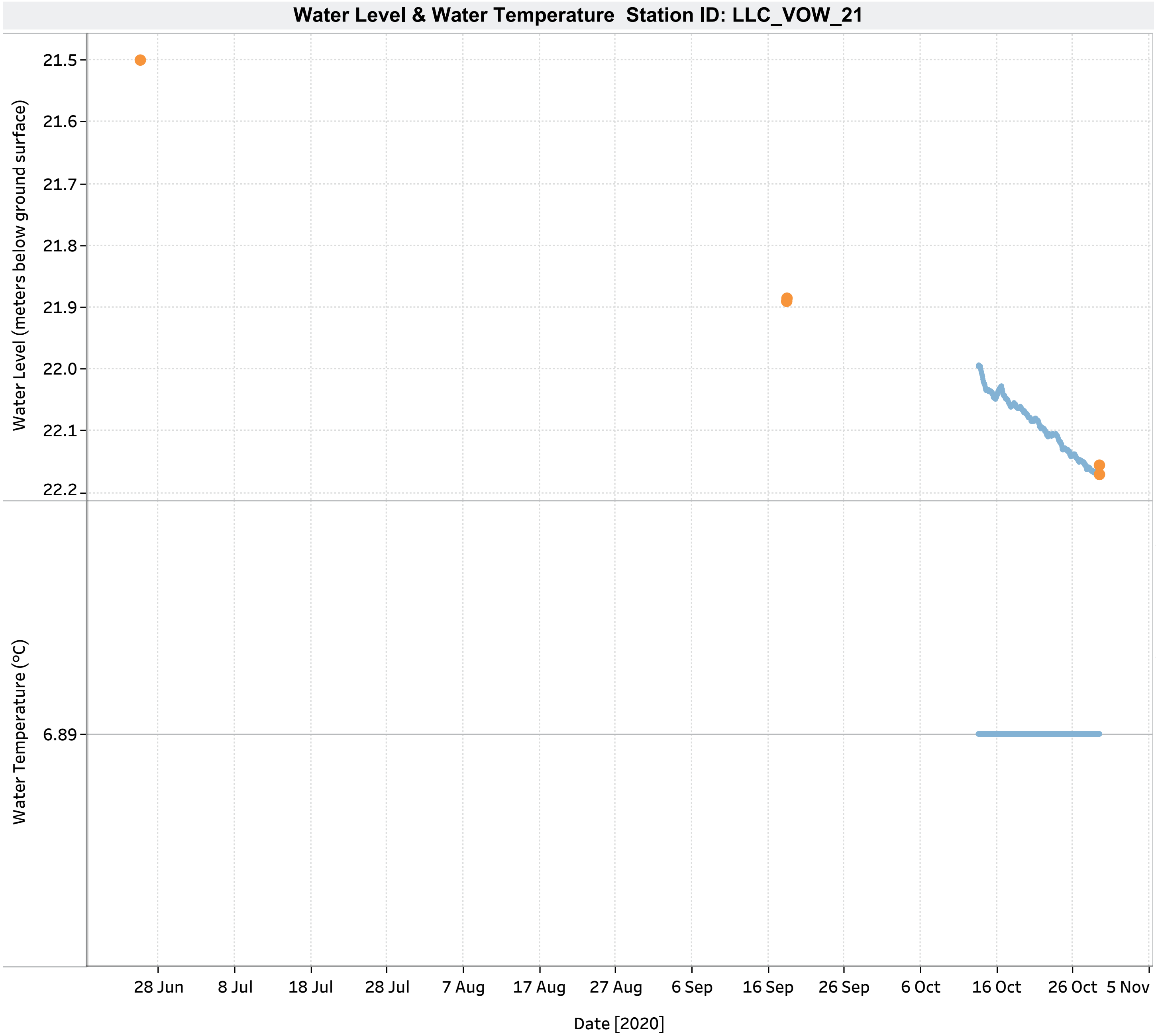
Living Lakes CANADA

Graphs produced by:

C Waters Consulting

GW SOLUTIONS


Water Level & Daily Total Precipitation
Station ID: LLC_VOW_20
Water level (meters below ground surface)
18.85
18.90
18.95
19.00
19.05
19.10
19.15
19.20
19.25
19.30
19.35
19.40
19.45
19.50
19.55
19.60
19.65
Daily total precipitation (mm)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
May 1
Jun 1
Jul 1
Aug 1
Sep 1
Oct 1
Nov 1
Dec 1
Jan 1
Date [2020]
Station ID Groundwater
LLC_VOW_20
Station ID Legend
1095
LLC_VOW_20
Precipitation
1095
NELSON RIXEN CREEK
Groundwater
LLC_VOW_20
LLC-VOW-20, South of Silverton, Oma Road.
Graphs produced by:



Station ID
LLC_VOW_21

Measurement Type
Manual data
Logger data

Well depth (mbgs)
24.07

Depth of Water Level Sensor (mbgs)
22.74

Recording Interval
1 hour

Water Level Sensor
HOBO-MX2001-01 (Range 9 m)

Graphs produced by: