



## Notice of Meeting and Meeting Agenda Fulford Water Service Commission

Friday, May 24, 2024

10:00 AM

SIMS Boardroom  
124 Rainbow Road  
Salt Spring Island BC

### Special Meeting

MS Teams: [Click here](#)

C. Eyles, G. Holman, A. Martin, D. Thompson, B. Walker,

The Capital Regional District strives to be a place where inclusion is paramount and all people are treated with dignity. We pledge to make our meetings a place where all feel welcome and respected.

1. Territorial Acknowledgment
2. Election of Chair
3. Approval of Agenda
4. Presentations/Delegations

*Delegations will have the option to participate electronically. Please complete the online application at [www.crd.bc.ca/address](http://www.crd.bc.ca/address) for "Addressing the Fulford Water Service Commission" no later than 4:30 pm two days before the meeting and staff will respond with details.*

*Alternatively, you may email your comments on an agenda item to the Fulford Water Service Commission at [saltspring@crd.bc.ca](mailto:saltspring@crd.bc.ca).*

#### 4.1. Presentations

#### 4.2. Delegations

- 4.2.1. [24-527](#) Delegation - David Fullbrook; Merchant House Capital Re: Item 5.1. 2621 and 2661 Fulford-Ganges Road - Application for Inclusion in the Fulford Water Local Service Area
- 4.2.2. [24-528](#) Delegation - Ian Peace; Resident Salt Spring Island Re: Item 5.1. 2621 and 2661 Fulford-Ganges Road - Application for Inclusion in the Fulford Water Local Service Area

**Attachments:** [Delegation request: I. Peace, May 22, 2024](#)

## 5. Special Meeting Matters

- 5.1. [24-372](#) 2621 and 2661 Fulford-Ganges Road - Application for Inclusion in the Fulford Water Local Service Area

**Recommendation:** The Fulford Water Service Commission recommends that the Ocean Estuary Development be granted permission to proceed with an application to be included in the Fulford Water Local Service Area.

**Attachments:** [Staff Report: 2126 and 2661 Fulford-Ganges Road – Application for Inclusion in Appendix A: Fulford Water System, Ocean Estuary Development Impact Assessment](#)  
[Appendix B: Ocean Estuary, Water Supplies for Suburban and Rural Fire Fighting](#)  
[Appendix C: Fulford Water System Expansion Assessment \(GW Solutions – Audit\)](#)  
[Appendix D: Lake Weston Water Availability and Climate Change Assessment \(C. Sunco\)](#)  
[Appendix E: Fulford Water: AC Watermain Replacement, Investigation, Analysis](#)  
[Appendix F: Fulford Water Service, Growth and Development Analysis \(C. Sunco\)](#)

## 6. Adjournment

### Next Meeting:

TBA

*To ensure quorum, please advise MacKenzie Williamson ([mwilliamson@crd.bc.ca](mailto:mwilliamson@crd.bc.ca)) if you or your alternate cannot attend*

**From:** [REDACTED] <[REDACTED]>  
**Sent:** Wednesday, May 22, 2024 4:17 PM  
**To:** Legserv <[Legserv@crd.bc.ca](mailto:Legserv@crd.bc.ca)>  
**Subject:** Addressing the Board - Submission

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.....

**Your name::**

Ian Peace

**I represent::**

**Telephone::**

[REDACTED]

**Fax::**

**Email address::**

[REDACTED]

**Street address (optional)::**

[REDACTED]

Salt Spring Island

**Municipality/Electoral Area in which you reside::**

Salt Spring Island E.A.

**I wish to address::**

Fulford Water service Commission

**Meeting Date::**

may 24, 2024

**Agenda Item::**

5.1

**My reason(s) for appearing (is/are) and the substance of my presentation is as follows::**

The CRD's 3-page issue summary may not include important issues described within the meeting documents. Also, information from the Madrona RAR study of Weston Creek.

**I will attend the meeting::**

In person

**I will have a PowerPoint or video presentation and will submit it at least 24 hours in advance of the meeting.:**

No

**The meeting and my presentation will be webstreamed live via the CRD website and recorded.:**

I understand,

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Submitted at:5/22/2024 4:16:47 PM

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## REPORT TO FULFORD WATER SERVICE COMMISSION MEETING OF FRIDAY, MAY 24, 2024

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**SUBJECT**     **2621 and 2661 Fulford-Ganges Road – Application for Inclusion in the Fulford Water Local Service Area**

### **ISSUE SUMMARY**

To consider including the proposed Ocean Estuary development at 2621 and 2661 Fulford-Ganges Road in the Fulford Water Local Service Area and to make a recommendation in that regard.

### **BACKGROUND**

The proposed Ocean Estuary project is a commercial and retail development located at 2621 and 2661 Fulford Ganges Road on Salt Spring Island, the former site of the old Fulford Inn which was demolished in 2015. The development is proposed to consist of seventeen (17) motel units within eight (8) cottage buildings and a village square consisting of a restaurant and small accessory retail sales buildings tied together by an outdoor plaza. The proponent received a Development Permit and Development Variance Permit for both 2661 and 2621 Fulford Ganges Road in February of 2023.

The Fulford Water Treatment Plant has a rated design flow of 4.5 L/s or 390 m<sup>3</sup>/ day which is approximately twice the Maximum Daily Demand recorded in 2011. The system presently serves approximately 100 single family equivalents (SFE). The system also includes a storage reservoir of 360 m<sup>3</sup> (80,000 Imperial Gallons). The distribution system consists of 3.4 km of distribution main and is made up of approximately 1.8 km of 50 mm to 100 mm asbestos cement pipe installed in 1970 and approximately 1.6 km of 50 mm to 150 mm PVC pipe installed in the late 2000s. The distribution system also includes fire hydrants, standpipes, gate valves, and water service connections, with only the commercial properties fitted with water meters. The intake line running from Lake Weston is approximately 2.9 km long, of which approximately 2.3 km is constructed of 100 mm asbestos cement pipe.

Additional background information relevant to this report is attached, and CRD staff recommends that Commissioners review all these documents in order to make an informed decision on this matter.

### **ALTERNATIVES**

#### *Alternative 1*

The Fulford Water Service Commission recommends that the Ocean Estuary Development be granted permission to proceed with an application to be included in the Fulford Water Local Service Area.

### *Alternative 2*

The Fulford Water Service Commission recommends to the Capital Regional District Board that the Ocean Estuary Development be denied permission to proceed with an application to be included in the Fulford Water Local Service Area.

### *Alternative 3*

That this report be referred back to staff for additional information.

## **IMPLICATIONS**

Factors and points to consider in favour of granting permission for Ocean Estuary's inclusion in the Service Area are:

- Improved system hydraulics as a function of looping a section (approximately 70 m of new pipe) of the distribution system and increasing the diameter of other sections of the piping, paid for by the proponent.
- As a part of the application, the proponent has committed to pay for the replacement of a portion of infrastructure (PVC line replacement ~ 650 m) some of which is asbestos cement (~ 100 m) and increase the line diameter to 200mm.
- Water consumption by Ocean Estuary will be controlled and metered, unlike all other users of the aquifer (other than Fulford Water Service (FWS)).
- The Fulford Water Treatment Plant has a rated design of 4.5 L/s or 390 m<sup>3</sup>/day. The Maximum Day Demand at full build out and including the Ocean Estuary development would be 2.85 L/s, well within plant capacity. Even Peak Hour Demand is below capacity at 4.25 L/s.
- With increased line size and improved system hydraulics, the fire department could withdraw water from system quicker without the risk of collapsing the old asbestos cement piping.
- Increased geographical footprint for effective fire protection along Fulford-Ganges Road.
- Improved fire capacity service including improved fire flow rates and residual pressures along Fulford – Ganges and Southridge Roads specifically and the system generally.
- Economic incentive for current residents to increase the user base in order to share fixed capital and operating costs amongst more users, specifically the upcoming project to replace all of the asbestos cement distribution and supply piping. There are five (5) properties along the proposed water main route (Lot #2681 through Lot #2795) as well as the Fulford Community Hall Association at #2581 Fulford – Ganges Road that may consider connecting to the Fulford system to further increase the user base.
- The GWS report from August 2023 concludes that surface water flow does not achieve the 10% MAD (Mean Annual Discharge) in Weston Creek in the summer. The data presented infers that surface flow historically has never been able to meet this threshold, with or without the Ocean Estuary project moving forward. The addition of the project will not make things better, but the increase in use associated with Ocean Estuary is expected to have less than a 5% influence on current flows.
- Ocean Estuary development requires a small allotment of water (2.85 USGPM, ~ 6 dam<sup>3</sup>), as compared to the current estimated system use of ~167 dam<sup>3</sup> (i.e., less than 5%). Note that one dam<sup>3</sup> is one million liters.

Factors and points to consider in favour of denying permission for Ocean Estuary's inclusion in the Service Area are:

- Small, incremental, negative effect on Mean Annual Discharge into Weston Creek.
- The "Stress Index" on Lake Weston goes from 27% to 28% which, although seemingly negligible, is in the "medium – high" range (20% to 40%) according to the World Resources Institute (2015). [GWT Datasets July 2015.pdf \(wbcsd.org\)](#). For reference, the aquifer stress index is a common measure of aquifer safe yield which compares the total amount of recharge in a watershed to the total water usage from the aquifer. For the Weston Lake watershed, total annual groundwater recharge is 615 dam<sup>3</sup> and current usage is 167 dam<sup>3</sup> calculating as 167/615 or 27%. Ocean Estuary would add another ~ 6 dam<sup>3</sup> per year increasing the index to 28%.
- Potential impact on future development of additional housing within existing FWS boundaries. Note that the proponent of the seven (7) lot development at the end of Morningside Road is now contemplating a three-lot development.
- Incremental increase of water drawdown from Lake Weston even though it is currently well below the licenced volume.

Factors and points to consider as general background information:

- If Ocean Estuary is not successful in joining the Service Area, they have indicated they will develop their own well and water treatment system drawing from a different aquifer. They have however stated they don't want to be in the water business.
- A dam or weir cannot be used to increase the level of Lake Weston as it is connected to the aquifer with a large fault, so the lake level is predominantly determined by the aquifer level, not surface drawdown.
- Various other users around Lake Weston and in the Fulford Water Local Service Area are not metered so their level of usage and impact on the aquifer is unknown.
- GW Solutions report of August 2023 recommends water meters for each property supplied by FWS.
- Increased and improved water conservation will ameliorate the situation.
- Lake Weston varies in elevation from 61.35 masl in January to 60.55 masl in August (an 800 mm variation).
- Weston Creek does not currently meet Environmental Flow Needs (EFN) of 10% Mean Annual Discharge (MAD) between July and September.
- The water licence for FWS can easily accommodate increased demand from Ocean Estuary (currently at 106,400 m<sup>3</sup> per year).
- Current FWS draw from Lake Weston is ~ 30,000 m<sup>3</sup> per year or about 28% of that allowed by the licence.
- The Fulford Water Treatment Plant has adequate capacity to produce the required water for the Ocean Estuary development.

**CONCLUSION**

The existing Fulford Water Treatment Plant produces adequate potable water to service the proposed Ocean Estuary development. The existing distribution system, along with the improvements and upgrades which would be provided by the proponent, is adequate to provide service to all current and proposed users. The impact to the level of Lake Weston with the addition of Ocean Estuary is incremental and negligible. Historically, MAD flow through Weston Creek in the summer does not reach 10% even without the addition of the Ocean Estuary development. As an additional user, Ocean Estuary (and any additional users along the new watermain route) would share in the fixed capital and operating costs of the system, particularly the inevitable project to replace all of the asbestos / cement water lines.

**RECOMMENDATION**

The Fulford Water Service Commission recommends that the Ocean Estuary Development be granted permission to proceed with an application to be included in the Fulford Water Local Service Area.

Submitted by:	Dean Olafson, P. Eng., MBA, Engineering Manager, Salt Spring Electoral Area
Concurrence:	Karla Campbell, MBA, BPA, Senior Manager, Salt Spring Electoral Area

**ATTACHMENTS**

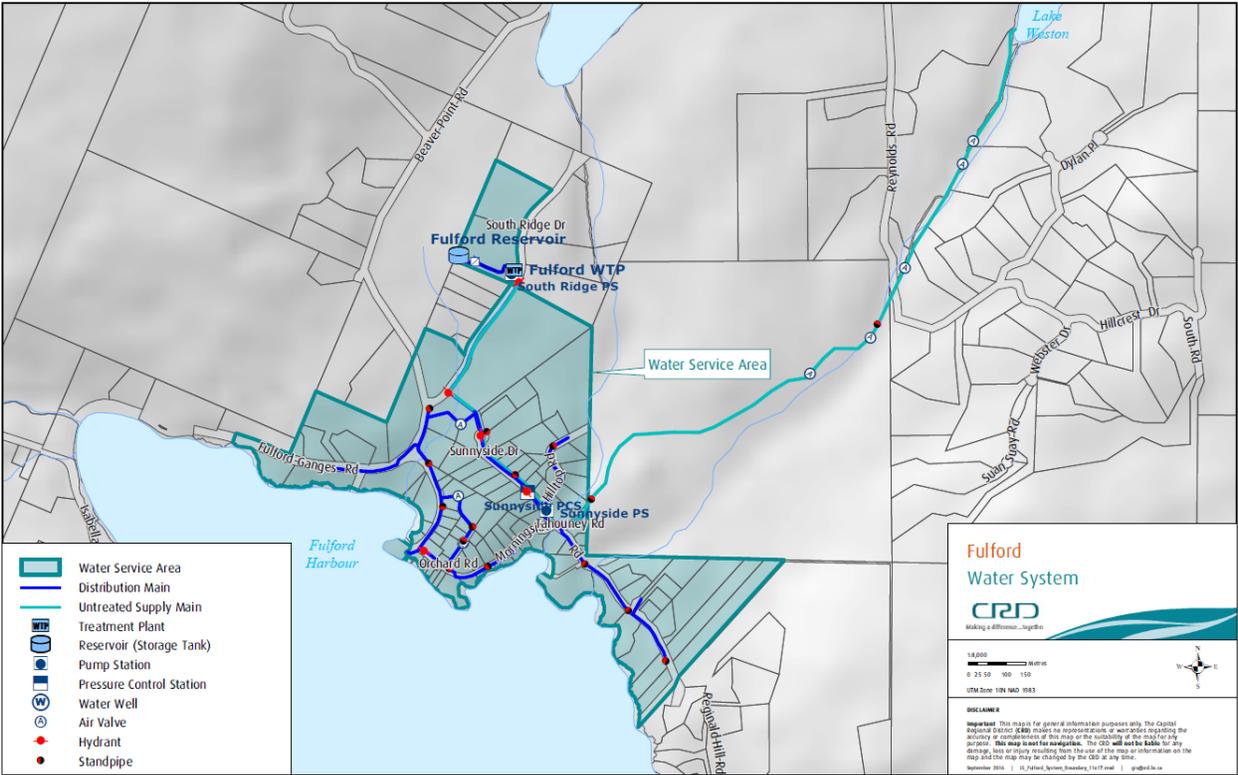
- Appendix A - Fulford Water System, Ocean Estuary Development Impact Assessment (McElhanney Ltd. – August 29<sup>th</sup>, 2022)
- Appendix B - Ocean Estuary, Water Supplies for Suburban and Rural Fire Fighting (Celerity Engineering Limited – November 4<sup>th</sup>, 2021)
- Appendix C - Fulford Water System Expansion Assessment (GW Solutions – August 14<sup>th</sup>, 2023)
- Appendix D - Lake Weston Water Availability and Climate Change Assessment (GW Solutions – July 26<sup>th</sup>, 2022)
- Appendix E - Fulford Water: AC Watermain Replacement, Investigation, Analysis, Criticality Assessment & Option Review (McElhanney Ltd. – March 10<sup>th</sup>, 2023)
- Appendix F - Fulford Water Service, Growth and Development Analysis (C. Sunderland, CRD, August 2011)

CRD Salt Spring Island Electoral Area

# Fulford Water System

## Ocean Estuary Development Impact Assessment

August 29, 2022 | Our File: 2243-17048-01



Prepared By:  
**McElhanney Ltd.**  
[www.mcelhanney.com](http://www.mcelhanney.com)

Date:  
**July 30, 2019**

# EXECUTIVE SUMMARY

McElhanney Ltd. (McElhanney) has been retained by the Ocean Estuary Development Owner **Merchant House Capital Inc.**

The proposed Ocean Estuary Development is located on 2621 and 2661 Fulford Ganges Road which is currently outside of the Fulford Water Service Area (FWSA). Expansion of the FWSA to include the proposed development is desired. McElhanney has undertaken a hydraulic assessment of the existing system and assess impact of the proposed development. This Technical Memorandum has been prepared to provide background information and summarize options for system improvements to service the Ocean Estuary development without adverse impact to existing FWSA users.

As part of this exercise the team met with the CRD and Saltsping Fire Department to define system modelling parameters including domestic and fire service flow criteria.

In summary, the hydraulic assessment shows:

1. Maximum Day Demand and Peak Hour Demand (Domestic Service) can be provided to the proposed Ocean Estuary Development without significant impact to the existing water system. No upgrades to the existing water supply, treatment, storage or distribution system would be anticipated. Connection would involve installation of a new pipe from the existing termination point (near 2807 Fulford - Ganges Road) to the Ocean Estuary Development (approximately 1,000m).
2. Fire flow (63.3 L/s) cannot be provided without improvement to the existing system. Improvements identified include:
  - a. 1,000 meters of 200mm diameter water main connecting the new development to the existing water system (near 2807 Fulford - Ganges Road).
  - b. Replacement 350 meters of existing 150mm diameter water main and 300 meters of existing 100mm diameter water main with 200mm diameter water main.
3. Proposed system improvements will provide Fire Service to the Ocean Estuary Development and improved Fire Service to other existing FWSA users along Fulford Ganges and Southridge Roads.

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REVISION No.	REVISION DESCRIPTION	DATE
1	Initial Results Review	July 30, 2019
2	Updated Recommendation / Appendix B Detailed Assessment Results Added	September 05, 2019
3	Updated Modelling Criteria and results	March 10, 2022
4	Revisions to suit August 24, 2022 CRD Comments	August 29, 2022

## ACKNOWLEDGEMENT

McElhanney would like to acknowledge and express their appreciation to the CRD staff during this assignment. A team effort was required to develop the Water System Assessment and it could not have been completed without the invaluable assistance of Karla Campbell and Dean Olafson .

# 1. EXISTING SYSTEM DESCRIPTION

## 1.1. SYSTEM DESCRIPTION SUMMARY

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The Fulford Water System is located in a semi-rural residential community with an elementary school and commercial component. The water system is situated on the north side of Fulford Harbour on Salt Spring Island. Lake Weston supplies raw water to the Fulford Water System and is at an elevation of approximately 60 m above sea level with the topography of the water service area ranging between sea level and 60 m.

The area is comprised of 102 parcels of land of which 91 parcels are presently connected to the system. **Please refer to Figure 1 – Existing System Summary**

The Fulford Water System is primarily comprised of the following assets:

### EXISTING WATER SUPPLY

The CRD holds two water licenses for Lake Weston to divert a total of up to 106,400 m<sup>3</sup> per year (292 m<sup>3</sup>/day) and store up to 49,300 m<sup>3</sup>. Lake Weston is estimated to have a total volume of 1,090,000 m<sup>3</sup>. Lake Weston is subject to seasonal water quality changes and is affected by algae blooms. We are not aware of any recent hydrological studies to determine the capacity of the lake. The peak volume of water withdrawn from the lake between 2014 and 2017 was 29,506 m<sup>3</sup>/ year. This peak volume is approximately 28% of the allowable capacity under the water licenses.

### LAKE INTAKE

The existing lake intake was constructed in conjunction with the current water treatment plant. The capacity of the intake meets the capacity of the treatment plant. There were no issues observed or identified with respect to the condition or operation of the existing lake intake.

### FULFORD WATER TREATMENT PLANT

The water treatment plant draws water from Lake Weston with a treatment process consisting of a rapid mix system, flocculation, dissolved air floatation (DAF), rapid filtration, ultraviolet (UV) disinfection, and chlorination. The water is then pumped to the reservoir.

The rated design flow for the water treatment plant is 4.5 L/s or 390 m<sup>3</sup>/day. This is approximately 2 times the MDD recorded in 2011. The treatment plant appears to have adequate capacity for the demand; however, further investigation should be conducted to assess plant efficiencies at lower demands.

### WATER STORAGE RESERVOIR

The Fulford reservoir has a capacity of 360 m<sup>3</sup> (80,000 IG) and is located south west of Fulford Community Elementary School. The reservoir operates a single pressure system and is at an elevation of approximately 90 m above sea level.

Water reservoir capacity is comprised of three components: balancing storage, fire storage and emergency storage. Balancing storage should be a minimum of 25% of maximum day demand. Fire storage is dependent on the properties being protected, but for rural residential should be a minimum of 60 L/s for 1.5 hours or a total of 324 m<sup>3</sup>. Emergency storage is 25% of the balancing + fire storage.

The Fulford reservoir has a storage volume of 360 m<sup>3</sup>. It supplies water to approximately 91 properties (95 SFE). The Fulford Reservoir is fed from the South Ridge pump station.

- Balancing storage requirements are 47.7 m<sup>3</sup>. Fire storage is 324 m<sup>3</sup> and emergency storage is 93 m<sup>3</sup>. The total storage for requirement for Fulford is 464.7 m<sup>3</sup>.

SYSTEM STATISTICS	
CURRENT PROPERTIES SERVICED	91
POTENTIAL PROPERTIES SERVICED	102
MDD CURRENT	2.2 L/s
MDD PROJECTED (102 PROPERTIES)	2.4 L/s
PHD PROJECTED	3.6 L/s **
FIRE SERVICE (CURRENT)	0-12 L/s
** NOTE: ASSUMED 1.5 PEAK FACTOR	

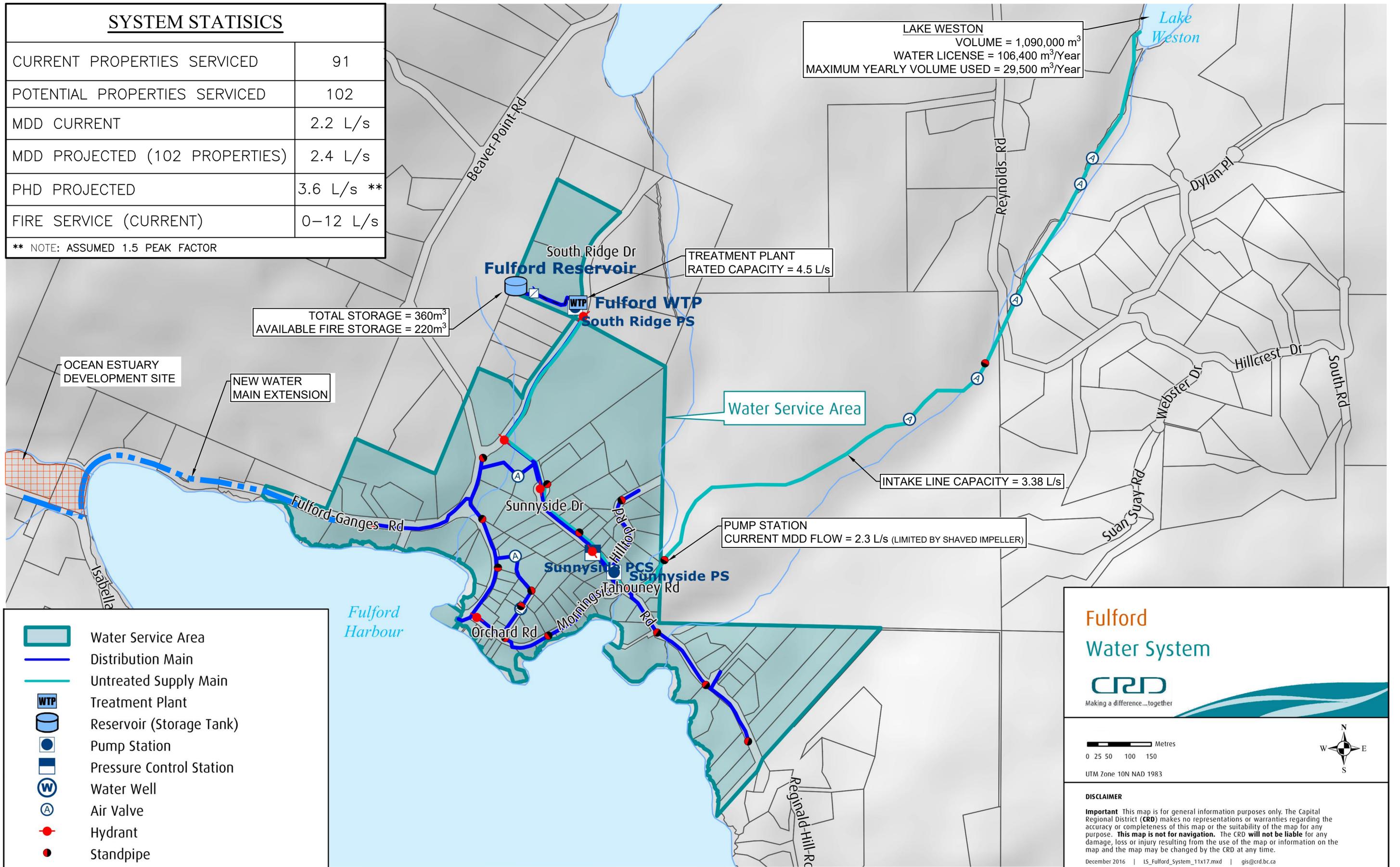


FIGURE 1 - EXISTING SYSTEM SUMMARY

- This reservoir has adequate storage for domestic flows; however only 220 m<sup>3</sup> is available for fire storage (360 m<sup>3</sup> –140m<sup>3</sup>). As only 220m<sup>3</sup> is available the reservoir does not meet the FUS required storage volume.

## FULFORD DISTRIBUTION SYSTEM

Approximately 4.5 km of water distribution pipe consists of 50 mm to 100 mm asbestos cement pipe installed in 1970 and approximately 2.2 km of 50 mm to 150 mm PVC watermains installed in the late 2000s. The distribution system also includes fire hydrants, standpipes, gate valves; and water service connections. Water is metered at the Water Treatment Plant

The 100 mm mains do not meet design guidelines and are under sized for fire flow as the friction head loss at fire flow would be excessive. At domestic flow rates, the friction head loss is lower, and the existing mains seem to provide adequate flow and pressure. In general, the minimum size for watermains should be 150 mm.

## SUNNYSIDE DRIVE PRESSURE REDUCING STATION

There is one (1) pressure reducing valve station, PRS Sunnyside, in front of 122 Sunnyside Drive.

## SUNNYSIDE DRIVE PUMP STATION

The Sunnyside Drive pump station is located across from the Hilltop Road and Sunnyside Drive intersection, specifically at 105 Hilltop Place. The pump station boosts the water supply from Lake Weston to the water treatment plant at a simultaneous pumping rate of 2.3 L/s (30 gpm) from 2 pumps.

## FIRE SERVICE

We have discussed this development with the Salt Spring Island Fire Department and have a better understanding of their fire service capability. In summary, the Fire Department uses bladder trucks for fire storage and have been FUS accredited for residential homes. The Fire department can produce a continuous flow (in defined areas) of 12 L/s using a Tender Shuttle (series of bladder trucks). It should be noted that this flow is not instantaneous (bladder trucks need to be dispatched to site) as such would not be satisfactory (instantaneous) for sprinkler system supply.

The Tender Shuttle and associated Letter of Accreditation from FUS has benefited residents through a reduction in insurance premiums.

We have worked with a Building Code and Fire Protection Expert (Celerity), the CRD and the Salt Spring Island Fire department to define a proposed Fire Flow rate based on current building code requirements and Salt Spring Island Fire Department response needs. The recommended fire flow rate at the Ocean Development Site is 3,800 L/min (66.3/l/s).

## 1.2. EXISTING AND FUTURE DEMANDS

The Fulford water service area is comprised of 102 properties of which 91 are connected to the system. Within those 91 parcels, there are 95 single family equivalents (SFE) as the use on some parcels represent more than one dwelling.

Between 2014 and 2017, total water produced has varied between 27,805 m<sup>3</sup>/year and 29,506 m<sup>3</sup>/year. The Fulford Water System does not have residential water meters; therefore, water consumption was not tracked and a single-family equivalent (SFE) water consumption was calculated. As per the 2017 annual report, the SFE water demand has increased from 234 m<sup>3</sup>/year in 2016 to 238 m<sup>3</sup>/year in 2017. Water consumption by users have been fluctuating by 5.8% over the past four years. This fluctuation may be typical throughout the CRD in areas with limited population growth as demand per capita has been decreasing.

Demand in the system varies significantly over the year, with the peak occurring in July or August. The measured Maximum Day Demand (MDD) in 2011 was 191 m<sup>3</sup>/day (2.2 L/s) or 1,900 L/day per service connection. This is significantly lower than the CRD design criteria for MDD of 2,680 L/day per service connection.

While population on Salt Spring is anticipated to grow by approximately 2.5% per year, it is also predicted that water consumption per person will continue to decrease. Currently 89% of the properties in the water district are serviced. Unless the boundaries of the water service area are expanded, or significant subdivision occurs within the water service boundaries, it is anticipated that future demand will remain at current levels or perhaps decrease slightly.

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## 2. PROPOSED DEVELOPMENT SERVICING CONCEPT AND DEMANDS

### 2.1. DEVELOPMENT DESCRIPTION

The Ocean Estuary project will consist of 17 motel units within 8 cottage buildings and a village square consisting of a restaurant and small accessory retail sales buildings tied together by an outdoor plaza. It is situated at the end of Fulford Harbour where the old Fulford Inn was located on the south of Salt Spring Island, BC. We have included the Architectural Development Permit Submission for your reference.

The development site consists of three separate properties. The current zoning of each property is shown in Figure 1. No changes to the current zoning are anticipated; however, variances with respect to commercial and retail areas will be sought.

*Figure 1 – Development Concept*



### 2.2. SERVICING CONCEPT AND DEMANDS

A new water main would be required to be extended from the Fulford Water Service boundary, along Fulford Ganges Road, to the subject property. Expansion of the Fulford Water Service Area would be required to incorporate the development site. **Please refer to Figure 1 – Existing System Summary**

McElhanney has developed a hydraulic model for the existing system to evaluate impacts of the proposed development on the existing water system and identify improvements, where necessary, to mitigate impact and or improve existing system function. Hydraulic Assessment Criteria and Assessment results are discussed in section 3 and 4 of this report. Fundamental findings and inputs include:

- The system will be extended to the development side and approximately 650m of existing undersized main will be replaced on Fulford Ganges Road. **Domestic service not impacted, and Fire Service along the Fulford Ganges Road spine is greatly improved as a result.**
- Existing Water Use rates were provided by the CRD.
- Domestic Service Requirements for the Ocean Estuary Development (Peak Hour Demand and Max Day Demand) were calculated based on the British Columbia Sewage System Standard Practice Manual.
- Fire Flow rate was defined by Celerity (Code Consultant) in coordination with the Salt Spring Island Fire Department and the CRD.

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### 3. HYDRUALIC ASSESMENT DESIGN CRITERIA

The following design guidelines and criteria were used in the hydraulic system assessment.

- Average Day Demand (ADD)
  - Existing ADD (91 Properties) = 80.8m<sup>3</sup> /year or 879 L/day/connection (Fulford Water System Asset Management Plan, McElhanney May 2020)
- Max Day Demand (MDD)
  - Existing MDD (91 Properties) = 2.2 L/s (Fulford Water System Asset Management Plan, McElhanney May 2020), or 2,089 L/day/connection
  - Full Build Out MDD (102 Properties) = 2.4L/s
  - Ocean Estuary MDD = 0.45 L/s (McElhanney October 22, 2018 Technical Memorandum)
- Peak Hour Demand
  - Existing PHD = 3.6 L/s (1.5x MDD). This has been equally distributed amongst the 15 nodes
  - Ocean Estuary PHD = 0.65 L/s (McElhanney October 22, 2018 Technical Memorandum)
- Fire Service
  - Fire Flow at Ocean Estuary = 3,800 L/min (63.33 L/s). Please refer to Celerity Memorandum Water Supply for Suburban and Rural Fire Fighting dated November 04, 2022
  - Required Fire Storage = 114m<sup>3</sup>. Please refer to Celerity Memorandum Water Supply for Suburban and Rural Fire Fighting dated November 04, 2022
  - Available Fire Storage = 220m<sup>3</sup> (Fulford Water System Asset Management Plan, McElhanney March 2019)
- Sprinklers
  - All buildings within the proposed development site will include fire sprinkler systems.
- Hazen Williams Formula, C = 140 for PVC Pipe
- Residual Pressures
  - 40 psi at PHD
  - 20 psi at MDD + Fire Service
  - Max allowable pressure is 123 psi (MMCD Design Guidelines 2014)
- Design Guidelines for Rural Residential Community Water System, BC (2012)

## 4. SYSTEM ASSESSMENT RESULTS

### 4.1. WATER SOURCE, INTAKE AND TREATMENT

We have reviewed the impact to these facilities at MDD (at full Build Out). Please see the table below. The addition of the Ocean Estuary development will not impact these facilities other than the intake pump. At present the intake pump is limited to 2.3 l/s due to a shaved impeller. The New MDD is calculated to be 2.8 L/s; as such, an upgrade to the pumps or impeller may be warranted. **Please refer to Figure 2 – Impact of Increased ADD and MDD.**

Facility	Capacity	Demand (at full build out)	Demand with Ocean Estuary	Comments
<b>Lake Weston</b>	Water License = 106,400 m <sup>3</sup> /year  Lake Volume = 1,090,000m <sup>3</sup>	29,500m <sup>3</sup> / year	34,860 m <sup>3</sup> / year	Within water license.
<b>Intake Line</b>	3.38 L/s	MDD = 2.4 L/s	MDD = 2.8 L/s	Intake line is adequate for current and future demands
<b>Pump Station</b>	2.3 L/s	MDD = 2.4 L/s	MDD = 2.8 L/s	Pump station upgrade required. – New Impeller.
<b>Water Treatment Plant</b>	Rated Capacity = 4.5 L/s	MDD = 2.4 L/s	MDD = 2.8 L/s	Treatment rate is adequate for current and future demands

### 4.2. PEAK HOUR DEMAND

We have reviewed the impact to the system at PHD (at Full Build Out). The addition of the proposed Ocean Estuary development does not measurably impact the existing system. **Please refer to Figure 3 – Impact of Increased PHD.**

### 4.3. FIRE FLOW

We have reviewed the impact of the 63.33 L/s fire flow rate at MDD (full build out) at the Ocean Estuary Development on the existing system. **Please refer to Figure 4 – Impact of Increased MDD +Fire.**

Modelling shows that the existing system would be negatively impacted without improvements. Figure 4 identifies residual pressures within the system without improvements (black) and with proposed improvements (blue). Nodes with pressures below the minimum 40PSI are highlighted in yellow.

Proposed improvements include:

- 1,000 meters of 200mm diameter water main connecting the new development to the existing water system (near 2807 Fulford - Ganges Road).
- Replacement 350 meters of existing 150mm diameter water main and 300 meters of existing 100mm diameter water main with 200mm diameter water main is required.

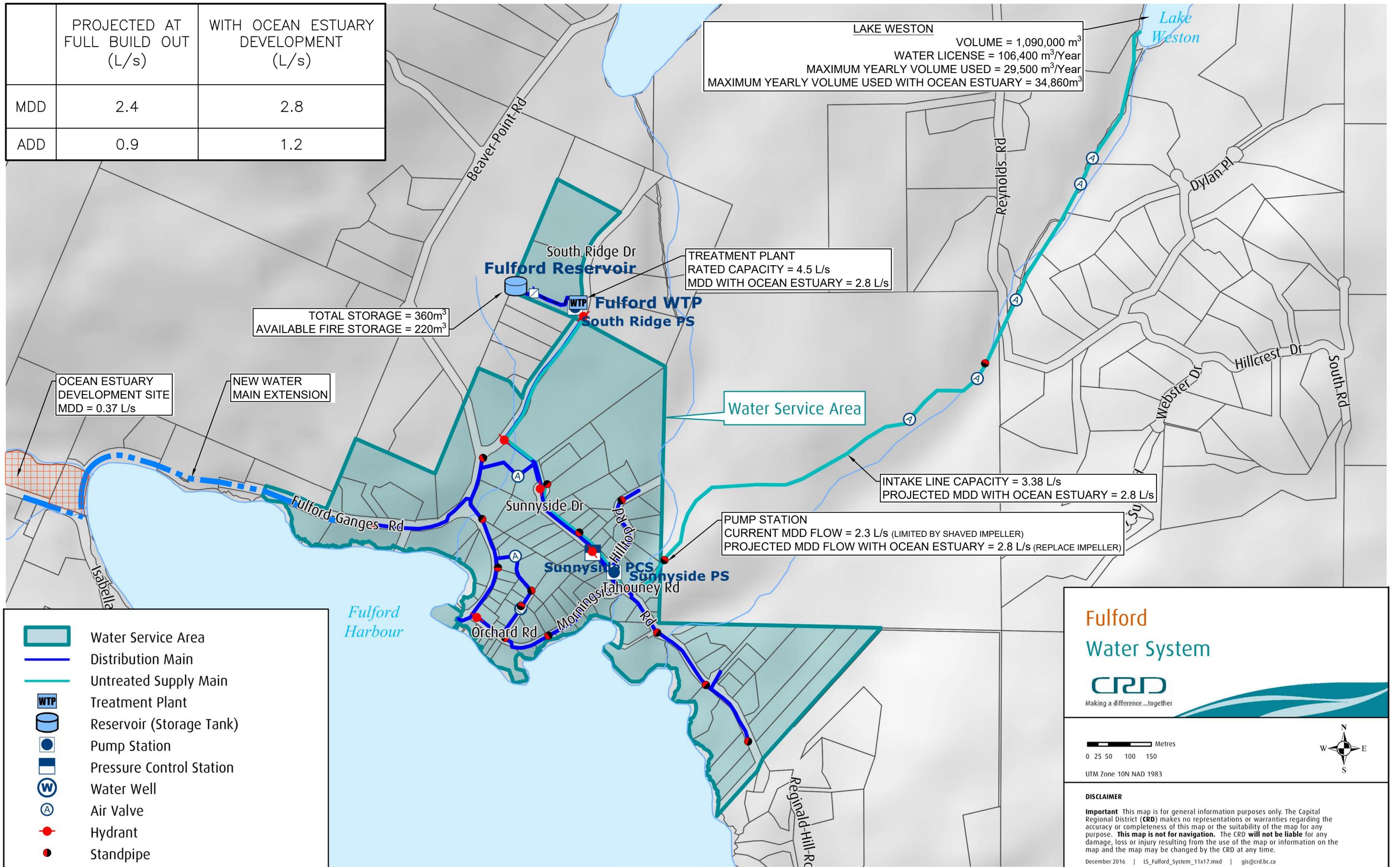


FIGURE 2 - IMPACT OF INCREASED A.D.D. & M.D.D.

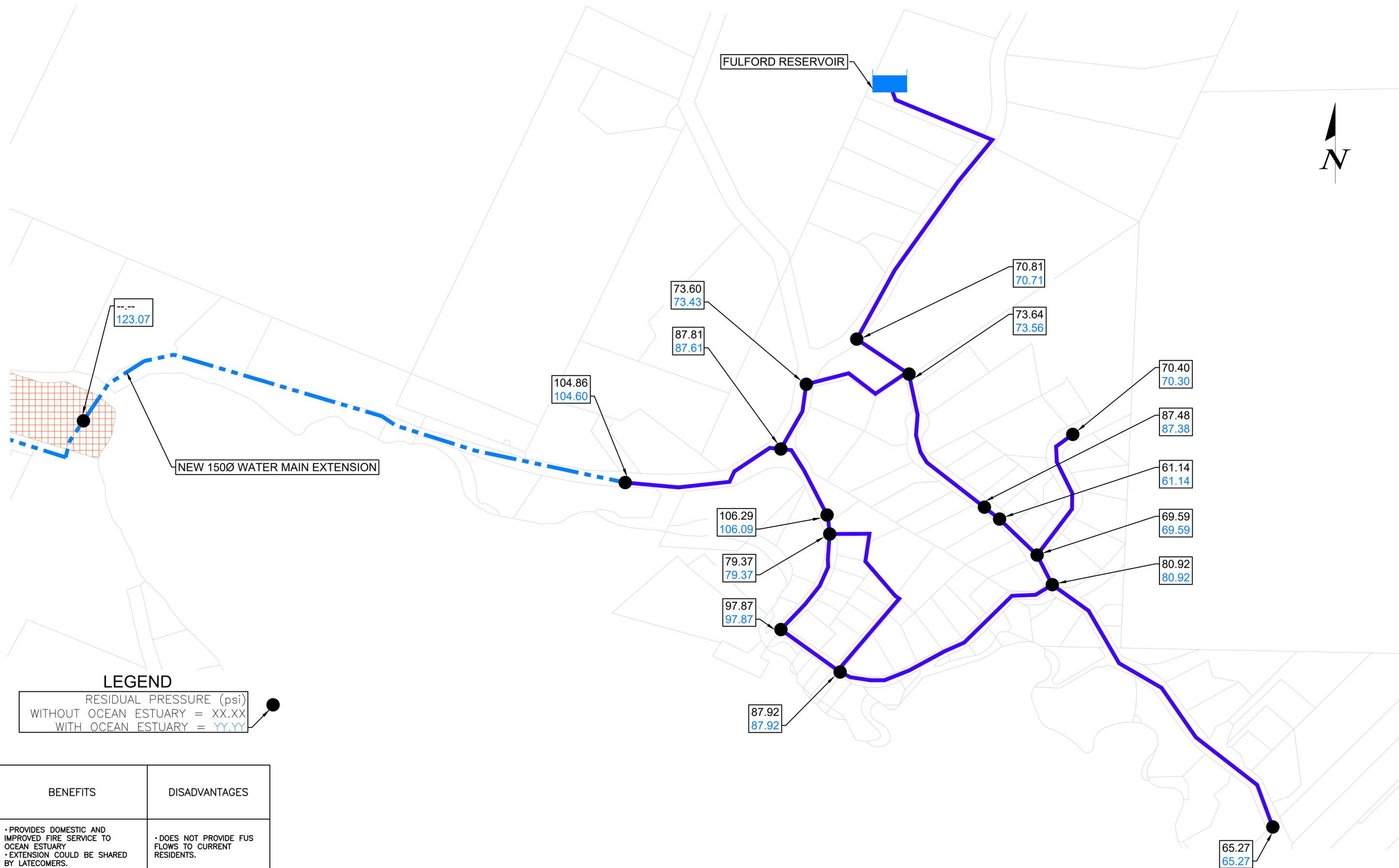


FIGURE 3 - IMPACT OF INCREASED P.H.D.

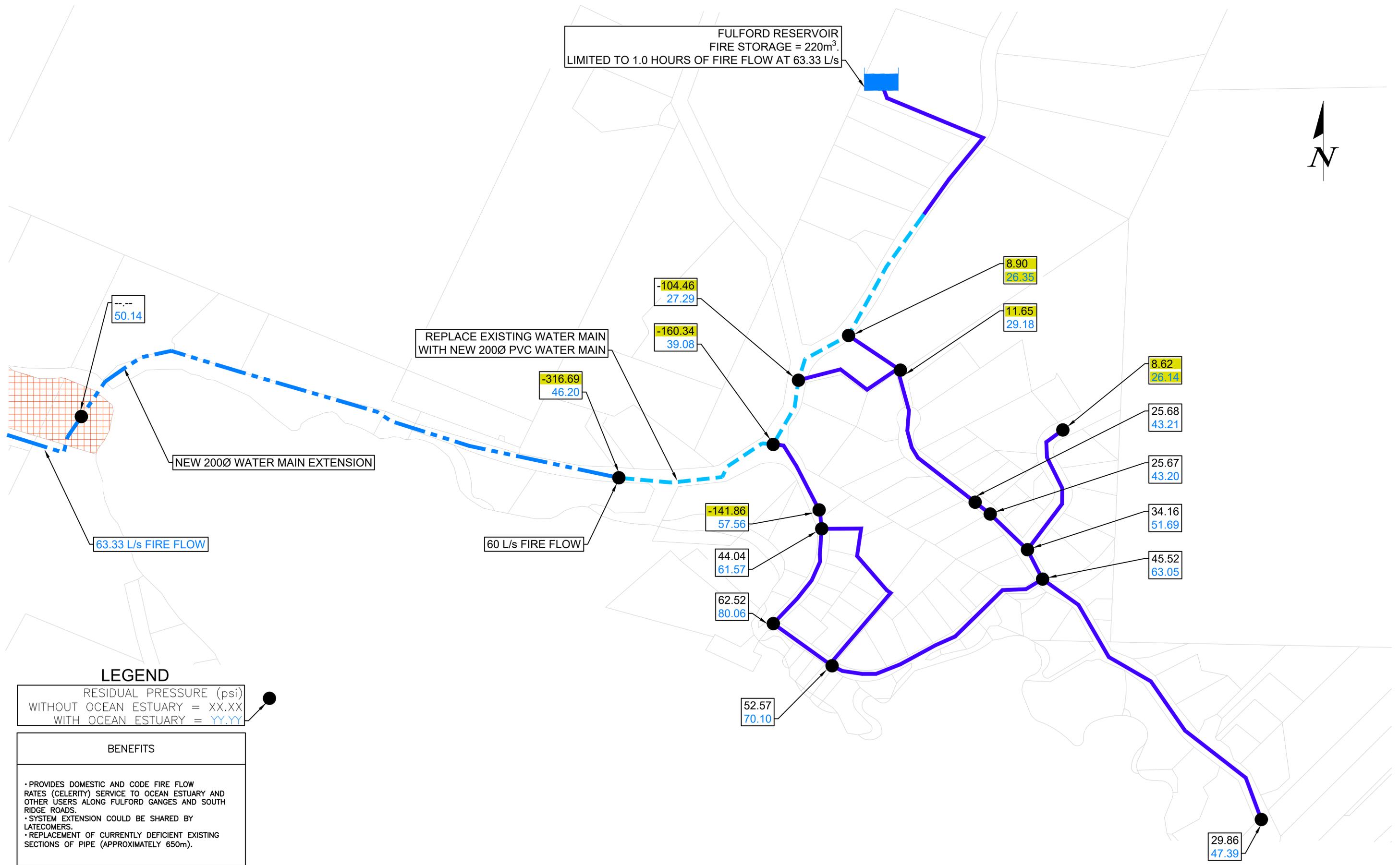


FIGURE 4 - IMPACT OF M.D.D. & FIRE AT 63.33 L/s

- Increase pipe diameter would increase available fire flow and reduce velocity within the mains. Residual pressure within the existing system are improved significantly.
- Proposed improvements result in adequate Fire Flow provided to the Ocean Estuary development, **along with an increased level of service to FWSA users including fire flow service of 66.3 L/s to properties along the Fulford Ganges Road spine.**

Estimated budgetary costs:

	Unit	Unit Price	Estimated Cost
New 200mm dia. Water main extension	1,000 m	\$700/m	\$700,000
Service Connection to Property	1	\$20,000	\$20,000
Replace existing 100mm dia. water main with 200mm dia. water main	350 m	\$750/m	\$262,500
Replace existing 150mm dia. water main with 200mm dia. water main	300 m	\$750/m	\$225,000
Bridge Crossing	1	\$80,000	\$80,000
			<b>\$1,287,500</b>

## 5. RECOMMENDATIONS

In summary, the hydraulic assessment shows that Max Day Demand and Peak Hour Demand (Domestic Service) can be provided to the proposed Ocean Estuary Development without significant impact to the existing water system.

Proposed system improvements would provide improved Fire Flow Rates to Ocean Estuary Development and other existing FWSA users along Fulford Ganges and Southridge Roads.

It is recommended that the CRD consider expansion of the FWSA system boundary to include the Ocean Estuary development.

This report has been prepared by **McELHANNEY LTD.**

Prepared by:

Reviewed by:

Ian Sander, P.Eng.  
Division Manager

Nathan Dunlop P.Eng.  
Senior Engineer

**6. APPENDIXES**

**6.1. APPENDIX A: MCELHANNEY OCTOBER 22, 2018, TECHNICAL MEMORANDUM**

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DRAFT

October 22, 2018

File No.: 2243-17-048 (4)

**Karla Campbell, Senior Manager, Salt Spring Island Electoral Area**  
 CRD - Saltspring Island  
 108-121 McPhillips Avenue  
 Salt Spring Island BC, V8K 2P6

Dear Ms. Campbell:

**RE: Fulford Harbour Water Service: Request for Service Expansion to Include the Ocean Estuary Development**

**Submission Purpose:**

The proposed Ocean Estuary Development is located on 2621 and 2661 Fulford Ganges Road which is currently outside of the Fulford Water Service Area (FWSA). Expansion of the FWSA to include the proposed development is desired. This Technical Memorandum has been prepared to provide project background information and summarize water service needs to allow CRD staff to initiate assessment of the existing system.

**1. Project Background**

The Ocean Estuary project will consist of 24 small cabins and a village square consisting of a restaurant and small accessory retail sales buildings tied together by an outdoor plaza, is situated at the end of Fulford Harbour where the old Fulford Inn was located on the south of Salt Spring Island, BC. We have attached the Architectural Development Permit Submission for your reference.

**Figure 1 – Development Concept**





With rich ecology and a unique geological history, the site is located directly over the Fulford Thrust fault line, where two separate geological systems meet. Emphasizing the importance of the site's history, the shapes, materials and language of the landscape and architecture can mimic another layer of the island's geology. Buildings create a rock formation nestled into the natural conditions of the site, with materials that pay homage to the black shale and mudstone below ground.

## 2. Current Zoning

The development site consists of three separate properties. The current zoning of each property is shown in Figure 2 below. No changes to the current zoning are anticipated; however, variances with respect to commercial and retail areas will be sought.

Figure 2 – Current Zoning



## 3. Anticipated Domestic Use Flow Rates

Two separate properties will be serviced as part of the development. 2661 Fulford Road (east property) will include a new Commercial Area and Restaurant, and 8 1-bedroom hotel units. 2621 Fulford Road (west property) will include 8 2-bedroom cabin units.

To develop flow estimates the flow rates from the British Columbia Sewage System Standard Practice Manual (Version 3 – September 2014) were used. A peaking factor of 3.5 was used to determine peak flow rates. Peak Hour flow rates for each lot are summarized in the tables below.



**Table 1 - 2661 Fulford Ganges Road**

USE	NUMBER / QTY	UNITS	AVERAGE FLOW PER UNIT (L/DAY)	TOTAL (L/Day)
Visitors, includes WC for coffee	100	patron	20	2000
Staff (stalls at market)	8	full time person	60	480
Staff (restaurant and hotel)	5	full time person	75	375
Coffee at restaurant, no WC (kitchen flows)	50	cups	4	200
Restaurant, full service	65	seats	90	5850
Hotel rooms, 1 bedroom	8	rooms	300	2400
Outside restaurant allowance for summer use	16	seats	90	1440
<b>Total ADD</b>				<b>12745</b>
<b>Peaking Factor (3.5)</b>				<b>38235</b>
<b>Peak Hour Demand (PHD) (L/s)</b>				<b>0.443</b>

**Table 2 - 2621 Fulford Ganges Road**

USE	NUMBER / QTY	UNITS	AVERAGE FLOW PER UNIT (L/DAY)	TOTAL (L/Day)
Hotel Bedroom Units (8 - 2-bedroom Units)	16	bedroom Units	400	6400
<b>Total ADD</b>				<b>6400</b>
<b>Peaking Factor (3.5)</b>				<b>19200</b>
<b>Peak Hour Demand (PHD) (L/s)</b>				<b>0.222</b>

Another option for estimating water demands is to use the MMCD Design Guideline. Section 2.4 indicates that a value of 22,500 litres/hectare/day can be applied in absence of other detailed development information to develop Max Day Demand (MDD). The total site area for 2661 and 2621 Fulford Ganges Road is 0.684 Ha.

$$22,500 \text{ L/Ha/Day} \times 0.684 \text{ Ha} = 15,390 \text{ L/Day (MDD)}, \text{ or } 23,085 \text{ L/Day (PHD)*}$$

\*assuming a peaking factor of 1.5

The total PHD calculated using the System Standard Practice Manual is 57,435 L/Day (0.665 L/s) and should be use in the system assessment.



#### **4. Fire Service**

We understand that the Fulford water service supply system currently has restrictions that limit the flow rate and the SSI Fire Departments uses bladder trucks and portable reservoirs and does not fully rely on the Fulford water system for service.

It is likely that the commercial area in 2261 Fulford Ganges Road will require sprinkler systems. If it is determined that the existing water system cannot develop the require flow rates alternative measures for onsite storage and pumping may need to be explored. It is anticipated that fire flow will need to be provide through system upgrades, and / or onsite improvements. Options will be explored once detailed system information is provided by the CRD.

#### **5. Servicing Concept**

A new water main would be required to be extended from the Fulford Water Service boundary, along Fulford Ganges Road, to the subject property. Figure 1 illustrates the proposed route. Figure 2 illustrates the onsite servicing concept.

We respectfully request that the Fulford Harbour Water Service consider expansion to include the Ocean Estuary Development and evaluate infrastructure extension. We would be happy to provide any additional information you require and to meet with you to discuss our project.

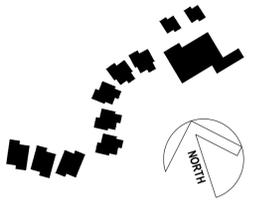
Sincerely,

**McElhanney Consulting Services Ltd.**

Ian Sander, P. Eng. PMP.  
Senior Project Manager

Attachments: Figure 1, Figure 2, Ocean Estuary DP Application Package

KEY PLAN



Issued For:

NO	DESCRIPTION	DATE

Project Title

## OCEAN ESTUARY PROJECT

2661 FULFORD-GANGES ROAD,  
SALT SPRING ISLAND BC, V8K 1Z4

Drawing Title

## CRD FULLFORD WATER SYSTEM

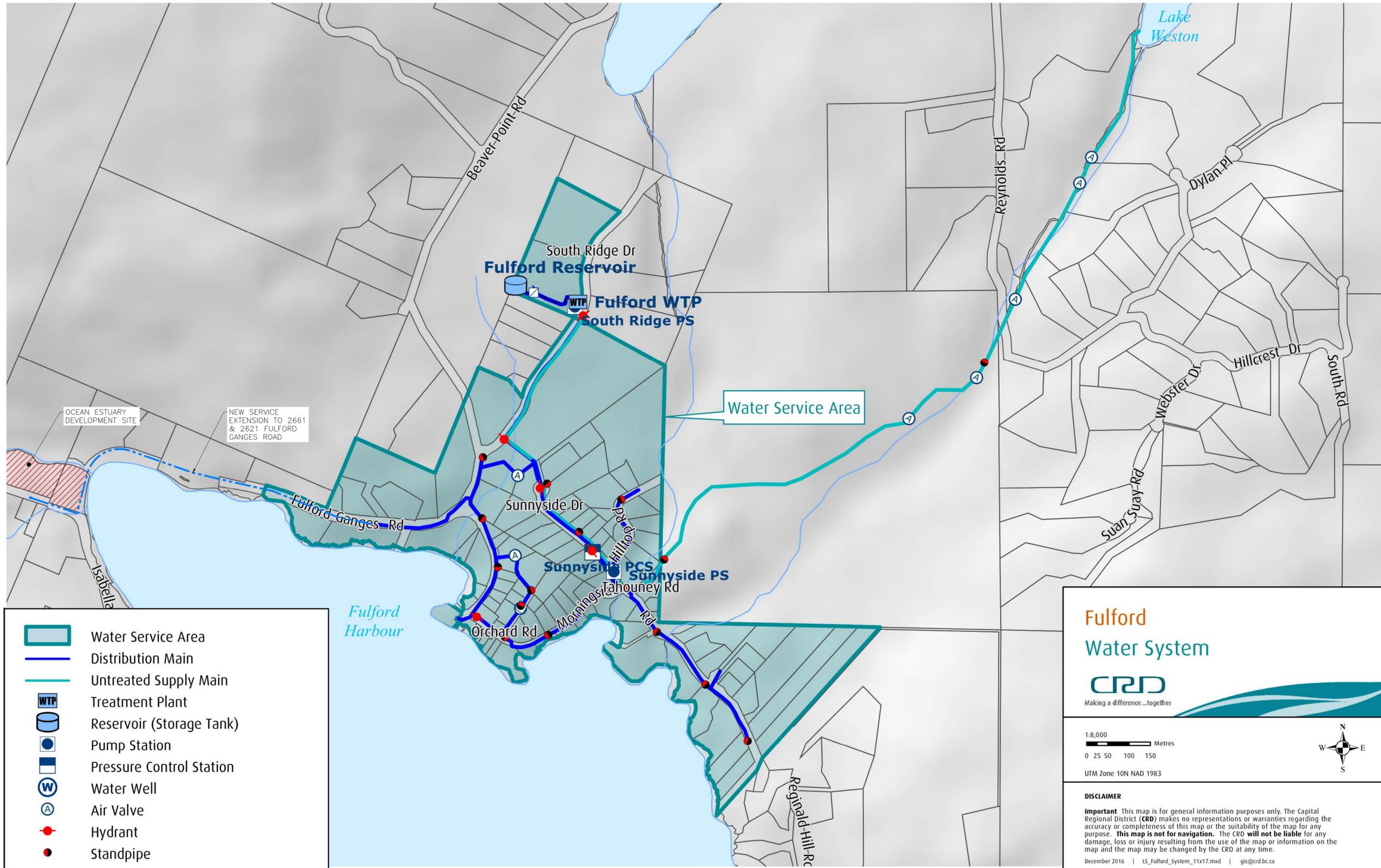
Sheet Information

Date:	2018-10-12
Project Number:	17-048-01
Drawn:	GS
Checked:	IS
Approved:	

Stamp

Drawing No.

# FIG. 1

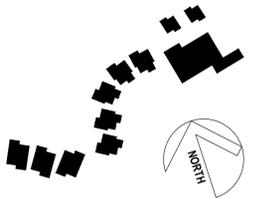


OCTOBER 12, 2018  
**FOR INFORMATION ONLY**

LEGEND

	CATCHMENT AREA 1
	CATCHMENT AREA 2
	CATCHMENT AREA 3

KEY PLAN



Issued For:

NO	DESCRIPTION	DATE
1.	REVISED RAIN GARDEN LOCATIONS	2018-10-12

Project Title

## OCEAN ESTUARY PROJECT

2661 FULFORD-GANGES ROAD,  
SALT SPRING ISLAND BC, V8K 1Z4

Drawing Title

## WATER SERVICE CONCEPT PLAN

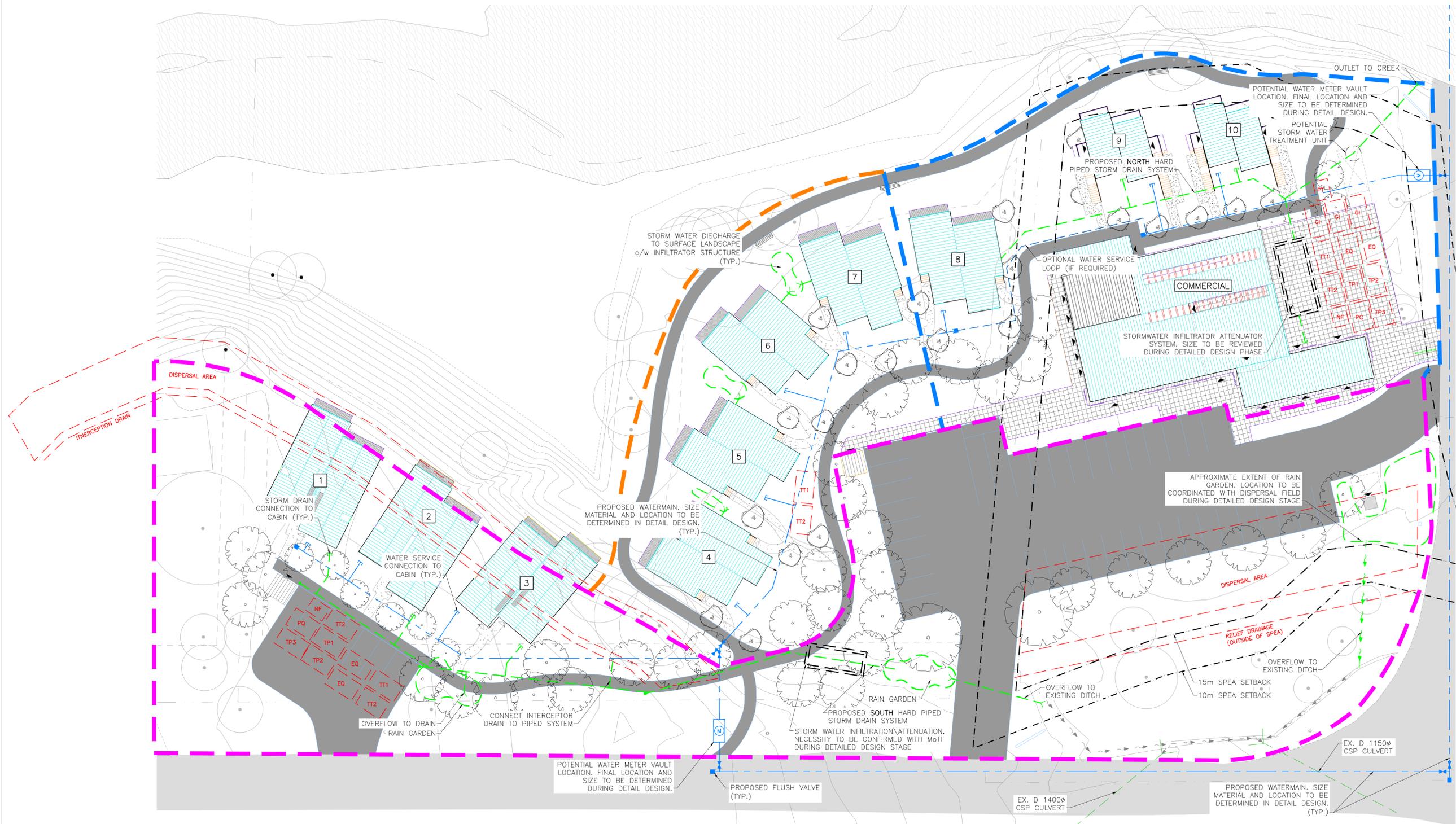
Sheet Information

Date:	2018-10-12
Project Number:	17-048-01
Drawn:	GS
Checked:	IS
Approved:	

Stamp

Drawing No.

# FIG. 2



OCTOBER 12, 2018

**FOR INFORMATION ONLY**

LEGEND

- CATCHMENT AREA 1
- CATCHMENT AREA 2
- CATCHMENT AREA 3

**6.2. APPENDIX B: CELERITY MEMORANDUM – WATER SUPPLY FOR  
SUBURBAN AND RURAL FIRE FIGHTING – NOVEMBER 22, 2021**

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DRAFT

## Memorandum

tel: (250) 410-2021 / (604) 375-0437  
web: [www.celerity.ca](http://www.celerity.ca)

From: **Stefan Germann, P.Eng.**  
Telephone: (604) 375-0437 x 212  
Email: [sgermann@celerity.ca](mailto:sgermann@celerity.ca)

Project: Ocean Estuary  
Subject: Water Supplies for Suburban and Rural Fire Fighting  
Project #: 21165  
Date: November 4, 2021

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To:	<b>Attention:</b> David Fullbrook	<b>Company:</b> Ocean Estuary	<b>Via:</b> Email
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The purpose of this document is to advise the minimum articulated fire water requirements required for the purposes of conducting fire fighting activities within Fulford Harbor Water Service area.



**Figure 1: Location of Proposed Works**

The safety requirements contained within this document are considered the minimum requirements needed to demonstrate compliance with Article 3.2.5.7 in the 2018 British Columbia Building Code.

This report will cover the assessment and make recommendations for volumes and flows of water necessary to satisfy the intent of the Building Code.

This is not a 'For Construction' document, but a performance document that is intended to be used by other consultants in implementing their detailed designs and preparing their working drawings and specifications. The consultants whose documentation is required to incorporate these fire safety requirements are expected to have read this report, understood the implications as it affects their scope of work, and incorporated the relevant fire requirements into their drawings, specifications, and other construction documents.

## SUPPORTING DOCUMENTS

This review is based on the architectural drawings for Development Permit, provided by Kirsten Reite Architecture dated February 19, 2020.

## EXTENT OF WORK

It is our understanding that the assessment contained within this report is required to determine the quantity of fire fighting water that is needed for a new proposed development.

The proposed development consists of 14 buildings. A single assembly use building is proposed, while the other 13 buildings are of residential occupancy.

The proposed building layout is shown in figure 2 below.



Figure 2: Development Layout

The details contained within this report reflect the requirements related to fire water supplies only. Details related to the overall distribution of other services it to be carried out by others.

It should be noted that detailed hydraulic calculations for the delivery of water for fire fighting purposes is to be carried out by others.

### **DANGEROUS GOODS**

This memo does not specifically consider the storage, use or handling of any dangerous goods, and therefore is not included within the scope.

### **WORK BY OTHERS**

#### **Building Code Report**

A building code report for building(s) identified within this report is not included within the scope.

#### **Fire Safety Plan**

Details and approval of a fire safety plan as required by the BC Fire Code is to be prepared by others.

#### **Fire Protection**

The details of the fire alarm system and fire protection system are to be completed by others.

### **REVIEW PHILOSOPHY**

It is noted that the British Columbia Building Code does not provide strict prescriptive requirements for the evaluation of minimum fire water supplies. However, “[t]he intent of [the Building Code] is that an adequate water supply for firefighting be readily available and of sufficient volume and pressure to enable emergency response personnel to control fire growth so as to enable the safe evacuation of occupants and the conduct of search and rescue operations, prevent the fire from spreading to adjacent buildings, and provide a limited measure of property protection.”

As such, this review of the minimum fire water requirements will take into consideration the following documents:

- NFPA 1142 – Standard on Water Supplies for Suburban and Rural Fire Fighting,
- ISO – Needed Fire Flow Guide, and
- Fire Underwriters Survey – Water Supply for Public Fire Protection.

### **1 GENERAL**

Typically, a water supply system is considered fully adequate if it can deliver the necessary volume and flow of water needed for a given period of time based on a specific hazard category. In urban conditions this is generally achieved through the municipal water distribution system and the town’s main.

The amount of water needed for rural structure fire fighting is dependent upon the following and should be available for no less than 30 minutes per the Notes to Part 3 of the Building Code:

- The size of the building,

- Type of building construction,
- Occupancy and use,
- Exposures, and
- Environmental impact.

It is our understanding that:

- the existing fire response within Fullford Harbour area is via water Tender Shuttles as the articulated water supply infrastructure is not available.
  - The district fire department carries FUS certification for Alternate Water Supplies for Public Protection.
  - Water for filling the tender vehicles is provided via an above ground cistern that has a capacity of 220,000 L for firefighting.
- The fire department has the capacity to draw a maximum of 3800L/min (1000 gpm) from an articulated water supply, and
- Water is available via an above ground cistern that has a capacity of 220,000 L for firefighting, and a total capacity of 350,000L.

## 2 ASSESSMENT

The following assessment for the volume of water required to address the needs for firefighting is based on a worst case accidental building fire scenario. Arson and wildfire scenarios are not considered.

A worst case scenario would be considered as a fire starting in the restaurant and spreading to one or all of the directly adjacent residential buildings. The restaurant is considered worst case as it generally has the largest floor area and/or building volume compared to other structures within the area. However, should the restaurant no longer be considered a worst case building, a new assessment for the fire water supply will be required.

It is our understanding that the restaurant building and residential buildings will be provided with automatic fire sprinkler systems in accordance with NFPA 13 and NFPA 13D, respectively, and the Building Code.

As this represents a worst case, a reassessment of the water requirements will be needed should future larger buildings be placed in the area or the proposed worst case changes. The calculations for water supply will take into account external exposure hazards i.e. adjacent structures, in the water supply requirement calculations.

The assessment detailed below follows the requirements within the NFPA, FUS and ISO documents noted above.

### 2.1 NFPA 1142 (2017) – Standard on Water Supplies for Suburban and Rural Fire Fighting

#### 2.1.1 Calculating Minimum Water Supplies

NFPA 1142 requires the following information for a given structure in order to determine the minimum water supply for firefighting:

- Occupancy hazard - A series of numbers from 3 through 7 that are mathematical factors used in a formula to determine total water supply requirements.
- Type of construction – As detailed in NFPA 5000
- Structure dimensions (length, width and height)
- Exposures - A structure within 50 ft (15.24 m) of another building and 100 ft<sup>2</sup> (9.3 m<sup>2</sup>) or larger in area.

For structures with unattached structural exposure hazards, the minimum water supply is determined using the following:

$$WS_{min} = \frac{VS_{tot}}{OHC} (CC) \times 1.5$$

where:

$WS_{min}$  = min water supply in Litres

$VS_{min}$  = total volume of the structure in ft<sup>3</sup>

$OHC$  = occupancy hazard classification number

$CC$  = construction classification number

Given the following for the restaurant and as detailed on the attached markup:

$$VS_{min} = (596 \text{ m}^2 \times 7.6 \text{ m}) \times (35.315 \text{ ft}^3 / \text{m}^3) = 159,963 \text{ ft}^3$$

$OHC$  = 5 for moderate hazard occupancies, as per NFPA 1142 Chapter 5.

$CC$  = 1.5 for Type V construction (Combustible Construction)

Therefore, the total available water supply needed for firefighting purposes, as per NFPA 1142 is:

$$WS_{min} = \frac{159,963}{5} (1.5) \times 1.5 = 71,983 \text{ L}$$

### 2.1.2 Water Delivery Rate to the Fire Scene

The water for firefighting shall be delivered at a rate of no less than 3800 L/min which allows for 19 minutes of hose stream.

Therefore, for a 30 minute supply 114,000 L is required.

### 2.1.3 Structures with Automatic Sprinkler Protection

It is noted that if buildings are provided with an automatic sprinkler system, the AHJ is permitted to reduce the water supply required by NFPA 1142 provided the sprinkler system is not compromised by manual firefighting operations.

As the buildings will be protected with automatic fire sprinkler systems in accordance with NFPA standards, the water supply can be reduced. However, it is our recommendation that a 3800L/min (63 L/s) be available at the development site via a fire hydrant for no less than 30 min. It is expected that the 3800 L/min would supply both the automatic sprinkler system and manual fire fighting. A fire sprinkler designer shall be engaged to determine if water supply can accommodate both automatic sprinkler system and manual fire fighting.

**2.2 ISO – Needed Fire Flow Guide**

**2.2.1 Calculating Minimum Water Supplies**

ISO requires the following information for a given structure in order to determine the minimum water supply for firefighting in an individual non sprinklered building:

- Occupancy type
- Type of construction
- Communication between buildings
- Exposures

The amount of water needed to fight a fire in an individual nonsprinklered building, ISO uses the following:

$$NFF = (C_i)(O_i)[(1.0 + (X + p)_i)]$$

where:

NFF = fire flow in gpm

$C_i$  = construction factor

$O_i$  = occupancy factor

$X + p$  = Exposure Factor

**CONSTRUCTION TYPE**

Construction Class 1 (wood frame construction)

Construction Type Coefficient	(F) =	1.5	
Effective Area (single storey)	( $A_i$ ) =	6,412	ft <sup>2</sup>

$C_i =$	$18F\sqrt{A_i}$	
$C_i =$	2250	Rounded to nearest 250

**OCCUPANCY TYPE**

Restaurant

Occupancy combustibility class (combustible) C-3

Occupancy Factor  $O_i = 1.0$  Combustible

**EXPOSURES**

The following conditions rule out exposure charges (X) from adjacent buildings:

- Buildings rated as habitational, including their appurtenant outbuildings

The following conditions rule out communication charges (p) from adjacent buildings:

- Buildings rated as habitational, including their appurtenant outbuildings, and
- Buildings rated sprinklered

**CALCULATION**

$$NFF_i = C \times O [1.0 + (X + P)]$$

= 1750 × 1.0 × 1.0	2250	gpm
	8,517	L/min

**2.2.2 Water Storage Required**

For a 30 minute water supply as recommended by the Building Code, 255,510 L of water is required.

**2.2.3 Structures with Automatic Sprinkler Protection**

ISO does not determine a needed fire flow for buildings rated and coded by ISO as protected by an automatic sprinkler system meeting applicable National Fire Protection Association standards.

As the buildings will be protected with automatic fire sprinkler systems in accordance with NFPA standards, the water supply is not required in accordance with ISO. However, it is our recommendation that a 3800L/min (63 L/s) be available at the development site via a fire hydrant for no less than 30 min. It is expected that the 3800 L/min would supply both the automatic sprinkler system and manual fire fighting. A fire sprinkler designer shall be engaged to determine if water supply can accommodate both automatic sprinkler system and manual fire fighting.

**2.3 Fire Underwriters Survey (FUS) – Water Supply for Public Fire Protection**

**2.3.1 Calculating Minimum Water Supplies**

FUS requires the following information for a given structure in order to determine the minimum water supply for firefighting:

- Type of construction
- Structure dimensions – the total floor area including all storeys but excluding basements.

An estimate of the minimum water supply is determined using the following:

$$F = 220C\sqrt{A}$$

where:

- $F$  = minimum fire flow in litres per minute  
 $C$  = construction coefficient  
 $A$  = total floor area

Given the following for the restaurant and as detailed on the attached markup:

- $C$  = 1.5 wood frame construction  
 $A$  = 596 m<sup>2</sup>

Therefore, the total available water supply needed for firefighting purposes, as per FUS is:

$$F = 220(1.5)\sqrt{376} = 8,056 \text{ L/min}$$

### 2.3.2 Water Volume Required

FUS notes that for fire flows of 8,056 L/min a 2 hour water supply should be provided, which equate to approx. 966,759 L of water to be available for fire fighting.

It should be noted that FUS assumes that there is a reasonable supply of water available and that the water is from a consistent and readily available and dependable source i.e. town's main.

It is noted that if a 30 minute supply was to be provided as recommended in the Building Code a supply of 241,680 L would be needed.

A 20% charge to the above water supply is required to address building exposures, therefore 290,016 L.

### 2.3.3 Structures with Automatic Sprinkler Protection

The value for the water supply needed is permitted to be reduced by up to 50% where an automatic fire sprinkler system is provided, depending on:

- the adequacy of the sprinkler system,
- The availability of a water supply for both the sprinkler system and required hose lines, and
- Whether or not the system is supervised.

The FUS requirements generally rely on the availability of water via an articulated water supply. The water supply requirements are onerous and can only be feasibly applied to urban centres with large town's main water supplies.

Furthermore, the Acceptable Solutions in the Building Code state:

Article 3.2.5.7. Water Supply

- 1) Every building shall be provided with an adequate water supply for firefighting.

2) Buildings that are sprinklered throughout with a sprinkler system conforming to Article 3.2.5.12. or have a standpipe system conforming to Article 3.2.5.8. to 3.2.5.10. are deemed to comply with Sentence (1).

As all the buildings are provided with a sprinkler system complying with NFPA and the Acceptable Solutions, the strict requirement for water supplies is deemed to be satisfied. However, it is our recommendation that a 3800L/min (63 L/s) be available at the development site via a fire hydrant for no less than 30 min. It is expected that the 3800 L/min would supply both the automatic sprinkler system and manual fire fighting. A fire sprinkler designer shall be engaged to determine if water supply can accommodate both automatic sprinkler system and manual fire fighting.

### 3 SUMMARY

The amount of water needed for rural structure fire fighting is dependent upon the following and should be available for no less than 30 minutes:

- The size of the building,
- Type of building construction,
- Occupancy and use,
- Exposures and
- Environmental impact.

As such, a review of the minimum fire water requirements was conducted using the following best practices:

- NFPA 1142 – Standard on Water Supplies for Suburban and Rural Fire Fighting,
- ISO – Needed Fire Flow Guide, and
- Fire Underwriters Survey – Water Supply for Public Fire Protection.

As detailed in the above assessment, the following summarises the volumes and flow rates of water needed for a 30 minute supply:

Standard	Volume (L)	Flow Rate (L/min)
NFPA 1142	114,000 <sup>1</sup>	3,800
ISO	255,510	8,517
FUS	290,016 <sup>1</sup>	8,056

1) It is noted that 30 minutes supplies are not strictly permitted by NFPA and FUS.

Water is available via an above ground cistern that has a capacity of 220,000 L for firefighting, and a total capacity of 350,000L.

However, it is noted that as each building within the development will be provided with an automatic fire sprinkler system. Thus, the water supply requirements are generally permitted to be waived or modified, provided the water supply for manual fire fighting does not compromise the sprinkler system.

This assessment only takes into account currently constructed buildings. Due to the variability of future works a reassessment may be required should the assumptions made in this report no longer be valid.

#### **4 SPRINKLER FLOW REQUIREMENTS**

Based on an assessment of automatic fire sprinkler water flow demand by Keith Trulson (Integral Group) the following sprinkler flows are required:

- NFPA 13D is a life safety system for 1 and 2 dwelling unit residential buildings.
  - The flow characteristics of this system is usually 151 LPM (40 USGPM) plus 20 L/min (5 USGPM) for domestic for a period of 10 minutes.
    - The total water flow requirement = 1 710 Litres (452 us gallons) per building.
- NFPA 13 is a commercial code for life safety and building protection. This would be the standard for the commercial Building (Restaurant/CRU).
  - The building would require a flow of 1 514 L/min (400 USGPM) plus a hose allowance of 946.25 LPM (250 USGPM) for a period of 60 minutes.
    - Total fire flow requirement = 147 615 litres (39,000 US Gallons).

#### **5 RECOMMENDATIONS**

The assessment within this document takes into account a worst case structural firefighting scenario with fire starting in the restaurant and spreading to one or all of the adjacent outbuildings within the development.

The water supply requirements are generally permitted to be waived or modified if an automatic fire sprinkler system is provided in accordance with an approved standard, provided the water supply for manual fire fighting does not compromise the sprinkler system. Therefore, to limit the probability of fire spread and amount of water needed for firefighting purposes, an automatic fire sprinkler system will be provided within each building in the development.

For the purposes of providing an adequate water supply the commercial buildings shall be provided with a fire sprinkler system in accordance with NFPA 13, and residential buildings shall be provided with a fire sprinkler system in accordance with NFPA 13D.

The calculations provided by Integral Group indicate that a worst case water supply for the fire sprinkler system is based on the demands as detailed by NFPA 13, which requires 1 514 L/min plus 946.25 L/min for hose stream allowances.

To supplement the automatic sprinkler systems, it is our recommendation that an additional 1 339.75 L/min be made available at the development site for no less than 30 min. Thus, the total flow to the site shall be no less than 3 800 L/min for 30 min.

Although not strictly required by the Building Code, the additional water flow allows for an additional hose stream allowance at 946.25 L/min for 60 min and an activation of a residential sprinkler system at 20 L/min for 10 min.

Based on the information provided by Integral Group the following details can be defined:

	Flow	Total Volume of Water Needed
<b>NFPA 13 Sprinkler:</b>		
Sprinkler Demand	1 514 L/min for 60 min	90 840 l
Hose Allowance	946.25 L/min for 60 min	56 775 l
<b>Additional Flow:</b>		
Extra Hose Allowance	946.25 L/min for 60 min	56 775 l
One Residential Sprinkler Activation	20 L/min for 10 min	200 l
	<b>Total</b>	<b>204 590 l</b>

Thus, the available water supply (220,000 L) for firefighting and the automatic sprinkler system exceeds that required for a 30 min supply at 3 800 L/min as noted in the Building Code.

Regards;

**CELERITY ENGINEERING LIMITED**

**Stefan Germann, P.Eng**  
 Senior Code Consultant

Limitation of Liability

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**Memorandum**

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**Project:** Ocean Estuary  
**Subject:** Water Supplies for Suburban and Rural Fire Fighting  
**Project #:** 21165  
**Date:** November 4, 2021

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<b>To:</b>	<b>Attention:</b> David Fullbrook	<b>Company:</b> Ocean Estuary	<b>Via:</b> Email
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The purpose of this document is to advise the minimum articulated fire water requirements required for the purposes of conducting fire fighting activities within Fulford Harbor Water Service area.



**Figure 1: Location of Proposed Works**

The safety requirements contained within this document are considered the minimum requirements needed to demonstrate compliance with Article 3.2.5.7 in the 2018 British Columbia Building Code.

This report will cover the assessment and make recommendations for volumes and flows of water necessary to satisfy the intent of the Building Code.

This is not a 'For Construction' document, but a performance document that is intended to be used by other consultants in implementing their detailed designs and preparing their working drawings and specifications. The consultants whose documentation is required to incorporate these fire safety requirements are expected to have read this report, understood the implications as it affects their scope of work, and incorporated the relevant fire requirements into their drawings, specifications, and other construction documents.

## SUPPORTING DOCUMENTS

This review is based on the architectural drawings for Development Permit, provided by Kirsten Reite Architecture dated February 19, 2020.

## EXTENT OF WORK

It is our understanding that the assessment contained within this report is required to determine the quantity of fire fighting water that is needed for a new proposed development.

The proposed development consists of 14 buildings. A single assembly use building is proposed, while the other 13 buildings are of residential occupancy.

The proposed building layout is shown in figure 2 below.



Figure 2: Development Layout

The details contained within this report reflect the requirements related to fire water supplies only. Details related to the overall distribution of other services it to be carried out by others.

It should be noted that detailed hydraulic calculations for the delivery of water for fire fighting purposes is to be carried out by others.

### **DANGEROUS GOODS**

This memo does not specifically consider the storage, use or handling of any dangerous goods, and therefore is not included within the scope.

### **WORK BY OTHERS**

#### **Building Code Report**

A building code report for building(s) identified within this report is not included within the scope.

#### **Fire Safety Plan**

Details and approval of a fire safety plan as required by the BC Fire Code is to be prepared by others.

#### **Fire Protection**

The details of the fire alarm system and fire protection system are to be completed by others.

### **REVIEW PHILOSOPHY**

It is noted that the British Columbia Building Code does not provide strict prescriptive requirements for the evaluation of minimum fire water supplies. However, “[t]he intent of [the Building Code] is that an adequate water supply for firefighting be readily available and of sufficient volume and pressure to enable emergency response personnel to control fire growth so as to enable the safe evacuation of occupants and the conduct of search and rescue operations, prevent the fire from spreading to adjacent buildings, and provide a limited measure of property protection.”

As such, this review of the minimum fire water requirements will take into consideration the following documents:

- NFPA 1142 – Standard on Water Supplies for Suburban and Rural Fire Fighting,
- ISO – Needed Fire Flow Guide, and
- Fire Underwriters Survey – Water Supply for Public Fire Protection.

## **1 GENERAL**

Typically, a water supply system is considered fully adequate if it can deliver the necessary volume and flow of water needed for a given period of time based on a specific hazard category. In urban conditions this is generally achieved through the municipal water distribution system and the town’s main.

The amount of water needed for rural structure fire fighting is dependent upon the following and should be available for no less than 30 minutes per the Notes to Part 3 of the Building Code:

- The size of the building,

- Type of building construction,
- Occupancy and use,
- Exposures, and
- Environmental impact.

It is our understanding that:

- the existing fire response within Fullford Harbour area is via water Tender Shuttles as the articulated water supply infrastructure is not available.
  - The district fire department carries FUS certification for Alternate Water Supplies for Public Protection.
  - Water for filling the tender vehicles is provided via an above ground cistern that has a capacity of 220,000 L for firefighting.
- The fire department has the capacity to draw a maximum of 3800L/min (1000 gpm) from an articulated water supply, and
- Water is available via an above ground cistern that has a capacity of 220,000 L for firefighting, and a total capacity of 350,000L.

## 2 ASSESSMENT

The following assessment for the volume of water required to address the needs for firefighting is based on a worst case accidental building fire scenario. Arson and wildfire scenarios are not considered.

A worst case scenario would be considered as a fire starting in the restaurant and spreading to one or all of the directly adjacent residential buildings. The restaurant is considered worst case as it generally has the largest floor area and/or building volume compared to other structures within the area. However, should the restaurant no longer be considered a worst case building, a new assessment for the fire water supply will be required.

It is our understanding that the restaurant building and residential buildings will be provided with automatic fire sprinkler systems in accordance with NFPA 13 and NFPA 13D, respectively, and the Building Code.

As this represents a worst case, a reassessment of the water requirements will be needed should future larger buildings be placed in the area or the proposed worst case changes. The calculations for water supply will take into account external exposure hazards i.e. adjacent structures, in the water supply requirement calculations.

The assessment detailed below follows the requirements within the NFPA, FUS and ISO documents noted above.

### 2.1 NFPA 1142 (2017) – Standard on Water Supplies for Suburban and Rural Fire Fighting

#### 2.1.1 Calculating Minimum Water Supplies

NFPA 1142 requires the following information for a given structure in order to determine the minimum water supply for firefighting:

- Occupancy hazard - A series of numbers from 3 through 7 that are mathematical factors used in a formula to determine total water supply requirements.
- Type of construction – As detailed in NFPA 5000
- Structure dimensions (length, width and height)
- Exposures - A structure within 50 ft (15.24 m) of another building and 100 ft<sup>2</sup> (9.3 m<sup>2</sup>) or larger in area.

For structures with unattached structural exposure hazards, the minimum water supply is determined using the following:

$$WS_{min} = \frac{VS_{tot}(CC)}{OHC} \times 1.5$$

where:

$WS_{min}$  = min water supply in Litres

$VS_{min}$  = total volume of the structure in ft<sup>3</sup>

$OHC$  = occupancy hazard classification number

$CC$  = construction classification number

Given the following for the restaurant and as detailed on the attached markup:

$$VS_{min} = (596 \text{ m}^2 \times 7.6 \text{ m}) \times (35.315 \text{ ft}^3 / \text{m}^3) = 159,963 \text{ ft}^3$$

$OHC$  = 5 for moderate hazard occupancies, as per NFPA 1142 Chapter 5.

$CC$  = 1.5 for Type V construction (Combustible Construction)

Therefore, the total available water supply needed for firefighting purposes, as per NFPA 1142 is:

$$WS_{min} = \frac{159,963}{5} (1.5) \times 1.5 = 71,983 \text{ L}$$

### 2.1.2 Water Delivery Rate to the Fire Scene

The water for firefighting shall be delivered at a rate of no less than 3800 L/min which allows for 19 minutes of hose stream.

Therefore, for a 30 minute supply 114,000 L is required.

### 2.1.3 Structures with Automatic Sprinkler Protection

It is noted that if buildings are provided with an automatic sprinkler system, the AHJ is permitted to reduce the water supply required by NFPA 1142 provided the sprinkler system is not compromised by manual firefighting operations.

As the buildings will be protected with automatic fire sprinkler systems in accordance with NFPA standards, the water supply can be reduced. However, it is our recommendation that a 3800L/min (63 L/s) be available at the development site via a fire hydrant for no less than 30 min. It is expected that the 3800 L/min would supply both the automatic sprinkler system and manual fire fighting. A fire sprinkler designer shall be engaged to determine if water supply can accommodate both automatic sprinkler system and manual fire fighting.

## 2.2 ISO – Needed Fire Flow Guide

### 2.2.1 Calculating Minimum Water Supplies

ISO requires the following information for a given structure in order to determine the minimum water supply for firefighting in an individual non sprinklered building:

- Occupancy type
- Type of construction
- Communication between buildings
- Exposures

The amount of water needed to fight a fire in an individual nonsprinklered building, ISO uses the following:

$$NFF = (C_i)(O_i)[(1.0 + (X + p)_i)]$$

where:

NFF = fire flow in gpm

$C_i$  = construction factor

$O_i$  = occupancy factor

$X + p$  = Exposure Factor

#### CONSTRUCTION TYPE

Construction Class 1 (wood frame construction)

Construction Type Coefficient	(F) =	1.5	
Effective Area (single storey)	( $A_i$ ) =	6,412	ft <sup>2</sup>

	$C_i =$	$18F\sqrt{A_i}$	
	$C_i =$	2250	Rounded to nearest 250

#### OCCUPANCY TYPE

Restaurant

Occupancy combustibility class (combustible)	C-3
--	-----

Occupancy Factor  $O_i =$  1.0 Combustible

**EXPOSURES**

The following conditions rule out exposure charges (X) from adjacent buildings:

- Buildings rated as habitational, including their appurtenant outbuildings

The following conditions rule out communication charges (p) from adjacent buildings:

- Buildings rated as habitational, including their appurtenant outbuildings, and
- Buildings rated sprinklered

**CALCULATION**

$$NFF_i = C \times O [1.0 + (X + P)]$$

= 1750 × 1.0 × 1.0	2250	gpm
	8,517	L/min

**2.2.2 Water Storage Required**

For a 30 minute water supply as recommended by the Building Code, 255,510 L of water is required.

**2.2.3 Structures with Automatic Sprinkler Protection**

ISO does not determine a needed fire flow for buildings rated and coded by ISO as protected by an automatic sprinkler system meeting applicable National Fire Protection Association standards.

As the buildings will be protected with automatic fire sprinkler systems in accordance with NFPA standards, the water supply is not required in accordance with ISO. However, it is our recommendation that a 3800L/min (63 L/s) be available at the development site via a fire hydrant for no less than 30 min. It is expected that the 3800 L/min would supply both the automatic sprinkler system and manual fire fighting. A fire sprinkler designer shall be engaged to determine if water supply can accommodate both automatic sprinkler system and manual fire fighting.

**2.3 Fire Underwriters Survey (FUS) – Water Supply for Public Fire Protection**

**2.3.1 Calculating Minimum Water Supplies**

FUS requires the following information for a given structure in order to determine the minimum water supply for firefighting:

- Type of construction
- Structure dimensions – the total floor area including all storeys but excluding basements.

An estimate of the minimum water supply is determined using the following:

$$F = 220C\sqrt{A}$$

where:

$F$  = minimum fire flow in litres per minute

$C$  = construction coefficient

$A$  = total floor area

Given the following for the restaurant and as detailed on the attached markup:

$C$  = 1.5 wood frame construction

$A$  = 596 m<sup>2</sup>

Therefore, the total available water supply needed for firefighting purposes, as per FUS is:

$$F = 220(1.5)\sqrt{376} = 8,056 \text{ L/min}$$

### 2.3.2 Water Volume Required

FUS notes that for fire flows of 8,056 L/min a 2 hour water supply should be provided, which equate to approx. 966,759 L of water to be available for fire fighting.

It should be noted that FUS assumes that there is a reasonable supply of water available and that the water is from a consistent and readily available and dependable source i.e. town's main.

It is noted that if a 30 minute supply was to be provided as recommended in the Building Code a supply of 241,680 L would be needed.

A 20% charge to the above water supply is required to address building exposures, therefore 290,016 L.

### 2.3.3 Structures with Automatic Sprinkler Protection

The value for the water supply needed is permitted to be reduced by up to 50% where an automatic fire sprinkler system is provided, depending on:

- the adequacy of the sprinkler system,
- The availability of a water supply for both the sprinkler system and required hose lines, and
- Whether or not the system is supervised.

The FUS requirements generally rely on the availability of water via an articulated water supply. The water supply requirements are onerous and can only be feasibly applied to urban centres with large town's main water supplies.

Furthermore, the Acceptable Solutions in the Building Code state:

Article 3.2.5.7. Water Supply

- 1) Every building shall be provided with an adequate water supply for firefighting.

2) Buildings that are sprinklered throughout with a sprinkler system conforming to Article 3.2.5.12. or have a standpipe system conforming to Article 3.2.5.8. to 3.2.5.10. are deemed to comply with Sentence (1).

As all the buildings are provided with a sprinkler system complying with NFPA and the Acceptable Solutions, the strict requirement for water supplies is deemed to be satisfied. However, it is our recommendation that a 3800L/min (63 L/s) be available at the development site via a fire hydrant for no less than 30 min. It is expected that the 3800 L/min would supply both the automatic sprinkler system and manual fire fighting. A fire sprinkler designer shall be engaged to determine if water supply can accommodate both automatic sprinkler system and manual fire fighting.

### 3 SUMMARY

The amount of water needed for rural structure fire fighting is dependent upon the following and should be available for no less than 30 minutes:

- The size of the building,
- Type of building construction,
- Occupancy and use,
- Exposures and
- Environmental impact.

As such, a review of the minimum fire water requirements was conducted using the following best practices:

- NFPA 1142 – Standard on Water Supplies for Suburban and Rural Fire Fighting,
- ISO – Needed Fire Flow Guide, and
- Fire Underwriters Survey – Water Supply for Public Fire Protection.

As detailed in the above assessment, the following summarises the volumes and flow rates of water needed for a 30 minute supply:

Standard	Volume (L)	Flow Rate (L/min)
NFPA 1142	114,000 <sup>1</sup>	3,800
ISO	255,510	8,517
FUS	290,016 <sup>1</sup>	8,056

1) It is noted that 30 minutes supplies are not strictly permitted by NFPA and FUS.

Water is available via an above ground cistern that has a capacity of 220,000 L for firefighting, and a total capacity of 350,000L.

However, it is noted that as each building within the development will be provided with an automatic fire sprinkler system. Thus, the water supply requirements are generally permitted to be waived or modified, provided the water supply for manual fire fighting does not compromise the sprinkler system.

This assessment only takes into account currently constructed buildings. Due to the variability of future works a reassessment may be required should the assumptions made in this report no longer be valid.

#### **4 SPRINKLER FLOW REQUIREMENTS**

Based on an assessment of automatic fire sprinkler water flow demand by Keith Trulson (Integral Group) the following sprinkler flows are required:

- NFPA 13D is a life safety system for 1 and 2 dwelling unit residential buildings.
  - The flow characteristics of this system is usually 151 LPM (40 USGPM) plus 20 L/min (5 USGPM) for domestic for a period of 10 minutes.
    - The total water flow requirement = 1 710 Litres (452 us gallons) per building.
- NFPA 13 is a commercial code for life safety and building protection. This would be the standard for the commercial Building (Restaurant/CRU).
  - The building would require a flow of 1 514 L/min (400 USGPM) plus a hose allowance of 946.25 LPM (250 USGPM) for a period of 60 minutes.
    - Total fire flow requirement = 147 615 litres (39,000 US Gallons).

#### **5 RECOMMENDATIONS**

The assessment within this document takes into account a worst case structural firefighting scenario with fire starting in the restaurant and spreading to one or all of the adjacent outbuildings within the development.

The water supply requirements are generally permitted to be waived or modified if an automatic fire sprinkler system is provided in accordance with an approved standard, provided the water supply for manual fire fighting does not compromise the sprinkler system. Therefore, to limit the probability of fire spread and amount of water needed for firefighting purposes, an automatic fire sprinkler system will be provided within each building in the development.

For the purposes of providing an adequate water supply the commercial buildings shall be provided with a fire sprinkler system in accordance with NFPA 13, and residential buildings shall be provided with a fire sprinkler system in accordance with NFPA 13D.

The calculations provided by Integral Group indicate that a worst case water supply for the fire sprinkler system is based on the demands as detailed by NFPA 13, which requires 1 514 L/min plus 946.25 L/min for hose stream allowances.

To supplement the automatic sprinkler systems, it is our recommendation that an additional 1 339.75 L/min be made available at the development site for no less than 30 min. Thus, the total flow to the site shall be no less than 3 800 L/min for 30 min.

Although not strictly required by the Building Code, the additional water flow allows for an additional hose stream allowance at 946.25 L/min for 60 min and an activation of a residential sprinkler system at 20 L/min for 10 min.

Based on the information provided by Integral Group the following details can be defined:

	Flow	Total Volume of Water Needed
<b>NFPA 13 Sprinkler:</b>		
Sprinkler Demand	1 514 L/min for 60 min	90 840 l
Hose Allowance	946.25 L/min for 60 min	56 775 l
<b>Additional Flow:</b>		
Extra Hose Allowance	946.25 L/min for 60 min	56 775 l
One Residential Sprinkler Activation	20 L/min for 10 min	200 l
<b>Total</b>		<b>204 590 l</b>

Thus, the available water supply (220,000 L) for firefighting and the automatic sprinkler system exceeds that required for a 30 min supply at 3 800 L/min as noted in the Building Code.

Regards;

**CELERITY ENGINEERING LIMITED**



**Stefan Germann, P.Eng**  
 Senior Code Consultant

Permit to Practice: #1001462

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## Fulford Water System Expansion Assessment

**Prepared for:**

Capital Regional District  
PO Box 1000  
Victoria, BC V8W 2S6

**Prepared by:**

GW Solutions Inc.  
August 14, 2023

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## 1 BACKGROUND

The Capital Regional District (CRD) require an assessment of the feasibility of expanding the Fulford Water System (FWS) to accommodate the estimated 5,000 m<sup>3</sup>/year additional water requirements for the new Ocean Estuary Development. The FWS is currently licensed for a total of 116,152 m<sup>3</sup>/year and uses an average of 30,000-40,000 m<sup>3</sup>/year. The FWS is supplied by a pipeline from Lake Weston which is in the adjacent Weston Creek watershed.

The purpose of this study is to assess the potential impacts of the additional 5,000 m<sup>3</sup>/year water-taking on Lake Weston, the aquifer that is directly connected to Lake Weston, and/or Weston Creek, which is fed both by Lake Weston and the aquifer. Thus, to assess the impacts of the additional water taking on Lake Weston is also necessary to assess the impacts on the aquifer and Weston Creek.

A study of the sustainable yield of Lake Weston was completed for the CRD in 2022 titled "Lake Weston Water Availability and Climate Change Assessment." This study draws upon the results of the 2022 study however the key data sets have been updated. This data includes FWS usage, Lake Weston levels, Weston Creek flows and key geochemical parameters.

The major conclusions and recommendations of the 2022 report regarding the sustainable yield of Lake Weston are as follows:

Lake Weston Level and Environmental Flow Needs of Weston Creek. For Weston Creek, to achieve 10%MAD flow the level of Lake Weston must be maintained at an elevation of at least 61 masl. Currently, this level is not maintained between July and September each year and this situation will worsen in the future according to the climate change predictions. To achieve even the minimum 10%MAD in Weston Creek the usage in the summer months would need to be reduced to usage levels similar to the winter months. This would require significant summer restrictions on irrigation (farm and household) usage. This highlights the need for accurate usage data to confirm these results and water conservation programs in the summer. It is not recommended that Lake Weston be pumped without consideration of EFNs (fish habitat in Lake Weston and Weston Creek) as the pumping of Lake Weston will lower the water table in the nearby aquifer affecting nearby water wells and inducing further degradation of water quality in Lake Weston.

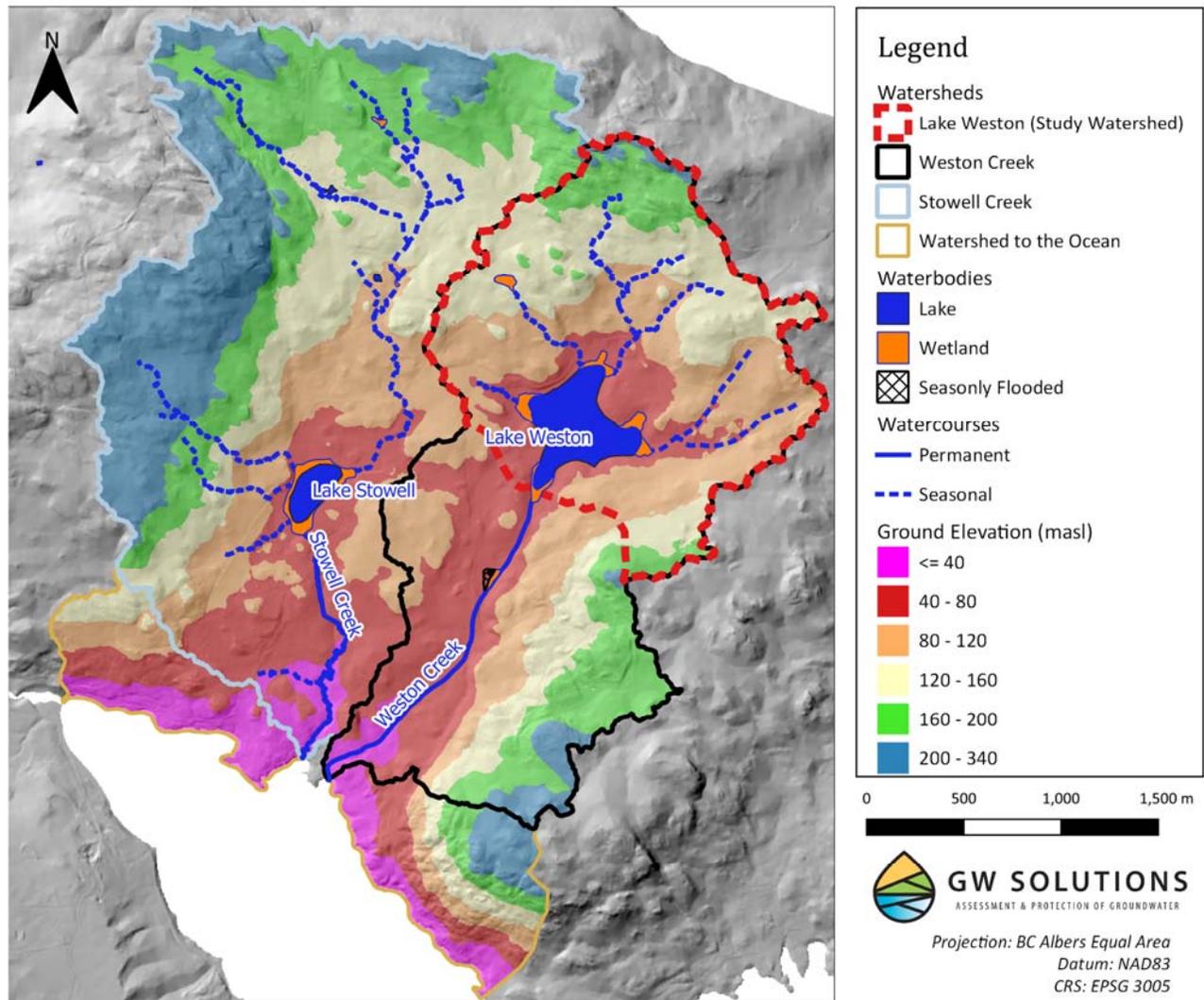
## 2 STUDY AREA DESCRIPTION

Figure 1 presents the Lake Weston Watershed boundary and some neighbouring watersheds in the study region. It is noted that the Lake Weston Watershed is a sub watershed of Weston Creek Watershed. The Lake Weston watershed is comprised of granitic rocks of the Salt Spring intrusions and volcanic rocks of the Nitinat Formation. The

bedrock throughout the southern Gulf Islands thus has been extensively folded and fractured (Journey and Morrison, 1999).

The Weston Creek watershed is dominated by the groundwater-fed Lake Weston and largely ephemeral drainages that do not flow year-round but only flow seasonally in the rainy season or temporarily following rain events. Lake Weston has an area of 180,137 m<sup>2</sup> and is in the crude shape of a cross with three distinct arms. The longest span between arms (northeast arm to southwest arm) is about 700m and the maximum depth is 12.2 meters. The lake appears to be at the intersection of several geologic faults which have weakened the rock and produced a depression in which the lake is formed. This type of lake is referred to as “flow-through,” since groundwater feeds and discharges directly into the lake via the faults on the upgradient northern side of the lake and seeps out of the lake on the downgradient southern side back into the groundwater zone. Flow-through lakes occur when the water table is higher on one side of the lake than the other, creating a gradient for groundwater to enter and leave the lake. The lake also has a stream outlet, Weston Creek, which flows year-round due to a combination of outflow from Lake Weston and groundwater discharge (baseflow) from the aquifer into the creek (see also Figure 6 for a regional cross-section through Lake Weston).

The proportion of water that is from groundwater in the Lake Weston inflow (E1) and the Weston Creek outflow (at the mouth) was studied by Howe and Allen (2020). They found the proportion of groundwater in the inflow varies from 10% during high flows (25 L/s) to 47% during low flow (4 L/s). In the Weston Creek outflow, the proportion varies from 12% during high flow (20 L/s) to 100% during low flow (1.1 L/s). This indicates the high proportion of groundwater discharging into both Lake Weston and Weston Creek. Land-use in the study region is dominated by rural residences, agricultural and forest.



- CRD Monitored Shoreline
- Stormwater Discharge Location
- River/Stream - Flow year-round
- - - River/Stream - Flow sometimes
- ▬ CRD Boundary
- ▬ Electoral Area Boundary
- 🔴 Watershed Boundary\*
- 8487 Watershed/Drainage Area ID
- 👉 Natural Drainage to Shoreline without Streams
- 👉 Urban Influenced Drainage to Shoreline via Storm Drain Networks
- 🌿 Wetland
- 🌊 Shoreline
- ▨ First Nation Reserve Land

Figure 1. Weston Creek watershed and neighboring watersheds (modified from CRD, 2018)

### 3 METHODOLOGY

The methodology is described in detail in the 2022 report (data up to 2021) to the CRD as explained above. To ensure the evaluation of the proposed FWS expansion is completed with the most recent available data (2022 and 2023), this data was compiled by CRD and Island Trust Committee (ITC) and provided to GWS to update all relevant results, calculations and figures. The 2022 and 2023 results were then compared to the 2022 report results to see any changes or variations in 2022 and 2023 that might impact the previous conclusions.

### 4 RESULTS

#### 4.1 Water Usage

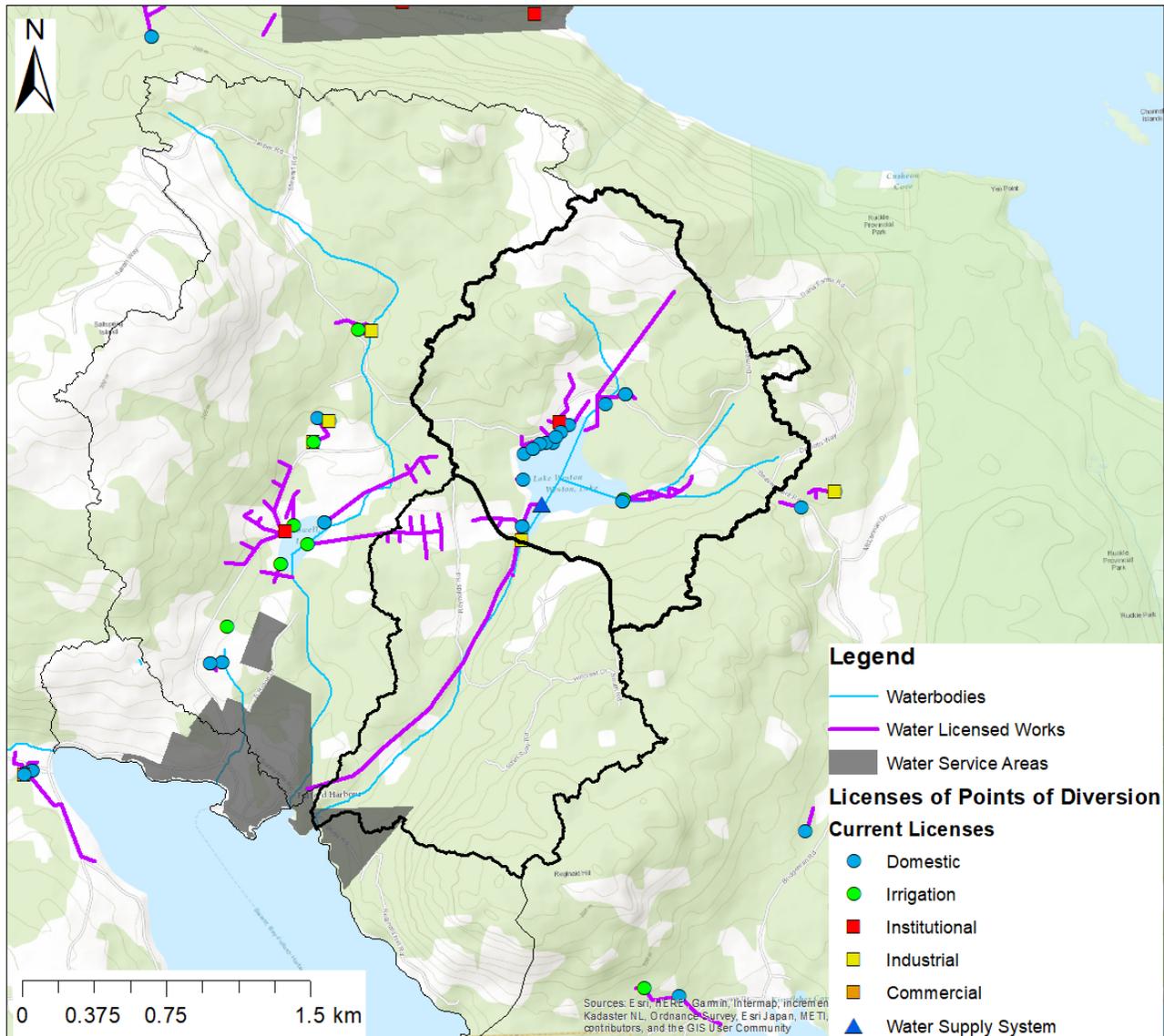
The only metered water system in the study area is Fulford Water System and this data was obtained from CRD. This metered information was critical to understand the temporal variability (month to month) in water usage. For all other water users (without metered data), we estimated water usage as described in the 2022 report.

Figure 2 shows the current licensed Points of Diversion (PODs) for the study area, limited to withdrawals and classified by type of use (i.e., domestic, irrigation, industrial/commercial, institutional and water supply systems). There are 24 PODs within the Lake Weston watershed with the largest associated with the Fulford Water System. All other water usage must be estimated based on licences and usage type. However, in an event of fire, the Fire Suppression license will become the largest at a potential maximum rate of 80 liters/second.

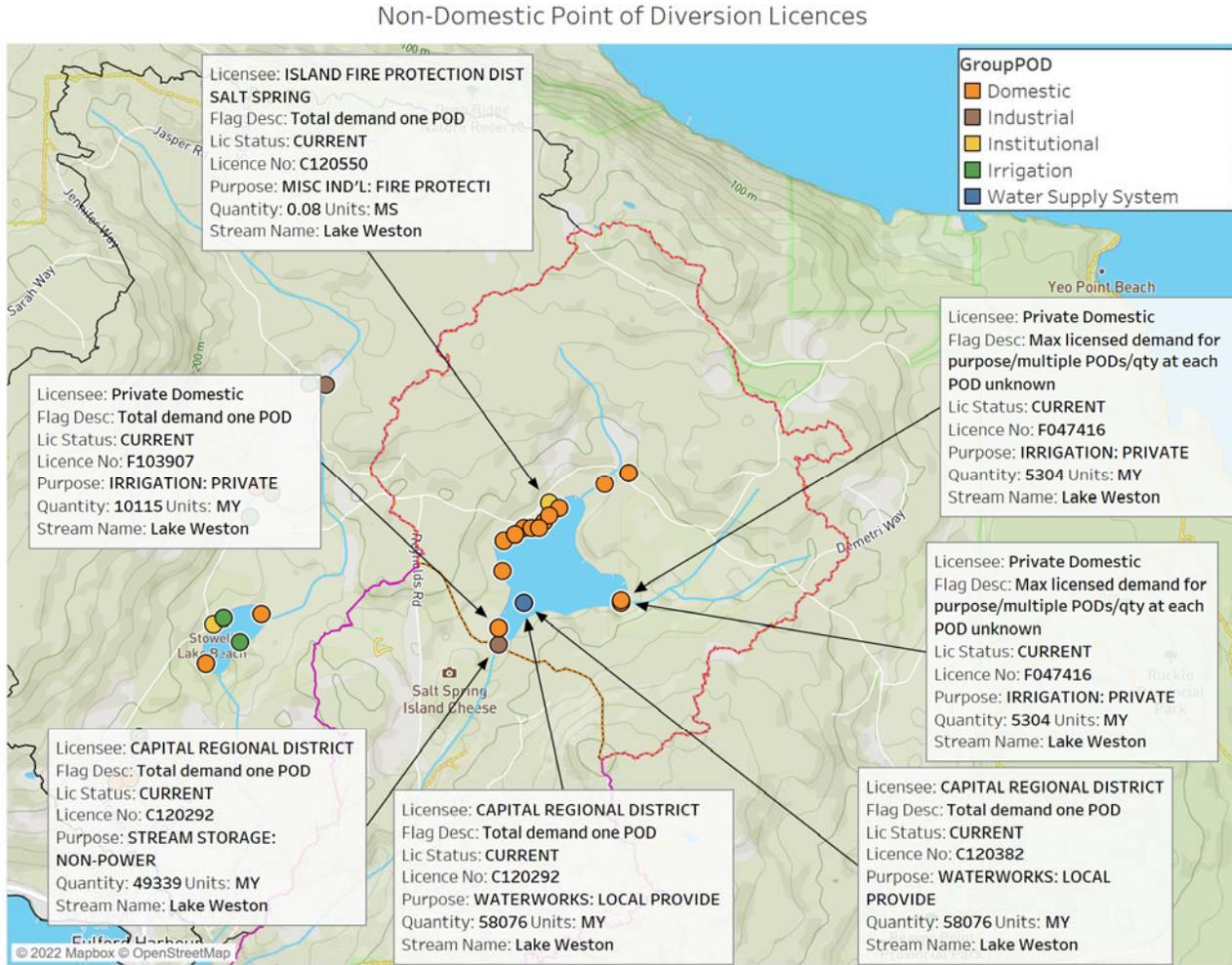
Detailed information for Non-Domestic PODs is provided in Figure 3. According to the licences the domestic use ranges between 2 to 5 cubic meters per day per licence.

Licensed volumes in the POD database are reported in yearly, monthly, daily, or hourly use rates. To normalize the licensed volumes to monthly rates, we applied coefficients that model seasonal patterns of water including seasonality from the Fulford Water System. Coefficients were estimated based on monthly use trends for water supply systems on Vancouver Island (i.e., North Salt Spring Waterworks District, Nanaimo and Fulford Water System), Ecofish Baseline Report and Rood and Hamilton (1995) (domestic), BC Ministry of Agriculture Livestock Watering Factsheets (livestock and irrigation), and the BC Agriculture Water Demand Model (irrigation).

The BC water wells database (GWELLS), land-use from the BC Assessment Authority, and water service areas were used to estimate groundwater withdrawal. The wells database includes the vast majority of wells; however, it does not include all wells since reporting to B.C was voluntary until the *Water Sustainability Act* came into force in 2016. The well use types are classified as: Water Supply System, Test Well, Private Domestic, Observation Well, Irrigation, Commercial and Industrial, Other and Unknown Well Use.



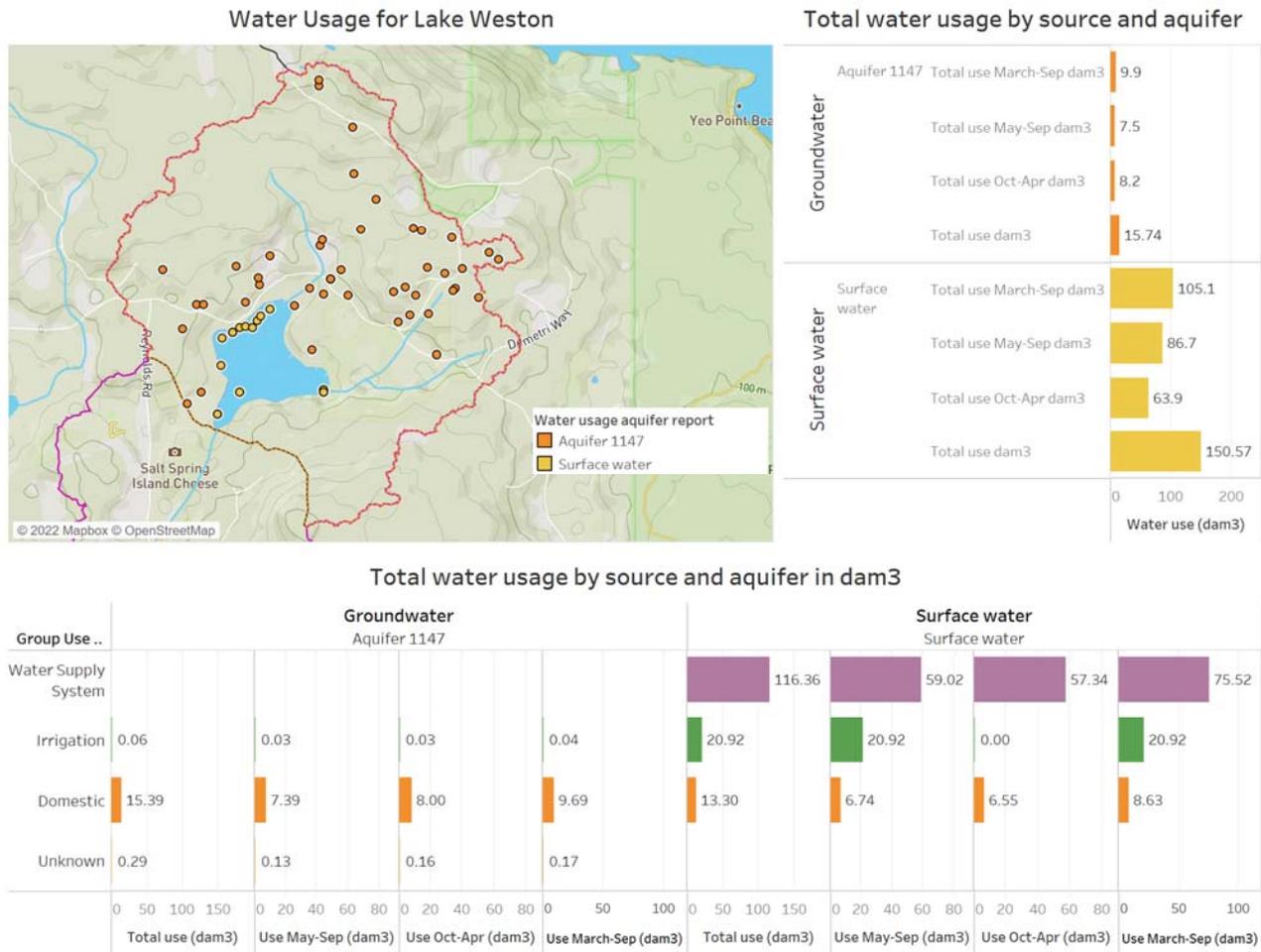
**Figure 2. Current water right licences for Points of Diversion according to type of usage (GW Solutions, 2022)**



**Figure 3. Details on non-domestic current licences for Points of Diversion**  
(MS=M<sup>3</sup>/second, MY=m<sup>3</sup>/year)

Figure 4 shows the estimated seasonal usage for both surface water and groundwater resources without the fire protection licence. The Lake Weston withdrawals are much larger than the groundwater withdrawals. The largest water usage from Lake Weston is the Fulford Water System and this usage increases significantly in July, August and September presumably due to household irrigation and increased visitors in the summer. There are also several private domestic water supplies taken and significant amount of water usage for irrigation taken from Lake Weston. Many residents within the study area obtain their domestic water from groundwater wells (15.74 dam<sup>3</sup>- bedrock aquifer 1147). It is also noted that the highest water usage from Lake Weston is the May-September period. This contrasts to groundwater usage which is similar in summer and winter.

1 dam<sup>3</sup> = 1,000 m<sup>3</sup>



**Figure 4. Total water usage by aquifer number and licenced surface water source (not including fire protection licence) (1 dam<sup>3</sup> = 1,000 m<sup>3</sup>)**

Figure 5. presents the average monthly water balance components and water usage for the study region. It can be seen the highest water usage is from April to September which also coincides with the period of little or no precipitation, groundwater recharge or runoff.

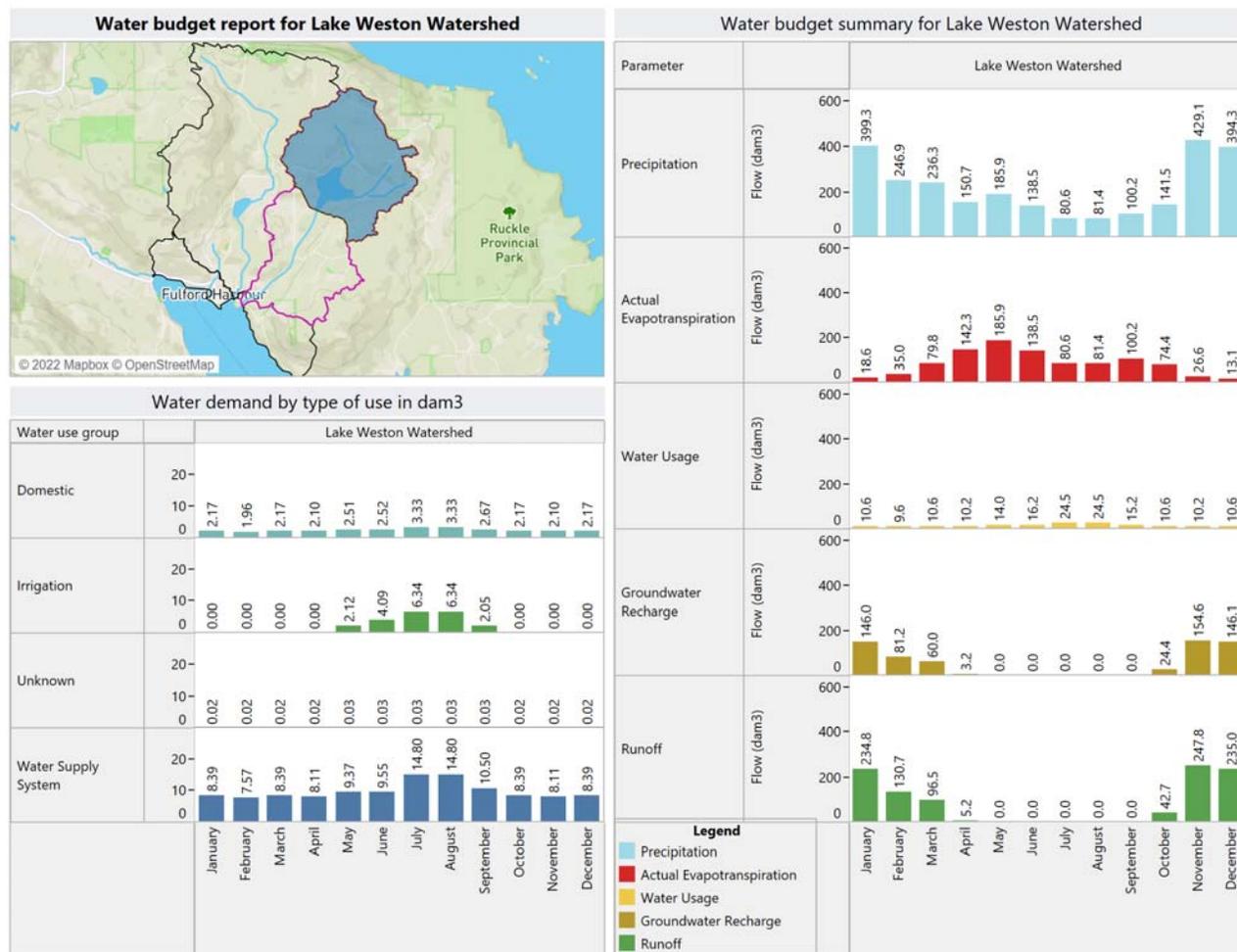


Figure 5. Monthly water demand by type of use and water budget summary (Fire protection licence not included).

### 4.2 Climate Change Predictions for the Lake Weston Watershed

The climate of the Lake Weston watershed is predicted to be significantly different in the coming decades. The winters will be warmer with more rain and less snow. The rain will fall over a shorter period (i.e. more intense events) leading to higher levels of surface runoff potentially leading to higher soil erosion and flooding and less groundwater recharge as saturated soils do not allow sufficient time for infiltration. The spring snowmelt will tend to disappear reducing the historical groundwater recharge heading into the dry summer months. During summer, temperatures will be higher, precipitation lower and groundwater baseflow (feeding creeks, lakes, wetlands) will therefore be lower. It will be common to experience too much water in winter and droughts in summer.

The climate change analysis has indicated that in the coming decades the water surplus (groundwater recharge and surface water runoff) could decrease by as much as 30% in the summer period. Although higher precipitation is predicted for the winter, much of this will come as storms that are too intense to allow for significant recharge. This means the total annual recharge could decrease leading to a gradual lowering of the water table. Recharge will certainly be reduced in the summer months; however, this decrease may not be balanced by increased recharge in the winter if the precipitation occurs as high intensity storms as predicted.

### 4.3 Environmental Flow Needs

Aquatic ecosystems consist of groundwater, springs, creeks, rivers, lakes, wetlands and estuaries and the water allocated to protect aquatic ecosystems is referred to as Environmental Flow Needs (EFNs). The aquatic ecosystem most commonly used to define EFNs is fish habitat in streams which is referred to as Instream Flow Requirements (IFR). Lake Weston and Weston Creek have been identified as habitat for cutthroat trout (Barnet et. al., 1993) and thus it is important that a minimum lake water level and creek flow be maintained year-round.

The most common method of defining IFRs to protect fish habitat is based on the Modified Tennant (a.k.a. Montana) Method (Table 1; Tennant, 1976) which assumes that some proportion of the mean annual discharge (MAD) is required to sustain the biological integrity of a river ecosystem to sustain fish spawning and rearing. Based on original field data collected from 11 rivers in Montana, Nebraska and Wyoming and further supplemented with additional data from hundreds of gauged flow regimens in 21 states, Tennant (1976) recommended percentage values of MAD predicted to sustain predefined ecosystem attributes. In drainages where fish are present, the minimum flow required to sustain the fisheries resource for fair spawning and rearing habitat is 10% of the Mean Annual Discharge (MAD).

**Table 1: Creek flows as a percentage of Mean Annual Discharge and fish spawning/rearing habitat condition (Tennant, 1976).**

Creek Flows as % of Mean Annual Discharge	Spawning/Rearing Habitat Condition
30-60% MAD	Excellent
20-30% MAD	Good
10-20% MAD	Fair
5-10% MAD	Poor
<5% MAD	Severely degraded

The B.C. Water Sustainability Act (WSA; 2016) specifically identifies stream flow requirements for ecosystems and species. Authority is given to temporarily protect flows in

times of drought and to order mitigation measures where water removal is likely to have significant adverse impacts on a stream.

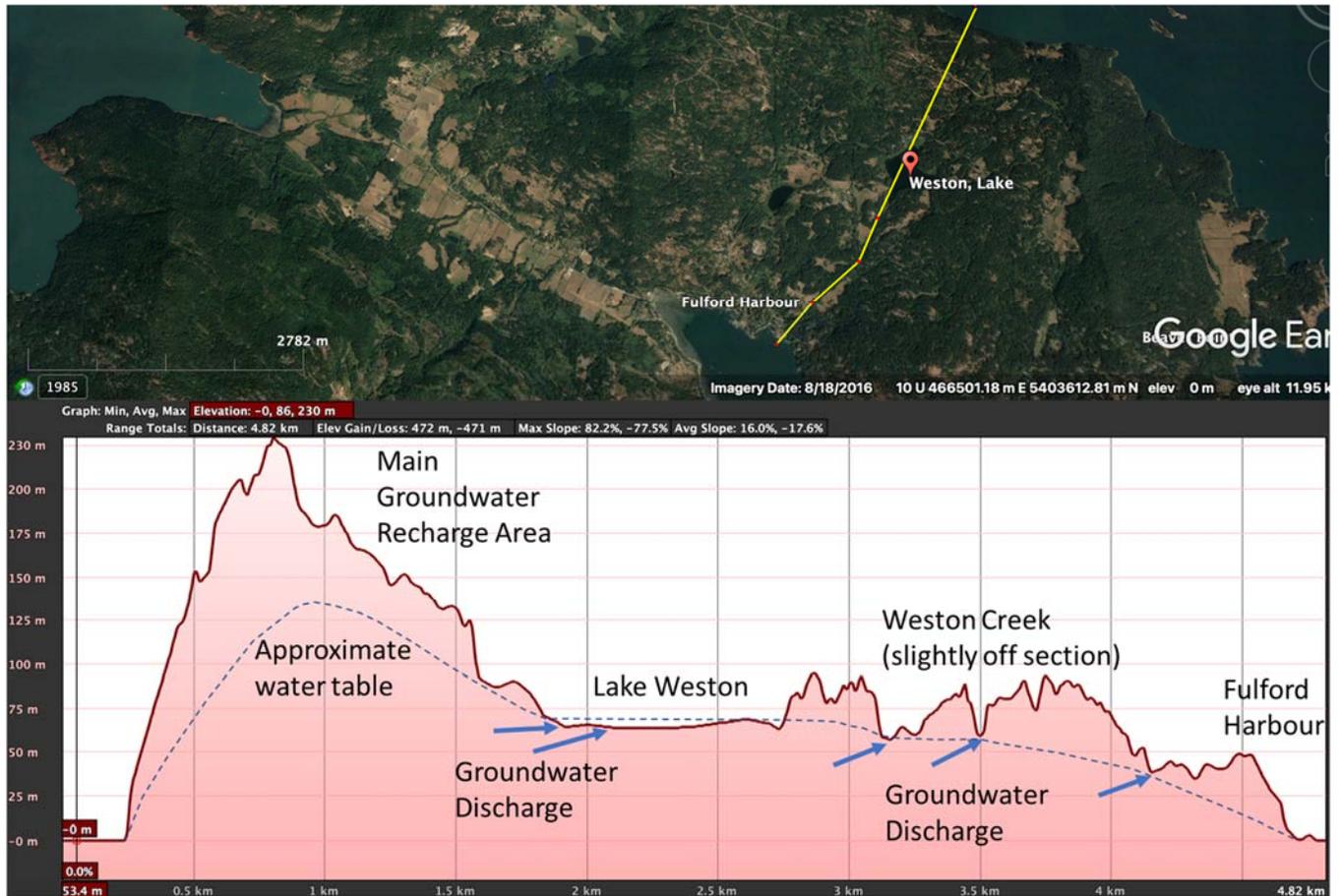
#### 4.4 Lake Weston Safe Yield

Lake Weston is directly fed by groundwater and its pumping is similar to that of a large well. The safe yield of a water well (or lake acting as a well) is the maximum annual water volume that can be sustainably extracted year-round and year after year without gradually drawing groundwater out of storage (causing declining levels in the well and/or nearby wells) or decreasing the groundwater seepage that feeds aquatic ecosystems (aquifers, springs, wells, wetlands, creeks, lakes) referred to as Environmental Flow Needs. The safe yield for Lake Weston consists of two components.

1. Water storage in Lake Weston. Water storage is important for aquatic life within the lake including maintaining water temperatures sufficiently low enough for certain species. Water storage in the lake also allows for a certain amount of water to be drawn for short-term emergency purposes (fire department or wildfire) or to sustain water supplies during a drought or the predicted hot dry summers in the decades to come.
2. Flow in Weston Creek. Sufficient flow during “normal” climatic variations year-round and year to year to maintain the creek as an aquatic ecosystem and habitat for cutthroat trout and other species.

Figure 6 shows an illustrative cross-section of the watershed passing through Lake Weston and following the approximate route (slightly off-section) of Weston Creek. It can be seen that Lake Weston is directly connected to and fed by the groundwater system. Weston Creek is fed by both outflow from Lake Weston and also by groundwater discharge at specific groundwater discharge locations controlled by faults along the course of the creek. These faults have not been mapped but are assumed based on the uneven (i.e. flat then steep drop) topography along the creek and evidence of groundwater discharge (flooding or fish habitat).

Figure 7 is a map of key groundwater discharge and fish habitat locations in the watershed. It can be seen that there are springs in several locations above Lake Weston and key areas of groundwater discharge along the various arms or creeks feeding Lake Weston. These are fish habitat in two of these arms, the northeast arm and east arm. Along Weston Creek there are several fish migration gradient barriers (i.e. steep gradient) and at least one fish habitat identified directly adjacent to an area of frequent groundwater discharge (leading to field flooding seasonally). There may be other smaller fish habitats fed by groundwater discharge along Weston Creek that have not been identified.



**Figure 6. Topographic profile and illustrative cross-section across entire Lake Weston and Weston Creek watershed.**

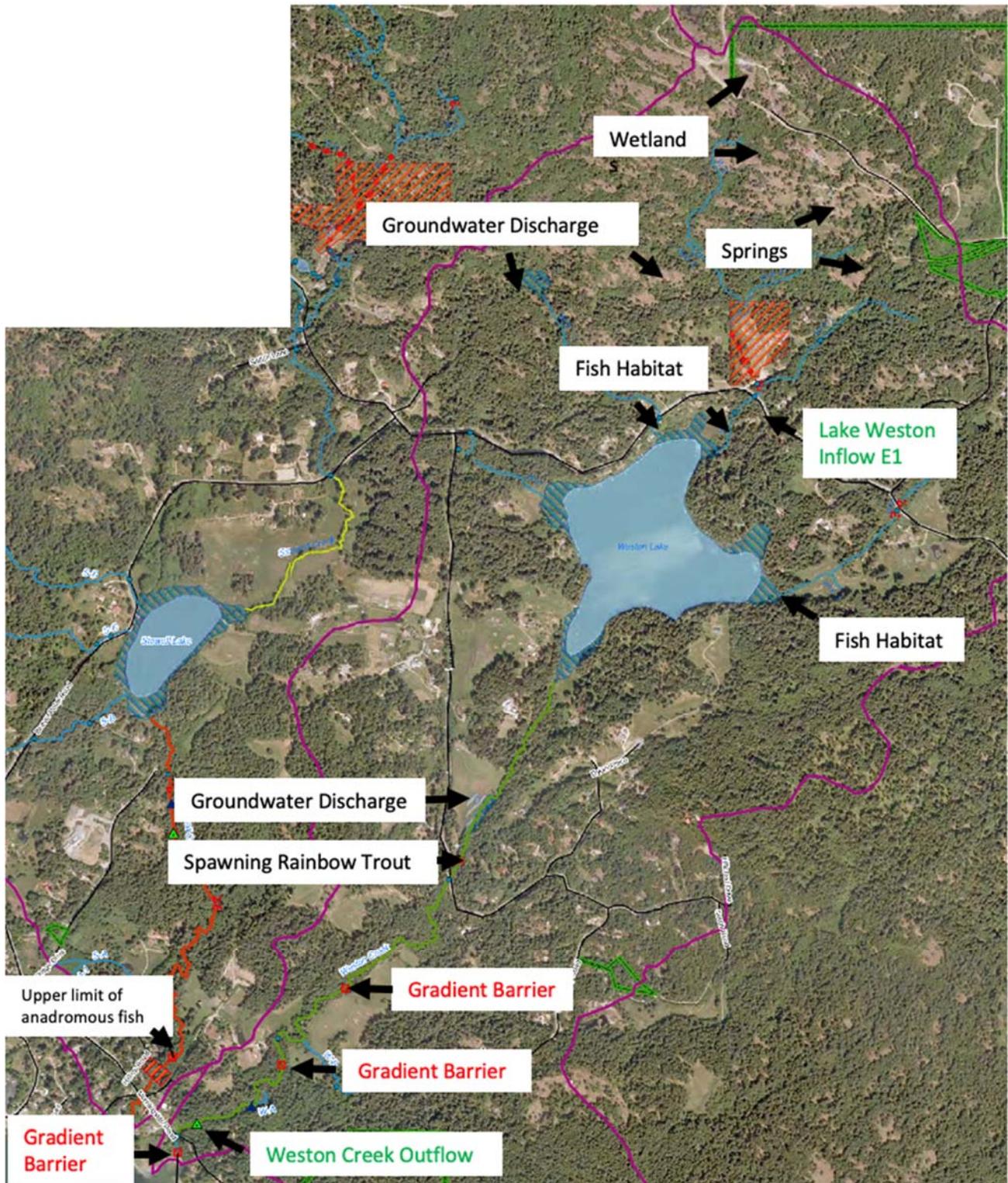


Figure 7. Groundwater discharge and fish habitat in Lake Weston and Weston Creek.

Lake Weston water volumes corresponding to different lake levels are shown in Figure 8. The Lake Weston level varies from a high of about 61.43 masl in March to a low of 60.59 masl in August (average 0.8 m variation) and appears to reach a level where it becomes stable in the summer months.

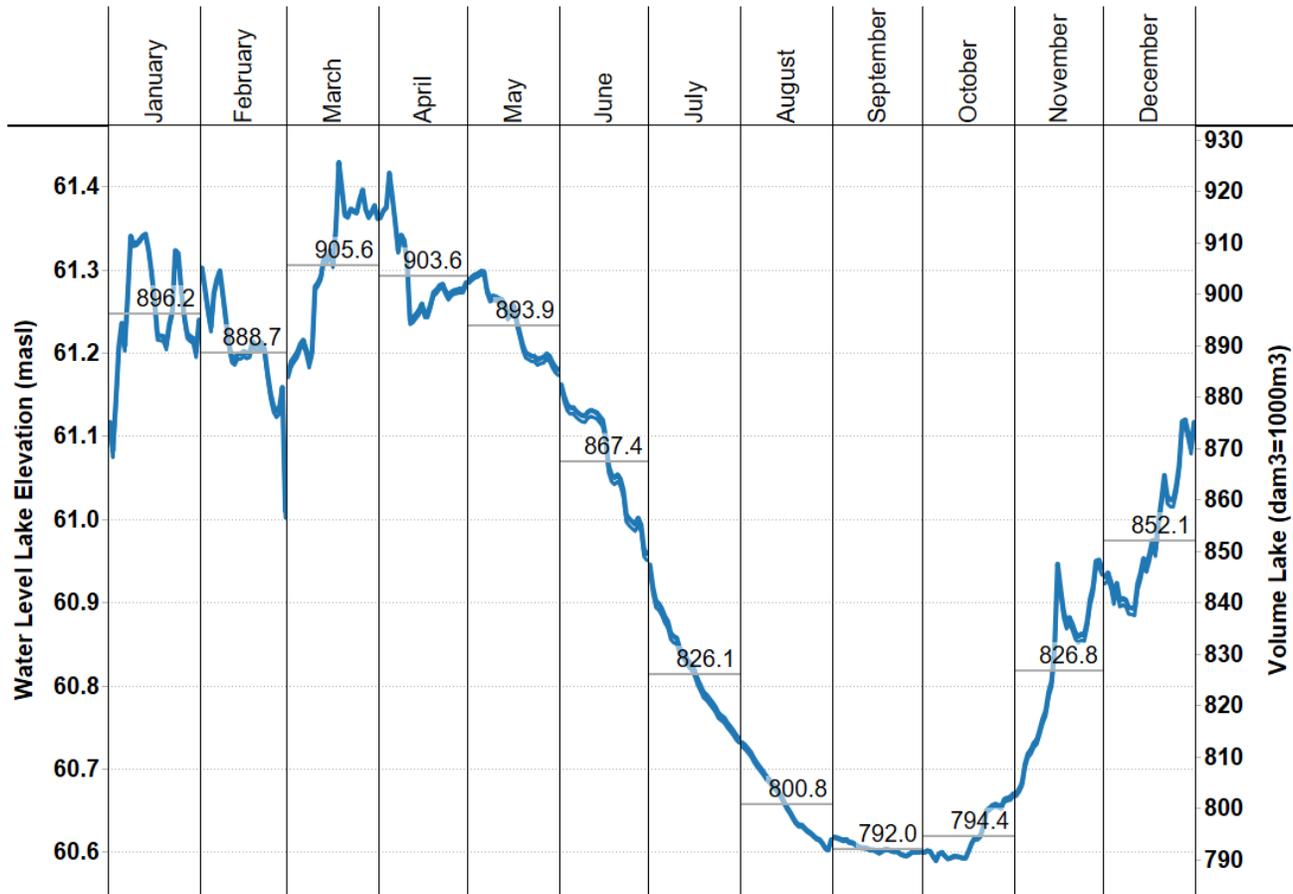


Figure 8. Lake Weston water level and storage volume from April, 2019 to March, 2023.

Lake Weston Water Levels

Figure 9 provide a comparison of Lake Weston water levels for each year data was available. Figure 10 shows a comparison of the previously compiled 2019-2021 baseline compared to recent data from 2022 and 2023. A comparison of the average water levels of the previous baseline period (2019-2021) to the entire period (2019-2023) is show in Figure 11.

It can be seen that the inclusion of the 2022 and 2023 data do not significantly change the overall pattern and seasonal elevations. It is noted as well that water level elevations were very high in 2022 from January to October however by November the elevations were back down to similar levels.

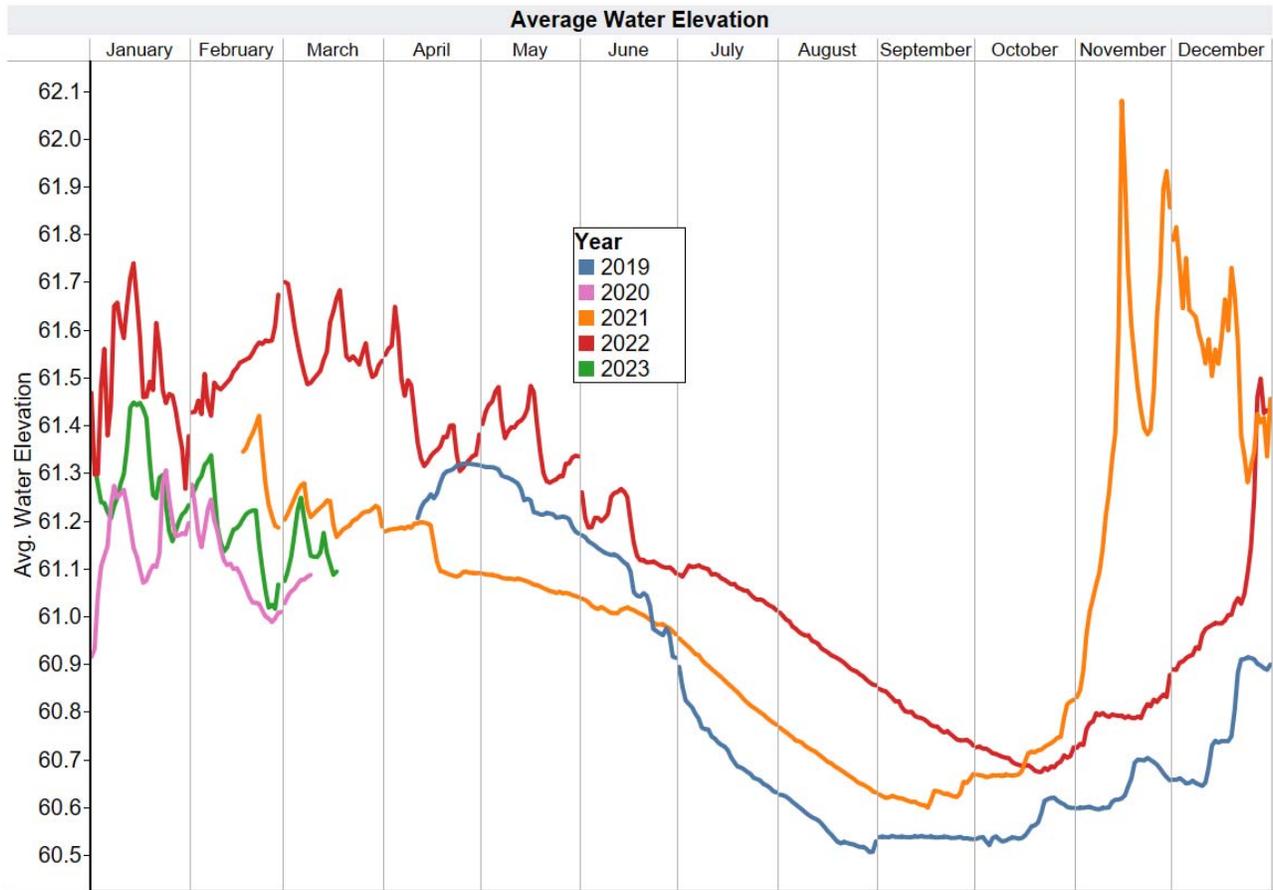


Figure 9. Average water elevations of Lake Weston 2019-2023

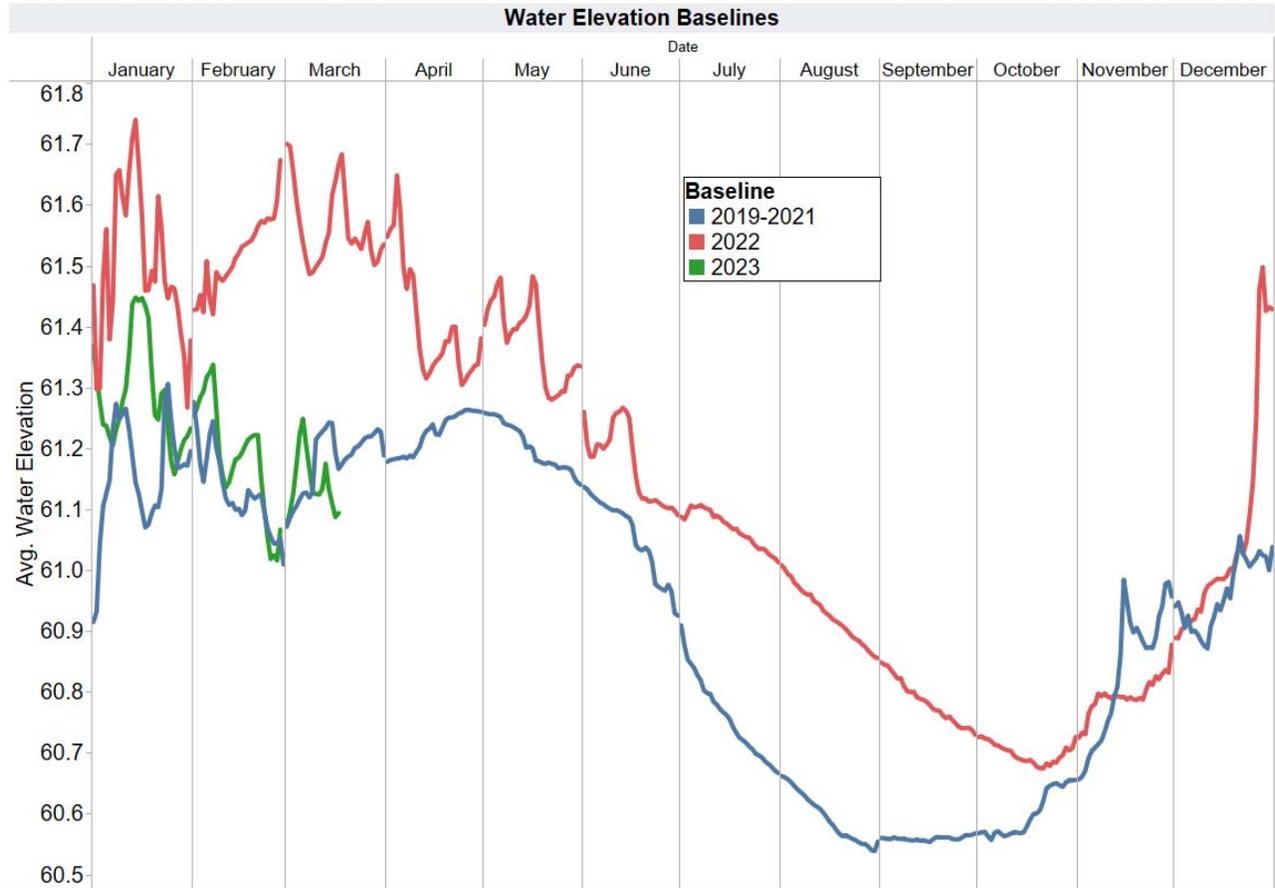
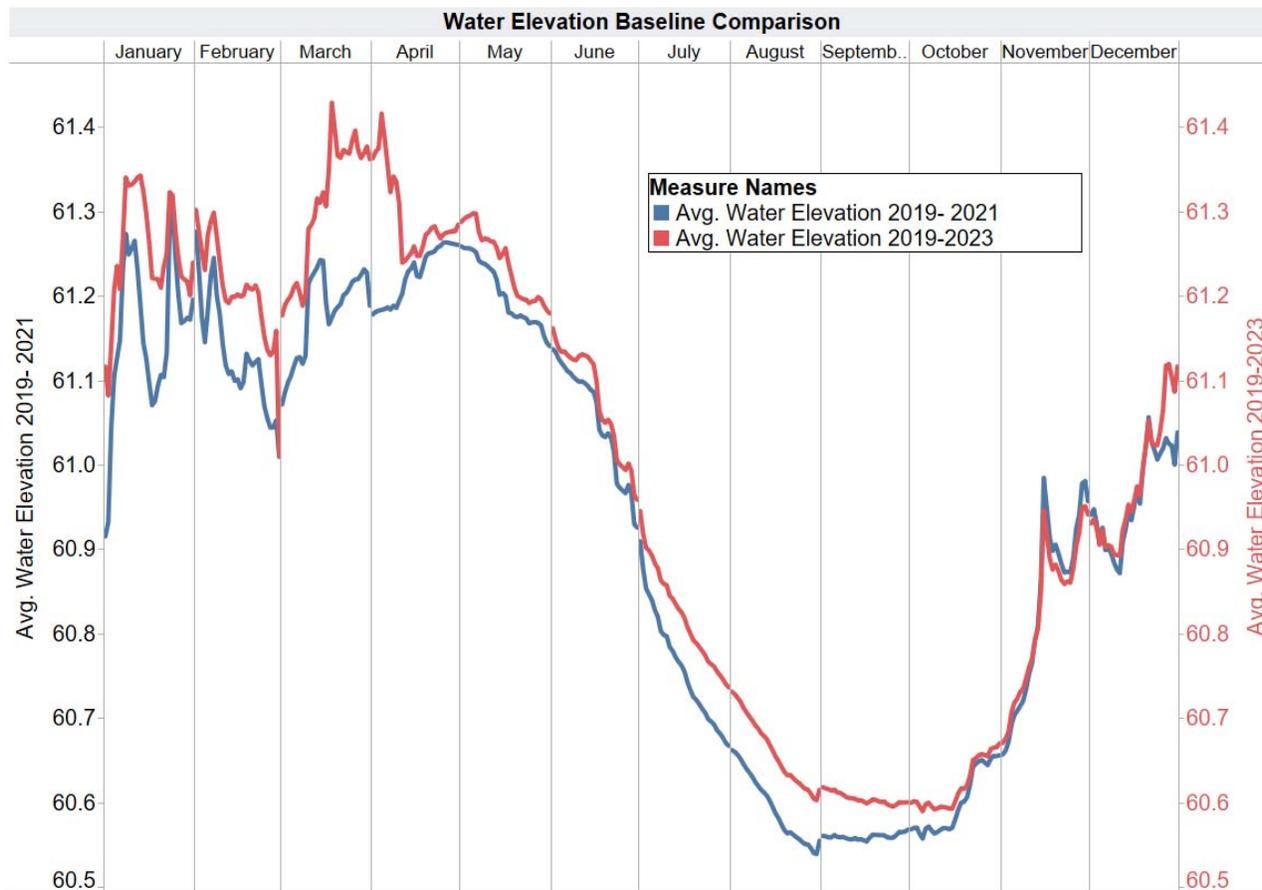


Figure 10. Average water elevations of Lake Weston (2019-2021 baseline compared to 2022 and 2023)

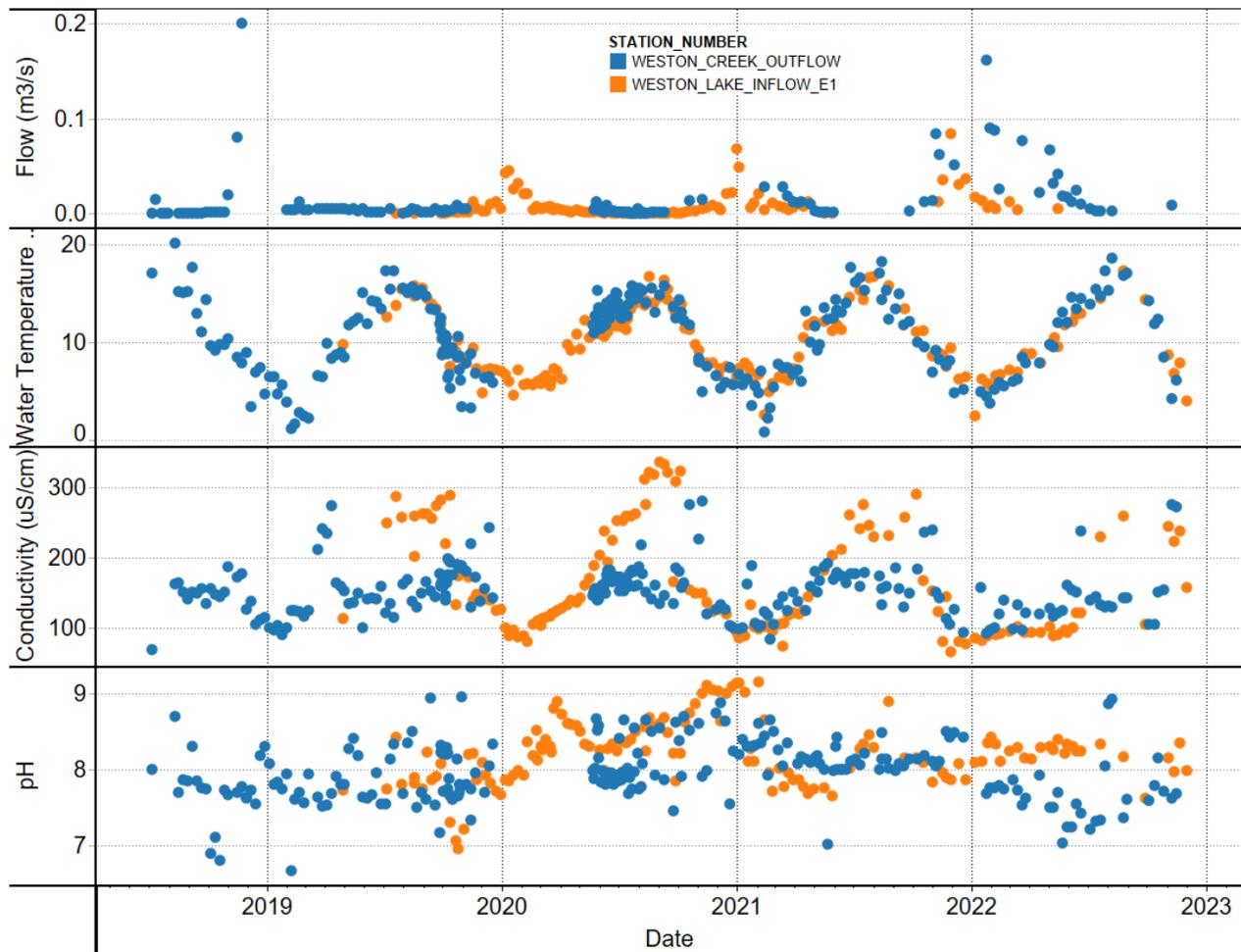


**Figure 11. Average water elevations of Lake Weston (2019-2021 baseline compared to updated 2019-2023 baseline)**

Figure 12 is a seasonal plot of flow, water temperature, water electrical conductivity (measures total dissolved solids) and pH for the Lake Weston inflow (E1) and Weston Creek outflow (see Figure 7 for the location of these two stations). Water temperature and electrical conductivity follow distinct seasonal trends for the inflow and outflow, however, it is noted the inflow electrical conductivity and pH become gradually higher in the summer season due to the predominance of groundwater (which is more mineralized than surface water or rainwater) at this time of year. As expected, the inflow E1 increases substantially during the winter season diminishing during the summer, this inflow creek shows clearer indications of groundwater baseflow (Millson, 2020, cf Howe and Allen 2020) than the Weston Creek outflow. The Weston creek outflow chemistry, in contrast to the inflow, does not increase significantly in the winter months as the outflow emanates mostly from Lake Weston which absorbs much of the runoff and dilutes groundwater baseflow in the discharge into Weston Creek, though Weston Creek is also fed through groundwater seepage along its course as it, like Lake Weston, is in direct connection with the aquifer.

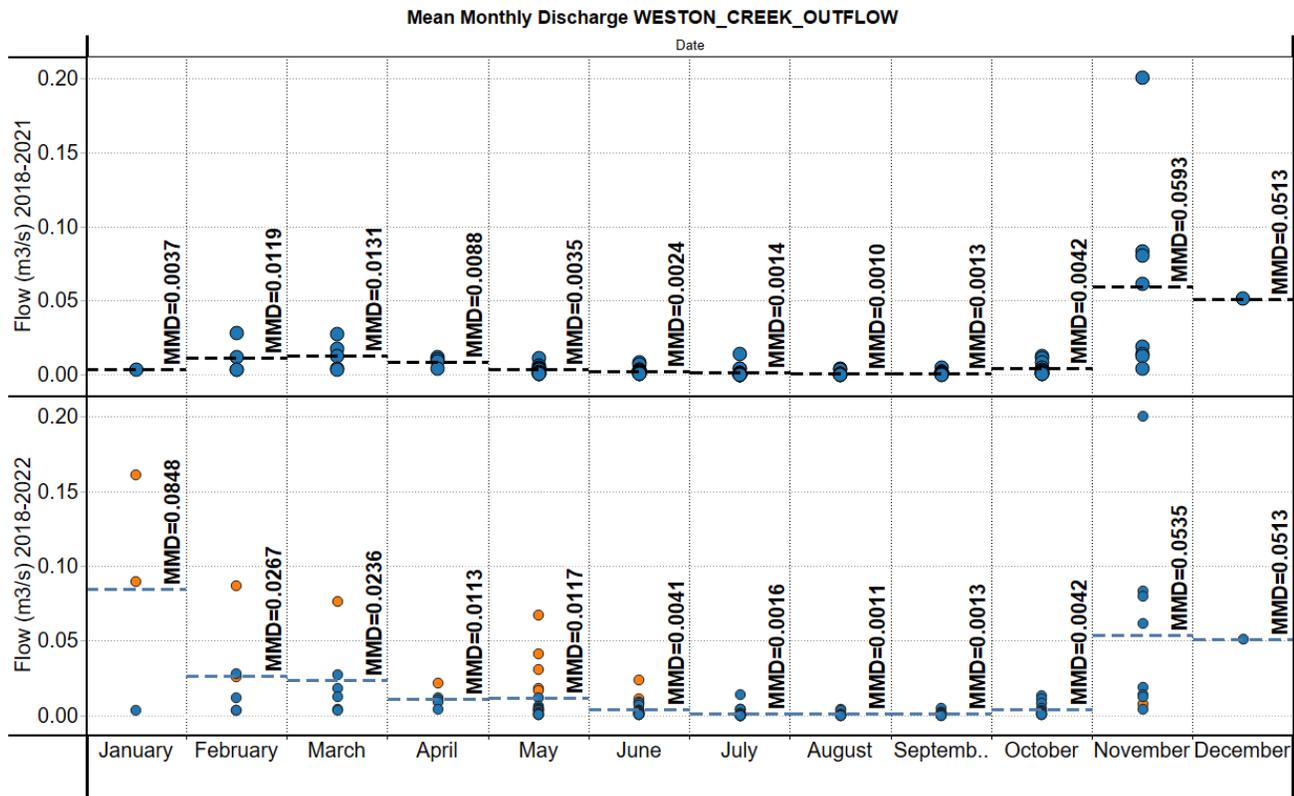
It is noted that inflow E1 is not the only inflow to Lake Weston as the lake is natural groundwater discharge body. Inflow E1 is one of two major surface water inflows to Lake

Weston (the other inflow is the east arm) and there may be other water-bearing faults intersecting the lake that are unseen. Lake Weston also likely receives some inflow in the subsurface through seepage from the smaller fractures in the aquifer.



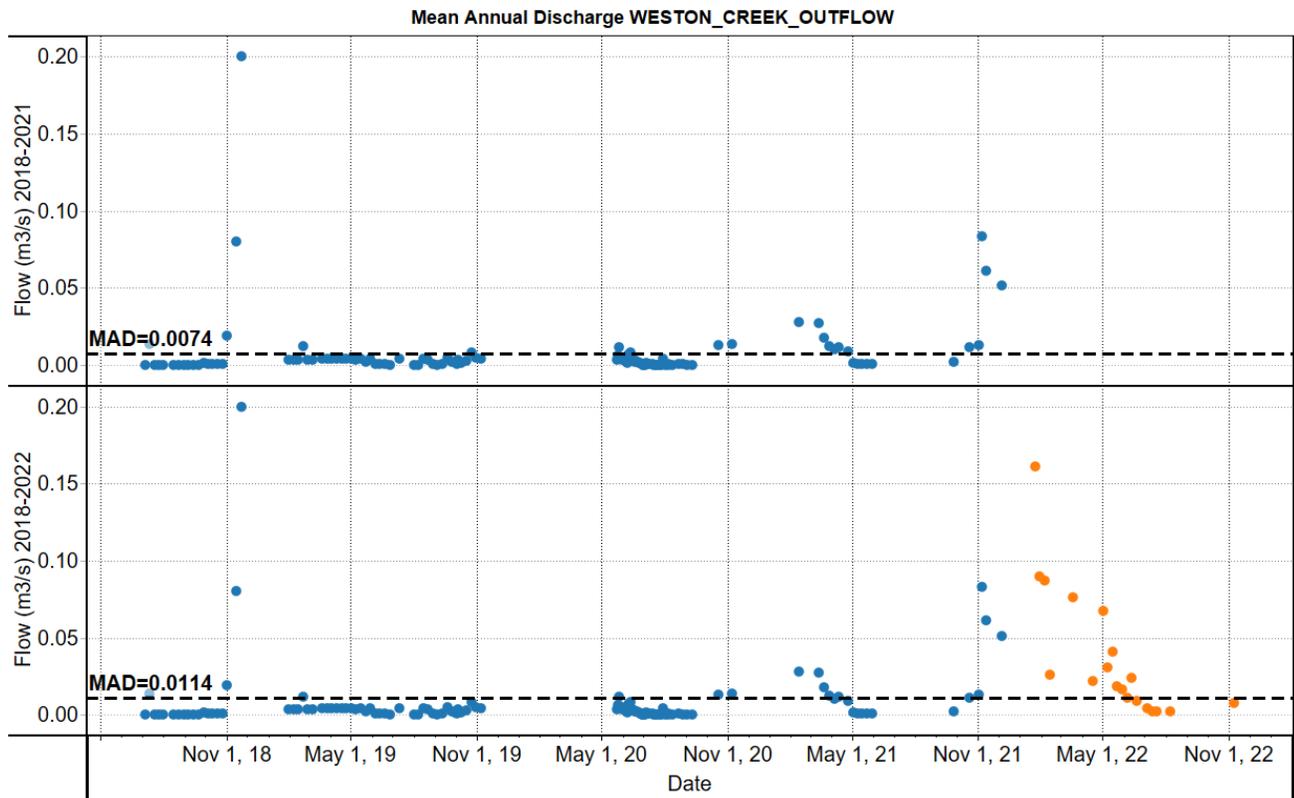
**Figure 12. Lake Weston inflow, Weston Creek outflow, temperature, electrical conductivity and pH from May, 2018 to December, 2022 (NB not all flow data is plotted).**

Figure 13 shows the mean monthly discharge (MMD) for Weston Creek outflow for the 2018-2021 period (upper plot) and the 2018-2022 period (lower plot). It can be seen Weston creek discharge varies seasonally from a high monthly average of 0.0848 m<sup>3</sup>/s in January to a low of 0.0011 m<sup>3</sup>/s in August.



**Figure 13. Mean monthly discharge for Weston Creek outflow for 2018-2021 (upper plot) and 2018-2022 (lower plot)**

Figure 14 shows a plot of the mean annual discharge (MAD) at the Weston Creek outflow from 2018 to 2021 (upper plot) and 2018 to 2022 (lower plot). It can be seen that the inclusion of the 2022 data (high rainfall year) increases the mean annual discharge slightly from 0.0074 to 0.0114 m<sup>3</sup>/s.



**Figure 14. Mean annual discharge (MAD) calculations for Weston Creek outflow for 2018-2021 (upper plot) and 2018-2022 (lower plot)**

Figure 15 (2018-2021 data set) and Figure 16 (2018-2022 data set) are plots of mean Lake Weston water levels on the vertical left axis and the Weston Creek outlet on the vertical right axis. Although the Weston Creek outflow average in August is 0.0011 m<sup>3</sup>/s, in reality, the flow is significantly less than this value for much of the summer. The level of Lake Weston is clearly lower than the 10%MAD (61.05 masl) level during the entire period from July to November.

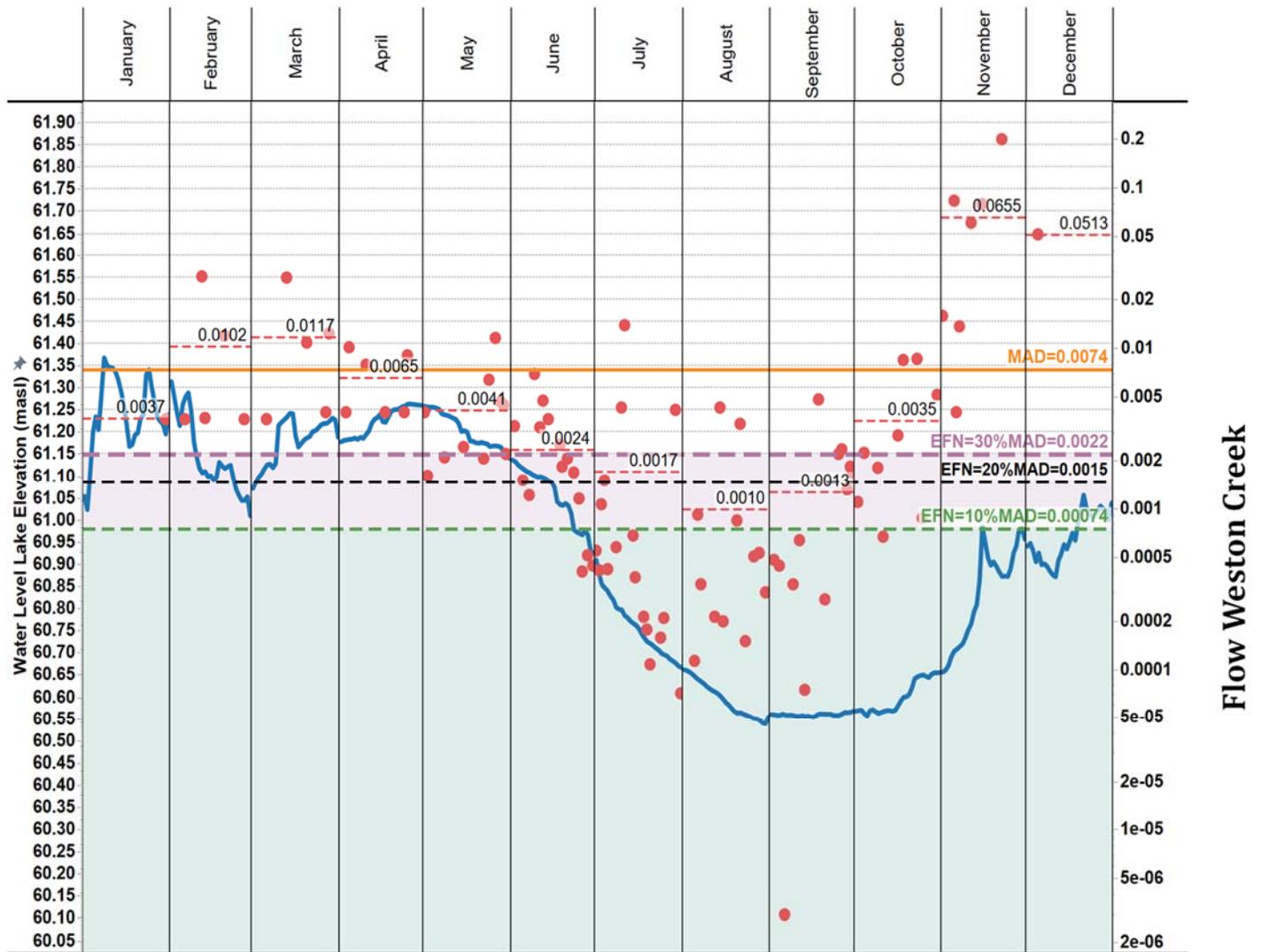
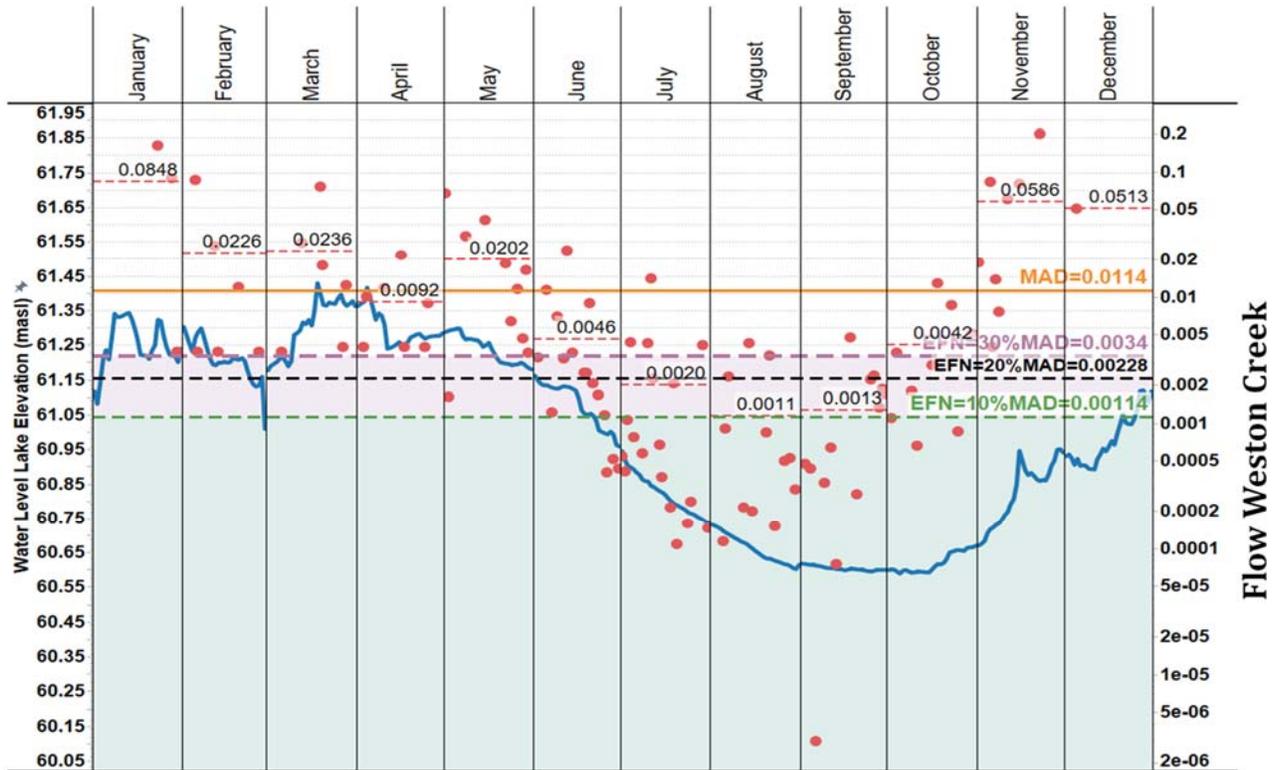


Figure 15. Lake Weston water level (blue line), Weston Creek outflow (red dots; with monthly averages) and various %MAD based on 2018-2021 data set.



**Figure 16. Lake Weston water level (blue line), Weston Creek outflow (red dots; with monthly averages) and various %MAD based on 2018-2022 data set.**

Figure 17 is a scatter plot comparing total water monthly usage (groundwater and surface water) to Lake Weston level. The additional usage of the FWS (5% extra) is indicated with red dots. It can be seen there is a weak inverse relationship between usage and lake water level and an approximate trend line has been drawn. Based on two data points a second trend line was drawn “Trend line upper limit” to provide the highest potential relationship between water usage and Lake Weston level. The high amount of scatter in the plot (indicating a weak correlation) is expected as water usage is not the only factor affecting the Lake Weston level. The lake level is also impacted by precipitation events (especially in the winter) which can produce short-term storm runoff and medium-term increases in groundwater inflow. It also noted that the water usage is an estimate as the FWS is the only water usage that is actually measured. The basic relationship between usage and Lake Weston level is represented with an approximate trend line providing an approximation of the usage that corresponds to the 10%MAD, 20%MAD and 30%MAD. To achieve even the minimum 10%MAD in Weston Creek, the usage in the summer months would need to be reduced to usage levels similar to the winter months. This would require significant summer restrictions on irrigation (farm and household) usage. This highlights the need for accurate usage data to confirm these results and water conservation programs.

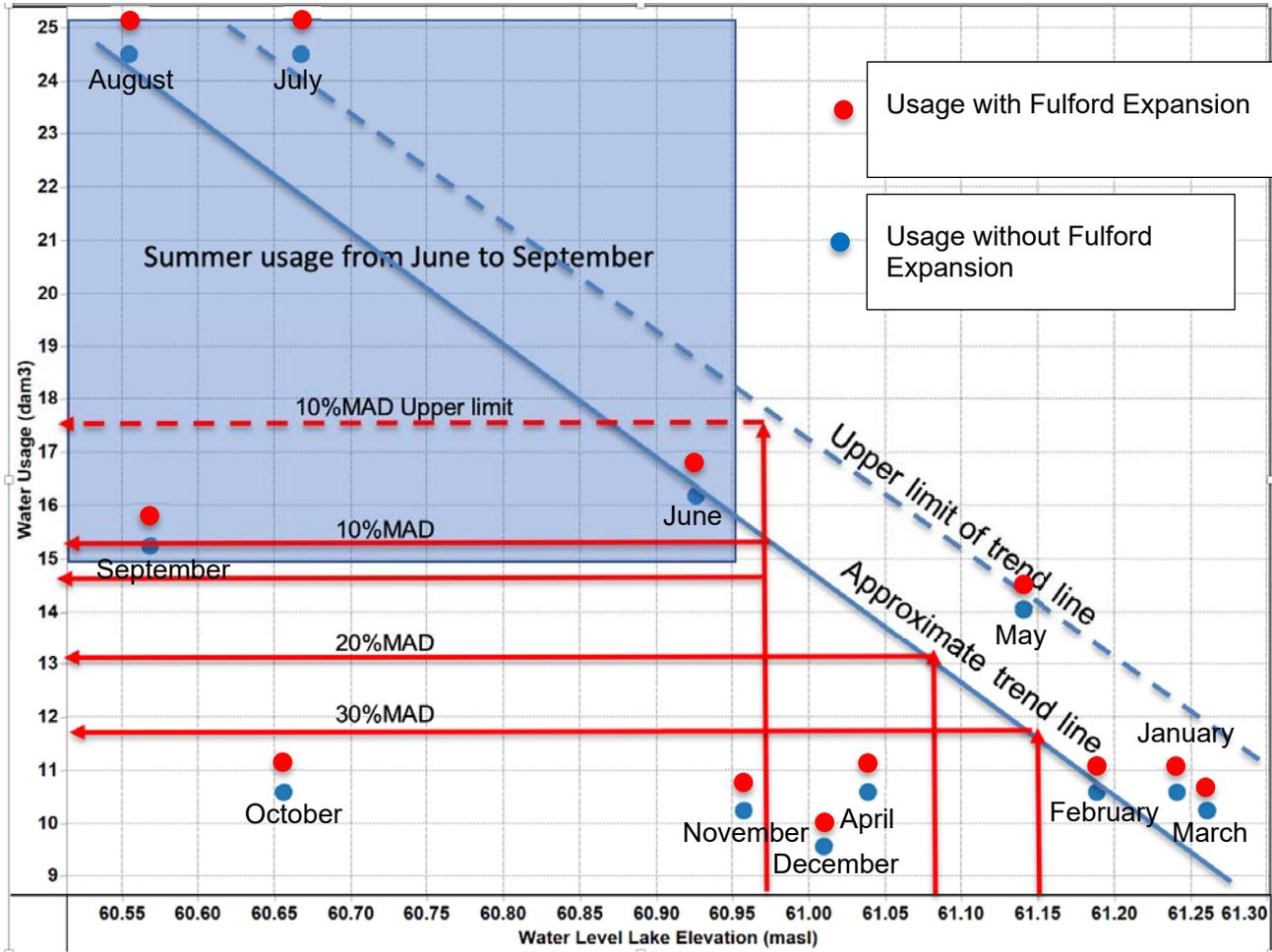


Figure 17. Lake Weston water levels versus estimated total water usage (groundwater and surface water; fire protection licence not included). Trend line is very approximate due to poor correlation. Upper limit of trend line indicates highest possible water usage for the Lake Weston level that maintains a 10%MAD.

#### 4.5 Lake Weston Water Stress Index

A common measure of aquifer safe yield is the *aquifer stress index* which compares the total amount of recharge in the watershed to the total water usage from the aquifer (Lake Weston and wells). The term is the same as the Water Stress Index which compares actual water usage to natural water availability.

For the Lake Weston watershed the total annual groundwater recharge is 615 dam<sup>3</sup> and the current total water usage is 167 dam<sup>3</sup> (151 dam<sup>3</sup> from Lake Weston and 16 dam<sup>3</sup> from wells). The Lake Weston aquifer stress index is calculated as:

$$167/615 \text{ or } 27\%$$

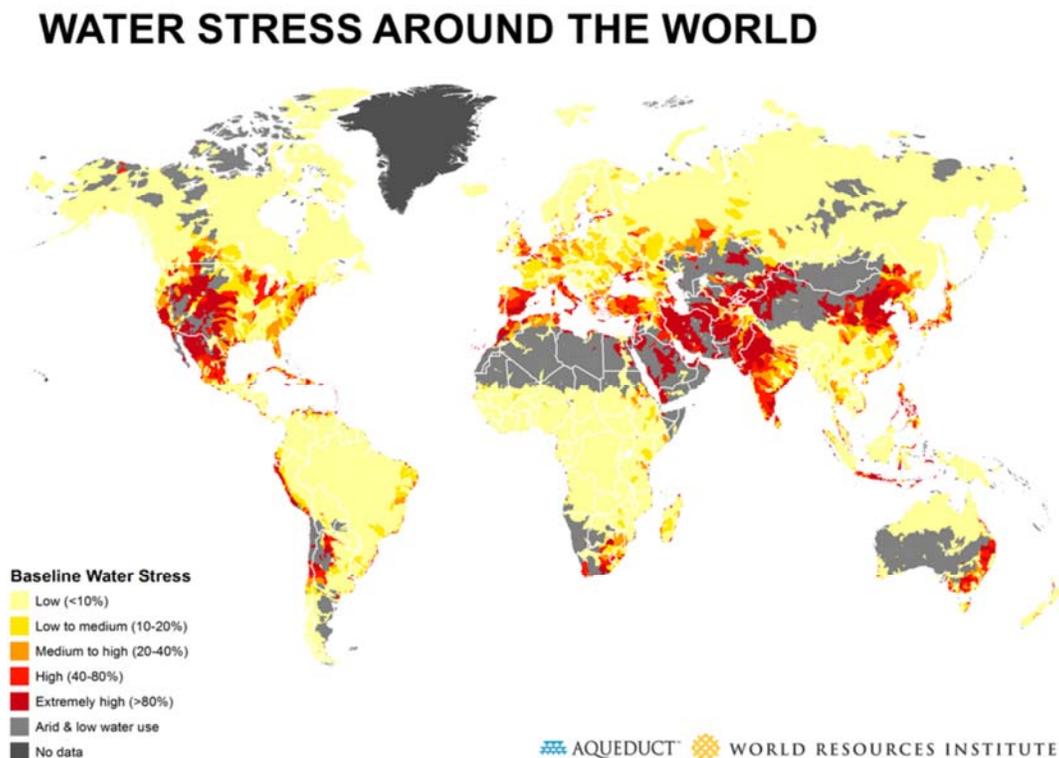
This means that 27% of the total annual groundwater recharge (replenishment) is mostly removed and 73% remains in the groundwater to feed the watershed's groundwater-dependent ecosystems. In reality, not all of the usage water is fully removed from the watershed but a certain amount (e.g. irrigation water, pipe leakage) returns to the groundwater.

The groundwater-dependent ecosystems that the 73% provide for include:

- Weston Creek itself as an aquatic habitat dependent on groundwater baseflow.
- the wetlands and groundwater seepage areas along and near the creek which support vegetation/trees which provide habitat for insects, birds, small animals, etc.
- the shoreline ecosystems along Lake Weston and the Fulford Harbour which depend on freshwater discharge from the watershed (creek outflow and direct groundwater discharge to shoreline).

If the additional 5 dam<sup>3</sup> per year for the Ocean Estuary is included in the usage, the aquifer stress index increases to 28%.

What is the significance of an aquifer stress index of 28%? A comparison to a global map of water stress (which compares water usage to recharge) by the World Resources Institute (2015) places 28% in the medium to high water stress category.



**Figure 18. Baseline Water Stress (World Resources Institute, 2015)**

## 5 CONCLUSIONS

**Water Usage.** Water usage consists of a combination of water wells, surface water (Lake Weston) and springs used for domestic water supply, irrigation, a community water system (Fulford Water System) and fire protection. The only available metered water usage data is from the Fulford Water System (average usage of 30,000-40,000 m<sup>3</sup>/year). Fire protection usage is sporadic (e.g. 3000 gallons were drawn in 2019 but none in 2020 and 2021). The total annual Lake Weston (surface water) usage is 151 dam<sup>3</sup> without any fire protection usage. Groundwater usage is much less at 16 dam<sup>3</sup>. The highest total (combined surface water and groundwater) usage is from April to September (peaking in July and August).

**Climate Change.** The climate change analysis has indicated that in the coming decades the water surplus (groundwater recharge and surface water runoff) could decrease by as much as 30% in the summer. Although higher precipitation is predicted for the winter, much of this will come as storms that are too intense to allow for significant recharge. This means the total annual recharge could decrease leading to a gradual lowering of the water table. Recharge will certainly be reduced in the summer months however this decrease may not be balanced by increased recharge in the winter if the precipitation occurs as high intensity storms as predicted.

**Environmental Flow Needs (EFNs).** The Lake Weston level varies from a high of about 61.35 masl in January to a low of 60.55 masl in August (0.8 m variation) and appears to reach a level where it becomes stable in the summer months. For Weston Creek, to achieve 10%MAD flow the level of Lake Weston must be maintained at an elevation of at least 61 masl. Currently, this level is not maintained between July and September each year and this situation will worsen in the future according to the climate change predictions.

**Safe Yield of Lake Weston and Impact of Additional Usage by Ocean Estuary.** The relationship between usage and Lake Weston level is represented with an approximate trend line providing an approximation of the usage that corresponds to the 10%MAD, 20%MAD and 30%MAD. To achieve even the minimum 5-10%MAD in Weston Creek the usage in the summer months would need to be reduced to usage levels similar to the winter months. This would require significant summer restrictions on irrigation (farm and household) usage. This highlights the need for accurate usage data to confirm these results and water conservation programs in the summer. It is not recommended that Lake Weston be pumped without consideration of EFNs (fish habitat in Lake Weston and Weston Creek) as the pumping of Lake Weston will lower the water table in the nearby aquifer affecting nearby water wells and inducing further degradation of water quantity and quality in Lake Weston. The additional 5 dam<sup>3</sup> (5,000 m<sup>3</sup>) per year for the Ocean Estuary represents an approximately 5% increase in water usage for the FWS and thus Lake Weston. The additional 5% usage will lead to a similar percentage of impact on the Lake Weston water level which will lead to a smaller percentage of change to the surrounding aquifer and possibly Weston Creek. The additional usage increases the aquifer stress index from 27% to 28% which is the medium-high water stress category according to the World Resources Institute (2015).

## 6 RECOMENDATIONS

**Water-use Metering.** There is only one metered water system in the area, the Fulford Water System thus water use for all other water supplies has been estimated using information from proxy models. An improved estimate of water usage is very important, and it is recommended that for each water well and surface water extraction system either a flow meter be added to the system or another method be applied to estimate the volume used over time. In addition, it is recommended that flow meters be added for each property supplied by the Fulford Water System.

**Environmental Flow Needs.** The flow in Weston Creek depends on the level of Lake Weston and on natural groundwater discharge to the creek (baseflow) from the aquifer. Thus, to protect the fish habitat of Lake Weston and Weston Creek, the overall watershed and aquifer need to be protected to ensure the continuation of natural groundwater recharge and the maintenance of groundwater levels in the aquifer. The incorporation of EFNs into a water budget will impact the local community by reducing the amount of water available for water supply.

**Additional Water Usage by Ocean Estuary.** The additional 5 dam<sup>3</sup> per year for the Ocean Estuary represents an approximately 5% increase in water usage for the FWS and thus Lake Weston which will lead to a similar percentage additional decrease in the Lake Weston water level and a smaller decrease in aquifer water levels. The additional usage by Ocean Estuary increases the aquifer stress index from 27% to 28% which is the medium-high water stress category according to the World Resources Institute (2015).

**Water Conservation.** Increased measures should be promoted to minimize water consumption from March to September and especially during July and August when the aquatic ecosystem is most stressed. Reducing usage in the summer months will also help maintain a sufficient amount of water in storage in the lake and the surrounding and thus avoid more serious water restrictions (e.g. limits on domestic usage) and maintaining sufficient flow in Weston Creek to maintain fish habitat even during late summer.

## 7 STUDY LIMITATIONS

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

In evaluating the subject study area and water quality data, GW Solutions has relied in good faith on the information provided. The factual data, interpretations and recommendations pertain to a specific project as described in this document, based on the

information obtained during the assessment by GW Solutions on the dates cited in the document, and are not applicable to any other project or site location. GW Solutions accepts no responsibility for any deficiency or inaccuracy contained in this document as a result of reliance on the aforementioned information.

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

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

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

## 8 CLOSURE

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

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

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

Yours truly,

**GW Solutions Inc.**

**Prepared by:**

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# Lake Weston Water Availability and Climate Change Assessment

**Prepared for:**

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PO Box 1000  
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**Prepared by:**

GW Solutions Inc.  
July 26, 2022

## Executive Summary

Capital Regional District (CRD) Parks & Environmental Services and the Salt Spring Island Local Trust Committee of the Islands Trust required a climate-adapted water availability study for the Lake Weston / Weston Creek watershed on Salt Spring Island (SSI). The purpose of this study is to assess future water supply availability for the Lake Weston watershed in consideration of current water licences and predicted climate change scenarios. The Fulford Water System is currently the only local community water service provider in the Lake Weston/Weston Creek watersheds. There are also 24 point-of-diversion licences to extract water for domestic and irrigation supply from Lake Weston. In consideration of future growth scenarios within, and outside of, the Lake Weston watershed, it is necessary to identify the safe yield of water supplies while ensuring water requirements for environmental flow needs are preserved to ensure aquatic ecosystems (wetlands, creeks, lakes, etc.) are protected.

To meet the goal of project, GW Solutions has developed a water balance model (based on the Thornthwaite-Mather approach) to assess the water availability within the watersheds that contribute to the main study area, Lake Weston watershed. We estimated water withdrawals/usage from groundwater and licenced surface water resources and compared this usage to water availability. Finally, the estimated available water (for both groundwater resources and surface water features) under different climate conditions based on global climate models (scenarios; 2030s, 2050s, and 2070s) has been compared with the current water usage in the study area. This comparison enables us to understand if the study area is likely to experience stress due to withdrawals that exceed available supply. The results also help the CRD to determine if there is potential for community expansion within the study watershed based on sustainable water supply.

The Lake Weston Watershed is dominated by the star-shaped approximately 500-metre-wide Lake Weston and a limited number of stream drainages; however, the majority of creeks and rivers are reported to not flow all year round or have very limited flow during the dry season. Lake Weston has a maximum depth of 12.2 meters and is connected to the upper groundwater system. The lake occurs within a topographic depression at the intersection of two faults which has enabled the lake to form. Groundwater feeds or discharges directly into the lake via the faults on the upgradient side of the lake and seeps out of the lake on the downgradient side back into the groundwater zone. The lake also has a surface water outlet, Weston Creek, which appears to flow all year round.

Water supply in the Lake Weston watershed is obtained from two sources: 1) directly from Lake Weston and 2) Aquifer 1147 which is pumped from wells distributed throughout much of the watershed. The only water usage that is measured (metered) is the Fulford Community Water System taken from Lake Weston. The remainder of the water usage from Lake Weston and Aquifer 1147 is not measured and can only be estimated based on the amounts in the water licences and applicable coefficients. The fire protection water licence (institutional) is the largest licence however this water is licenced for firefighting and firefighting training only and is used only intermittently (e.g. 3000 gallons were drawn in 2019 but none in 2020 and 2021). Most of the water withdrawn for training is circulated

back to Lake Weston. There are several private domestic water supplies taken from Aquifer 1147 and significant water usage for irrigation taken from Lake Weston. The highest water usage from Lake Weston is the May-September period likely reflecting increased irrigation in summer. This contrasts to the assumed pumpage from domestic wells which is similar in summer and winter.

The water balance model shows the total annual precipitation in the watershed is about 2585 dam<sup>3</sup>/year and the water surplus is 1608 dam<sup>3</sup>/year which is comprised of both surface water runoff (993 dam<sup>3</sup>/year) and groundwater recharge (615 dam<sup>3</sup>/year). Of the total precipitation, evapotranspiration represents 35%, surface water runoff represents 40% and groundwater recharge represents 25%.

A comparison of annual groundwater recharge and total annual water usage (from Lake Weston and wells), as estimated from water licences, indicates that on an annual basis groundwater recharge is sufficient to satisfy the current total demand. However, groundwater recharge occurs mostly in the winter months while the water demand is higher in the dry summer months, mostly for water supply and irrigation. This means that during the summer months, water supply demand exceeds recharge which leads to seasonally declining water levels of Lake Weston and Aquifer 1147. These levels then rise again each fall and winter in response to recharge events.

Climate change models predict that winters in the CRD will be warmer with more rain and less snow. The rain will fall as more intense events leading to higher levels of surface runoff potentially leading to higher soil erosion and flooding and potentially less groundwater recharge. The spring snowmelt will tend to disappear reducing the historical groundwater recharge heading into the dry summer months. During summer, temperatures will be higher, precipitation lower and groundwater baseflow (feeding creeks, lakes, wetlands) will therefore be lower. Runoff is predicted to decrease significantly in the summer months (-20% to -28%) while in the winter months runoff will increase by a small amount (2% to 4%). Water shortage is predicted from March to September when the demand will seasonally exceed the surplus of water. This means that during this period, licenced withdrawals exceed groundwater recharge (replenishment of supply) potentially leading to decreased groundwater baseflow to the creek and thus water available for environmental flow needs (aquatic ecosystems: lakes, creeks, wetlands, etc.).

The Lake Weston level varies from a high of about 61.35 masl (meters above sea level) in January to a low of 60.55 masl in August (average 0.8 m variation) and appears to reach a level where it becomes stable (increasing very slightly) in the summer months. In drainages where fish are present, the minimum flow required to sustain the fisheries resource for fair spawning and rearing habitat is 5-10% of the Mean Annual Discharge (MAD). For Weston Creek, 10%MAD corresponds to a Lake Weston water level of about 61 masl. A 20%MAD corresponds to a lake level 10 cm higher at about 61.1 masl and a 30%MAD is about 61.15 masl.

The relationship between usage and Lake Weston level is represented with an approximate trend line providing an approximation of the usage that corresponds to the 10%MAD,

20%MAD and 30%MAD. It can be seen that to achieve even the minimum 10%MAD in Weston Creek the usage in the summer months would need to be reduced to usage levels similar to the winter months. This would require significant summer restrictions on irrigation (farm and household) usage. This highlights the need for accurate usage data to confirm these results and to allow consideration of the need for more appropriate water conservation programs.

Development and implementation of water conservation measures, for all water users, from March to September is recommended to minimize water shortages during summer months. Additional monitoring is recommended including installation of a new climate station in the upper elevations of the watershed where the majority of groundwater recharge occurs. In addition, it is recommended the installation of dedicated groundwater monitoring wells and/or the identification of suitable existing wells that could be monitored. Monitoring should prioritize understanding the impact of water usage and climate change on the watershed. Additionally, work is needed to better define environmental flow needs for both Lake Weston and Weston Creek based a detailed survey of the groundwater-dependant aquatic habitat and the measurement of the minimum flows necessary to maintain the habitat.

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## **APPENDICES**

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Glossary

## 1 BACKGROUND

The Capital Regional District (CRD) Parks & Environmental Services and the Islands Trust Salt Spring Island Local Trust Committee required a climate-adapted water availability study for the Lake Weston/ Weston Creek watershed (ID: 08HA0020) on Salt Spring Island (SSI).

The purpose of this study is to assess future water supply availability for the Lake Weston watershed in consideration of current water licences and predicted climate change scenarios.

The Fulford Water System is currently the only community water supply system in the Lake Weston and Weston Creek watersheds. In consideration of future residential density changes within the study area, it is necessary to identify the safe yield of water supply while ensuring that water requirements for environmental flow needs are preserved.

## 2 STUDY AREA DESCRIPTION

Figure 1 and Figure 2 present the Lake Weston Watershed boundary and some neighbouring watersheds in the study region. It is noted that the Lake Weston Watershed is a sub watershed of Weston Creek Watershed. The bedrock geology (Figure 3) of Salt Spring Island was mapped in detail by Greenwood and Mihalynuk (2009) by studying outcrops and interpreting existing borehole stratigraphy data. The Lake Weston watershed is comprised of granitic rocks of the Salt Spring intrusions and volcanic rocks of the Nitinat Formation. The structural distribution of the Upper Nanaimo Group was created by multiple ancient deformational (Mustard, 1994) and more recent glacier glacio-isostatic deformations (Clague, 1983). The bedrock throughout the southern Gulf Islands thus has been extensively folded and fractured (Journeay and Morrison, 1999).

The watershed is dominated by a groundwater-fed lake (Lake Weston; Water Body ID: 315620) and largely ephemeral drainages that do not flow year-round but only flow seasonally in the rainy season or temporarily following rain events. Lake Weston has an area of 180,137 m<sup>2</sup> and is in the crude shape of a cross with three distinct arms. The longest span between arms (northeast arm to southwest arm) is about 700m and the maximum depth is 12.2 meters (Figure 4). The lake appears to be at the intersection of several geologic faults which have weakened the rock and produced a depression in which the lake is formed. This type of lake is referred to as “flow-through,” since groundwater feeds and discharges directly into the lake via the faults on the upgradient northern side of the lake and seeps out of the lake on the downgradient southern side back into the groundwater zone. Flow-through lakes occur when the water table is higher on one side of the lake than the other, creating a gradient for groundwater to enter and leave the lake. An illustration of a flow-through lake is provided in Figure 5. The lake also has a stream outlet, Weston Creek, which flows year-round due to a combination of outflow from Lake Weston and groundwater discharge (baseflow) from the aquifer into the creek (see also Figure 38 for a regional cross-section through Lake Weston).

The proportion of water that is from groundwater in the Lake Weston inflow (E1) and the Weston Creek outflow (at the mouth) was studied by Howe and Allen (2020). They found the proportion of groundwater in the inflow varies from 10% during high flows (25 L/s) to 47% during low flow (4 L/s). In the Weston Creek outflow, the proportion varies from 12% during high flow (20 L/s) to 100% during low flow (1.1 L/s). This indicates the high proportion of groundwater discharging into both Lake Weston and Weston Creek.

Land-use in the study region is dominated by rural residences, agricultural and forest (Figure 6).

GW Solutions has developed a water balance model as a tool to assess the water availability within the Lake Weston watershed. This report describes the model to quantify water availability as runoff and groundwater recharge under different conditions of climate change. An analysis of estimated water withdrawals/usage from groundwater and surface water resources was also completed and compared to water availability.

To meet the goals of the project, the estimated available water (from both groundwater resources and surface water features) under different climate conditions has been compared with the current water usage in the study area. This comparison enables an evaluation of whether the area is under stress due to large withdrawals in comparison to water availability. The results will assist the CRD to determine the potential for community expansion within this area, in a sustainable manner.

Two main factors have been considered for this study.

a) *Understanding and planning for climate change*; the results are presented for investigations for three-time frame scenarios: 2030s, 2050s, and 2070s.

b) *Protection of valuable water resources and the aquatic ecosystems*; it is understood that the Water Availability Study should incorporate the baseline requirements for, not only water use by the community, but also for preservation of the health of aquatic ecosystems (aquifers, creeks, springs, wetlands, lakes).

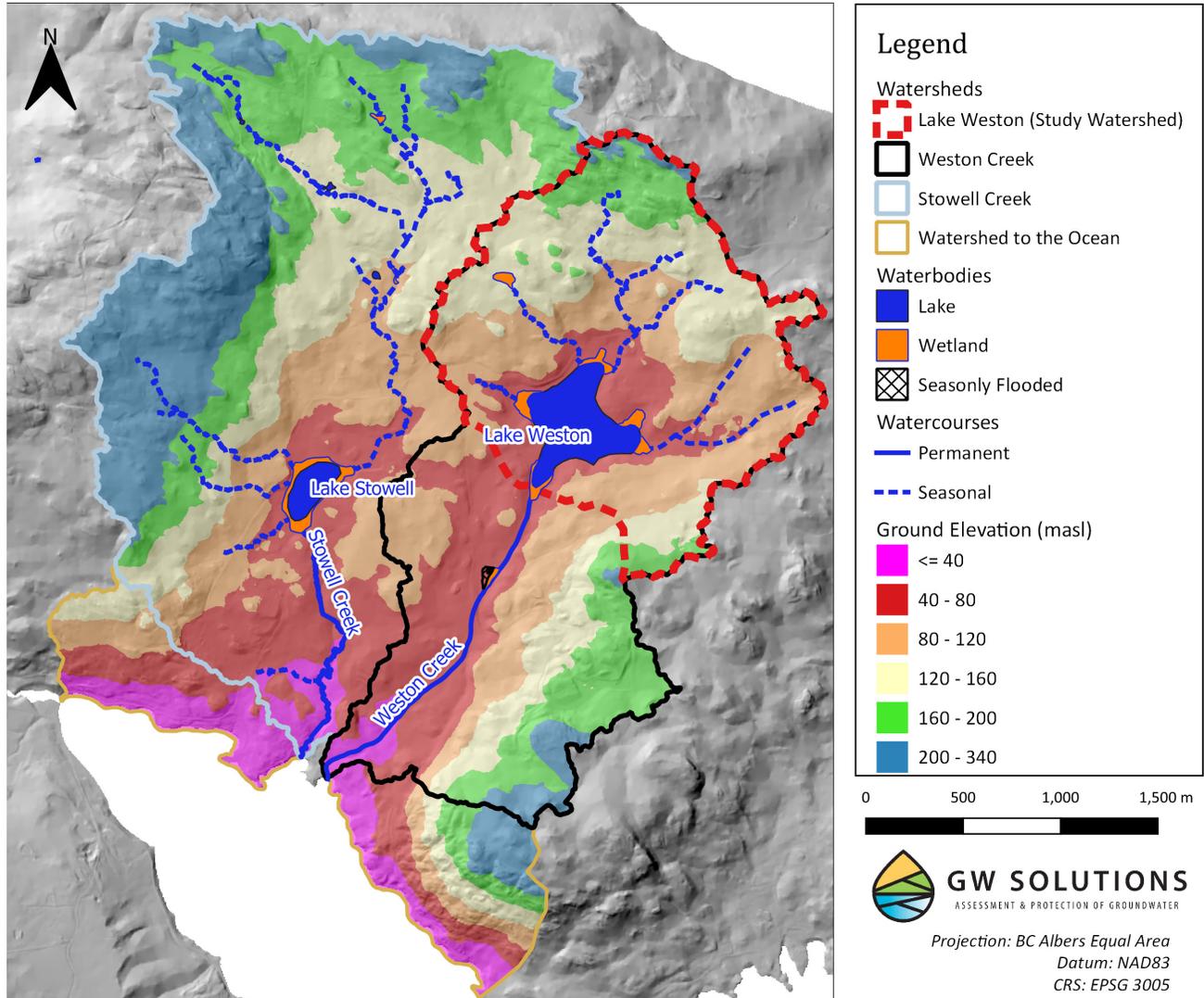
The report is divided into the following four sections:

**Section 4: Water Usage.** All water usage quantities from surface water and groundwater sources quantified and/or estimated and classified according to use of water (domestic, irrigation, institutional, community water supply).

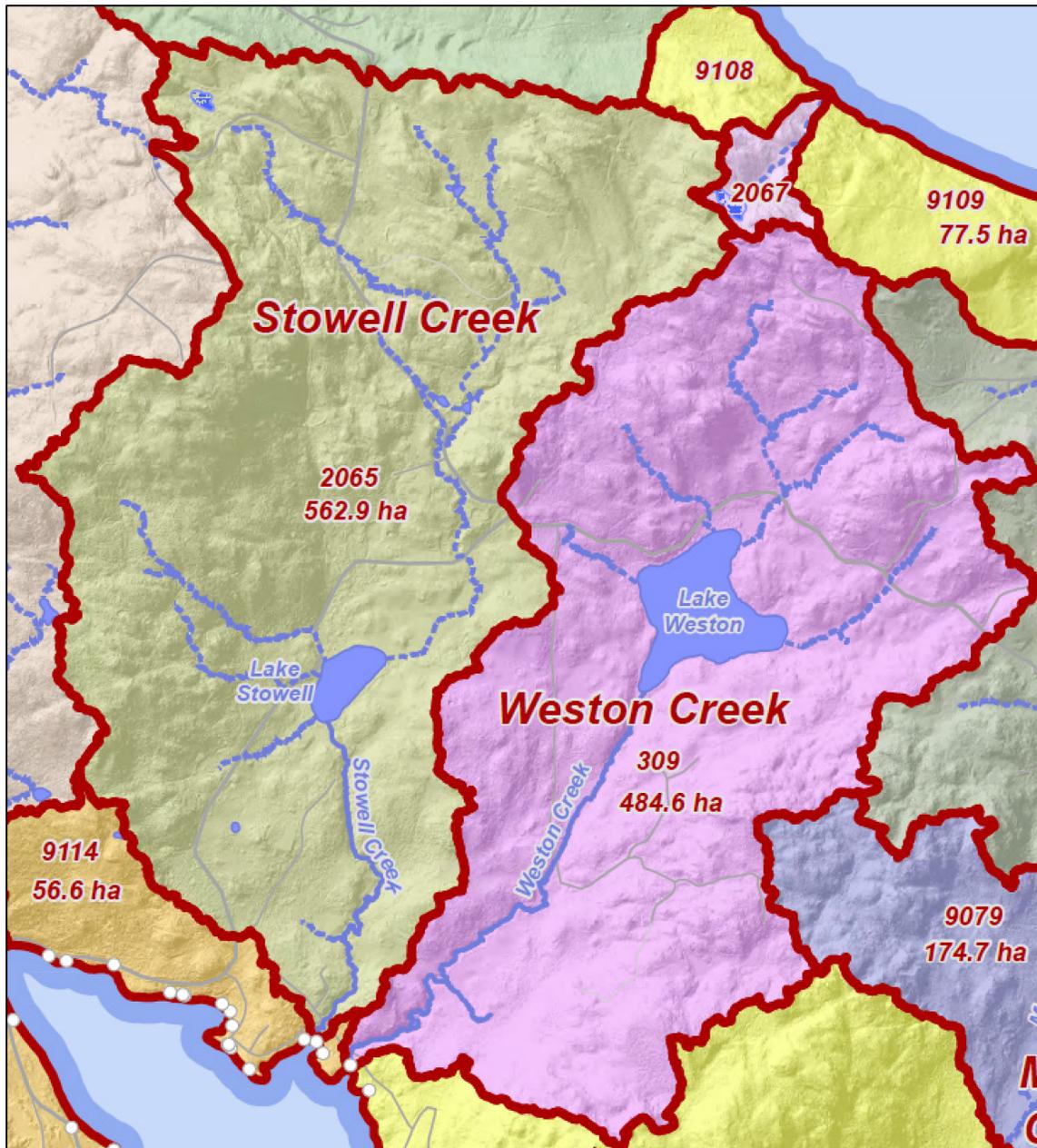
**Section 5: Water Balance.** Development of data sets and equations for estimating various components of the water balance including monthly estimates of groundwater recharge and surface water runoff.

**Section 6: Climate Change Analysis.** Analysis of the impacts of various climate change severity scenarios (based on global climate models) on the water budget for various time periods in the future 2030s, 2050s, and 2070s.

**Section 7: Analysis of Results and Data Gaps.** Analysis of the key results of the study and additional data (i.e. data gaps) that would help improve the accuracy of the predictions.

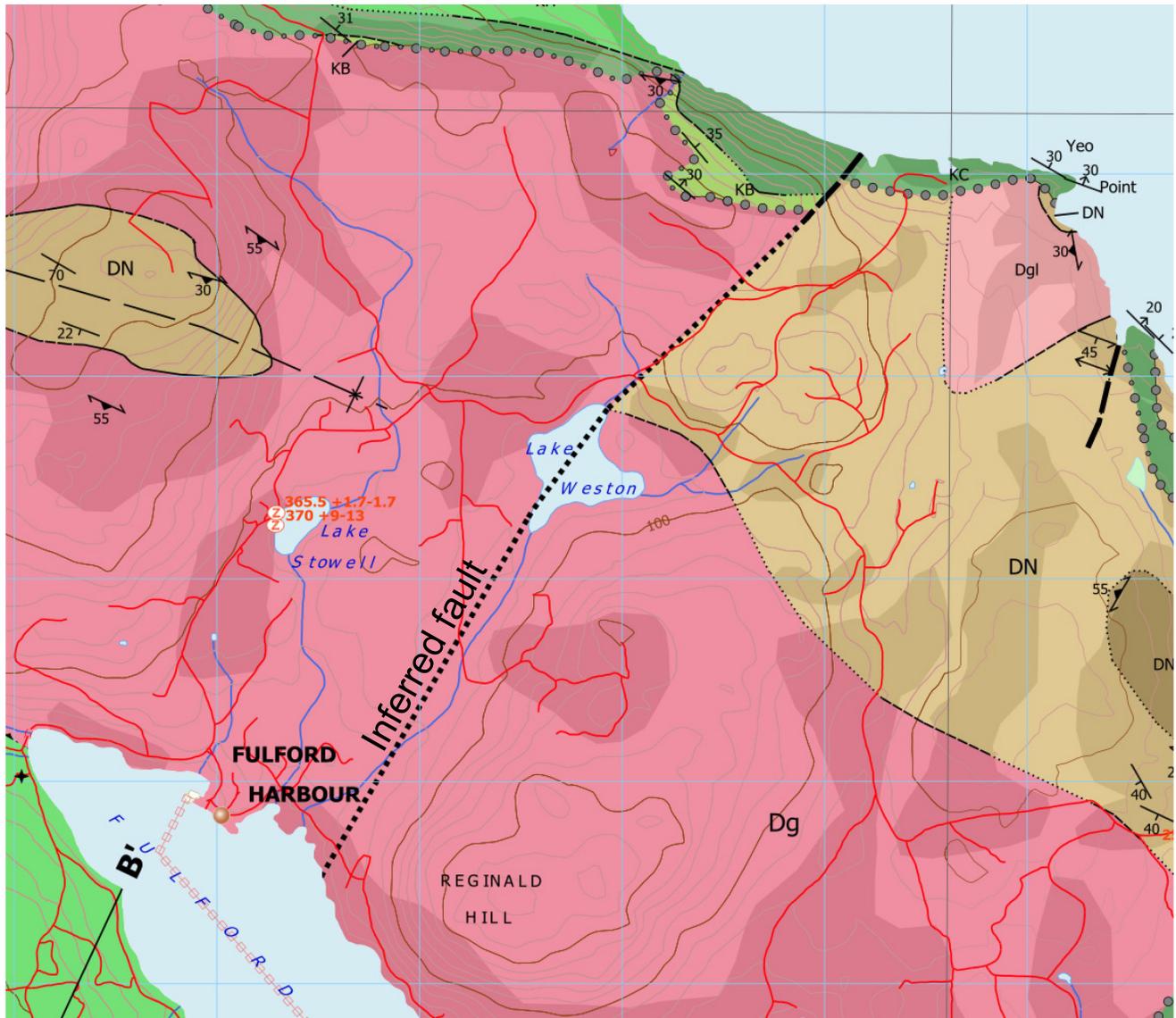


**Figure 1. Lake Weston and Weston Creek watersheds.**



- CRD Monitored Shoreline
- Stormwater Discharge Location
- River/Stream - Flow year-round
- - - River/Stream - Flow sometimes
- ▬▬▬ CRD Boundary
- ▬▬▬ Electoral Area Boundary
- 🔴 Watershed Boundary\*
- 8487 Watershed/Drainage Area ID
- 🌿 Natural Drainage to Shoreline without Streams
- 🏠 Urban Influenced Drainage to Shoreline via Storm Drain Networks
- 🌿 Wetland
- 🌊 Shoreline
- ▨ First Nation Reserve Land

Figure 2. Weston Creek watershed and neighboring watersheds (CRD, 2018)



**Sicker Group Volcanics**

**DN** Nitinat Formation  
 Pyroxene-phyric mafic agglomerate, pyroxene bearing tuffs, lapilli tuffs and flows. Individual sub units and flows are difficult to trace confidently. Pyroxene crystals are commonly altered to actinolite.

**Saltspring Intrusions**

**Dg** Granite and granodiorite, undivided (Dg) commonly protomylonitic with conspicuous quartz 'eyes'. Produces a hornfels texture in Nitinat Formation country rocks.

**Figure 3. Study area geology (from Greenwood and Mihalynuk, 2009)**

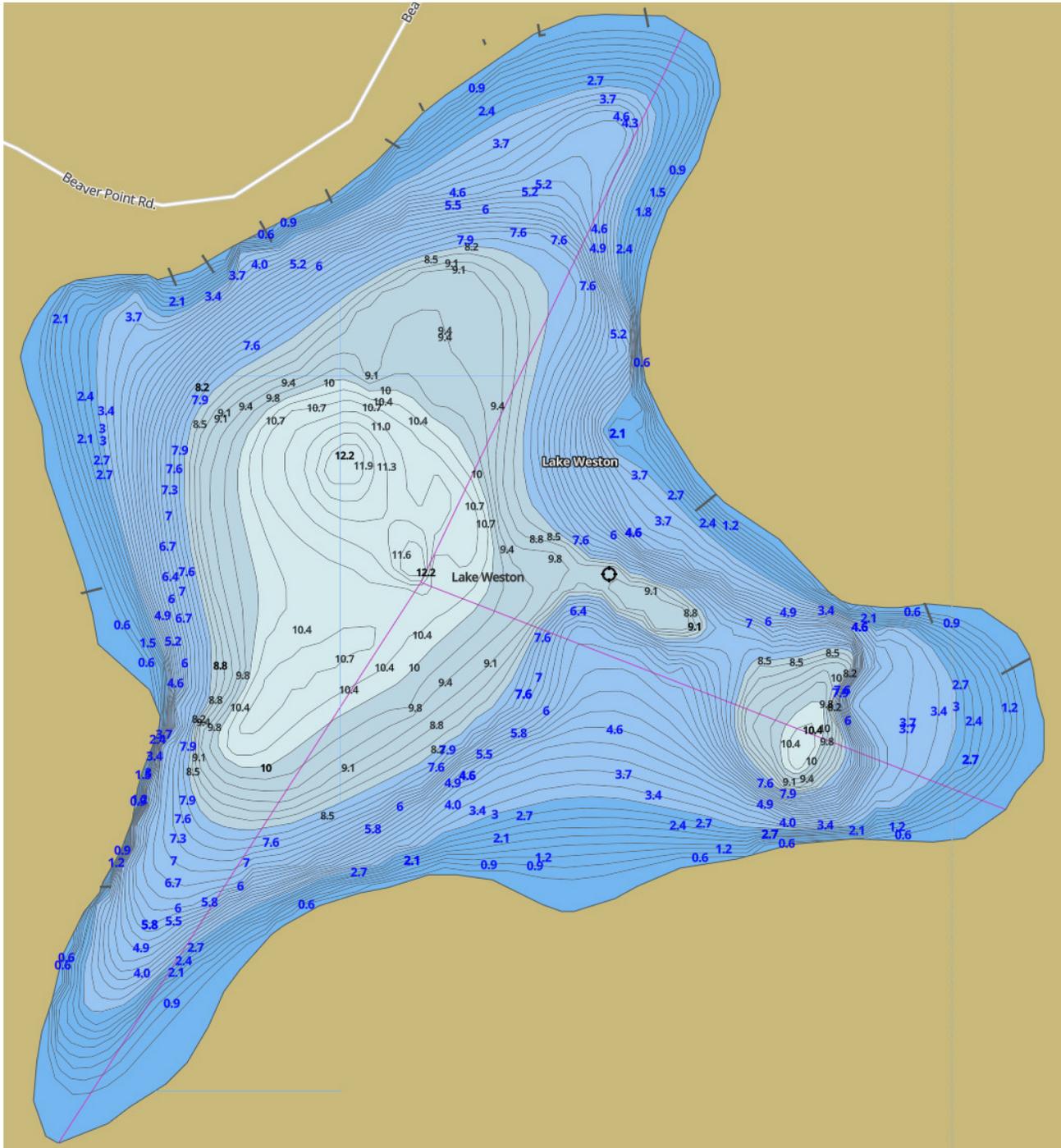
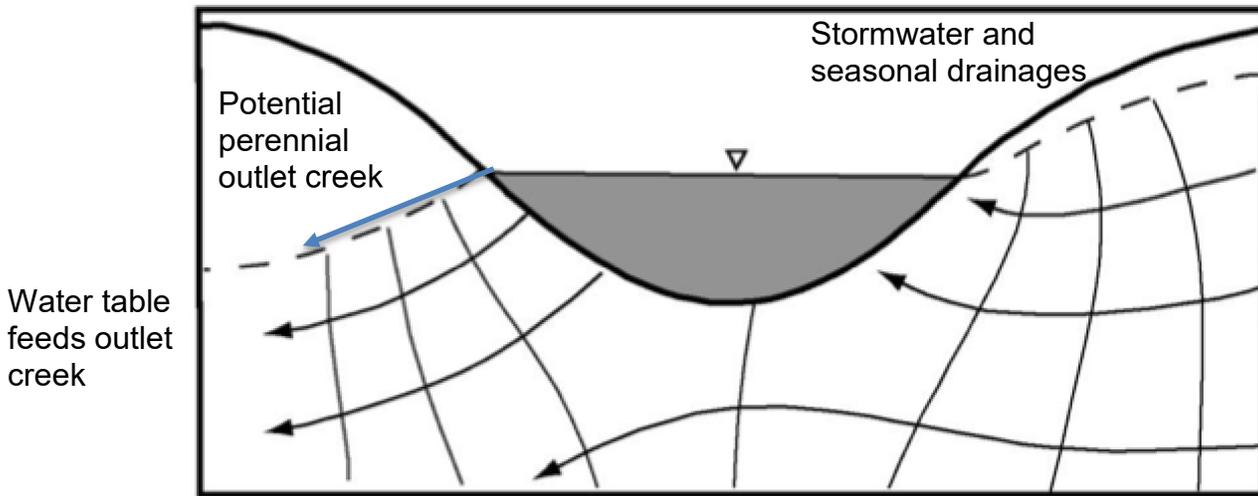
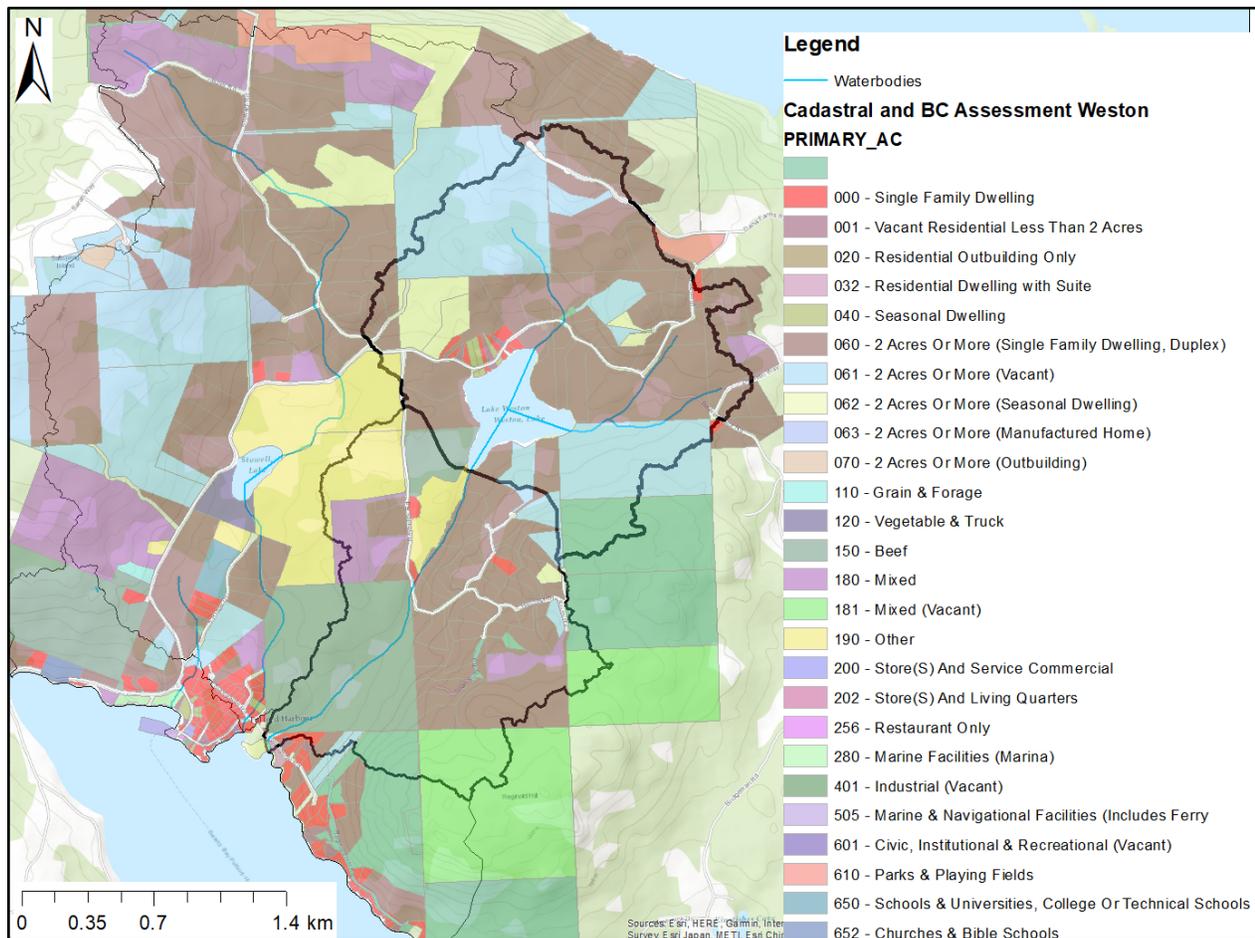


Figure 4. Lake Weston depth in meters, shape and dimensions (www.gpsnauticalcharts.com)



**Figure 5. Flow-through lake. The water table is higher on one side of the lake than the other thus groundwater seeps into the lake on the upgradient side and seeps out of the lake on the downgradient side.**



**Figure 6. Land-use within and near study area**

### 3 APPROACH

We employed the following approach:

1. To understand the current water demand for the Lake Weston watershed, water usage for surface water and groundwater sources has been estimated using a methodology developed by GW Solutions which includes licensed points of diversion (surface water and springs), points of well diversion, parcel information and the GWELLS database. Metered water use data for the Fulford Water System was provided by the CRD.
2. The next step in our water availability assessment is understanding the water balance for the study area. A baseline water balance model has been developed by using Climate Normals (average monthly climate variables data 1981-2010) as input. For this project, GW Solutions has used an ArcGIS based water balance tool created by James Dyer from the University of Ohio (Dyer, 2019, 2021). The model estimates monthly potential evapotranspiration, soil moisture storage, actual evapotranspiration, soil moisture deficit, and soil moisture surplus using the grid-based Thornthwaite-Mather approach. The water balance methodology is described in detail in Section 5. The water balance model estimates the available moisture *Surplus* (among other outputs), which is defined as the moisture remaining after evapotranspiration and therefore available for surface water runoff and groundwater recharge. GW Solutions on behalf of Island Trust has developed a recharge mapping methodology to estimate groundwater recharge and surface runoff volumes. In this approach the groundwater recharge flux is estimated and differentiated from *Surplus* by applying several deterministic coefficients (e.g. surficial composition, lineaments, estimated depth to groundwater and satellite-based delineations of preferential groundwater recharge and discharge areas) for groundwater recharge. The baseline water balance model is calibrated using a statistical approach for actual measured flow data.
3. The climate change effects on the climate variables such as precipitation, radiation and temperature, have been projected for three time-periods – 2030, 2050, and 2070 using ClimateBC Data Project with selecting the IPCC's most recent *Coupled Model Intercomparison Project* (CMIP6) scenarios.
4. The outcomes of climate change projections were then entered into the calibrated water balance model as input and the water availability/surplus was estimated as the output for different climate change scenarios.
5. Finally, the current water usages were compared to the water availability of surface water and groundwater resources considering different climate change conditions to understand the degree of water stress in the watershed.

## 4 WATER USAGE

Understanding and estimating the water usage within the Lake Weston area is critical to the sustainable management of surface water and groundwater resources. GW Solutions worked collaboratively with the Capital Regional District (CRD) and Island Trust to compile available measured water usage (groundwater and surface water). The only metered water system in the watershed is Fulford Water System and this data was obtained from CRD. This metered information was critical to understand the temporal variability (month to month) in water usage. For all other water users (without metered data), we estimated water usage as described in the following sections.

### 4.1 Estimation of Surface Water Withdrawals

The water availability assessment requires an estimation of monthly and yearly surface water withdrawal volumes. The BC Water Rights database, which includes water licence information for surface water sources, was used to estimate the surface water withdrawal volumes. A water source (i.e., spring, pond, or stream) can have multiple licenses and associated Points of Diversion (POD's); and each license can have one or more POD's. For each water license, basic information is provided such as license status, expiry date, licensed volume (units), water use purpose and period of usage.

Figure 7 shows the current licensed PODs for the study area, limited to withdrawals and classified by type of use (i.e., domestic, irrigation, industrial/commercial, institutional and water supply systems). There are 24 PODs within the Lake Weston watershed with the largest associated with the Fulford Water System which as the only metered system in the study area (Figure 8). All other water usage must be estimated based on licences and usage type. However, in an event of fire, the Fire Suppression license will become the largest at a potential maximum rate of 80 liters/second.

Detailed information for Non-Domestic PODs is provided in Figure 9. According to the licences the domestic use ranges between 2 to 5 cubic meters per day per licence. A complete list of Water Rights for Lake Weston is presented in Appendix 5.

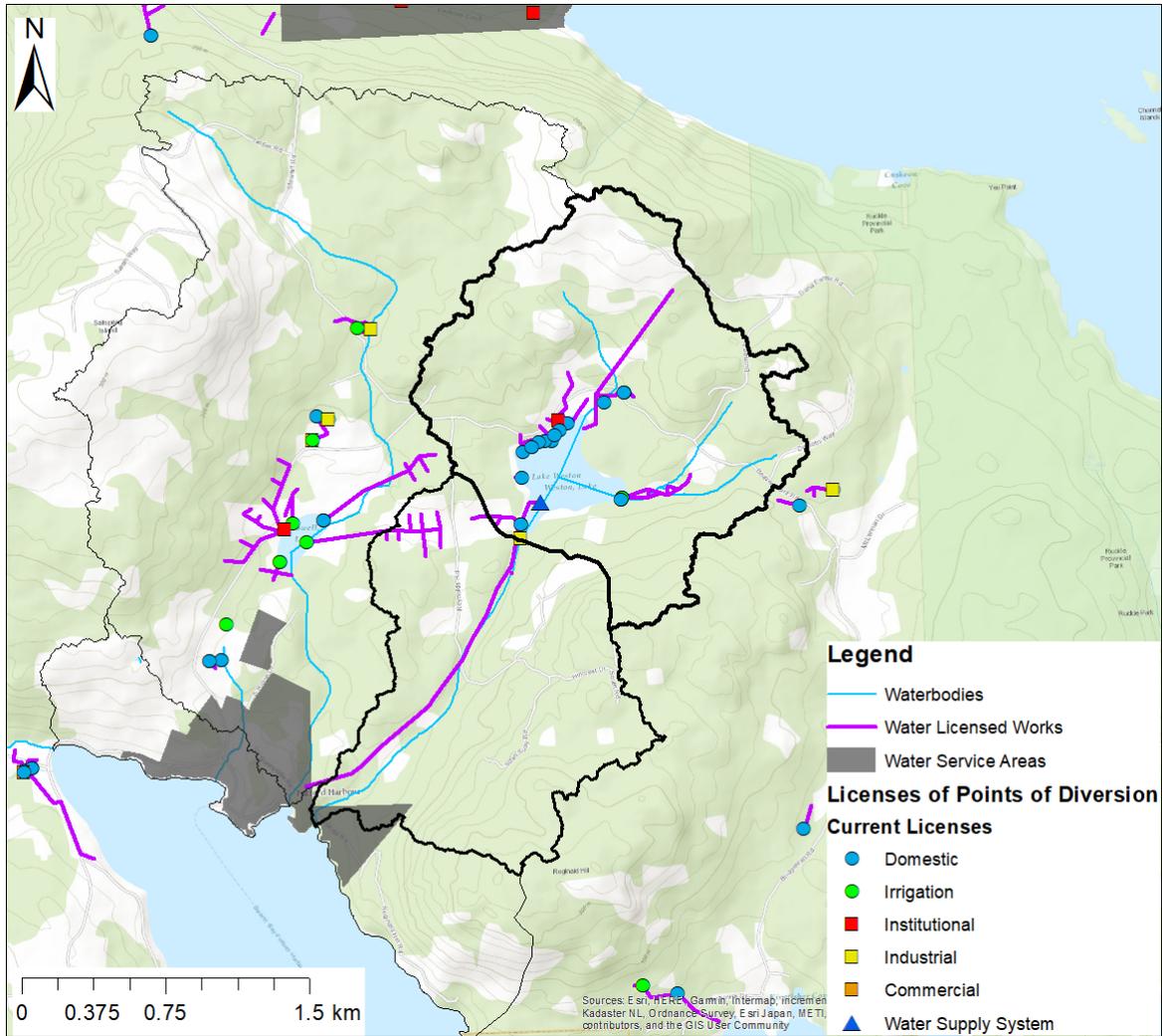


Figure 7. Current water right licences for Points of Diversion according to type of usage

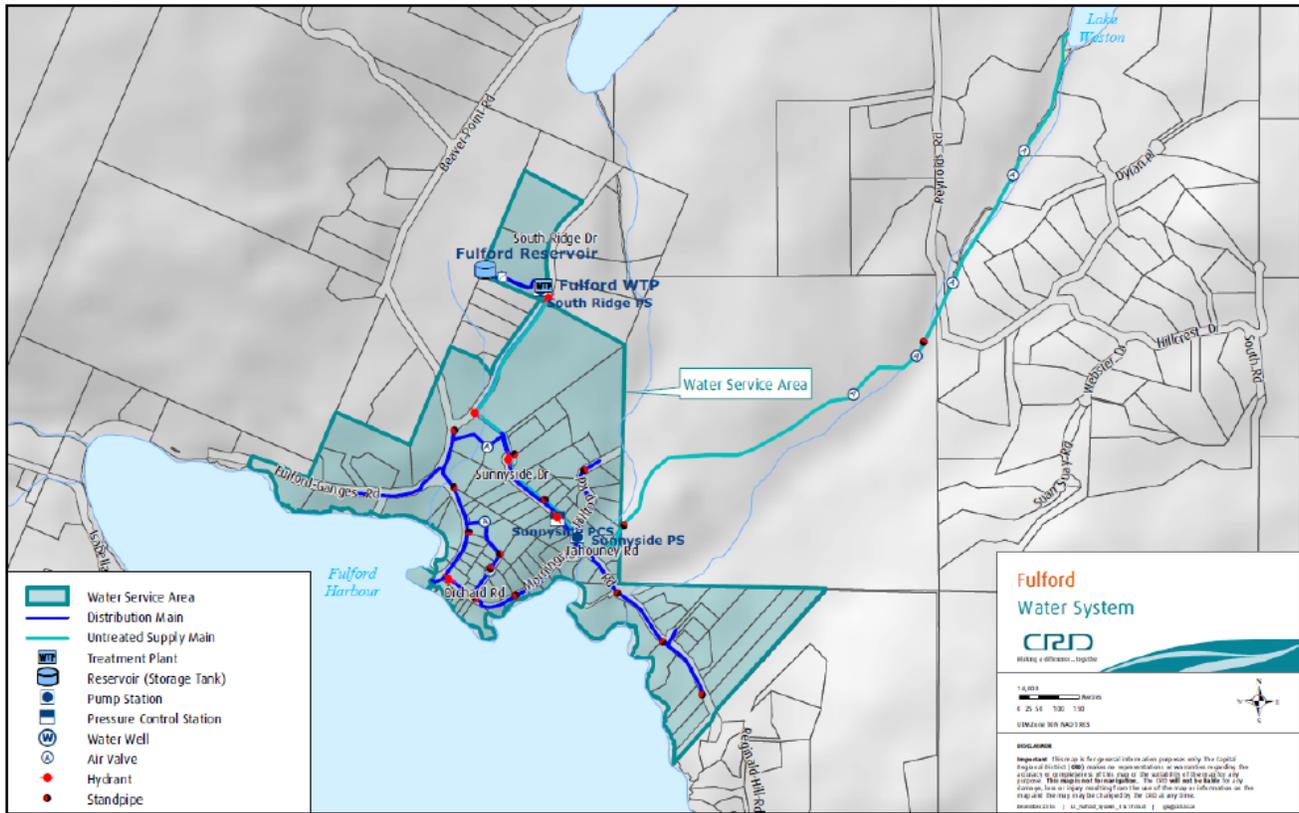


Figure 8. Service areas for Fulford Water Supply System regulated by CRD

Non-Domestic Point of Diversion Licences

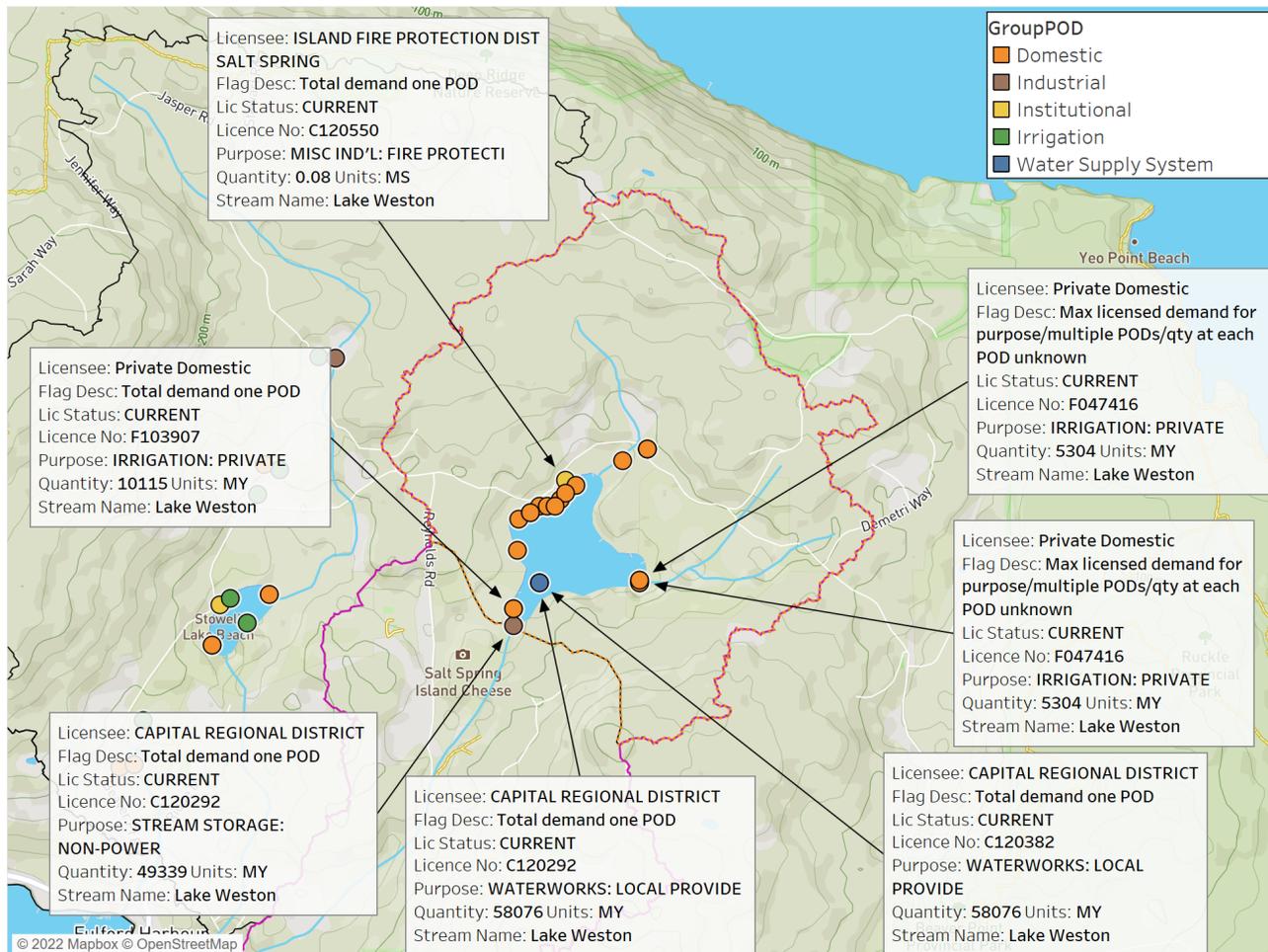


Figure 9. Details on non-domestic current licences for Points of Diversion

MY=m<sup>3</sup>/year, MS=m<sup>3</sup>/s

4.1.1 Methodology and estimation of volumes for current PODs (surface water)

Licensed volumes in the POD database are reported in yearly, monthly, daily, or hourly use rates. To normalize the licensed volumes to monthly rates, we applied coefficients that model seasonal patterns of water including seasonality from the Fulford Water System. Coefficients were estimated based on monthly use trends for water supply systems on Vancouver Island (i.e., North Salt Spring Waterworks District, Nanaimo and Fulford Water System), Ecofish Baseline Report and Rood and Hamilton (1995) (domestic), BC Ministry of Agriculture Livestock Watering Factsheets (livestock and irrigation), and the BC Agriculture Water Demand Model (irrigation).

Table 1 summarizes the monthly coefficients used for the conversion to monthly rates including when the information was converted to consistent units. Monthly rates were then added to derive yearly water use for surface streams and springs. The sum of the all the months equals to 12. The coefficient indicates months where greater water use happens and the proportion of water usage for each month. For instance, in *Irrigation: Private* under current climate scenarios there is no water usage from October to April (coefficient=0), the water usage in July and August (coefficient=3.6) is three times higher than in May and September (coefficient=1.2) and 33% more than the usage in June (coefficient=2.4).

**Table 1. Monthly allocation coefficients for estimated water use from PODs**

Group POD	Purpose	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Domestic	DOMESTIC	0.85	0.85	0.85	0.85	0.95	1.00	1.50	1.50	1.10	0.85	0.85	0.85
Irrigation	IRRIGATION: PRIVATE	0.00	0.00	0.00	0.00	1.20	2.40	3.60	3.60	1.20	0.00	0.00	0.00
Irrigation	LAND IMPROVE: GENERAL	0.95	0.95	0.95	0.95	1.05	1.07	1.08	1.08	1.07	0.95	0.95	0.95
Irrigation	LIVESTOCK & ANIMAL: STOCK	0.85	0.85	0.85	0.85	0.95	1.00	1.50	1.50	1.10	0.85	0.85	0.85
Irrigation	LWN, FAIRWAY & GRDN: RES	0.00	0.00	0.00	1.20	2.40	2.40	2.40	2.40	1.20	0.00	0.00	0.00
Industrial	GRNHOUSE & NURSERY: GRNHO	0.00	0.12	0.12	0.24	1.20	1.68	2.88	2.88	2.04	0.72	0.12	0.00
Industrial	LWN, FAIRWAY & GRDN: WATE	0.00	0.00	0.00	1.20	2.40	2.40	2.40	2.40	1.20	0.00	0.00	0.00
Commercial	COMM. ENTERPRISE: ENTERPR	0.95	0.95	0.95	0.95	1.05	1.07	1.08	1.08	1.07	0.95	0.95	0.95
Institutional	MISC IND'L: FIRE PROTECTI	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00
Water Supply System	WATERWORKS: LOCAL PROVIDE	0.85	0.85	0.85	0.85	0.95	1.00	1.50	1.50	1.10	0.85	0.85	0.85

*BC fire season from April to September*

## 4.2 Estimation of Groundwater Withdrawals

### 4.2.1 Water wells database, cadastral information, and water service areas

The BC water wells database (GWELLS), land-use from the BC Assessment Authority, and water service areas were used to estimate groundwater withdrawal. The wells database includes the vast majority of wells; however, it does not include all wells since reporting to B.C was voluntary until the *Water Sustainability Act* came into force in 2016. Additionally, dug wells typically are not registered within GWELLS. The well use types are classified as:

Water Supply System, Test Well, Private Domestic, Observation Well, Irrigation, Commercial and Industrial, Other and Unknown Well Use. There are known water supply systems utilizing groundwater within the Lake Weston watershed. Additionally, no non-domestic groundwater license Points of Well Diversion or non-domestic groundwater use applications were found within watershed at the time of data compilation.

Wells that do not extract water were removed from the analysis, including abandoned or decommissioned wells, dry holes, test wells and observation wells.

The GWELLS database does not include information on pumped volumes. To estimate the water use from groundwater wells, we combined the following information:

- Parcel boundary and land use data from BC Assessment, provided by the ITC.
- Active wells from the GWELLS database (Figure 10).

#### 4.2.1.1 *Estimation of water volumes (groundwater) using wells database and cadastral information*

Groundwater use was estimated based on joining active wells to the parcel's land use (the "primary actual use" attribute from BC Assessment). Wells could then be classified by type of use: Water Supply System, Recreational, Irrigation, Institutional, Industrial, Domestic, Transportation and Commercial.

Average groundwater use for each land use type was estimated and adapted from Miles and Guy (2009) and is summarized in Table 2. The effects of seasonality and parcel size on water use were also taken into account. Three seasonality labels are used:

- "Area based": volume estimation based on parcel area,
- "Seasonal use (May-Sep)": volume estimation based on 5 months of water use (May to September); and
- "Area based and seasonal use (May-Sept)": volume estimation based on combination of parcel area and period of use (May to September).

Coefficients from the BC Agricultural Water Demand Model (irrigation) and the BC Ministry of Agriculture's Livestock Watering Factsheets (livestock and irrigation) were used for agricultural users (parcels with an irrigation use). Monthly and seasonal variations were estimated based on reported use for the domestic and water supply systems (Table 1). The coefficients are similar to those used for the POD water use estimation.

It is expected parcels within the Irrigation category will overestimate water demand. The method assumes 50% of the land is actively irrigated with volumes assigned according to the seasonal percentages in Table 3. However, to more accurately estimate the irrigated land, field survey and data collection will be required.

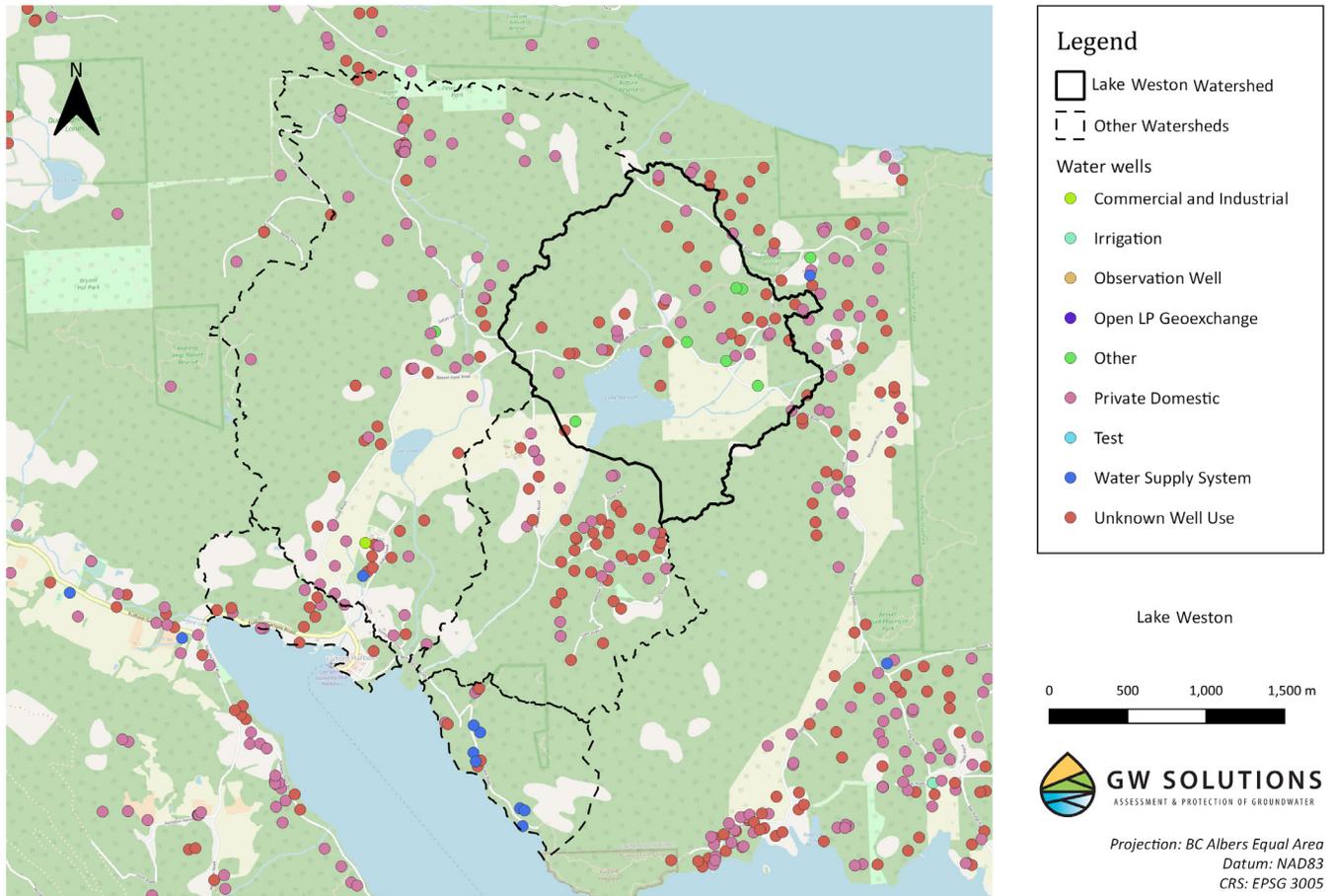
The estimate of total groundwater use was calculated based on data from springs (POD) and water wells.

**Table 2. Average water use estimates based on parcel information**

Group	Primary Actual Use	Estimation type and seasonality	L/day/parcel	Number per ha
Domestic	000 - Single Family Dwelling		625	
Domestic	040 - Seasonal Dwelling	Seasonal use (May-Sep)	625	
Domestic	060 - 2 Acres or More (Single Family Dwelling, Duplex)		1,250	
Domestic	062 - 2 Acres or More (Seasonal Dwelling)	Seasonal use (May-Sep)	1,250	
Irrigation	150 - Beef	Area based	50	1
Irrigation	180 - Mixed	Area based and seasonal use (May-Sept)	10,000	
Irrigation	190 - Other	Area based and seasonal use (May-Sept)	10,000	

**Table 3: Monthly seasonal variations for estimation of monthly pumped volumes**

Month	No of days	Irrigation	Water Supply System	Domestic and others
		Distributed (%)	Increased by (%)	Increased by (%)
January	31		0%	0%
February	28		0%	0%
March	31		0%	0%
April	30		0%	0%
May	31	10%	15%	10%
June	30	20%	25%	12%
July	31	30%	80%	14%
August	31	30%	80%	14%
September	30	10%	20%	13%
October	31		0%	0%
November	30		0%	0%
December	31		0%	0%



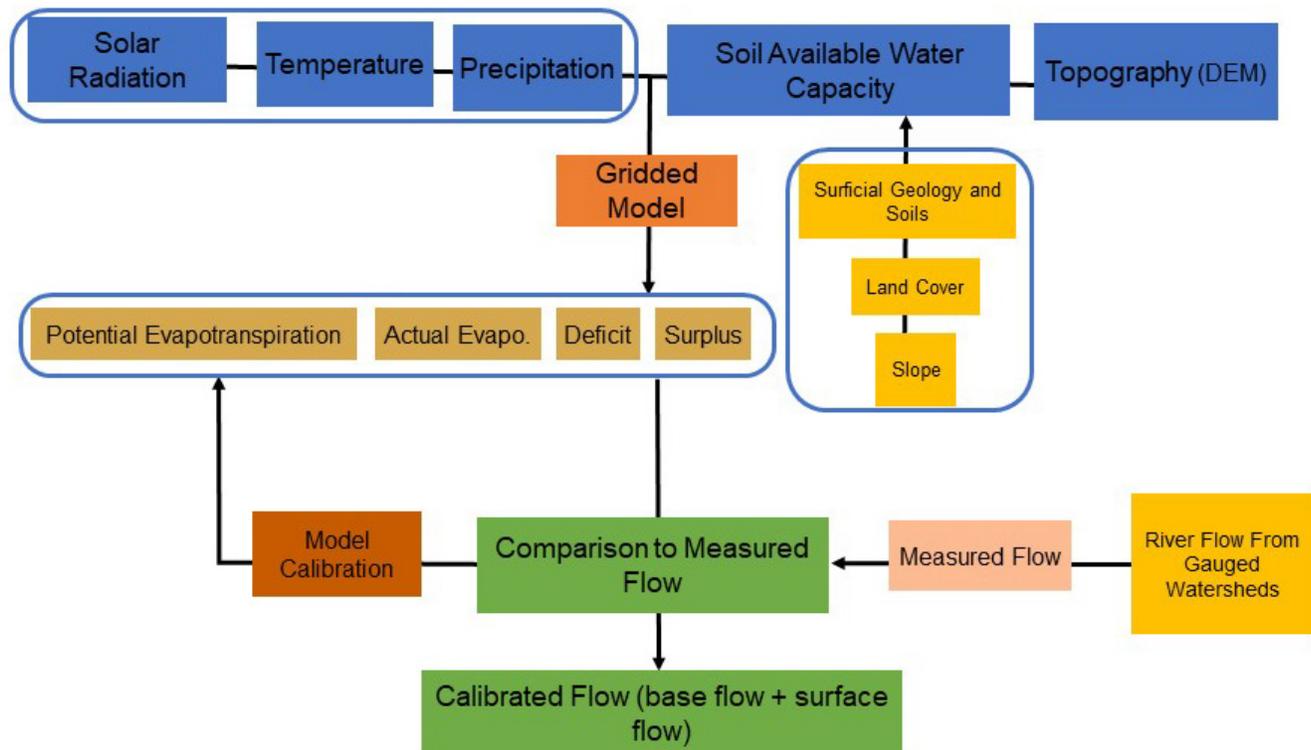
**Figure 10. Registered Groundwater Wells in the Study Area**

## 5 WATER BALANCE

### 5.1 Methodology

A water balance for the Lake Weston Watershed was estimated using an ArcGIS-based model developed by James Dyer from the University of Ohio (Dyer, 2019, 2021). The model estimates monthly potential evapotranspiration, soil moisture storage, actual evapotranspiration, soil moisture deficit, and soil moisture surplus using a grid-based, Thornthwaite-Mather approach (Thornthwaite and Mather, 1955).

Figure 11 summarizes the gridded water balance model methodology as a flowchart.



**Figure 11. Gridded water balance model methodology**

#### 5.1.1 Model inputs

The main data inputs were monthly temperature (average), monthly total precipitation, a digital elevation model (DEM), soil available water capacity (AWC), and monthly total solar radiation. Each input is described in more detail in Table 4.

**Table 4. The details of Model Inputs for the water balance**

Model Input	Description	Source
Monthly average temperature and total precipitation	Gridded, monthly precipitation and temperature maxima and minima were obtained from the Pacific Climate Impact Consortium (PCIC).	PCIC (2020)
Digital Elevation Model (DEM)	A digital elevation model (DEM) was used to derive rasters of Slope (inclination of the ground), and Aspect (direction of the slope). The DEM was derived from LiDAR elevations and was upscaled to a 20 x 20-meter grid size.	BC Lidar (2021)
Soil Available Water Capacity (AWC)	Soil related data was retrieved from the British Columbia Soil Information Finder Tool that includes soil composition (mineral or organic), texture, coarse fragment content, drainage, layer thicknesses and characteristics, soil physical and chemical properties, as well as landform and parent material. Soil mapping also includes available water holding capacity at different depths (0.15, 0.30, 0.45, 0.60, 0.75, 0.90, 1.05 and 1.20 m).	Province of British Columbia (2020)
Monthly total solar Radiation	Solar radiation was estimated based on topographic surface (DEM), geographic location and time of the year. Solar radiation data ( $\text{kJ m}^{-2} \text{day}^{-1}$ ) was obtained from WorldClim ( <a href="http://worldclim.org/version2">http://worldclim.org/version2</a> ) at a resolution of 30 seconds ( $\sim 1 \text{ km}^2$ ). This data was converted to watt hours per square meter ( $\text{wh/m}^2$ ) per month for the model.	WorldClim (2020)

### 5.1.2 Model outputs

The model outputs are:

- **Potential Evapotranspiration (PE)** –the evaporative water loss from vegetation for which water availability is not a limiting factor. PE depends mainly on heat and solar radiation. Estimated using the Turc method.
- **Actual Evapotranspiration (AE)** – the water loss from vegetation given actual water availability (from precipitation and soil moisture storage). If water is not a limiting factor, actual evapotranspiration is equal to potential evapotranspiration.
- **Deficit** – the moisture stress and occurs when the evaporative and vegetation demand is not met by available water. In other words, it is the difference between potential and actual evapotranspiration.
- **Surplus** – the excess water that is not evaporated or transpired or stored in the soil. When soil moisture field capacity is reached, surplus leaves a site through either surface runoff or soil infiltration (groundwater recharge) or a combination of both.

Appendix 3 describes the water balance inputs and output for the study region including the Lake Weston Watershed.

### 5.1.3 Model calibration

Measured stream flow information for one hydrometric station, Fulford Creek near Fulford Harbour (08HA0020) were used to calibrate the water balance model. The measured flow data was downloaded from BC Aquarius web portal. Figure 12 shows the historical fluctuation of surface water flow and daily and monthly average of surface water flow for Fulford Creek station. Figure 13 shows the delineated watershed for the station.

#### 5.1.3.1 Water flux model calibration

Water fluxes calculated with the water balance model were compared to measured flow values for the gauged watershed. Figure 13 shows the measured and modeled flows in cubic decameters ( $\text{dam}^3$ ) for the gauged watershed, Fulford Creek near Fulford Harbour.

The difference in flow (modeled vs measured) could also be attributed to the following:

- Monthly Precipitation Grids are a result of an interpolation of the available climate normal data, the number and spatial distribution of climate stations and topography climate model correction. Errors will also result from interpolation, density of monitoring stations and altitude correction in the interpretation of the temperature grid data. There is no active climate station within the watershed.
- The water balance model does not include measured water extraction (i.e. well pumping volumes or surface water points of diversion). Additionally, water usage might have increased over time which might have influenced the modelled flows in watersheds where the water usage is large.
- The actual timing of snow melt has not been included in the model. Precipitation is the sum of snow and rain in the month they occur, however, most of the snow melt occurs in the late winter and early spring.
- The incompleteness of measured values. For example, Fulford Creek does not have normal data for the period 1981-2010.

#### 5.1.3.2 Model outputs acceptability assessment

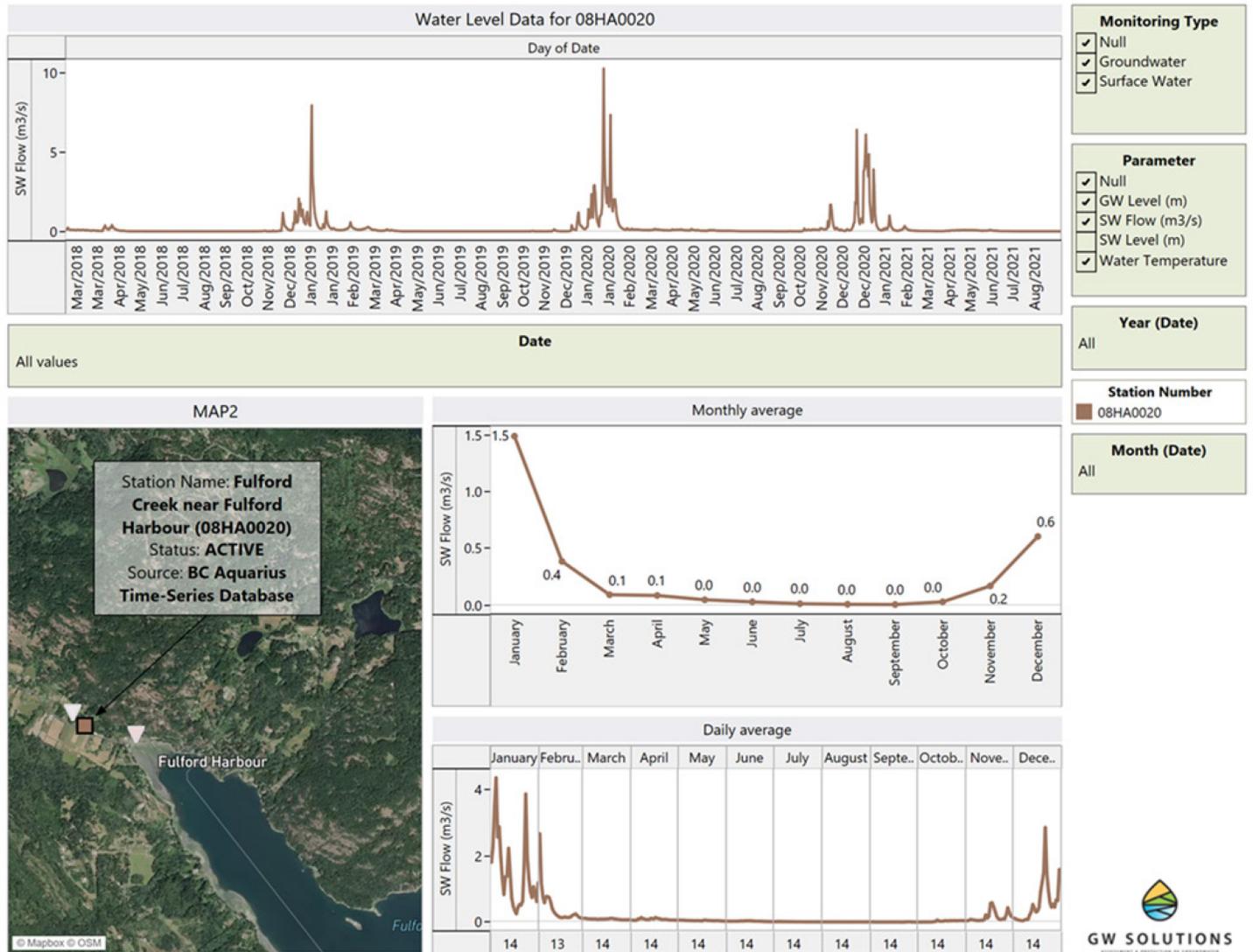
To evaluate the acceptability of the water balance model, measured flows were compared to modelled flows using three statistical approaches: Nash-Sutcliffe Efficiency (NSE), Percent Bias (PBIAS) and the RMSE-Observations Standard Deviation Ratio (RSR).

The statistical results are presented in Table 5. In general, NSE varies from negative infinity to 1 where close to 1 is highly satisfactory. RSR varies from 0 (highly satisfactory) to any large number. PBIAS is reported as percentage where the lower values indicate generally good match between modelled and measured values. GW Solutions considers a satisfactory model if  $\text{NSE} > 0.85$ ,  $\text{RSR} < 0.40$ , and  $\text{PBIAS} < 15\%$  for streamflow modeling.

Historical flow data for Fulford Creek is presented in Figure 12. The monthly comparison of modelled and measured flows for the Fulford Creek station (Figure 13) indicates a good match between modelled and measured flows.

**Table 5. Statistical comparison between modelled and measured flows**

Station Number	Station Name	Data Group	RSR	NSE	PBIAS
08HA0020	Fulford Creek near Fulford Harbour	From 2017 to 2021	0.10	0.99	5.5%



**Figure 12. Historical flow data for the Fulford Creek station (08HA0020)**

Gauged watershed



Model calibration for station FULFORD CREEK NEAR FULFORD HARBOUR (08HA0020)

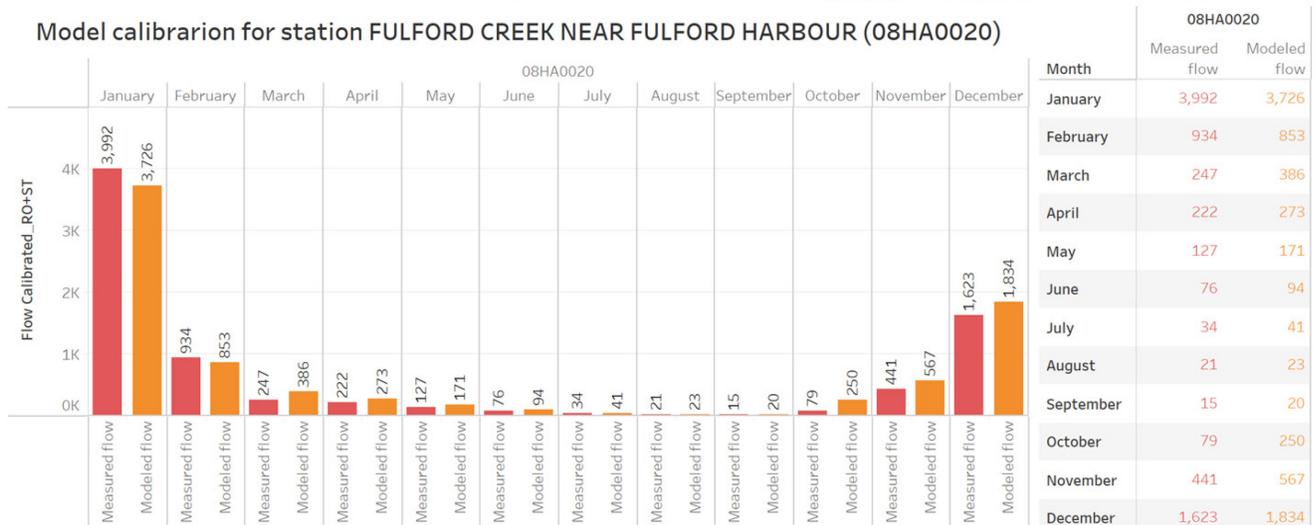


Figure 13. Monthly comparison of modeled and measured flows for the Fulford Creek watershed (08HA0020)

## 5.2 Estimation of Groundwater Recharge and Runoff

The water balance model estimates monthly potential evapotranspiration, soil moisture storage, actual evapotranspiration, soil moisture deficit, and soil moisture surplus (i.e. runoff and groundwater recharge). To differentiate the groundwater recharge component from the surplus, an equation for Groundwater Recharge Potential has been developed and applied. Figure 14 is a flowchart showing how the water surplus (i.e. groundwater recharge and surface water runoff) is calculated.

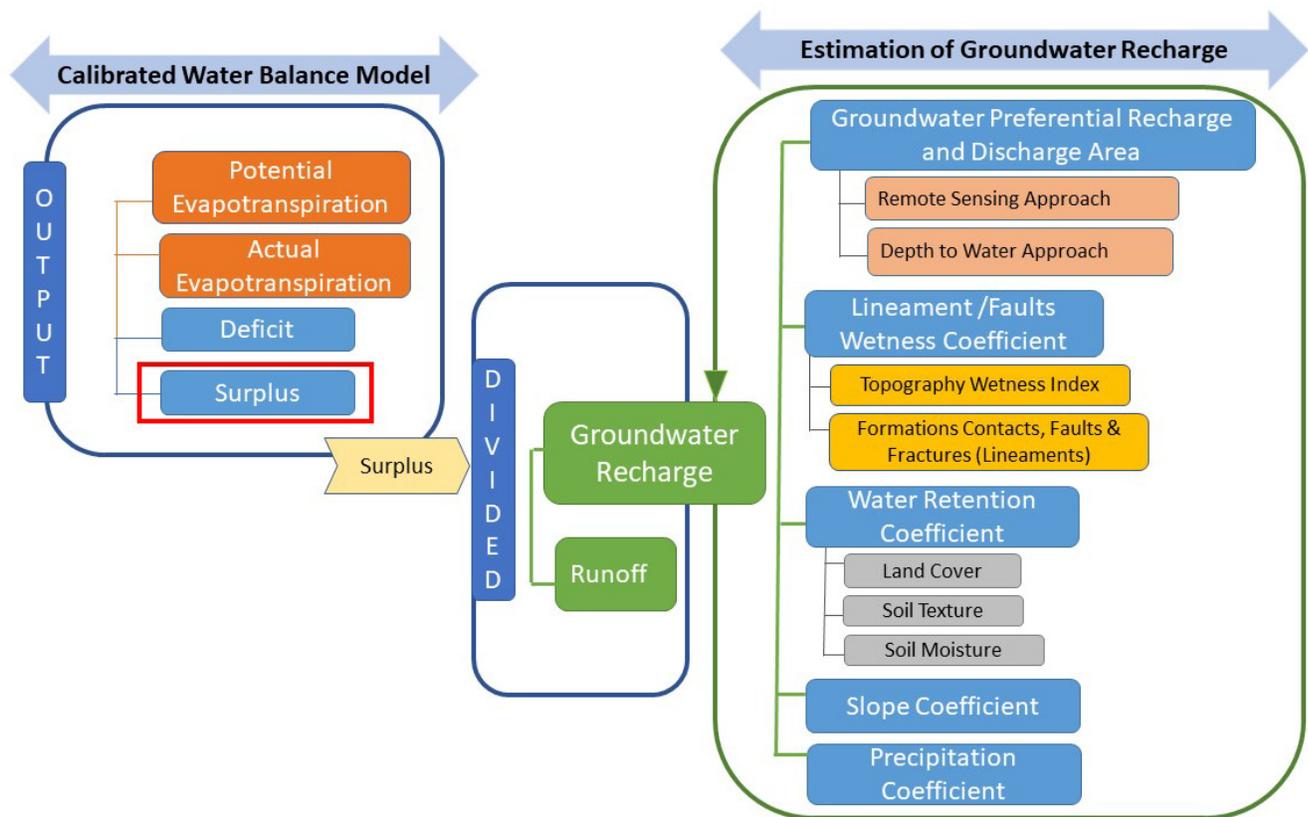
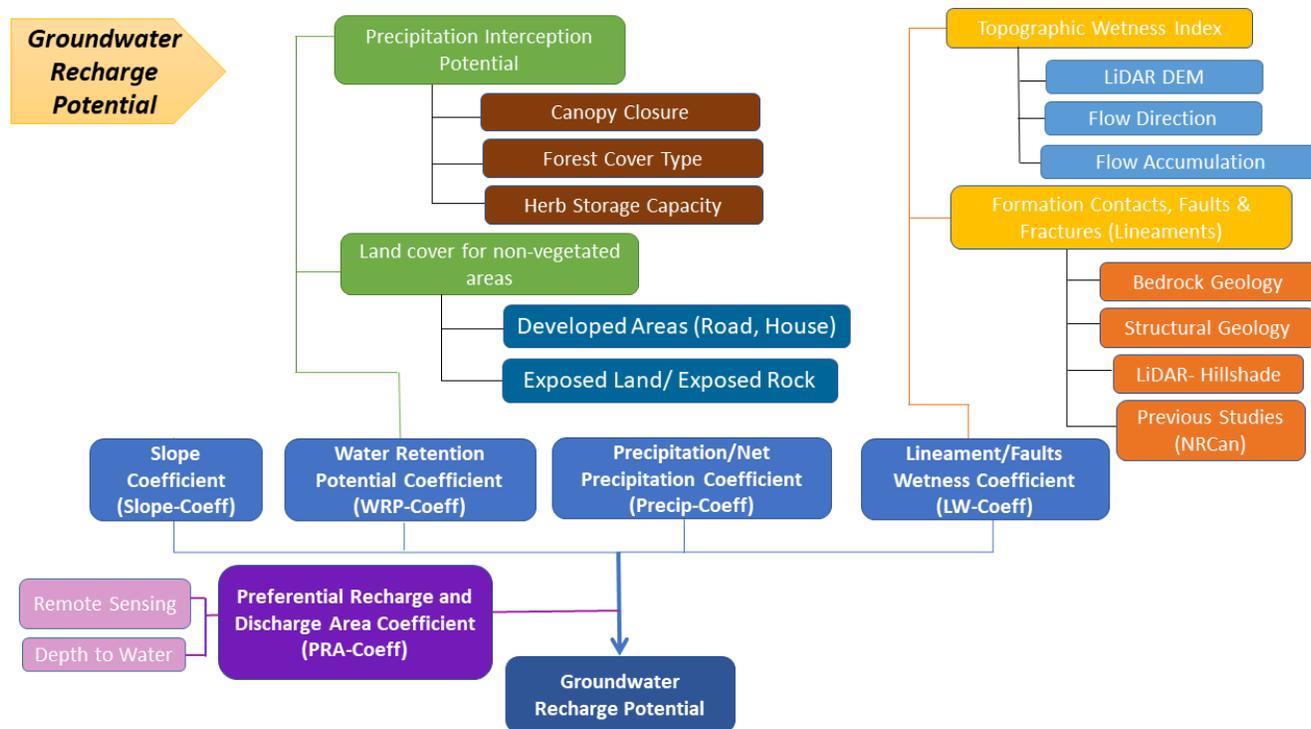


Figure 14. A flowchart presenting a differentiating the groundwater recharge component from surplus

### 5.2.1 Groundwater Recharge Potential

GW Solutions on behalf of Island Trust has developed a GIS-based methodology that incorporates diffuse and localized recharge pathways to estimate the spatial variability of recharge potential. The method uses infiltration/groundwater recharge coefficients for each of the spatial variables controlling recharge. Figure 15 is a flowchart for the integration of data inputs to estimate the groundwater recharge potential.

Groundwater recharge is the process whereby water moves from precipitation to the subsurface and consequently to replenish aquifers. Groundwater recharge is dependent upon factors such as the amount of precipitation (snow/rain), land surface slope (topography), the amount of water interception by plants (water retention or water used by plants), evaporation of open water or water on the land surface, and the permeability of the soil and subsurface geologic formations. Each of these factors is assigned an appropriate weighting factor in the calculation of recharge potential. Weighting factors were determined based on previous studies and predominant factors influencing groundwater recharge observed across Vancouver Island.



**Figure 15. A flowchart showing the integration of data inputs to estimate the groundwater recharge potential**

The following datasets or layers of information were used for groundwater recharge mapping and recharge estimation:

Slope Factor

Topography greatly influences the potential for water infiltration to the subsurface. In groundwater recharge areas, low slopes promote infiltration whereas steep slopes promote runoff and decreased infiltration.

LiDAR at 1-meter resolution as well as a 1-meter Digital Elevation Model (DEM) were downloaded from BC LiDAR and processed by GW Solutions. Slope was derived from the 1-meter DEM previously processed from LiDAR imagery.

### Water Retention Potential (WRP) Factor

GW Solutions used vegetation effects and land cover data into a Water Retention Potential coefficient.

#### *a) Precipitation Interception Potential*

Vegetation affects groundwater recharge through the interception of precipitation by the foliage (i.e., evapotranspiration); Greater foliage interception leads to longer exposure to the atmosphere and increased evaporation. The Islands Trust recently investigated the role of soil and vegetation on precipitation, producing a precipitation interception potential map. The map was developed as follows:

- A literature review to determine which vegetation characteristics contribute significantly to precipitation interception.
- The Vegetation Resource Inventory (VRI) available for the Islands Trust region was correlated with vegetation interception characteristics.
- A weighting scheme was developed, based on the literature review, that assigns a relative importance of relevant VRI attributes that impact precipitation interception.
- The variables that have been considered for quantifying and mapping of precipitation interception include 1) Canopy Closure, 2) Forest Cover Type, and 3) Herb Storage Capacity. Each of the variables of interception were assigned a weight describing their relative importance to rainfall interception.
- VRI attributes were processed in GIS; assigned weighting values were used to create a surface representing precipitation interception potential for the Islands Trust area.

#### *b) Land Cover/Land Surface*

For non vegetated areas (exposed rock and developed areas), GW Solutions used NRCAN circa 2000 Land Cover vector polygons to derive land cover classes.

### Bedrock geology; faults, lineaments and bedrock formation contacts

Groundwater in bedrock aquifers is mostly stored and transmitted in fractures and faults, which are largely controlled by regional bedrock lineaments (Surrett et. al., 2008; Allen et. al., 2002). Groundwater is also preferentially recharged via bedrock lineaments, however quantifying the role of each lineament is highly complex.

Detailed mapping of the landscape is now possible due to the availability of LiDAR imagery. The LiDAR imagery is processed to derive a “bare earth” model of the landscape, which can reveal subtle structures (bedrock faults, bedding planes and lineaments) not visible from the ground. We have delineated fracture zones using the following sources of information:

- 1- LiDAR with 1m resolution was obtained from LiDAR BC; Bedrock lineaments were digitized from a high-resolution hillshade
- 2- Bedrock geology maps of formation contacts and large-scale structural geology (faults and folds).
- 3- Lineament maps produced by NRCan, which have been reviewed and revised based on the LiDAR-1m.

The lineation is considered to be potential groundwater recharge pathways in the recharge zones and groundwater discharge pathways in the discharge zones.

### Topographic Wetness Index

GW Solutions generated the Topographic Wetness Index (TWI) using the 1-metre LiDAR. The TWI is commonly used to assess topographic effects on hydrologic processes. TWI is a function of the slope and the upstream contributing area. Large values of TWI are typically associated with low slopes (i.e. valleys or flat lowlands) and large catchment areas.

### Precipitation

Annual total precipitation gridded data were obtained from the Pacific Climate Impact Consortium (PCIC, 2020). The information corresponds to normal data for the 1981-2010 period. Total annual normal precipitation varies across the study area from 880 to 1033 mm.

### Preferential Groundwater Recharge and Discharge Areas

Groundwater recharge mainly occurs where the water table is deeper below the land surface and the soils are sufficiently permeable or “well-drained” to allow infiltration. The areas where the water table is shallow, intercepts the land surface (e.g. springs) and where groundwater feeds wet areas (e.g., creeks, lakes, wetlands) are known as groundwater discharge areas.

Groundwater recharge is typically characterized by the downward movement of groundwater while groundwater discharge is defined as the upward movement of groundwater to the land surface. Groundwater discharge areas are typically located in topographic lows such as stream valleys providing seasonal or year-round discharge (a.k.a. baseflow) to streams, or feeding lakes, wetlands, and estuaries. In contrast, groundwater recharge typically occurs in upland areas where precipitation rates are high and evapotranspiration is low, leading to high amounts of surplus (runoff and recharge).

Many approaches have been proposed for estimating the presence of preferential areas for groundwater discharge and recharge, using a variety of data sources. GW solutions reviewed several academic and public-sector methodologies to select methods for defining and delineating groundwater discharge and recharge potential areas that could be applied to the study area. Two approaches were selected:

- Interpreted depth to groundwater (inferred from the BC GWells database, and Salt Spring Island Leapfrog modelling).
- Remote sensing, satellite-based multispectral image analysis (from the Sentinel satellite mission 20x20 meter resolution)

These selected approaches and their applications are explained as follow:

a) *Depth to Groundwater Methodology*

The depth to groundwater is a dominant control of groundwater recharge across the Salt Spring Island. Previous studies have shown that the depth of water table has a significant role in controlling groundwater recharge rate. Despite surficial conditions that are suitable for groundwater infiltration, a shallow water table limits the amount of water that can infiltrate underground.

When a sufficient number of water level measurements are available in a given area, the depth of the water table is derived from the differentiation of elevation of the ground surface and groundwater elevation surface. We use the terminology “average interpreted groundwater elevation” and “depth to water” to describe the potential for groundwater recharge. For instance, if the groundwater level is above the ground surface, it will limit groundwater recharge and indicate mostly groundwater discharge is occurring. The opposite condition will occur when the groundwater level is below ground and groundwater recharge is the dominant process.

$$\text{Average Interpreted Depth to Water} = \text{Ground Surface Elevation} - \text{Average Interpreted Groundwater Elevation}$$

The Average Interpreted Groundwater Elevation surfaces were interpolated from classified groundwater elevation points derived from the Average Interpreted Depth to Water from BC Government’s GWELLS and the locations of known springs from surface water licences. Springs are locations where groundwater discharges to the land surface.

Using a Leapfrog 3-D model developed for Salt Spring Island, a surface of groundwater elevation (Groundwater Elevation Grids) was created then exported into QGIS as a raster file. The Average Interpreted Piezometric Level is the average water level in water wells. The Average Interpreted Depth to Water was generated by subtracting the Average Interpreted Groundwater Elevation from the Land Surface Elevation (DEM) using QGIS.

According to active monitoring wells across Salt Spring Island (e.g. PGOWN and SSI Island Trust community well network), the water table elevation can fluctuate by several meters over the year; groundwater levels are closer to the ground surface in winter and deeper in late summer/early fall. This leads to areas with *temporary groundwater discharge*, especially in the spring or after major rain events, yet these areas are groundwater recharge areas for the remainder of the year. For example, this could include areas at high elevation (i.e. Mount Belcher) where wells periodically exhibit artesian conditions.

For this study, all areas with either permanent or temporary groundwater discharge were classified as groundwater discharge areas. Areas where the range of groundwater fluctuations is always above the water table were classified as groundwater recharge areas.

#### *b) Remote Sensing/ Satellite Multispectral Image Analysis Methodology*

The approach of using satellite multispectral image analysis includes application of the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Moisture Index (NDMI). This method was chosen due to its ease of implementation, reliance on free and publicly available data, and accuracy in identifying soil moisture levels on the landscape. Soil moisture level is then used as a proxy for groundwater discharge potential.

The method focuses on identifying areas of potential groundwater discharge by using the spectral signatures of soil moisture and green vegetation. High perennial (year-round) soil moisture can darken soils or encourages green vegetation to flourish in otherwise dry climatic conditions. Such indications of landscape “wetness” and “greenness” are thus indications of potential groundwater discharge, and can be isolated from the rest of the landscape using satellite-based spectral indices.

A *spectral index* can be understood as a mathematical manipulation of certain wavelengths of detectable light that are designed to highlight characteristics of the landscape, such as greenness or wetness, while minimizing other confounding effects. A vast number of spectral indices have been defined for various scenarios. The NDVI (Normalized Difference Vegetation Index) and the NDMI (Normalized Difference Moisture Index) are both well-known and widely used indices that have been applied to a broad variety of applications for detecting landscape wetness or vegetation.

The NDVI is designed to highlight the presence of dense, green vegetation, or “greenness”, while the NDMI is designed to highlight the level of moisture within vegetation or soil, defined as “wetness”. By comparing landscape “greenness” and “wetness” between the wet season and the dry, it is possible to observe which areas of the landscape *preserve* their wetness and greenness through the wet and into the dry season. Such areas indicate either direct groundwater discharge (e.g., spring, wetland, lake) or a shallow water table allowing the survival of phreatophyte (groundwater dependent) vegetation. Comparisons between the wet and dry seasons are critical since the method relies on isolating the *persistence* of wetness between seasons.

Implementing this method required multispectral satellite images for the wet and dry season over the study area. These images were available free of charge from both the Landsat and the Sentinel satellite missions. Data from the sentinel mission was preferred due to its higher spatial and spectral resolution compared to Landsat.

#### *C) Preferential recharge/discharge areas (PRDA)*

The *Depth to Water* and *NDVI-NDMI* methods were selected as inputs to estimate the spatial variability of recharge/discharge potential. Both these methods could be implemented with the available data, and their respective results matched well.

Based on the groundwater discharge probability maps, an attribute ratings system has been developed to assign specific values to each groundwater discharge/recharge probability group. Table 6 presents the assigned groundwater recharge coefficients based on the discharge/recharge probabilities.

The areas of low probability of groundwater discharge (low-medium, low, very low), are the preferential areas for groundwater recharge.

**Table 6. Groundwater recharge potential coefficient based on the probability of groundwater discharge.**

Groundwater Recharge Potential	Probability of Groundwater Discharge Area	Groundwater Recharge coefficient
Very Low	High probability	0.1
Moderate	Medium probability	0.3
Moderately High	Low-Medium probability	0.7
High	Low probability	0.9
Very High	Very Low probability	1

### 5.2.2 Calculation of groundwater recharge potential

GW Solutions has used the following equation (Equation 1) to estimate the groundwater recharge potential.

Within the study area, the groundwater flow system is in both bedrock and overburden media, thus the sum of slope, soil and land cover, precipitation coefficients, and also geological structure coefficient (e.g. faults, geologic contacts) determine the areas of high potential groundwater recharge.

$$\text{Equation 1) } RP = R_{PRDA} [30\%*(R_{WRP}) + 20\%*((R_{\text{slope}}) + 25\%*(R_{LW}) + 25\%*(R_{\text{precipitation}})]$$

Where:

RP= Recharge potential (0 - 1)

R<sub>PRDA</sub>= Preferential recharge/discharge areas Factor (0.1-1)

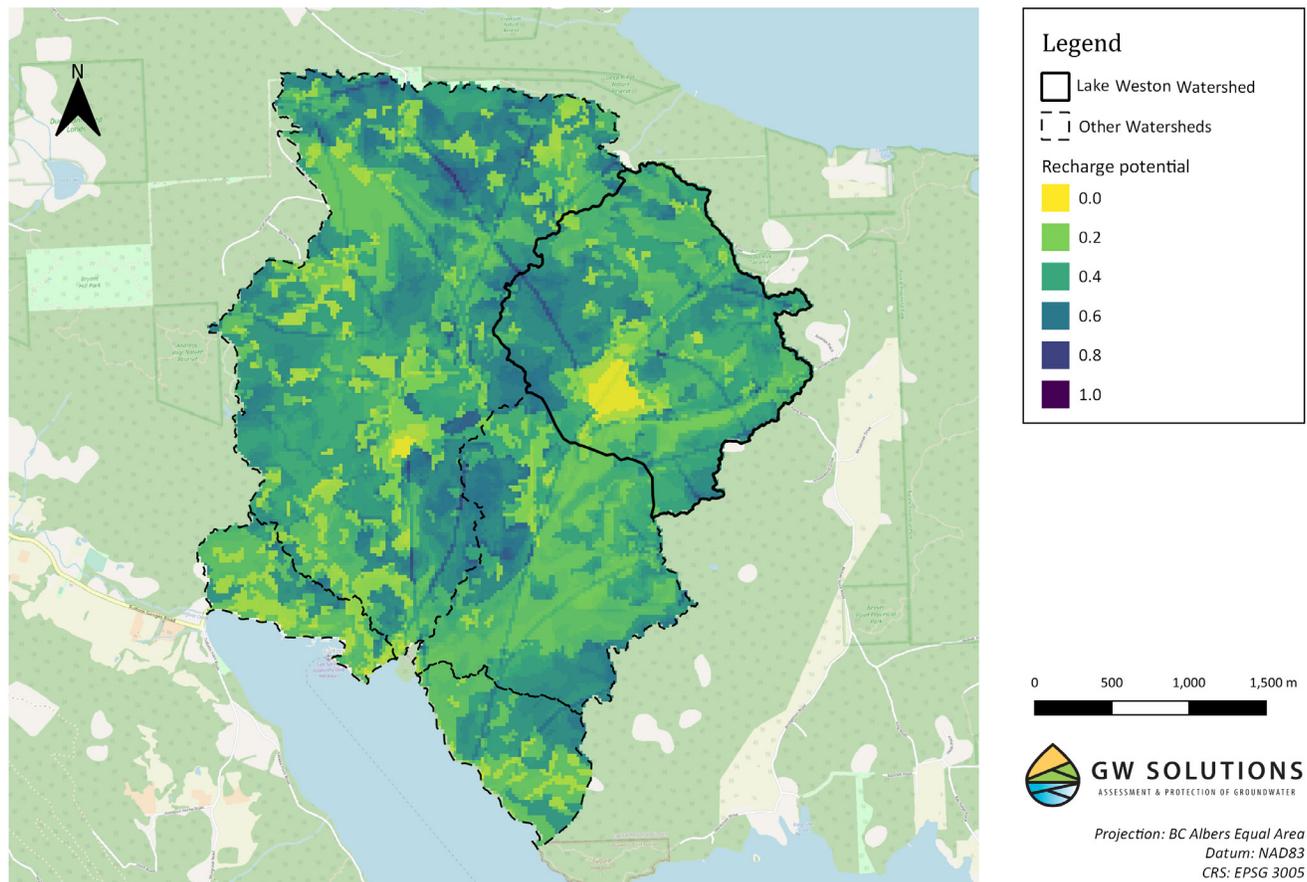
R<sub>WRP</sub> = Water Retention Potential Factor (0.1 – 0.3)

R<sub>slope</sub> = Slope Factor (0.03 – 2.0)

R<sub>LW</sub> = Bedrock Lineaments Wetness Factor (0.1 – 0.25)

R<sub>precipitation</sub> = Precipitation Factor (0.1 – 0.25)

Appendix 2 provides the maps for all groundwater recharge coefficients. Figure 16 presents the resulting map for the integrated groundwater recharge potential.



**Figure 16: Groundwater recharge potential map for the study region**

### 5.3 Sensitivity Analysis

The Sensitivity Analysis for the water balance analysis consisted of evaluating twelve scenarios which represent the range of possible variations for the following input parameters:

- Precipitation
- AWHC Available Water Holding Capacity (water available to vegetation)
- Solar Radiation
- Temperature

The scenarios, listed in Table 7, are designed to vary the inputs by either + or -15% from normal (i.e. long-term average). Precipitation was also varied by the most extreme values ever recorded (lowest and highest) at meteorologic station 235 (Victoria International Airport). Solar radiation was also varied for only the summer months when values are the highest.

**Table 7. Scenarios for Water Balance Sensitivity Analysis**

Parameter	Scenario
AWHC	-15% from normal
AWHC	+15% from normal
Precipitation	-15% from normal
Precipitation	+15% from normal
Precipitation	Driest condition experienced in 1985
Precipitation	Wettest condition experienced in 1997
Solar radiation	summer months +15% from normal
Solar radiation	summer months -15% from normal
Solar radiation	all months +15% from normal
Solar radiation	all months -15% from normal
Temperature	+15% from normal
Temperature	-15% from normal

The results, summarized in Figure 17., show that for the study area the most sensitive input parameter is precipitation affecting the surplus estimates by -50% to +87%. The remaining input parameters affect recharge by less than 5%. This highlights the importance of collecting more complete precipitation data over the entire watershed to reduce the uncertainty of this parameter.

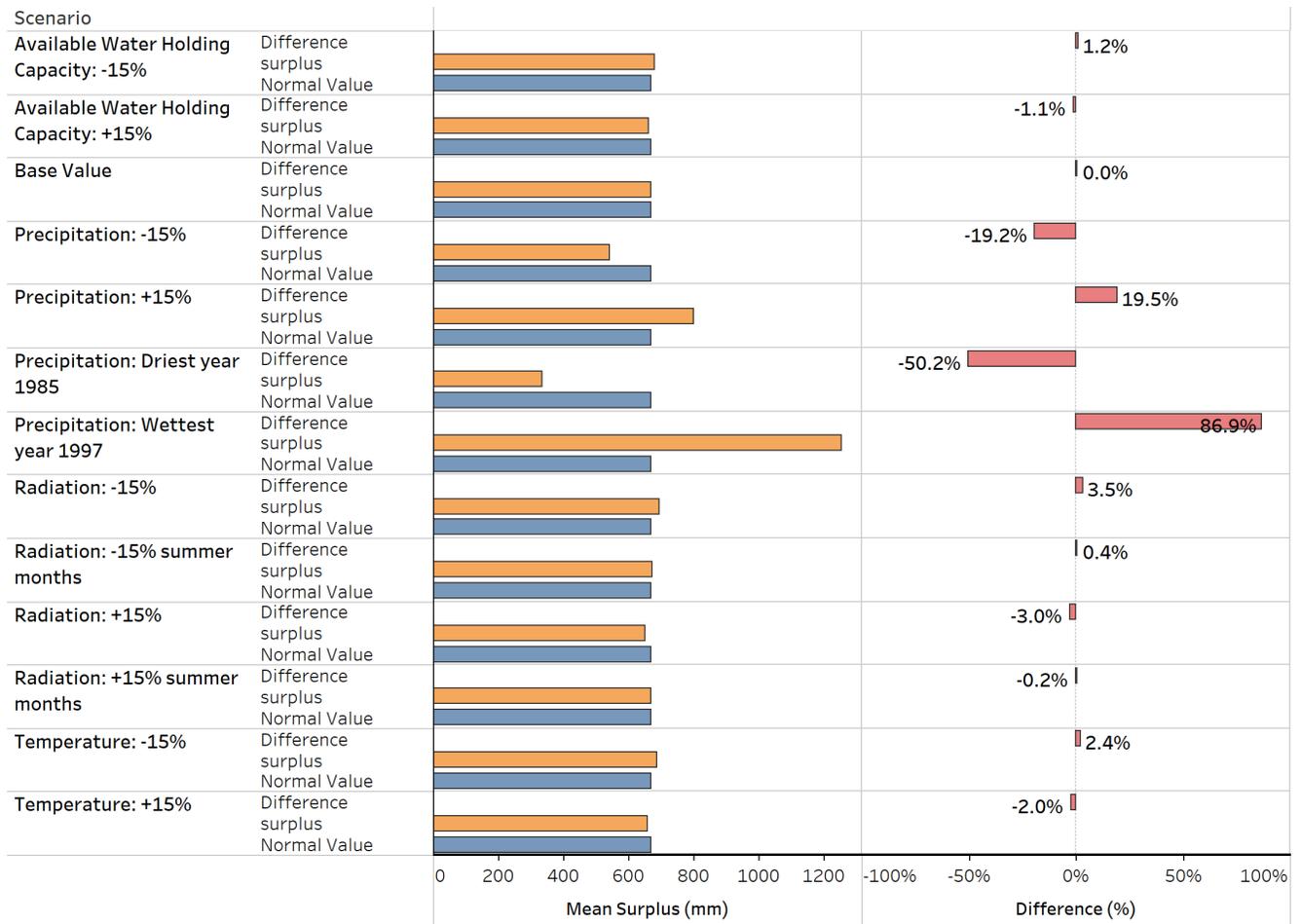


Figure 17. Results of Sensitivity Analysis to water balance inputs

## 6 CLIMATE CHANGE ASSESSMENT

### 6.1 Impacts of Climate Change on Freshwater Resources

Over the past 50 years, the amount of rain falling during very heavy precipitation events has increased for much of the world as the amount of rain falling during the most intense 1% of storms has increased as much as 30%. Warming winter temperatures cause more precipitation to fall as rain rather than snow. Furthermore, rising temperatures cause snow to begin melting earlier in the year. This alters the timing of streamflow in rivers that have their sources in mountainous areas.

Alterations in the seasonal timing, type (rain versus snow) and amount of precipitation in a certain area effects the entire freshwater cycle. Shorter and more intense rainy seasons increase surface water runoff and decrease groundwater recharge leading to a lowering of the water table and less groundwater discharge to groundwater dependent ecosystems (e.g., shallow aquifers, springs, creeks, rivers, lakes, wetlands, and estuaries). Thus, there is too much water in the winter and too little water in the summer.

Climate change is probably one of the most challenging pressures facing freshwater resources. Climate change is expected to produce reductions in freshwater availability in the future. The key change associated with global warming is an increase in near-surface air temperature which has profound negative impacts on the global water cycle affecting all freshwater systems. The increase in surface temperature leads to several changes to freshwater resources, as described below, in Table 8.

**Table 8: Climate change impacts on water resources**

Climate impact	Description
Decreased Snowpack	Decreased snowpack can significantly impact dry-season water availability. If precipitation falls as rain instead of snow, then groundwater recharge occurs throughout the winter instead of the usual pattern of a spring groundwater recharge event. The spring recharge event helps maintain a high water table at the beginning of summer when precipitation is reduced and water levels in general are at their lowest. Continued recharge through the winter results in a shift in peak river runoff to winter/early spring, away from late spring/summer (when water demand is often highest) thus leading to drier or potentially drought-like conditions in late summer/autumn.
Higher Evapotranspiration	Higher evaporation (from all surfaces, soils, and water bodies) and higher transpiration occur due to an increase in temperature, leaving less water to infiltrate into the soil and causing a reduction in groundwater recharge.

Climate impact	Description
Higher Intensity Rainfall Events	When the atmospheric temperature is warmer, particularly during the summer months, the increased evapotranspiration causes precipitation events to tend to occur as high-volume, high-intensity events, especially during winter months. Sporadic, high intensity rainfall – rather than low-volume, temporally distributed rainfall – tends to produce a large amount of surface runoff (soil erosion, flooding) but very little groundwater recharge as there is a limit to the amount of water that can infiltrate in most soils at any given time, based on the soil’s “field capacity”.
Degradation of Water Quality	Decreased groundwater recharge or increased sporadicity in the timing of recharge can lead to a reduced amount of freshwater to dilute water contamination (e.g., saltwater intrusion, nitrogen/phosphorous from septic systems leading to algal blooms, acid mine drainage), especially during the dry summer months. This can result in increased concentrations of harmful substances in the water (water pollution), negatively affecting aquatic ecosystems, and undermine the health and sustainability of groundwater and groundwater-dependent ecosystem. These reduced-flow conditions may also result in the accumulation of water-borne contaminants at water supply intakes being used by humans and animals, and the deterioration of lakes and rivers often used for recreational purposes. Changes in hydrological and thermal regimes may further increase the risk of disease outbreaks in aquatic systems, impact eutrophication, create hypoxic and dead zones, as well as lead to community transitions that alter ecosystem structure and function.

## 6.2 Projected Climate Change for the Capital Regional District

The 2017 report Climate Projections for the Capital Regional District (CRD) uses current climate model outcomes to provide a “best estimate” snapshot of how climate change will unfold across the CRD over the coming decades. All models project daytime high and nighttime low temperatures to rise. While temperature can be expected to increase year-round, the greatest increases will occur in the summer months. Monthly high and low temperatures show that the “new normal” for the region may be very unlike the past. Rising temperatures will lead to hotter summer days and nights, milder winters with the near loss of frost days and snowpack in all but the highest elevations. There will be a modest increase in annual precipitation by the 2050s, though the increase in precipitation will be distributed unevenly over the seasons. The largest increases will occur in the fall season, while rain will decrease significantly in the summer months. Our region can expect stronger and more frequent extreme rainfall events, longer summer dry spells, and an extension of the dry season into September and October.

### 6.3 Model-Predicted Climate Change for the Next Decades

The impact of climate change to the water resources of the study region was analyzed using data from the ClimateBC data project (Wang et al., 2016), which provides statistically downscaled climate projection data across BC, based on a selection of models from the IPCC's most recent *Coupled Model Intercomparison Project* (CMIP6). The CMIP6 *Global Climate Models* (GCMs) aim to estimate the patterns of future climate change under different scenarios of climate "forcing". These scenarios are called "shared socio-economic pathways" (SSPs) and are meant to represent various possible socio-economic pathways that society could take to attend to climate change in the coming years (Riahi et. al., 2017). In the present analysis, 4 SSP scenarios have been considered, SSP 2.6, 4.5, 7.0 and 8.5 spanning the range from most optimistic (high rates of emission reduction and mitigation policies over the coming decade) to pessimistic (little to no climate change mitigation, leading to runaway climate change). Additionally, future climate change under each of these scenarios has been predicted for three time-periods – 2030, 2050, and 2070. Further details about climate models and input data selection are presented in Appendix 4.

Once data representing projected climate change for the 4 SSPs in the three future periods was obtained, we calculated future projected water budgets for each of these scenarios and compared the results to the current "normal" values observed in the past 30 years (1981-2010). The comparison was done spatially over the Lake Weston watershed as well as its adjacent watersheds. Model-predicted changes to the Lake Weston water budget are thus described for each climate variable followed by an interpretation of how these changes will impact water resources in the region.

The data is presented in two types of figures to show the predicted changes across the watershed for the major climate and water budget variables (temperature, precipitation, soil storage and moisture surplus). Charts are generated for every combination of projection years and SSP scenarios:

- charts for each variable by month, showing: the projected values, the absolute change in the value compared to present normals and the percentage change in the value compared to normal
- summary charts comparing the percentage change of all variables compared to normal ; and
- maps of Lake Weston and the surrounding watersheds showing the predicted amount of change for each variable and how it varies within each region

Figure 18 presents an example for summary charts comparing the percentage change of climate variables such as precipitation, temperature and radiation for different projection year compared to normals for SSP 8.5.

Figure 19 to Figure 21 show the spatial change of predicted climate variables comparing to normals for the projection year of 2050 for SSP 8.5.

Appendix 4 provides the summary charts and related maps for predicted climate variables and their comparison to normals for 4 SSP scenarios (SSP 2.6, 4.5, 7.0 and 8.5) and for three time-periods – 2030, 2050, and 2070.

The projected data from the 13-model ensemble predict a significant increase in precipitation during the winter, and a smaller yet still considerable increase in spring and fall precipitation. The magnitude of increase is greatest during the December to February period. The data also predict a decrease in summer precipitation. These patterns are consistent across all the SSP scenarios, and indeed the magnitude of these changes is higher the more pessimistic the SSP is.

Solar radiation is projected to increase during the summer months and decrease during the fall and spring periods, remaining relatively unchanged during the rest of the winter. Interestingly, the magnitude of change is projected to be the strongest within the 2030s period, suggesting that the most meaningful shifts in radiation patterns will happen within the next 2 decades. As with precipitation, the magnitude of change is higher with more pessimistic SSPs. Additionally, all SSPs and year periods seem to project a slight increase in radiation during March alone, amid an otherwise reduced-radiation Spring.

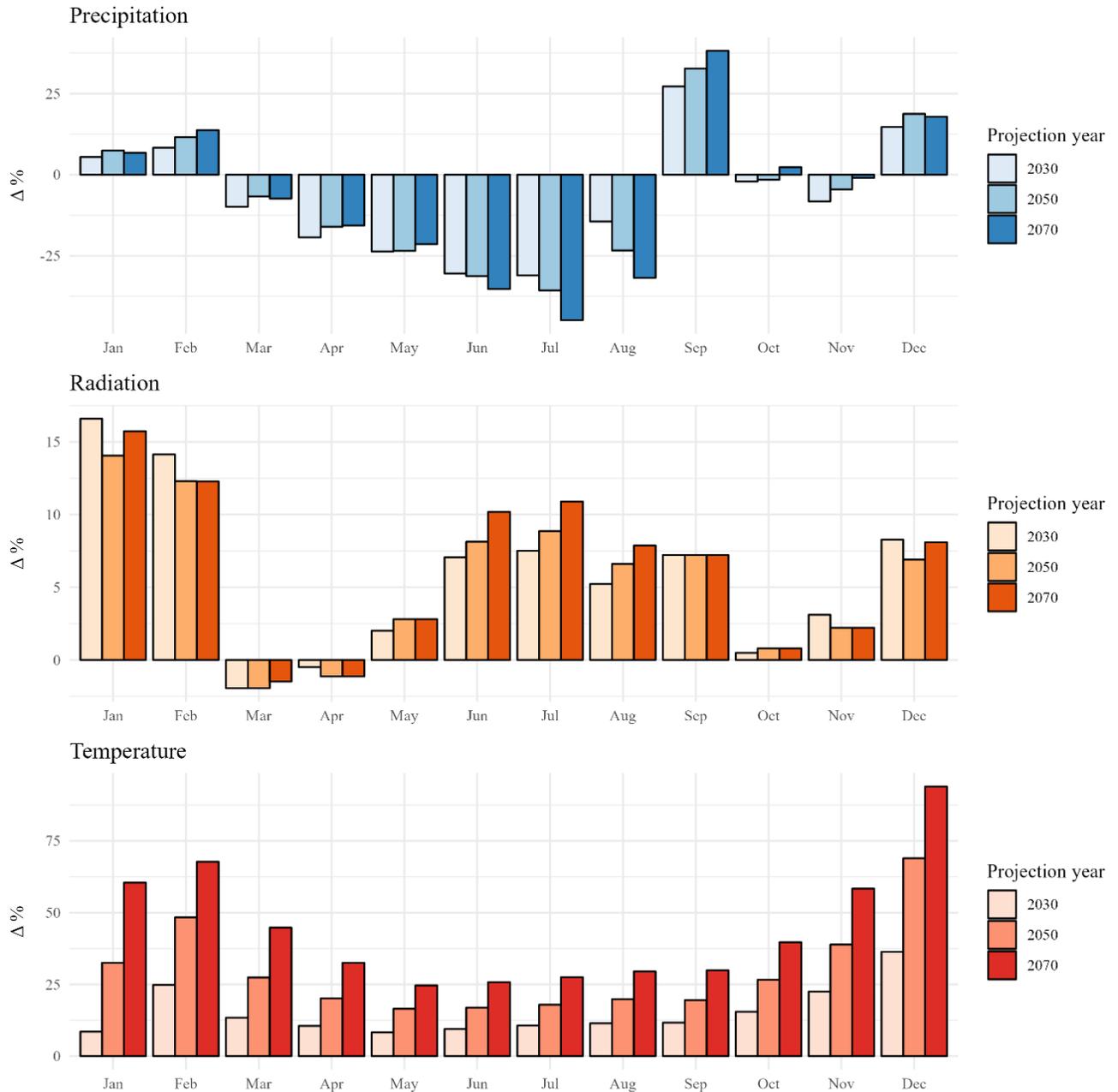
Average temperatures are projected to increase in all months for 2030, 2050 and 2070 across all SSP scenarios, with the highest increases being in July and August. Even under the most optimistic scenario (SSP 2.6), temperatures are projected to rise by nearly 2 degrees Celsius in July and August by 2070. In contrast, under SSP 8.5 the projected increase in July and August is nearly 5 degrees.

Available moisture surplus is projected to increase considerably during the winter months of December to February, while also increasingly slightly during the fall months of October and November. Additionally, surplus is projected to decrease during the spring period, especially in March. As with the others, the magnitude of these patterns is exacerbated under less optimistic SSPs.

These patterns are consistent with changes expected under climate change globally. Increasing temperatures, particularly during the summer months, combined with higher solar radiation and lower summer precipitation will mean a reduced potential for groundwater recharge during the summer. The current hydrological regime, however, already operates within a pattern of excess water during the winter months and low precipitation during the summer. The impact of climate change on this system appears to be a reduction in the available window or annual time-period for groundwater recharge.

Precipitation is projected to occur in higher magnitudes within a smaller time-period (primarily December to February). There is also an increase in precipitation during September which is attributed to rain events associated with the change in seasons from summer to fall weather patterns. This combined with reduced solar radiation during months leads to an excess of moisture surplus during the winter, increasing the possibility of flash flooding since the capacity for groundwater infiltration at any given time cannot be exceeded upon saturation. Furthermore, reduced precipitation and higher temperatures during the summer reduces the potential for groundwater recharge during the months when groundwater uptake is greatest. The projected decline in moisture surplus during March

illustrates a reducing temporal window within which moisture surplus can recharge aquifers. Overall, these patterns will adversely affect the sustainability of the groundwater system by leading to a pattern of excess water when it is not needed and water deficits during periods when it is necessary.



**Figure 18. Percentage change relative to climate normal, summarized by month for the Lake Weston watershed, SSP 8.5**

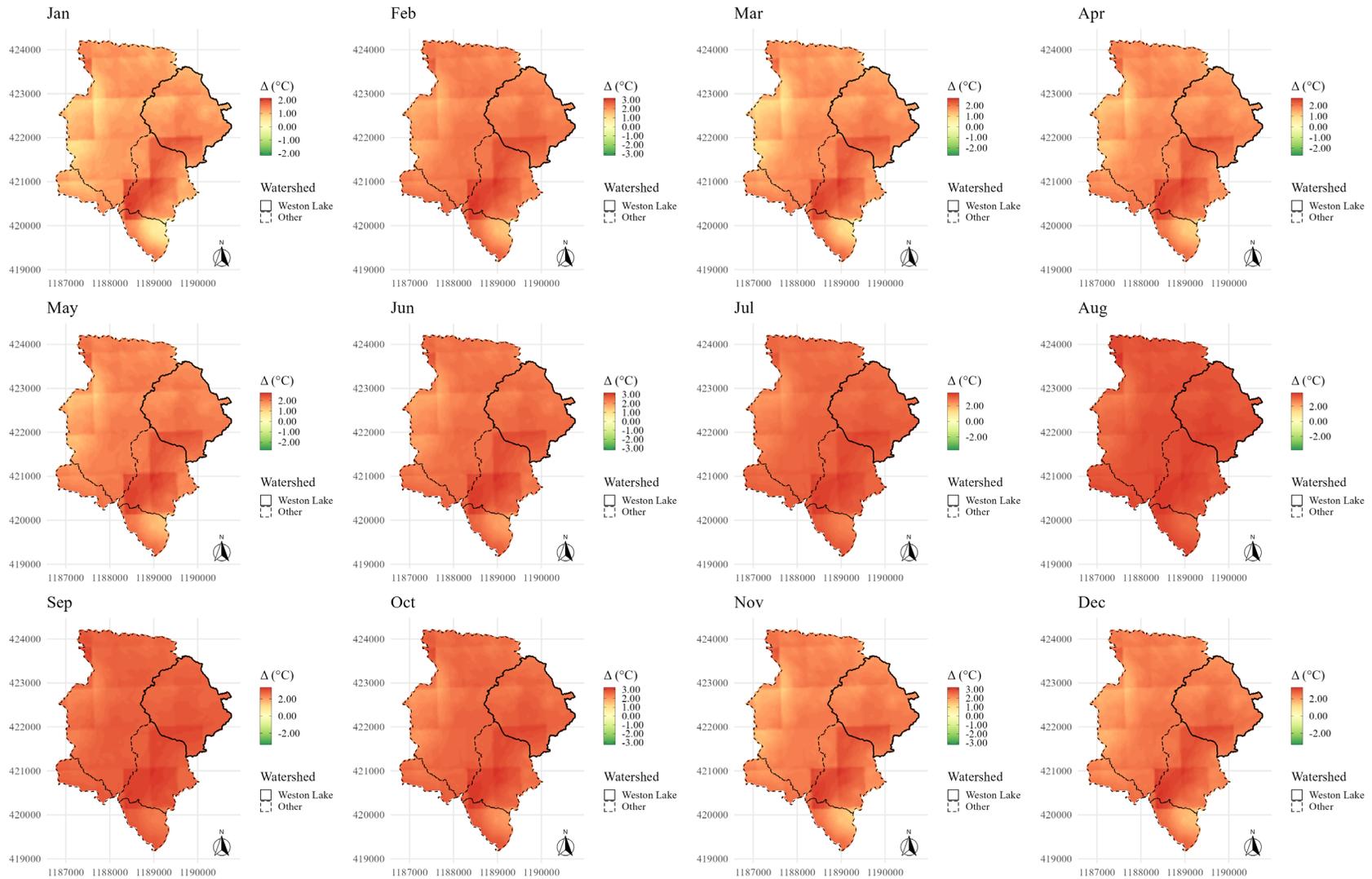


Figure 19: Monthly change in average temperature between year 2050 and present normals, SSP 8.5

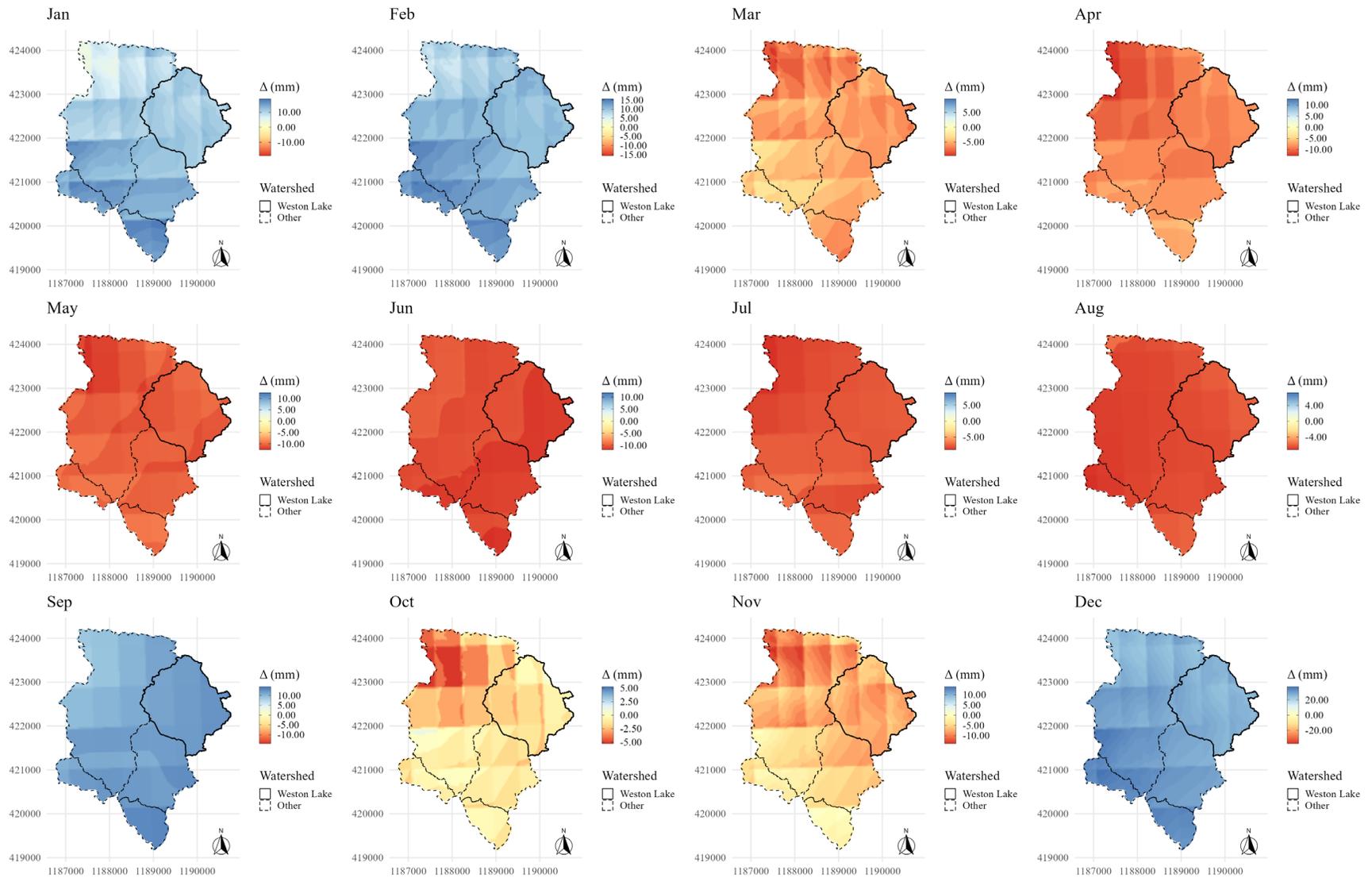


Figure 20: Monthly change in precipitation between year 2050 and present normals, SSP 8.5

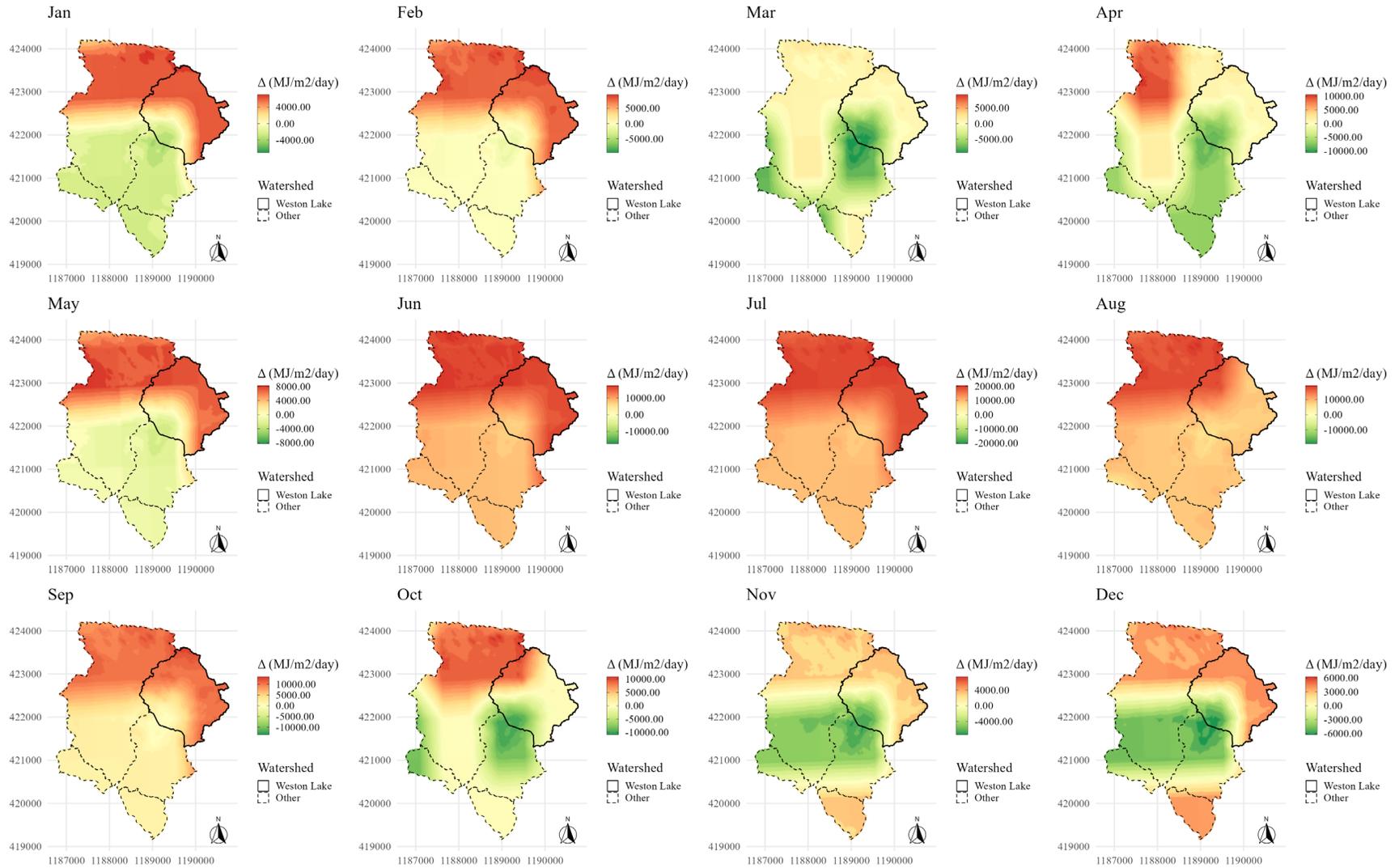


Figure 21: Monthly change in radiation between year 2050 and present climate normals, SSP 8.5

### 6.3.1 Temperature

Minimum, average, and maximum temperatures are projected to increase in all months for 2030, 2050 and 2070 across both modeled areas, with the largest increase in July and August.

### 6.3.2 Precipitation

Generally, the climate change model predicts a significant increase in precipitation for fall and winter (October to February), mostly as rain, and a slight increase in spring precipitation. The model also predicts a considerable decrease in precipitation in summer. Precipitation as rain therefore occurs over a shorter period (fall-winter) with more intense rainfall events thus leading to an increase in surface water runoff (increasing soil erosion and flood risk) and a decrease in groundwater recharge as the soil infiltration rate is limited as soils become saturated to their field capacity.

The largest increase in precipitation (during winter) and the largest decrease in precipitation (during summer) occurs at the higher elevations where most of the precipitation falls.

### 6.3.3 Solar Radiation

Solar radiation is projected to increase during the summer months and decrease during the late-winter, early-spring period, remaining relatively unchanged during the rest of the winter.

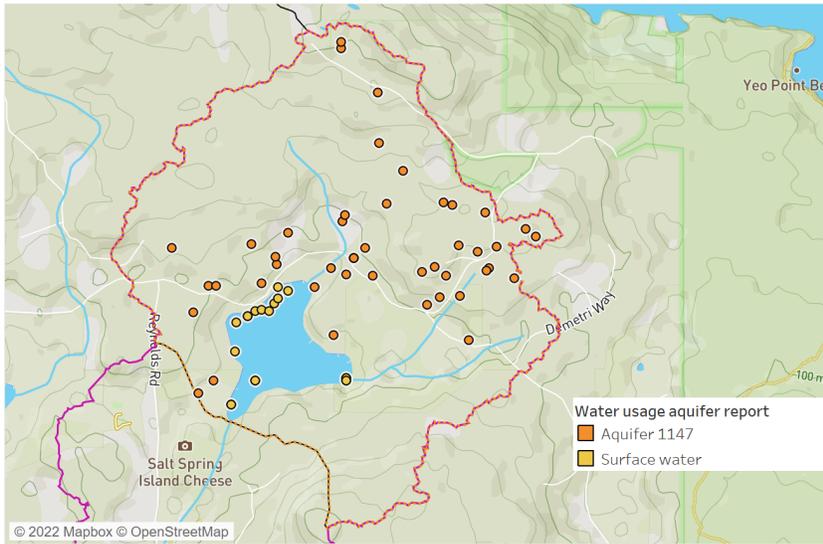
## 7 RESULTS ANALYSIS

### 7.1 Water Usage

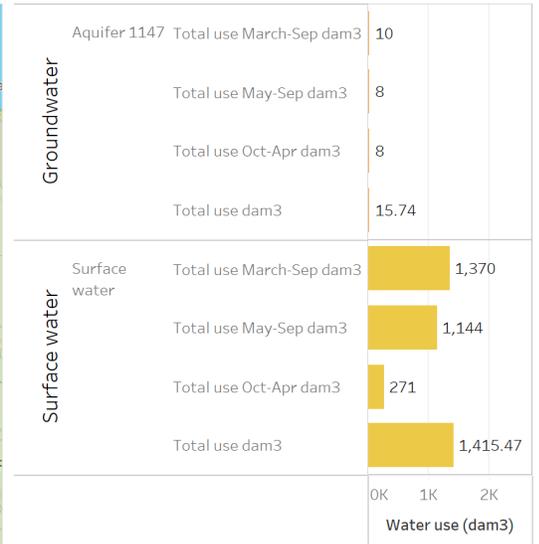
Water use is estimated in cubic decameters or  $\text{dam}^3$  (1,000  $\text{m}^3$  equals 1  $\text{dam}^3$ ) and presented for groundwater (Aquifer 1147) and Surface Water (Lake Weston). Figure 22 shows the results for the current estimated water usage including the fire protection licence. Figure 23 shows the seasonal usage for both surface water and groundwater resources without the fire protection licence.

The Lake Weston withdrawals are much larger than the groundwater withdrawals and the fire protection licence (institutional) water usage is by far the largest amount. Aside from the fire protection licence, the major water usage is for the Fulford Water System. It is noted the Fulford system usage increases significantly in July, August and September presumably due to household irrigation. There are also several private domestic water supplies taken and significant amount of water usage for irrigation taken from Lake Weston. Many residents within the study area obtain their domestic water from groundwater wells (15.74  $\text{dam}^3$ - aquifer 1147). It is also noted that the highest water usage from Lake Weston is the May-September period. This contrasts to groundwater usage which is similar in summer and winter.

Water Usage for Lake Weston



Total water usage by source and aquifer



Total water usage by source and aquifer in dam3

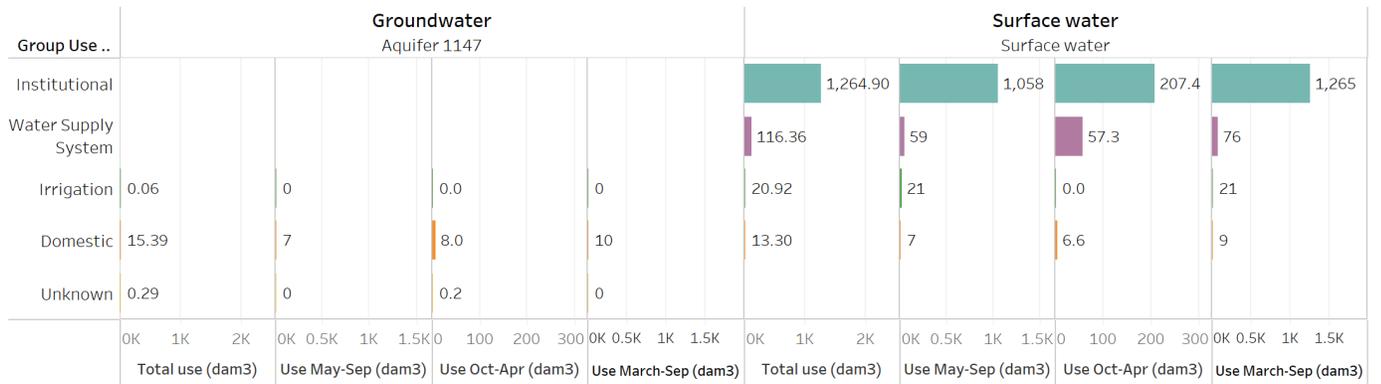
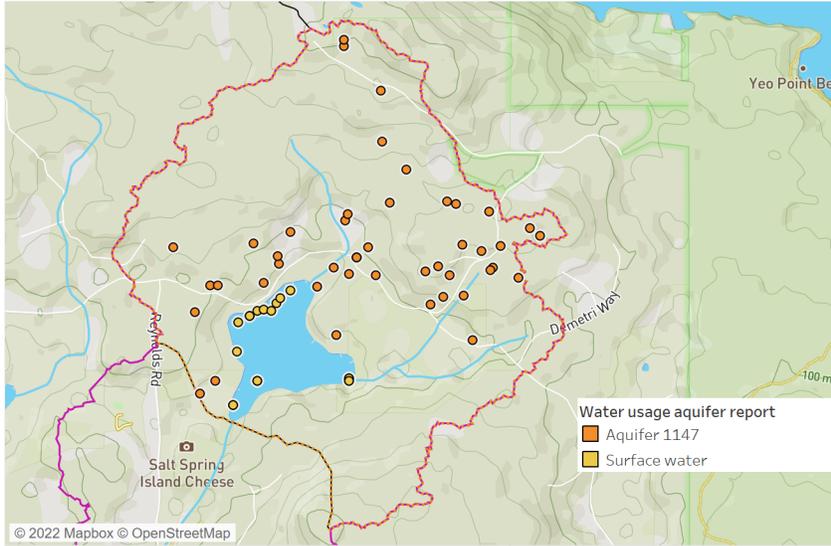
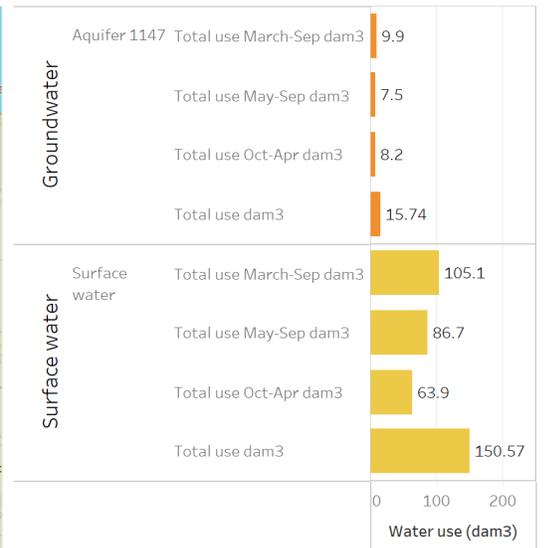


Figure 22. Total water usage by aquifer number and licenced surface water source (including fire protection licence)

Water Usage for Lake Weston



Total water usage by source and aquifer



Total water usage by source and aquifer in dam3

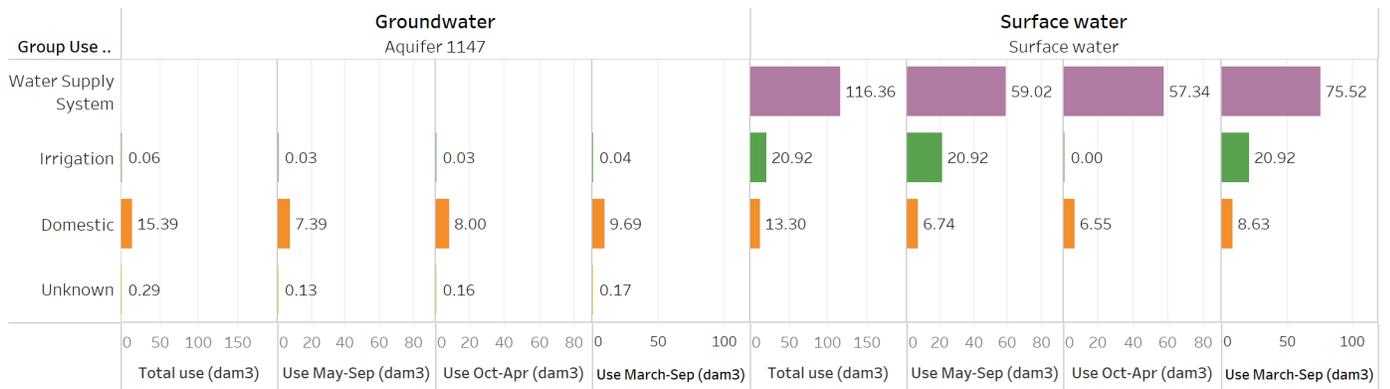


Figure 23. Total water usage by aquifer number and licenced surface water source (not including fire protection licence)

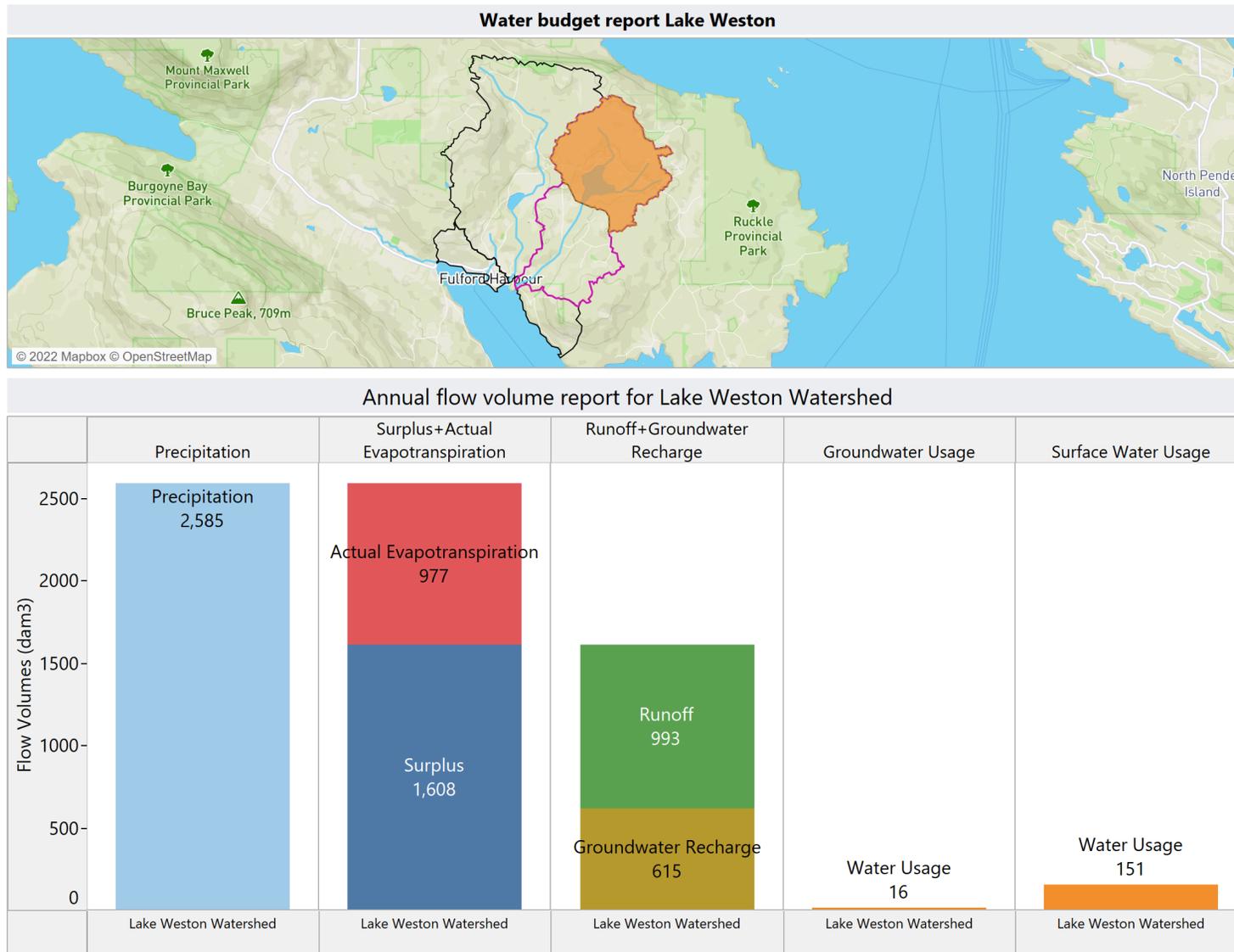
## 7.2 Watershed Budget

The groundwater surplus in a watershed is the difference between in the annual volumes of groundwater recharge and groundwater usage for a watershed or aquifer. This surplus groundwater is a major component of the water cycle and feeds springs, creeks, rivers, lakes, wetlands and coastal areas and is accounted for in B.C. as environmental flow needs (EFNs).

Figure 24 presents the water balance components for an entire year, including precipitation, evapotranspiration and water surplus (surface water runoff and groundwater recharge). On the usage side, it can be seen that groundwater usage ( $16 \text{ dam}^3$ ) is significantly less than surface water usage (Lake Weston  $151 \text{ dam}^3$ ) and both are significantly less than groundwater recharge ( $615 \text{ dam}^3$ ) which feed the groundwater and Lake Weston.

Figure 25 shows the seasonal water balance components (Wet: October to February and Dry: March to September). It is observed during the dry period (March to September) the water usage is larger than both runoff and groundwater recharge.

Figure 26. presents the average monthly water balance components and water usage for the study region. It can be seen the highest water usage is from April to September which also coincides with the period of little or no precipitation, groundwater recharge or runoff.



**Figure 24: Water balance components compared to water usage from groundwater and surface water (Fire protection licence not included).**

Annual flow volume report for Lake Weston Watershed

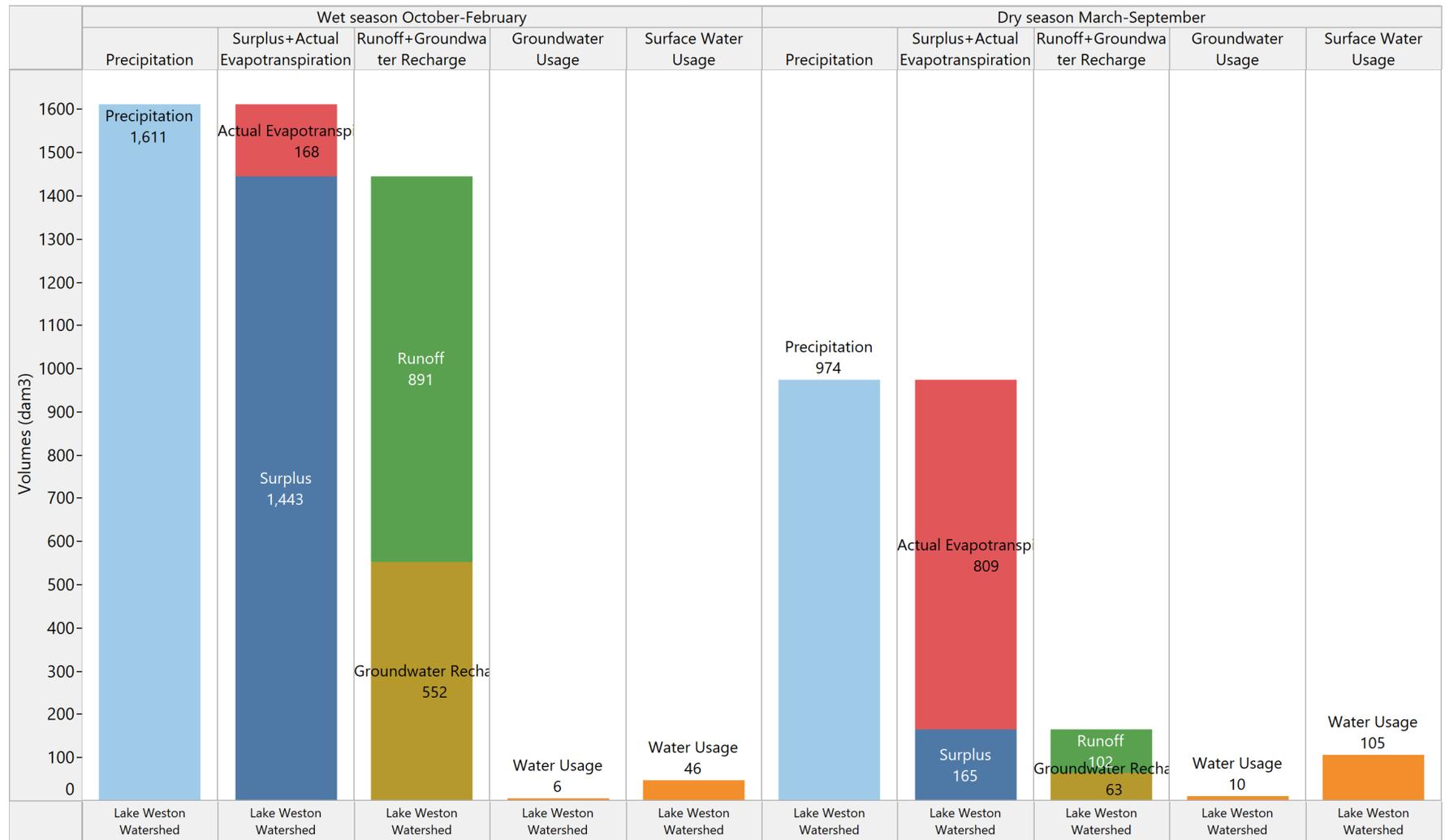


Figure 25. Annual water budget volumes for the wet season (Oct-Feb) and dry season (Mar-Sep) (Fire protection licence not included).

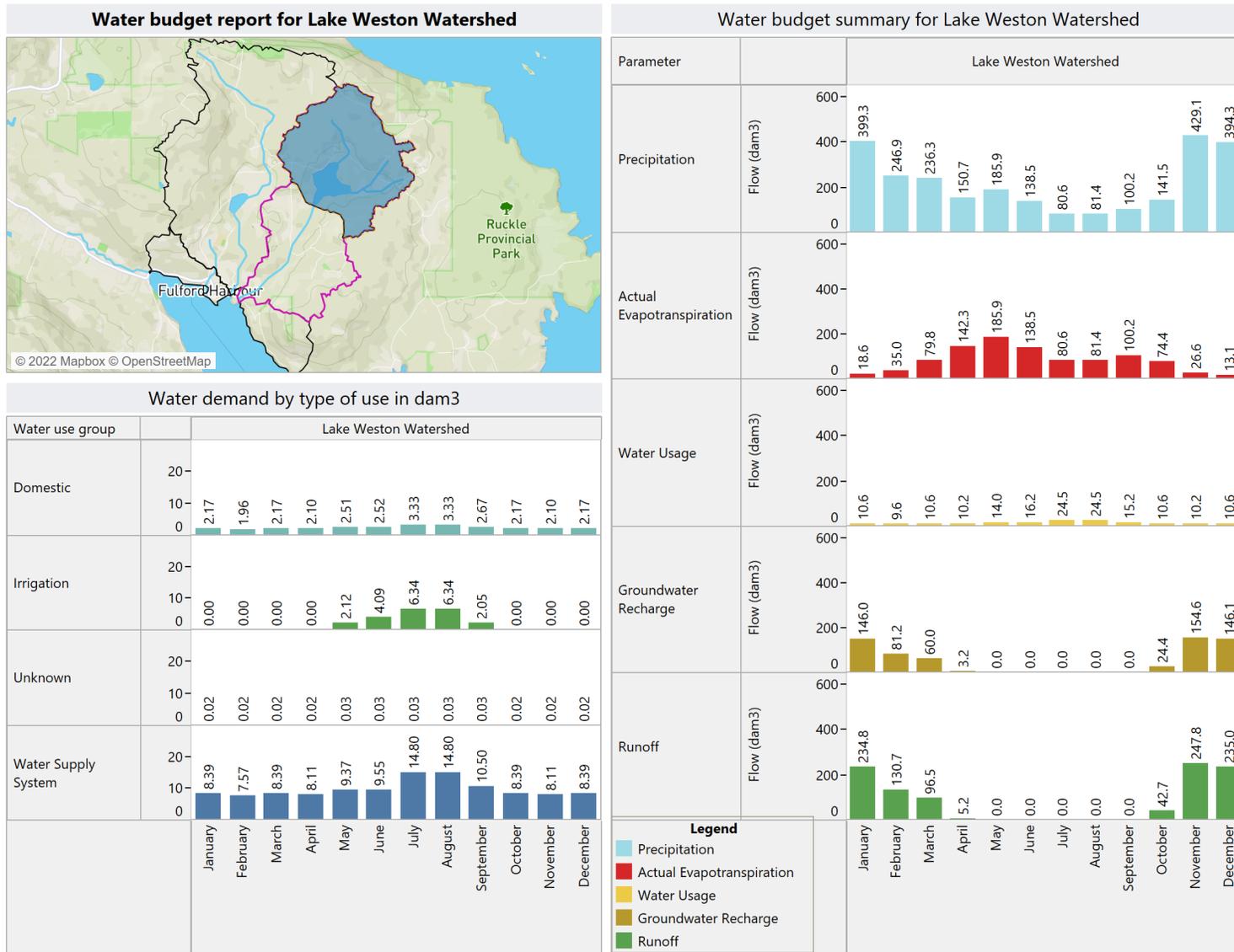
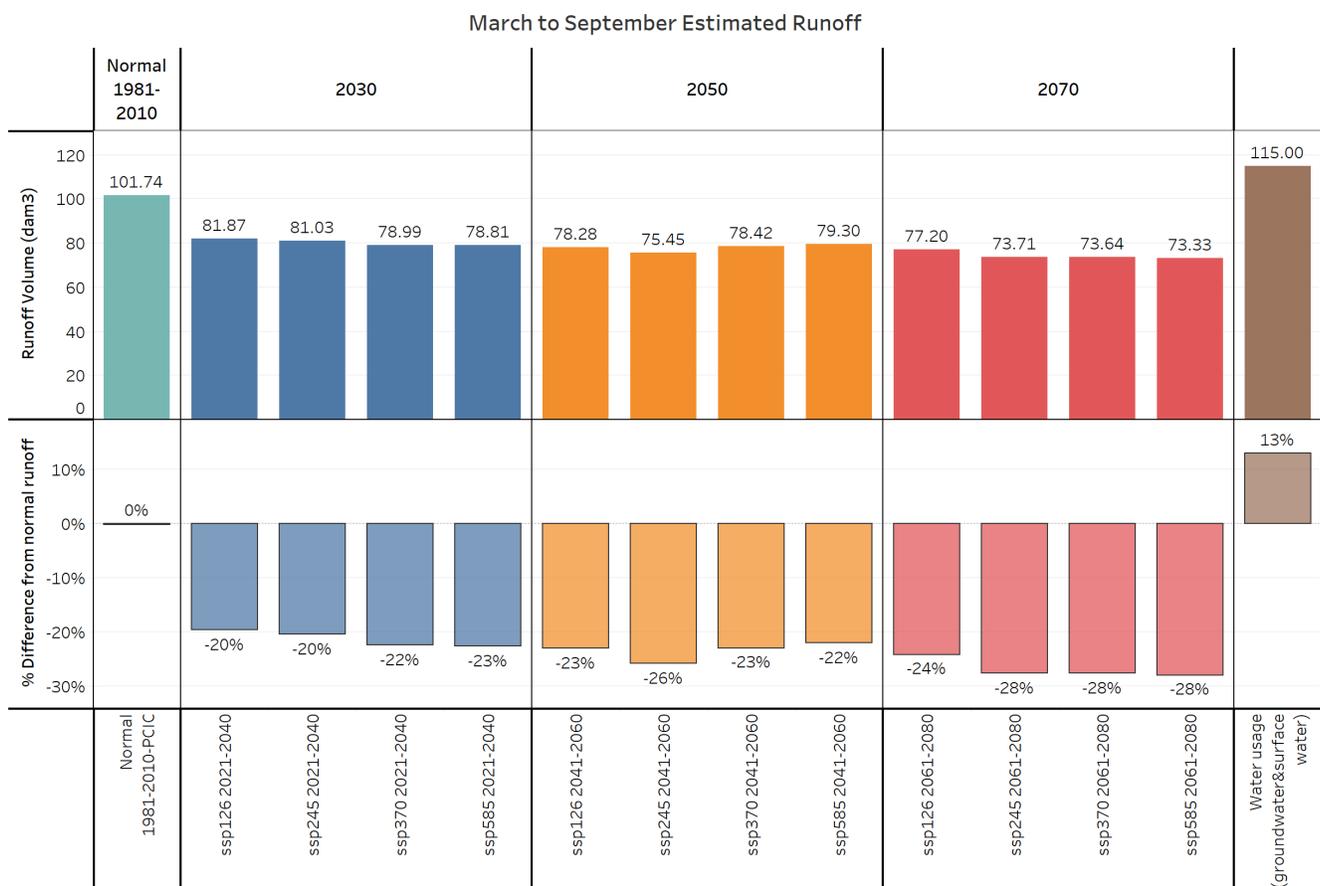


Figure 26. Monthly water demand by type of use and water budget summary (Fire protection licence not included).

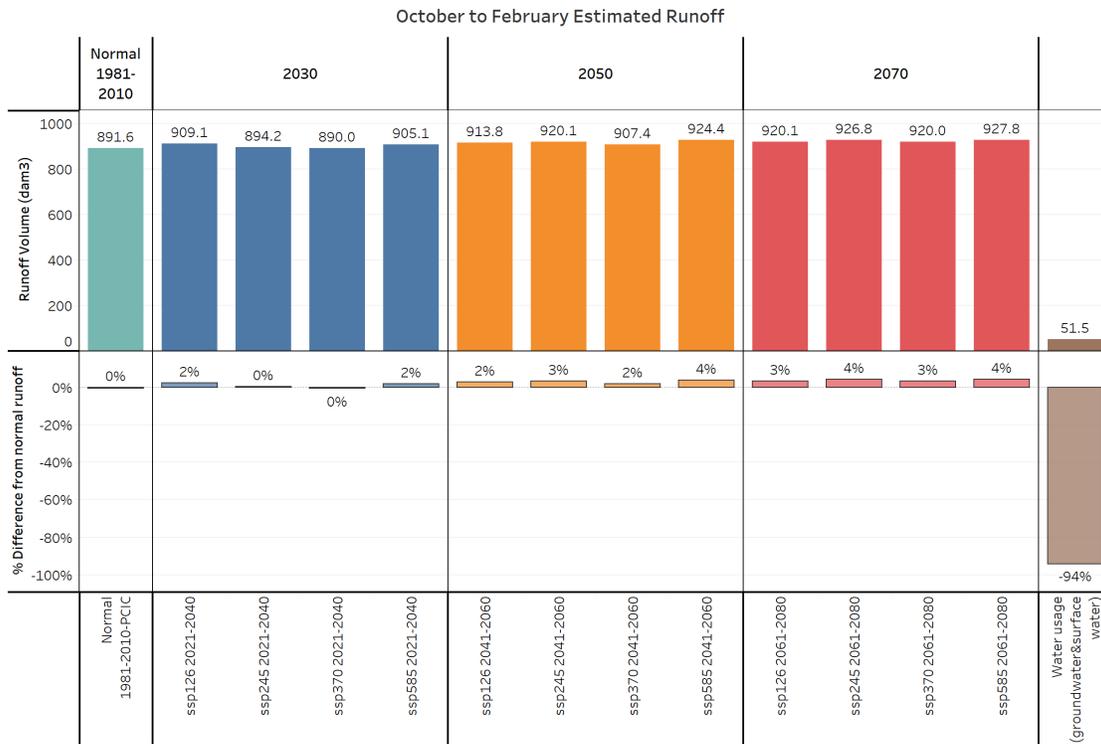
### 7.3 Climate Change Predictions for the Lake Weston Watershed

The climate of the Lake Weston watershed is predicted to be significantly different in the coming decades. The winters will be warmer with more rain and less snow. The rain will fall over a shorter period (i.e. more intense events) leading to higher levels of surface runoff potentially leading to higher soil erosion and flooding and less groundwater recharge as saturated soils do not allow for infiltration. The spring snowmelt will tend to disappear reducing the historical groundwater recharge heading into the dry summer months. During summer, temperatures will be higher, precipitation lower and groundwater baseflow (feeding creeks, lakes, wetlands) will therefore be lower. It will be common to experience too much water in winter and droughts in summer.

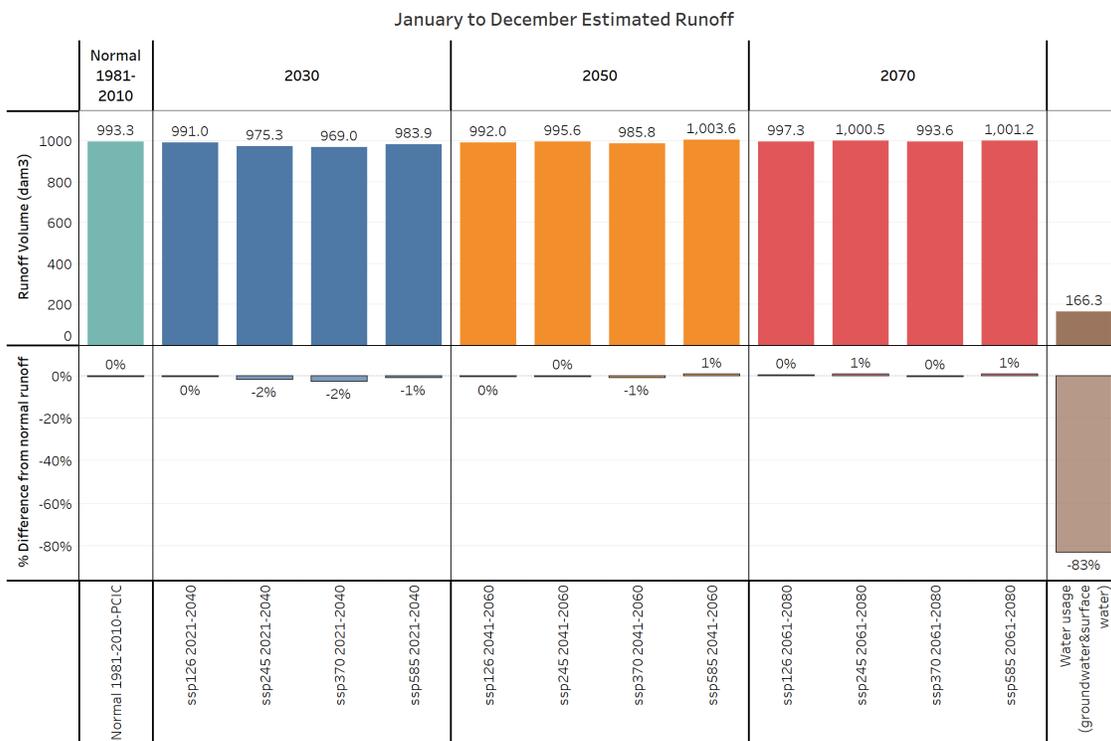
Estimated runoff for March to September (Figure 27), October to February (Figure 28) and December to January (Figure 29) is presented for various climate severity scenarios for the years 2030, 2050 and 2070. For the summer months, runoff is predicted to decrease significantly (-20% to -30%) while in the winter months runoff will increase by a small amount (2% to 4%). This reduction in runoff is translated to water deficit in the future where demand will surpass surplus.



**Figure 27. Estimated Runoff for March to September for various climate scenarios for the current conditions (normals), and years 2030, 2050 and 2070 compared to licensed surface water (fire protection licence not included).**



**Figure 28. Estimated Runoff for October to February for various climate severity scenarios for the years 2030, 2050 and 2070 (fire protection licence not included).**



**Figure 29. Estimated Runoff for January to December for various climate severity scenarios for the years 2030, 2050 and 2070 (fire protection licence not included).**

### 7.3.1 Surface Water and Groundwater Monitoring on Salt Spring Island

There are several active and inactive groundwater and surface water monitoring points located within and near the study area (Figure 30).

There are two active groundwater monitoring wells:

- SSIWPAGWM-1009 (ITC) data from 2018-2020.
- Figure 31, although the data covers a short time period, it indicates a slight decrease in water level of 20-30cm over these years.

As there are no groundwater monitoring wells in the study area with a long-term data set, data from Provincial Groundwater Observation Well OW373 on Salt Spring Island to the north of Lake Weston was obtained. The data shows a downward trend line of water levels for all months except November, December and February for the years 2006 to 2021 (Figure 32). The black dashed lines indicate the statistical trend for all the years during each month (upward/increasing over time, downward/decreasing over time or flat/unchanged with time). The downward trends are especially pronounced during August and September.

There is one active streamflow station:

- Fulford Creek (BC Aquarius database) monthly streamflow data from 2017-2021. This data is plotted in Figure 33 and indicates increasing trends from October to February, decreasing trends in March and April (reflecting less snow melt) and steady trends during the summer months.

There are three active surface water stations in the Weston Creek watershed:

- Lake Weston Inflow creek E1 which is monitored by the Water Preservation Society (WPS) SSI FWC Project (SSI Freshwater Catalogue).
- Lake Weston at outlet (SSIWPA) with data from 2019-2020.
- Weston Creek near mouth which is monitored by the WPS SSI FWC Project (SSI Freshwater Catalogue).

Data from these stations is presented in Section 7.5.

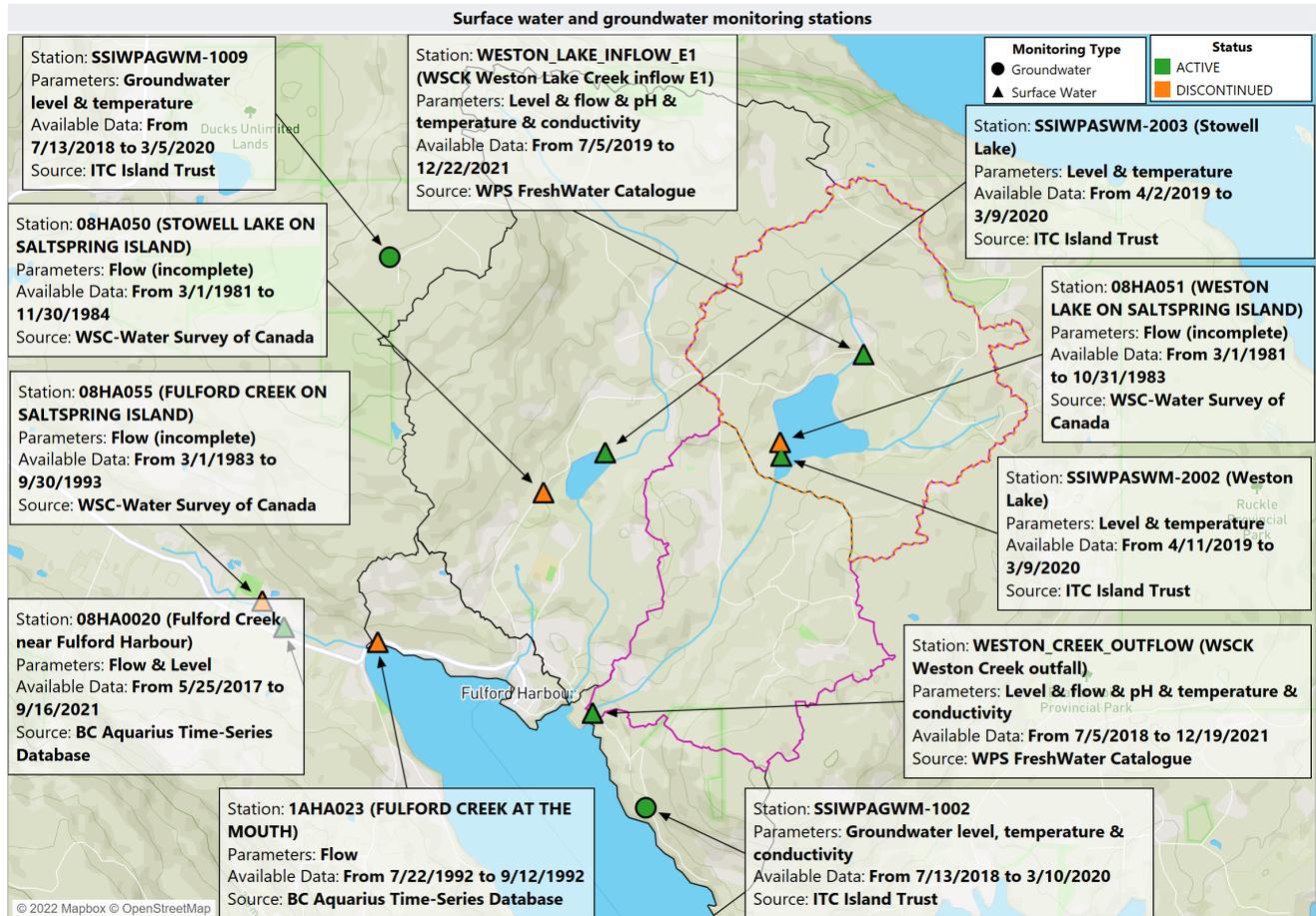


Figure 30 Surface water and groundwater monitoring stations

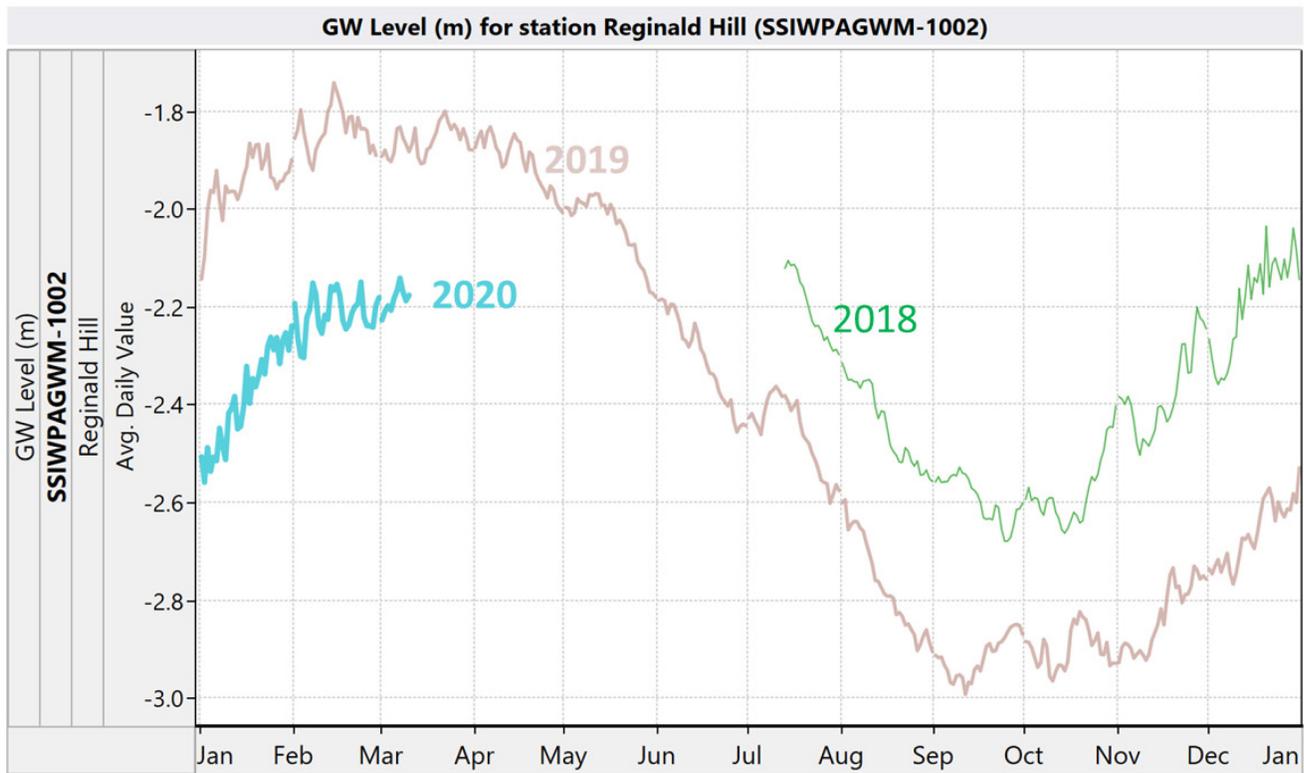
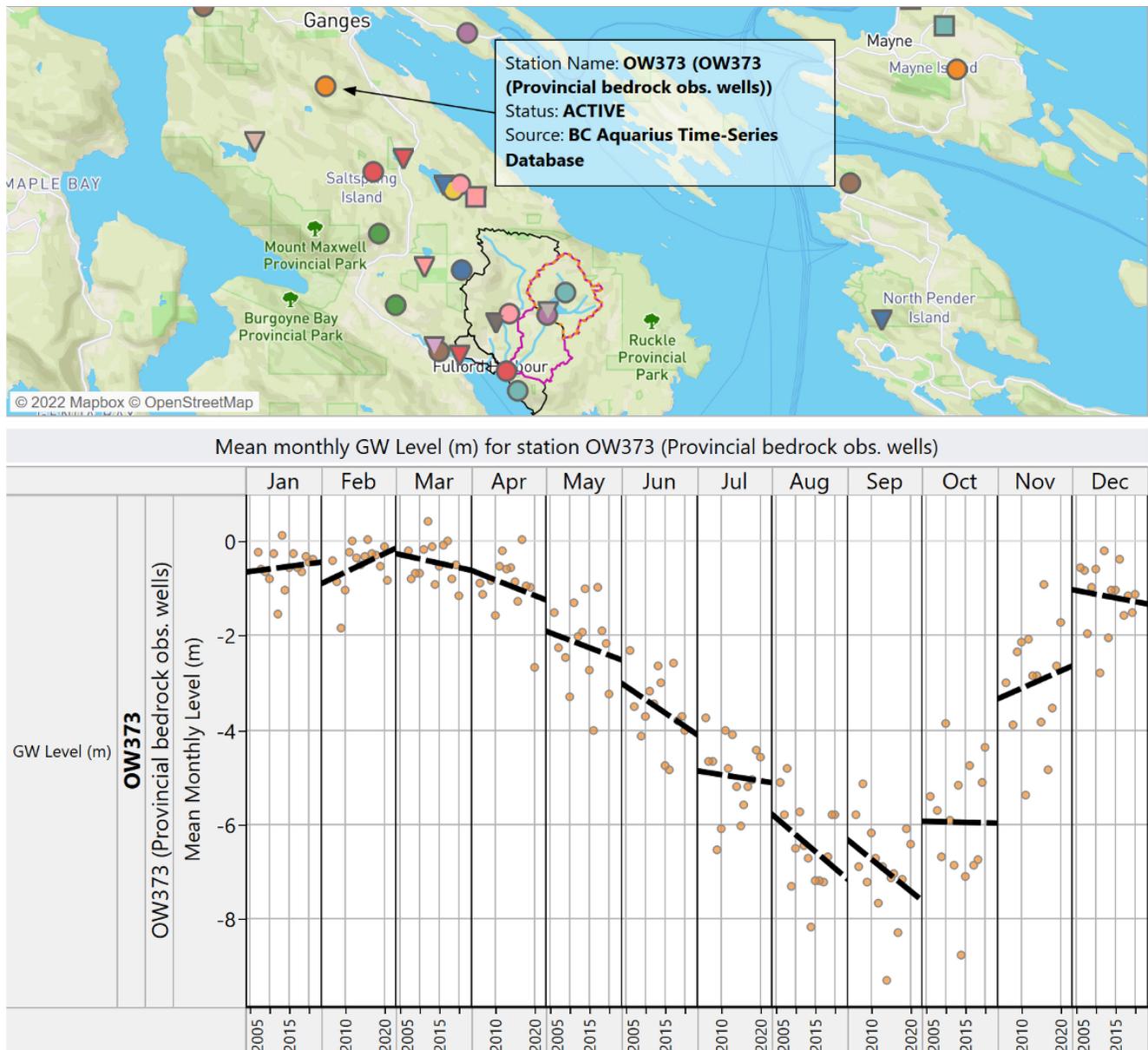
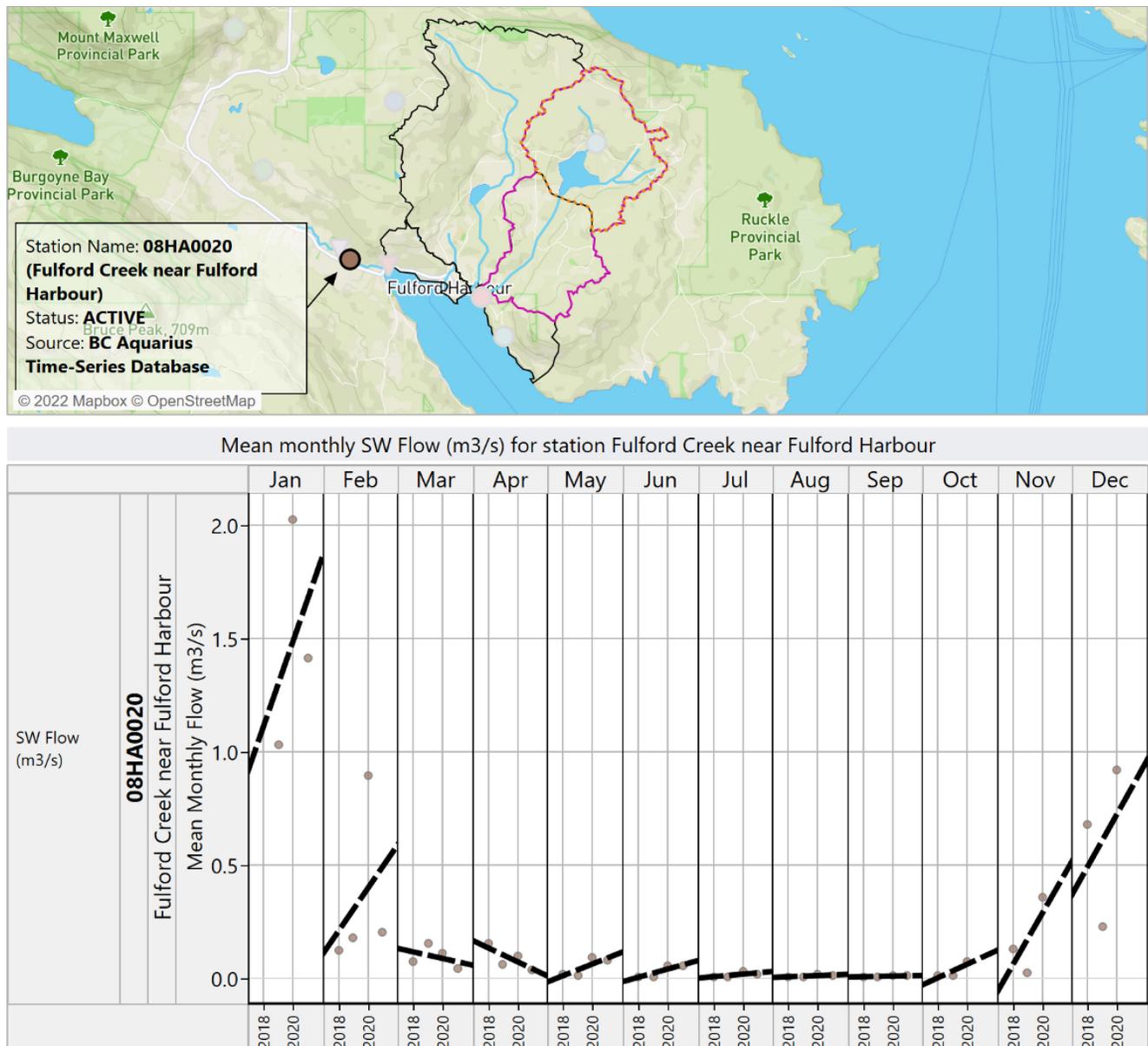


Figure 31 Groundwater level for Reginald Hill volunteer observation well.



**Figure 32. Mean monthly groundwater levels for OW373 (Provincial Observation Wells Network) from 2006 to 2021.**



**Figure 33. Mean monthly flow trends in Fulford Creek from 2018-2021.**

### 7.4 Environmental Flow Needs

Aquatic ecosystems consist of groundwater, springs, creeks, rivers, lakes, wetlands and estuaries and the water allocated to protect aquatic ecosystems is referred to as Environmental Flow Needs (EFNs). The aquatic ecosystem most commonly used to define EFNs is fish habitat in streams which is referred to as Instream Flow Requirements (IFR). Lake Weston and Weston Creek have been identified as habitat for cutthroat trout (Barnet et. al., 1993) and thus it is important that a minimum lake water level and creek flow be maintained year-round.

The most common method of defining IFRs to protect fish habitat is based on the Modified Tennant (a.k.a. Montana) Method (Table 9; Tennant, 1976) which assumes that some proportion of the mean annual discharge (MAD) is required to sustain the biological integrity of a river ecosystem to sustain fish spawning and rearing. Based on original field data collected from 11 rivers in Montana, Nebraska and Wyoming and further supplemented with additional data from hundreds of gauged flow regimens in 21 states, Tennant (1976) recommended percentage values of MAD predicted to sustain predefined ecosystem attributes. In drainages where fish are present, the minimum flow required to sustain the fisheries resource for fair spawning and rearing habitat is 10% of the Mean Annual Discharge (MAD).

**Table 9: Creek flows as a percentage of Mean Annual Discharge and fish spawning/rearing habitat condition (Tennant, 1976).**

Creek Flows as % of Mean Annual Discharge	Spawning/Rearing Habitat Condition
30-60% MAD	Excellent
20-30% MAD	Good
10-20% MAD	Fair
5-10% MAD	Poor
<5% MAD	Severely degraded

The B.C. Water Sustainability Act (WSA; 2014) specifically identifies stream flow requirements for ecosystems and species. Authority is given to temporarily protect flows in times of drought and to order mitigation measures where water removal is likely to have significant adverse impacts on a stream.

The key sections of the WSA pertaining to EFNs are:

Section 15: Statutory decision makers must consider EFNs when issuing new surface and groundwater licences (for aquifers that are connected to surface water). This policy is not a method or enforceable law for determining EFNs but instead provides guidelines for assessing risk to EFNs. It sets out different management actions depending on different levels of risk and assist the decision maker in identifying where cautionary measures could be taken or additional analysis is needed.

Sections 86-88: Water users are required to cease water withdrawals during drought under a *critical flow protection order* or *fish population order*.

Section 43: Water and land-use decision makers have the ability to set water objectives (including water flows and quality) that must be considered when issuing authorizations.

The BC EFN policy establishes three risk management levels by evaluating stream sensitivity, stream size, cumulative withdrawals from the stream, and hydrological characteristics of the stream.

In many parts of B.C. groundwater discharges contribute a high percentage of base flow in streams and groundwater extractions from aquifers that are hydraulically connected to a stream can significantly diminish streamflow, particularly in small streams during critical low flow periods. The WSA recognizes the hydraulic connection between groundwater and surface water, particularly in shallow sand and gravel aquifers where groundwater withdrawals directly affect availability of stream water for other users and for aquatic ecosystems. The WSA thus recognizes that groundwater and surface water must be managed under the same regulatory regime. Groundwater use is integrated into the water-licensing system, similarly to how surface water was previously managed. The WSA applies the consideration for EFN to aquifers that are *reasonably likely to be hydraulically connected to a stream*. For an application to be successful, the technical assessment would need to demonstrate that sufficient water is available to meet the needs of the intended use, and that the requested water withdrawal will not cause undue harm to other water users or the EFNs of hydraulically connected streams.

It is important to note the very different time frames between groundwater, which generally flows very slowly (e.g. months to centuries) and surface water, which flows relatively quickly (e.g. days). This results from the flow restriction of the natural geologic materials and, as a result, the time required for the impacts of groundwater pumping (or water-diversion from a spring) can take decades to be observed with declining water levels in wells or baseflow to creeks or other groundwater-dependant ecosystems.

### **Case Study: Sooke River, Vancouver Island**

A value of 10% MAD (mean annual discharge) was determined using the modified Tennant method as the conservation flow (i.e. EFN) in the low flow months (Burt, 2006). Monitoring of the conservation flow releases has been carried out and the results indicate that flow releases from the Sooke reservoir result in an increase in the variety and abundance of aquatic invertebrates. An improvement in the health of trout fry has also been observed.

### **Case Study: Tsolum River, Comox, Vancouver Island**

The Courtenay Water Allocation Plan uses the Modified Tennant (Montana) Method to recommend that an estimated minimum of 10% of MAD (mean annual discharge) be maintained in the Tsolum to support aquatic life (Riddell & Bryden, 1996). Provincial scientists have decided that maintaining flows of 10% MAD in Vancouver Island streams may not be realistic. Many streams on the east coast of Vancouver Island have highly variable flow regimes and may not have had flows above 10% MAD in the summer prior to human disturbance. It has been suggested that a more appropriate target may be to maintain 5% MAD in the Tsolum River watershed during low flows (Szcot, 2018).

## 7.5 Lake Weston Safe Yield

Lake Weston is directly fed by groundwater and its pumping is similar to that of a large well. The safe yield of a water well (or lake acting as a well) is the maximum annual water volume that can be sustainably extracted year-round and year after year without gradually drawing groundwater out of storage (causing declining levels in the well and/or nearby wells) or decreasing the groundwater seepage that feeds aquatic ecosystems (aquifers, springs, wells, wetlands, creeks, lakes) referred to as Environmental Flow Needs. The safe yield for Lake Weston consists of two components.

1. Water storage in Lake Weston. Water storage is important for aquatic life within the lake including maintaining water temperatures sufficiently low enough for certain species. Water storage in the lake also allows for a certain amount of water to be drawn for short-term emergency purposes (fire department or wildfire) or to sustain water supplies during a drought or the predicted hot dry summers in the decades to come.
2. Flow in Weston Creek. Sufficient flow during “normal” climatic variations year-round and year to year to maintain the creek as an aquatic ecosystem and habitat for cutthroat trout and other species.

### Water Storage in Lake Weston:

Lake Weston water volumes corresponding to different lake levels are shown in Figure 34 to Figure 36. The Lake Weston level varies from a high of about 61.35 masl in January to a low of 60.55 masl in August (average 0.8 m variation) and appears to reach a level where it becomes stable (increasing very slightly) in the summer months. It can also be seen that as the water level declines the decrease in volume becomes more pronounced as the lake is a conical shape (Figure 36).

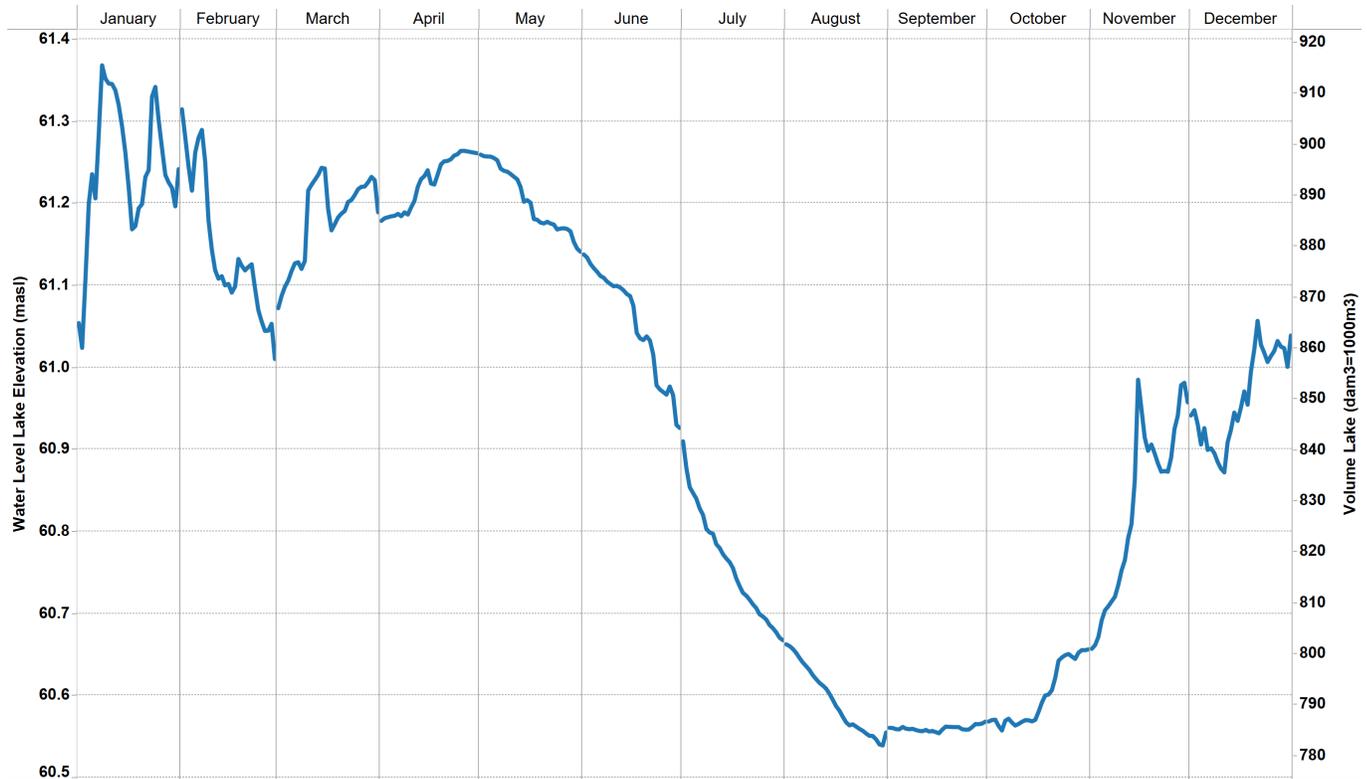


Figure 34. Lake Weston water level and storage volume from April, 2019 to March, 2020.

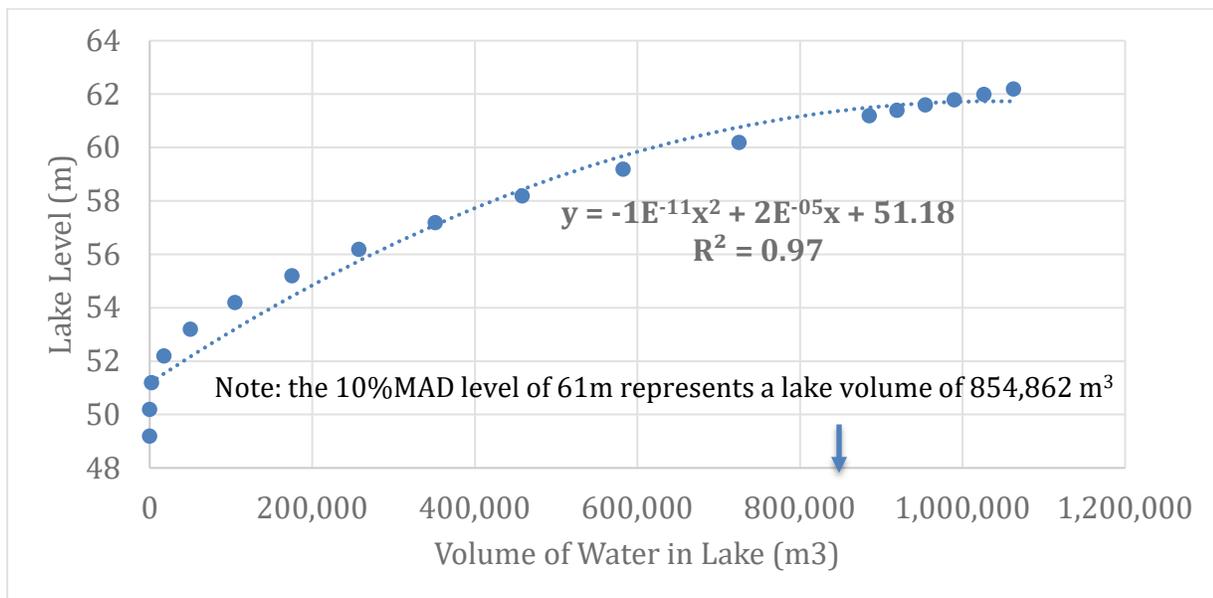
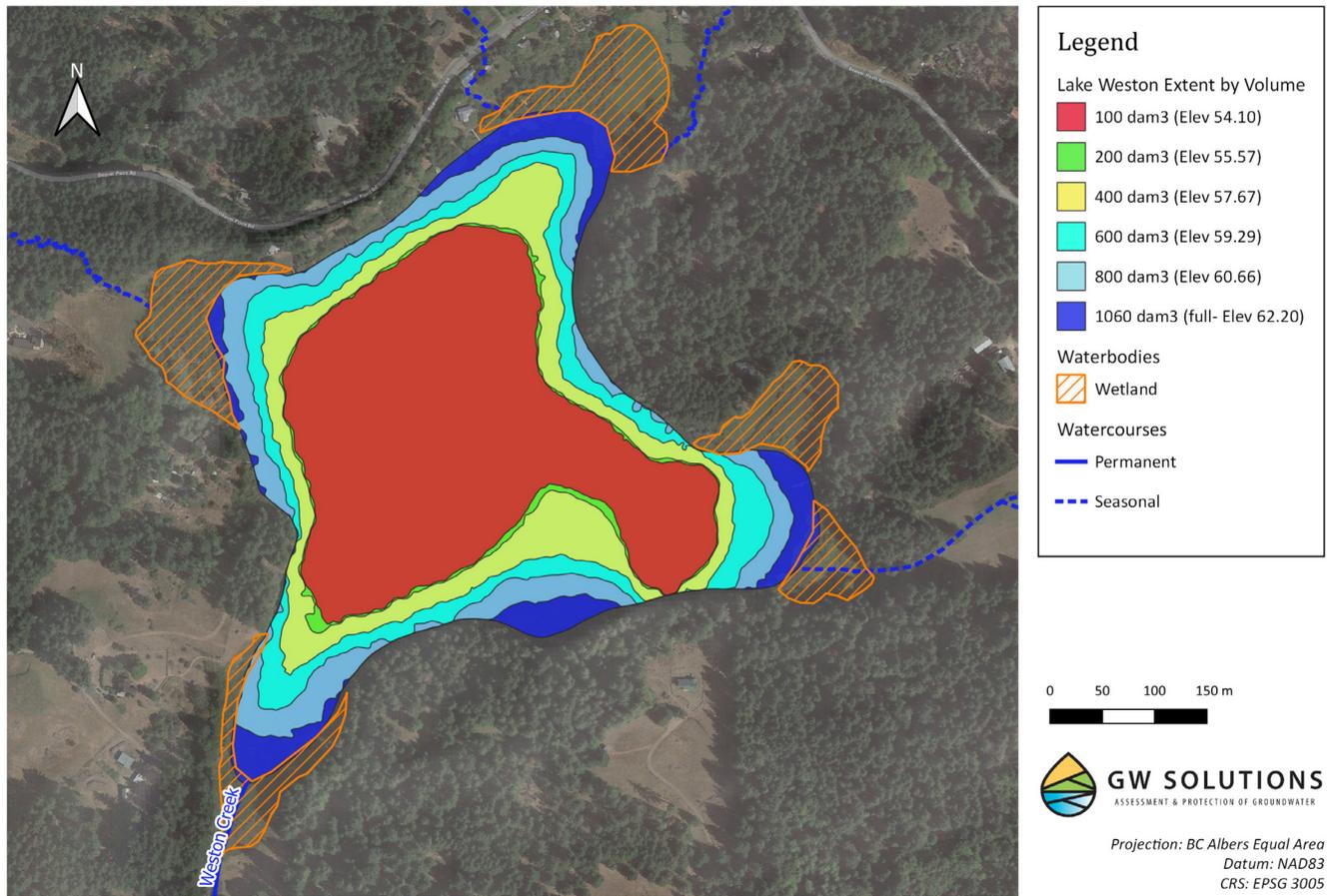


Figure 35. Lake Weston water level (April, 2019 to March, 2020) versus volume of water in lake.



**Figure 36. Lake Weston volumes for various areal extents.**

Figure 37 is a monthly graph of water volumes of Lake Weston for various climate scenarios (2030, 2050, 2070). It can be seen Lake Weston volumes are predicted to decrease significantly in the next decades during the summers when groundwater recharge and runoff are non-existent or negligible.

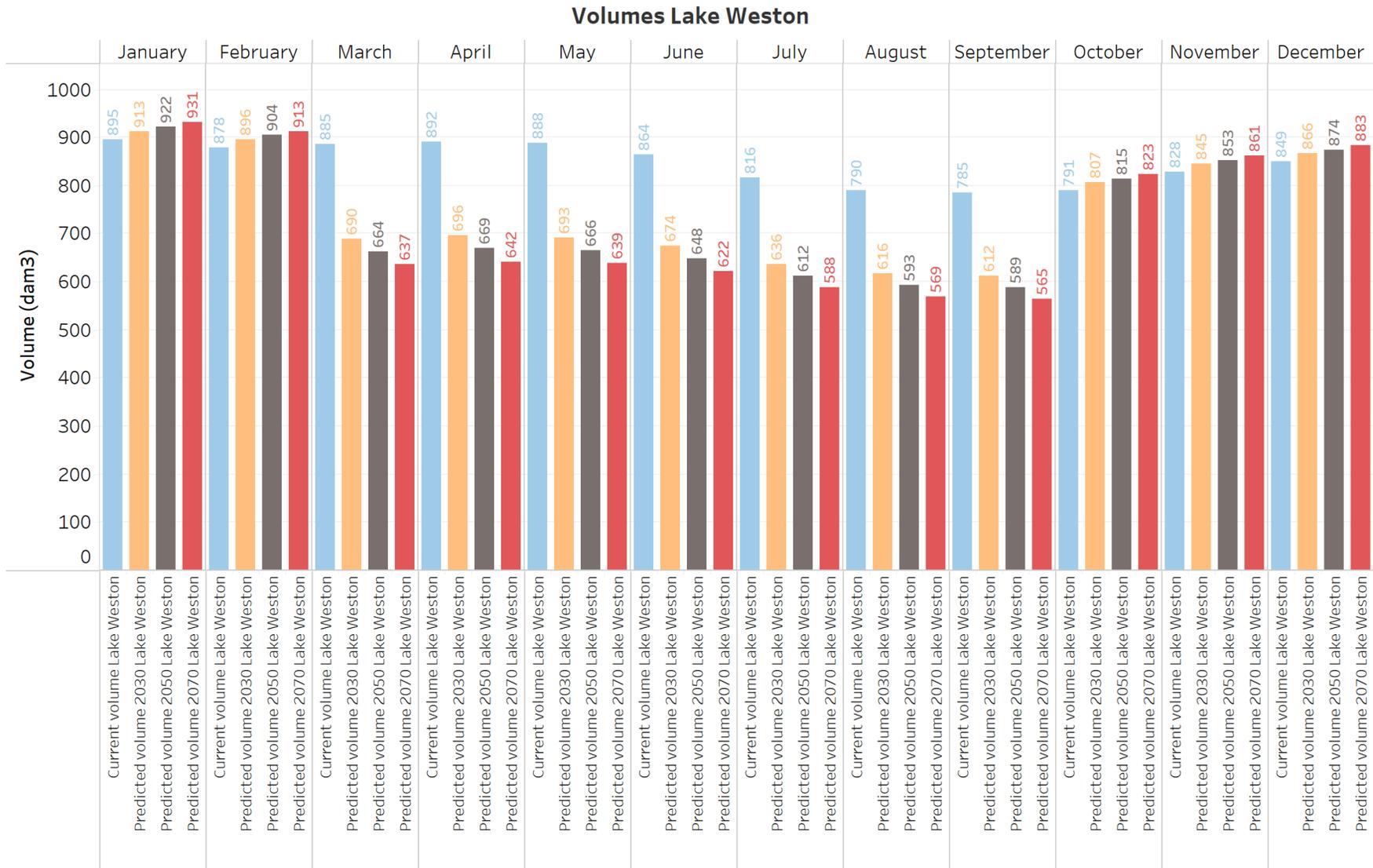


Figure 37. Lake Weston monthly volumes for climate scenarios.

### Weston Creek Flow:

Figure 38 shows an illustrative cross-section of the watershed passing through Lake Weston and following the approximate route (slightly off-section) of Weston Creek. It can be seen that Lake Weston is directly connected to and fed by the groundwater system. Weston Creek is fed by both outflow from Lake Weston and also by groundwater discharge at specific groundwater discharge locations controlled by faults along the course of the creek. These faults have not been mapped but are assumed based on the uneven (i.e. flat then steep drop) topography along the creek and evidence of groundwater discharge (flooding or fish habitat).

Figure 39 is a map of key groundwater discharge and fish habitat locations in the watershed. It can be seen that there are springs in several locations above Lake Weston and key areas of groundwater discharge along the various arms or creeks feeding Lake Weston. These is fish habitat in two of these arms, the northeast arm and east arm. Along Weston Creek there are several fish migration gradient barriers (i.e. steep gradient) and at least one fish habitat identified directly adjacent to an area of frequent groundwater discharge (leading to field flooding seasonally). There may be other smaller fish habitats fed by groundwater discharge along Weston Creek that have not been identified.

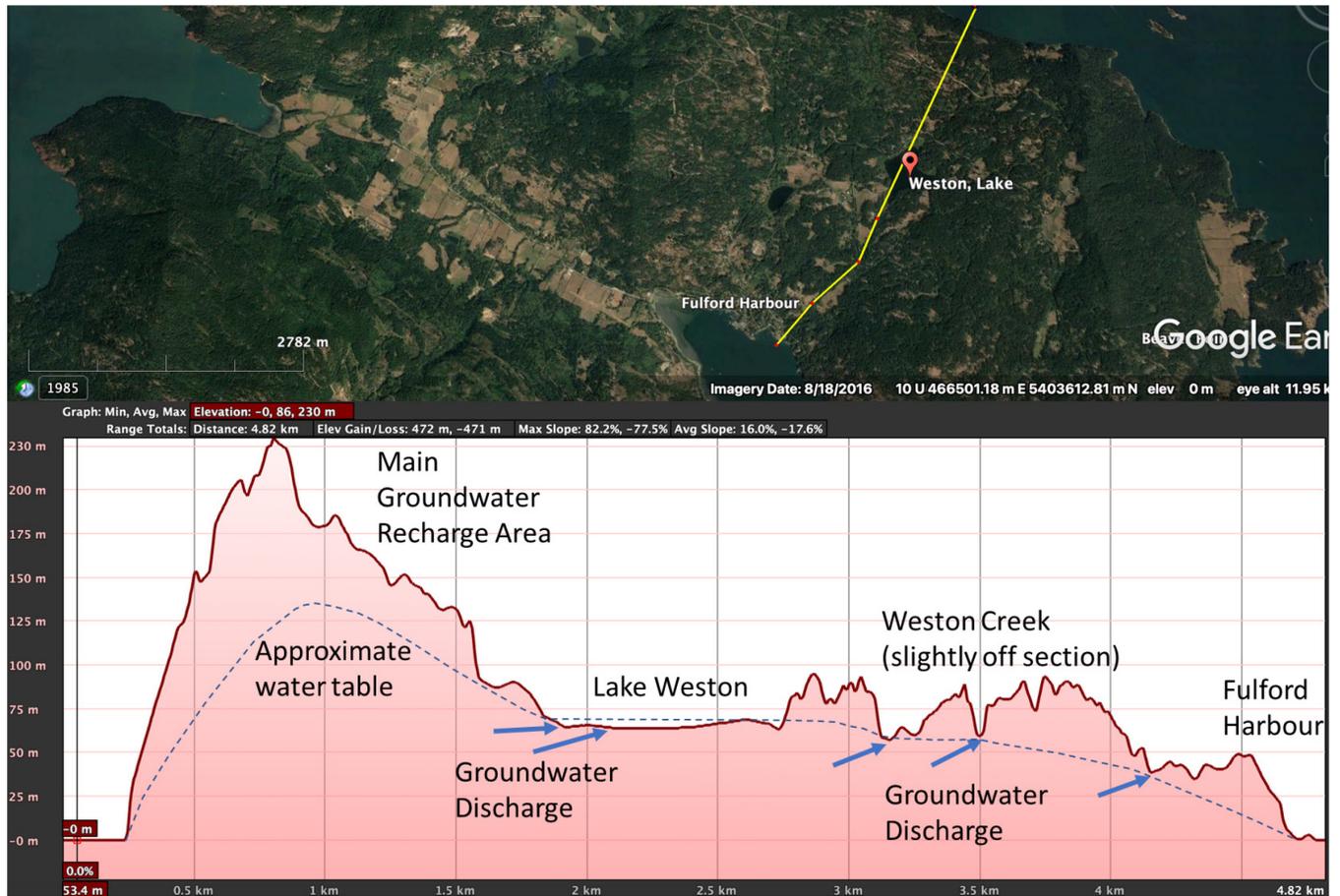
Figure 40 shows a plot of Lake Weston water level, the Weston Creek outflow and total water usage (groundwater and surface water). Weston creek varies seasonally from a high monthly average of 0.017 m<sup>3</sup>/s in March to a low of 0.0010 m<sup>3</sup>/s in August. Based on the data obtained, it appears the flow can become very low during the summer, from the three plus years of flow records (WPS SSIFWC) Weston Creek flows year-round, though with very limited summer flow.

As noted earlier in this report, water usage is highest in the May-September period and it is especially high in July and August when rainfall is low and evaporation is high. If increased water usage leads to lowered groundwater levels then groundwater-dependent creeks (like Weston Creek) can temporarily become dry or almost dry during late summer.

In Figure 41, water temperature and electrical conductivity follow distinct seasonal trends for the inflow and outflow, however, it is noted the inflow electrical conductivity and pH become gradually higher in the summer season due to the predominance of groundwater (which is more mineralized than surface water or rainwater) at this time of year. As expected, the inflow E1 increases substantially during the winter season diminishing during the summer, this inflow creek shows clearer indications of groundwater baseflow (Millson, 2020, cf Howe and Allen 2020) than the Weston Creek outflow. The Weston creek outflow chemistry, in contrast to the inflow, does not increase significantly in the winter months as the outflow emanates mostly from Lake Weston which absorbs much of the runoff and dilutes groundwater baseflow in the discharge into Weston Creek, though Weston Creek is also fed through groundwater seepage along its course as it, like Lake Weston, is in direct connection with the aquifer.

It is noted that inflow E1 is not the only inflow to Lake Weston as the lake is natural groundwater discharge body. Inflow E1 is one of two major surface water inflows to Lake

Weston (the other inflow is the east arm) and there may be other water-bearing faults intersecting the lake that are unseen. Lake Weston also likely receives some inflow in the subsurface through seepage from the smaller fractures in the aquifer.



**Figure 38. Topographic profile and illustrative cross-section across entire Lake Weston and Weston Creek watershed.**

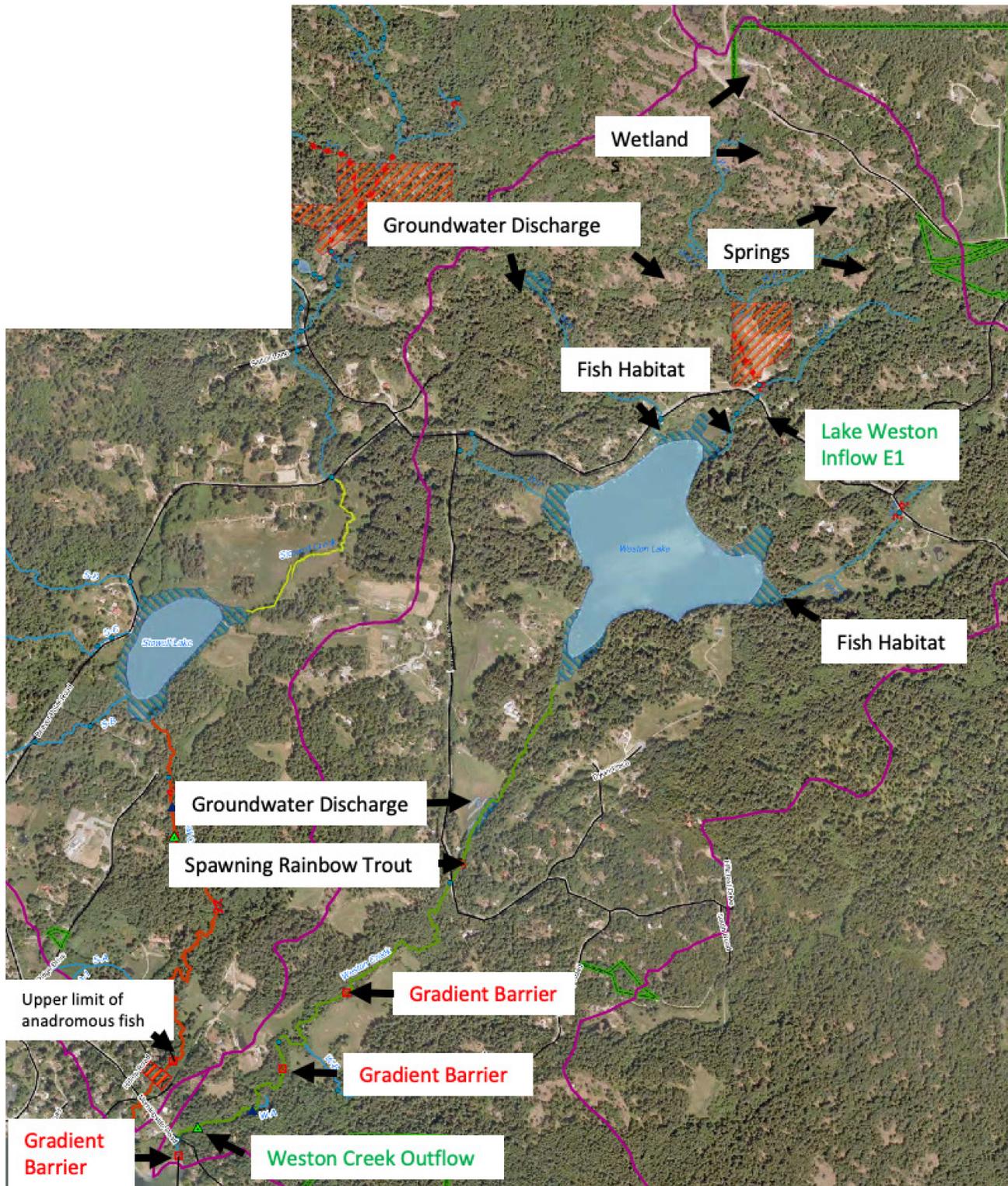


Figure 39. Groundwater discharge and fish habitat in Lake Weston and Weston Creek.

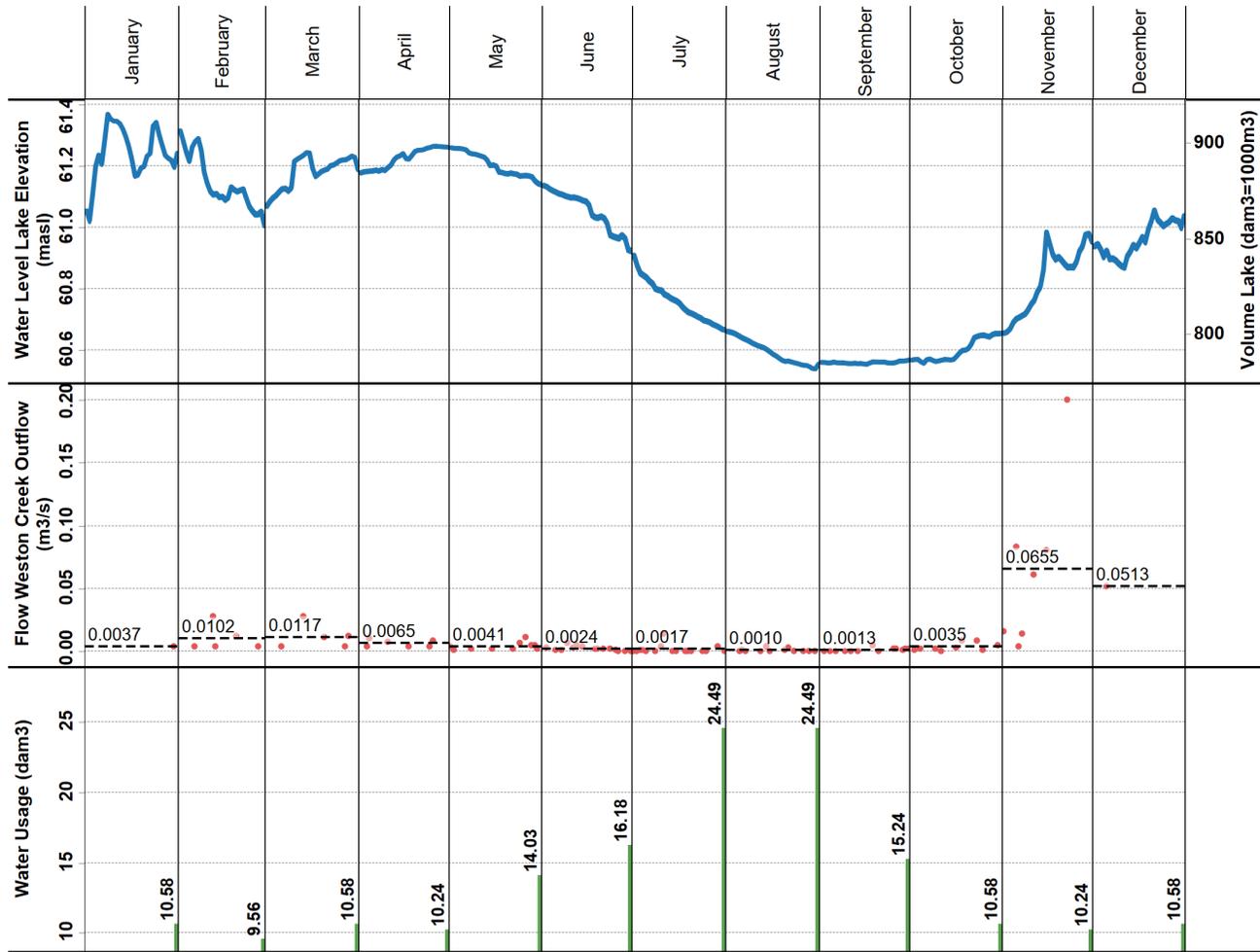
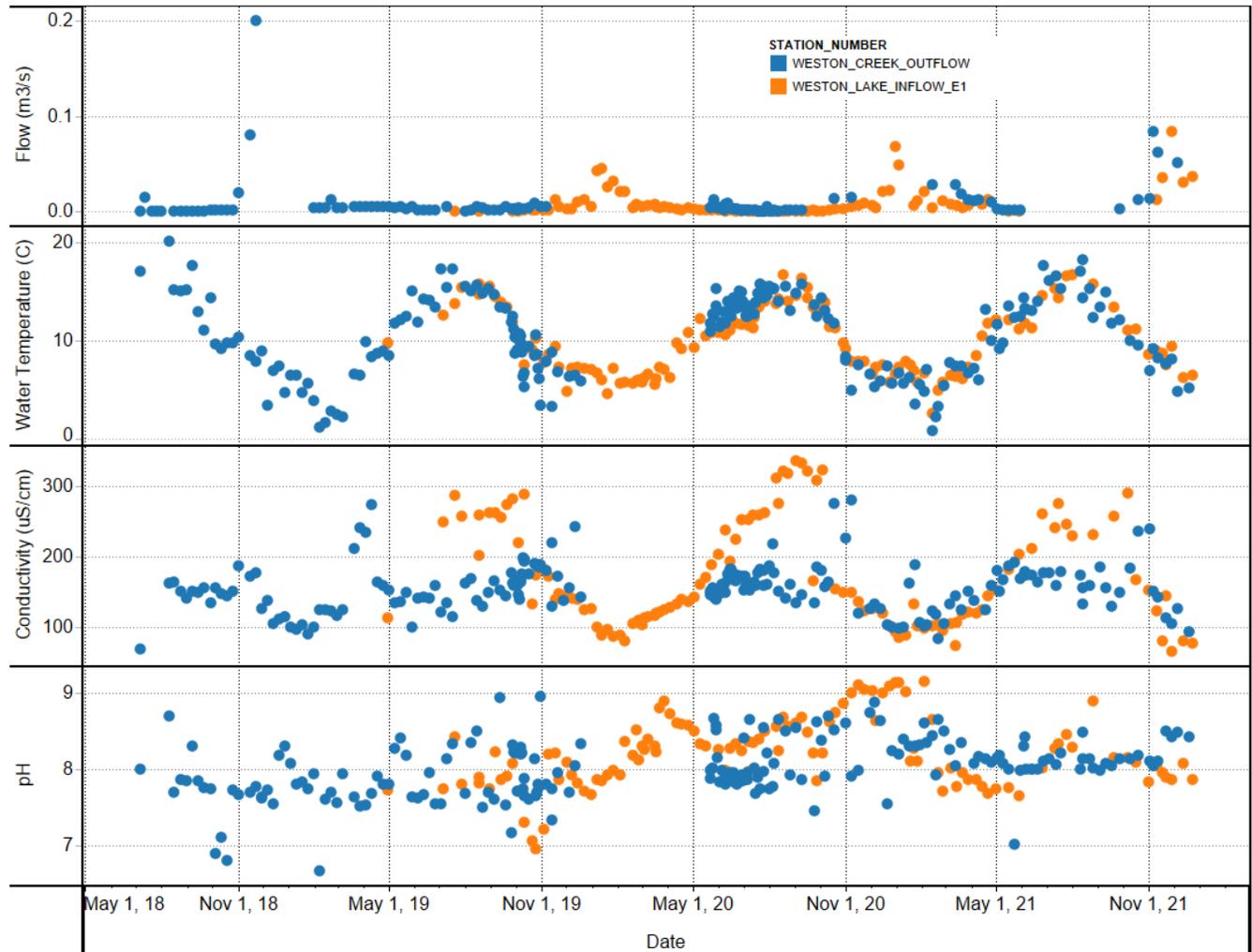
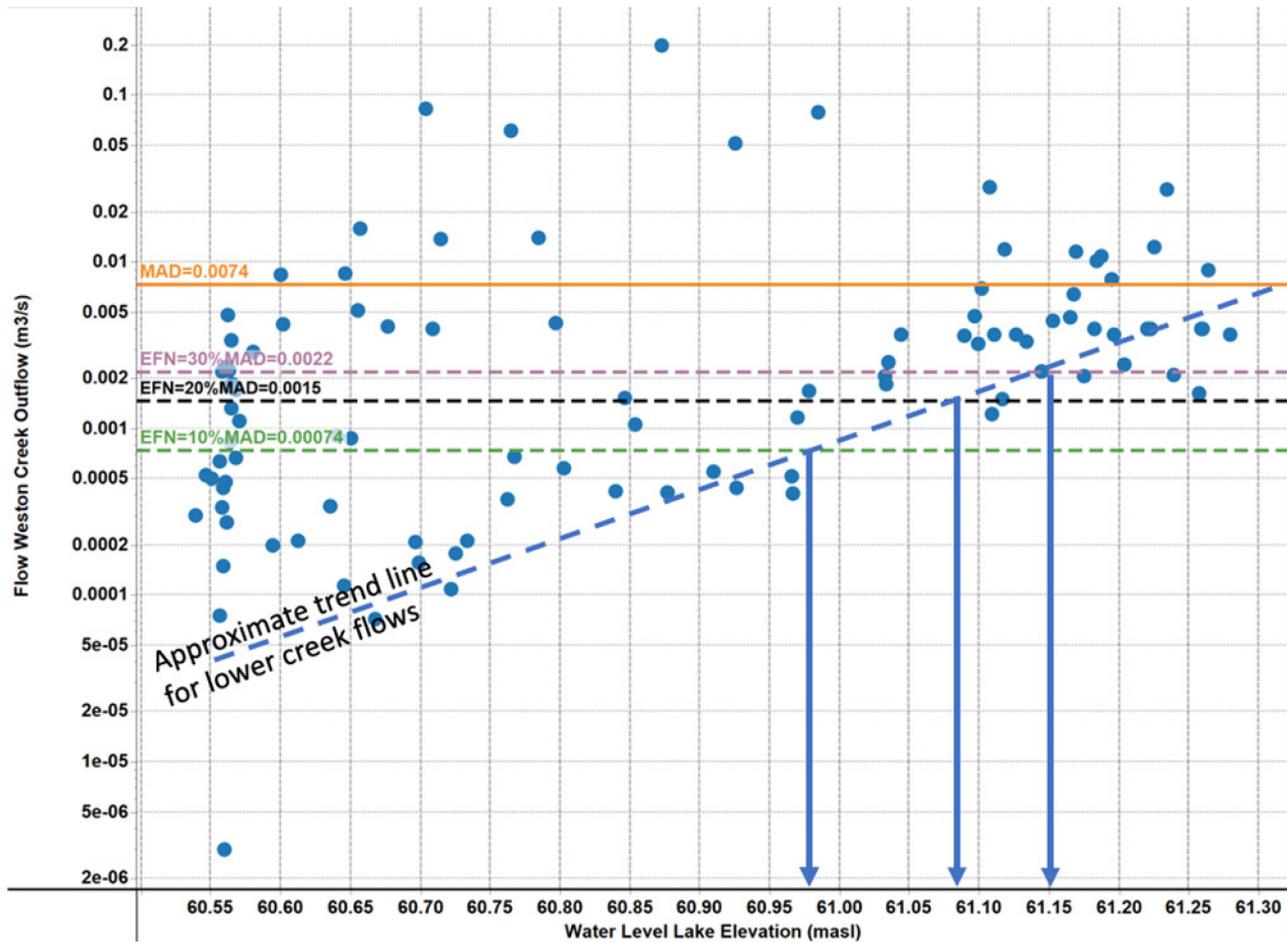


Figure 40. Lake Weston water levels, Weston Creek flow (April, 2019 to March, 2020) compared to estimated water usage (fire protection licence not included).



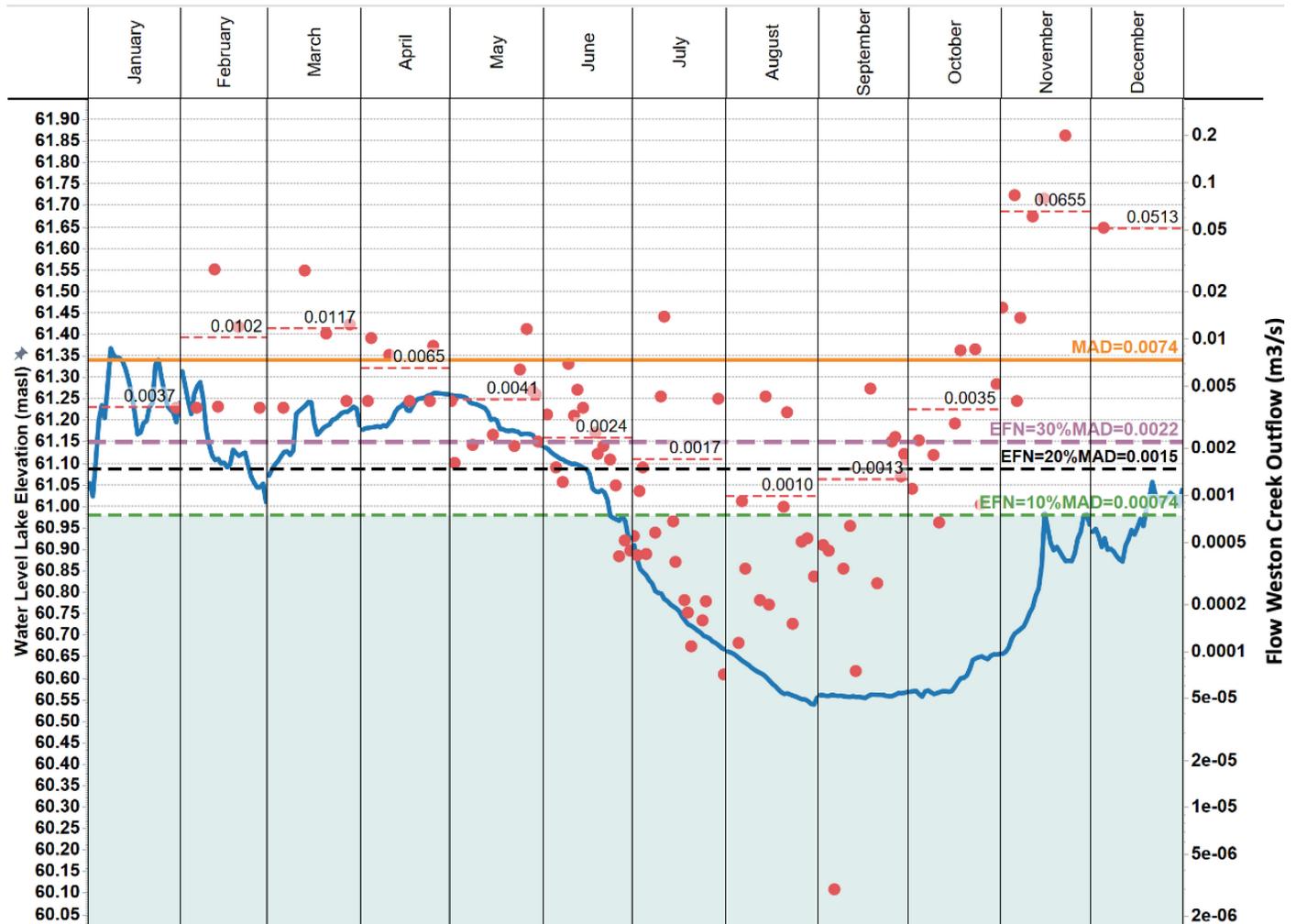
**Figure 41. Lake Weston inflow, Weston Creek outflow, temperature, electrical conductivity and pH from May, 2018 to December, 2021 (NB not all flow data is plotted).**

Figure 42 is a scatter plot comparing Weston Creek flow (vertical axis) and Lake Weston water levels (horizontal axis). An approximate trend line is drawn through the data points with the lower flows (less influenced by short-term spikes from storms) to give an approximate relationship between the lake water level and the creek flow. As explained in the section on Environmental Flow Needs, the minimum flow to maintain an aquatic habitat for fish varies between 10%MAD and 30%MAD (Tennant, 1976). The minimum 10%MAD for Weston Creek corresponds to a Lake Weston water level of about 61 masl (meters above sea level). A 20%MAD corresponds to a lake level 10 cm higher at about 61.1 masl and a 30%MAD is about 61.15 masl.



**Figure 42. Lake Weston water level versus Weston Creek outflow with various %MAD (mean annual discharge).**

Figure 43 is a plot of Lake Weston water level on the vertical left axis and the Weston Creek outlet on the vertical right axis showing all data collected over several years for each month. Although the Weston Creek outflow average in August is  $0.001 \text{ m}^3/\text{s}$ , the flow is significantly less than this value for much of the summer months. The level of Lake Weston is clearly lower than the 10%MAD (61 masl) level during the July-November period and, to achieve this level in the summer, the usage during the summer would need to be reduced. It is noted that the volume of water in Lake Weston at a level of 61 masl is approximately  $854,862 \text{ m}^3$  (see Figures 35 and 36).



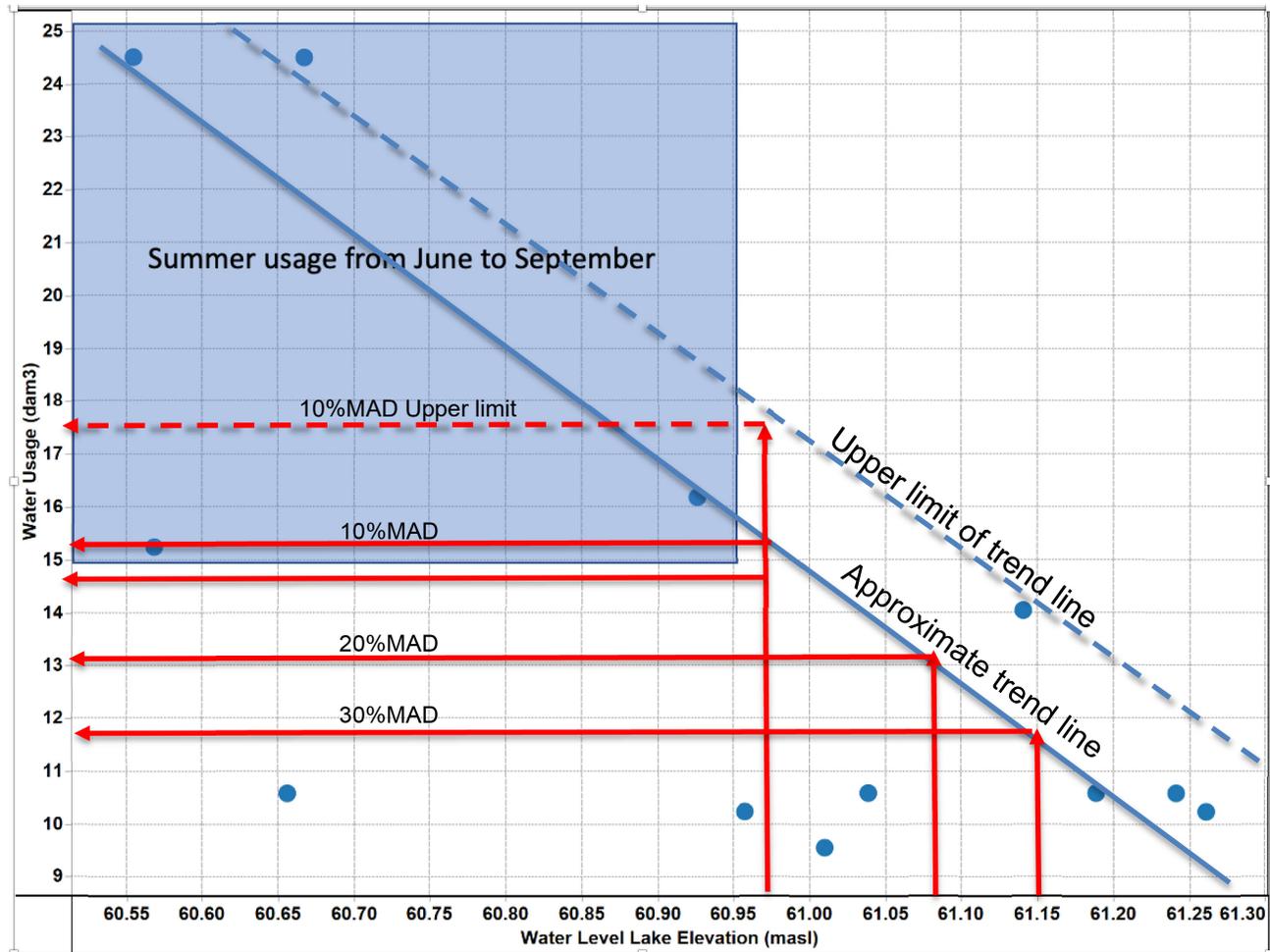
**Figure 43. Lake Weston water level (blue line), Weston Creek outflow (red dots; with monthly averages) and various %MAD (mean annual discharge).**

Figure 44 is a scatter plot comparing total water usage (groundwater and surface water) to Lake Weston level. It can be seen there is a weak inverse relationship and an approximate trend line has been drawn. Based on two data points a second trend line was drawn “Trend line upper limit” to provide the highest potential relationship between water usage and Lake Weston level. The high amount of scatter in the plot (indicating a weak correlation) is expected as water usage is not the only factor affecting the Lake Weston level. The lake level is also impacted by precipitation events (especially in the winter) which can produce short-term storm runoff and medium term increases in groundwater inflow. It also noted that the water usage is an estimate as the Fulford Water System is the only water usage that is actually measured. The basic relationship between usage and Lake Weston level is represented with an approximate trend line providing an approximation of the usage that corresponds to the 10%MAD, 20%MAD and 30%MAD. It can be seen that in order to achieve even the minimum 10%MAD in Weston Creek the usage in the summer months would need to be reduced to usage levels similar to the winter

months. This would require significant summer restrictions on irrigation (farm and household) usage. This highlights the need for accurate usage data to confirm these results and water conservation programs.

The climate change analysis has indicated that in the coming decades the water surplus (groundwater recharge and surface water runoff) could decrease by as much as 30% in the summer. Although higher precipitation is predicted for the winter, much of this will come as storms that are too intense to allow for significant recharge. This means the total annual recharge could decrease leading to a gradual lowering of the water table. Recharge will certainly be reduced in the summer months however this decrease may not be balanced by increased recharge in the winter if the precipitation occurs as high intensity storms as predicted.

The other major factor that can affect the Lake Weston water level (and thus Weston Creek) is land-use in the watershed which can affect the ability of the land to absorb water and recharge groundwater. It is critical in a small groundwater-dependent watershed like Weston Creek that land-use is not altered (e.g. deforestation, buildings, pavement) to ensure groundwater recharge is not affected. Finally, it is noted that the groundwater of the Weston creek watershed does not have a natural geologic layer above it to protect it from contamination thus the groundwater (and lake) is highly vulnerable to contamination from septic systems or agricultural runoff and various geochemical studies (e.g. Nordin, 1986) have confirmed the rise in nutrients in Lake Weston.



**Figure 44. Lake Weston water levels versus estimated total water usage (groundwater and surface water; fire protection licence not included). Trend line is very approximate due to poor correlation. Upper limit of trend line indicates highest possible water usage for the Lake Weston level that maintains a 10%MAD.**

Table 10 is a monthly summary of water usage volumes, volumes for Lake Weston and flow in Weston Creek. This data is plotted as monthly bar graphs in Figure 45. It can be seen that estimated water usage during the summer months, July and August in particular, is significantly higher than the remainder of the year. Actual usage of the Fulford Water System only increases slightly in the summer months. This is in contrast to the licenced surface water withdrawals for irrigation in the summer which are significantly higher than the remainder of the year.

### 7.6 Lake Weston Safe Yield Without Consideration of EFNs

An analysis of the safe yield of Lake Weston without consideration of EFNs was requested and provided as follows. Note that the consideration of EFNs is fundamental for the determination of safe yield and a lack of consideration of EFNs could have significant consequences to the aquatic ecosystem which is naturally vulnerable due to the small island setting (i.e. small recharge areas).

It is important to understand that the safe yield of Lake Weston cannot be determined independently of the safe yield of the entire aquifer within the watershed as Lake Weston is directly connected to and fed by the aquifer. This any additional lowering of the water level of Lake Weston will lead to a lowering of the water table in the aquifer immediately surrounding the lake which could affect water wells. Thus, the safe yield of the entire watershed must be considered and not only that of Lake Weston.

A common index of aquifer stress compares the total amount of recharge in the watershed to the total water usage. For the Lake Weston watershed the total annual groundwater recharge is 615 dam<sup>3</sup> and the total water usage is 167 dam<sup>3</sup> (151 dam<sup>3</sup> from Lake Weston and 16 dam<sup>3</sup> from groundwater wells). The amount of usage is thus 27% of recharge for this watershed which is reasonably high and indicates the maximum amount of water is already being pumped from this aquifer.

Another indicator of aquifer stress is water quality degradation. When wells (or groundwater-fed lakes being pumped like a well) are pumped heavily, such that the water table is lowered, they will draw water from further and further away increasing the well's zone of capture and the potential to draw contaminated groundwater. Excessive pumping can also induce recharge directly from poorer quality surface waters. Additionally, Excessive pumping can also divert groundwater that would have discharged into a surface water thus decreasing the baseflow of the surface water with resultant lower flows and higher concentrations of contaminants.

**Table 10. Weston Creek flow, Lake Weston level and Water Usage.**

Month	Estimated current use of GW (dam <sup>3</sup> )	Estimated current use of SW (dam <sup>3</sup> )	Estimated current use GW+SW (dam <sup>3</sup> )	Current use FWS (dam <sup>3</sup> )	Current Max use FWS (dam <sup>3</sup> )	Licensed use FWS (dam <sup>3</sup> )	Licensed use SW (dam <sup>3</sup> )	Licensed use SW (dam <sup>3</sup> )	Licensed use GW (dam <sup>3</sup> )	Licensed use GW+SW (dam <sup>3</sup> )	Total volume in Lake Weston (dam <sup>3</sup> )	Monthly mean flow Weston Creek (m <sup>3</sup> /s)	Monthly mean flow Weston Creek (dam <sup>3</sup> )	Predicted volume 2030 in Lake Weston (dam <sup>3</sup> )	Predicted volume 2050 in Lake Weston (dam <sup>3</sup> )	Predicted volume 2070 in Lake Weston (dam <sup>3</sup> )	GW recharge (dam <sup>3</sup> )	Runoff (dam <sup>3</sup> )
JAN	1.2	3.3	4.5	2.4	3.9	8.4	9.3	9.3	0	10.5	895	0.0037	9.9	913	922	931	146	235
FEB	1.1	3.2	4.3	2.4	4.5	7.6	8.4	8.4	0	9.5	878	0.0119	28.8	896	904	913	81	131
MAR	1.2	3.7	4.9	2.7	7.4	8.4	9.3	9.3	0	10.5	885	0.0131	35.1	690	664	637	60	97
APR	1.2	3.4	4.5	2.4	3.7	8.1	216.4	9.0	0	10.2	892	0.0088	22.8	696	669	642	3	5
MAY	1.4	6.1	7.6	2.9	2.6	9.4	226.8	12.6	0	14.0	888	0.0035	9.4	693	666	639	0	0
JUN	1.4	8.4	9.8	3.2	3.4	9.6	222.1	14.7	0	16.1	864	0.0024	6.2	674	648	622	0	0
JUL	1.6	11.7	13.3	3.6	2.8	14.8	237.1	22.8	0	24.5	816	0.0014	3.7	636	612	588	0	0
AUG	1.6	11.8	13.5	3.8	5.6	14.8	237.1	22.8	0	24.5	790	0.001	2.7	616	593	569	0	0
SEPT	1.5	5.9	7.3	2.6	3.9	10.5	221.1	13.7	0	15.2	785	0.0013	3.4	612	589	565	0	0
OCT	1.2	3.3	4.5	2.3	3.4	8.4	9.3	9.3	0	10.5	791	0.0042	11.2	807	815	823	24	43
NOV	1.2	3.2	4.3	2.2	4.0	8.1	9.0	9.0	0	10.2	828	0.0593	153.7	845	853	861	155	248
DEC	1.2	3.2	4.4	2.3	3.6	8.4	9.3	9.3	0	10.5	849	0.0513	137.4	866	874	883	146	235
<b>Totals</b>	<b>16</b>	<b>67</b>	<b>83.0</b>	<b>33</b>	<b>49</b>	<b>116</b>	<b>1415</b>	<b>151</b>	<b>0</b>	<b>166.3</b>			<b>424</b>				<b>615</b>	<b>993</b>
Comments		Is assumed Fire Suppression use of 57 m <sup>3</sup>		Average 2011-2020	2011 recorded use	Two licenses C120382 and C120292	It includes Fire Suppression at 7000 m <sup>3</sup> /day from April to September	It does not include Fire Suppression	No license applications	For GW use we include the estimated since no groundwater license is present. No fire protection		January to March might not be representative due to the lack of data		March to September -22%. Oct to Feb +2%	March to September -25%. Oct to Feb +3%	March to September -28%. Oct to Feb +4%	Water balance model	Water balance model

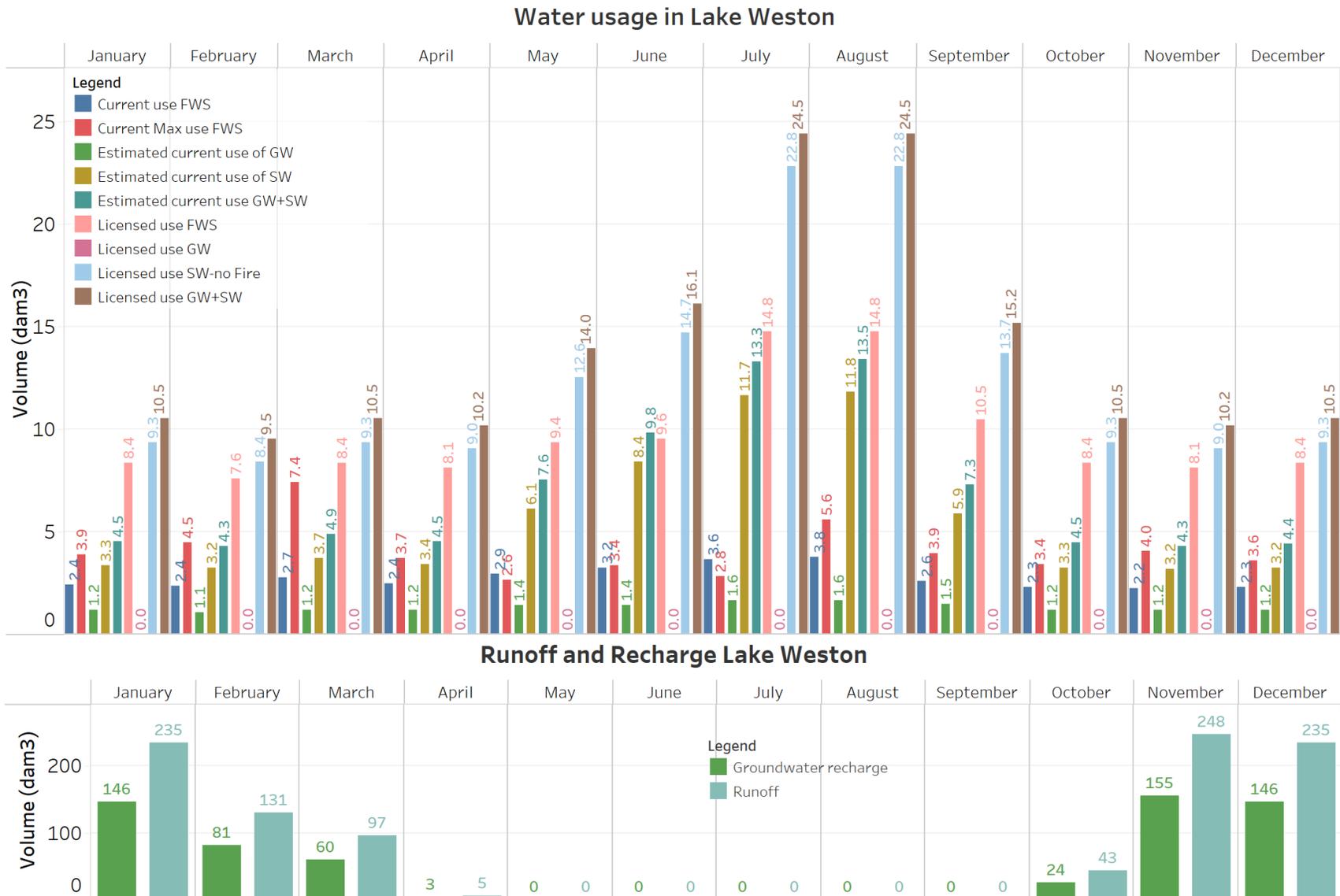


Figure 45. Monthly volumes comparing current estimated and licenced usages.

## 8 CONCLUSIONS

- 1. Water Usage (Actuals).** Water usage consists of a combination of water wells, surface water (Lake Weston) and springs used for domestic water supply, irrigation, a community water system (Fulford Water System) and fire protection. The only available metered water usage data is from the Fulford Water System (average usage of 33 dam<sup>3</sup>). Fire protection usage is sporadic (e.g. 3000 gallons were drawn in 2019 but none in 2020 and 2021). The total annual Lake Weston (surface water) usage is 151 dam<sup>3</sup> without any fire protection usage. Groundwater usage is much less at 16 dam<sup>3</sup>. The highest total (combined surface water and groundwater) usage is from April to September (peaking in July and August).
- 2. Water Usage (Licences).** The total amount of licenced water is 1415 dam<sup>3</sup> which is comprised of the fire licence (1264 dam<sup>3</sup>), the Fulford Water System (116 dam<sup>3</sup>) and several private irrigation licences (totalling 35 dam<sup>3</sup>).
- 3. Water Balance.** Total annual precipitation in the Lake Weston watershed is about 2585 dam<sup>3</sup>/year and the surplus is 1608 dam<sup>3</sup>/year which is divided between surface water runoff (993 dam<sup>3</sup>/year) and groundwater recharge (615 dam<sup>3</sup>/year). Surface water runoff represents approximately 40% of total precipitation and groundwater recharge represents 25% of total precipitation. These values are typical for humid coastal hydrogeologic environments. A comparison of annual groundwater recharge and total annual water usage (from Lake Weston and wells) indicates that, on an annual basis, groundwater recharge is sufficient to satisfy the current demand. However, groundwater recharge occurs mostly in the winter months while the water demand is higher in the dry summer months, mostly for water supply and irrigation. This means that during the summer months, water supply demand exceeds recharge which leads to seasonally declining water levels of Lake Weston and Aquifer 1147. These levels then rise again each fall and winter in response to recharge events.
- 4. Climate Change.** Climate change models for 2030, 2050 and 2070 predict that winters in the CRD will be warmer with more rain and less snow. The rain will fall as more intense events leading to higher levels of surface runoff potentially leading to higher soil erosion and flooding and potentially less groundwater recharge. The spring snowmelt will tend to disappear reducing the historical groundwater recharge heading into the dry summer months. During summer, temperatures will be higher, precipitation lower and groundwater baseflow (feeding creeks, lakes, wetlands) will therefore be lower. Runoff is predicted to decrease significantly in the summer months (-20% to -28%) while in the winter months runoff will increase by a small amount (2% to 4%). Water shortage is predicted from March to September when the demand will seasonally exceed the surplus of water. This means that during this period, licenced withdrawals exceed groundwater recharge (replenishment of supply) potentially leading to decreased groundwater baseflow to the creek and thus water available for environmental flow needs (aquatic ecosystems: lakes, creeks, wetlands, etc.).

5. **Environmental Flow Needs.** The Lake Weston level varies from a high of about 61.35 masl in January to a low of 60.55 masl in August (0.8 m variation) and appears to reach a level where it becomes stable in the summer months. For Weston Creek, to achieve 10%MAD flow the level of Lake Weston must be maintained at an elevation of at least 61 masl. Currently, this level is not maintained between July and September each year and this situation will worsen in the future according to the climate change predictions.
6. **Safe Yield of Watershed and Lake Weston.** The relationship between usage and Lake Weston level is represented with an approximate trend line providing an approximation of the usage that corresponds to the 10%MAD, 20%MAD and 30%MAD. To achieve even the minimum 5-10%MAD in Weston Creek the usage in the summer months would need to be reduced to usage levels similar to the winter months. This would require significant summer restrictions on irrigation (farm and household) usage. This highlights the need for accurate usage data to confirm these results and water conservation programs in the summer. It is not recommended that Lake Weston be pumped without consideration of EFNs (fish habitat in Lake Weston and Weston Creek) as the pumping of Lake Weston will lower the water table in the nearby aquifer affecting nearby water wells and inducing further degradation of water quality in Lake Weston.

## 9 RECOMMENDATIONS AND DATA LIMITATIONS

1. **Water level monitoring:** Additional groundwater monitoring throughout the area to create a watershed level water monitoring network and understand where in the watershed surface water or groundwater levels are declining over time. The importance of a groundwater monitoring network is accentuated by the fact that Lake Weston is a groundwater fed lake thus it is very dependent on healthy groundwater levels in the aquifer and natural groundwater recharge in the watershed above the lake. Groundwater monitoring data throughout the watershed is very important to ensure any changes in groundwater levels (e.g. due to higher well pumping) or decreased recharge are observed providing early indications of potential problems before they grow too large. Groundwater monitoring can be done either through the use of dedicated observation wells, or with privately-owned wells (volunteer observation wells) that are equipped with dataloggers that continuously measure water level and electrical conductivity (a proxy for salinity which is an indicator of salt-water intrusion and/or contamination). Further in-creek flow and chemistry monitoring may refine the understanding of in-creek groundwater baseflow contributions to lake recharge and ecosystem health.
2. **Climate stations.** Given that precipitation is the most sensitive parameter for estimating groundwater recharge and runoff, it is especially important to collect local precipitation data. The only climate station in the study area is at the Fulford Elementary School; however, this station has not been active since 2020. It is

recommended that this station be operated continuously and maintained by the Islands Trust or CRD to ensure data integrity and continuity.

3. **Hydrometric stations.** There is one active hydrometric station in Lake Weston which is maintained and operated by Island Trust. This station measures water level and temperature. In addition to this, we recommend measuring flow at the mouth of the lake. This information will be critical for future decisions regarding impact of climate change on the water availability and further calibrate water balance model.
4. **Water use metering.** There is only one metered water system in the area, the Fulford Water System thus water use for all other water supplies has been estimated using information from proxy models. An improved estimate of water usage is very important, and it is recommended that for each water well and surface water extraction system either a flow meter be added to the system or another method be applied to estimate the volume used over time. In addition, is it recommended that flow meters be added for each property supplied by the Fulford Water System.
5. **Water conservation.** Increased measures should be promoted to minimize water consumption from March to September and especially during July and August when the aquatic ecosystem is most stressed. Reducing usage in the summer months will also help maintain a sufficient amount of water in storage in the lake and the surrounding and thus avoid more serious water restrictions (e.g. limits on domestic usage) and maintaining sufficient flow in Weston Creek to maintain fish habitat even during late summer.
6. **Environmental flow needs.** EFNs for the Lake Weston watershed consist of sufficient baseflow to Lake Weston and sufficient flow in Weston Creek to maintain fish habitats that have been identified at three locations: the two arms of Lake Weston and a groundwater discharge area along the creek. The maintenance of these fish habitats by ensuring sufficient water level of Lake Weston and flow in Weston Creek will also have the added benefit of continuing the natural discharge of freshwater to Fulford Harbour. Each of these three locations should be assessed in the field to determine: a) the fish species present, b) the minimum flow required to maintain the habitat and c) how to monitor the water level or flow at each location. The minimum flow may or may not be 10%MAD (i.e. the minimum MAD level) as there is evidence (e.g. Toslum Creek, BC) that lower MAD levels may be suitable. The level of Lake Weston depends on natural groundwater recharge from the watershed and thus land-use (Recommendation 7). The flow in Weston Creek depends on the level of Lake Weston and on natural groundwater discharge to the creek (baseflow) from the aquifer. Thus, to protect the fish habitat of Lake Weston and Weston Creek, the overall watershed and aquifer need to be protected to ensure the continuation of natural groundwater recharge and the maintenance of groundwater levels in the aquifer. The incorporation of EFNs into a water budget will impact the local community by reducing the amount of water available for water supply.
7. **Watershed protection and land-use decision making.** Place a high importance on land development and land management decisions that do not jeopardize water resources. Given the high importance of groundwater in the watershed it is highly

recommended that the areas with the highest groundwater recharge potential be protected to ensure land-use activities do not disturb the soil and its ability to absorb water and recharge groundwater.

## 10 STUDY LIMITATIONS

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

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

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

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

The produced graphs, images, and maps have been generated to visualize results and assist in presenting information in a spatial and temporal context. The conclusions and recommendations presented in this document are based on the review of information

available at the time the work was completed, and within the time and budget limitations of the scope of work.

ITC and CRD may rely on the information contained in this memorandum subject to the above limitations.

## 11 CLOSURE

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

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

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

Yours truly,

**GW Solutions Inc.**

**Prepared by:**

July 26, 2022




Antonio Barroso, M.Sc, P.Eng  
Project Hydrogeologist, President

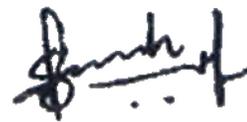
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**GW SOLUTIONS**

ASSESSMENT & PROTECTION OF GROUNDWATER

July 26, 2022  
Project No. 22-01

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## **APPENDIX 1**

GW SOLUTIONS INC. GENERAL CONDITIONS AND LIMITATIONS

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

### 1.0 USE OF REPORT

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

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

### 2.1 INFORMATION PROVIDED TO GW SOLUTIONS BY OTHERS

During the performance of the work and the preparation of this report, GW SOLUTIONS may

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

### 3.0 LIMITATION OF LIABILITY

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

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

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

### 4.0 JOB SITE SAFETY

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

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

### 5.0 DISCLOSURE OF INFORMATION BY CLIENT

The client agrees to fully cooperate with GW SOLUTIONS with respect to the provision of all available information on the past, present, and

proposed conditions on the site, including historical information respecting the use of the site. The client acknowledges that in order for GW SOLUTIONS to properly provide the service, GW SOLUTIONS is relying upon the full disclosure and accuracy of any such information.

#### **6.0 STANDARD OF CARE**

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

#### **7.0 EMERGENCY PROCEDURES**

The client undertakes to inform GW SOLUTIONS of all hazardous conditions, or possible hazardous conditions which are known to it. The client recognizes that the activities of GW SOLUTIONS may uncover previously unknown hazardous materials or conditions and that such discovery may result in the necessity to undertake emergency procedures to protect GW SOLUTIONS employees, other persons and the environment. These procedures may involve additional costs outside of any budgets previously agreed upon. The client agrees to pay GW SOLUTIONS for any expenses incurred as a result of such discoveries and to compensate GW SOLUTIONS through payment of additional fees and expenses for time spent by GW SOLUTIONS to deal with the consequences of such discoveries.

#### **8.0 NOTIFICATION OF AUTHORITIES**

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

#### **9.0 OWNERSHIP OF INSTRUMENTS OF SERVICE**

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

#### **10.0 ALTERNATE REPORT FORMAT**

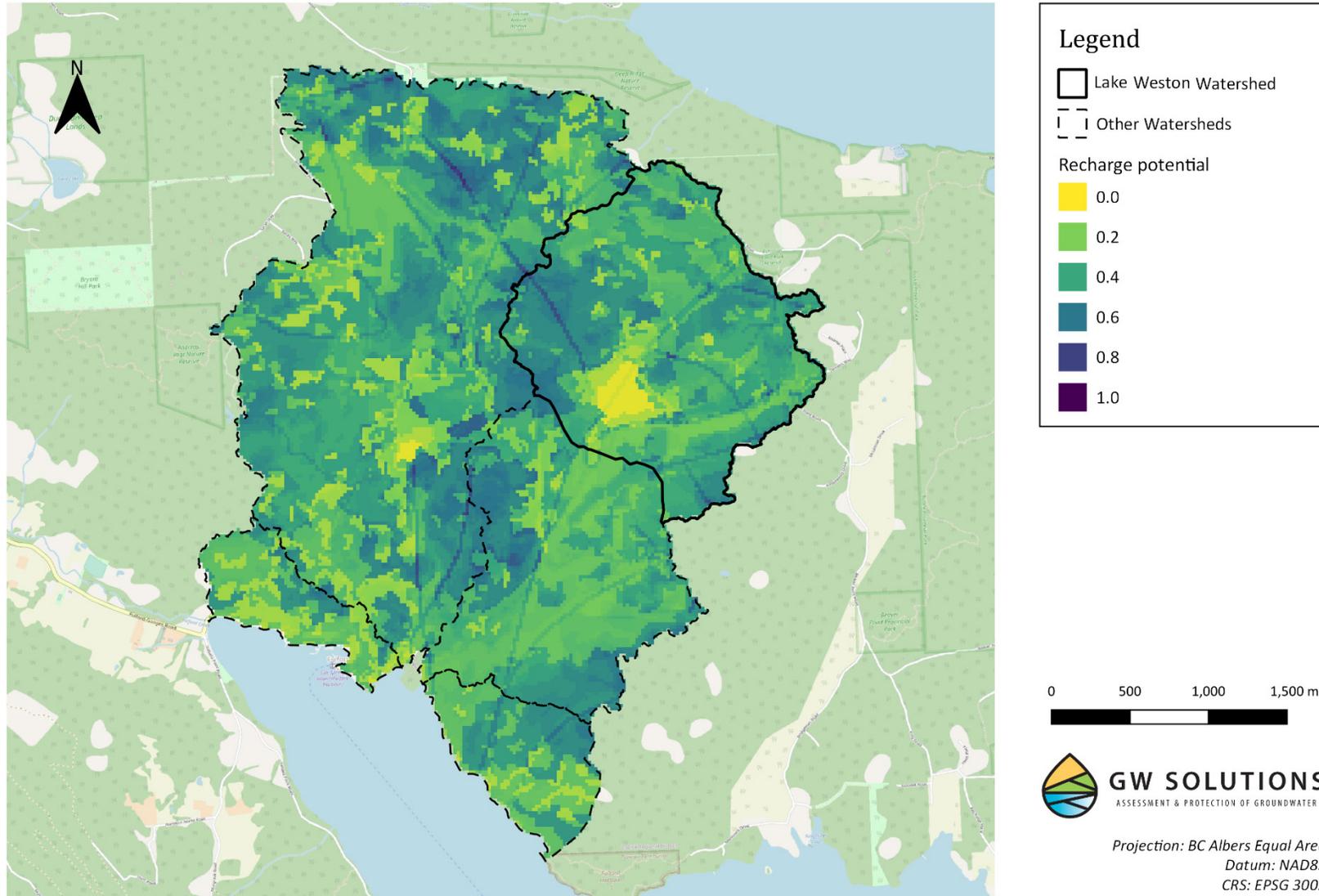
Where GW SOLUTIONS submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed GW SOLUTIONS's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered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

## APPENDIX 2

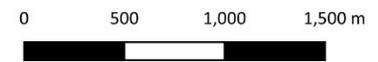
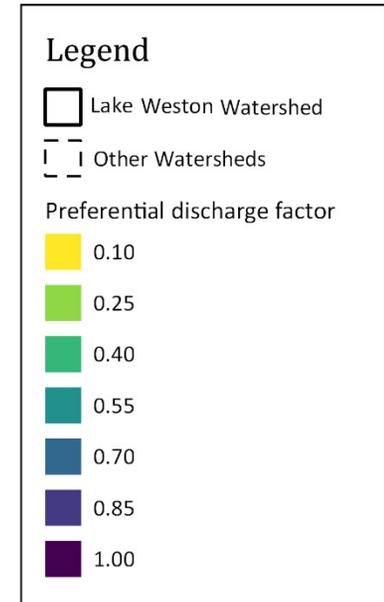
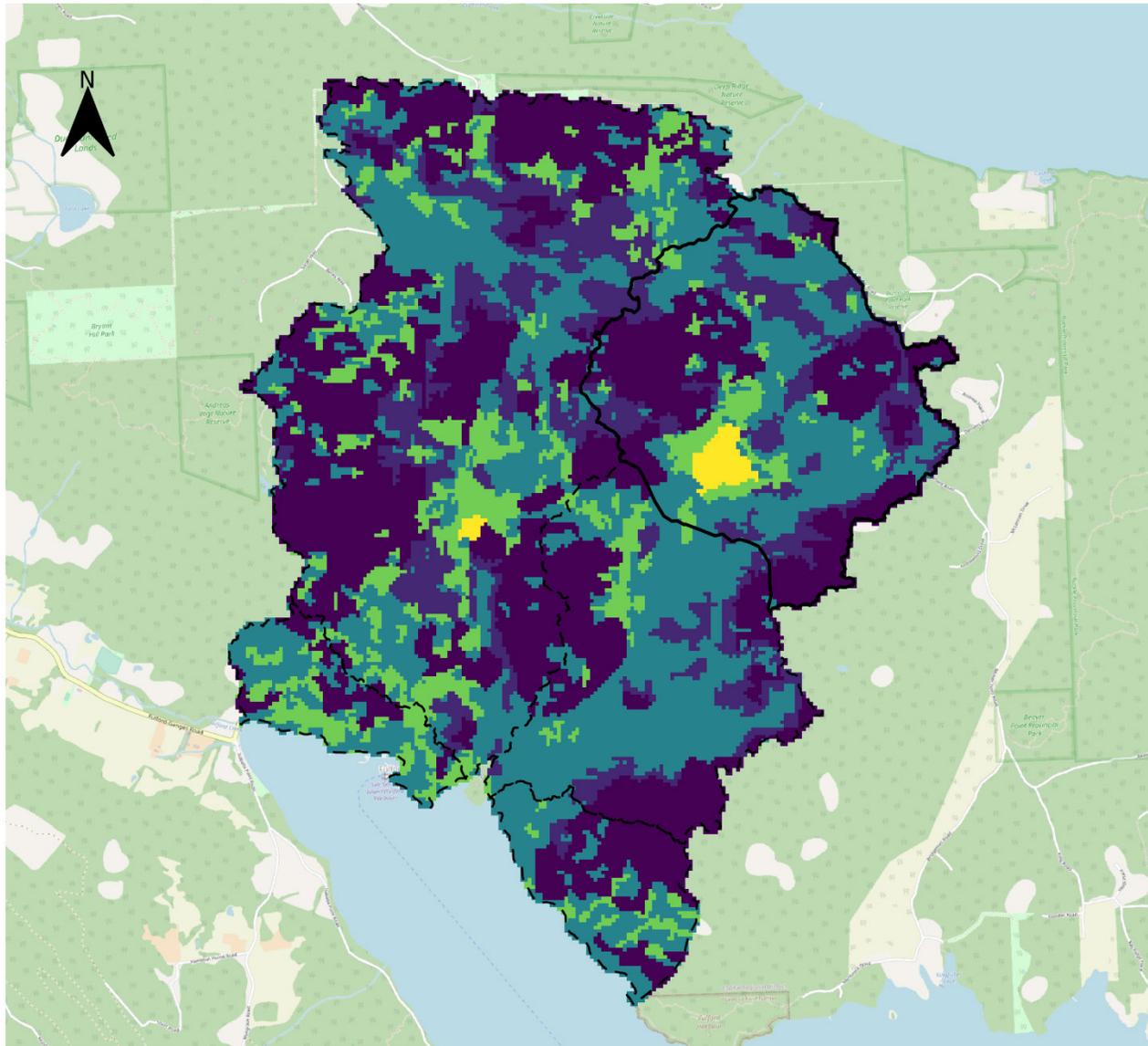
Groundwater Recharge Coefficients and Groundwater Recharge Potential and Recharge Coefficients

## APPENDIX 2: MAPS OF GROUNDWATER RECHARGE POTENTIAL INPUTS

### 1.1 Groundwater recharge potential

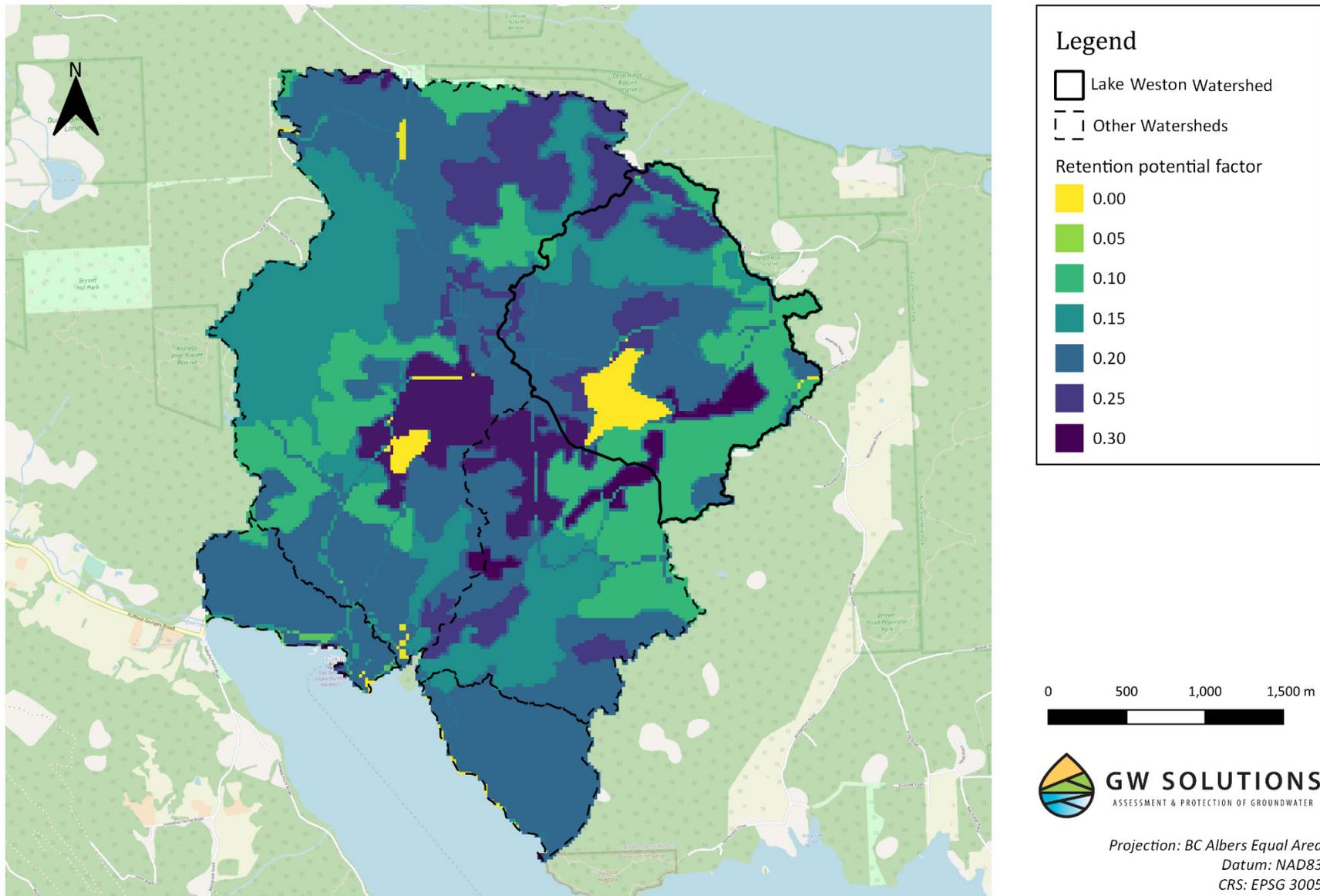


## 1.2 Preferential recharge/discharge factor

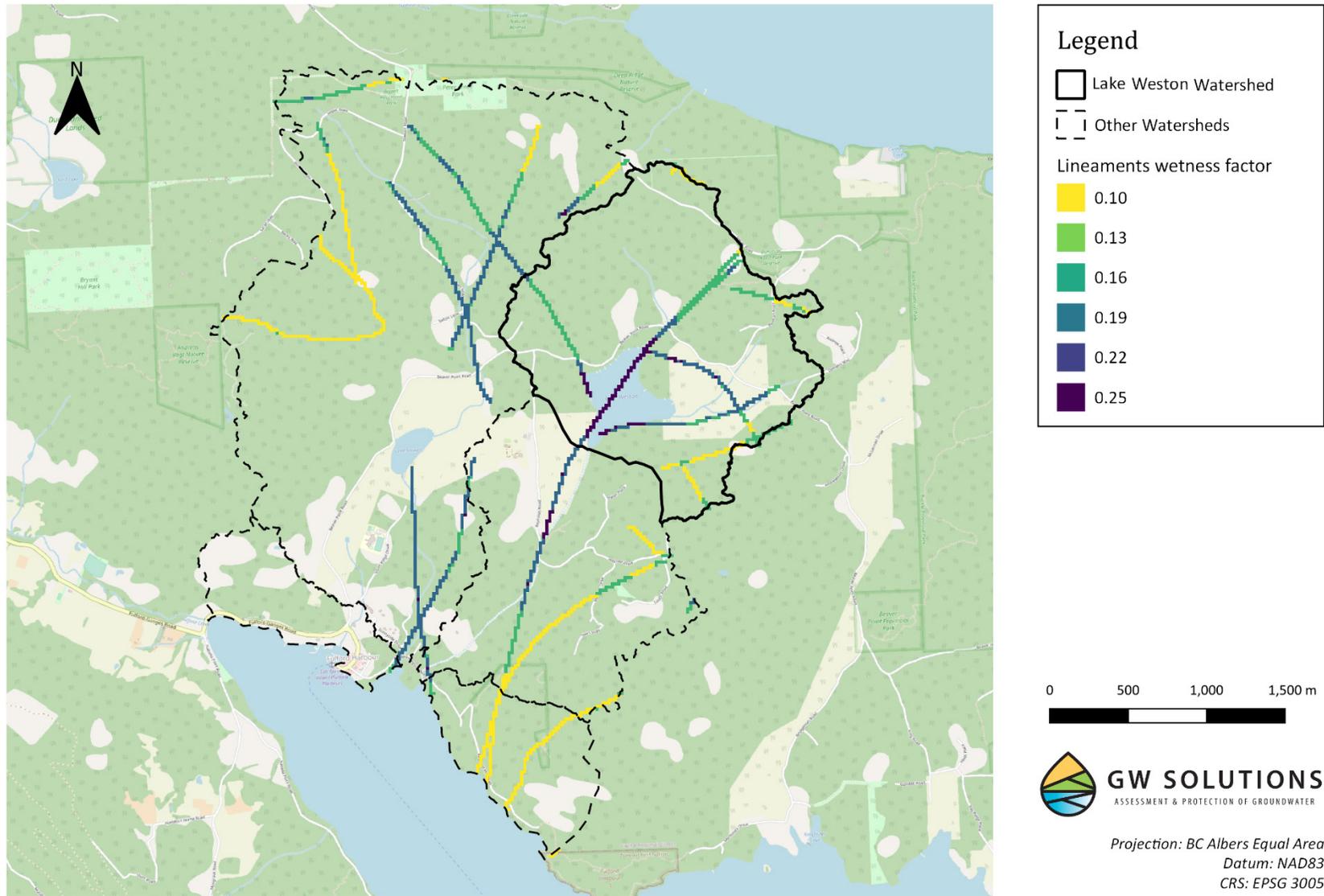


Projection: BC Albers Equal Area  
Datum: NAD83  
CRS: EPSG 3005

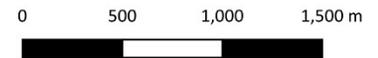
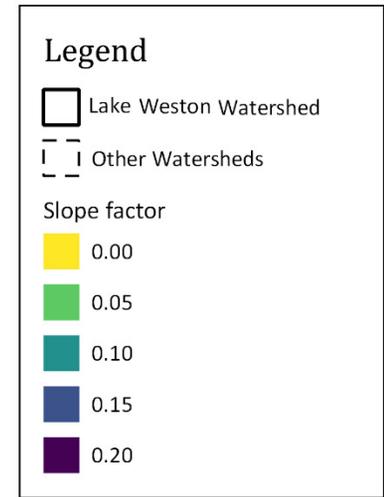
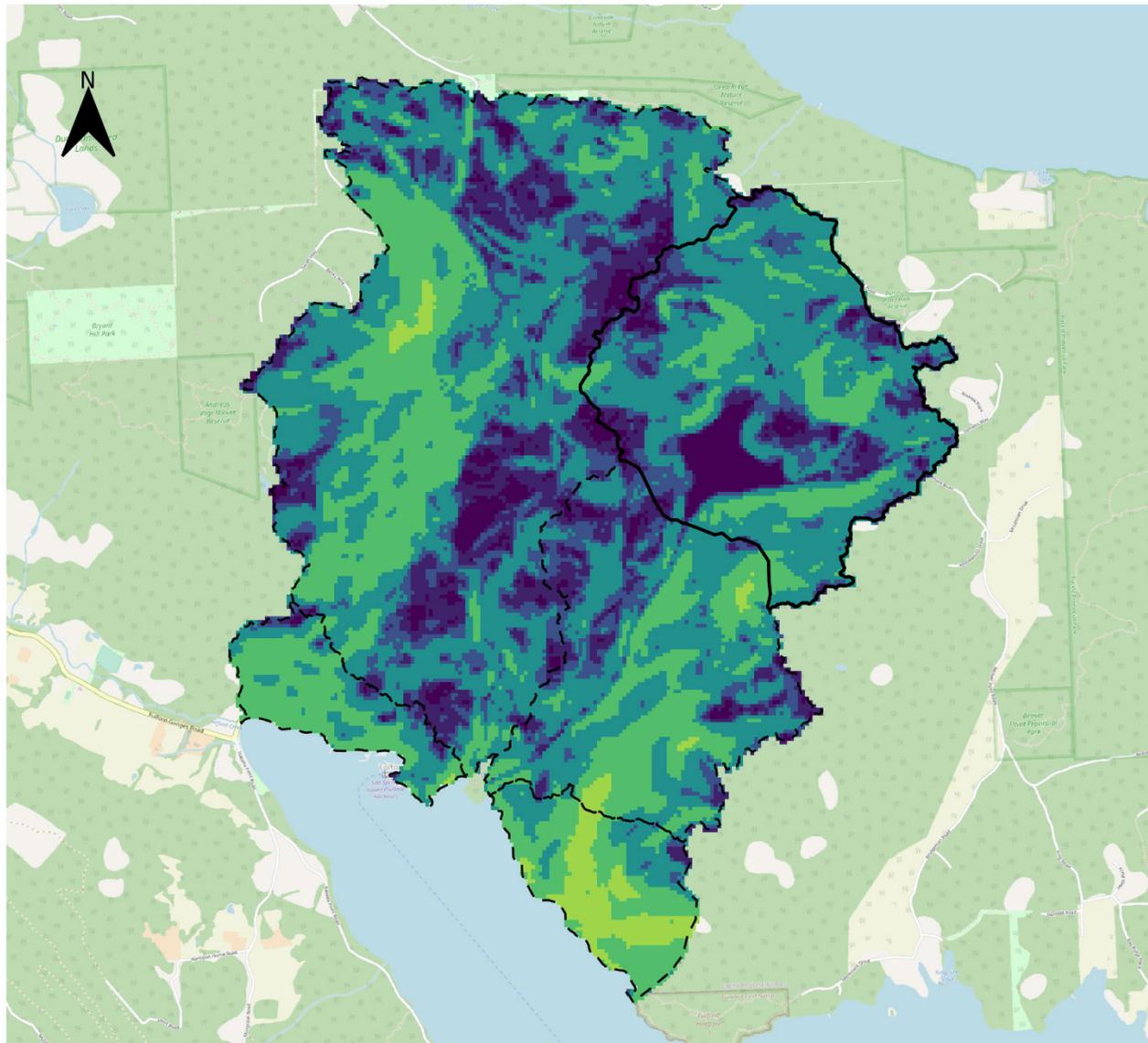
### 1.3 Water retention potential factor



### 1.4 Bedrock lineament wetness factor

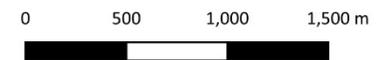
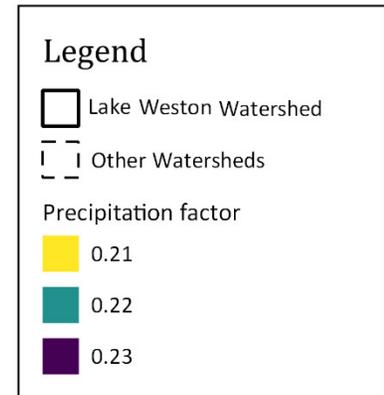
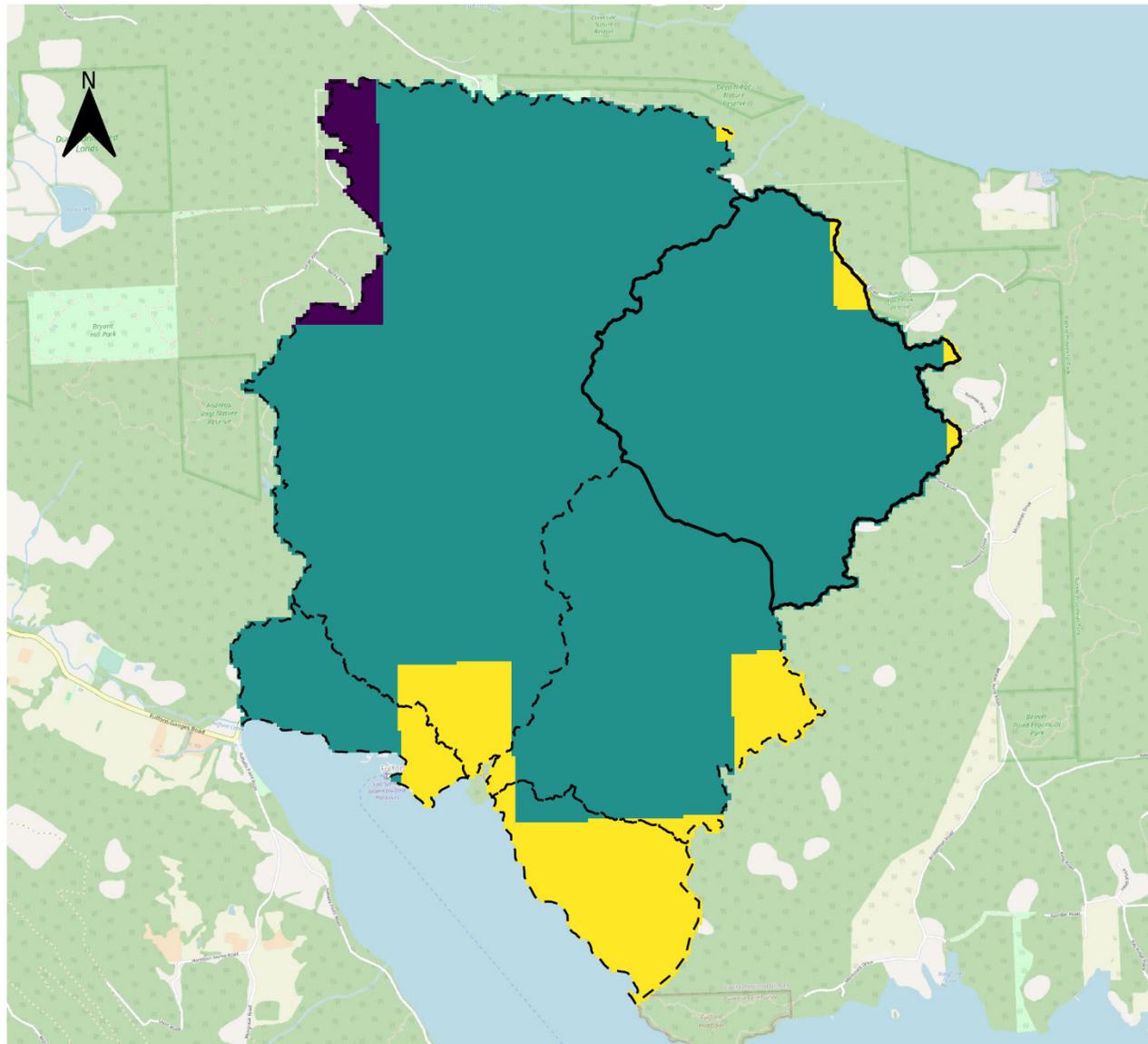


## 1.5 Slope factor



Projection: BC Albers Equal Area  
Datum: NAD83  
CRS: EPSG 3005

## 1.6 Precipitation factor



Projection: BC Albers Equal Area  
Datum: NAD83  
CRS: EPSG 3005

## **APPENDIX 3**

### Water Balance Inputs and Outputs

## APPENDIX 3: WATER BALANCE OUTPUTS FOR LAKE WESTON

### 1.1 Summary of Water Balance Parameters

The water balance model used by GW solutions requires four primary inputs: precipitation, average temperature, total solar radiation, and soil available moisture capacity (AWC). All inputs are obtained as monthly raster layers at a 20m resolution, with exception of AWC, which does not vary over an annual timescale and thus is only a single layer.

Using these as inputs, the water balance model used by GW solutions produces several outputs. These are described as follows:

Output name	Short Name	Description
Potential evapotranspiration	PET	The evaporative water loss from a vegetated surface in which <i>water is not a limiting factor</i> . It represents moisture demand, and is calculated using the Turc method, depending mainly on temperature and radiation.
Soil storage	ST	The amount of moisture stored in the soil in any given month. It depends on the soil AWC as well as PET. When soil storage is full, it is equal to the AWC. When soil storage is 0, any precipitation input must first restore soil moisture capacity to be equal to AWC before it can contribute to runoff or groundwater recharge.
Actual evapotranspiration	AET	The evaporative water loss from a vegetated surface <i>given water availability</i> (where water availability is combination of both precipitation and current soil moisture storage). If water is not limiting (that is, soil storage is full and precipitation exceeds PET), actual evapotranspiration is equal to potential evapotranspiration.
Surplus	S	The excess water not evaporated or transpired, thereby contributing to runoff or subsurface flow. There can be no surplus if storage is not full.
Deficit	D	A theoretical value representing moisture stress. It occurs when evaporative demand is not met by available water. In effect, it is the difference between potential and actual evapotranspiration.

Following the calculation of the water balance output for Lake Weston and its surrounding watersheds, GW solutions combined the available moisture surplus output with the recharge potential layer created through the enhanced recharge potential mapping process. The combined results thus allow the calculation of two additional outputs:

Output name	Short Name	Description
Groundwater recharge	GWR	The amount of surplus that is estimated to contribute to subsurface flow, or groundwater recharge. This is a proportion of the total moisture surplus, and it depends on the landscape's recharge potential.
Surface runoff	RO	The amount of surplus that is estimated to contribute to overland flow, through surface runoff. This is a proportion of the total moisture surplus, and it depends on the landscape's recharge potential.

## 1.2 Water Balance Model Outputs

Outputs from the water balance model for Lake Weston and the surrounding watersheds are summarized in the following plots. The maps show the spatial pattern for each variable by month. The boxplots summarize the overall distribution of values by month, helping emphasize any seasonal patterns present for each variable.

### 1.2.1 Precipitation

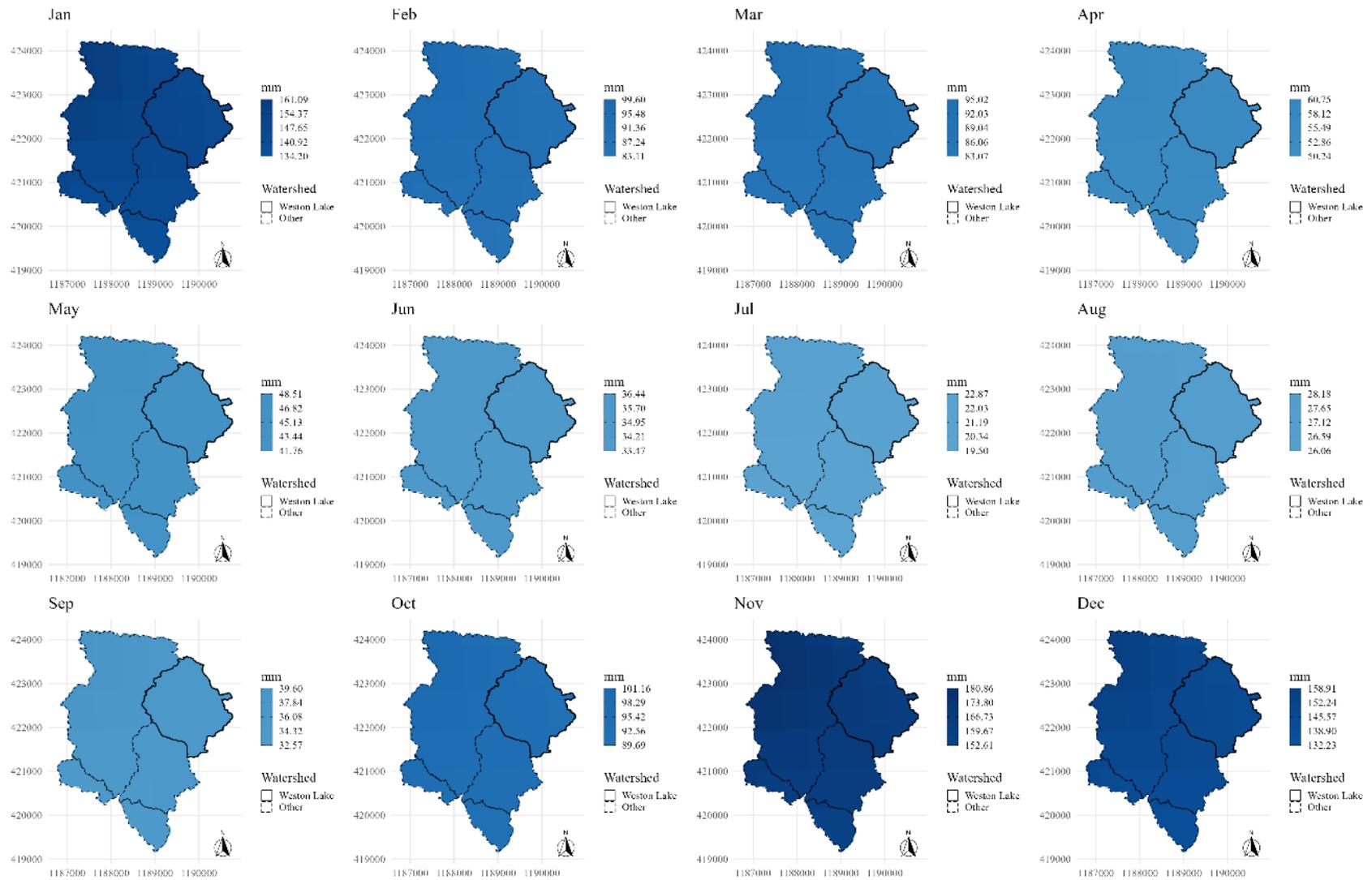


Figure 1: Precipitation by month over Lake Weston and its surrounding watersheds

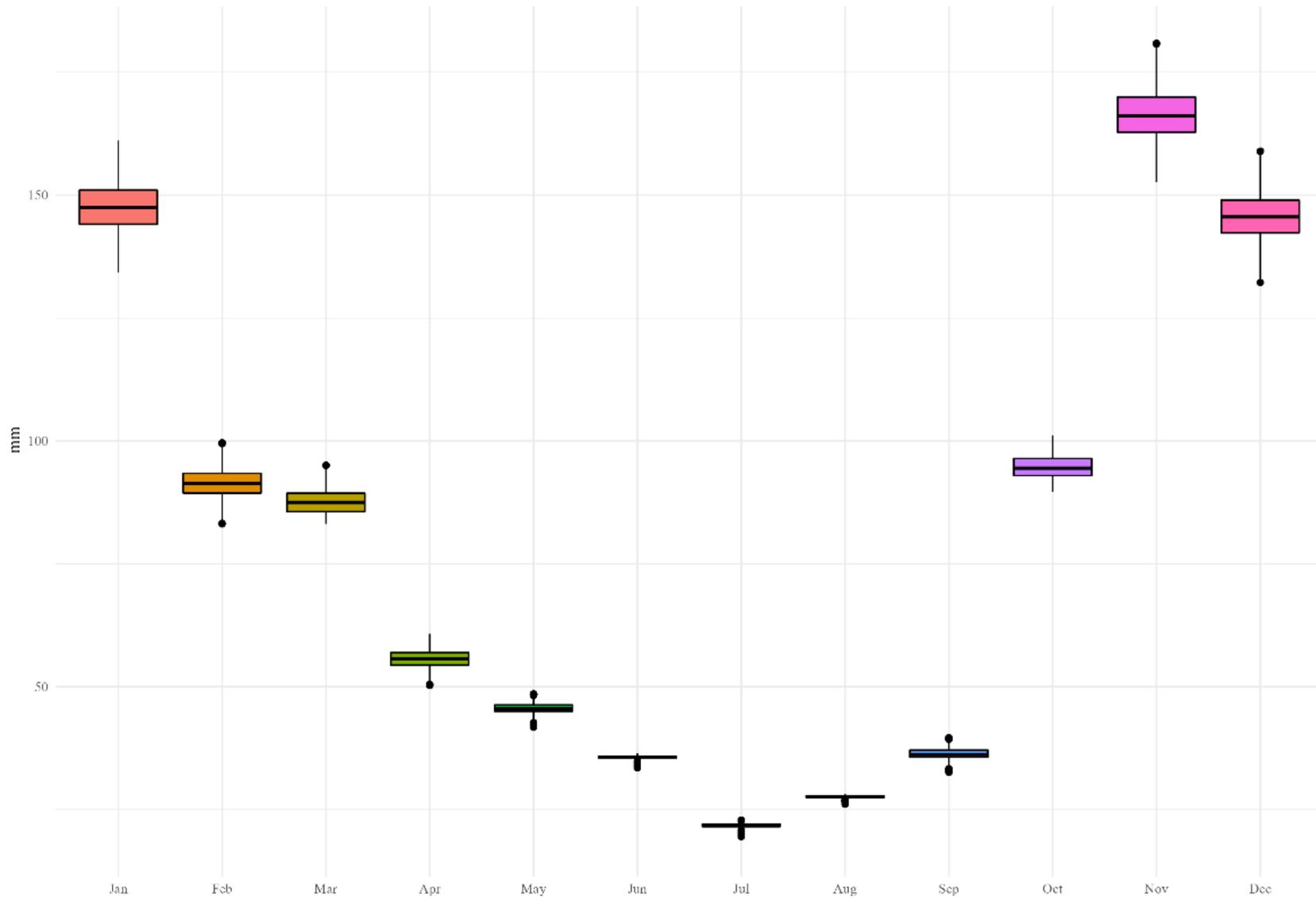


Figure 2: Monthly spread in precipitation over Lake Weston and its surrounding watersheds

### 1.2.2 Temperature

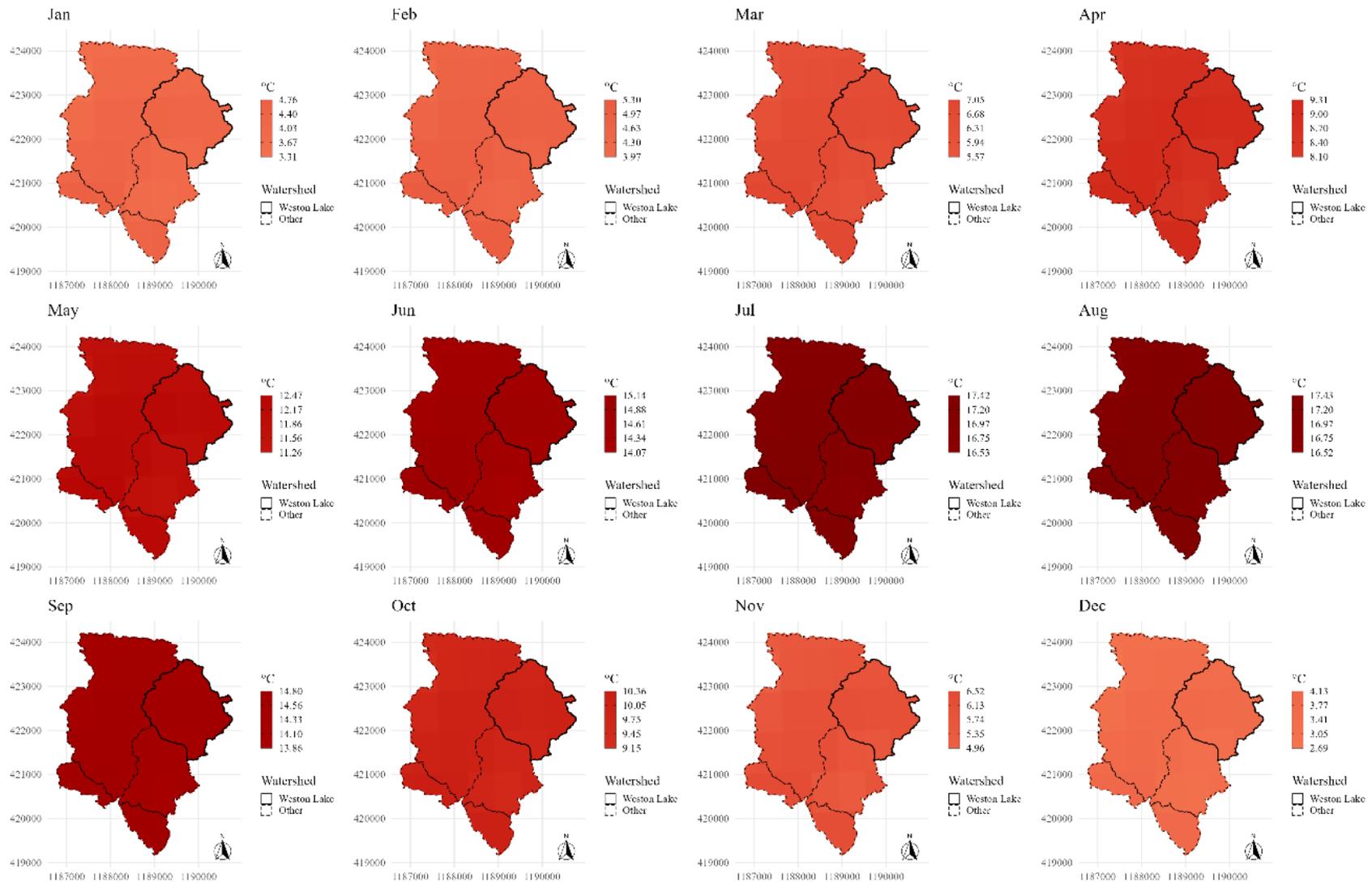


Figure 3: Temperature by month over Lake Weston and its surrounding watersheds

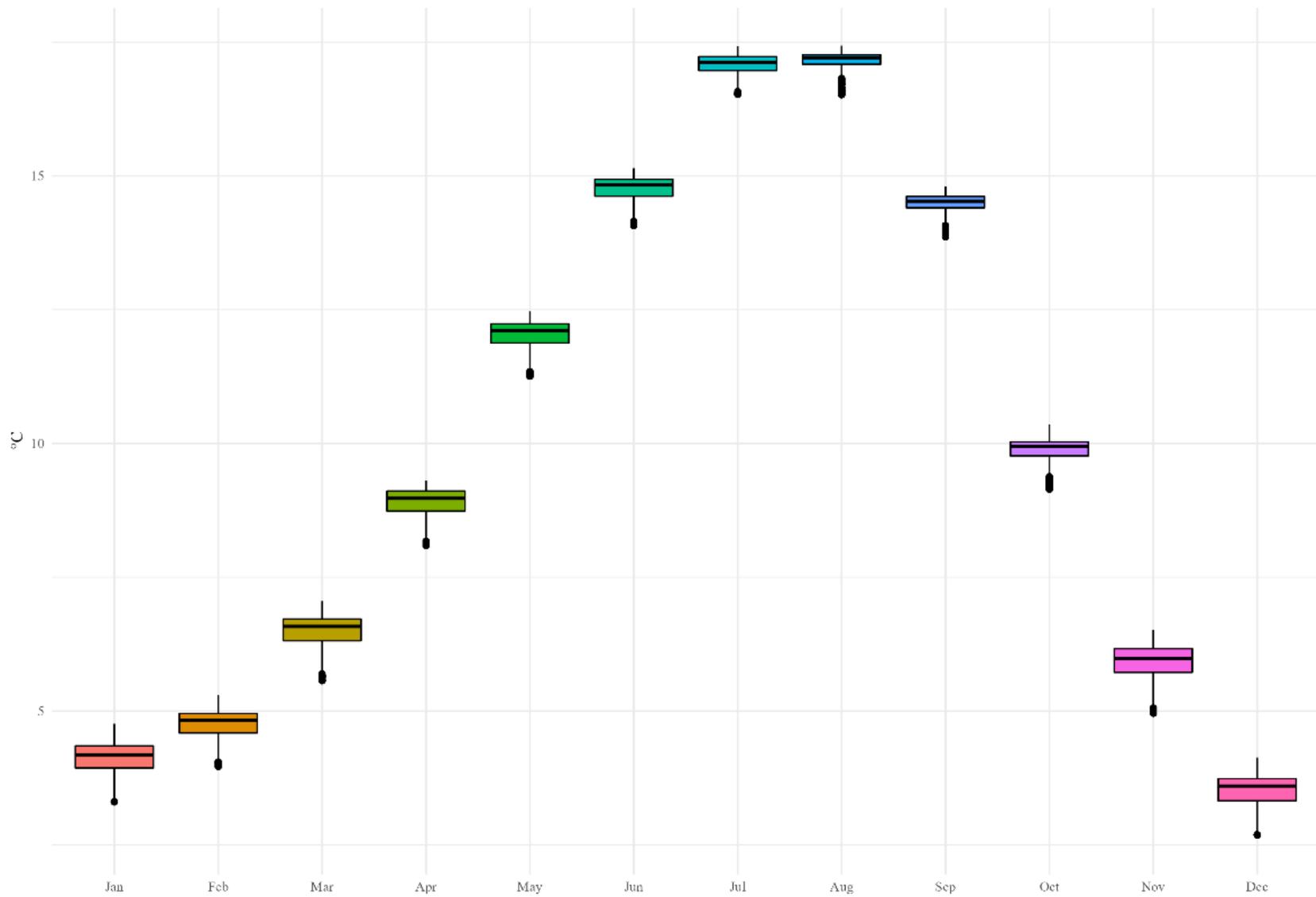


Figure 4: Monthly spread in temperature over Lake Weston and its surrounding watersheds

### 1.2.3 Radiation

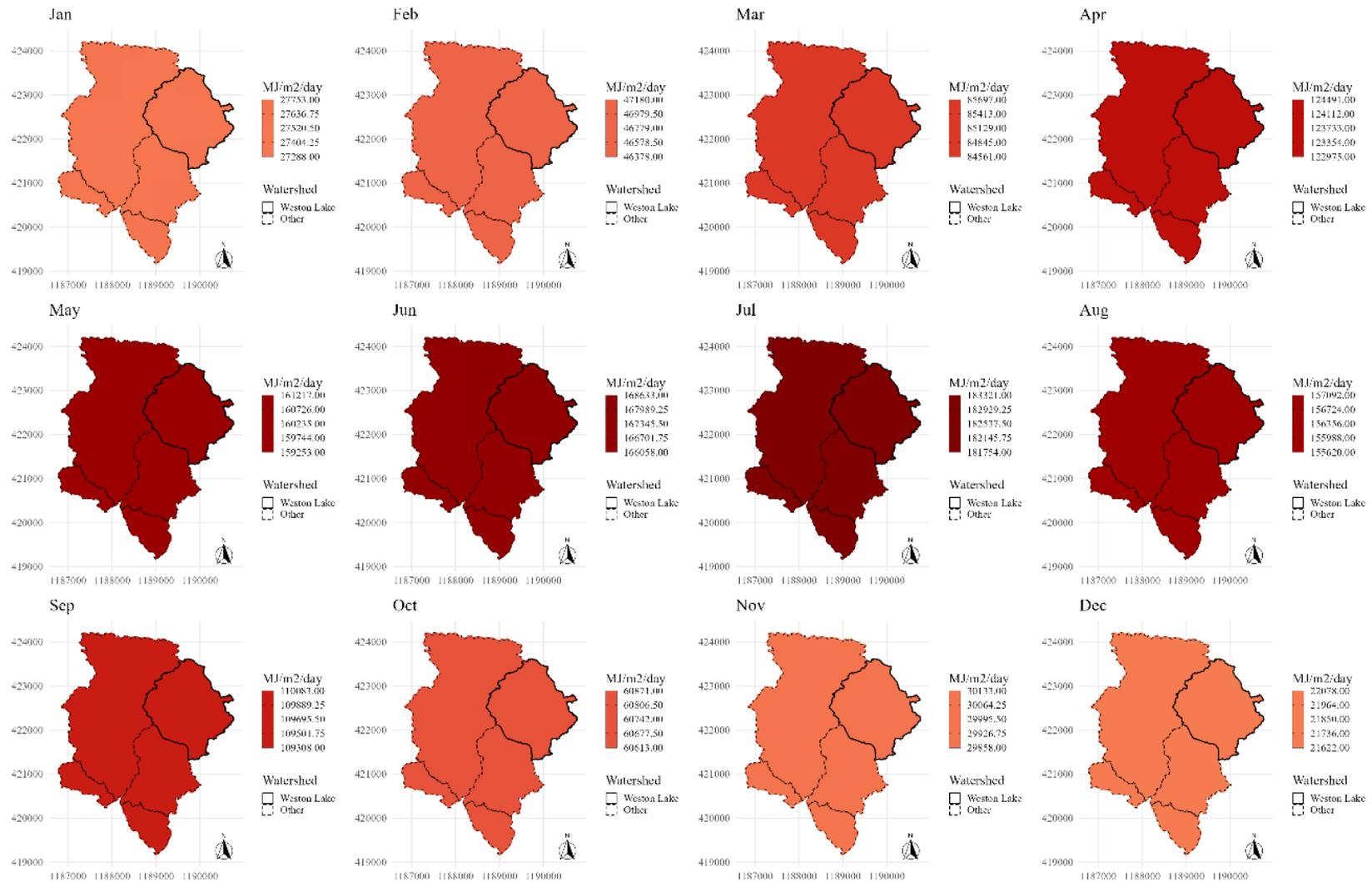
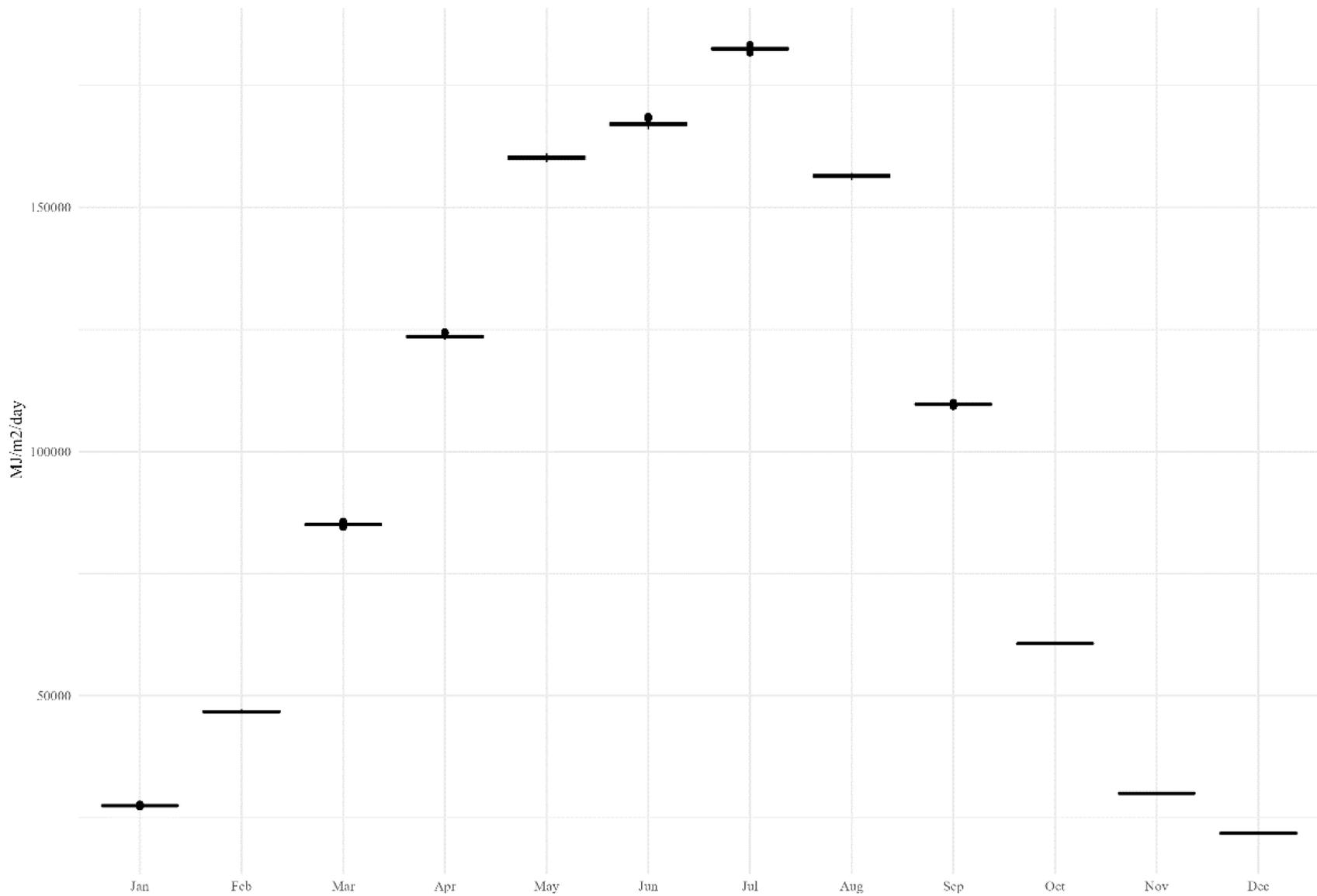


Figure 5: Radiation by month over Lake Weston and its surrounding watersheds



**Figure 6:** Monthly spread in radiation over Lake Weston and its surrounding watersheds

### 1.2.4 Potential Evapo-transpiration

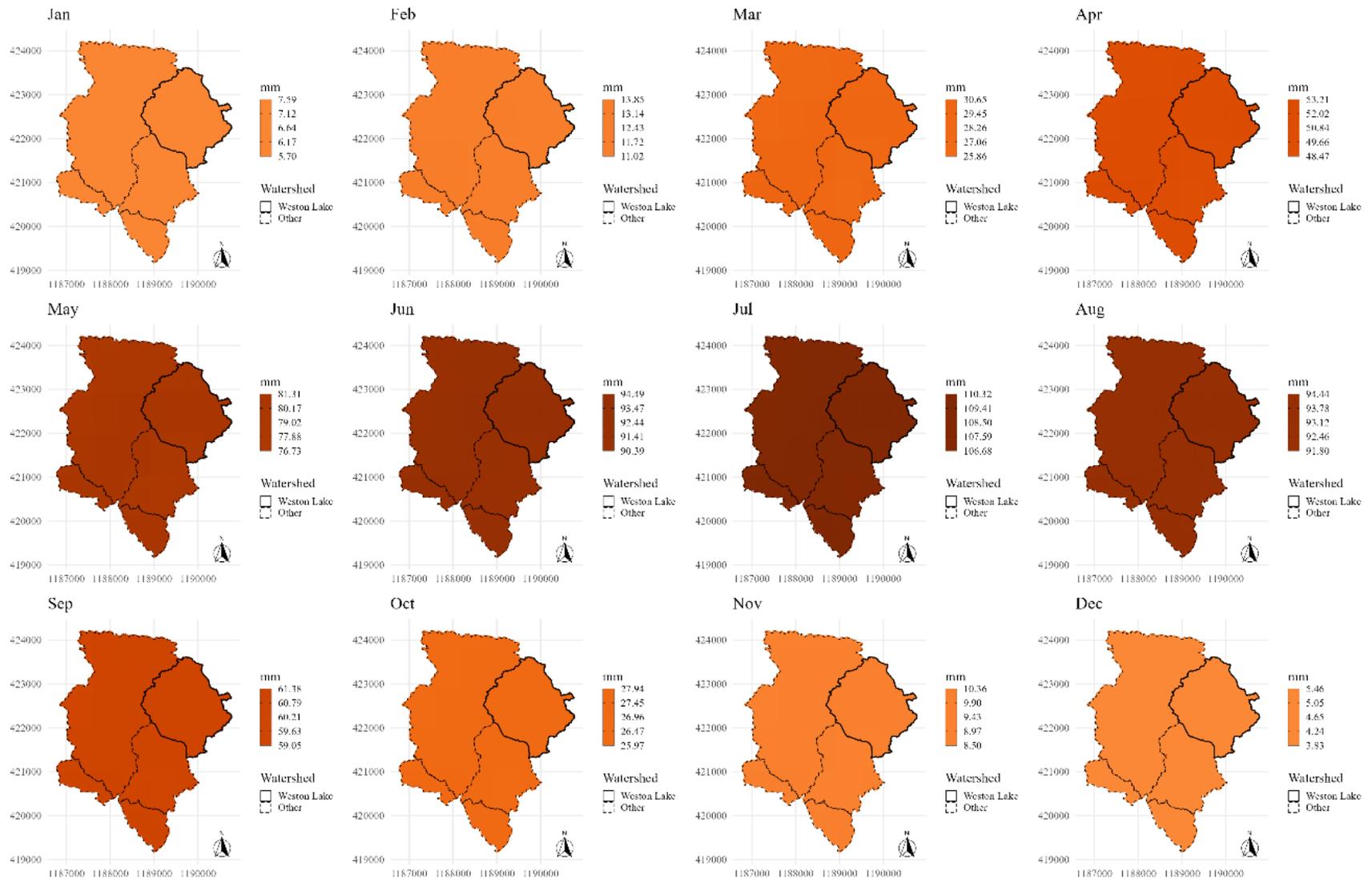
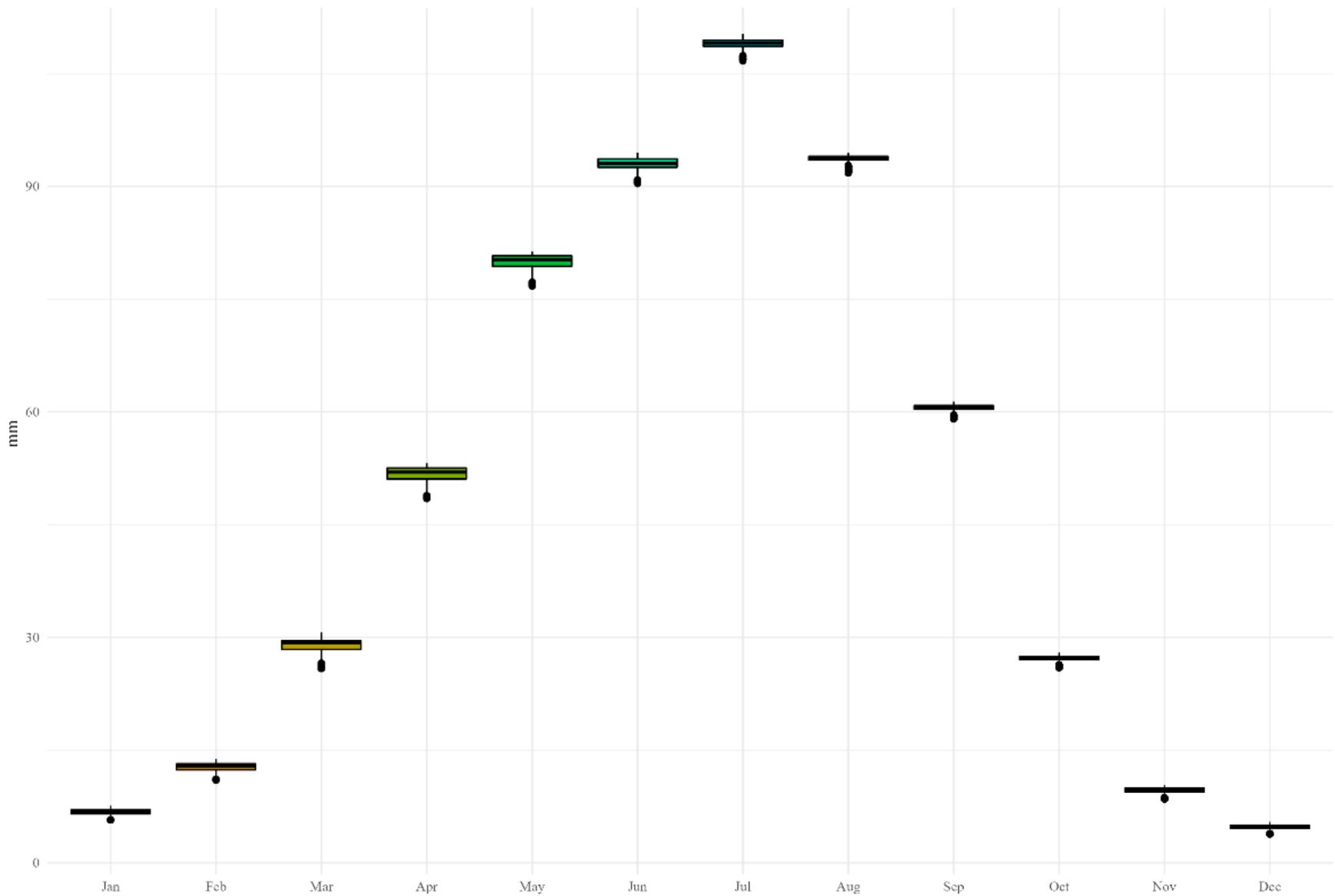


Figure 7: Potential evapo-transpiration by month over Lake Weston and its surrounding watersheds



**Figure 8:** Monthly spread in potential evapo-transpiration over Lake Weston and its surrounding watersheds

### 1.2.5 Actual Evapo-transpiration

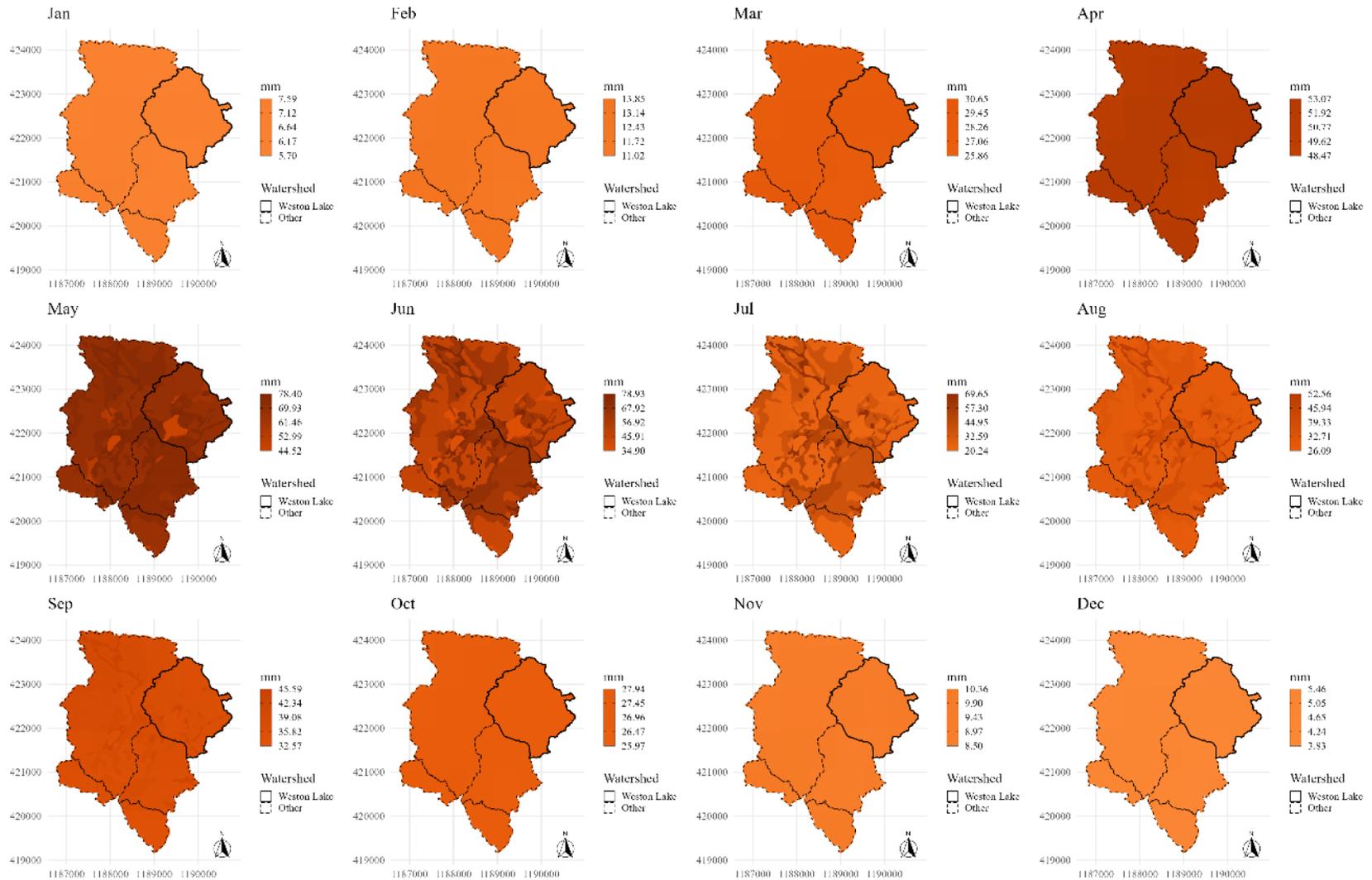


Figure 9: Actual evapo-transpiration by month over Lake Weston and its surrounding watersheds

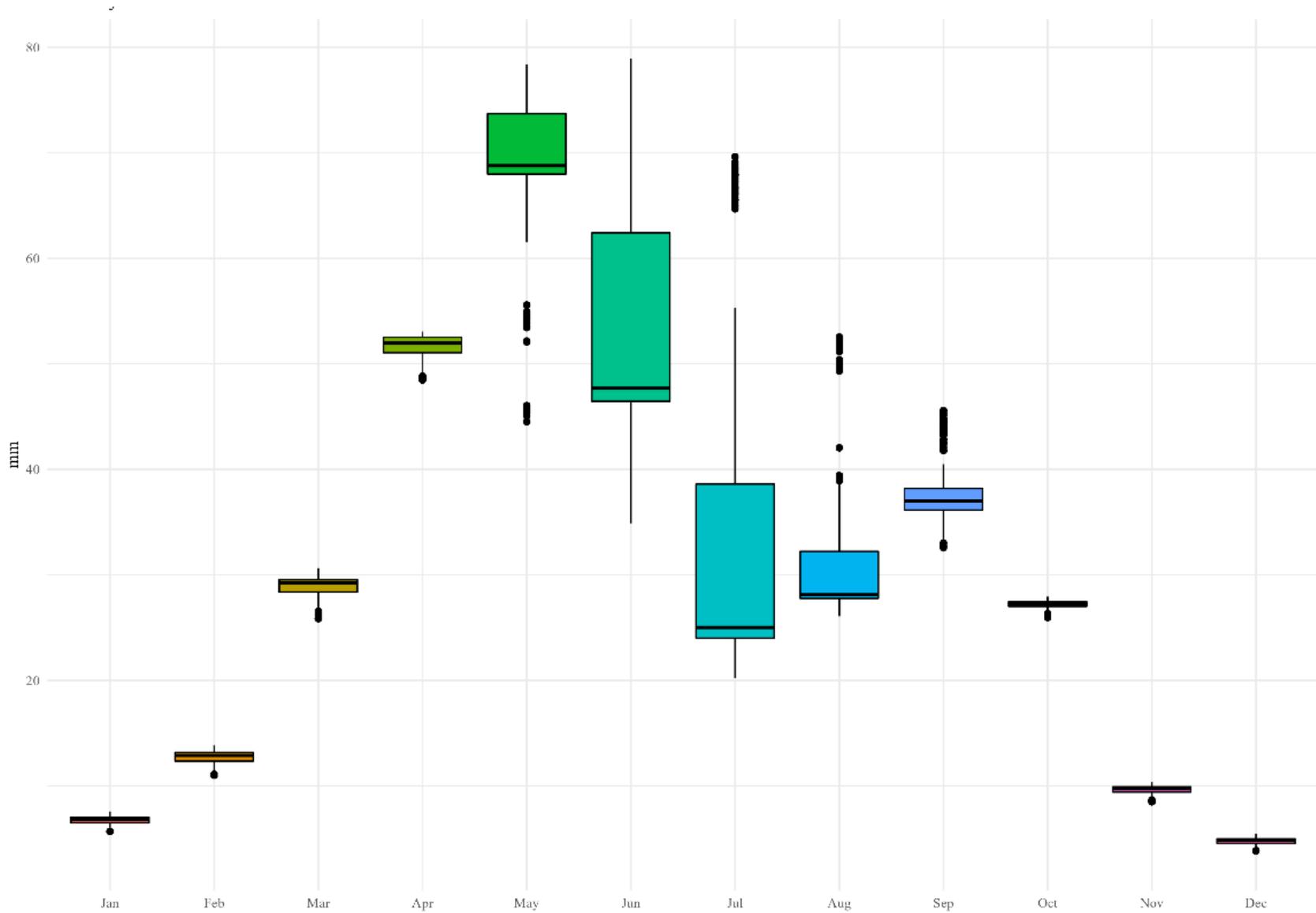


Figure 10: Monthly spread in actual evapo-transpiration over Lake Weston and its surrounding watersheds

### 1.2.6 Soil Storage

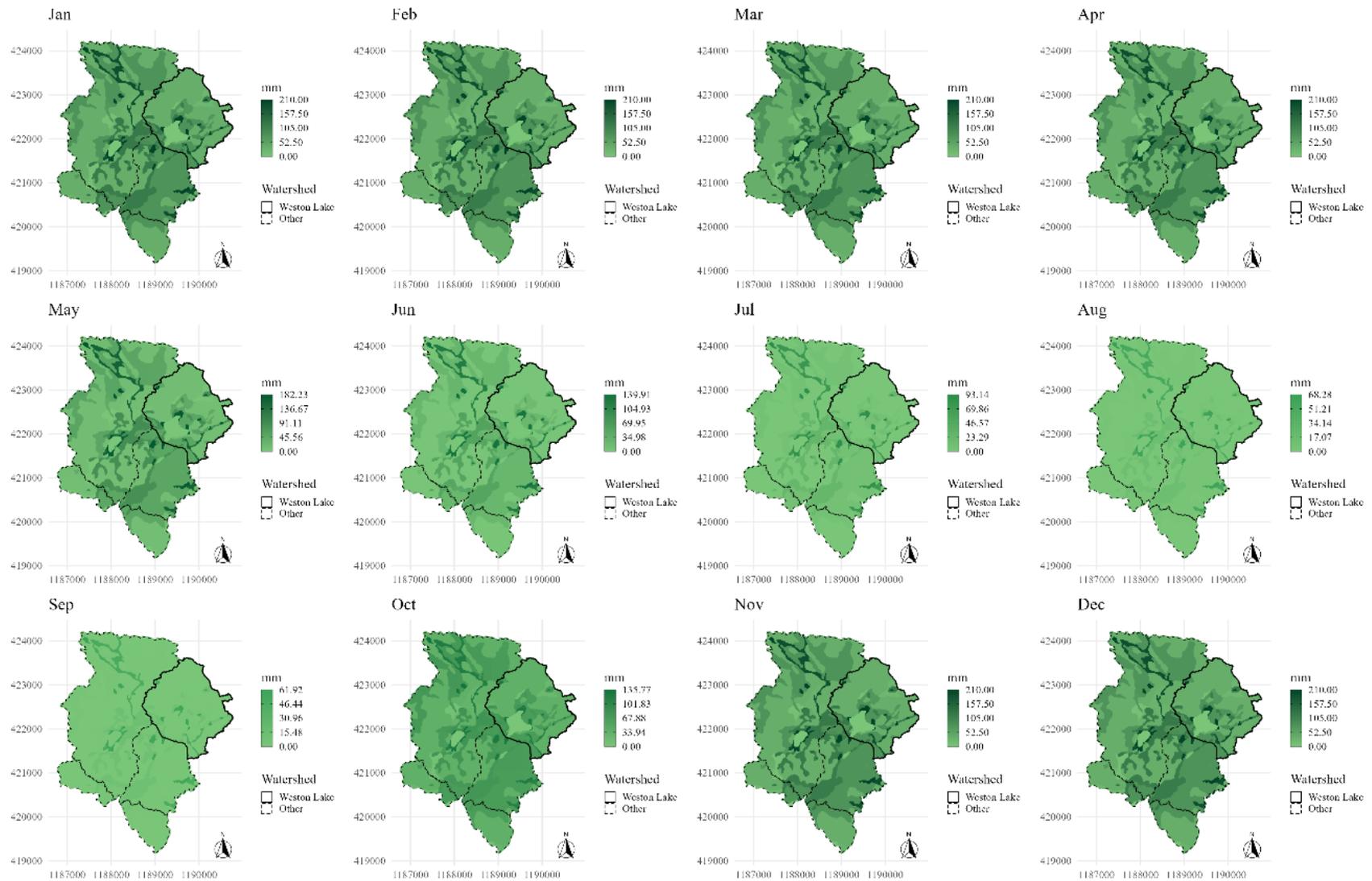
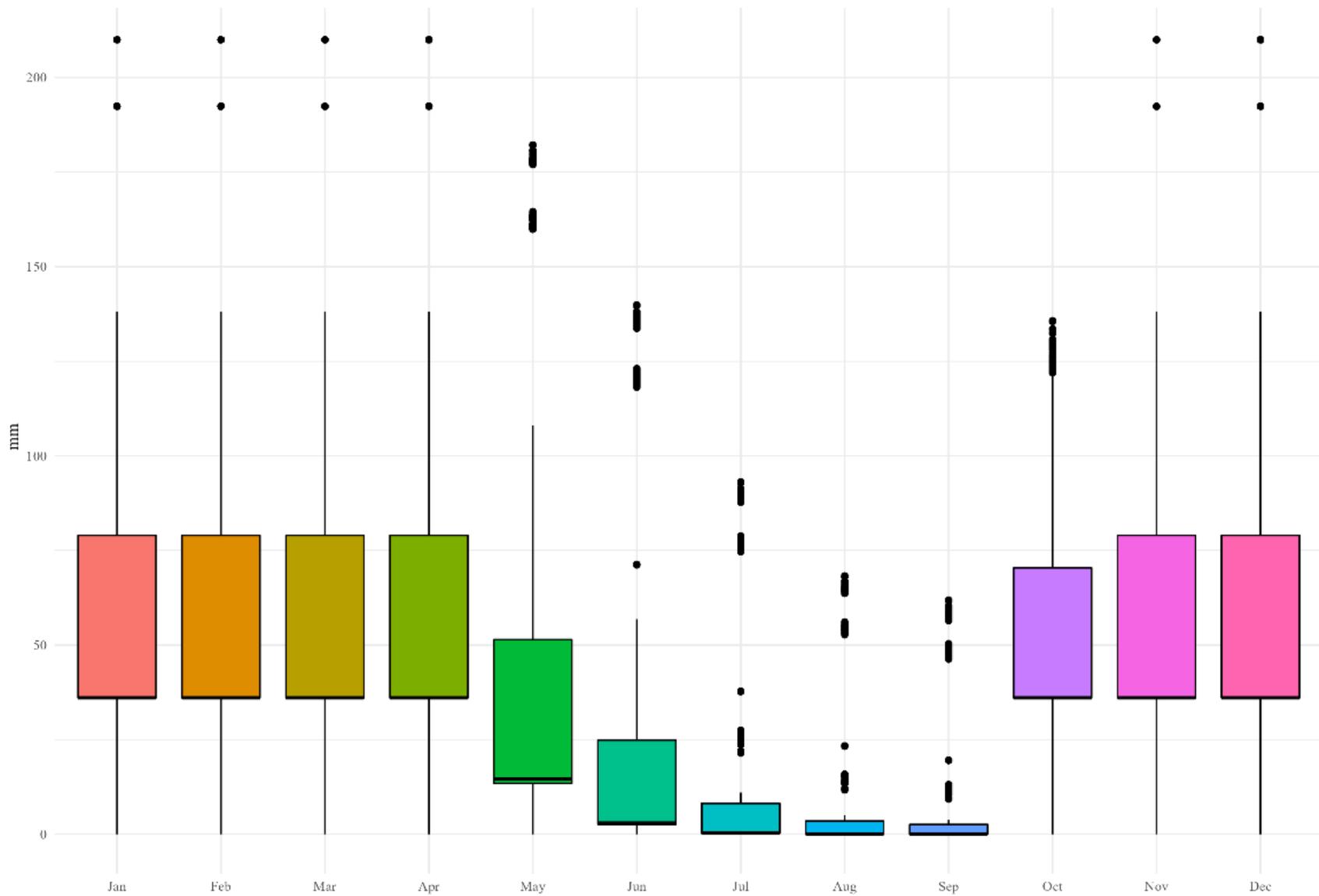


Figure 11: Soil storage by month over Lake Weston and its surrounding watersheds



**Figure 12:** Monthly spread in soil storage over Lake Weston and its surrounding watersheds

### 1.2.7 Moisture Deficit

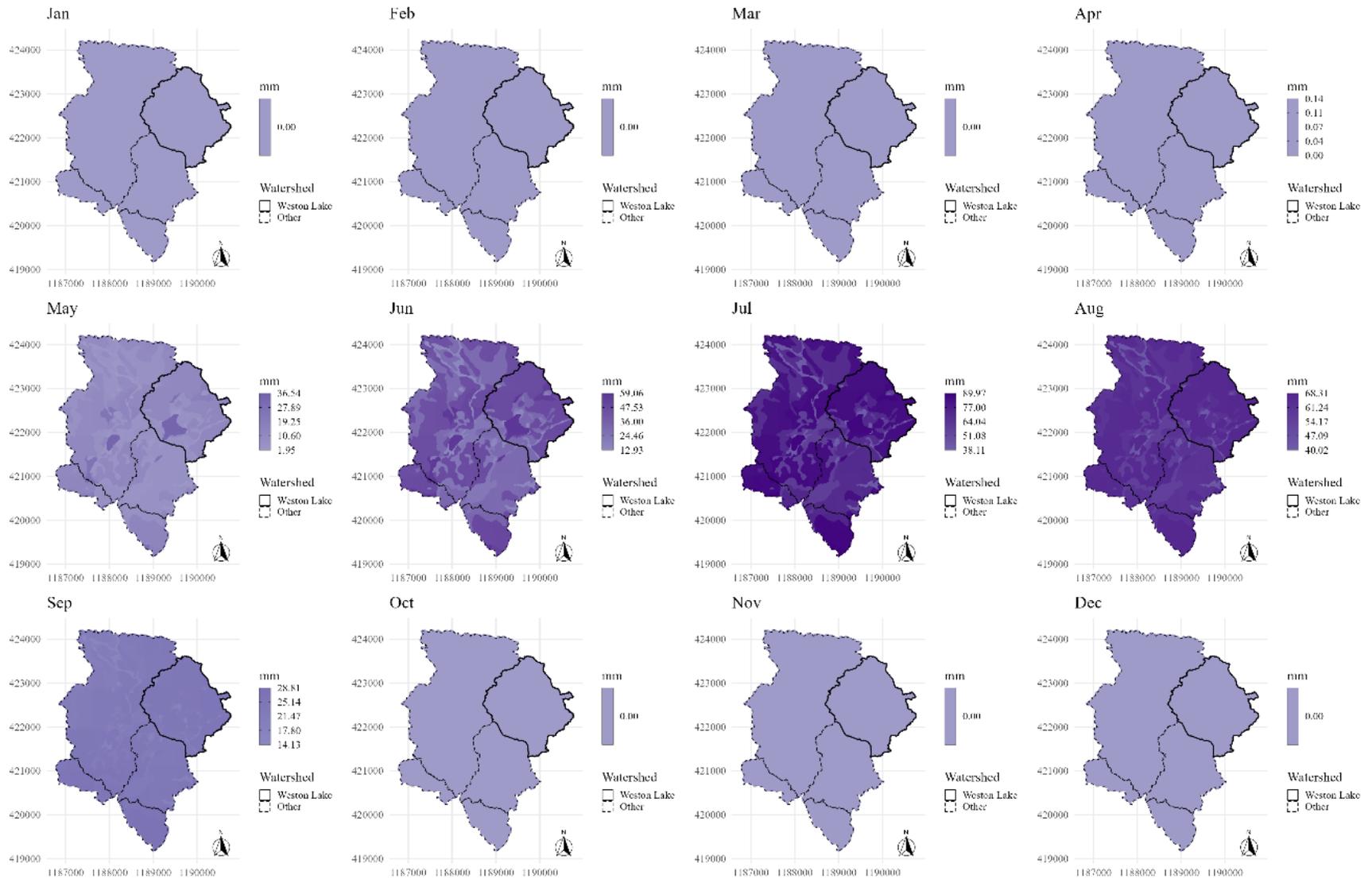


Figure 13: Moisture deficit by month over Lake Weston and its surrounding watersheds

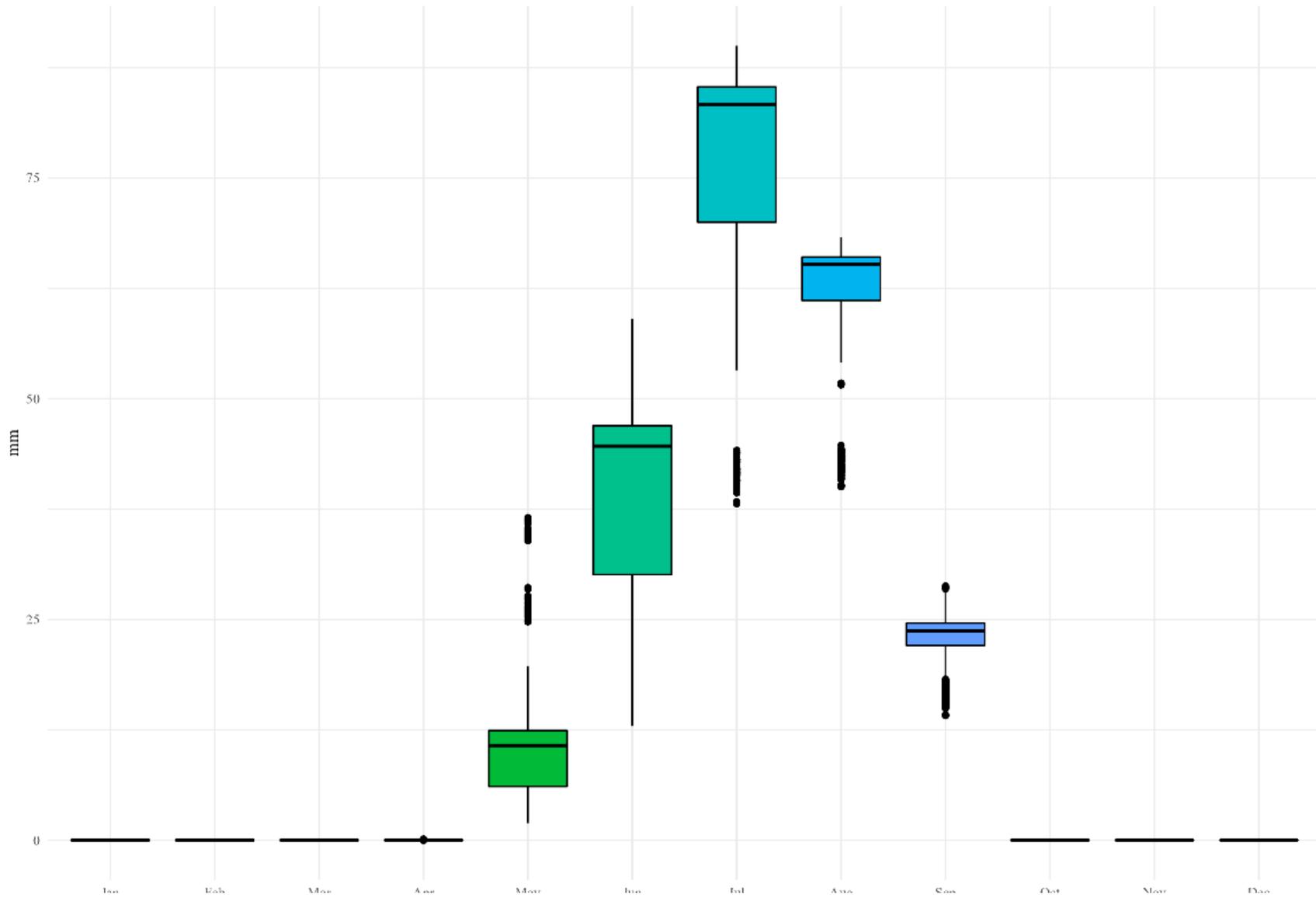


Figure 14: Monthly spread in moisture deficit over Lake Weston and its surrounding watersheds

### 1.2.8 Moisture Surplus



Figure 15: Moisture surplus by month over Lake Weston and its surrounding watersheds

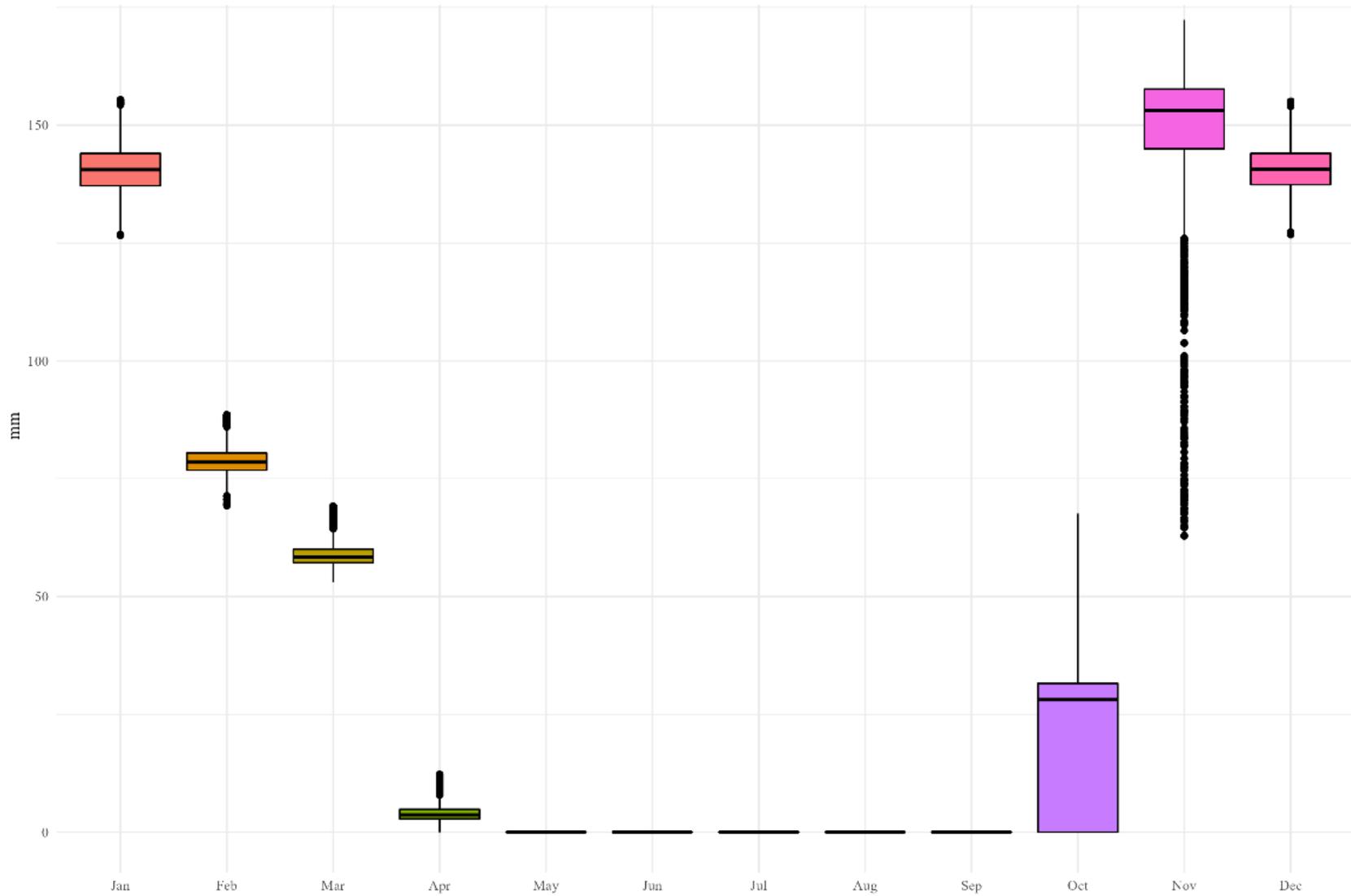


Figure 16: Monthly surplus in moisture deficit over Lake Weston and its surrounding watersheds

### 1.2.9 Groundwater recharge

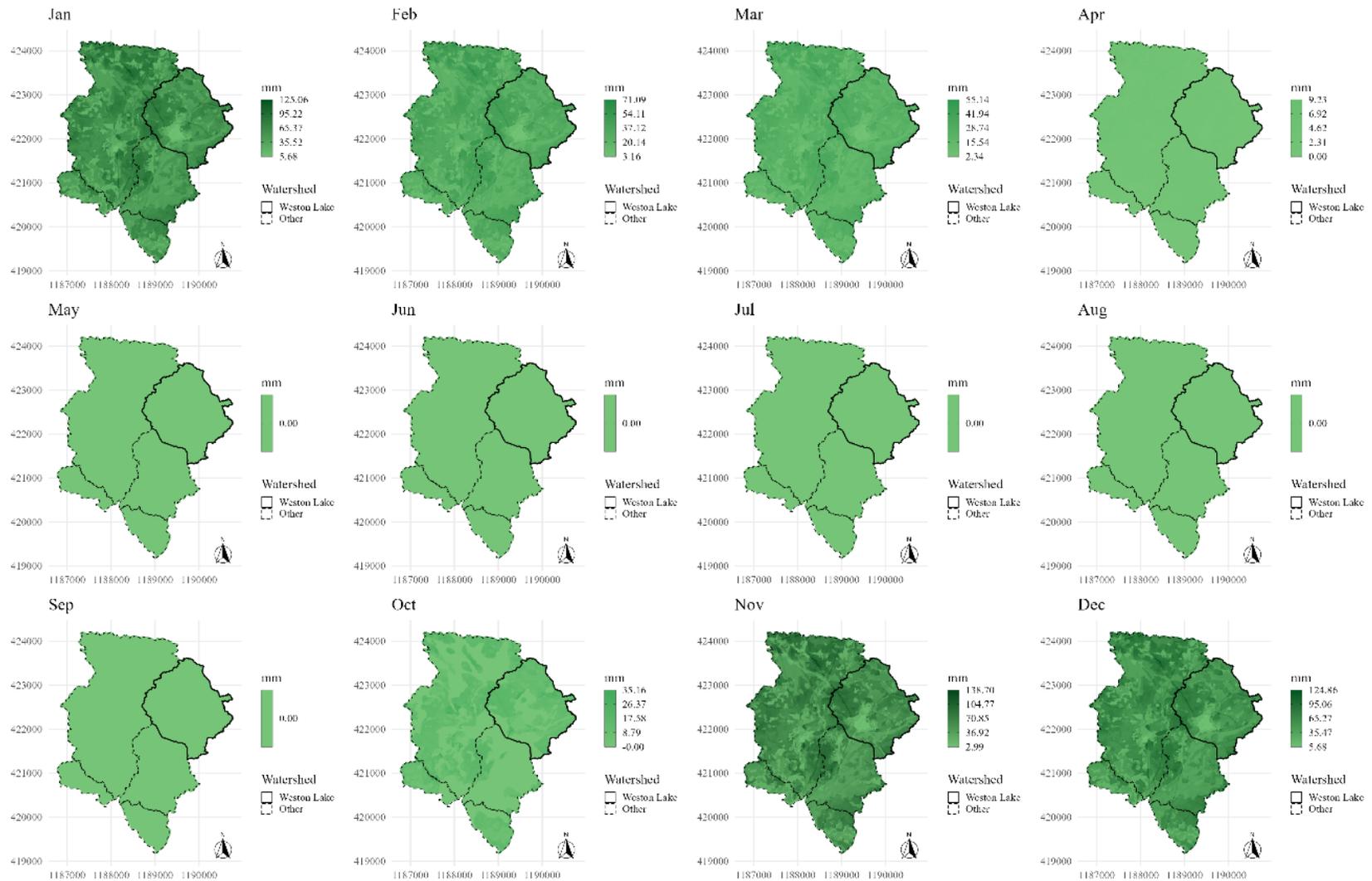


Figure 17: Groundwater recharge by month over Lake Weston and its surrounding watersheds

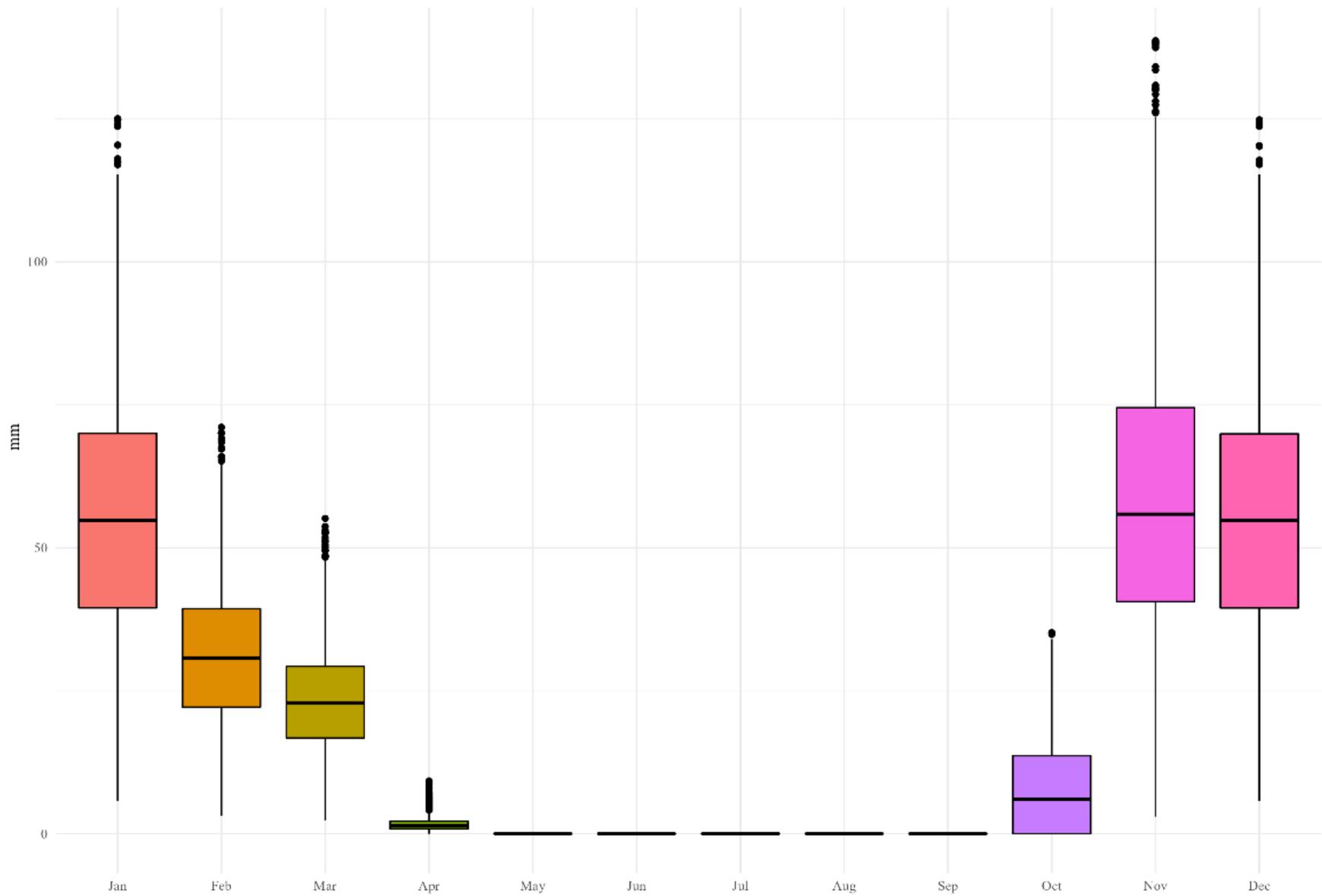


Figure 18: Monthly spread in groundwater recharge over Lake Weston and its surrounding watersheds

### 1.2.10 Surface runoff

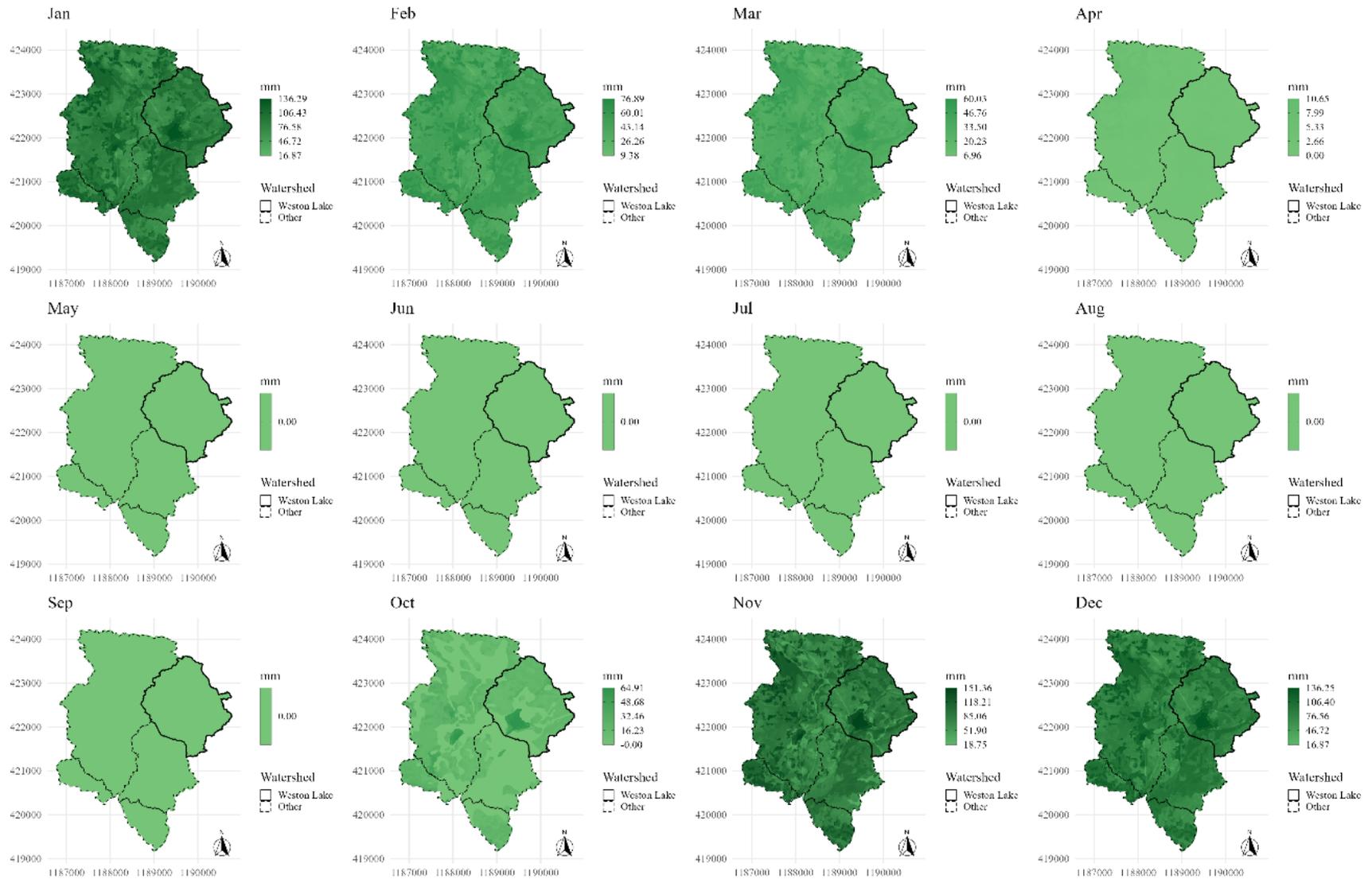


Figure 19: Surface runoff by month over Lake Weston and its surrounding watersheds

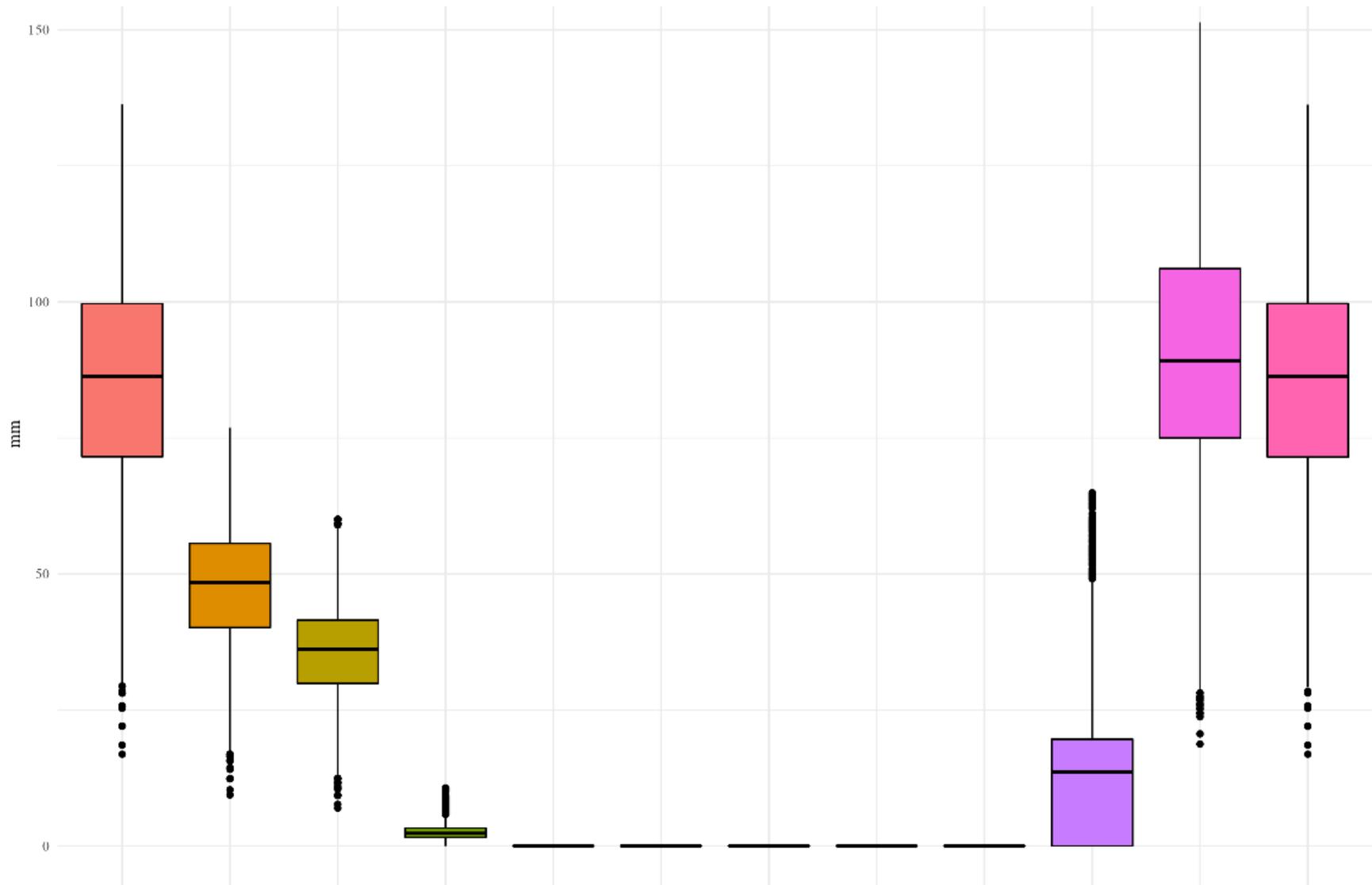


Figure 20: Monthly spread in surface runoff over Lake Weston and its surrounding watersheds

## **APPENDIX 4**

### Climate Change Analysis

## APPENDIX 4: CLIMATE CHANGE ANALYSIS

### 1.1 Introduction to Climate Models and their Evolution

Mathematical models that simulate climate, known as climate models, are commonly used to understand the Earth’s climate. These climate models are a conceptualization of the physics of the atmosphere, oceans, and the cycling of chemicals between living things and their environment. These models have increased in complexity over time, with different components affecting the Earth’s climate being integrated to form coupled systems. The coupled General Circulation Models (GCMs), also called Global Climate Models simulate climate variables considering the circulation of air and water in the atmosphere and oceans, as well as the transfer of heat.

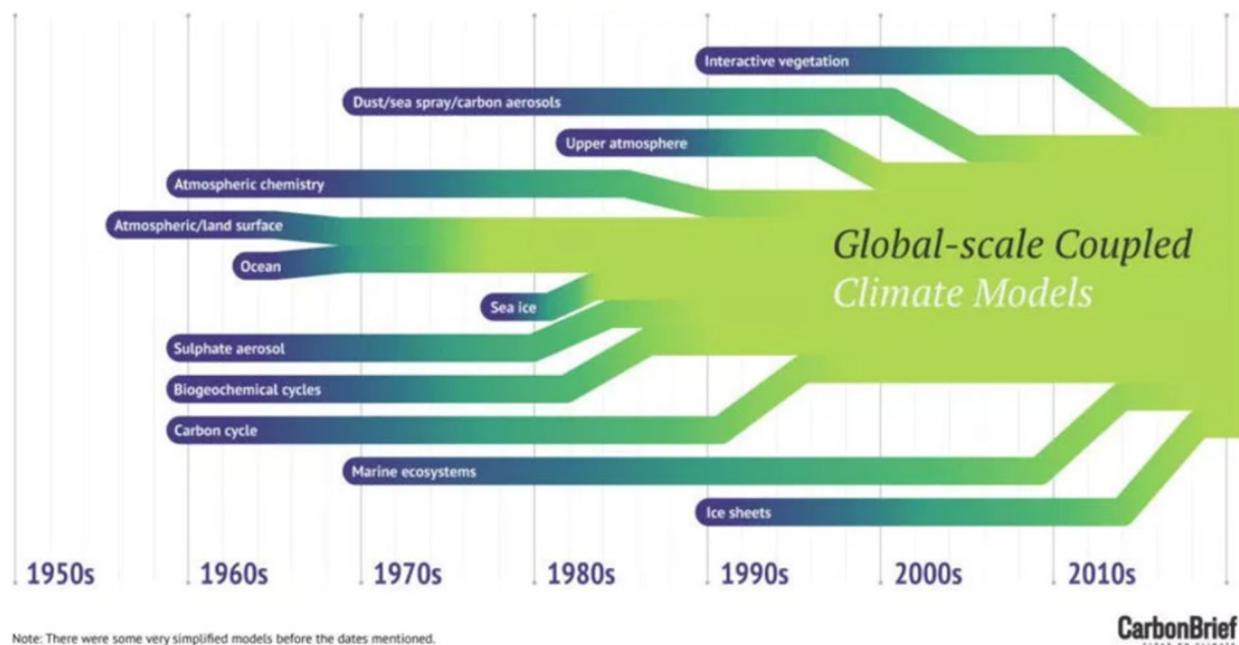


Figure 1: Improvement of climate change models over time (source: McSweeney and Hausfather, 2018)

Processes that affect climate change are challenging to estimate and model. Additionally, human responses to climate change, through decisions regarding policy, land-use and climate mitigation add uncertainty as they affect how future climate change mitigation will unfold. When modelling climate, then, it is useful to consider multiple greenhouse gas emission scenarios, ranging from low to high emissions. As there is no single climate future, such projection scenarios can be used to illustrate a range of possible futures, depending on how human and natural systems respond to climate forcing.

Integrated Assessment Models (IAMs) are tools that model emissions scenarios by analyzing how various kinds of social and economic decisions will impact climate change. Combining insights from GCMs and IAMs, the climate research community has developed a set of 4 “shared socio-economic pathways” (SSPs) – models of climate forcing that each represent different projected human responses to climate change. These SSPs are named SSP 2.6, SSP 4.5, SSP 7.0 and SSP 8.5. Each SSP serves as a representation of future climate forcing under certain conditions of mitigation, thereby reflecting different degrees of optimism regarding the human response to climate change. SSP1- 2.6 considers aggressive mitigation measures, which ensure that climate warming by 2100 does not exceed the 2-degree mark. In contrast, SSP5 - 8.5 reflects a status quo scenario with no mitigation measures. The other scenarios fall in between these two extremes. The SSPs thus enable the GCMs to model a range of possible climate change scenarios, offering greater insight into the breadth of potential impacts that climate change can have on the earth system.

## 1.2 Defining Applicable Models and Scale

GCMs undertake the momentous task of modelling the climate across the entire earth. Large volumes of climate data, usually in gridded raster form, have become available in recent years, including interpolated historical data from weather stations and future predictions from General and Regional Circulation Models. However, the spatial resolution of global climate model outputs is often too coarse to provide sufficient local detail on climate. To analyze climate impacts locally thus requires a process of “downscaling” projected climate data.

One way this is achieved is through Regional Climate Models (RCMs), which are similar to GCMs, but aim to model the climate over a limited area of the Earth, leading to greater spatial detail. Since RCMs are not available for most parts of the earth, however, another common process is to use “statistical downscaling”. This involves establishing an empirical relationship between locally observed and globally modelled climate. This relationship is then used to further downscale projected climate data to model local changes.

Two tools that offer statistically downscaled climate data are ClimateNA and ClimateBC (Wang et al., 2016), encompassing western North America and British Columbia, respectively. Both are stand-alone software packages that provide monthly historic and climate change data, downscaled to any grid scale through a combination of bilinear interpolation, elevation adjustment, and application of the PRISM high-resolution 1971-2000 baseline climatology. The scale-free downscaling method employed can better account for local variations in elevation, as well as considerably improve statistical accuracy compared to downscaling using regular climate grids (Wang et al., 2016). The program was updated with historical monthly data for the years 1901- 2018 in June 2019 to improve its accuracy.

The software includes the option to downscale climate data from 13 GCMs, all of which were part of the Coupled Model Intercomparison Project 6 (CMIP6), included in the IPCC Sixth Assessment Report (IPCC, 2014). The tool offers data from a subset of 13 models including in CMIP6 which were selected following an evaluation of all 44 CMIP6 GCMs, using a number of criteria to select only those models that best characterized climatic patterns across North America (Mahony et al., 2022). The tool provides projection data from each individual model, as well as an aggregate of climate data across all 13 models – a useful reference dataset, as there is evidence that combining knowledge across multiple models can improve accuracy over single-model forecasts (Tebaldi and Knutti, 2007). We chose to use the entire 13-model ensemble rather than a single model subset since we were interested in a single representative projection that could characterize the entire possible range of project climate change in the study area (Mahony et al., 2021).

The variables for ClimateBC provides include temperature, precipitation, solar radiation, as well as several derived climate variables for historic and future periods. Projected climate data are available for four future periods: 2030s (2021-2040), 2050s (2041-2060), 2070s (2061-2080), and 2090s (2081-2100). These projected years are available for all four SSP scenarios – SSP 2.6, SSP 4.5, SSP 7.0 and SSP 8.5.

### 1.3 Study Area and Data Selection

GW Solutions used ClimateBC version 7.21 (Wang et al, 2016, updated in 2022) to gather statistically downscaled, monthly, climate variables for 2030, 2050 and 2070. To estimate the climate of these time-periods, GW Solutions gathered projected data averaged across all 13 GCMs in the ClimateBC tool – a 13-model ensemble<sup>1</sup>.

ClimateBC reads a digital elevation model (DEM) to interpolate monthly, seasonal, or annual climate variables. The climate data are then downscaled to the resolution of the provided DEM. GW Solutions used a 20m-by-20m resolution DEM raster file (\*.asc) of the Lake Weston watershed study area as the input. The outputs were raster files of monthly climate variables, clipped to the boundaries of the study area. The monthly climate variables for which data were gathered include:

Variable Name	Description
Tave01 – Tave12	January - December mean temperatures (°C)
PPT01 – PPT12	January - December precipitation (mm)
Rad01 – Rad12	January - December solar radiation (MJ m <sup>-2</sup> d <sup>-1</sup> )

### 1.4 Data Analysis Methodology

Once gathered, all the climate data for each projection year (2030, 2050 and 2070) were compared against averages of current observed climate data, or “climate normals”, for the period 1981-2010. The comparison process involved the creation of raster files that showed the cell-by-cell change between the observed “normal” period and climate projections

<sup>1</sup> The models included in this ensemble average are ACCESS-ESM1.5, BCC-CSM2, CanESM5, CNRM-ESM2-1, EC-Earth3, GFDL-ESM4, GISS-E2.1, INM-CM5.0, IPSL-CM6A-LR, MIROC6, MPI-ESM1.2-HR, MRI-ESM2.0, and UKESM1 (Mahony et al., 2022)

for all three time-periods. These changes were then mapped to show the spatial variation in the projected changes for all the climate variables.

Additionally, water budget calculations were performed using inputs from each climate change scenario and were also compared to the water budget outputs from the normal periods. This allowed a comparison of not just raw input climate data, but also an estimation of how important water balance variables – like monthly available moisture surplus – are projected to change with climate change.

Comparisons between projected future data and climate normals were performed for all four SSP scenarios under consideration – SSP 2.6, 4.5, 7.0 and 8.5. Maps showing the results of these comparisons for each SSP, and each year were generated to examine the spatial variation of change for each climate variable. Moreover, summary charts showing average changes across the Lake Weston watershed were also calculated for all climate variables. These summary charts depict changes by month and included data from all SSPs to illustrate how the magnitude of impact changes under each SSP.

All the analysis and visualization were completed in the R programming language. The maps and charts produced during this analysis are presented in section 1.6.

## 1.5 Generalized Interpretation of Climate Change Results

The projected data from the 13-model ensemble predict a significant increase in precipitation during the winter, and a smaller yet still considerable increase in spring and fall precipitation. The magnitude of increase is greatest during the December to February period. The data also predict a decrease in summer precipitation. These patterns are consistent across all the SSP scenarios, and indeed the magnitude of these changes is higher the more pessimistic the SSP is.

Solar radiation is projected to increase during the summer months and decrease during the fall and spring periods, remaining relatively unchanged during the rest of the winter. Interestingly, the magnitude of change is projected to be the strongest within the 2030s period, suggesting that the most meaningful shifts in radiation patterns will happen within the next 2 decades. As with precipitation, the magnitude of change is higher with more pessimistic SSPs. Additionally, all SSPs and year periods seem to project a slight increase in radiation during March alone, amid an otherwise reduced-radiation Spring.

Average temperatures are projected to increase in all months for 2030, 2050 and 2070 across all SSP scenarios, with the highest increases being in July and August. Even under the most optimistic scenario (SSP 2.6), temperatures are projected to rise by nearly 2 degrees Celsius in July and August by 2070. In contrast, under SSP 8.5 the projected increase in July and August is nearly 5 degrees.

Finally, available moisture surplus is projected to increase considerably during the winter months of December to February, while also increasingly slightly during the fall months of October and November. Additionally, surplus is projected to decrease during the spring period, especially in March. As with the others, the magnitude of these patterns is exacerbated under less optimistic SSPs.

These patterns are consistent with changes expected under climate change globally. Increasing temperatures, particularly during the summer months, combined with higher solar radiation and lower summer precipitation will mean a reduced potential for groundwater recharge during the summer. The current hydrological regime, however, already operates within a pattern of excess water during the winter months and low precipitation during the summer. The impact of climate change on this system appears to be a reduction in the available window or annual time period for groundwater recharge.

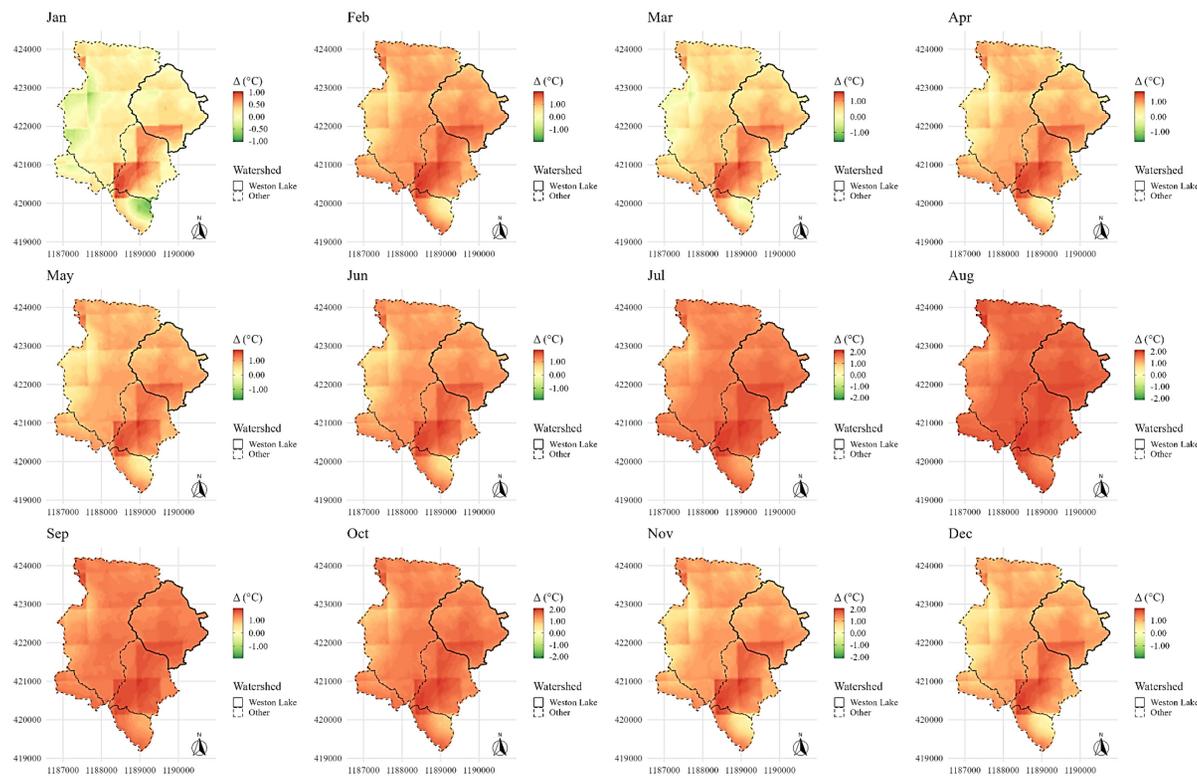
Precipitation is projected to occur in higher magnitudes within a smaller time period (primarily December to February). This combined with reduced solar radiation during months leads to an excess of moisture surplus during the winter, increasing the possibility of flash flooding since the capacity for groundwater infiltration at any given time cannot be exceeded upon saturation. Furthermore, reduced precipitation and higher temperatures during the summer reduces the potential for groundwater recharge during the months when groundwater uptake is greatest. The projected decline in moisture surplus during March illustrates a reducing temporal window within which moisture surplus can recharge aquifers. Overall, these patterns will adversely affect the sustainability of the groundwater system by leading to a pattern of excess water when it is not needed and water deficits during periods when it is necessary.

## 1.6 Analysis Results

Figures 2 to 57 present the model-predicted changes between climate normals (1981-2010) and the predicted climate variables for 2030, 2050 and 2070. While maps and charts were calculated for all climate and water budget variables, only the most important variables have been shown here, namely: average temperature, precipitation, radiation, and available

moisture surplus. These were selected since temperature, precipitation and radiation are the three primary inputs that have the greatest impact on the water cycle, as they affect the availability of water as well as the rate of water loss through evapotranspiration. Moisture surplus was selected from among the water budget variables as it is the primary parameter of interest that can enable the calculation of available surface runoff and groundwater recharge.

**1.6.1 SSP 2.6**  
**1.6.1.1 Average Temperature**



**Figure 1: Monthly change in average temperature between year 2030 and present normals, SSP 2.6**

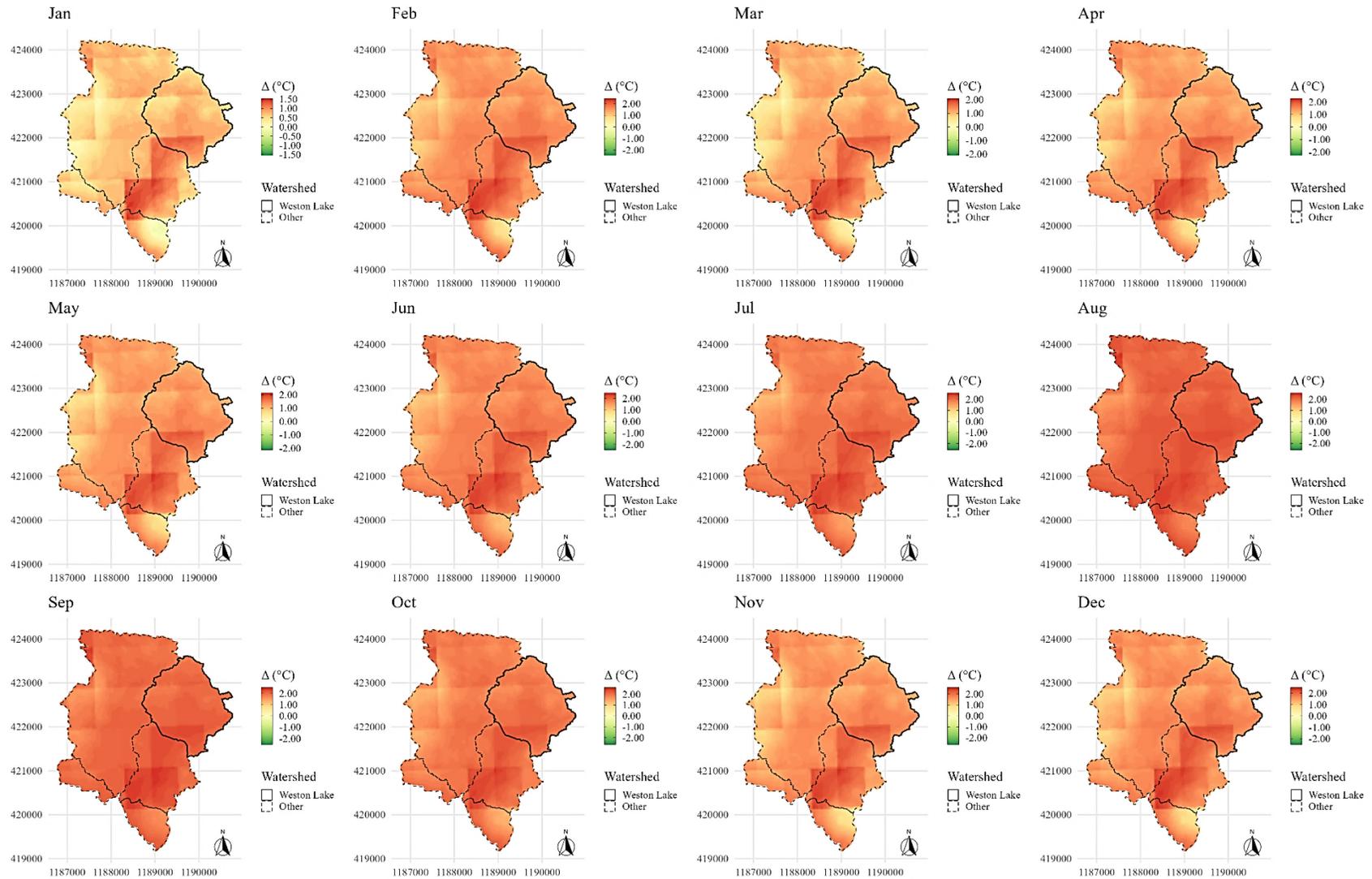


Figure 2: Monthly change in average temperature between year 2050 and present normals, SSP 2.6

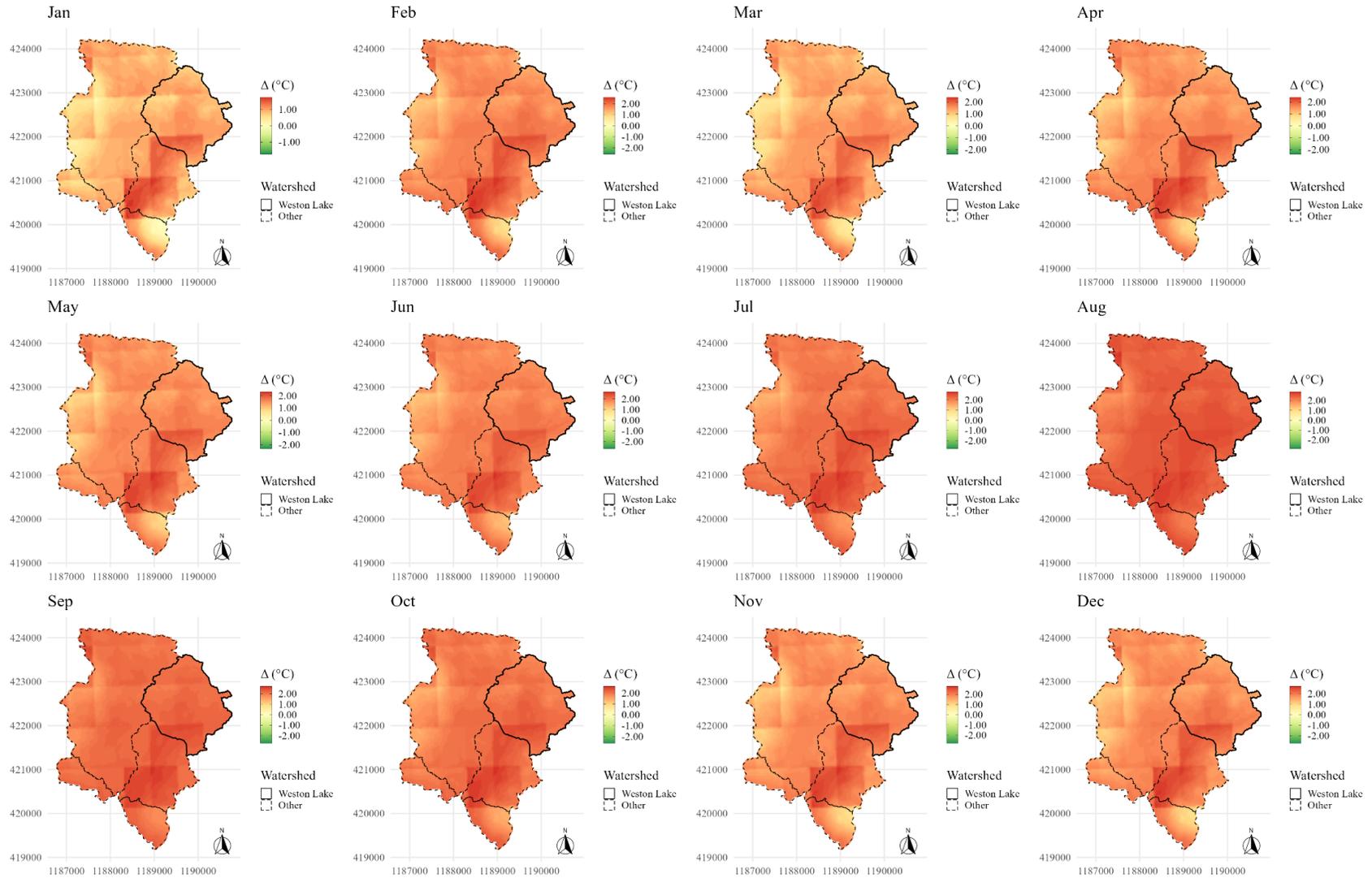


Figure 3: Monthly change in average temperature between year 2070 and present normals, SSP 2.6

1.6.1.2 *Precipitation*

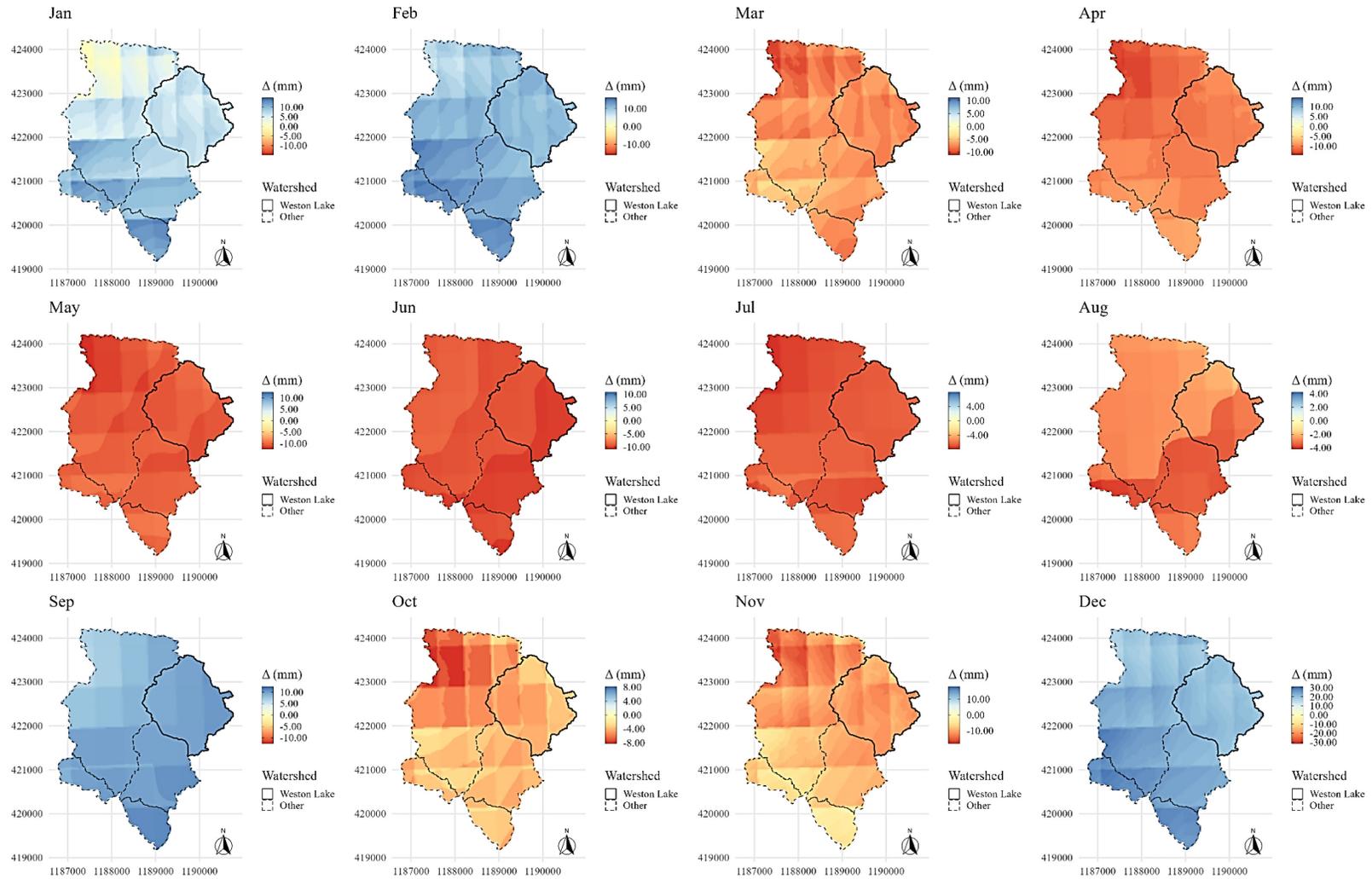


Figure 4: Monthly change in precipitation between year 2030 and present normals, SSP 2.6

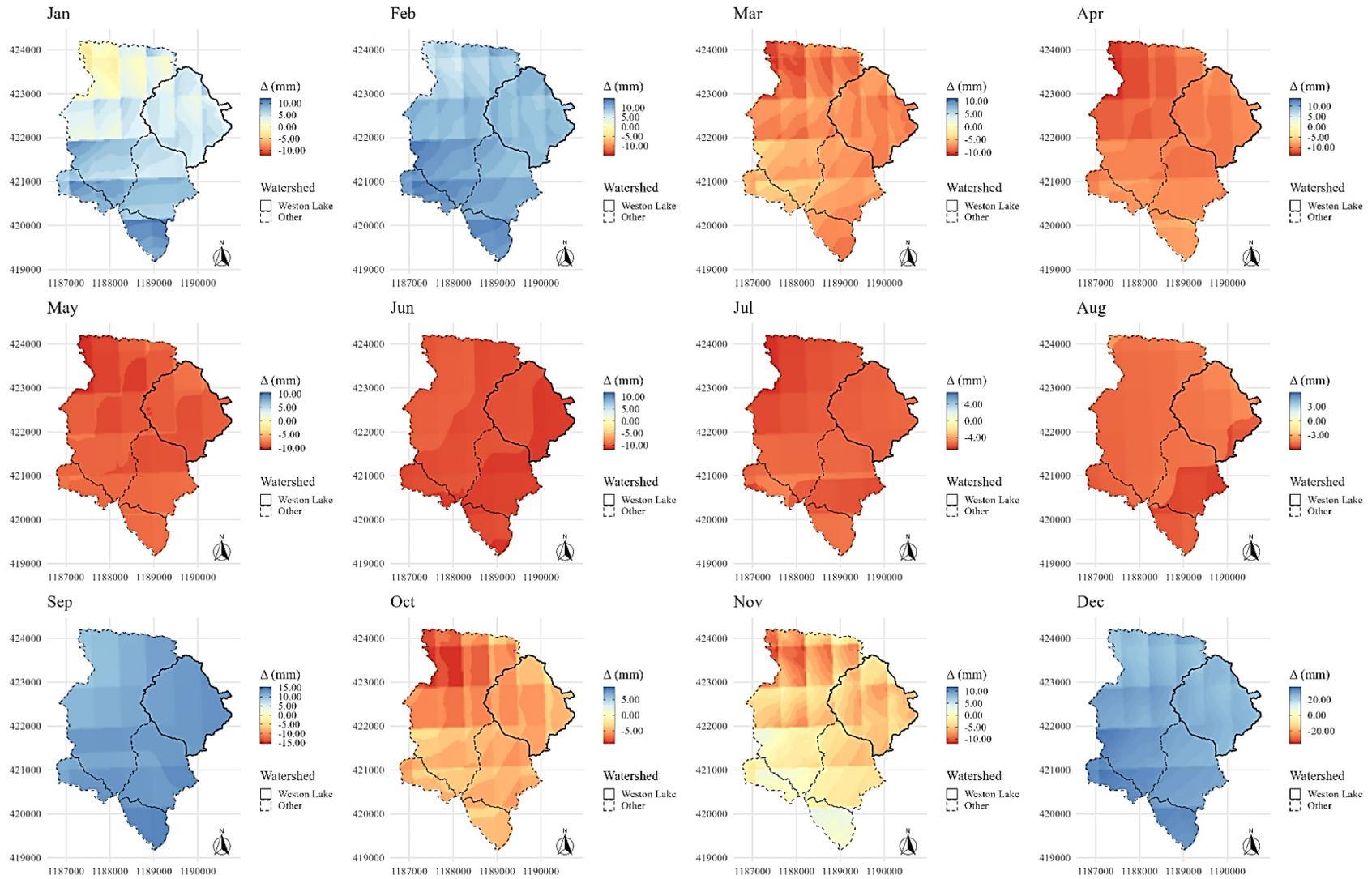


Figure 5: Monthly change in precipitation between year 2050 and present normals, SSP 2.6

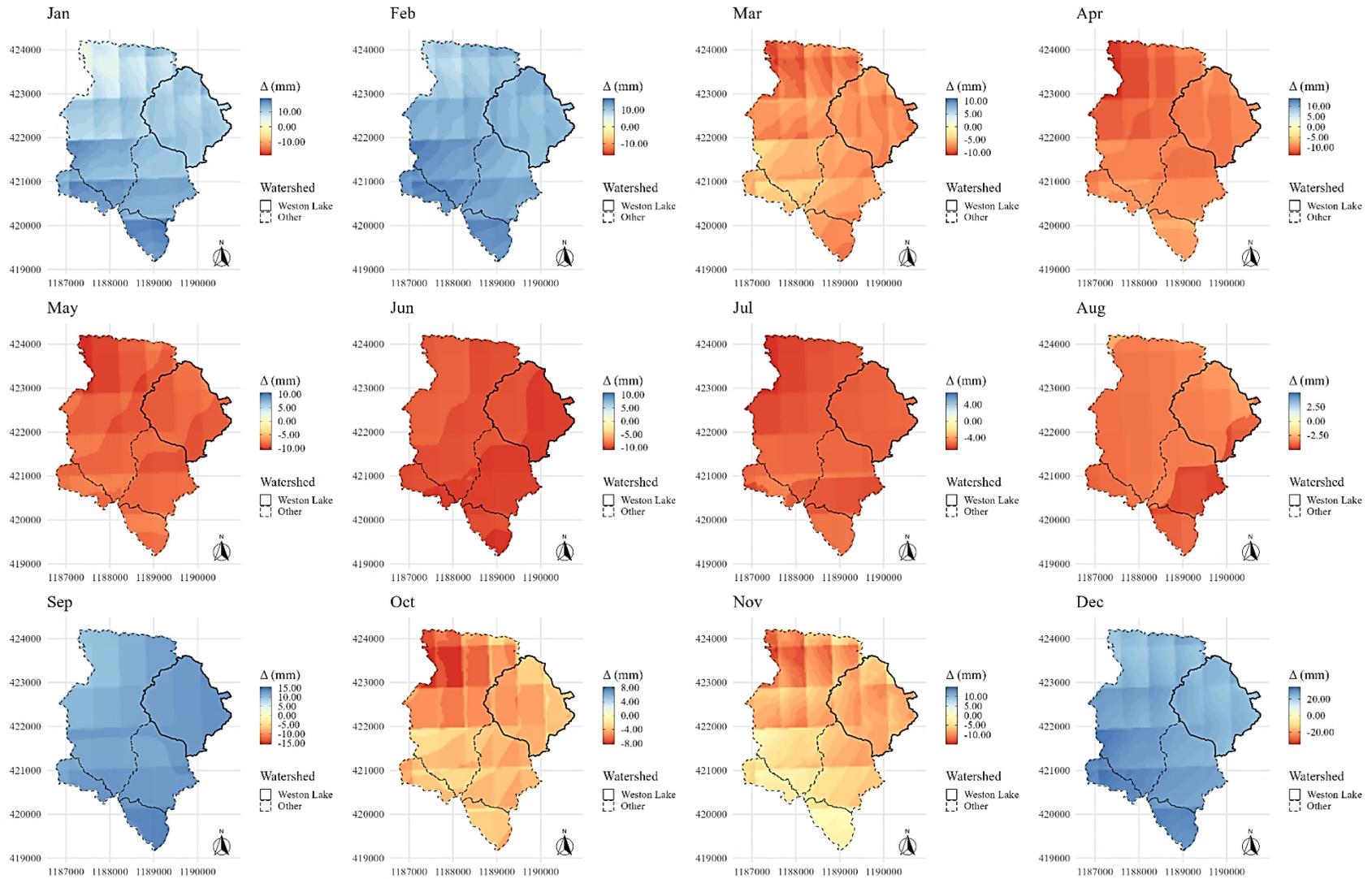


Figure 6: Monthly change in precipitation between year 2070 and present normals, SSP 2.6

1.6.1.3 Solar Radiation

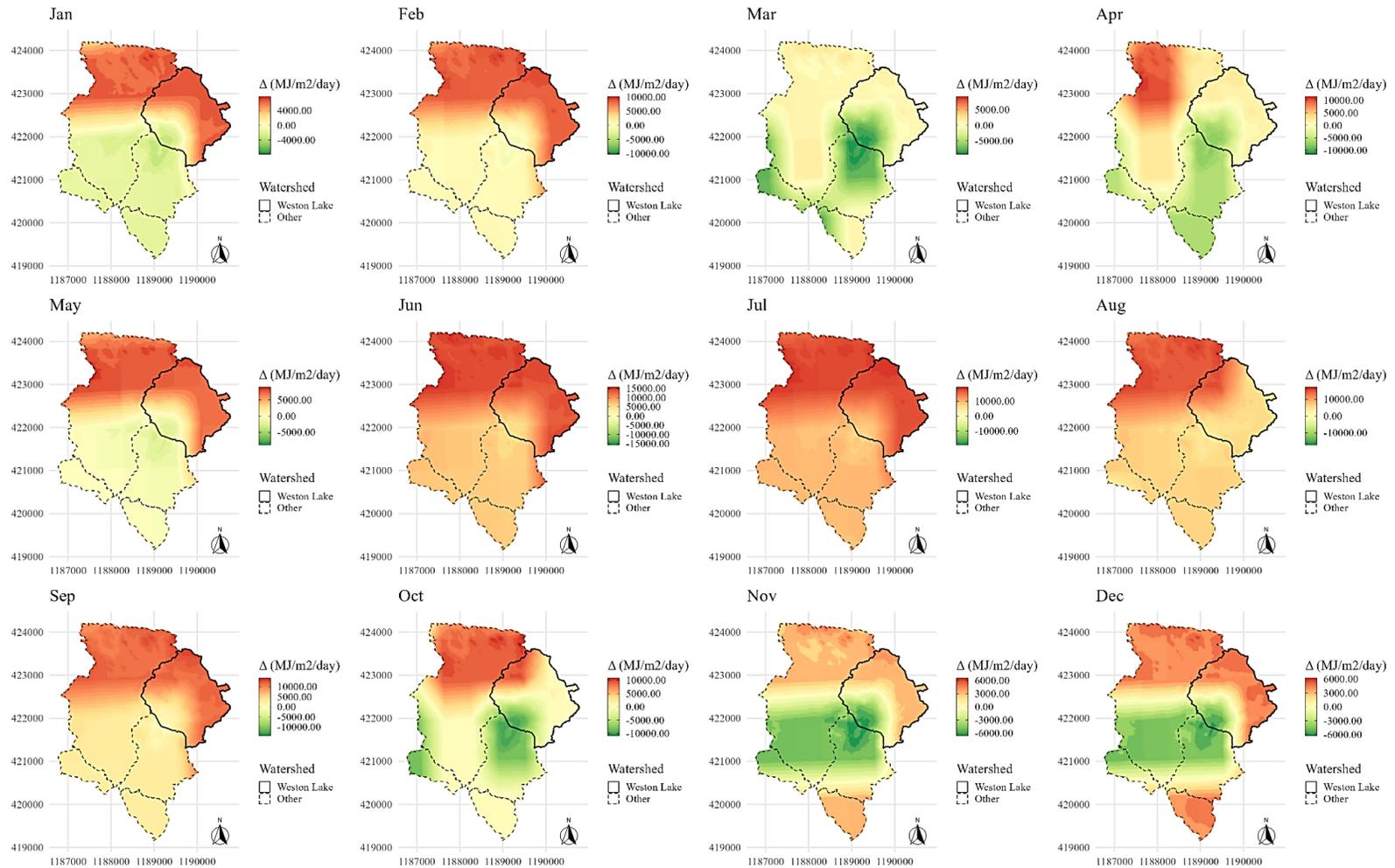


Figure 7: Monthly change in radiation between year 2030 and present normals, SSP 2.6

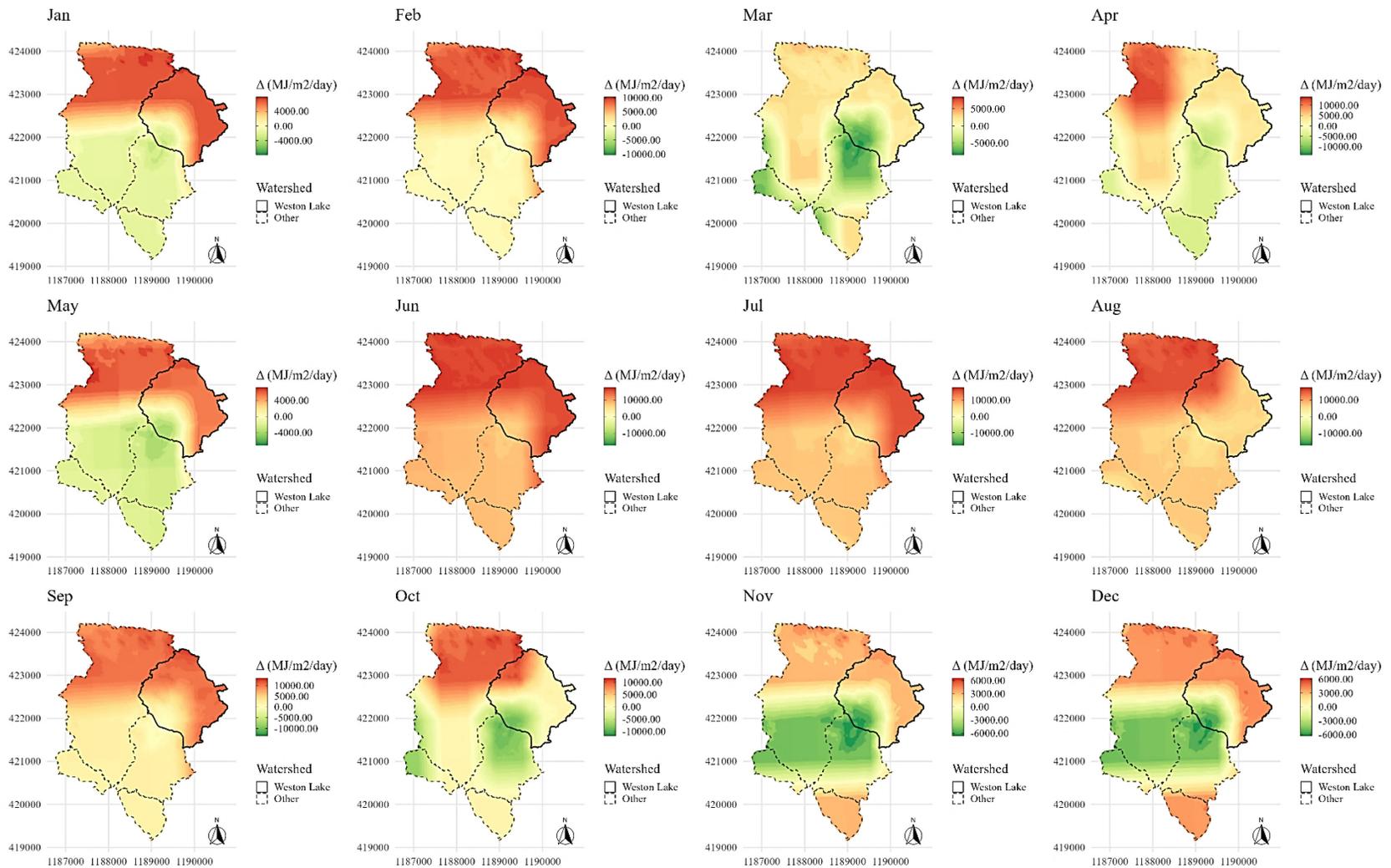


Figure 8: Monthly change in radiation between year 2050 and present normals, SSP 2.6

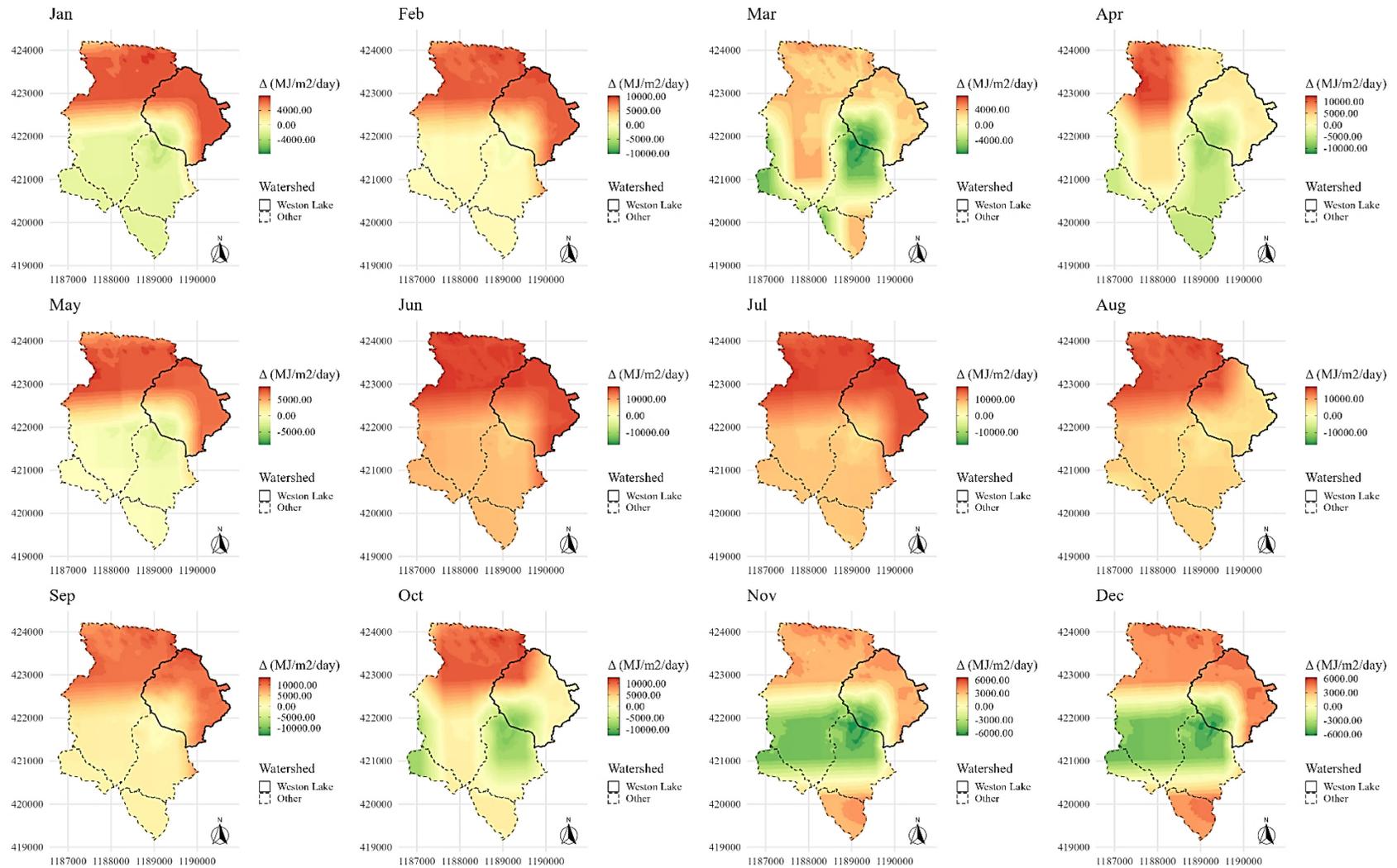


Figure 9: Monthly change in radiation between year 2070 and present normals, SSP 2.6

1.6.1.4 Available Moisture Surplus

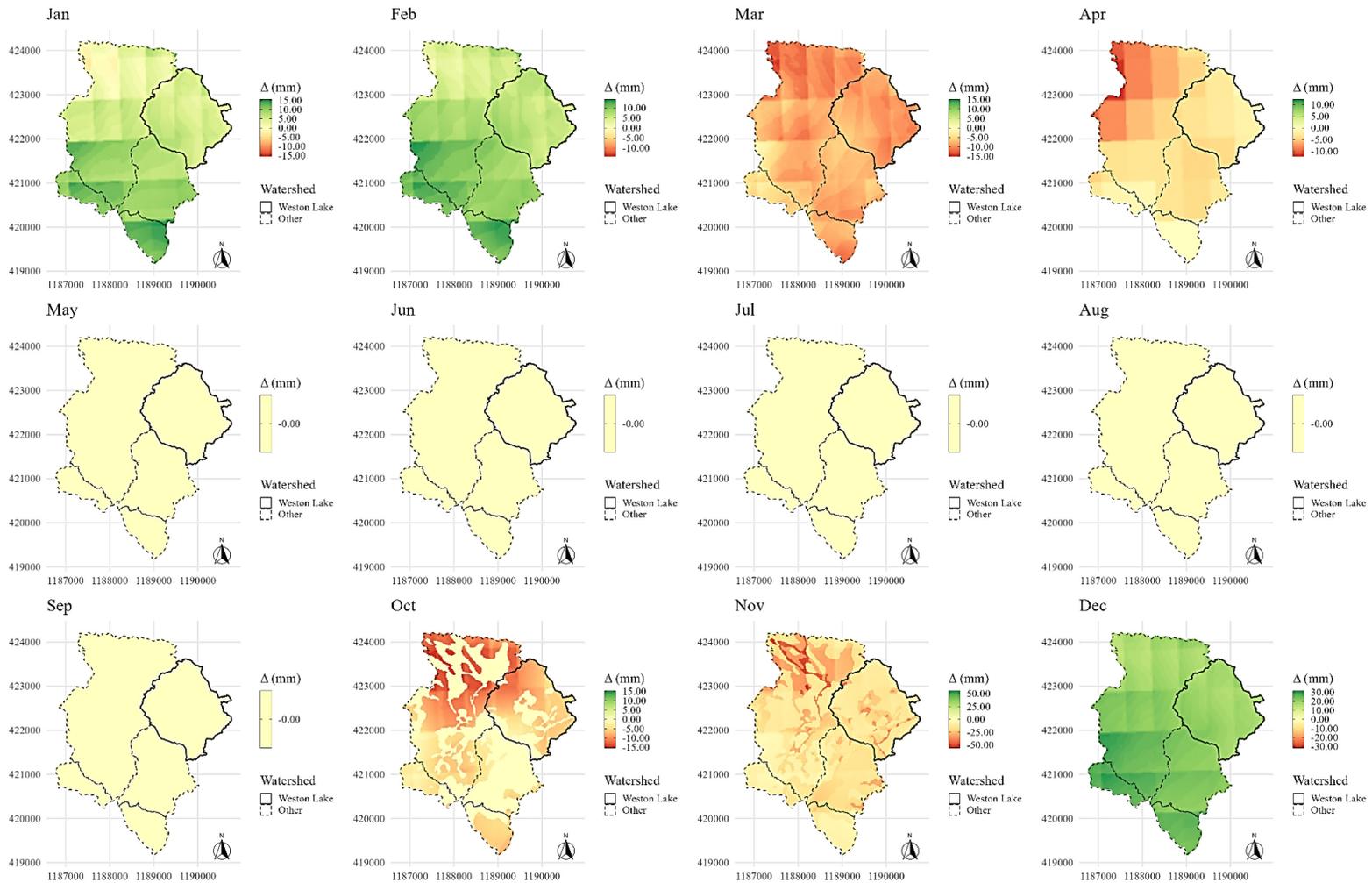


Figure 10: Monthly change in available moisture surplus between year 2030 and present normals, SSP 2.6

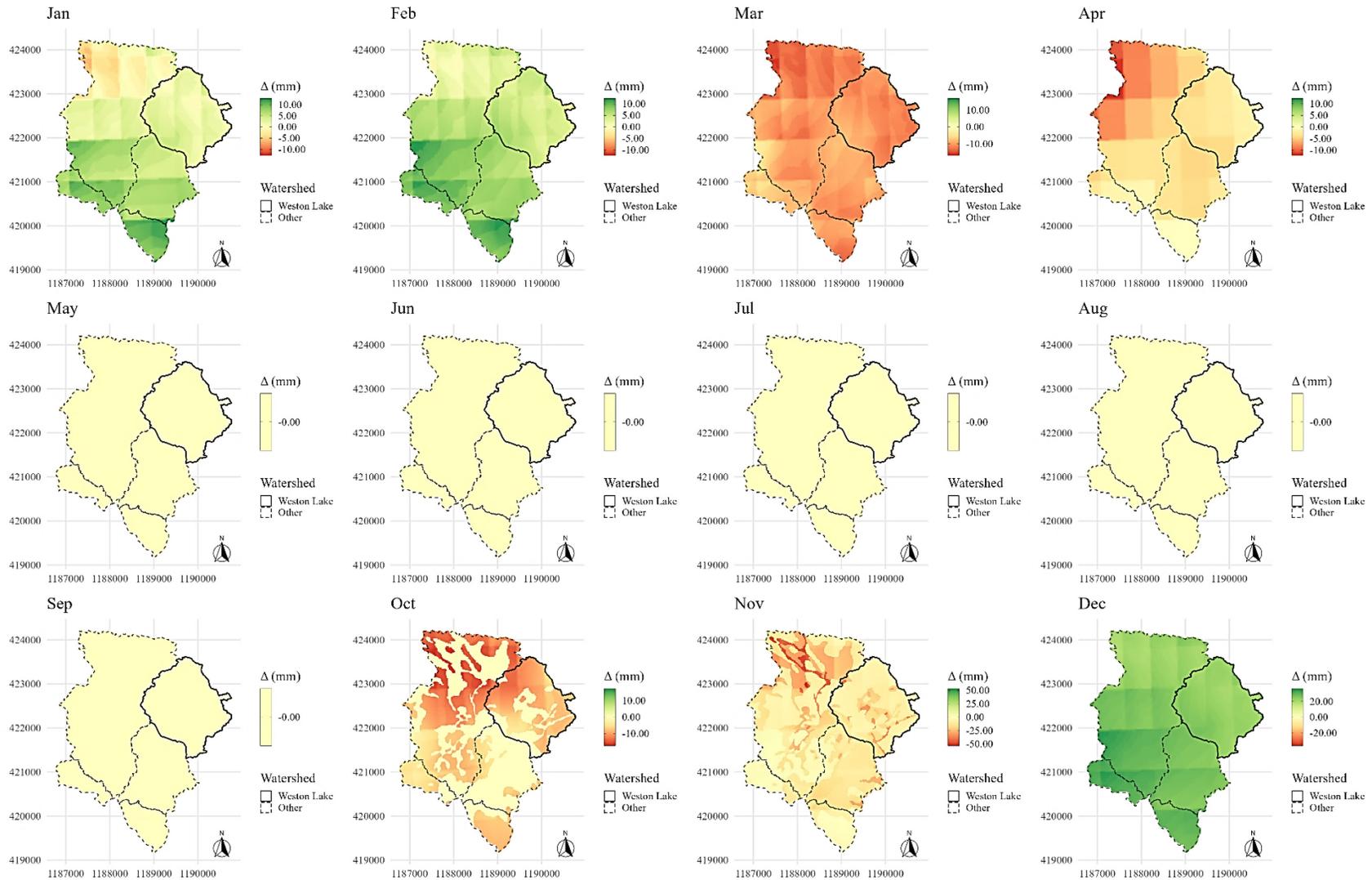


Figure 11: Monthly change in available moisture surplus between year 2050 and present normals, SSP 2.6

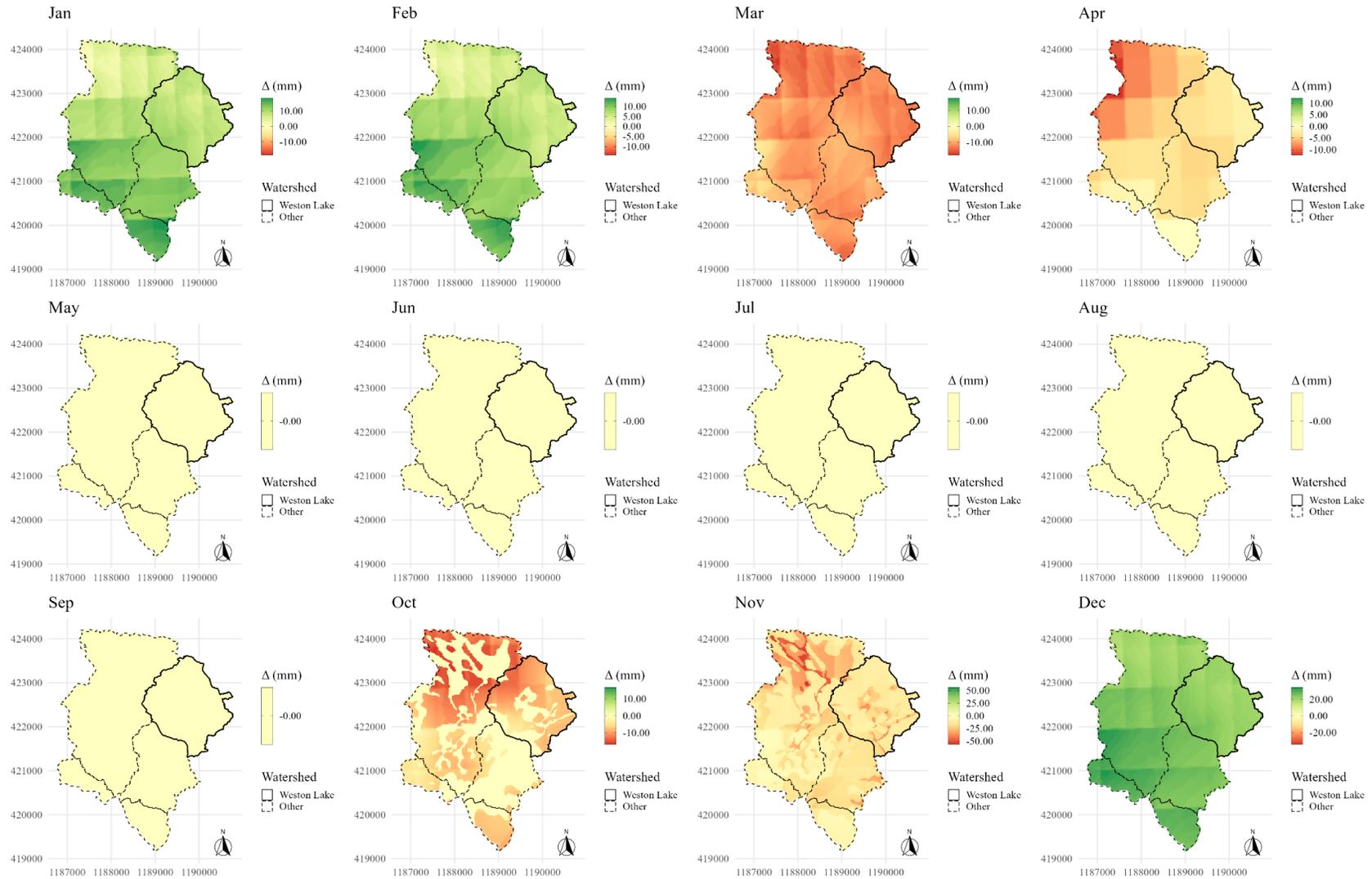
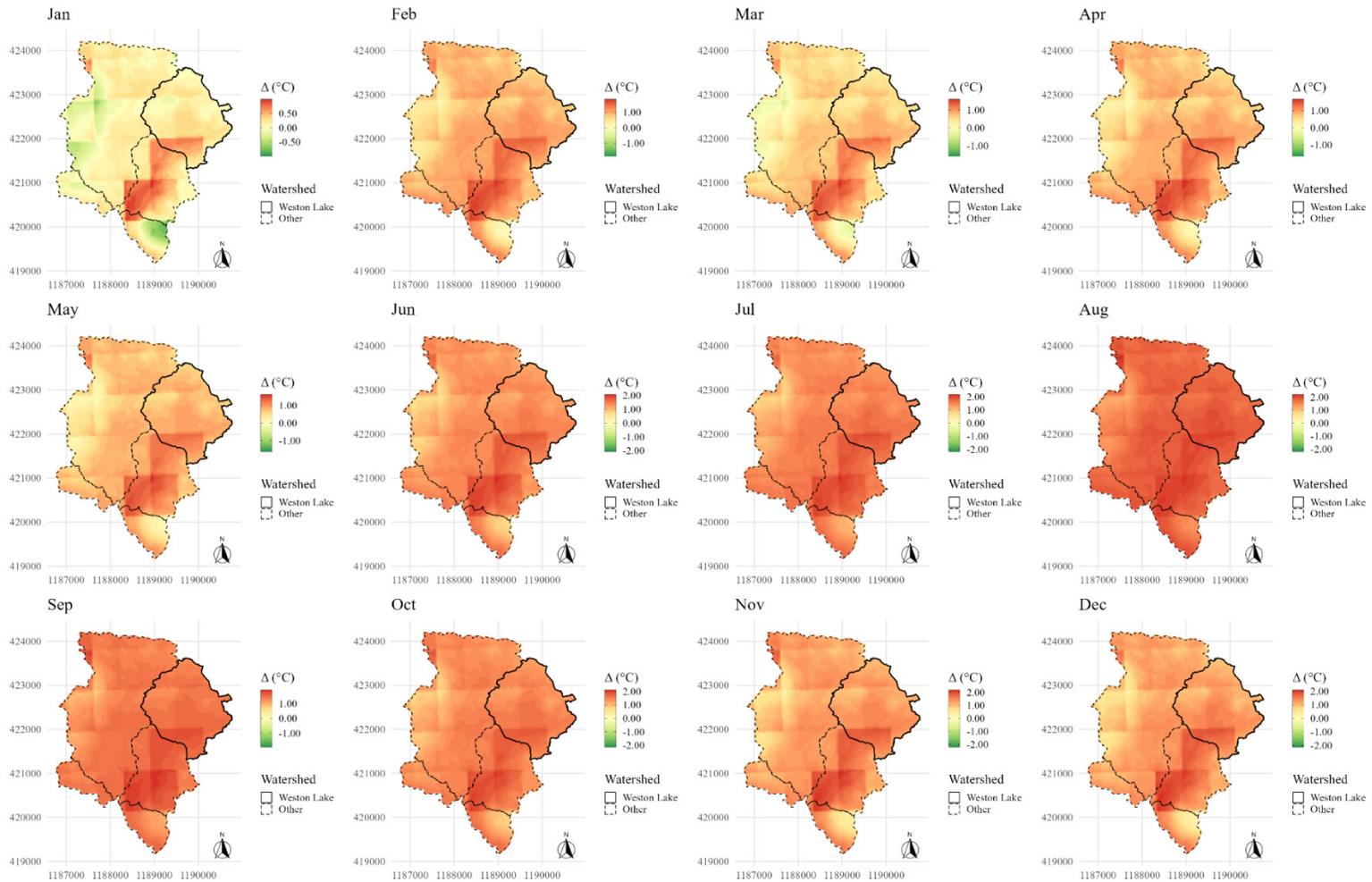


Figure 12: Monthly change in available moisture surplus between year 2070 and present normals, SSP 2.6

**1.6.2 SSP 4.5**  
**1.6.2.1 Average Temperature**



**Figure 13: Monthly change in average temperature between year 2030 and present normals, SSP 4.5**

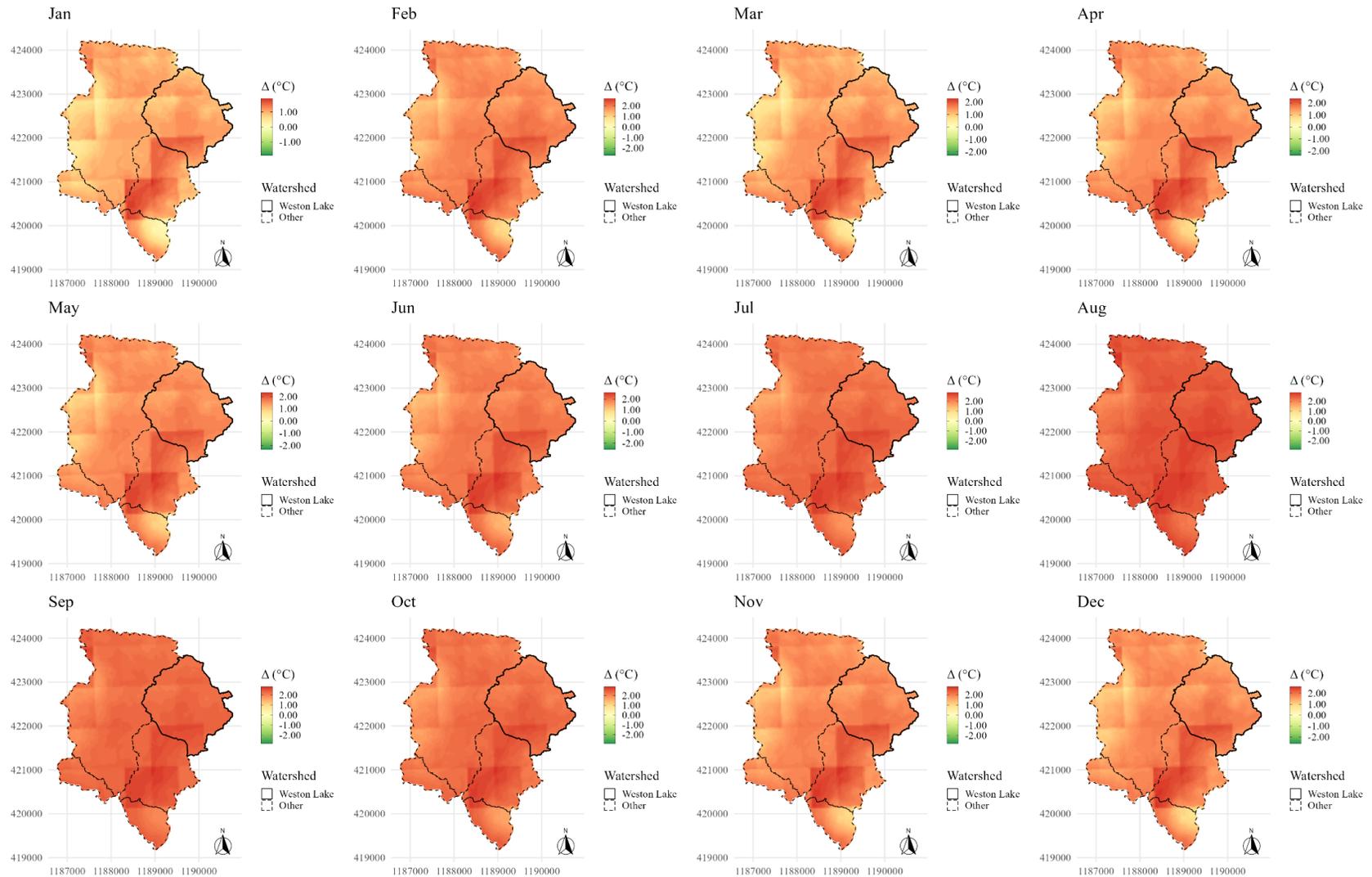


Figure 14: Monthly change in average temperature between year 2050 and present normals, SSP 4.5

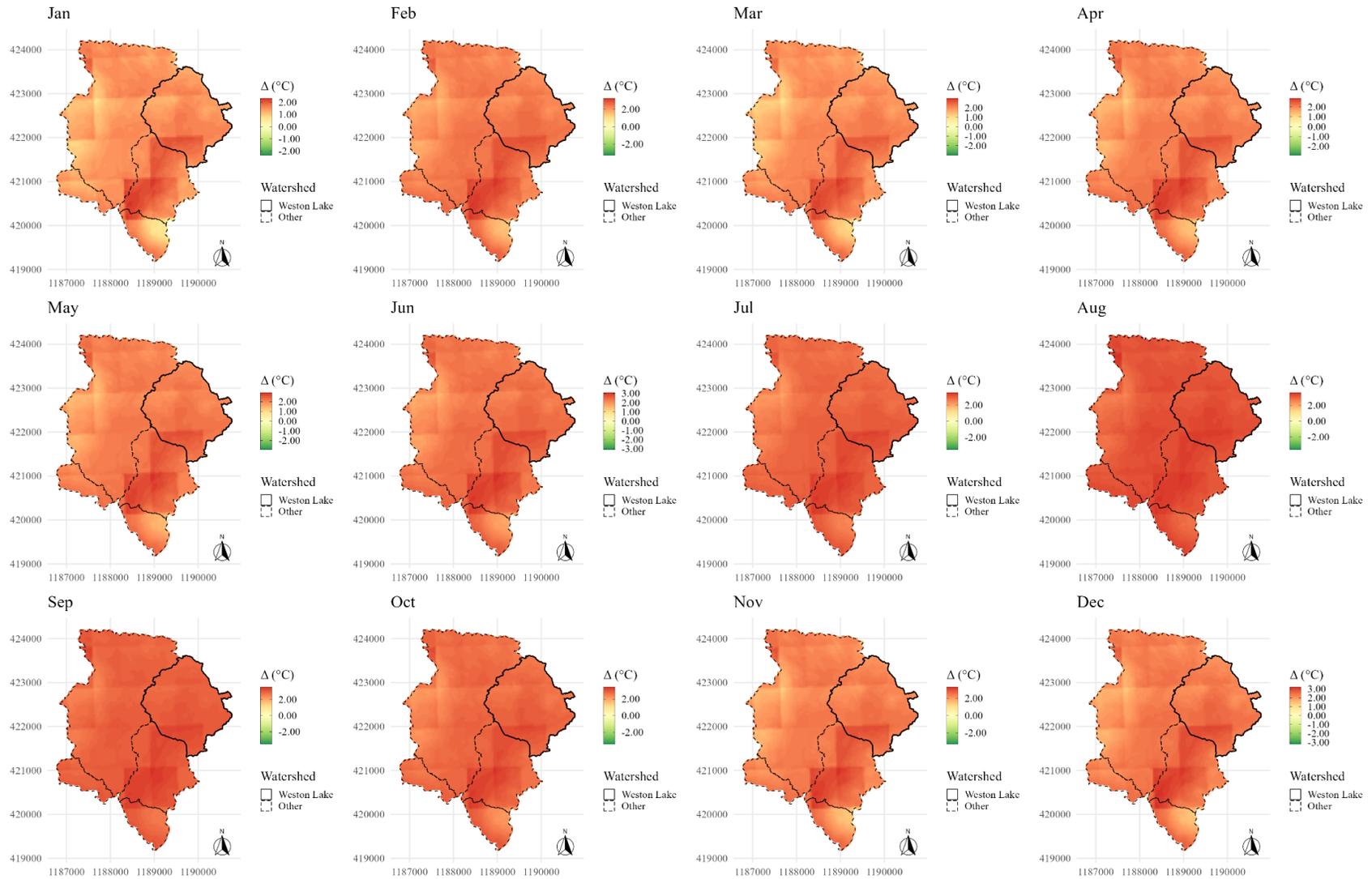


Figure 15: Monthly change in average temperature between year 2070 and present normals, SSP 4.5

1.6.2.2 *Precipitation*

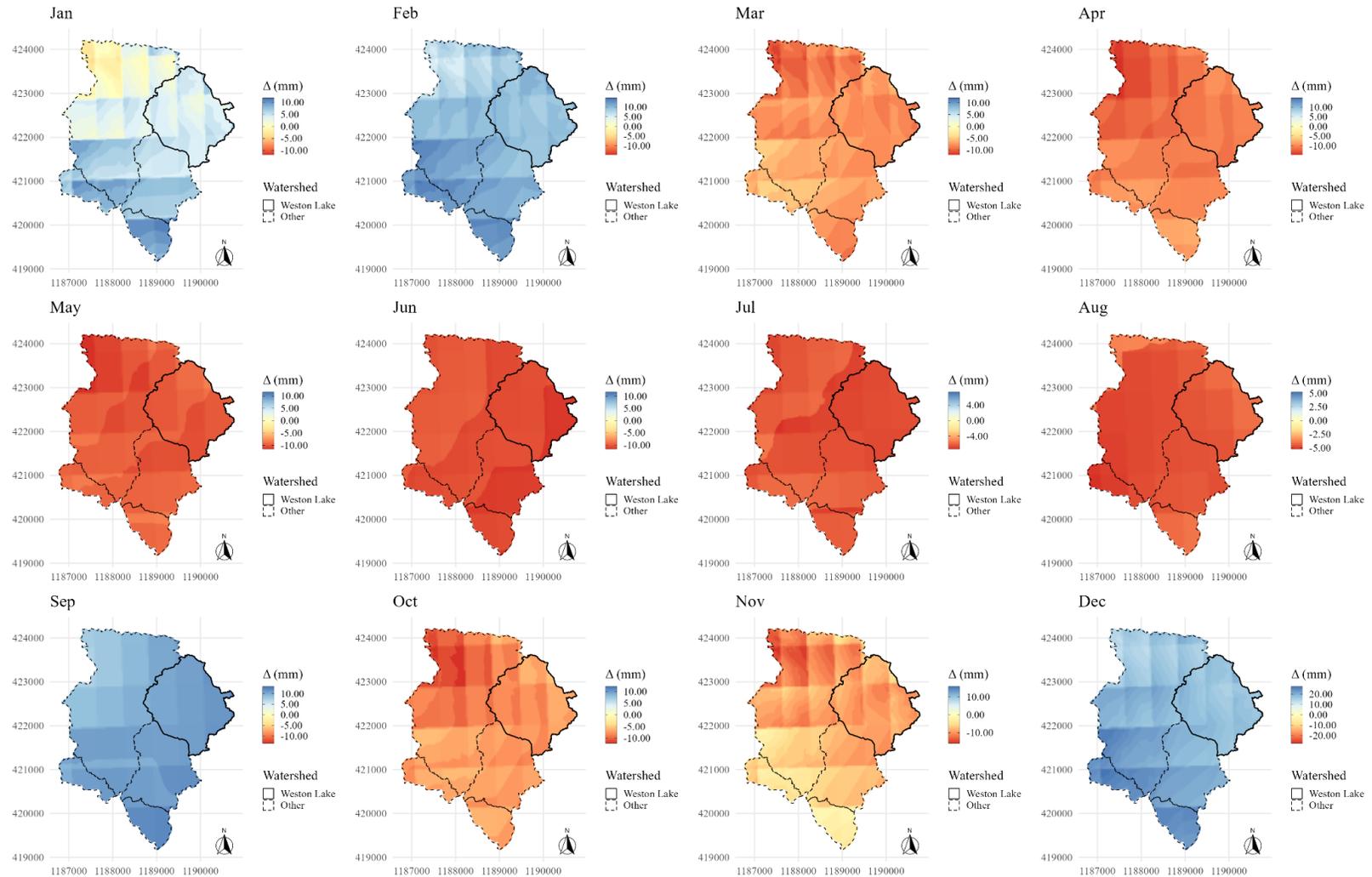


Figure 16: Monthly change in precipitation between year 2030 and present normals, SSP 4.5

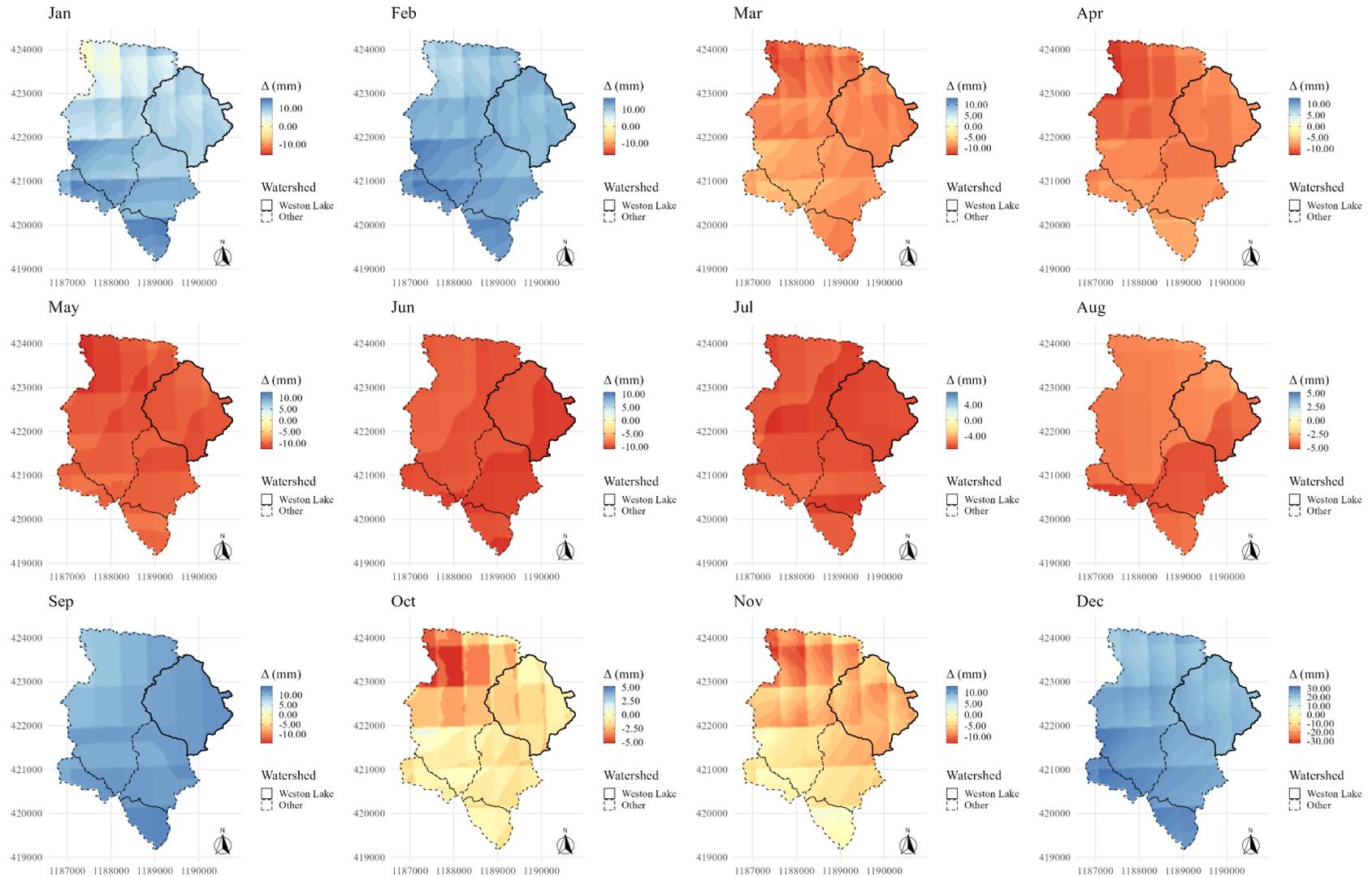


Figure 17: Monthly change in precipitation between year 2050 and present normals, SSP 4.5

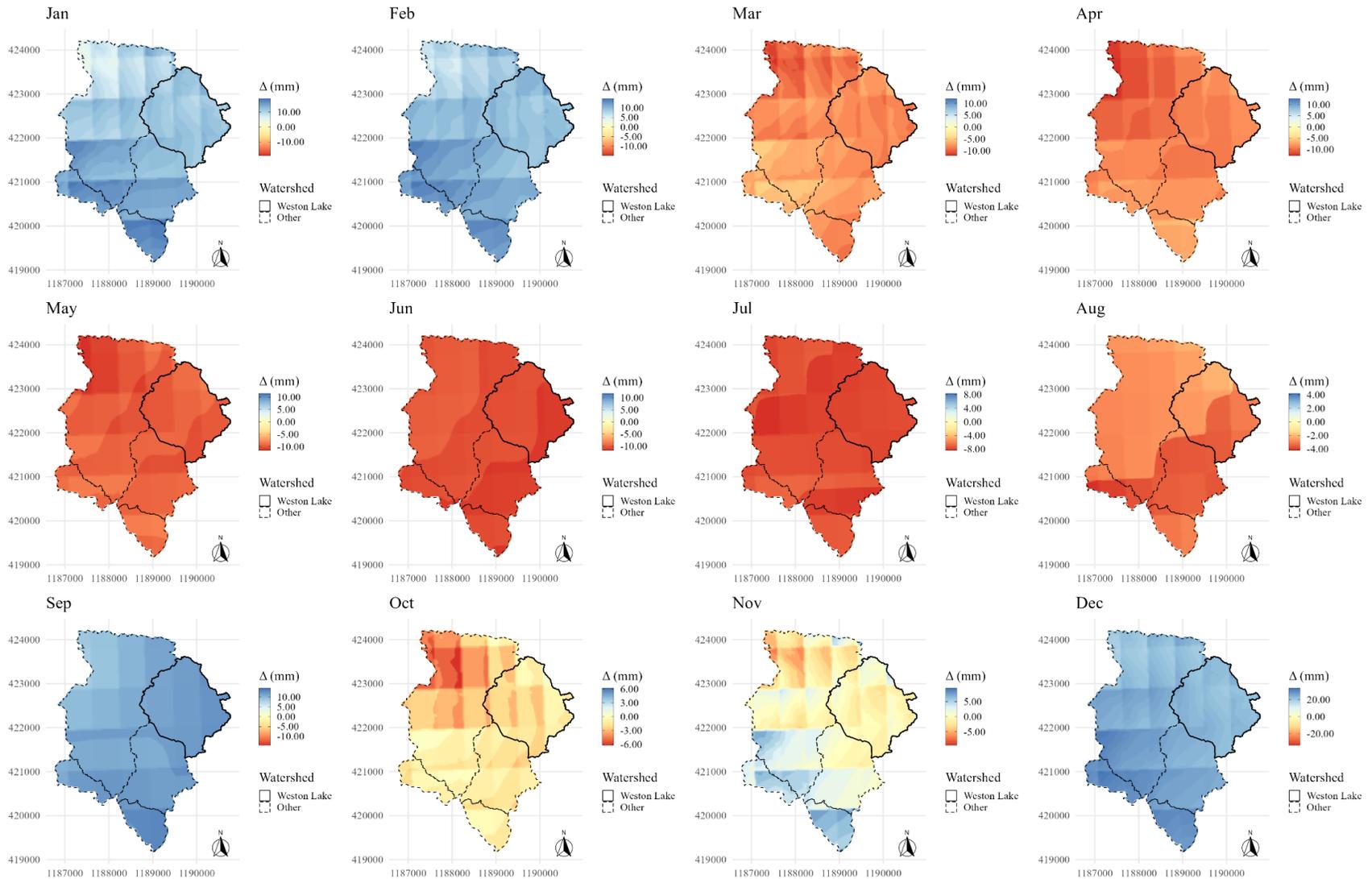


Figure 18: Monthly change in precipitation between year 2070 and present normals, SSP 4.5

1.6.2.3 Solar Radiation

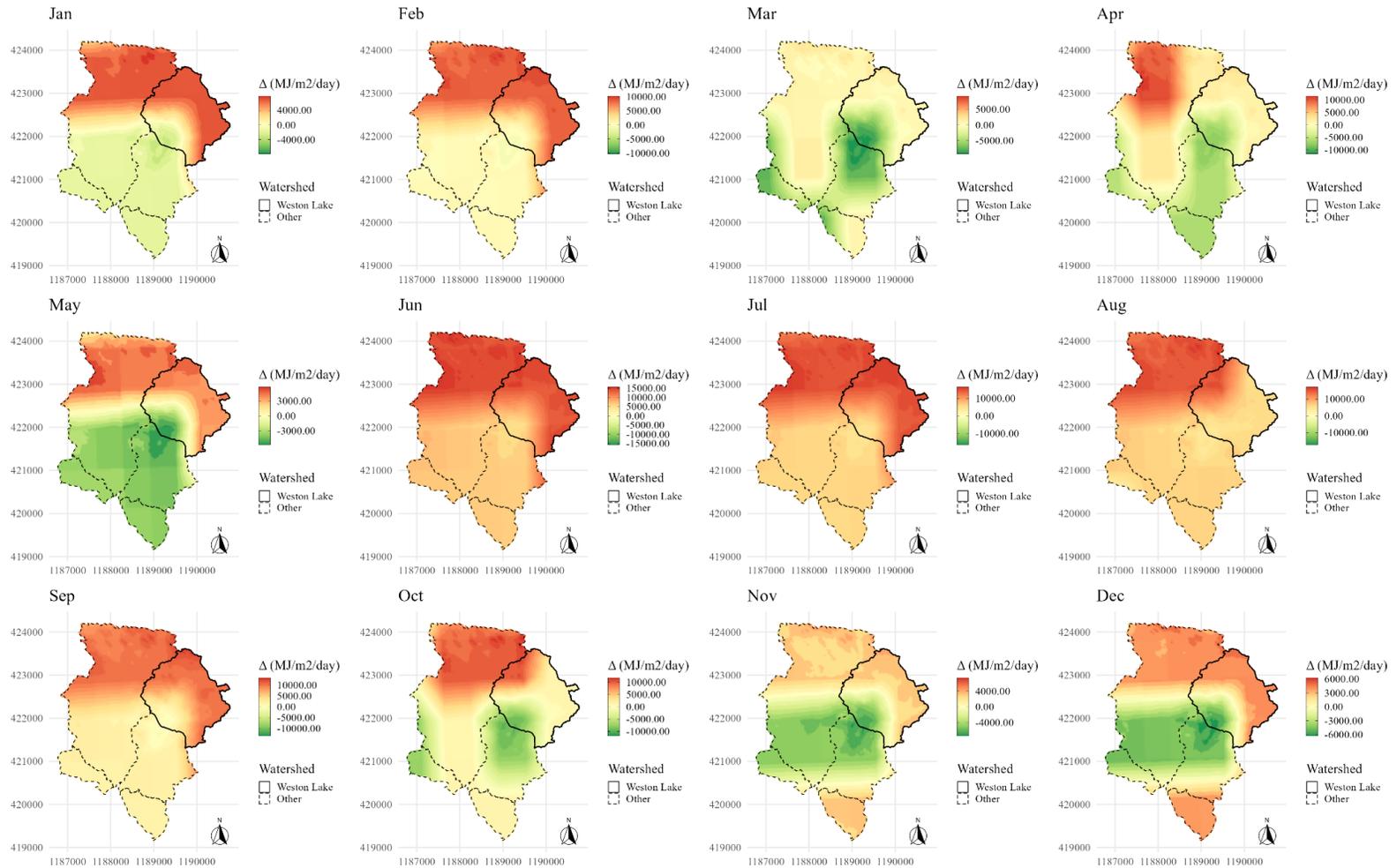


Figure 19: Monthly change in radiation between year 2030 and present normals, SSP 4.5

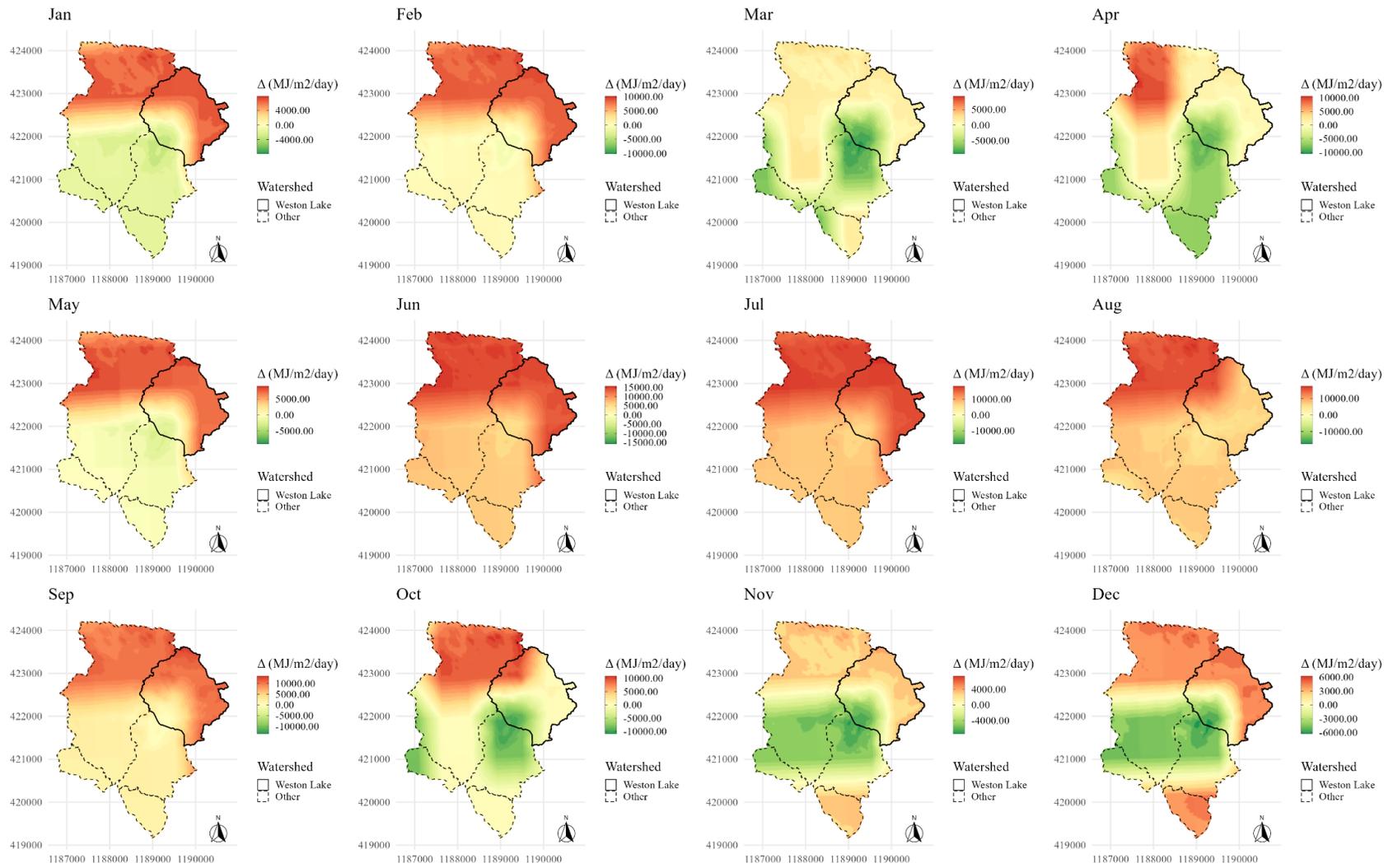


Figure 20: Monthly change in radiation between year 2050 and present normals, SSP 4.5

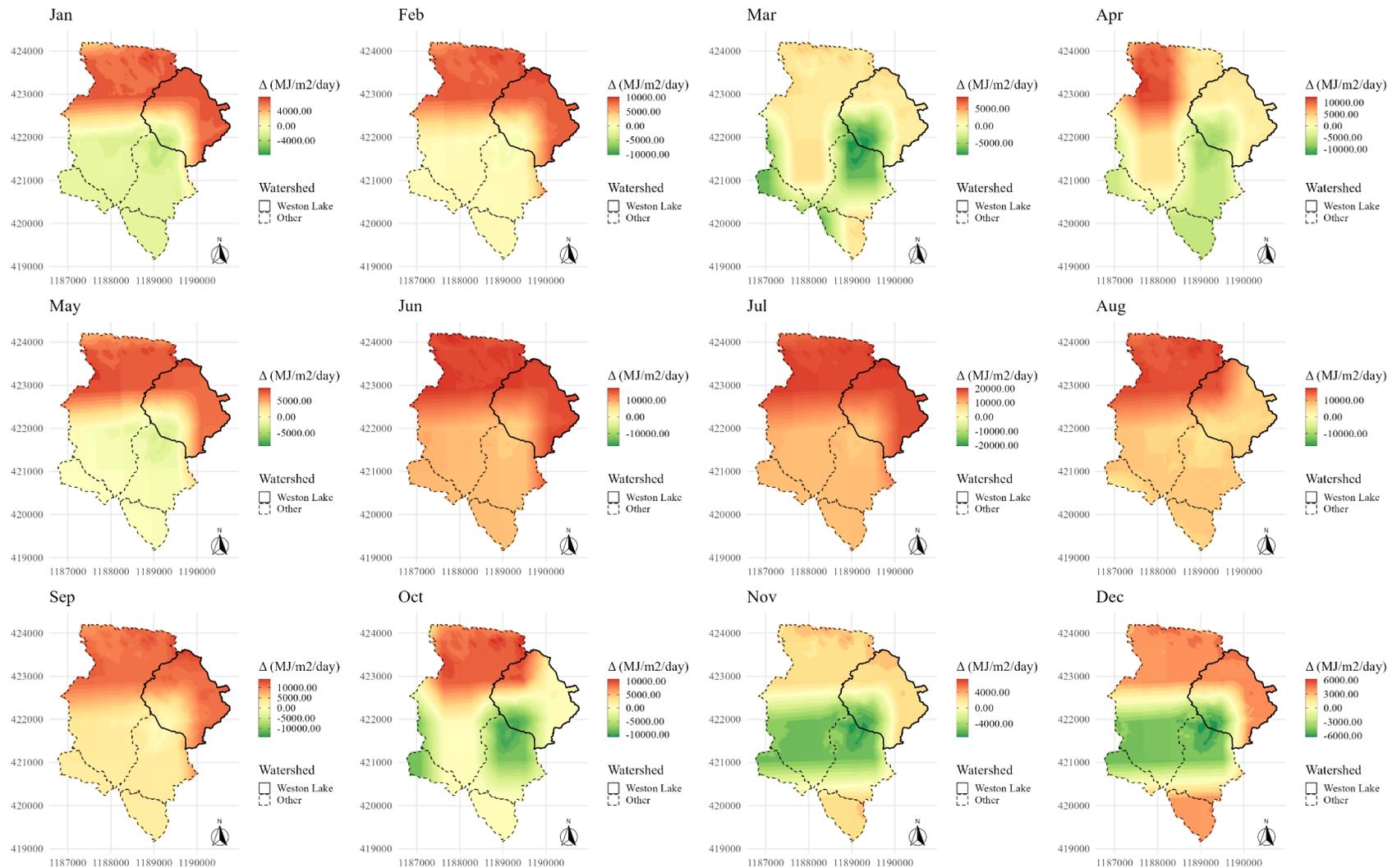


Figure 21: Monthly change in radiation between year 2070 and present normals, SSP 4.5

1.6.2.4 Available Moisture Surplus

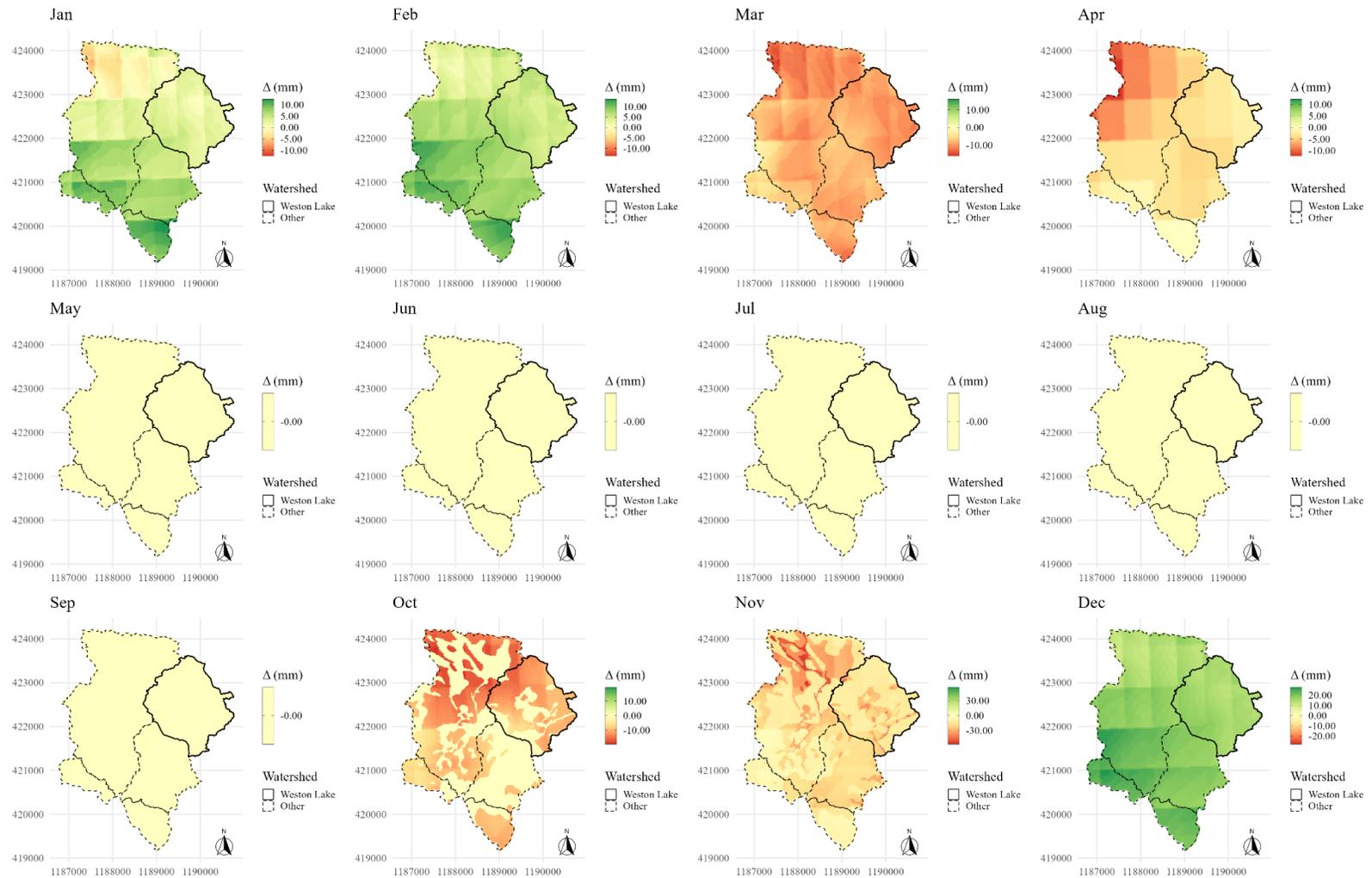


Figure 22: Monthly change in available moisture surplus between year 2030 and present normals, SSP 4.5

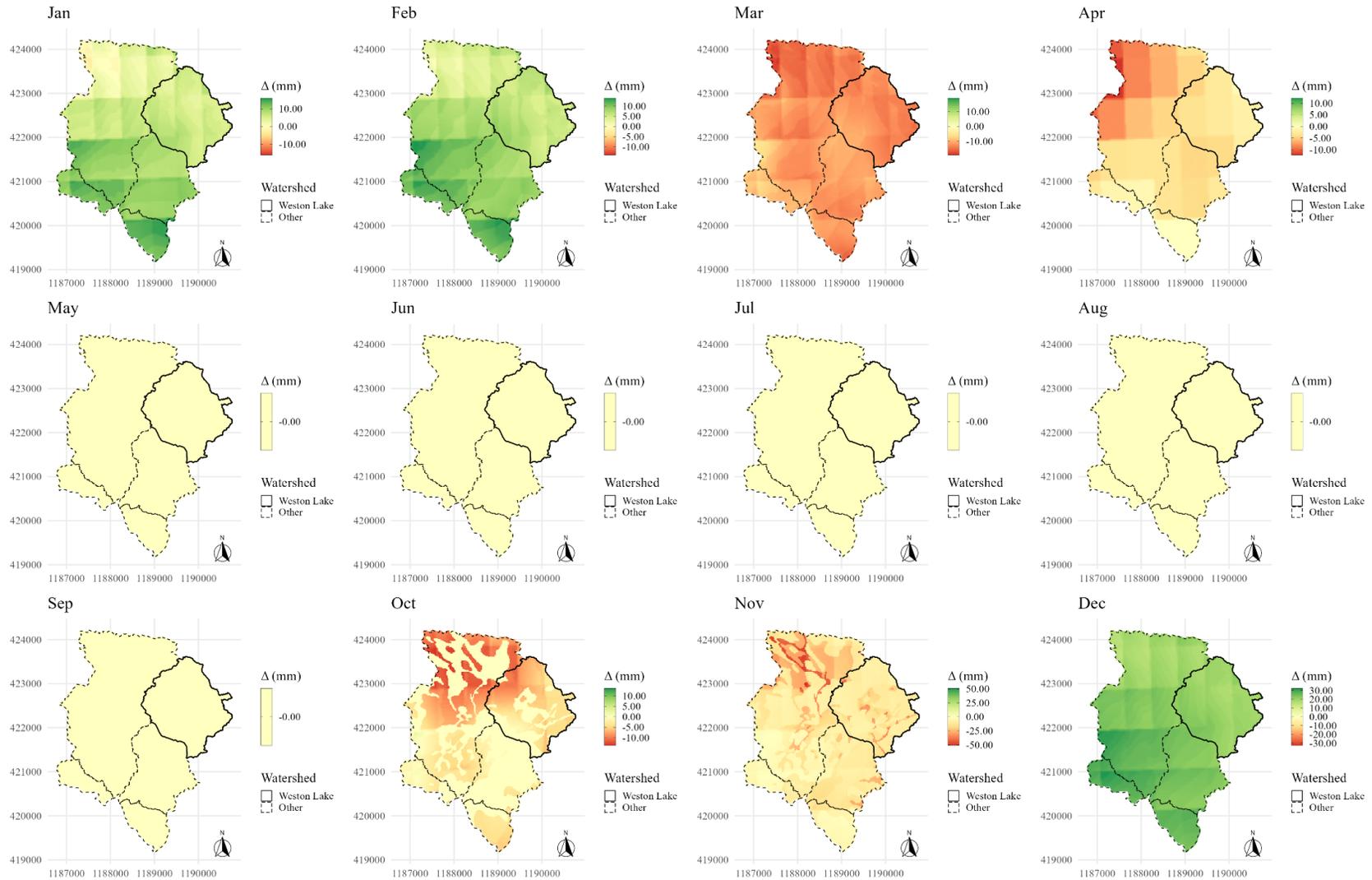


Figure 23: Monthly change in available moisture surplus between year 2050 and present normals, SSP 4.5

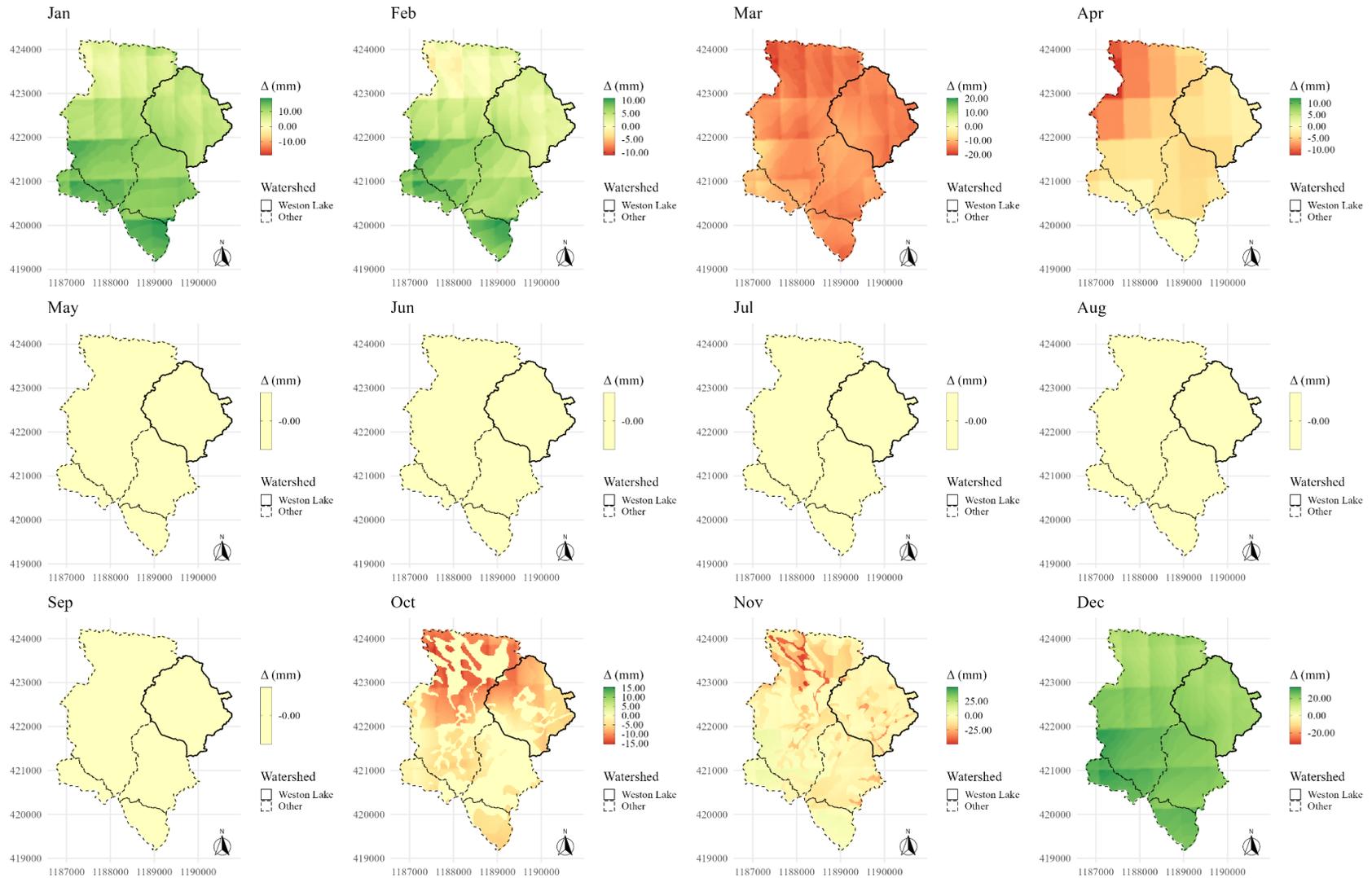
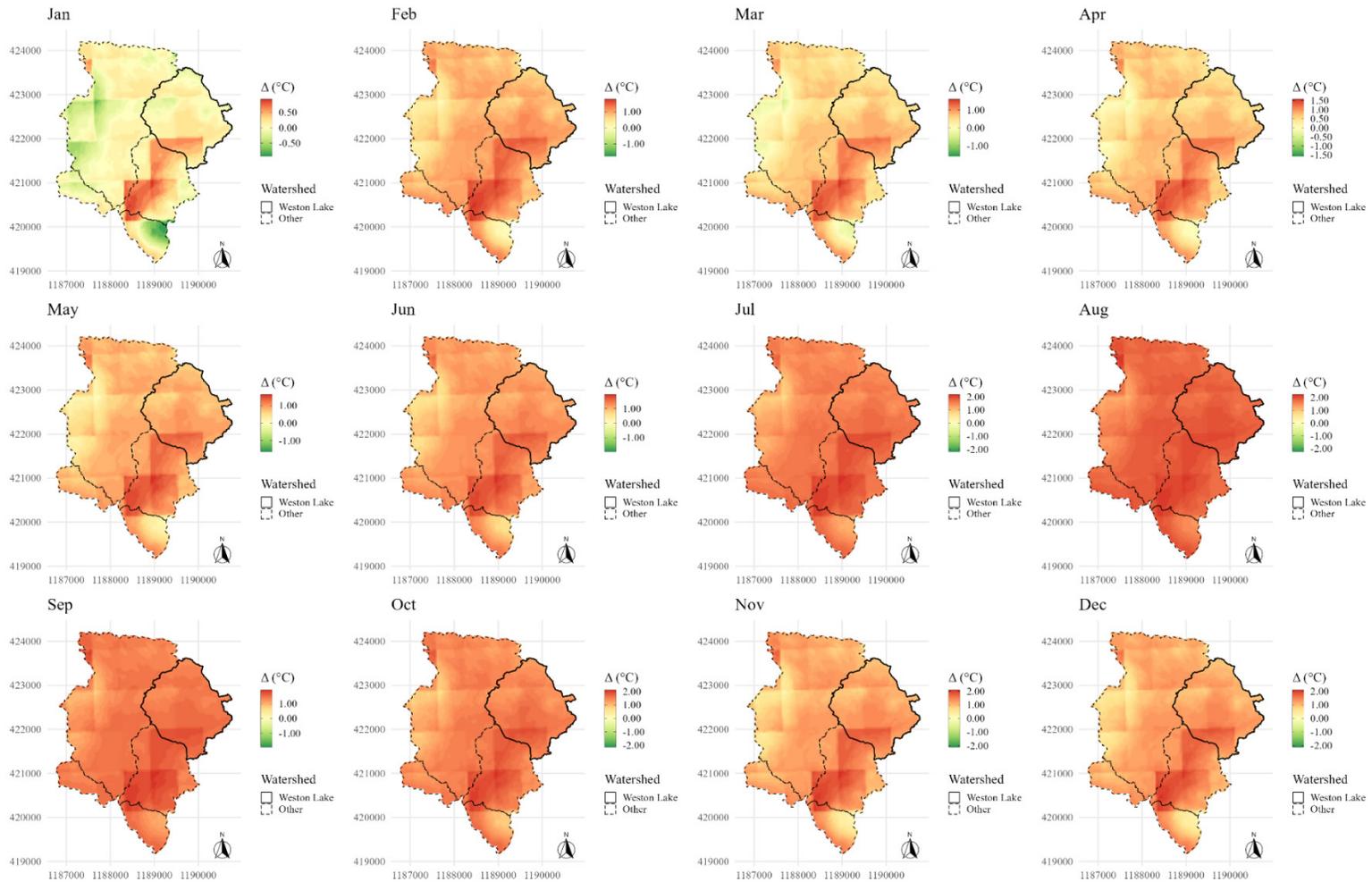


Figure 24: Monthly change in available moisture surplus between year 2070 and present normals, SSP 4.5

**1.6.3 SSP 7.0**

**1.6.3.1 Average Temperature**



**Figure 25: Monthly change in average temperature between year 2030 and present normals, SSP 7.0**

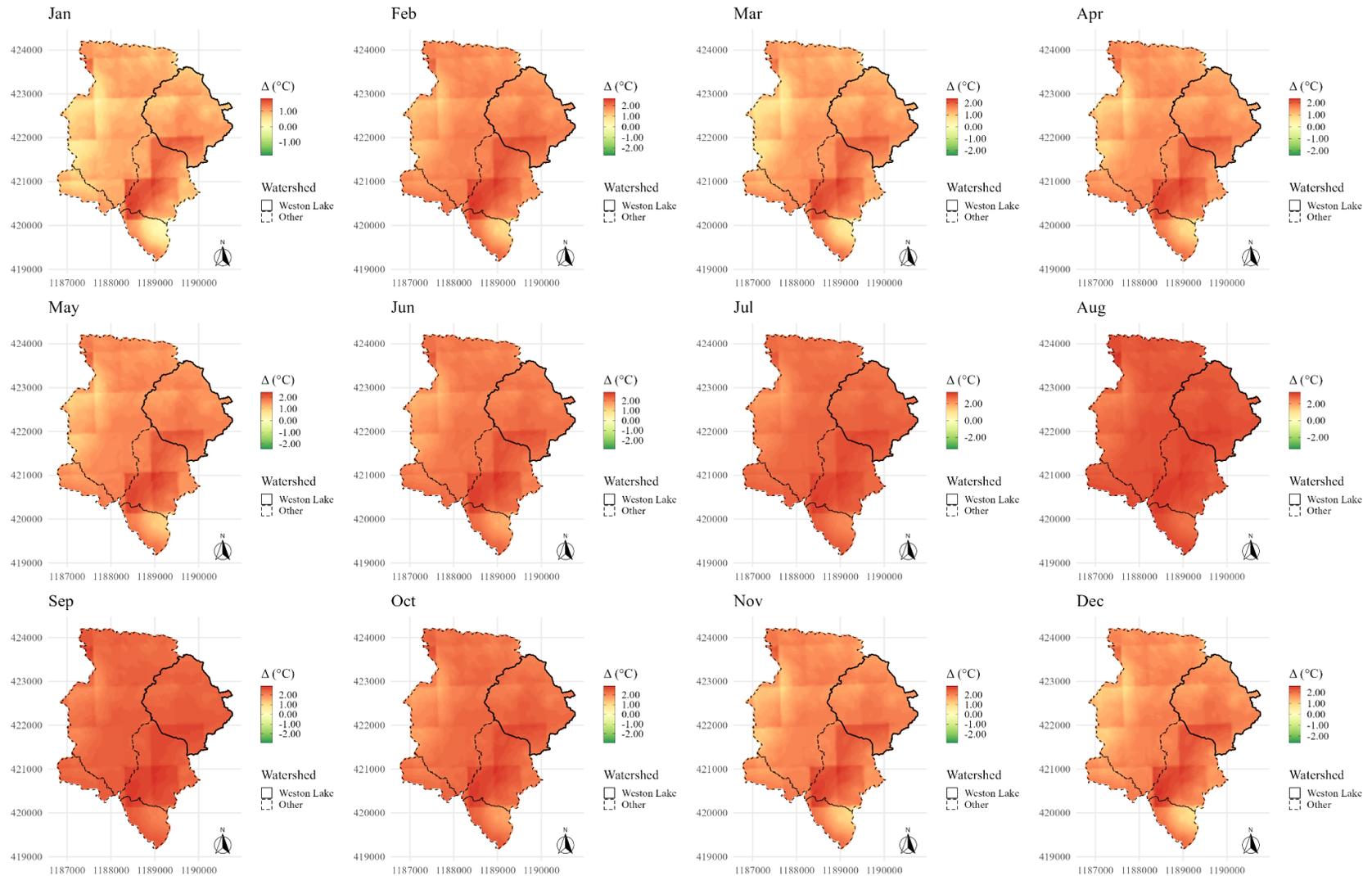


Figure 26: Monthly change in average temperature between year 2050 and present normals, SSP 7.0

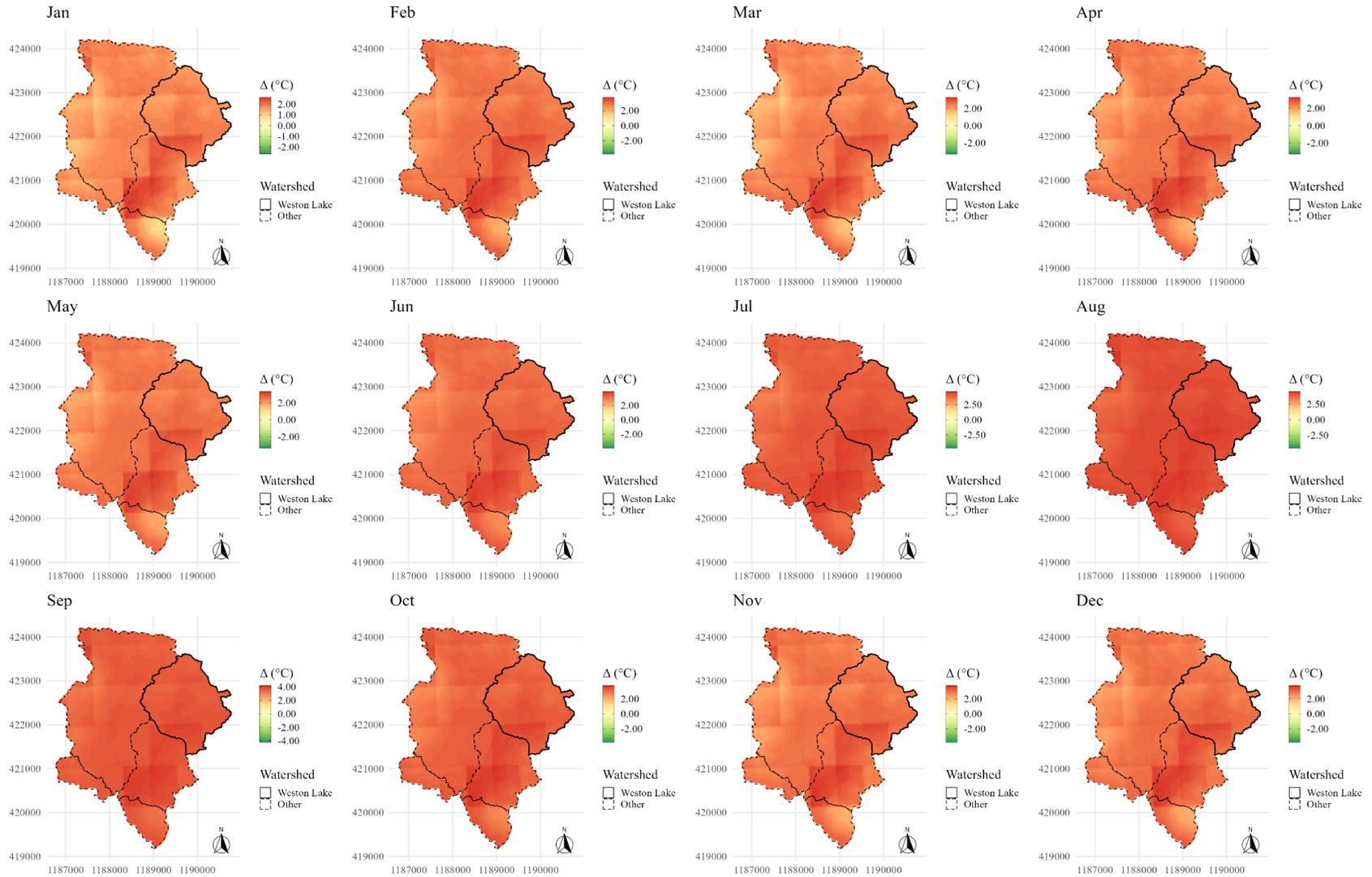


Figure 27: Monthly change in average temperature between year 2070 and present normals, SSP 7.0

1.6.3.2 Precipitation

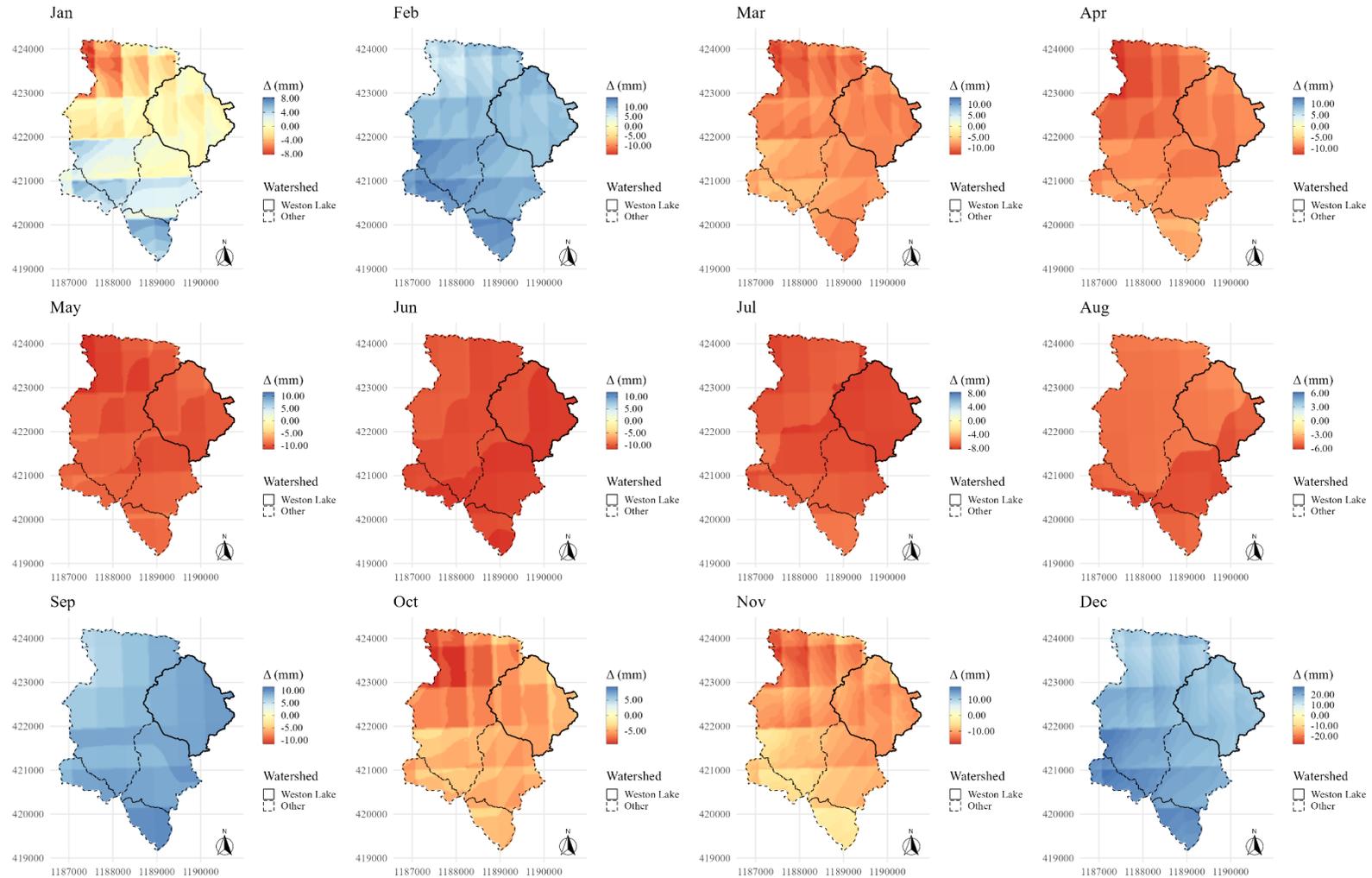


Figure 28: Monthly change in precipitation between year 2030 and present normals, SSP 7.0

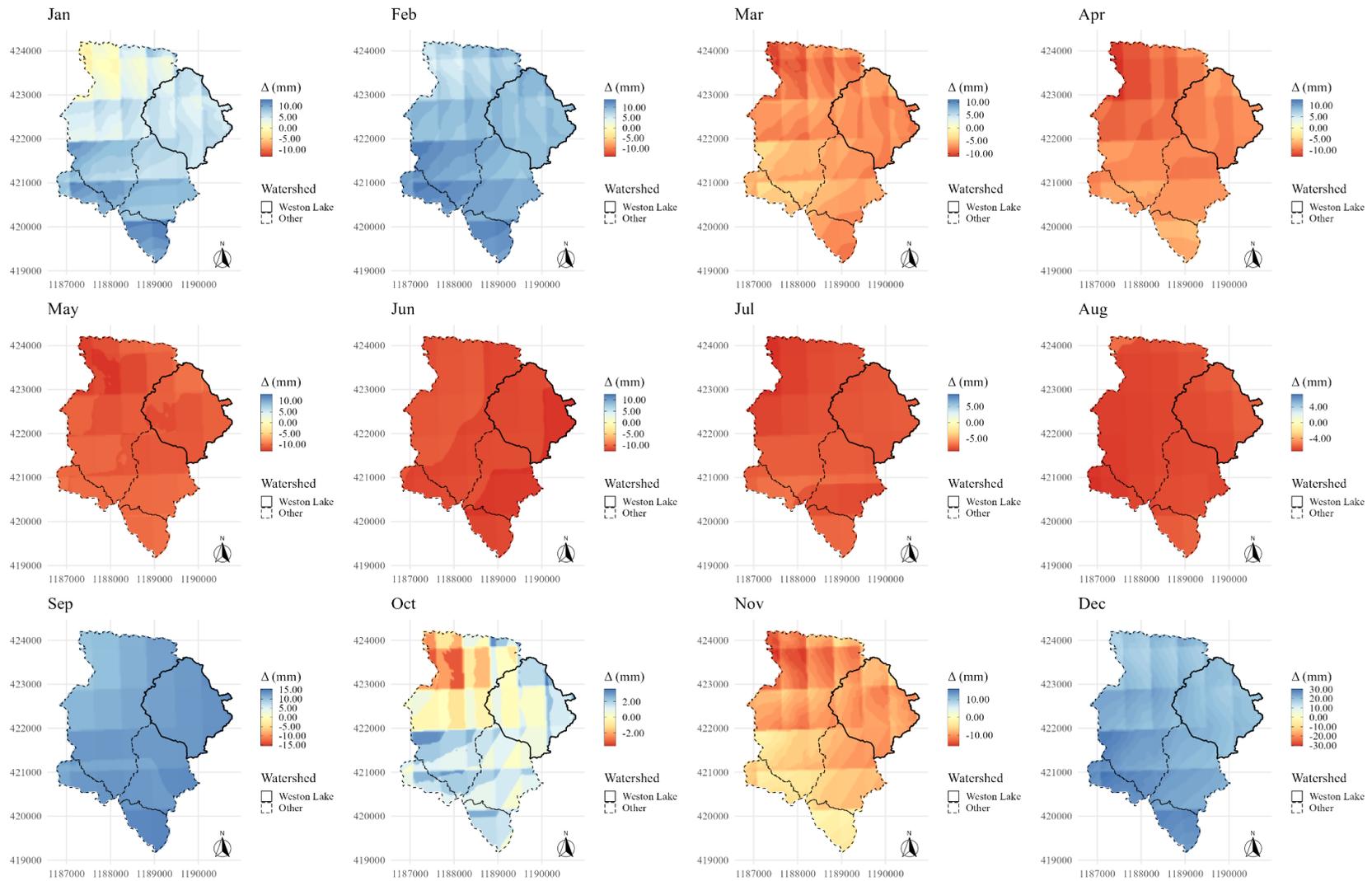


Figure 29: Monthly change in precipitation between year 2050 and present normals, SSP 7.0

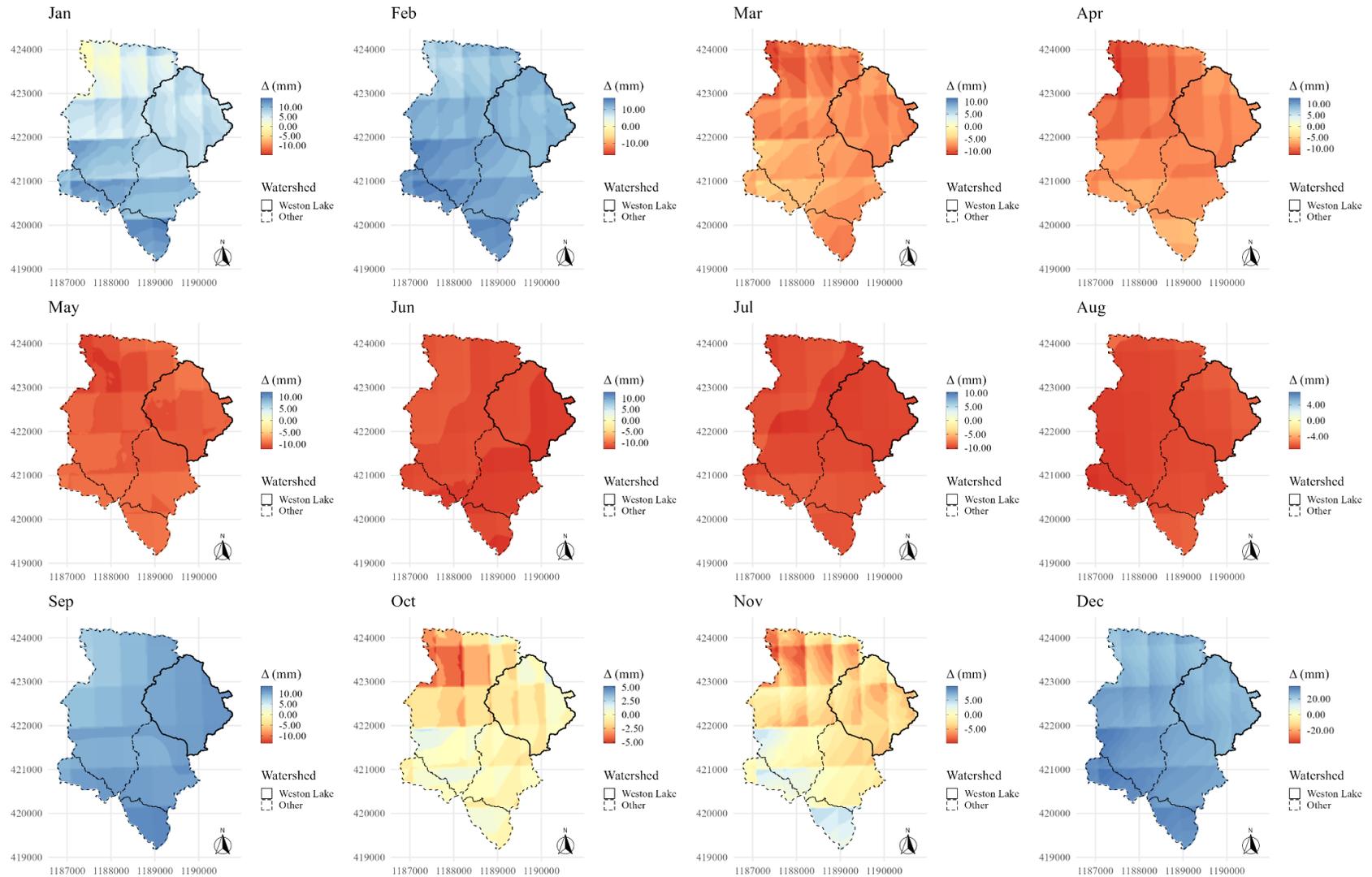


Figure 30: Monthly change in precipitation between year 2070 and present normals, SSP 7.0

1.6.3.3 Solar Radiation

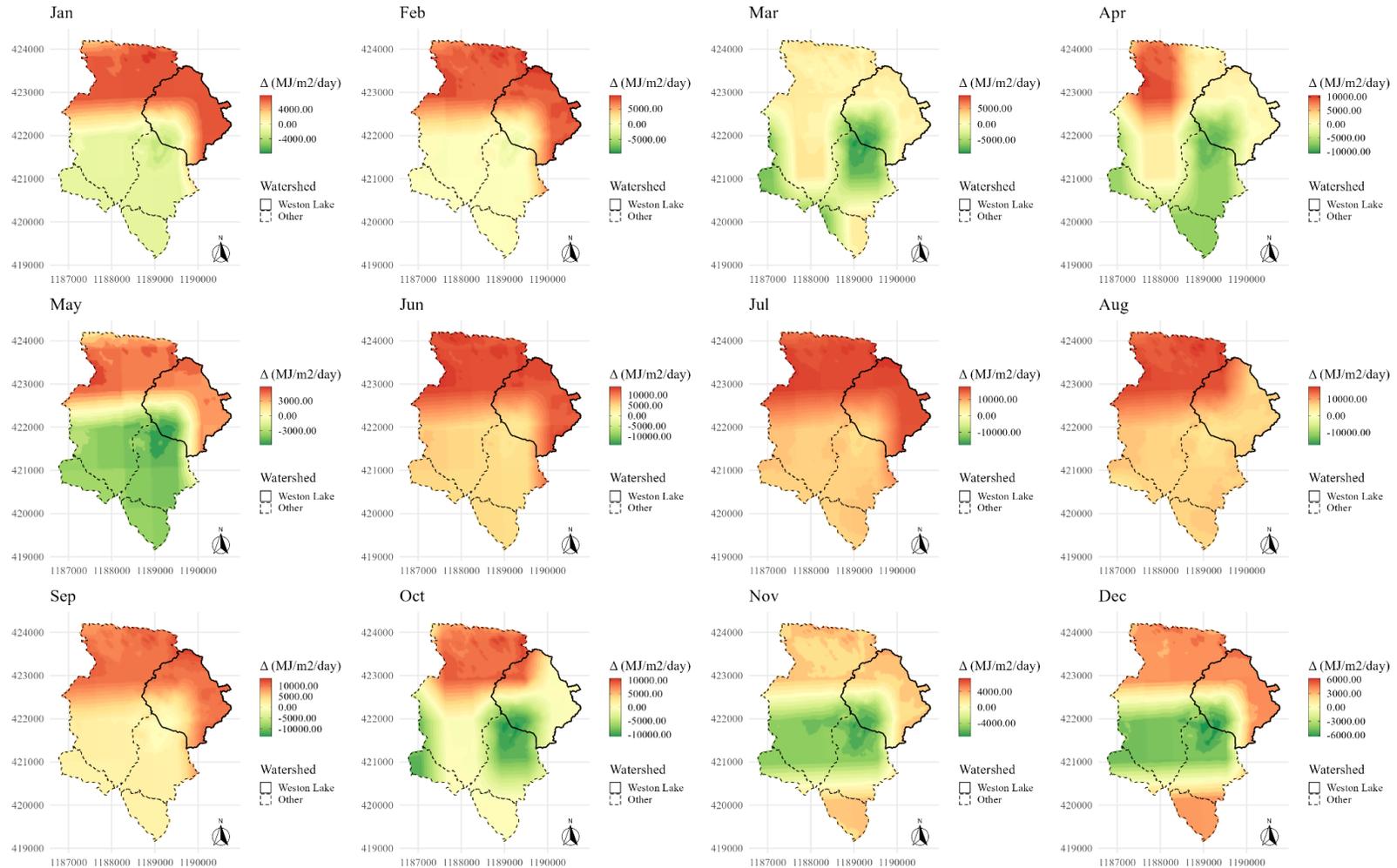


Figure 31: Monthly change in radiation between year 2030 and present normals, SSP 7.0

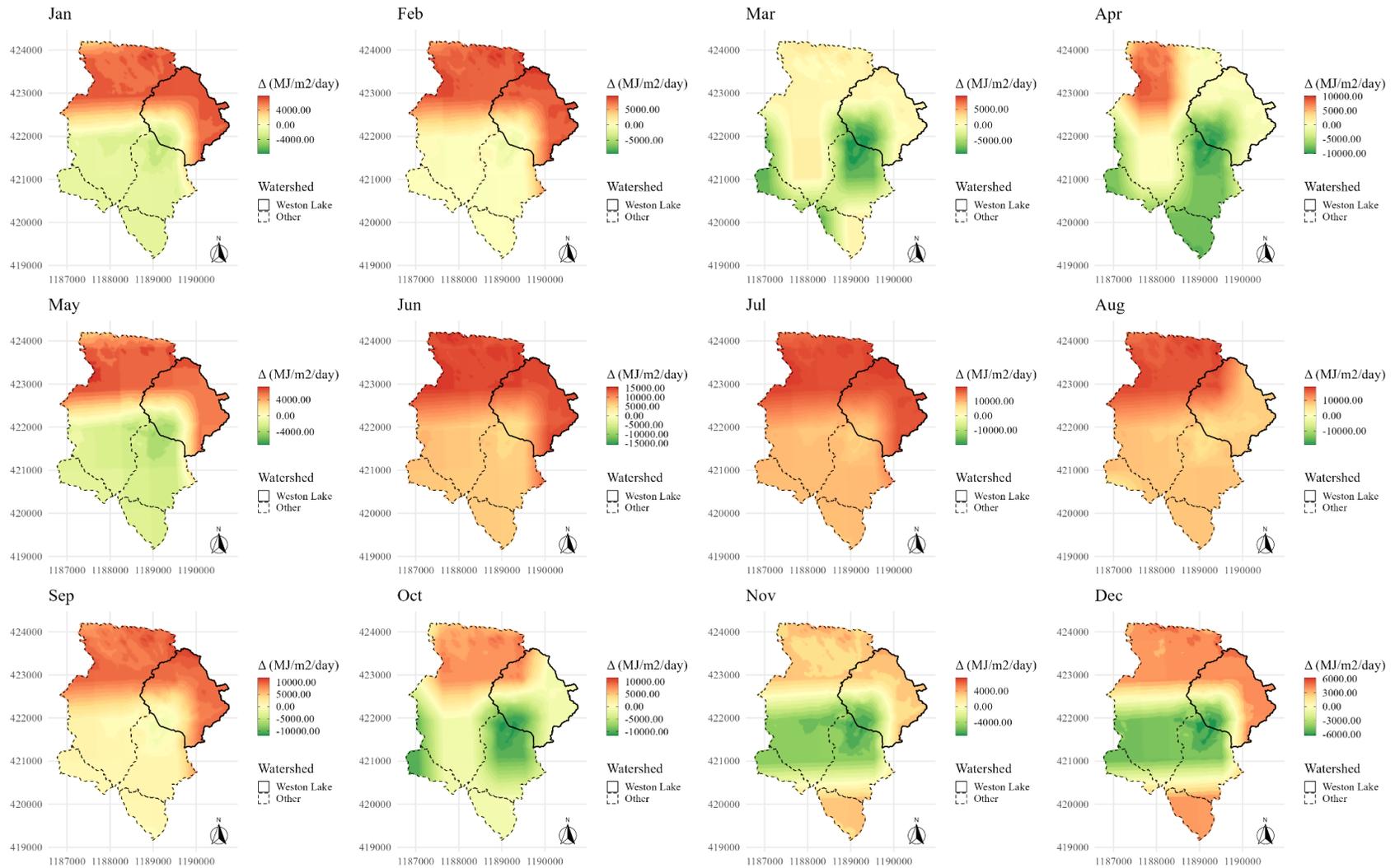


Figure 32: Monthly change in radiation between year 2050 and present normals, SSP 7.0

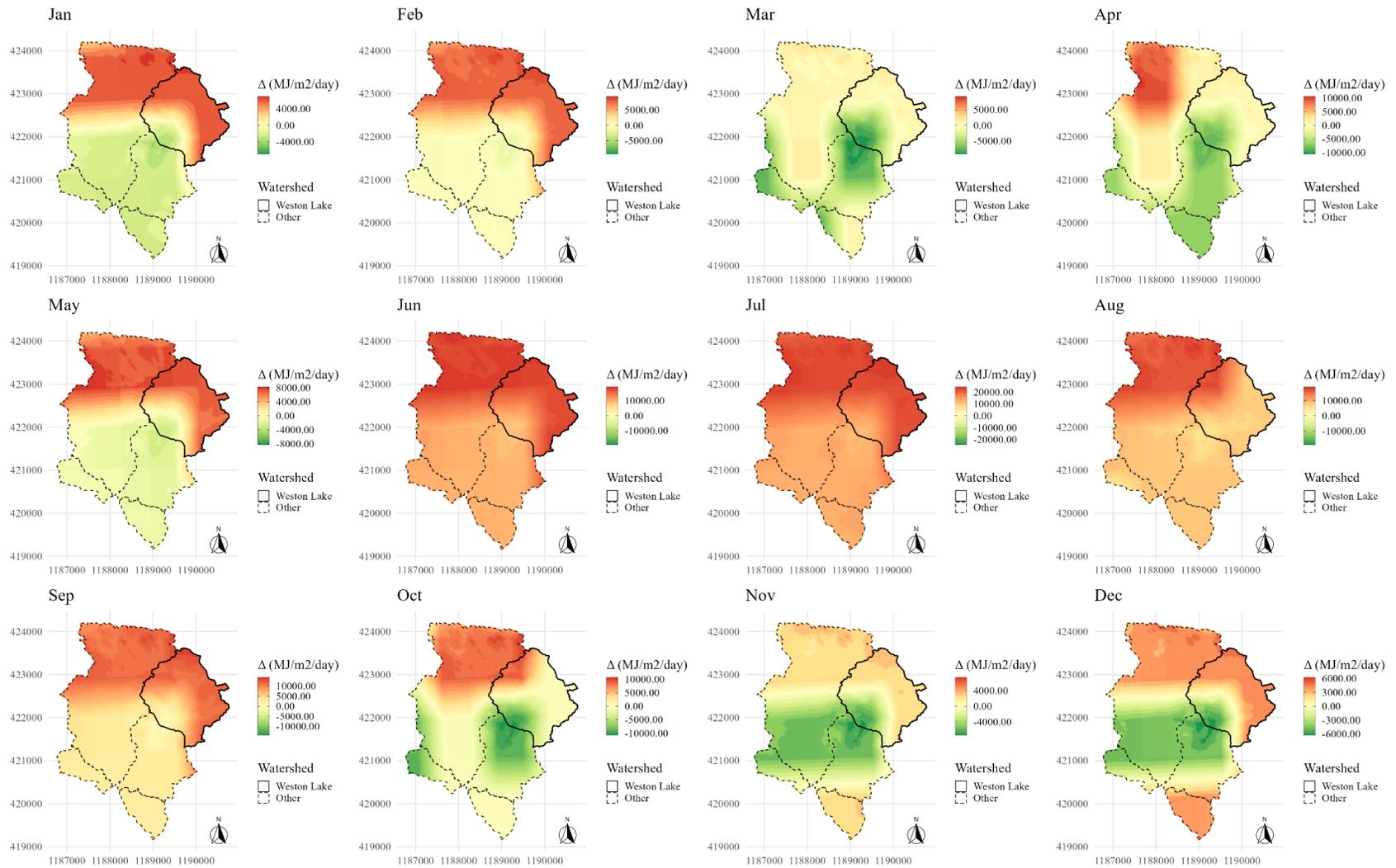


Figure 33: Monthly change in radiation between year 2070 and present normals, SSP 7.0

1.6.3.4 Available Moisture Surplus

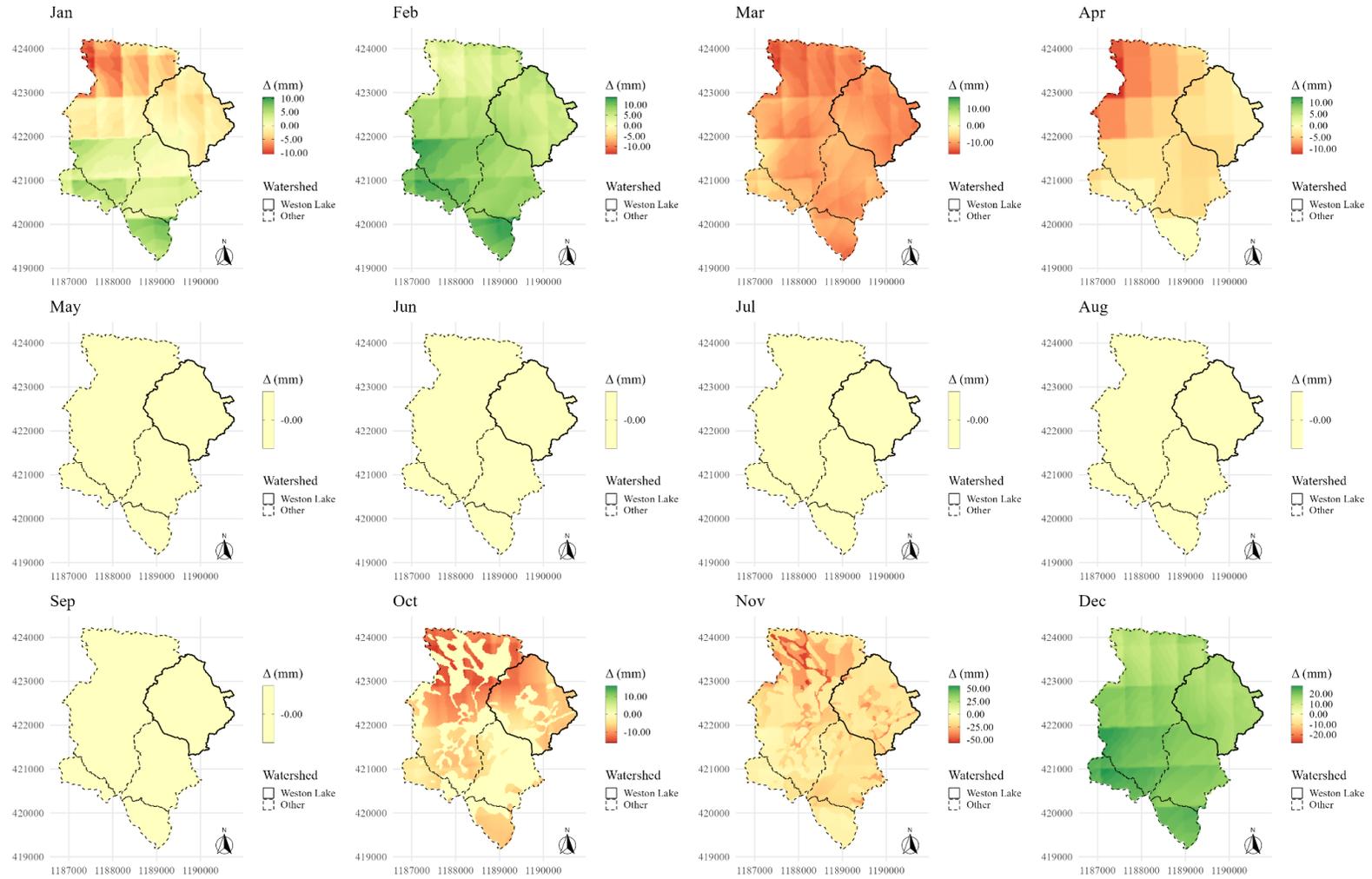


Figure 34: Monthly change in available water surplus between year 2030 and present normals, SSP 7.0

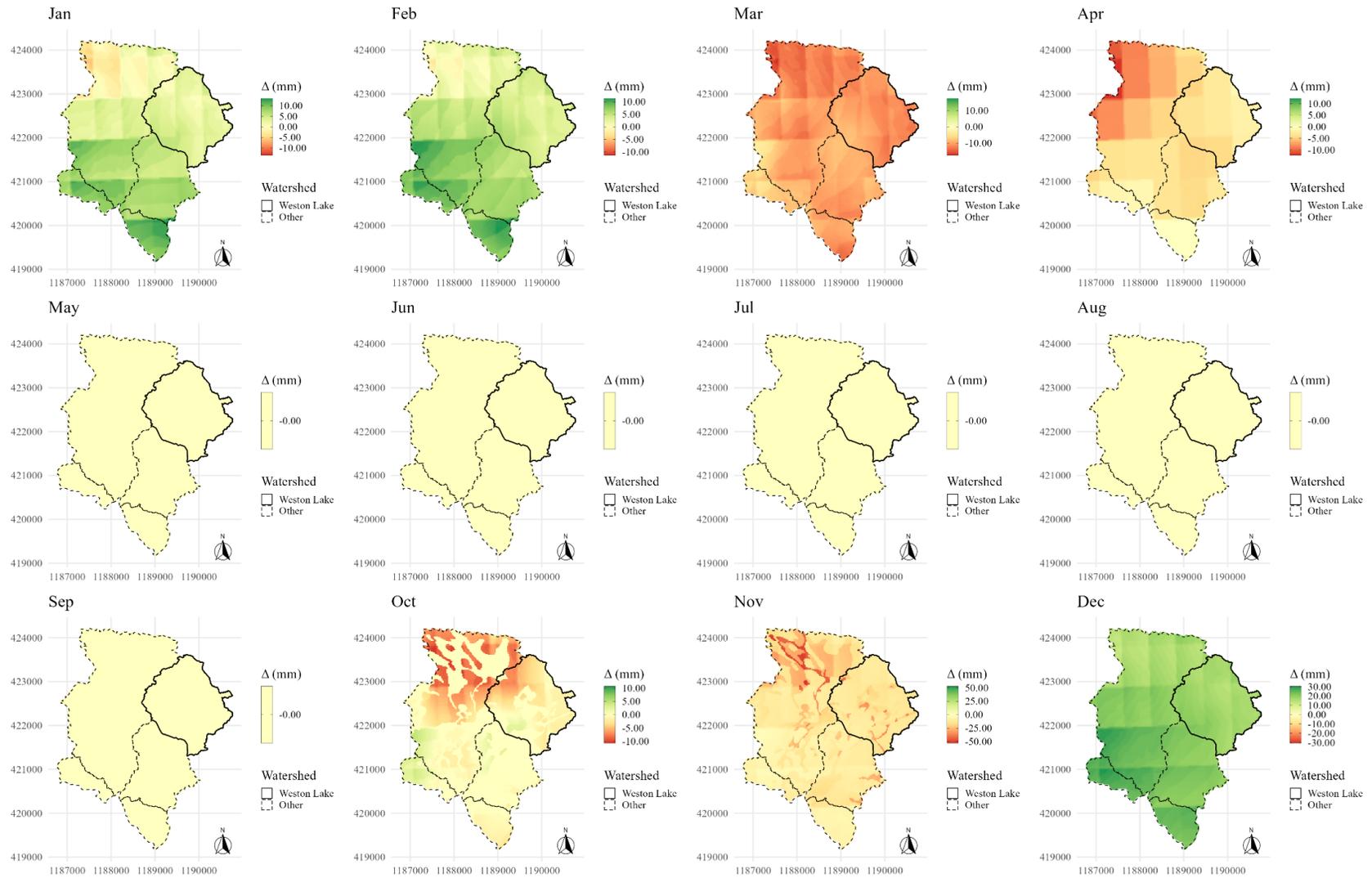


Figure 35: Monthly change in available water surplus between year 2050 and present normals, SSP 7.0

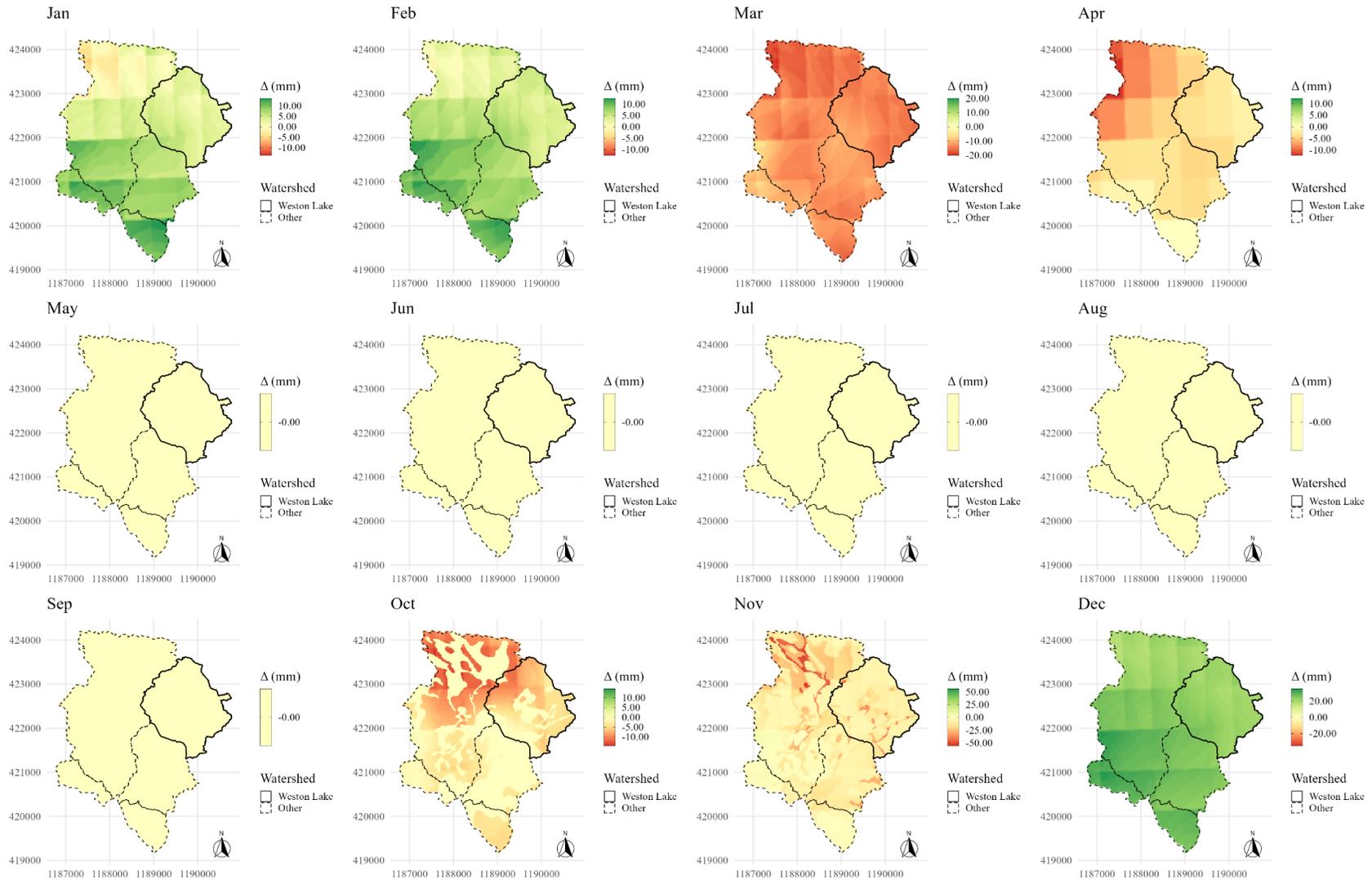
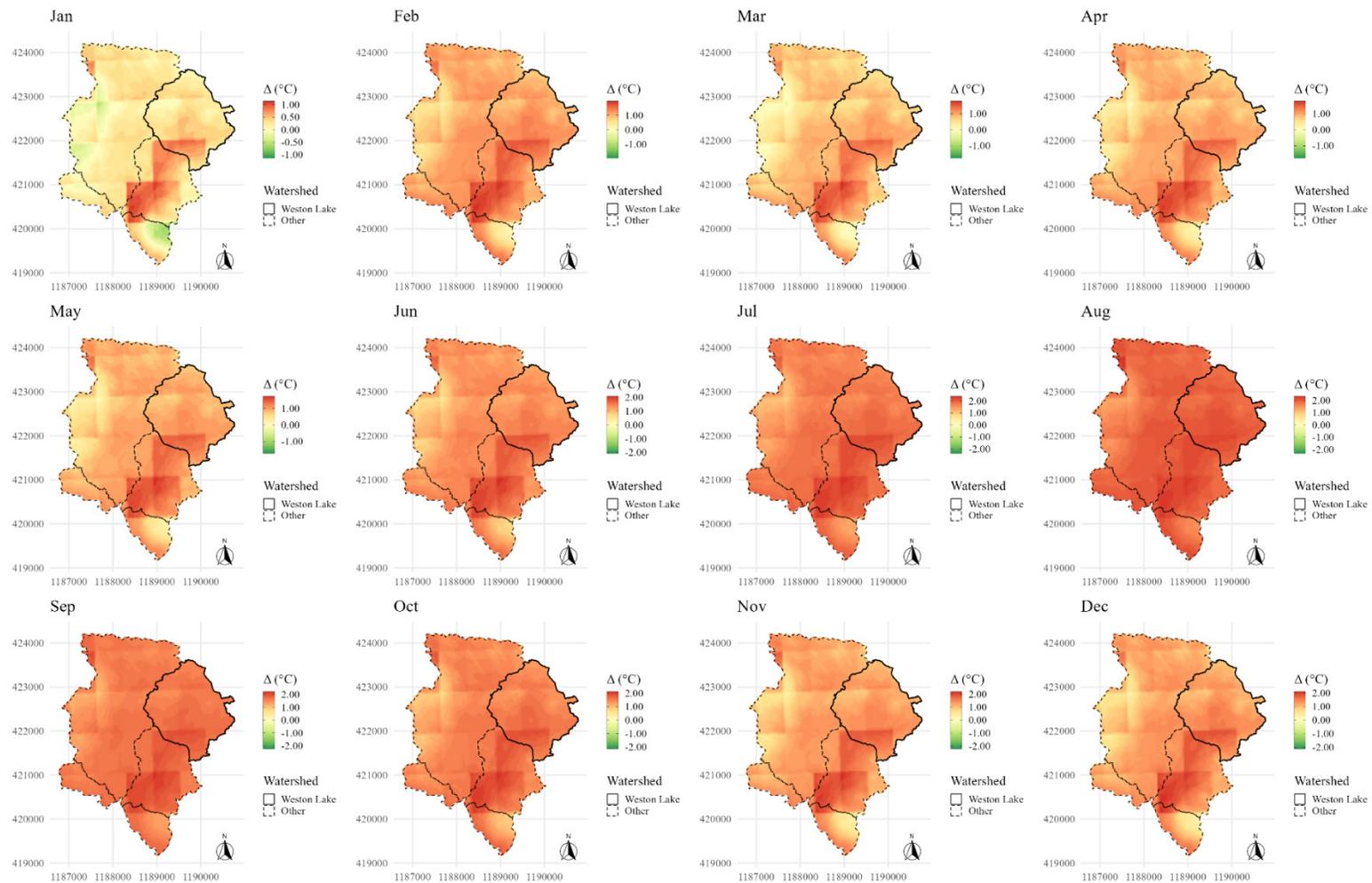


Figure 36: Monthly change in available water surplus between year 2070 and present normals, SSP 7.0

**1.6.4 SSP 8.5**

**1.6.4.1 Average Temperature**



**Figure 37: Monthly change in average temperature between year 2030 and present normals, SSP 8.5**

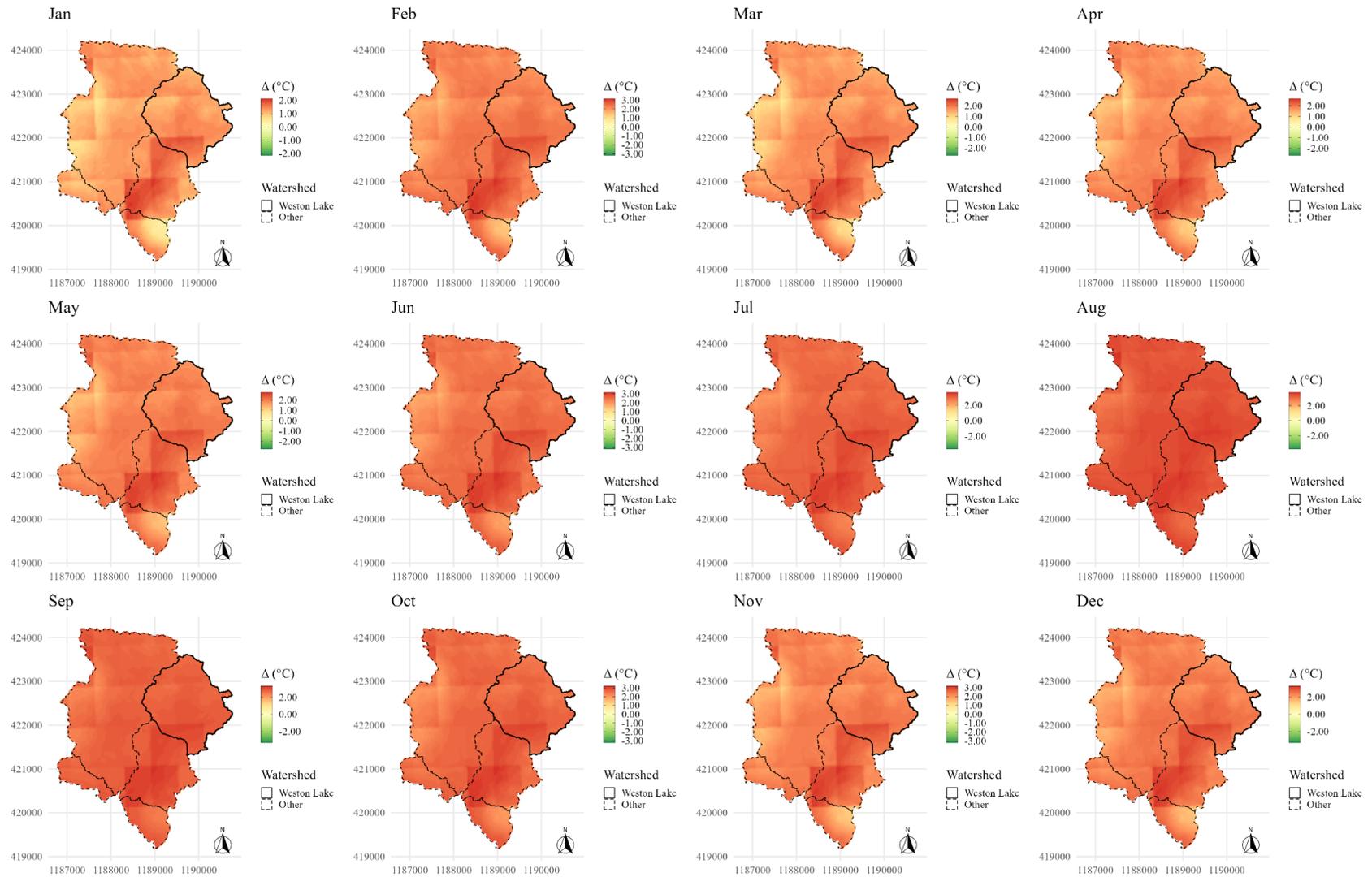


Figure 38: Monthly change in average temperature between year 2050 and present normals, SSP 8.5

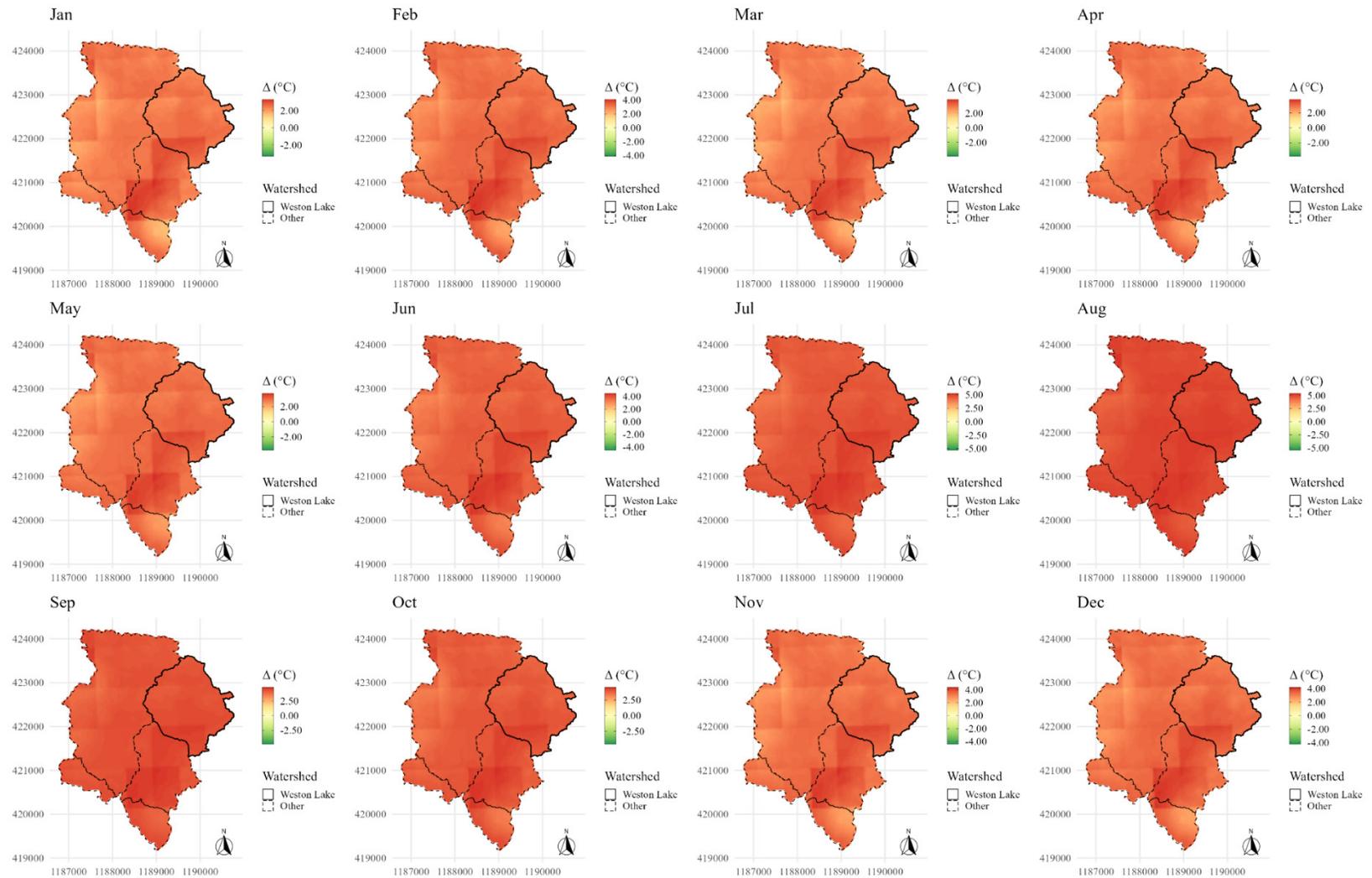


Figure 39: Monthly change in average temperature between year 2070 and present normals, SSP 8.5

1.6.4.2 Precipitation

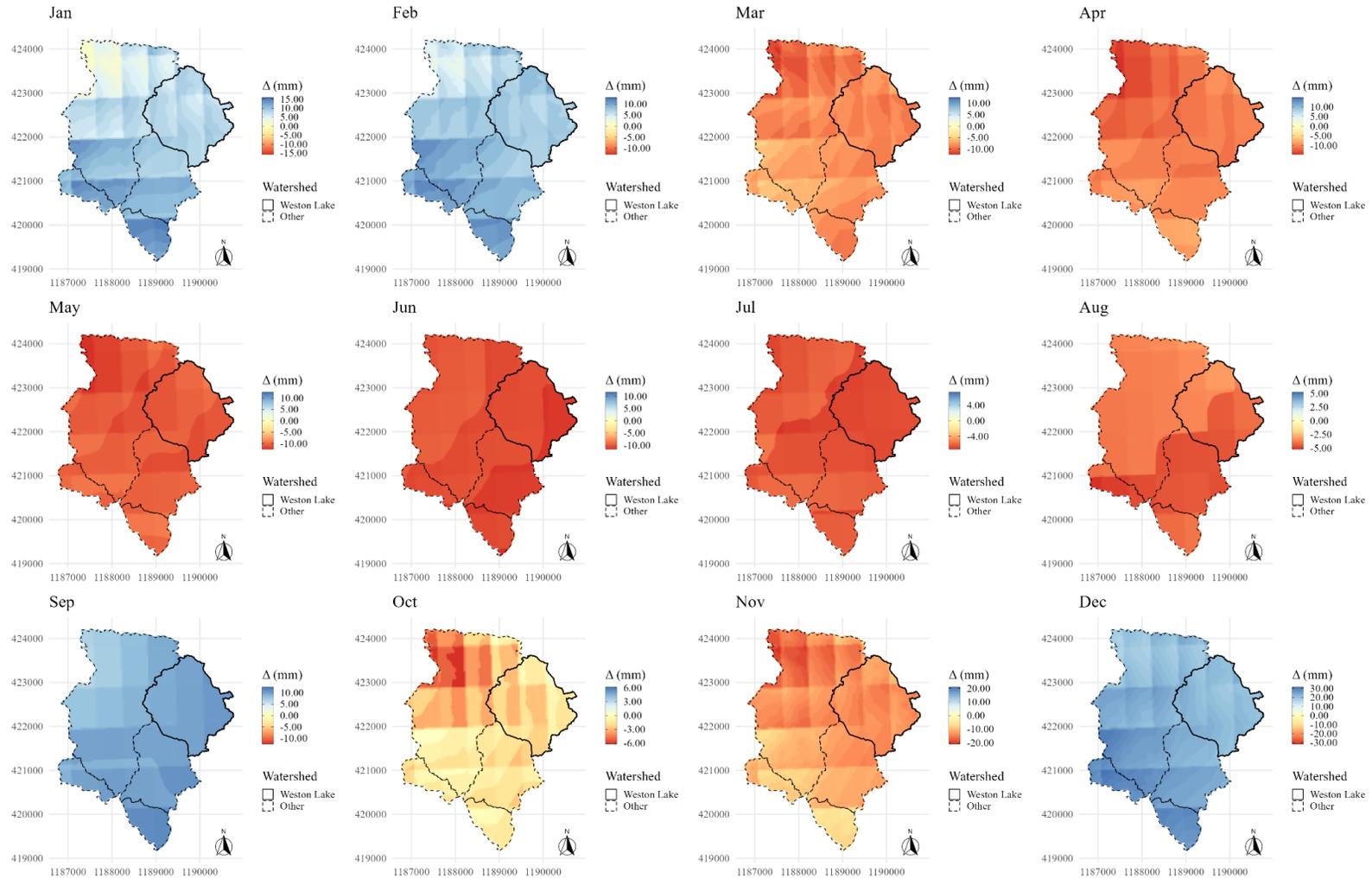


Figure 40: Monthly change in precipitation between year 2030 and present normals, SSP 8.5

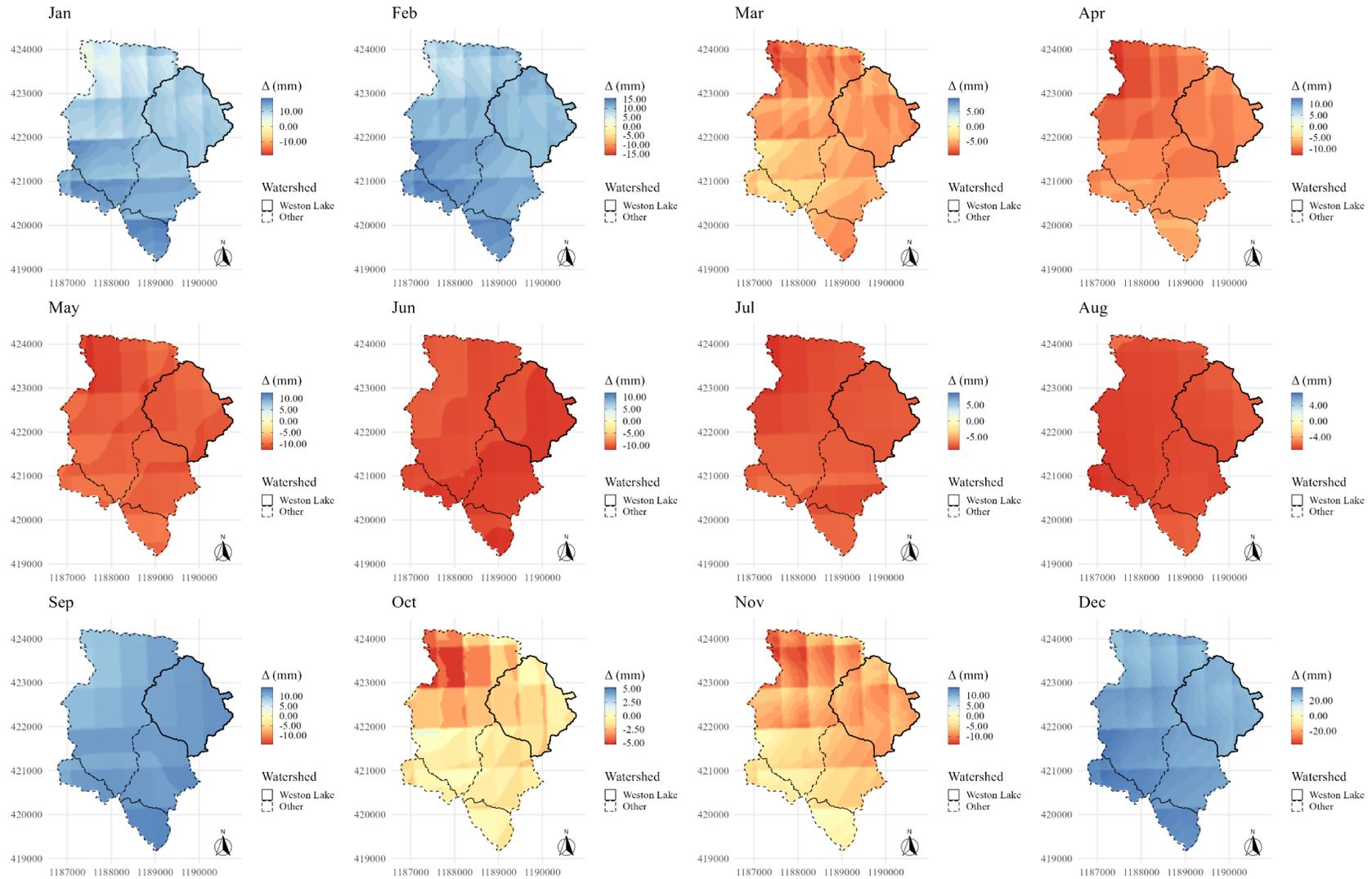


Figure 41: Monthly change in precipitation between year 2050 and present normals, SSP 8.5

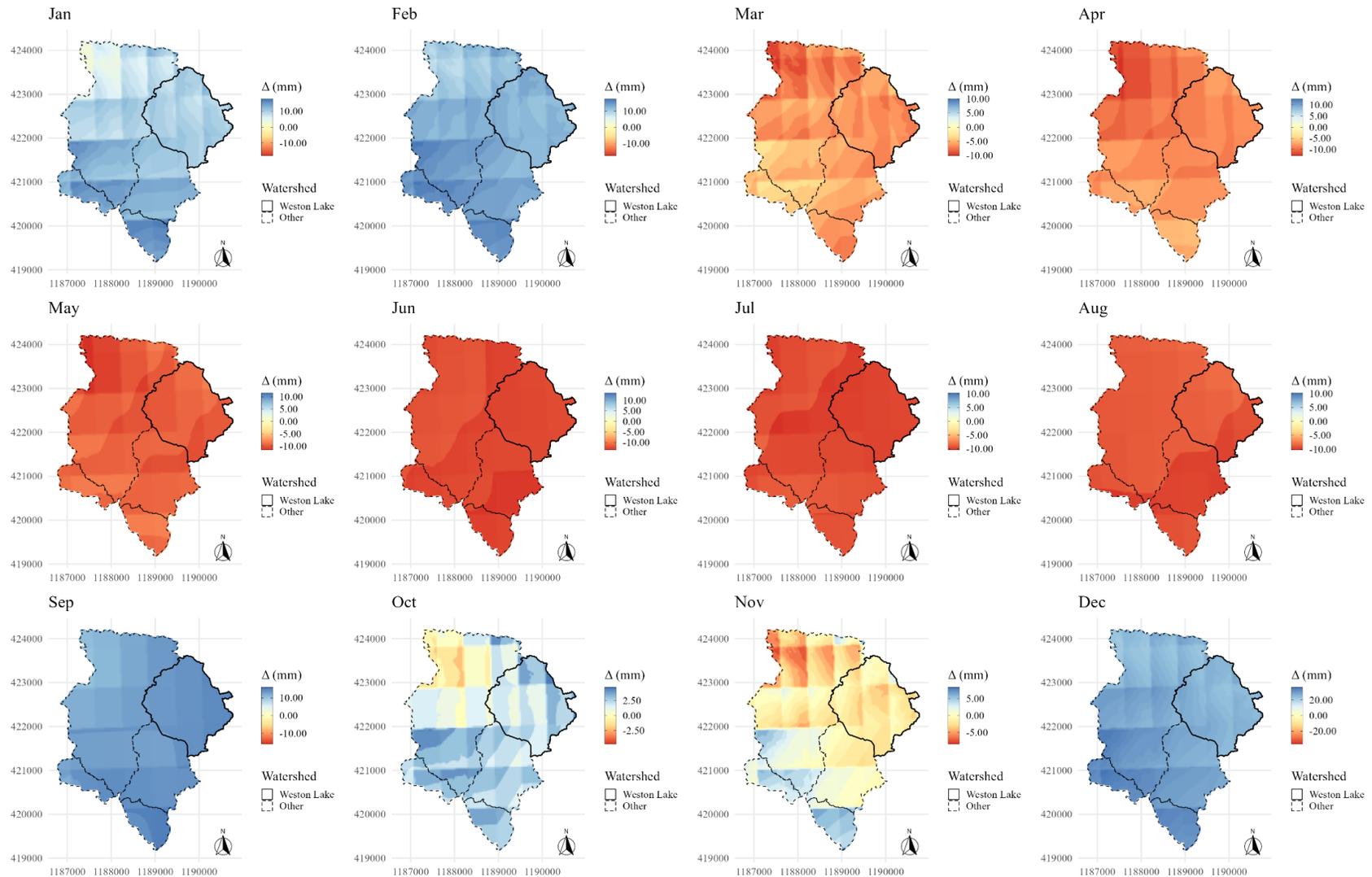


Figure 42: Monthly change in precipitation between year 2070 and present normals, SSP 8.5

1.6.4.3 Solar Radiation

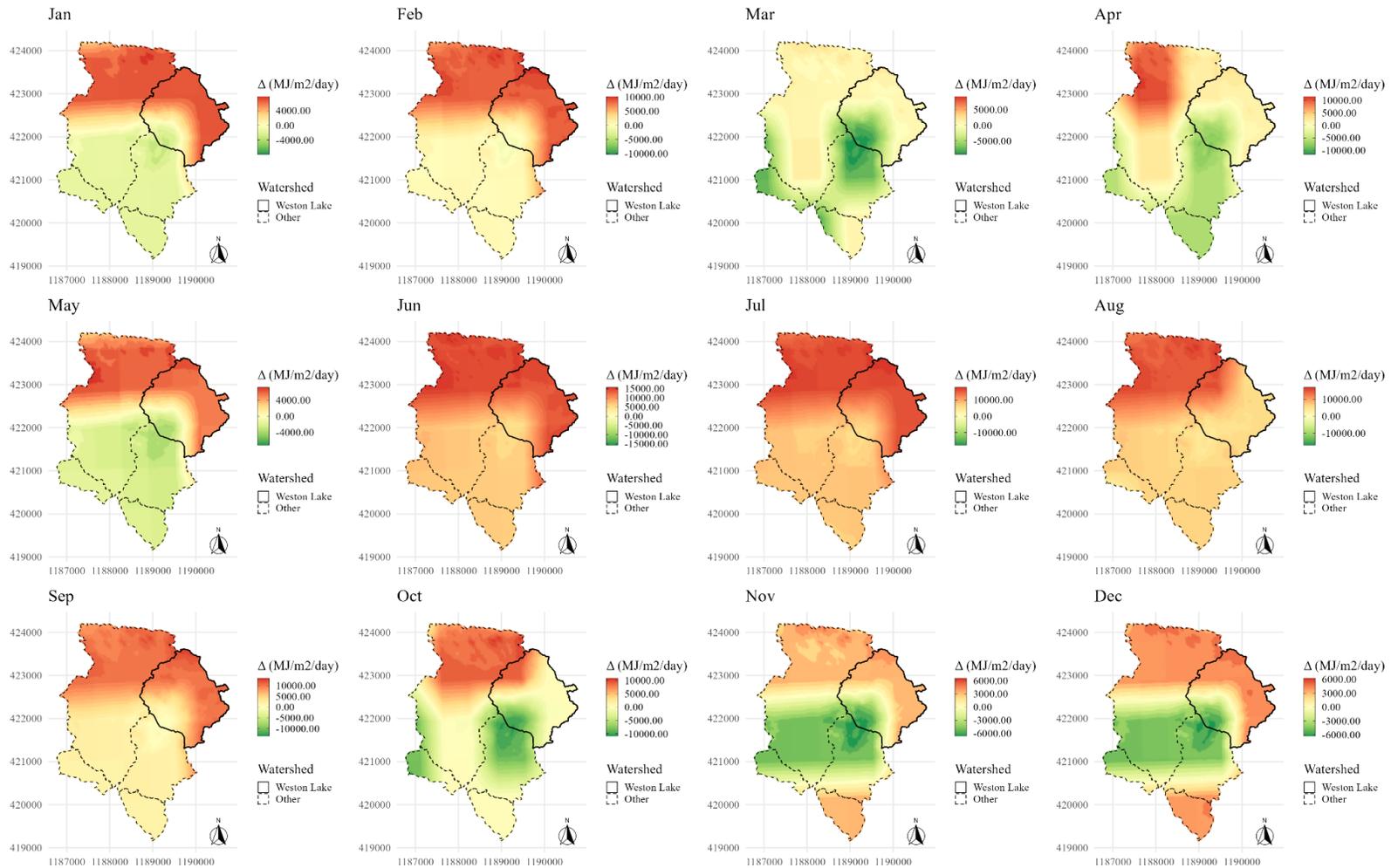


Figure 43: Monthly change in radiation between year 2030 and present normals, SSP 8.5

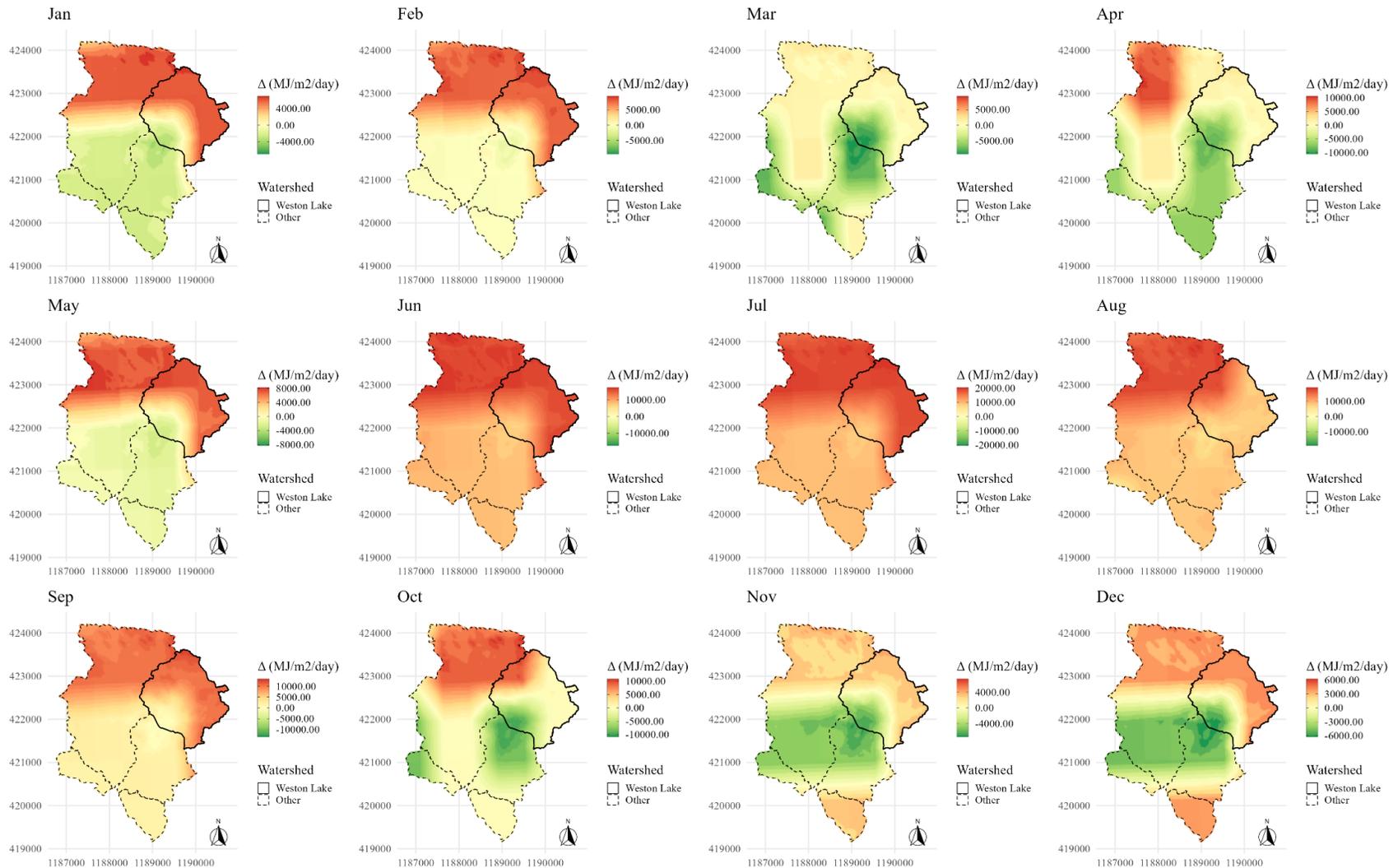


Figure 44: Monthly change in radiation between year 2050 and present normals, SSP 8.5

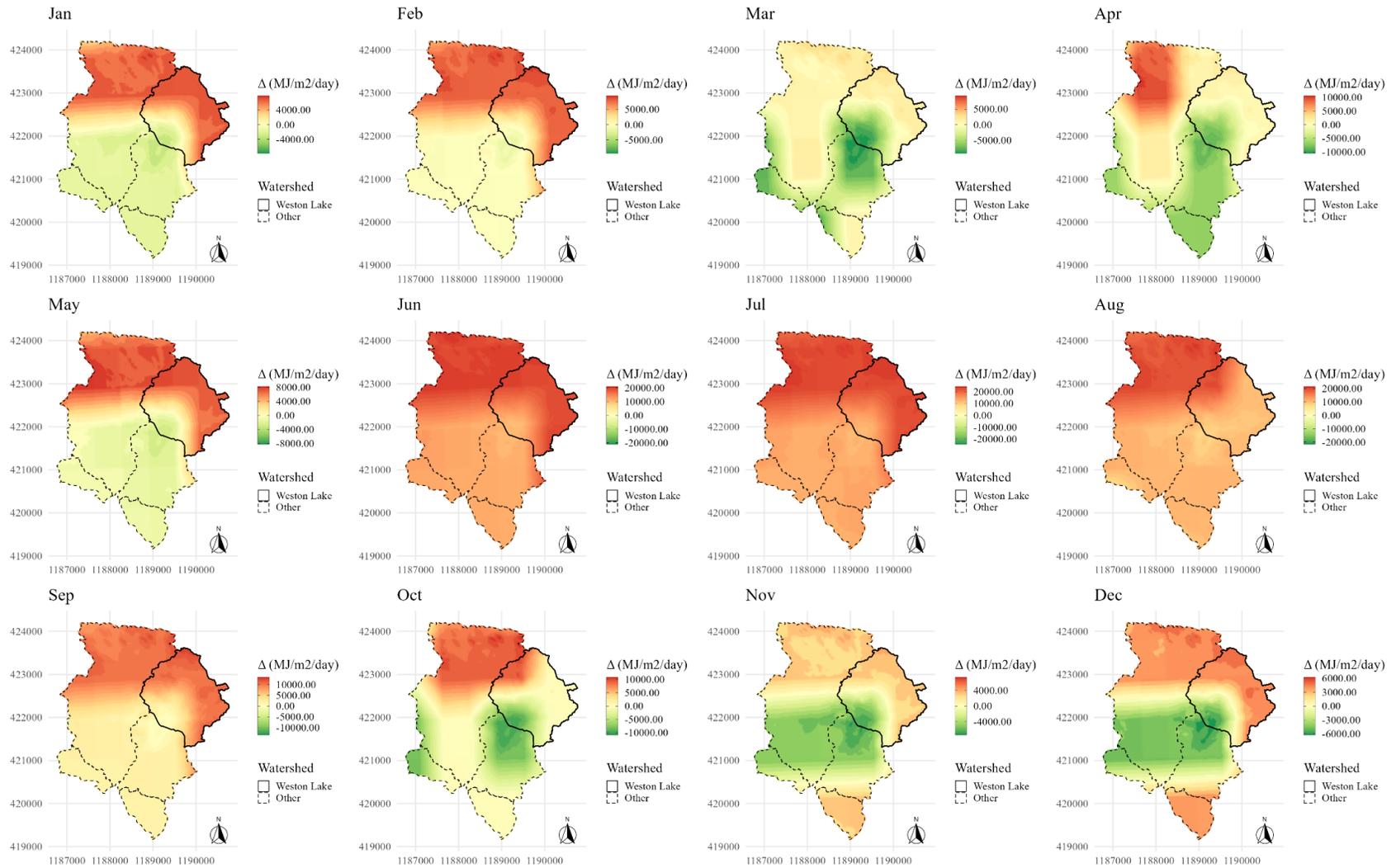


Figure 45: Monthly change in radiation between year 2070 and present normals, SSP 8.5

1.6.4.4 Available Moisture Surplus

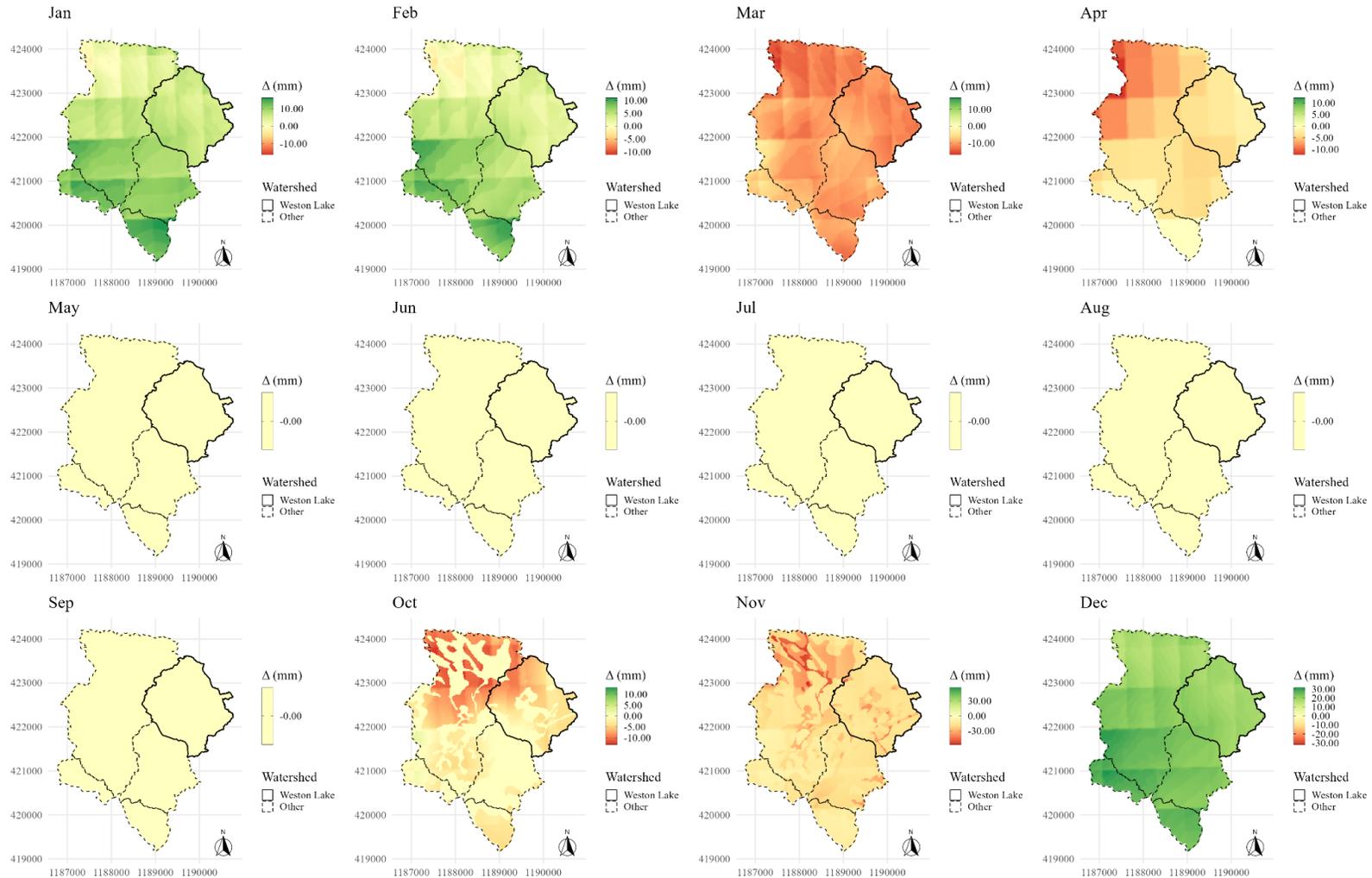


Figure 46: Monthly change in available moisture surplus between year 2030 and present normals, SSP 8.5

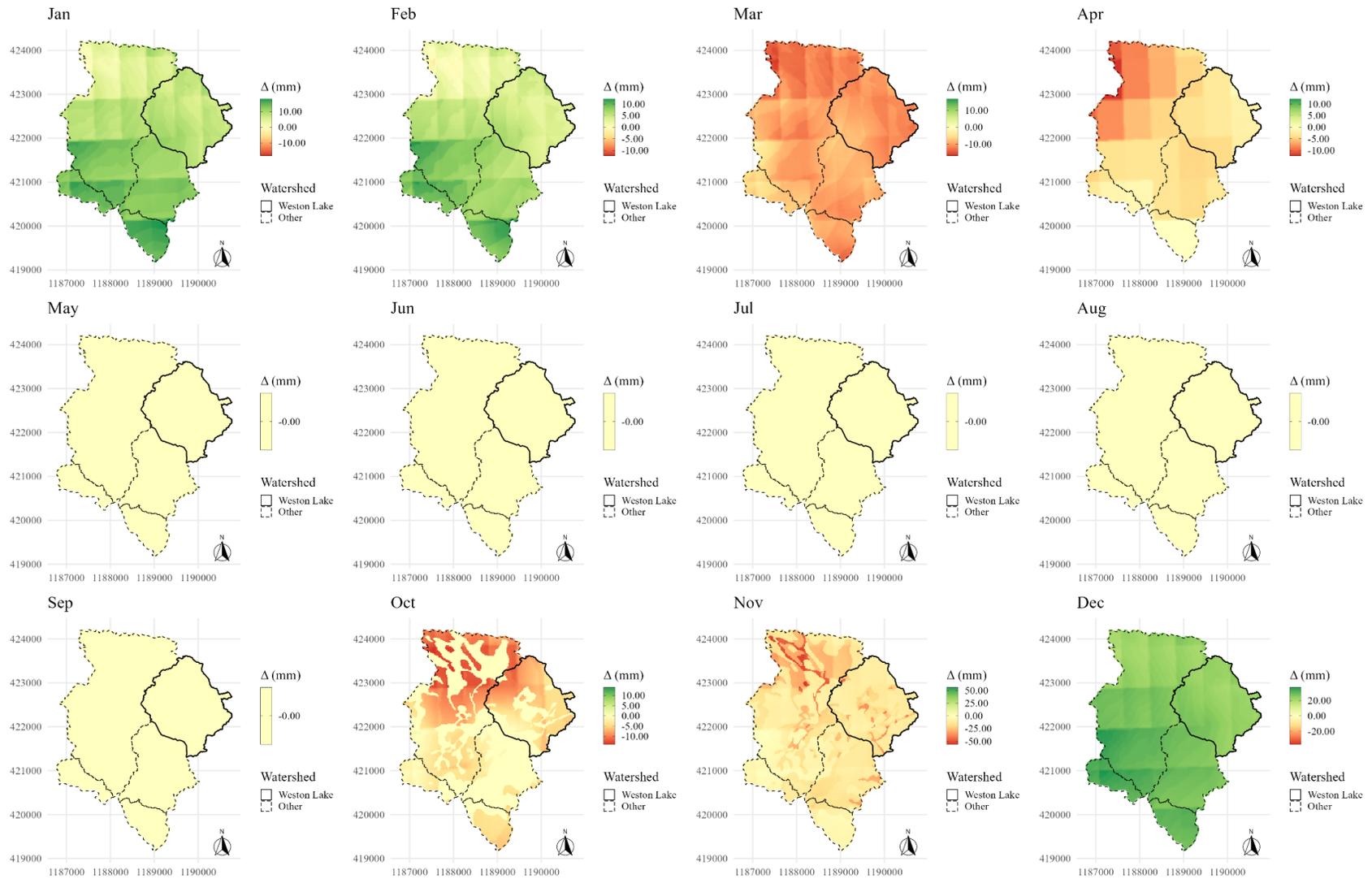


Figure 47: Monthly change in available moisture surplus between year 2050 and present normals, SSP 8.5

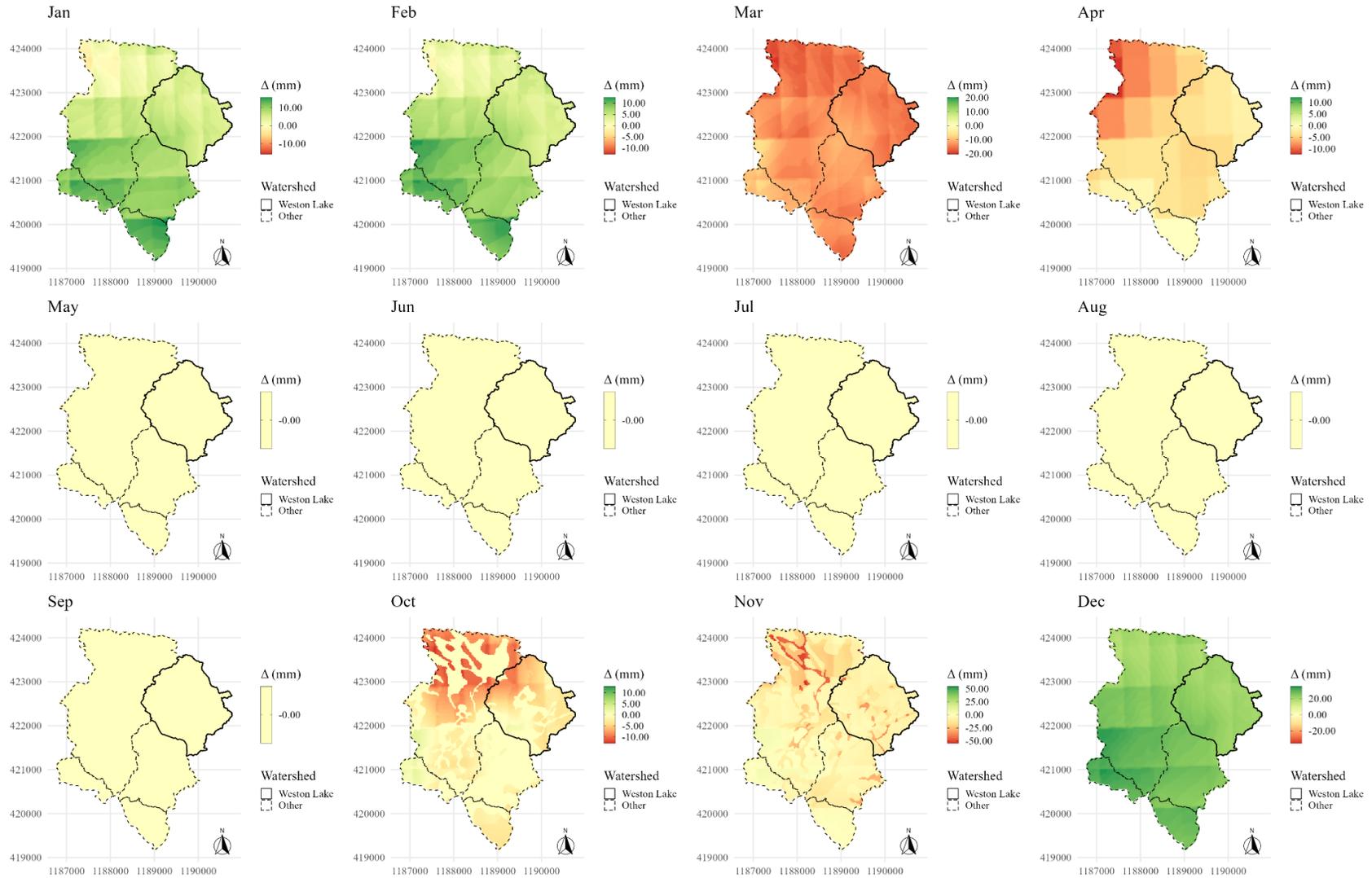
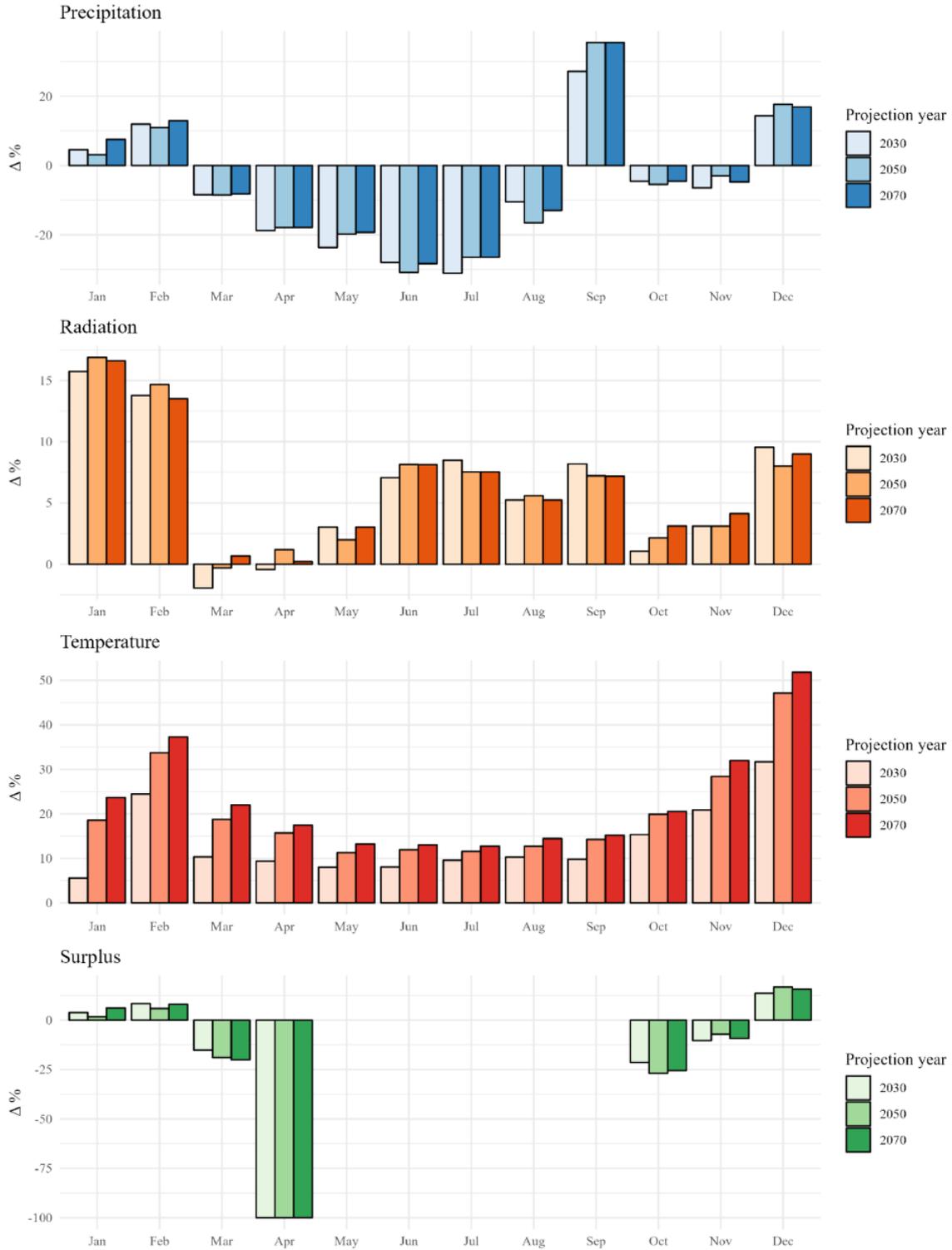


Figure 48: Monthly change in available moisture surplus between year 2070 and present normals, SSP 8.5

### 1.6.5 Lake Weston Watershed Summary Charts



**Figure 49: Percentage change relative to climate normal, summarized by month for the Lake Weston watershed, SSP 2.6**

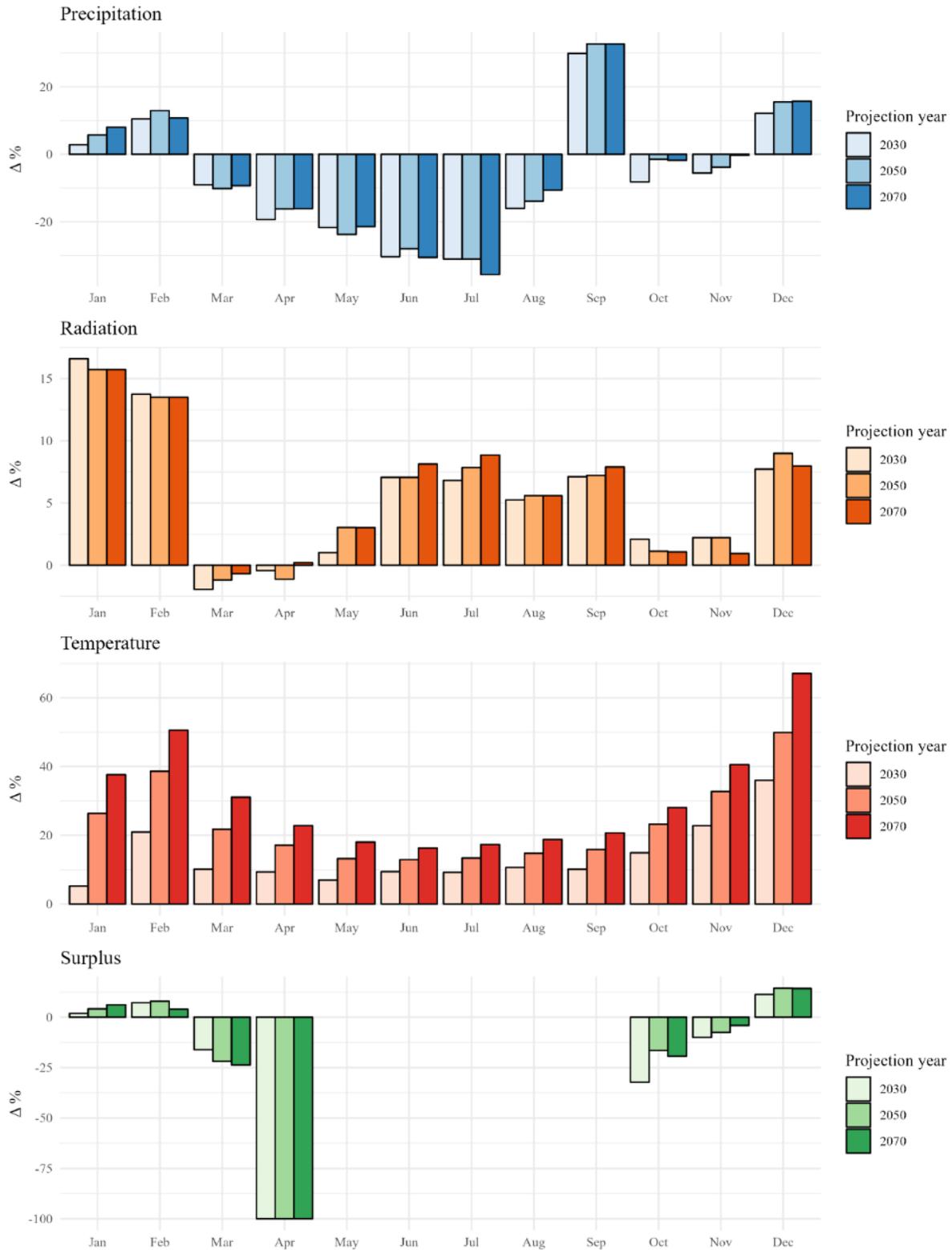
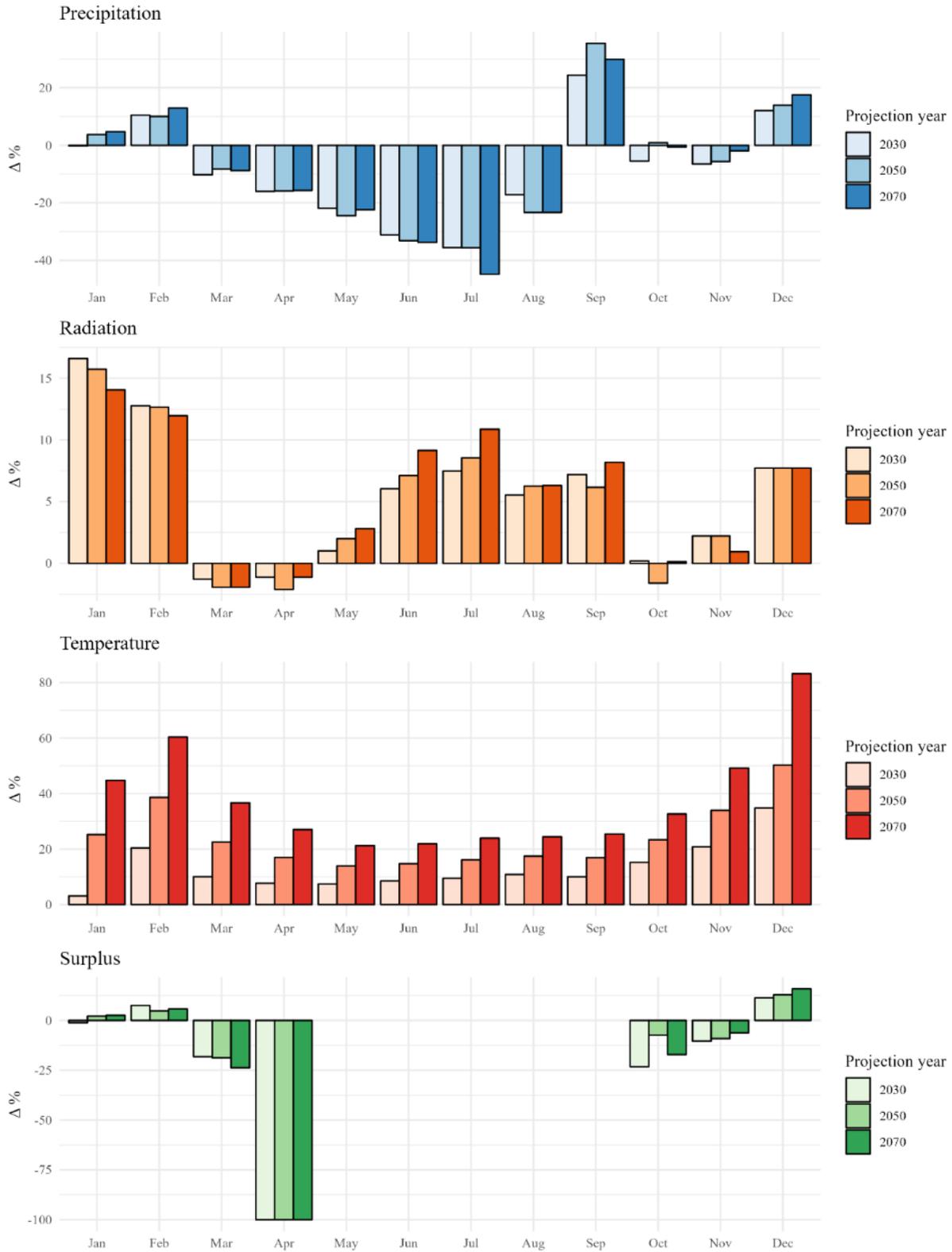


Figure 50: Percentage change relative to climate normal, summarized by month for the Lake Weston watershed, SSP 4.5



**Figure 51: Percentage change relative to climate normal, summarized by month for the Lake Weston watershed, SSP 7.0**

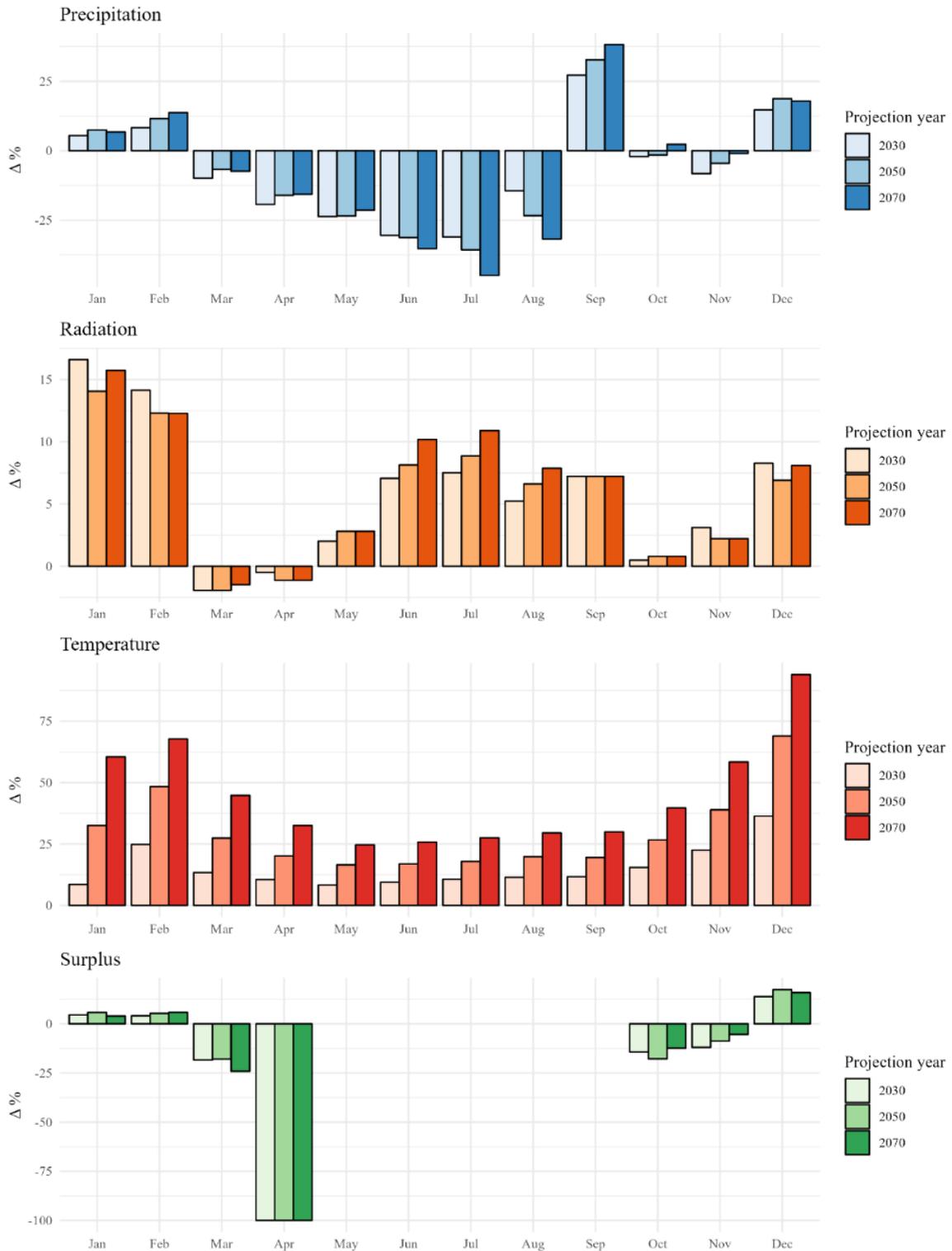


Figure 52: Percentage change relative to climate normal, summarized by month for the Lake Weston watershed, SSP 8.5

## 1.7 References

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## **APPENDIX 5**

Water Rights Licences: Points of diversions (accessed February 2022)

APPENDIX 5: WATER RIGHTS LICENCES: POINTS OF DIVERSIONS

POD NUMBER	STATUS	FILE NUMBER	LICENCE NUMBER	PRIORITY DATE	PURPOSE	SOURCE	QUANTITY	UNIT	QUANTITY DESCRIPTION	PRIMARY LICENSE NAME
PD33584	Active	300787	C037411	2/22/1971	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33586	Active	250393	F041199	6/24/1963	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33592	Active	277651	F047416	2/29/1968	01A - Domestic	Lake Weston	4.54609	m3/day	Maximum licensed demand for purpose, multiple PODs, quantity at each POD unknown	PRIVATE INDIVIDUAL NAME
PD33593	Active	277651	F047416	2/29/1968	01A - Domestic	Lake Weston	4.54609	m3/day	Maximum licensed demand for purpose, multiple PODs, quantity at each POD unknown	PRIVATE INDIVIDUAL NAME
PD33592	Active	277651	F047416	2/29/1968	03B - Irrigation: Private	Lake Weston	5303.964	m3/year	Maximum licensed demand for purpose, multiple PODs, quantity at each POD unknown	PRIVATE INDIVIDUAL NAME
PD33593	Active	277651	F047416	2/29/1968	03B - Irrigation: Private	Lake Weston	5303.964	m3/year	Maximum licensed demand for purpose, multiple PODs, quantity at each POD unknown	PRIVATE INDIVIDUAL NAME
PD33589	Active	290081	F045514	8/1/1969	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33585	Active	237701	F041041	7/27/1961	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33591	Active	305544	F047419	6/22/1971	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33589	Active	290081	F045514	8/1/1969	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD78964	Active	1002434	C120550	3/17/2005	02I12 - Misc Ind'l: Fire Protection	Lake Weston	0.08014	m3/sec	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33594	Active	346455	C120382	1/18/1946	00A - Waterworks: Local Provider	Lake Weston	58076.2998	m3/year	Total demand for purpose, one POD.	Capital Regional District (12780)

POD NUMBER	STATUS	FILE NUMBER	LICENCE NUMBER	PRIORITY DATE	PURPOSE	SOURCE	QUANTITY	UNIT	QUANTITY DESCRIPTION	PRIMARY LICENSE NAME
PD33597	Active	305338	C059393	4/26/1971	01A - Domestic	Garvey Spring	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33599	Active	285911	C035832	7/14/1969	01A - Domestic	Spencer Spring	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33594	Active	226409	C120292	7/2/1959	00A - Waterworks: Local Provider	Lake Weston	58076.2998	m3/year	Total demand for purpose, one POD.	Capital Regional District (12780)
PD33596	Active	226409	C120292	7/2/1959	00A - Waterworks: Local Provider	Lake Weston	0	m3/year		Capital Regional District (12780)
PD33599	Active	269377	F042626	5/31/1966	01A - Domestic	Spencer Spring	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33596	Active	226409	C120292	7/2/1959	08A - Stream Storage: Non-Power	Lake Weston	49339.2	m3/year	Total demand for purpose, one POD.	Capital Regional District (12780)
PD33594	Active	226409	C120292	7/2/1959	08A - Stream Storage: Non-Power	Lake Weston	0	m3/year		Capital Regional District (12780)
PD33595	Active	159262	F103906	1/25/1946	01A - Domestic	Lake Weston	4.54609	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33595	Active	231119	F103907	5/31/1960	03B - Irrigation: Private	Lake Weston	10114.536	m3/year	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33583	Active	310389	C040375	6/27/1972	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33587	Active	305153	F047418	4/21/1971	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33590	Active	267198	F040731	2/10/1966	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33599	Active	285910	F047417	7/14/1969	01A - Domestic	Spencer Spring	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33589	Active	290081	F045514	8/1/1969	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD70355	Active	1001808	C109036	11/24/1994	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME
PD33589	Active	285885	F045515	7/8/1969	01A - Domestic	Lake Weston	2.27305	m3/day	Total demand for purpose, one POD.	PRIVATE INDIVIDUAL NAME

## APPENDIX 6

### Glossary

## APPENDIX 6: GLOSSARY

Term	Definition
<i>Aquifer</i>	An underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand) from which groundwater can be extracted using a water well.
<i>Aquitard</i>	An aquitard is a zone in the ground or bedrock that restricts the flow of groundwater from one aquifer to another, or from the surface to the subsurface. Aquitards are usually comprised of silt, clay, or non-porous (aka solid) rock of low hydraulic conductivity.
<i>Bedrock Aquifer</i>	In solid rock, groundwater is stored in the fractures, joints, bedding planes and cavities of the rock mass. Despite the potential for having voids, a rock can only act as an aquifer if those voids are saturated and connected via conduits such as fractures and faults.
<i>Elevation</i>	Elevation is given in meters above sea level. Ground elevations were projected/interpolated from a 1m Digital Elevation Model (DEM) provided by the Island Trust (ITC) for the current project.
<i>Evaporation</i>	Evaporation is the process by which water is transferred from surface water bodies (i.e.: lakes and rivers) to the atmosphere. The rate of evaporation is driven by air temperature, water temperature, wind speed and solar radiation. For this study, monthly average air temperature and maximum daylight hours per month have been used as indices for lake evaporation.
<i>Evapotranspiration</i>	Evapotranspiration is the process by which water is transferred from soil moisture to the atmosphere through either <u>transpiration</u> by plants or direct <u>evaporation</u> from leaves, standing

Term	Definition
	water on the ground or surface water bodies. The rate of evapotranspiration is driven by air temperature, wind speed, solar radiation and plant species or land cover.
<i>Groundwater</i>	Groundwater is water found in the soil or rock below the land surface where the pores and openings are filled entirely with water. The upper boundary of the groundwater zone is called the water table which is equivalent to the water level in shallow well.
<i>Groundwater Recharge</i>	Groundwater recharge is the process by which water flows from shallow soil moisture storage into groundwater in the subsoil.
<i>Groundwater Storage</i>	Groundwater storage is the capacity of subsoil (i.e.: below the root zone) to store water. This water is available to flow into surface water bodies through groundwater seepage (i.e.: springs or seeps).
<i>Licensed Withdrawal Limit</i>	The Licensed Withdrawal Limit is the maximum volume of water permitted to be withdrawn by water licence holders from surface water sources.
<i>Precipitation</i>	Precipitation is the total volume of rainfall and snowfall over a given time period. Precipitation is recorded as a depth, the total volume of precipitation falling across the watershed over a given time period is then calculated by multiplying the depth of precipitation by the watershed area.

Term	Definition
<i>Soil Moisture Capacity And Soil Moisture Storage</i>	The capacity of soil within the root zone of plants and trees to store water. The soil moisture capacity defines the total volume of water that can be stored in the soil while storage moisture storage is the amount of water in soil moisture at any given time. The soil moisture can be transferred back to atmosphere via evapotranspiration and can pass into groundwater storage through groundwater recharge. When soil moisture storage is at the maximum soil moisture capacity all excess precipitation is surface runoff.
<i>Surface Water</i>	Surface water is water that can be seen on land and is usually freshwater. It includes lakes, rivers, streams, creeks, ponds, and wetlands. Surface waters are most often at least partially fed by groundwater.
<i>Surface Water Runoff</i>	Surface Water Runoff is the water available to flow into surface water bodies across the land surface and through shallow horizontal flow through soils (known as interflow) over a given time period. It is the excess water available from precipitation after all other hydrological processes are accounted for including evapotranspiration and replenishment of soil moisture storage. A portion of surface water runoff includes Direct Runoff which includes precipitation that runs off directly to surface water bodies. This is usually represented by a percentage of precipitation in a given period and is typically based on an estimate of the impervious area within a watershed.
<i>Unconfined Aquifer</i>	Where no aquitards overlie the aquifer, the aquifer is said to be “unconfined” and is vulnerable to impacts from human activities at the land surface, particularly if the water table is shallow.
<i>Water Balance</i>	The water balance is based on the law of conservation of mass in a closed system such that the volume of water entering the system must be equal to the amount of water leaving the system plus change of volume of water stored within the system. The water balance for this study considers precipitation as the only input to the closed system with lake outflow,

Term	Definition
	deep aquifer loss, evaporation and transpiration as outputs. Storage in the system includes lake storage, soil moisture storage and groundwater storage.
<i>Water Budget</i>	Comparison of the amount of surface water available in the watershed over-time (supply) and the amount of water required for use over time (demand). When the volume of water for demand is greater than the volume of water available in supply over a given time period, for this study a monthly time period is used, then the difference must be provided by storage.
<i>Water Surplus</i>	This term refers to a combination of surface water runoff and groundwater recharge which are the surplus or remaining water budget components following evapotranspiration.
<i>Watershed</i>	A watershed is the area of land that, due to its topography, collects water from precipitation and drains into a receiving surface water body (a river, a lake, a foreshore). Every piece of land is part of a watershed.
<i>Well</i>	A well is an excavation or structure created in the ground by digging, driving, or drilling to access liquid resources, usually water.



McElhanney



**SSI 2022-002**

**FULFORD WATER: AC  
WATERMAIN REPLACEMENT**

**Investigation, Analysis,  
Criticality Assessment, &  
Option Review**

**TECHNICAL REPORT**

March 10, 2023 | Revision 01

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Prepared for Capital Regional District | Prepared by McElhanney Ltd.

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McElhanney Project # 2231-54641-01

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**Your Challenge.  
Our Passion.**

March 10, 2023

Our File: 2231-54641-01

Capital Regional District  
108 – 121 McPhillips Avenue  
Salt Spring Island, BC V8K 2T6

## SSI 2022-002 Fulford Water - AC Watermain Replacement: Investigation, Analysis, Criticality Assessment, & Option Review – Technical Report

Please find attached the AC Watermain Replacement (Investigation, Analysis, Criticality Assessment, & Option Review) Technical Report for the Fulford Water System. We note the report has been updated to reflect CRD comments provided on February 8, 2023 and subsequent discussions.

The Technical Report provides a summary of our investigation, analysis, and criticality assessment of the existing system as well as analysis, options review, and recommendations to support the AC watermain replacement in the Fulford Water System. The key information summarized in the report includes:

- Project Rationale
- Design Criteria / Analysis Input
- Watermain Replacement Prioritization (Criticality Assessment)
- System Hydraulic Analysis (Existing System, Proposed System, and Potential Future Expansion)
- Conceptual Design Option Review for Replacement Network – Pipeline Alignments and Sizes
- Recommendations & Next Steps.

Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Sincerely,  
McElhanney Ltd.

Prepared by:

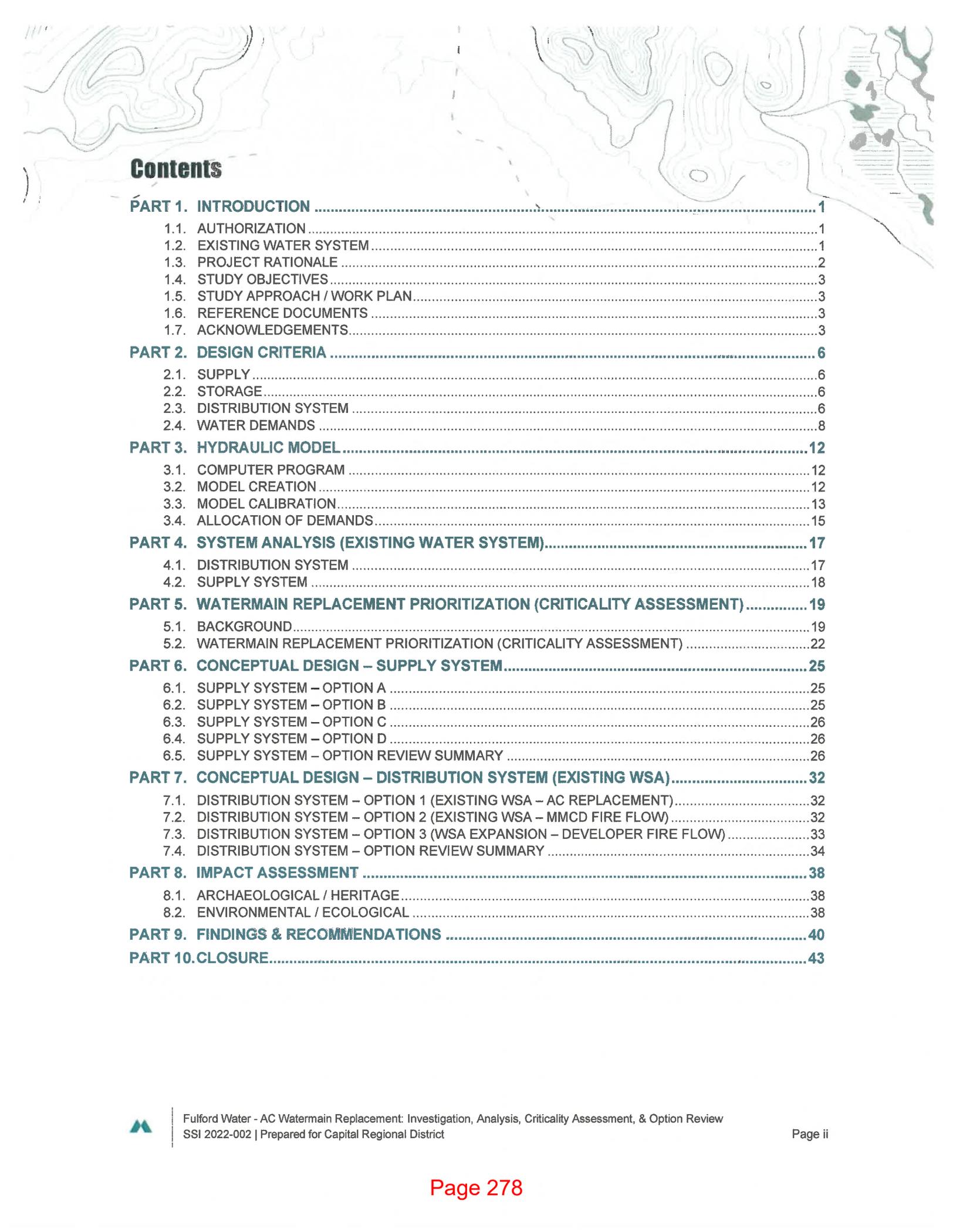
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## PART 1. INTRODUCTION

### 1.1. AUTHORIZATION

In December 2022, the Capital Regional District (CRD) authorized McElhanney Ltd. (McElhanney) to carry out the Fulford Water - AC Watermain Replacement Analysis, Strategy, & Works Program.

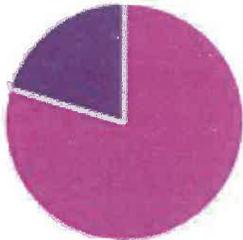
### 1.2. EXISTING WATER SYSTEM

The Fulford Water System is located in a semi-rural residential community with an elementary school and commercial development. The water system is situated on the north side of Fulford Harbour on Salt Spring Island. The project location and existing system configuration is shown in **Figure 1**. The existing water service area and pressure zones are shown in **Figure 2**. The Fulford Water System is primarily comprised of the following assets:

#### Supply System – Fulford Supply System Piping

The supply system includes approximately 2,330m of 100mm diameter asbestos cement (AC) pipe installed in the 1970s and approximately 600m of 100mm diameter Polyvinyl Chloride (PVC) pipe installed in the late 2000s. The supply system piping (material type & size) is summarized in **Table 1-1**.

Diameter (mm) & Pipe Material	Length (m)	% of Total
100 AC	2330	80%
100 PVC	600	20%
<b>Total</b>	<b>2930</b>	



#### Supply System – Sunnyside Drive Pump Station

The Sunnyside Drive pump station is located across from the Hilltop Road and Sunnyside Drive intersection, specifically at 105 Hilltop Place. The pump station boosts the water supply from Lake Weston to the water treatment plant at a simultaneous pumping rate of 2.3 L/s (30 gpm) from 2 pumps.

#### Treatment – Fulford Water Treatment Plant & Pump Station

The water treatment plant draws water from Lake Weston with a treatment process consisting of a rapid mix system, flocculation, dissolved air floatation (DAF), rapid filtration, ultraviolet (UV) disinfection, and chlorination. The water is then pumped to the reservoir.

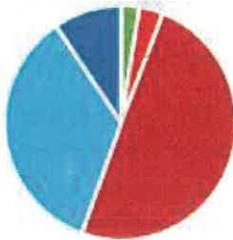
#### Storage – Reservoir

The Fulford reservoir has a capacity of 360 m<sup>3</sup> (80,000 IG) and is located southwest of Fulford Community Elementary School.

### Distribution System – Fulford Distribution System Piping

The Distribution system includes approximately 85m of 50mm diameter High-density polyethylene (HDPE), approximately 1,775m of 50-100mm diameter AC pipe installed in the 1970s and approximately 1,490m of 100-150mm diameter PVC pipe installed in the late 2000s. The distribution system also includes fire hydrants, standpipes, gate valves; and water service connections. The distribution system piping (material type & size) is summarized in **Table 1-2**.

Diameter (mm) & Pipe Material	Length (m)	% of Total
50 HDPE	85	3%
50 AC	155	5%
100 AC	1620	48%
100 PVC	1170	35%
150 PVC	320	9%
<b>Total</b>	<b>3350</b>	



### Distribution System – Sunnyside Drive Pressure Reducing Station

There is one (1) pressure reducing valve station, PRS Sunnyside, in front of 122 Sunnyside Drive. The operator has confirmed set points including inlet pressure = 92 psi and outlet pressure = 45 psi. This creates two pressure zones in the water service area which are shown in **Figure 2**.

## 1.3. PROJECT RATIONALE

The Fulford Water System Asset Management Plan (AMP) dated May 2020 references several recommendations made in the 2011 AMP regarding the distribution system including:

- “The existing distribution system currently meets the domestic needs of the community but the non-revenue water production of 40% is considered significant. The water distribution system is not designed to provide fire protection. The mains are two-thirds asbestos cement (4,500 m) and reported to have been constructed in the late 1980s<sup>(1)</sup>, making them almost 30 years old. The other third of the mains is PVC (2,200 m) and the majority of this pipe is less than 10 years old.”
- “A program to replace the asbestos cement distribution mains should be initiated to reduce the water loss in the system. It would be desirable to replace the AC mains within the next five to ten years.”
- “The system contains a number of dead-end mains that cannot be interconnected as they service narrow areas that are at the extremities of the system or difficult terrain makes them difficult to loop. Flushing these mains during the summer months will be required to ensure chlorine residual and to maintain water quality.”
- “Distribution components associated with the asbestos cement watermains will be replaced as part of any watermain replacement program. Many of these components are as old as the mains. The valves need to be located and those that operate should be exercised regularly. The valves that do not operate should be identified and only replaced if they are critical to the operation of the distribution system.”
- “The watermains would need to be upgraded to a minimum 150 mm in order to provide fire protection.”

<sup>1</sup> We note that this statement conflicts with our understanding of the probable AC pipe age and McElhanney AMP dated 2020 which states that the AC watermains were installed in the 1970s.



## 1.4. STUDY OBJECTIVES

The objective of this study is to develop a strategy and program for the replacement of the existing 4.1km of AC watermains in the Fulford Water System. It is expected that this will lead to detailed design and phased construction program to replace all AC watermains and provide a new water meter and new service connection to each property (service connection from main to property line). Where PVC watermains have been installed, scope will include adding water meter at property line and water service replacement (to property line), where required.

## 1.5. STUDY APPROACH / WORK PLAN

The work plan adopted for this study is based on the RFP, including Investigation, Analysis and Criticality Assessment (Step 1) & Renewal Program and Costs (Step 2) which is outlined in our proposal dated November 9, 2022.

## 1.6. REFERENCE DOCUMENTS

The following documents have been provided by the CRD which have been referenced while completing this study:

- CRD - CAD Standards / Engineering Specifications and Drawings
- Leak Report Data for Fulford
- Subsurface Contours Weston Lake
- Available Record Drawings including, Sunnyside Water Main, Water Main Extension Fulford Ganges Road, & Fulford Reservoir
- Statutory Right-of-Way Plans Raw Water Line
- Info From 2022 Annual Plan, Annual Water Production, Monthly Production, High Lever Meter Data
- Drawing Reservoir and Site Plan
- Drawing Plant Schematic
- Email Information From NSSWW; Plant Settings, PRV Settings, Plant Production, Reservoir Settings

## 1.7. ACKNOWLEDGEMENTS

McElhanney would like to acknowledge and express their appreciation to the CRD and North Salt Spring Waterworks District (NSSWD) staff during this assignment. A team effort was required to complete this study; and it could not have been completed without the invaluable assistance provided by the following key individuals.

- Dean Olafson, P.Eng., MBA – Manager, Engineering, CRD
- Doug Weihing, C.Tech, NZCE – Engineering Technologist, CRD
- Luke Sturdy – Operations and Maintenance Operator, CRD
- Grant Tamboline – Waterworks Supervisor, NSSWD





LOCATION PLAN  
SALT SPRING ISLAND

**LEGEND**

- WATER SERVICE AREA
- DISTRIBUTION MAIN
- UNTREATED SUPPLY MAIN
- STORAGE FACILITY
- TREATMENT PLANT
- PUMP STATION
- PRESSURE CONTROL STATION
- MANHOLE
- AIR VALVE
- HYDRANT
- STANDPIPE
- SUPPLY BALL VALVE
- CHECK VALVE
- GATE VALVE - CLOSED

Drawing No. **FIGURE 1**

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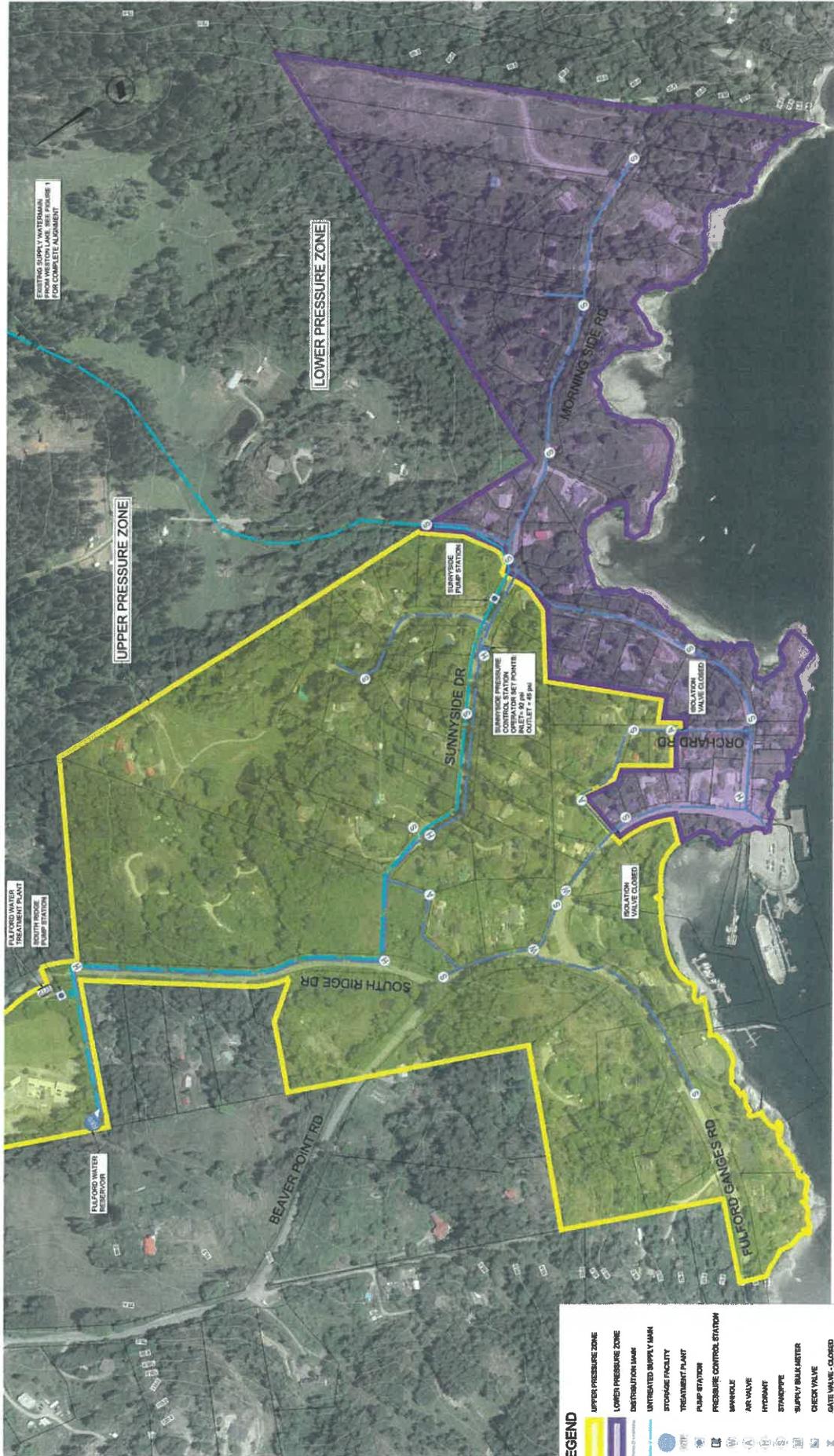
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Civil Engineering  
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EXISTING SOUTH WASTEWATER FROM WESTON LAKE. SEE FIGURE 1 FOR COMPLETE ALIGNMENT

UPPER PRESSURE ZONE

LOWER PRESSURE ZONE

FULFORD WATER TREATMENT PLANT SOUTH RIDGE PUMP STATION

FULFORD WATER RESERVOIR

SOUTH RIDGE DR

BEAVER POINT RD

SUNNYSIDE DR

SUNNYSIDE PUMP STATION

SUNNYSIDE PRESSURE CONTROL STATION INLET = 90 PSI OUTLET = 85 PSI

POPULATION VALVE CLOSED

ORCHARD RD

ISOLATION VALVE CLOSED

MORNING SIDE RD

FULFORD GANGES RD

**LEGEND**

- UPPER PRESSURE ZONE
- LOWER PRESSURE ZONE
- DISTRIBUTION MAIN
- UNTRATED SUPPLY MAIN
- TREATMENT PLANT
- PUMP STATION
- PRESSURE CONTROL STATION
- SPRINKLE
- AIR VALVE
- HYDRANT
- STAMPING
- SUPPLY BALL METER
- CRACK VALVE
- GATE VALVE - CLOSED

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FIGURE 2  
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## PART 2. DESIGN CRITERIA

In establishing the capacity of a water supply and distribution system, three levels of water demand are normally considered, in addition to fire flows. These are:

Average Day Demand (ADD) =  $\frac{\text{Total annual consumption}}{365 \text{ days}}$

Maximum Day Demand (MDD) = Day with highest demand for the year

Peak Hour Demand (PHD) = Highest flow rate maintained for one hour  
(generally occurring on maximum day of the year)

### 2.1. SUPPLY

The water supply source(s) must be capable of meeting the system's Maximum Day Demand. The Peak Hour Demand and Fire Flow demands are to be met by the water storage reservoirs.

The CRD has noted that the replacement supply main shall be designed to suit design flow rate of 4.0 L/s which is consistent with the Fulford WTP design treatment capacity.

Note that the supply source review is not included in this study scope.

### 2.2. STORAGE

Water reservoirs perform three functions:

- Storage for fire fighting
- Storage for emergencies (such as a watermain break or booster pump failure / power outage)
- Storage for equalization to manage hourly peaks in demand

Note that reservoir storage volume review is not included in this study scope.

### 2.3. DISTRIBUTION SYSTEM

The water distribution system must be capable of delivering all demands as well as delivering fire flow demands during maximum day demands while operating within acceptable pressure ranges.

#### 2.3.1. Pressures & Velocities

The adequacy of the distribution system for various demand conditions is judged by the residual pressure available throughout the system and by the maximum velocity in the mains. The criteria applied to this study are listed in **Table 2-1** which are consistent with the CRD standard requirements.

Table 2-1: Distribution System Design Criteria		
Parameter	Value	
<b>Under Peak Hour Demand Conditions</b>		
Minimum residual pressure at road	414 kPa	(60 psi)
Minimum residual pressure at property line	267 kPa	(40 psi)
Maximum pipe velocity	1.5 m/s	(4.9 ft/s)
<b>Under Fire Flow Demand Conditions (during Maximum Day Demands)</b>		
Minimum residual pressure at hydrant	140 kPa	(20 psi)
Maximum pipe velocity	3.0 m/s	(9.8 ft/s)

### 2.3.2. Unit Design Demands – CRD Standards

Estimating demands should be based on flow meter records and developed for each land use type. In the absence of water consumption records, the CRD Engineering Specifications (2009) - Section 4.12.1 provides guidance for residential and non-residential land-use design demands. These specifications shall govern the design of new waterworks within or connected to the Juan de Fuca Water Distribution System. It has been agreed with the CRD that these standards will not govern the design for the Fulford Water System as water usage records are available.

### 2.3.3. Unit Design Demands – Proposed

The design demands will be based on available water use records which were provided by the CRD. The water demands including existing usage and projected usage is summarized in Section 2.4 Water Demands.

### 2.3.4. Fire Flows

We are advised that historically, the Fulford Water System has no mandate to supply fire flow to their customers. Salt Spring Island Fire Rescue (SSIFR) successfully completed the Fire Underwriters Survey (FUS) Superior Tanker Shuttle Service Accreditation Testing requirements on April 9, 2011 and provides fire protection on Salt Spring Island by Superior Tender Shuttle Service rather than local fire hydrants.

In the event that the District decides to provide fire flows in the future, we have summarized common standards for consideration. Note that fire flows shall be in accordance with the bylaws of the municipality having jurisdiction over the area in which the waterworks are to be constructed, and in accordance with Fire Underwriters Survey (FUS). The common standards are compared in Table 2-2.

Table 2-2 – Fire Flow Standards (Minimum Required)			
Development	MMCD	FUS	CRD
	Flow (L/s)	Flow (L/s)	Flow (L/s)
Single/Two Family Residential	60	33-134	80
Apartments, Townhouses	90	-	-
Commercial	150	-	83.3
Institutional	150	-	83.3
Industrial	225	-	83.3



There are several larger wood frame institutional structures and industrial businesses in the Fulford Water Service Area. The fire flow demands for these structures may be higher than the minimum flows listed in **Table 2-2**.

In the event that the District decides to provide fire flows in the future, we have analyzed several design fire flow scenarios for the system, each of which have a different set of upgrades required.

Based on discussions with the District, the following fire flow scenarios have been reviewed:

- Existing System
  - Available Fire Flows
- Proposed System (Existing WSA)
  - Option 1 – Available Fire Flows
    - Based on replacing existing AC watermains with 150mm Dia. PVC
  - Option 2 – Design Flow = 60 L/s
    - Based on MMCD Design Guideline (2014) minimum fire flow requirements for Single/Two Family Residential without sprinklers
- Proposed System (WSA Expansion)
  - Option 3 – Design Flow @ Ocean Estuary Development = 64 L/s
    - Based on Ocean Estuary Development Impact Assessment, Prepared by McElhanney Ltd dated August 29, 2022 (Revision No. 4).

## 2.4. WATER DEMANDS

### 2.4.1. Existing Demand Review

We have reviewed the Fulford Water System demands based on the available Fulford Water Service - 2021 Annual Report. This report summarizes the annual usage for the last 6-years which we have projected for 2022. The existing and projected 2022 demands have been summarized in **Table 2-3**.

Year	Usage (m3 / year)	ADD (L/s) <sup>1</sup>	MDD (L/s) <sup>1</sup>	PHD (L/s) <sup>1</sup>
<i>PF</i> <sup>2</sup>	-	-	2.5	1.4
2016	27,805	0.88	2.20	3.09
2017	28,336	0.90	2.25	3.14
2018	30,529	0.97	2.42	3.39
2019	27,302	0.87	2.16	3.03
2020	30,494	0.97	2.42	3.38
2021	29,248	0.93	2.32	3.25
2023 <sup>3</sup>	30,834	0.98	2.44	3.42

**Notes:**

1. Calculations used more significant figures than shown resulting in minor rounding discrepancies
2. Peaking Factors, CRD Engineering Specifications (2009) - Criteria for Design of Facilities
  - a. Maximum Day = 2.5 times Average Day Demand
  - b. Peak Hour = 1.4 times Maximum Day Demand



3. We have applied 1% increase to the max recent annual usage to estimate 2023 usage. It is understood that these demands are from the existing 95 lots connected to the system. Based on our review there are 108 lots that are within the existing water service area. We have therefore increased base design demands accordingly (2023 ADD = 0.98 L/s). Demands used for analysis are as follows:

- ADD = 1.12 L/s
- MDD = 2.80 L/s
- PHD = 3.92 L/s

#### 2.4.2.Future Demand Estimate (Existing Water Service Area)

As noted in the RFP, while the population on Salt Spring is anticipated to grow by approximately 2.5% per year, it is also predicted that water consumption per person will continue to decrease. Unless the boundaries of the water service area are expanded, or significant subdivision occurs within the water service boundaries, it is anticipated that future demand will remain at current levels or perhaps decrease slightly. As there are many factors effecting population growth & related water demands, three growth scenarios have been developed for this report: low; moderate; and high.

A time period of 50 years was applied to calculate varying levels of long-term growth and associated design demands. The future demands have been projected in 10-year increments for each growth rate and are summarized in Table 2-4.

Year	ADD (L/s)		
	Low Growth (0.5%)	Moderate Growth (1.0%)	High Growth (1.5%)
<b>2023</b>	<b>1.12</b>	<b>1.12</b>	<b>1.12</b>
2033	1.18	1.24	1.30
2043	1.24	1.37	1.51
2053	1.30	1.51	1.75
2063	1.37	1.67	2.03
2073	1.44	<b>1.84</b>	2.36
50-Year Increase	28%	64%	111%

We have used the moderate growth (1.0%) scenario for our future design demand (ADD = 1.84 L/s) to review estimate usage within the existing service boundary. This results in the following future (50-year projection) design demands:

- ADD = 1.84 L/s
- MDD = 4.60 L/s
- PHD = 6.45 L/s



### 2.4.3. Future Demand Estimate (Water Service Area Expansion)

As requested by the CRD, we have considered a future demand scenario which includes expanded water service area to include the “Ocean Estuary Development” and potential service area expansion along the watermain extension. The conceptual water service area expansion is shown in **Figure 3**.

The potential water service expansion area includes 8 additional properties which would result in an estimated design demand of ADD = 0.14 L/s, MDD = 0.49 L/s, & PHD = 0.49 L/s.

It is understood that the “Ocean Estuary Development” would require the following design flows:

- Ocean Estuary MDD = 0.45 L/s (McElhanney October 22, 2018 Technical Memorandum)
- Ocean Estuary PHD = 0.65 L/s (McElhanney October 22, 2018 Technical Memorandum)

Based on the information above, and moderate growth (1.0%) scenario for the existing water service area, this results in the following design demands:

- MDD = 5.40 L/s
- PHD = 7.59 L/s

### 2.4.4. Design Demand Summary

Design demands for the various scenarios have been summarized in **Table 2-5**.

Scenario		Design Demands		
System	Properties Served	ADD (L/s)	MDD (L/s)	PHD (L/s)
Current Usage	95	0.98	2.44	3.42
Existing System	108	1.12	2.80	3.92
Proposed System (Existing WSA)	108 + 1.0% Growth	1.84	4.60	6.45
Proposed System (WSA Expansion)	108 + 8 + 1.0% Growth + Ocean Estuary	2.16	5.40	7.59





## PART 3. HYDRAULIC MODEL

### 3.1. COMPUTER PROGRAM

Modelling of the Fulford water distribution system was carried out utilizing the computer software program WaterCAD. This water distribution modelling and management software is in use throughout North America by engineering consultants, municipalities, and utility companies and is used by McElhanney because of its reliability, versatility, AutoCAD and GIS interface, and support by its creator Bentley Systems Inc.

WaterCAD is a powerful, user-friendly program created to analyse, design, and optimize water distribution systems. The programs many features include steady state and extended time modelling, multiple fire flow events modelling while evaluating flows and pressures across the entire system, and peak hour pressure analyses. Modelling results are presented in tabular and graphical form.

### 3.2. MODEL CREATION

A computer model of the water system (existing and proposed) was created by McElhanney to complete hydraulic analysis of the supply line and distribution network for the purposes of designing replacement pipeline sizing as well as supporting criticality assessment. The water model provides a mathematical representation of the water system.

Model inputs define the physical characteristics of the system and the anticipated flows. Pipes in the model are assigned the physical characteristics of pipes in the field (length, diameter, and roughness), the nodes define the points of connection between the lines and define the water demand in the system (both domestic and fire flows).

#### 3.2.1. Existing Distribution System

The WaterCAD water model layout was developed to reflect the existing distribution system including various pipe sizes and materials. The water system layout including existing pipe size and materials is shown in **Figure 4**. The following references were used to develop the water model:

- System Layout - Available record drawings, CRD water system map, Operator input
- System Elevations - CRD contours
- PRV Set Points – Provided by Operator
- Reservoir HGL – Calculated using PRV pressure set points and estimated CRD contour elevations
- Pressure Zones – System isolation valve locations confirmed by Operator

#### 3.2.2. Future Distribution System (Existing Water Service Area)

The WaterCAD water model layout was updated to reflect the proposed distribution system upgrades to model two design scenarios for the existing water service area. The scenarios and related distribution system upgrades are summarized in **Part 7 (Option 1 & 2)**.

### 3.2.3.Future Distribution System (Expanded Water Service Area)

As requested by the CRD, we have completed an additional WaterCAD water model layout update to reflect the proposed “Ocean Estuary Development” and potential service area expansion. The related distribution system upgrades are summarized in **Part 7 (Option 3)**.

## 3.3. MODEL CALIBRATION

The accuracy of the models depends on the calibration process. Calibration can be performed with onsite flow and pressure test results. The calibration process defines the friction coefficients, which may vary a lot depending on the pipe material and age and the corrosiveness of the water.

Calibration of the system has not been included. However, even an un-calibrated model is still a good representation of the system’s behavior under different conditions.

### 3.3.1.Pipe Friction Factors

A Hazen Williams friction factor was entered in the model for varying pipe materials, as listed in **Table 3-1**.

Table 3-1: Pipe Friction Factors		
Pipe Material		Friction Factor, ‘C’ <sup>1</sup> (Hazen Williams Formula)
HDPE	High Density Polyethylene	140
PVC	Polyvinyl Chloride	140
AC	Asbestos Cement	130
DI	Ductile Iron	130
CI	Cast Iron	110

**Notes:**

1. The modeled friction factors were selected to consider the reduction in capacity that occurs in the distribution system where fittings and service connection points are present and sliming on pipe walls that occurs with age.

To better calibrate the friction factors in the water system, controlled field testing would be required during times of peak hour flows, where pressure losses in the various pipe types and sizes could be determined. Flow testing was not included in the scope of work for this study. Due to the significant system operators’ time required to conduct flow tests, no specific flow testing was carried out. In general, except for the oldest pipe sections, the values listed are believed to be conservative.



EXISTING SUPPLY WATERMAIN FROM WILKINSON LAKE (SEE FIGURE 1) FOR COMPLETE PLACEMENT

SUNNYSIDE PUMP STATION

EXISTING PRESSURE CONTROL STATION

PALFORD WATER TREATMENT PLANT SOUTH RIDGE PUMP STATION

EXISTING WATER RESERVOIR

- LEGEND**
- SUPPLY - 1008 AC
  - SUPPLY - 1008 PVC
  - DISTRIBUTION - 508 HDPE
  - DISTRIBUTION - 508 AC
  - DISTRIBUTION - 1008 AC
  - DISTRIBUTION - 1008 PVC
  - DISTRIBUTION - 1008 PVC
  - STORAGE FACILITY
  - TREATMENT PLANT
  - PUMP STATION
  - PRESSURE CONTROL STATION
  - MANHOLE
  - AIR VALVE
  - HYDRANT
  - STANDPIPE
  - SUPPLY BULK METER
  - CHECK VALVE
  - GATE VALVE - CLOSED

FIGURE 4  
 CAPITAL REGIONAL DISTRICT  
 FULFORD WATER SYSTEM  
 AC WATER PIPELINES REPLACEMENT  
 WATER SYSTEM LAYOUT  
 EXISTING PIPE SIZES & MATERIALS

PERMIT TO PRACTICE  
 PROJECT NUMBER: 1025290  
 ENGINEER AND CONSULTANT OF RECORD

McElhenny  
 1337 E. Main Street  
 Greensboro, NC 27407  
 Tel: 336.335.3333

Scale: 1" = 12,000'  
 0 12,000'

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Rev.	Date	Description
B	2023-09-08	ISSUED FOR PERMIT
A	2023-09-08	ISSUED FOR PERMIT
1		

## 3.4. ALLOCATION OF DEMANDS

### 3.4.1. Existing Conditions

Water demands were distributed throughout the model at nodal points (pipe intersections, end of mains and pipe diameter changes) based on relation to properties / expected service locations. The service locations / demand allocation map is summarized in **Figure 5**.

The Average Day Demand was used as the base. Maximum Day Demands were modelled by multiplying each individual demand by the appropriate ratio (ADD to MDD, 2.5 and MDD to PHD, 1.4).

### 3.4.2. Future Conditions (Existing Water Service Area)

To reflect future demands the existing demands were scaled throughout the model at nodal points (pipe intersections, end of mains and pipe diameter changes) based on our future demand estimate (refer to Section 2.4.2).

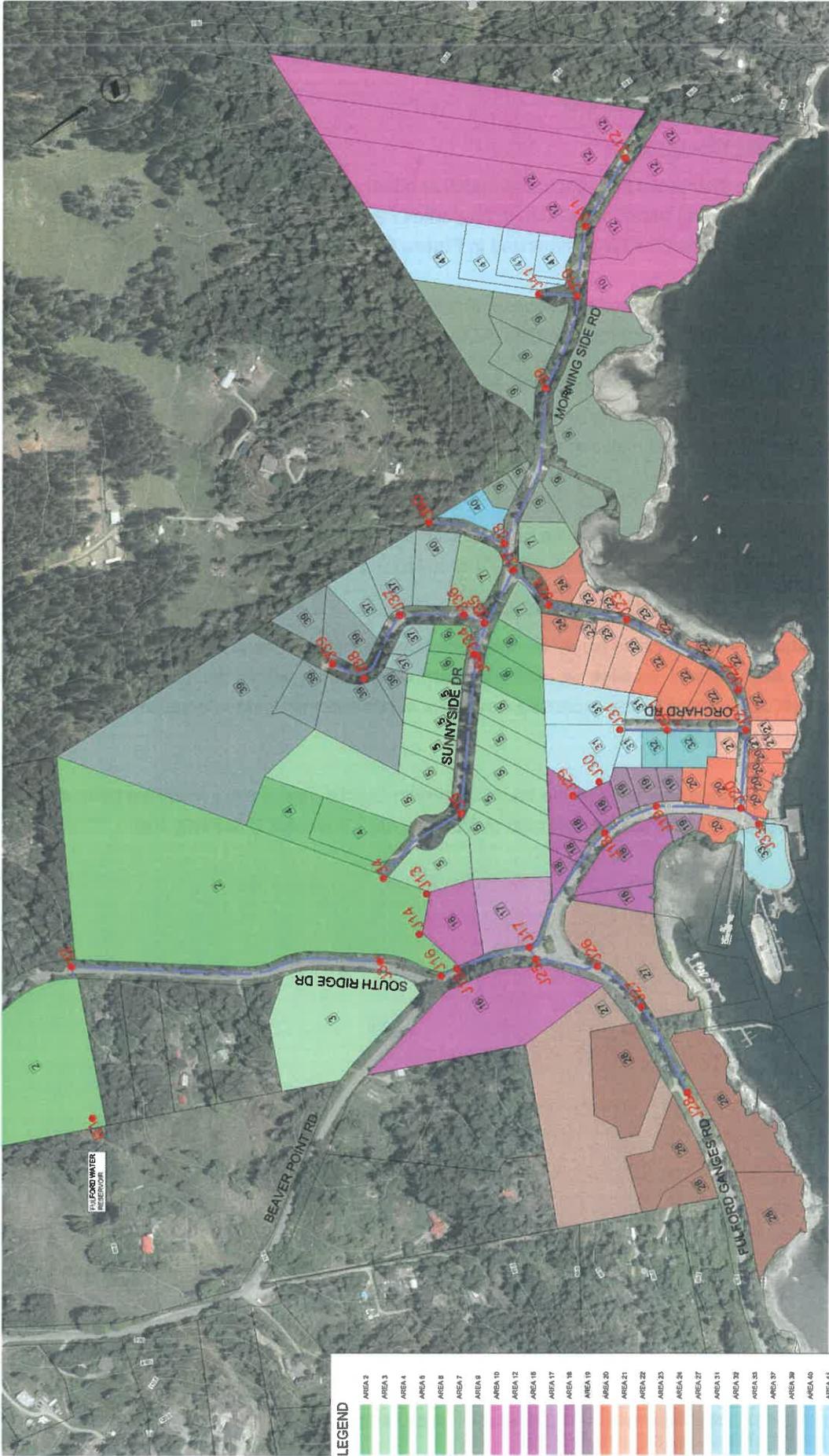
The Average Day Demand was used as the base. Maximum Day Demands were modelled by multiplying each individual demand by the appropriate ratio (ADD to MDD, 2.5 and MDD to PHD, 1.4).

### 3.4.3. Future Conditions (Expanded Water Service Area)

Future demands were added to the model to reflect the "Ocean Estuary Development" which were added to the specific development location as well as potential demands within the potential service area expansion which were added to the expanded water model nodal points (pipe intersections, end of mains and pipe diameter changes).

The Average Day Demand was used as the base. Maximum Day Demands were modelled by multiplying each individual demand by the appropriate ratio (ADD to MDD, 2.5 and MDD to PHD, 1.4).





**LEGEND**

AREA 2	Light Green
AREA 3	Light Green
AREA 4	Light Green
AREA 5	Light Green
AREA 6	Light Green
AREA 7	Light Green
AREA 8	Light Green
AREA 9	Light Green
AREA 10	Light Green
AREA 11	Light Green
AREA 12	Light Green
AREA 13	Light Green
AREA 14	Light Green
AREA 15	Light Green
AREA 16	Light Green
AREA 17	Light Green
AREA 18	Light Green
AREA 19	Light Green
AREA 20	Light Green
AREA 21	Light Green
AREA 22	Light Green
AREA 23	Light Green
AREA 24	Light Green
AREA 25	Light Green
AREA 26	Light Green
AREA 27	Light Green
AREA 28	Light Green
AREA 29	Light Green
AREA 30	Light Green
AREA 31	Light Green
AREA 32	Light Green
AREA 33	Light Green
AREA 34	Light Green
AREA 35	Light Green
AREA 36	Light Green
AREA 37	Light Green
AREA 38	Light Green
AREA 39	Light Green
AREA 40	Light Green
AREA 41	Light Green

<p>McElhenney</p> <p>1301 Eastman Road          Fayetteville, NC 28404          Phone: 704.781.2700          Fax: 704.781.2326</p>		<p>PERMIT TO PRACTICE</p> <p>McElhenney LLC          1301 Eastman Road          Fayetteville, NC 28404          Registration No. 00000000000000000000</p>		<p>Approved Stamp</p>	
<p>Scale: 1" = 200'</p> <p>0 100 200</p>		<p>FIGURE 5</p>		<p>Project Number: 2231-5841-01-SK          Date: B</p>	
<p>Capital Regional District          Fullford Water System          AC Water Pipelines Replacement          Service Locations &amp;          Demand Allocation Map</p>		<p>100 - 121 McPhillips Avenue, Salt Springs, BC, V8C 2T6</p>		<p>Drawing No.</p>	

## PART 4. SYSTEM ANALYSIS (EXISTING WATER SYSTEM)

### 4.1. DISTRIBUTION SYSTEM

The existing distribution system was evaluated under steady state conditions to determine the system pressures under peak hour conditions and to determine available fire flows during maximum day demands.

#### 4.1.1. Peak Hour Pressures

The system pressures under peak hour demand under existing conditions are shown in **Table 4-1** and illustrated on **Model Figure A (Appendix B)**. Pressures below the acceptable design minimum of 414 kPa (60 psi) have been highlighted in red.

Table 4-1: Peak Hour Pressures (Ex. System)				Table 4-1: Peak Hour Pressures			
Node	~ Elevation (m)	Demand (L/s)	Pressure (psi)	Node	~ Elevation (m)	Demand (L/s)	Pressure (psi)
J-2	62.7	0.11	43	J-23	14.9	0.22	63
J-3	40.0	0.03	75	J-24	16.0	0.07	62
J-4	40.0	0.07	75	J-25	30.6	0.00	88
J-5	39.2	0.40	76	J-26	23.5	0.00	98
J-6	28.4	0.14	92	J-27	17.3	0.07	107
J-7	14.7	0.11	64	J-28	14.1	0.18	112
J-8	16.0	0.00	62	J-29	25.8	0.00	95
J-9	14.7	0.33	64	J-30	24.9	0.00	97
J-10	16.0	0.03	62	J-31	26.4	0.11	94
J-11	23.0	0.00	52	J-32	20.0	0.07	103
J-12	26.8	0.26	47	J-33	0.0	0.03	85
J-13	40.0	0.00	75	J-34	28.6	0.00	91
J-14	40.0	0.00	75	J-35	25.8	0.00	95
J-15	40.0	0.00	75	J-36	26.8	0.00	94
J-16	40.0	0.07	75	J-37	34.9	0.14	82
J-17	30.7	0.03	88	J-38	40.0	0.00	75
J-18	16.9	0.22	108	J-39	40.0	0.22	75
J-19	12.3	0.14	67	J-40	29.4	0.03	43
J-20	2.3	0.26	81	J-41	24.7	0.14	50
J-21	10.0	0.14	70	J-42	19.4	0.00	57
J-22	7.8	0.26	73	J-43	16.5	0.00	61

### 4.1.2. Available Fire Flows

The available fire flows during maximum day demand for the current conditions are shown in **Table 4-2** and illustrated on **Model Figure B (Appendix B)**.

The available fire flows, while maintaining minimum residual pressure in system of 140 kPa (20 psi), are all less than a typical design fire flow of 60 L/s (MMCD Design Guideline (2014) minimum fire flow requirements for Single/Two Family Residential without sprinklers).

Table 4-2: Available Fire Flow (Ex. System)			Table 4-2: Available Fire Flow (Ex. System)		
Node	~ Elevation (m)	Available Fire Flow (L/s)	Node	~ Elevation (m)	Available Fire Flow (L/s)
J-2	62.7	52	J-23	14.9	23
J-3	40.0	52	J-24	16.0	23
J-4	40.0	52	J-25	30.6	23
J-5	39.2	52	J-26	23.5	23
J-6	28.4	49	J-27	17.3	23
J-7	14.7	49	J-28	14.1	23
J-8	16.0	23	J-29	25.8	23
J-9	14.7	22	J-30	24.9	23
J-10	16.0	18	J-31	26.4	23
J-11	23.0	16	J-33	20.0	6
J-12	26.8	14	J-34	0.0	27
J-13	40.0	23	J-35	28.6	27
J-14	40.0	23	J-36	25.8	27
J-15	40.0	23	J-37	26.8	23
J-16	40.0	23	J-38	34.9	23
J-17	30.7	23	J-39	40.0	23
J-18	16.9	23	J-40	40.0	6
J-19	12.3	17	J-41	29.4	6
J-20	2.3	19	J-32	24.7	23
J-21	10.0	21	J-42	19.4	6
J-22	7.8	22	J-43	16.5	16

### 4.2. SUPPLY SYSTEM

The supply system was evaluated under steady state conditions to confirm that the existing supply pipe is hydraulically suitable for the current design flow of 2.4 L/s and the preferred design flow of 4.0 L/s. The general supply system layout and estimated supply system pressures are shown in **Model Figure C (Appendix B)**.



## PART 5. WATERMAIN REPLACEMENT PRIORITIZATION (CRITICALITY ASSESSMENT)

This section of the report outlines the risk-based approach to water main replacement for the Fulford Water System to help confirm order of priority for watermain replacement.

### 5.1. BACKGROUND

#### 5.1.1. Risk Management

Risk management is a systematic and logical approach used to assist in prioritizing infrastructure replacement. Risk depends on both the probability and consequence of an event and is often represented using the following equation:



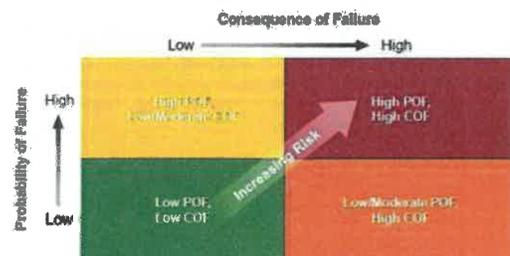
Probability of Failure (POF) represents the likelihood that that a specific asset will fail (not deliver the required level of service). Consequence of Failure (COF) represents the overall impact of an asset failing.

#### 5.1.2. Approach for Prioritization Analysis

The purpose of a water main prioritization analysis is to provide a systematic methodology for the prioritization of water main replacement based on the consequence of failure (COF) and probability of failure (POF) for each water main segment.

**Figure 5-1** illustrates a typical risk matrix. The matrix indicates that a water main with a high consequence of failure and high probability of failure presents a high risk to the District. The higher the risk the more critical the replacement is. Conversely, a water main in very good condition with a low consequence of failure provides a low risk to the District. However, a water main with a high consequence of failure in good condition could still pose a moderate level of risk and consequently requires a greater level of action than a low-risk water main.

The recommended methodology to prioritize the water main replacement program is based on the risk equation that assigns an overall priority to each water main segment. The proposed approach the performing the watermain prioritization analysis is illustrated in **Figure 5-2**.



**FIGURE 5-1: TYPICAL RISK MATRIX**



**FIGURE 5-2: APPROACH FOR PRIORITIZATION ANALYSIS**

### 5.1.3. Probability of Failure

**Table 5-1** summarizes potential probability of failure (POF) components for a water main prioritization analysis.

Table 5-1: Probability of Failure (POF) Components for Watermain Prioritization Analysis		
Component	Description	Data
Leaks and Breaks	As water mains deteriorate, pipe leaks and/or breaks become more prevalent; therefore, break history can provide a good indication of the condition of the water distribution system and the probability of failure.	<ul style="list-style-type: none"> <li>• Leak/break location</li> <li>• Date of leak/break</li> <li>• Cause of leak/break</li> </ul>
Remaining Useful Life	Water mains generally deteriorate with age.	<ul style="list-style-type: none"> <li>• Water main installation date</li> <li>• Water main material</li> <li>• Survival curves (normally developed from above data)</li> </ul>
Hydraulic Performance	Hydraulic performance (Hazen Williams C-Values) is an indication of the corrosion/condition of the inside of the pipe.	<ul style="list-style-type: none"> <li>• Hydraulic model (C-values generally determined during calibration of the hydraulic model)</li> </ul>
Complaints	Water quality in the distribution network can provide an indication of the condition or deterioration of water mains. For example, high customer complaints (related to water quality issues such as odor, taste, and appearance) can indicate that the mains in that area are corroding or deteriorating	<ul style="list-style-type: none"> <li>• Historical complaint records                             <ul style="list-style-type: none"> <li>○ Location</li> <li>○ Date</li> <li>○ Description/type</li> </ul> </li> </ul>
Fire Flow Deficiency Improvements	Some water mains may need to be replaced/upsized based on available fire flows in the system.	<ul style="list-style-type: none"> <li>• Fire flow deficiency results (potentially from hydraulic model)</li> <li>• Pipes identified for replacement</li> </ul>
Material	Some communities have historical data indications certain pipe materials are more likely to fail.	<ul style="list-style-type: none"> <li>• Pipe Material</li> </ul>



### 5.1.4. Consequence of Failure

Table 5-2 summarizes potential consequence of failure components for a water main prioritization analysis.

Table 5-2: Consequence of Failure (COF) Components for Watermain Prioritization Analysis		
Component	Description	Data
Critical Users	Consequence of water main failing is generally related to the customers that a water main serves (critical customers) and the number of services each critical customer has.	<ul style="list-style-type: none"> <li>Service locations &amp; demand allocation map</li> </ul>
Large Users	Consequence of water main failing is related to the volume of water the customers use.	<ul style="list-style-type: none"> <li>Service locations &amp; demand allocation map</li> </ul>
Land Use/ Type of Use	Land use or type of use (residential, institution, river crossing) is generally a good indicator of the consequence of a water main failing.	<ul style="list-style-type: none"> <li>Zoning map</li> </ul>
Diameter	Generally, the larger the diameter of the pipe the more significant the pipe is in the overall service to customers; therefore, water main diameter considered for consequence of failure.	<ul style="list-style-type: none"> <li>Water main diameter</li> </ul>
Sensitive Areas	Specific sensitive areas for repairs/construction may exist including wetlands, contaminated areas, adjacent to street cars, etc.	<ul style="list-style-type: none"> <li>Map with sensitive areas</li> </ul>
Redundancy	Consequence of water main failing is related to the redundancy of that main. Therefore, mains that provide all or most of the flow to an area (e.g. neighborhood, pressure zone, etc.) have a higher consequence of failure.	<ul style="list-style-type: none"> <li>Hydraulic model evaluations and/or engineering judgement/review</li> </ul>

### 5.1.5. Other Considerations

Generally, watermain replacement programs should be coordinated with other construction projects being planned (i.e if road, terminal, or other utilities replacement are being constructed, it may be most efficient to replace segment of watermain at the same time).

## 5.2. WATERMAIN REPLACEMENT PRIORITIZATION (CRITICALITY ASSESSMENT)

The Fulford Water System Piping (Distribution & Supply) has been broken into segments with each section of piping within the segment having an associated unique identifier. Through the development of a risk matrix, each segment has been ranked by priority. The risk matrix can be found in **Appendix C**.

The result of the Watermain Replacement Prioritization Analysis (Criticality Assessment) is summarized in **Table 5-3** and is illustrated on **Figure 6**.

Table 5-3: Watermain Replacement Prioritization Analysis Results						
Segment	Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material
Priority #1	P-50	20	R-2	J-50	100	AC
	P-51	66	J-50	J-51	100	AC
	P-52	125	J-51	J-52	100	AC
	P-53	729	J-52	J-53	100	AC
	P-54	73	J-53	J-54	100	AC
	P-55	129	J-54	J-55	100	AC
	P-56	283	J-55	J-56	100	AC
	P-57	187	J-56	J-57	100	AC
	P-58	260	J-57	J-58	100	AC
	P-59	49	J-58	J-59	100	AC
	P-60	22	J-59	J-60	100	AC
	P-61	57	J-60	PMP-1	100	AC
	P-62	75	PMP-1	J-62	100	AC
	P-63	136	J-62	J-63	100	AC
	P-64	44	J-63	J-64	100	AC
	P-65	63	J-64	J-65	100	AC
		<b>2318</b>			<b>100</b>	<b>AC</b>
Priority #2	P-12	49	J-4	J-13	100	AC
	P-13	44	J-13	J-14	100	AC
	P-14	54	J-14	J-15	100	AC
			<b>147</b>			<b>100</b>
Priority #3	P-15	19	J-15	J-16	100	AC
	P-16	82	J-15	J-17	100	AC
	P-17	149	J-17	J-18	100	AC
			<b>250</b>			<b>100</b>



Table 5-3: Watermain Replacement Prioritization Analysis Results						
Segment	Label	Length (m)	Start Node	Stop Node	Diameter (mm)	Material
Priority #4	P-18	63	J-18	J-19	100	AC
	P-19	90	J-19	J-20	100	AC
	P-20	84	J-20	J-21	100	AC
	P-21	45	J-21	J-22	100	AC
	P-22	142	J-22	J-23	100	AC
	P-23	88	J-23	J-24	100	AC
	P-24	54	J-24	J-7	100	AC
	P-33	84	J-32	J-21	50	AC
	P-34	26	J-20	J-33	50	AC
			<b>676</b>			<b>100/50</b>
Priority #5	P-7	31	J-7	J-8	100	AC
	P-8	174	J-8	J-9	100	AC
	P-9	106	J-9	J-10	100	AC
	P-10	76	J-10	J-11	100	AC
	P-11	85	J-11	J-12	100	AC
	P-42	43	J-10	J-41	100	AC
			<b>515</b>			<b>100</b>
Priority #6	P-38	68	J-36	J-37	100	AC
	P-39	79	J-37	J-38	100	AC
	P-40	38	J-38	J-39	100	AC
			<b>185</b>			<b>100</b>

Table 5-3: Watermain Replacement Prioritization Analysis Results				
Segment	Length (m)	Diameter (mm)	Material	System
Priority #1	2318	100	AC	Supply
<b>Sub-Total</b>	<b>2318</b>			<b>Supply</b>
Priority #2	147	100	AC	Distribution
Priority #3	250	100	AC	Distribution
Priority #4	676	100/50	AC	Distribution
Priority #5	515	100	AC	Distribution
Priority #6	185	100	AC	Distribution
<b>Sub-Total</b>	<b>1773</b>			<b>Distribution</b>
<b>Total</b>	<b>4091</b>			<b>Supply / Dist.</b>





EXISTING SUPPLY WATERMAIN  
FROM WATSON LAKE (SEE FIGURE 1)  
FOR SUPPLY TO REPLACEMENT

FULFORD WATER  
TREATMENT PLANT  
SOUTH RIDGE  
PUMP STATION

FULFORD WATER  
RESERVOIR

SUNNY SIDE  
PUMP STATION

GRANITE PRESSURE  
CONTROL STATION

**LEGEND**

- SUPPLY - 100% PVC
- DISTRIBUTION - 50% HDPE
- DISTRIBUTION - 100% PVC
- REPLACEMENT PRIORITY #1
- REPLACEMENT PRIORITY #2
- REPLACEMENT PRIORITY #3
- REPLACEMENT PRIORITY #4
- REPLACEMENT PRIORITY #5

**FIGURE 6**

Project Number: 221-5641-01-8K  
Rev: B

**CAPITAL REGIONAL DISTRICT**  
105-121 McPhillips Avenue, Salt Spring Island BC, V8K 2T5  
**FULFORD WATER SYSTEM**  
**AC WATER PIPELINES REPLACEMENT**  
**WATERMAIN REPLACEMENT**  
**PRIORITIZATION MAPPING**

Approved By: \_\_\_\_\_  
Approved Signature:

**PERMIT TO PRACTICE**  
Professional Registration: 00000000  
Engineer and Geoscientist of B.C.

**McElhanney**  
Suite 1  
1301 Eglon Road  
Victoria, BC V8W 2Y2  
Canada V8S 2Y2  
Tel: 250-718-2288

Scale: 1:12,500  
0 12,500 300  
CONTAINS: 2025-08-08 08:58:52 01-8K-01-8K

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Rev	Date	Description	Drawn/Checked/Approved
B	2025-08-08	FOR B.C. PERMIT	RS / SO
A	2025-01-02	FOR B.C. PERMIT	OS / SO

## PART 6. CONCEPTUAL DESIGN – SUPPLY SYSTEM

We have developed and reviewed four (4) conceptual pipeline alignment routing options for the supply main replacement. This option review considered the existing route and potential alignments along existing road corridors as well as alternate routes to shorten the length of pipe.

### 6.1. SUPPLY SYSTEM – OPTION A

This proposed supply main replacement option is based on the CRD developed potential routing options sketch included in the RFP. The conceptual replacement alignment runs from Weston Lake along Beaver Point Road and connects to South Ridge Drive through private property.

This option includes the following proposed upgrades:

- New Raw Water Intake from Weston Lake (Beaver Point Road)
- New Pump Station
- New 100mm PVC Supply Watermain – 2,900m long
- Property Acquisition / SRW for connection between Beaver Point Road & South Ridge Drive
- Existing 100mm AC Supply Main Decommissioned

The proposed supply watermain replacement (Option A) is shown on **Figure 7**.

### 6.2. SUPPLY SYSTEM – OPTION B

This proposed supply main replacement option is similar to Option A however the alignment continues along existing road corridor instead of crossing private property. The conceptual replacement alignment runs from Weston Lake along Beaver Point Road and connects to the existing supply system at the intersection of Beaver Point Road and South Ridge Drive.

This option includes the following proposed upgrades:

- New Raw Water Intake from Weston Lake (Beaver Point Road)
- New Pump Station
- New 100mm PVC Supply Watermain – 3,100m long
- Existing 100mm AC Supply Main Decommissioned

The proposed supply watermain replacement (Option B) is shown on **Figure 8**.

### 6.3. SUPPLY SYSTEM – OPTION C

This proposed supply main replacement option investigated finding a shorter route from the existing lake intake point to the water treatment plant. The conceptual replacement alignment runs from Weston Lake west, through private property to Reynolds Road, then runs south along Reynolds Road and connects to South Ridge Drive through private property. Two alternate alignments were reviewed for this option.

This option includes the following proposed upgrades:

- Updated Raw Water Intake from Weston Lake (Existing Intake Location)
- New Pump Station
- New 100mm PVC Supply Watermain – 1,700m long (C1) / 2,100m long (C2)
- Property Acquisition / SRW for connection between Intake and Reynolds Road as well as connection between Reynolds Road & South Ridge Drive
- Existing 100mm AC Supply Main Decommissioned

The proposed supply watermain replacement (Option C1/C2) is shown on **Figure 9**.

### 6.4. SUPPLY SYSTEM – OPTION D

This option review considered replacement of the supply watermain along the existing route which generally follows Weston Creek from Weston Lake to the south. Replacing the supply watermain along the existing alignment would have significant impact on the riparian area.

This option includes the following proposed upgrades:

- Updated Raw Water Intake from Weston Lake (Existing Intake Location)
- New 100mm PVC Supply Watermain – 2,300m long
- Replacement along existing SRW, however additional width for installation / access expected for replacement
- Existing 100mm AC Supply Main Decommissioned

The proposed supply watermain replacement (Option D) is shown on **Figure 10**.

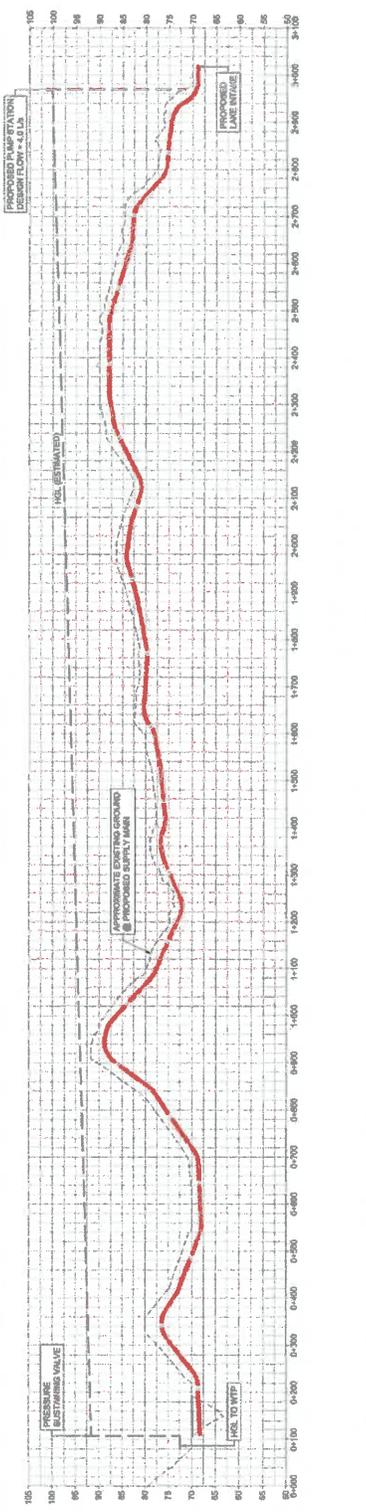
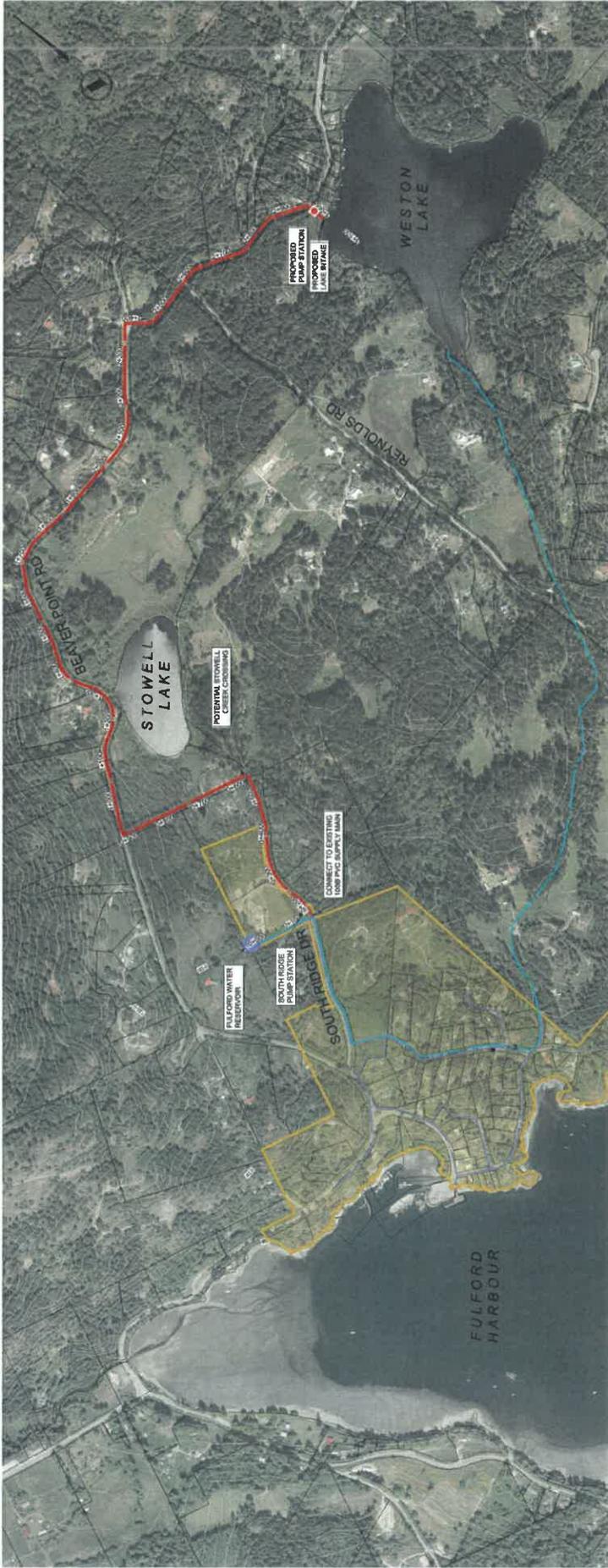
### 6.5. SUPPLY SYSTEM – OPTION REVIEW SUMMARY

We have summarized the four (4) conceptual pipeline alignment routing options that were reviewed for the supply main replacement in **Table 6-1**.



Table 6-1: Supply System – Watermain Replacement Option Review				
Option	Land Tenure Requirements	Intake / Pumping Requirements	Replacement Length (m)	Additional Considerations
A	<ul style="list-style-type: none"> <li>- MOTI Permitting for installation along roadway (Beaver Point Road)</li> <li>- Two (2) private property crossings anticipated</li> </ul>	<ul style="list-style-type: none"> <li>- New Raw Water Intake from Weston Lake (Beaver Point Road)</li> <li>- New Pump Station</li> </ul>	2,900	<ul style="list-style-type: none"> <li>- Stowell Creek crossing likely required</li> </ul>
B	<ul style="list-style-type: none"> <li>- MOTI Permitting for installation along roadway (Beaver Point Road).</li> </ul>	<ul style="list-style-type: none"> <li>- New Raw Water Intake from Weston Lake (Beaver Point Road)</li> <li>- New Pump Station</li> </ul>	3,100	<ul style="list-style-type: none"> <li>- Several road culverts will need to be crossed</li> <li>- Potential for roadside MUP to be constructed above watermain installation</li> </ul>
C1	<ul style="list-style-type: none"> <li>- MOTI Permitting for installation along roadway (Reynolds Road)</li> <li>- Three (3) private property crossings anticipated</li> </ul>	<ul style="list-style-type: none"> <li>- Updated Raw Water Intake from Weston Lake (Existing Intake Location)</li> <li>- New Pump Station</li> </ul>	1,700	<ul style="list-style-type: none"> <li>- Stowell Creek crossing required</li> <li>- Alignment runs through long section for forested area (on private property)</li> </ul>
C2	<ul style="list-style-type: none"> <li>- MOTI Permitting for installation along roadway (Reynolds Road)</li> <li>- Two (2) private property crossings anticipated</li> </ul>	<ul style="list-style-type: none"> <li>- Updated Raw Water Intake from Weston Lake (Existing Intake Location)</li> <li>- New Pump Station</li> </ul>	2,100	<ul style="list-style-type: none"> <li>- Stowell Creek crossing required</li> <li>- Alignment runs through long section for forested area (on private property)</li> </ul>
D	<ul style="list-style-type: none"> <li>- Replacement along existing SRW.</li> <li>- Additional width for installation / access expected for replacement</li> <li>- Environmental Permitting Required</li> <li>- Environmental Compensation</li> </ul>	<ul style="list-style-type: none"> <li>- Updated Raw Water Intake from Weston Lake (Existing Intake Location)</li> <li>- Existing Sunnyside Pump Station</li> </ul>	2,300	<ul style="list-style-type: none"> <li>- Following Weston Creek</li> </ul>





**LEGEND**

- WATER SERVICE AREA
- EXISTING DISTRIBUTION MAIN
- EXISTING UNTREATED SUPPLY MAIN
- PROPOSED UNTREATED SUPPLY MAIN
- EXISTING STORAGE FACILITY
- EXISTING TREATMENT PLANT
- EXISTING PUMP STATION
- EXISTING PRESSURE CONTROL STATION
- PROPOSED PUMP STATION

Drawing No. **FIGURE 7**  
Project Number: 221-5-641-01-SK Rev: B

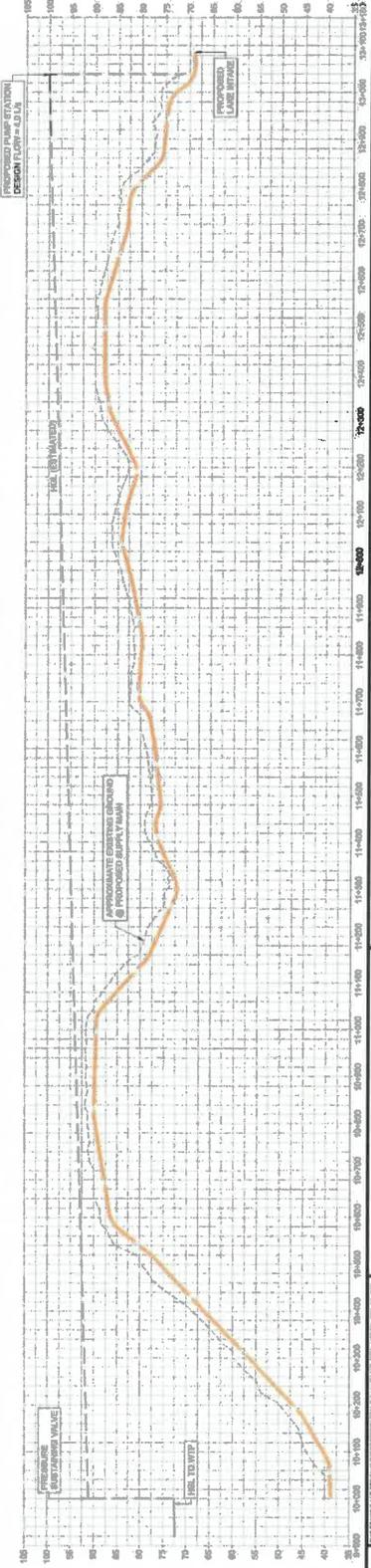
**McElhenney**

PERMIT TO PRACTICE  
 McElhenney Ltd.  
 PROJECT NO. 221-5-641-01-SK  
 SYSTEM AND CONTROL PLAN (A)

CAPITAL REGIONAL DISTRICT  
 101 - 121 McPHERSON AVENUE, WALT BIRING ISLAND BC, V1C 2T6  
**FULFORD WATER SYSTEM**  
 AC WATER PIPELINES REPLACEMENT  
 PROPOSED SUPPLY MAIN  
 REPLACEMENT (OPTION A)

Scale: 1:500  
 150' Equivalent Feet  
 McElhenney Ltd.  
 Vancouver BC  
 14 280 718 5238  
 14 280 718 5238  
 (Drawing Date: 2022, Scale: 1/4" = 1'-0")

Rev	Date	Description	Drawn	Checked	Appr'd
1	2022-04-21	ISSUED FOR PERMIT			
2	2022-04-21	ISSUED FOR PERMIT			



**LEGEND**

- Water Service Area
- Existing Distribution Main
- Existing Untreated Supply Main
- Proposed Untreated Supply Main
- Existing Storage Facility
- Existing Treatment Plant
- Existing Pump Station
- Existing Pressure Control Station
- Proposed Pump Station

**FIGURE 8**

**CAPITAL REGIONAL DISTRICT**  
 100 - 521 Southridge Drive, Suite 200, West Kelowna, BC V1Y 9V6

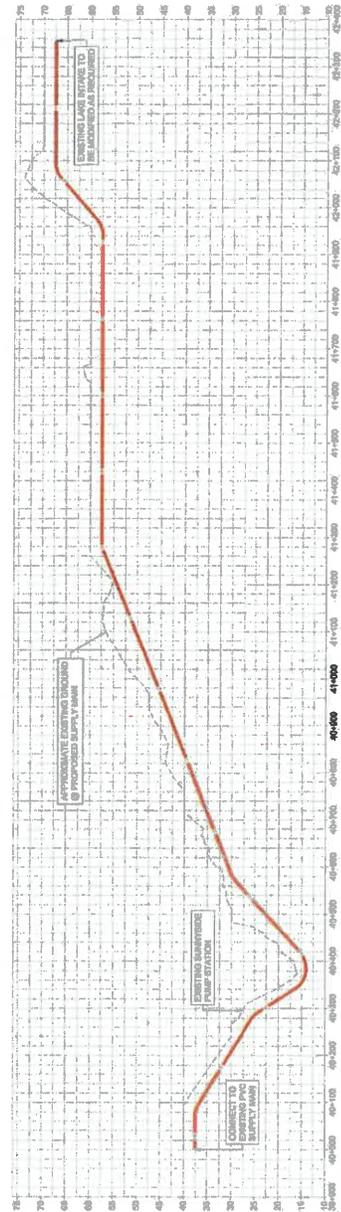
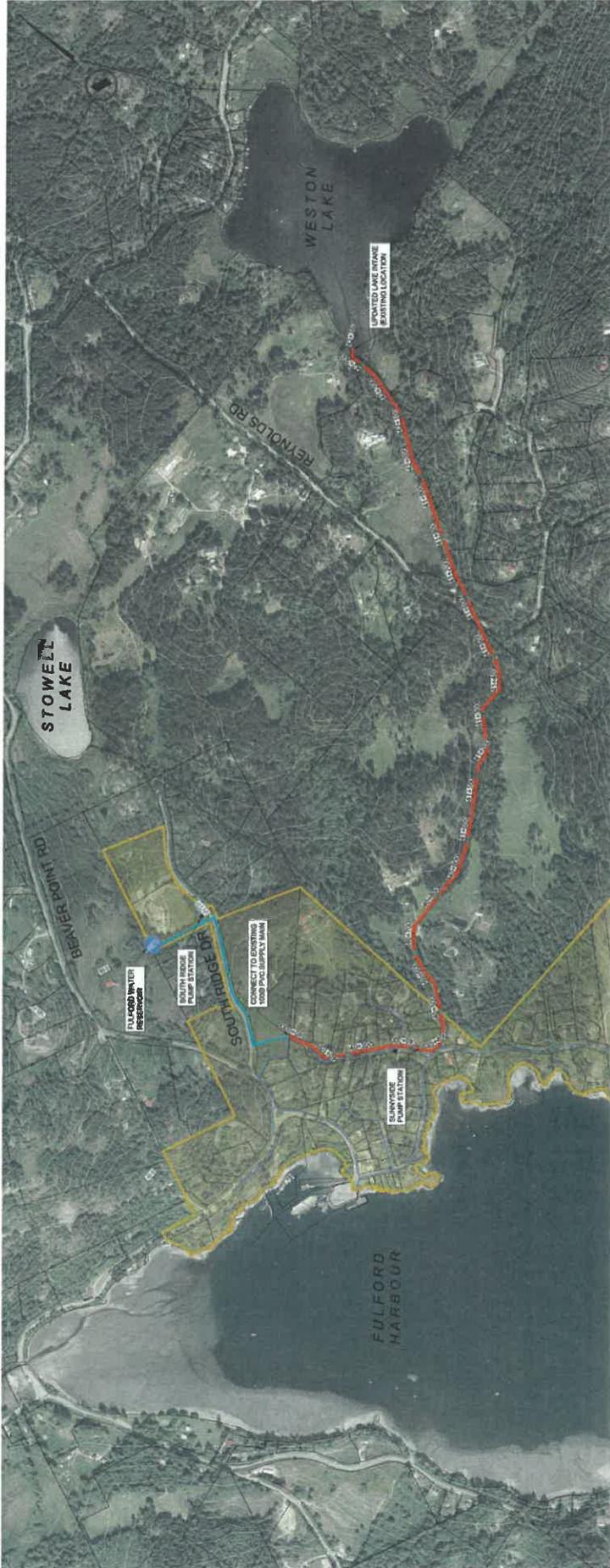
**FULFORD WATER SYSTEM**  
**AC WATER PIPELINES REPLACEMENT**  
**PROPOSED SUPPLY MAIN**  
**REPLACEMENT (OPTION B)**

**McElhanney**

**PERMIT TO PRACTICE**  
 McElhanney Ltd.  
 Permit Number: 1000000  
 Registered Professional Engineer

Scale: 1:10,000  
 Drawing No. 2201-66140-3K  
 Revision: B





**LEGEND**

- WATER SERVICE AREA
- EXISTING DISTRIBUTION MAIN
- EXISTING UNTREATED SUPPLY MAIN
- PROPOSED UNTREATED SUPPLY MAIN
- EXISTING STORAGE FACILITY
- EXISTING TREATMENT PLANT
- EXISTING PUMP STATION
- EXISTING PRESSURE CONTROL STATION

Drawing No. **FIGURE 10**  
 Project Number 2201-54641-01-SK Rev. 8  
 CAPITAL REGIONAL DISTRICT  
 105-101 BEAVER POINT RD., SUITE 275  
 FULLFORD WATER SYSTEM  
 AC WATER PIPELINES REPLACEMENT  
 PROPOSED SUPPLY MAIN  
 REPLACEMENT (OPTION D)

**McElhenny**  
 2001 Dundas Street West  
 Unit 100  
 Fullford, ON N3B 2Z9  
 905.882.2222  
 www.mcelhenny.com

**PERMIT TO PRACTICE**  
 McElhenny Ltd.  
 Permit Number: 100000  
 Registered Professional Engineer

Scale: 1" = 100'  
 15,000'

Date: 2024-01-10  
 Design: JSP  
 Check: JSP

## PART 7. CONCEPTUAL DESIGN – DISTRIBUTION SYSTEM (EXISTING WSA)

### 7.1. DISTRIBUTION SYSTEM – OPTION 1 (EXISTING WSA – AC REPLACEMENT)

The proposed distribution system (Option 1) was evaluated under steady state conditions to determine the system pressures under peak hour conditions and to determine available fire flows during maximum day demands.

This option includes the following proposed upgrades:

- Existing AC Watermains Replaced with 150mm Dia. PVC
- Pressure Control Station Added (Beaver Point Rd / Fulford-Ganges Rd) – Set Point @ 60 psi
- Sunnyside PCS Revised Set Point – Set Point @ 60 psi (*Revised from Current 45 psi*)
- Removal of Check Valves & Opening Isolation Valves to provide looped system

The proposed distribution system (Option 1) is shown on **Figure 11**.

#### 7.1.1. Peak Hour Pressures

The system pressures under peak hour demand under existing conditions are compared to other scenarios in **Table A-1 (Appendix A)** and illustrated on **Model Figure D (Appendix B)**. Pressures below the acceptable design minimum of 414 kPa (60 psi) have been highlighted in red.

#### 7.1.2. Available Fire Flows

The available fire flows during maximum day demand for the proposed upgrades are compared to other scenarios in **Table A-2 (Appendix A)** and illustrated on **Model Figure E (Appendix B)**.

The available fire flows, while maintaining minimum residual pressure in system of 140 kPa (20 psi), are all less than a typical design fire flow of 60 L/s (MMCD Design Guideline (2014) minimum fire flow requirements for Single/Two Family Residential without sprinklers).

### 7.2. DISTRIBUTION SYSTEM – OPTION 2 (EXISTING WSA – MMCD FIRE FLOW)

The proposed distribution system (Option 2) was evaluated under steady state conditions to determine the extent of required upgrades to provide a typical design fire flow of 60 L/s (MMCD Design Guideline (2014) minimum fire flow requirements for Single/Two Family Residential without sprinklers).

This option would require the following proposed upgrades:

- Pressure Control Station Added (Beaver Point Rd / Fulford-Ganges Rd) – Set Point @ 60 psi
- Sunnyside PCS Revised Set Point – Set Point @ 60 psi
- Removal of Check Valves & Opening Isolation Valves to provide looped system
- Existing PVC & AC Watermains Replaced with 200mm Dia. PVC
  - Some limited sections of existing AC & PVC watermains (P-17 to P-24 & P-33) could be replaced with 150mm Dia. PVC and still achieve design fire flow

The proposed distribution system (Option 2) is shown on **Figure 12**.

### 7.2.1. Peak Hour Pressures

The system pressures under peak hour demand under existing conditions are compared to other scenarios in **Table A-1 (Appendix A)** and illustrated on **Model Figure F (Appendix B)**. Pressures below the acceptable design minimum of 414 kPa (60 psi) have been highlighted in red.

### 7.2.2. Available Fire Flows

The available fire flows during maximum day demand for the proposed upgrades are compared to other scenarios in **Table A-2 (Appendix A)** and illustrated on **Model Figure G (Appendix B)**. The Figure also shows the required pipe sizes to meet the design fire flow.

## 7.3. DISTRIBUTION SYSTEM – OPTION 3 (WSA EXPANSION – DEVELOPER FIRE FLOW)

The distribution system (Option 3) was evaluated under steady state conditions to determine the extent of required upgrades to provide a design fire flow of 64 L/s @ the “Ocean Estuary Development”. This target design flow was provided to the CRD by the developer.

Based on our initial review, the minimum watermain size of 200mm dia. is required to provide 64 L/s fire flow while maintaining velocities within maximum of 3.0 m/s. As such this option would require the following proposed upgrades:

- Existing PVC & AC Watermains Replaced with 200mm Dia. PVC from Reservoir (R-1) to end of system on Fulford-Ganges Road (J-28)
- Extension of 200mm dia. PVC watermain from J-28 to development
  - Note that a 300m section of 150mm dia. PVC watermain from the reservoir towards the development wouldn't need to be replaced to provide target fire flow, if the maximum velocity requirement was revised from 3.0m/s to 3.7m/s

The conceptual distribution system (Option 3) is shown on **Figure 13**.

As shown in the figure, this analysis was based on the existing system configuration with upgrades focused on providing design fire flow to the development outside of the current WSA (does not reflect the proposed AC watermain replacements shown in Option 1 & Option 2).

### 7.3.1. Peak Hour Pressures

The system pressures under peak hour demand under existing conditions are compared to other scenarios in **Table A-1 (Appendix A)** and illustrated on **Model Figure H (Appendix B)**. Pressures below the acceptable design minimum of 414 kPa (60 psi) have been highlighted in red. Pressures above the maximum allowable pressure (MMCD Design Guideline, 2014) of 850 kPa (123 psi) have been highlighted in yellow. The guidelines also note that subject to approval of the local authority, the maximum allowable pressure may be increased to 1035 kPa (150 psi) for systems with multiple pressure zones.

### 7.3.2. Available Fire Flows

The available fire flows during maximum day demand for the proposed upgrades are compared to other scenarios in **Table A-2 (Appendix A)** and illustrated on **Model Figure I (Appendix B)**.

Available fire flows greater than the design fire flow of 64 L/s have been highlighted in green.

## 7.4. DISTRIBUTION SYSTEM – OPTION REVIEW SUMMARY

We have summarized the three (3) conceptual options that were reviewed for the distribution system in **Table 7-1**.

<b>Table 7-1: Distribution System – Watermain Replacement Option Review</b>		
<b>Option</b>	<b>Design Considerations</b>	<b>Scenario Purpose</b>
1	- Replace AC Watermains with 150mm Diameter PVC pipe for future domestic demand estimates	- To confirm AC watermain replacement sizing (Domestic Demands) and to provide the CRD an understanding of available fire flows
2	- Replace Existing PVC and AC Watermains with PVC pipe, sized to suit MMCD fire flow standards (60L/s)	- To provide the CRD an understanding of required distribution system upgrades to meet a fire flow standard
3	- Replace Existing PVC and AC Watermain with PVC pipe, sized to provide developer fire flow @ Ocean Estuary Development (including potential service expansion area)	- To provide the CRD an understanding of required distribution system upgrades to provide design fire flow at potential development







**LEGEND**

- EXISTING SUPPLY - 1000
- EXISTING DISTRIBUTION - 800 HIPS
- EXISTING DISTRIBUTION - PVC TO REMAIN 1000
- EXISTING DISTRIBUTION - PVC TO BE REPLACED WITH 1000
- EXISTING DISTRIBUTION - AC TO BE REPLACED WITH 1000
- EXISTING DISTRIBUTION - AC TO BE REPLACED WITH 2000
- PROPOSED PRESSURE CONTROL STATION

Drawing No. **FIGURE 12**

Project Number: **Z271-2081-01-SK**

Revision: **B**

---

**CAPITAL REGIONAL DISTRICT**  
**FULFORD WATER SYSTEM**  
**AC WATER PIPELINES REPLACEMENT**  
**PROPOSED DISTRIBUTION SYSTEM (OPTION 2)**

---

**McElhenny**

1331 Elmwood Road  
 Columbia, SC 29203  
 803.757.7100

---

**PERMIT TO PRACTICE**  
 REGISTRATION NUMBER: 17002009  
 EXPIRES: 12/31/2025  
 EXPIRES AND REISSUES BY: AC

---

Scale: 1" = 1,000'

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0 1,000 2,000

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10/20/2025 10:00 AM

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Rev	Date	Description	Drawn	Checked	App'd



Drawing No. **FIGURE 13**  
 PROJECT NUMBER: 2201-0461-04-SK  
 SHEET: B

**CAPITAL REGIONAL DISTRICT**  
 100 - 121 BERTHLENN AVENUE, SUITE 2000, CHARLOTTE, NC 28203  
**FULFORD WATER SYSTEM**  
**AC WATER PIPELINES REPLACEMENT**  
**PROPOSED DISTRIBUTION SYSTEM**  
 (OPTION 3)

**McElhanney**  
 1001 N. W. 10th Street  
 Fort Lauderdale, FL 33304  
 PHONE: 954.575.1000  
 FAX: 954.575.1001

**PERMIT TO PRACTICE**  
 No. 10000000000000000000  
 EXPIRES: 12/31/2025

FOR CONTINUATION, SEE THIS SHEET (RIGHT)

NO.	DESCRIPTION	DATE	BY	CHECKED
1	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
2	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
3	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
4	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
5	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
6	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
7	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
8	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
9	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
10	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
11	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
12	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
13	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
14	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
15	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
16	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
17	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
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31	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
32	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
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34	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
35	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
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37	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
38	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
39	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
40	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
41	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
42	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
43	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
44	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
45	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
46	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
47	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
48	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
49	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN
50	DESIGNED	08/14/2024	J. B. BROWN	M. J. BROWN

## PART 8. IMPACT ASSESSMENT

### 8.1. ARCHAEOLOGICAL / HERITAGE

Based on our desktop review of the Remote Access to Archaeological Data (RAAD) Maps it appears that there is a potential for Archaeological / Heritage findings along the proposed watermain replacement alignments.

We recommend that an Archaeological Overview Assessment (AOA) be completed at the start of the detailed design process.

This work would generally include:

- The AOA will review the background data available on the BC Archaeology Branch Remote Access to Archaeological Data (RAAD) website. This includes any previously recorded archaeological sites and/or areas of archaeological potential in conflict or in the vicinity of the project.
- A letter will be compiled with the data collected from the AOA and will make recommendations regarding the need for further archaeological work, such as a permitted archaeological impact assessment, permitted monitored site alterations or no further archaeological work for the construction phase of the project. The AOA will make an estimate of all probable archaeological services costs and time frames for the construction phase as well.
- If additional archaeological work is required, such as an archaeological impact assessment or archaeological permit application, estimated costs will be summarized.

### 8.2. ENVIRONMENTAL / ECOLOGICAL

Based on our desktop review of the CRD GIS Mapping, it appears that there is a potential for watermain replacement alignments to cross through sensitive environmental / ecological areas.

We recommend that an Environmental Screening Report (ESR) be completed at the start of the detailed design process due to the nature of the site.

The objective of the ESR is to provide an overview of the proposed project and the existing environmental features to determine the level and extent of any further environmental review requirements. This screening level desktop study will provide a general description of the biophysical conditions and natural landscape features of the site and a brief assessment of potential impacts. This report will assist in determining Environmentally Valuable Resources (EVRs) that would require a more in-depth review.

Additional assessments may be required depending on the findings of the ESR, including the development of an Environmental Assessment (EA) that would build on the ESR and include field verification of key EVRs identified in the desktop review. Additional environmental services may be needed to support project permitting requirements and facilitate environmental protection during construction.

We anticipate that the Environmental Screening Report will include the following sections:

- Introduction / Background Information
- Project Description
- Regulatory Framework
- Desktop Assessment of Biophysical Resources, including a review of site photographs
- Potential Impact Assessment (high level)
- Potential Permitting Requirements
- Summary
- References

We also recognize that an Environmental Management Plan should be prepared near the end of the detailed design process.

The Environmental Management Plan (EMP) would be developed by a Qualified Environmental Professional (QEP). The objective of the EMP will be to provide a framework for the Contractor in the development of a Construction Environmental Management Plan (CEMP), to identify key regulatory requirements for the project, and to support permitting applications, if required. The EMP will be included in the tender package to help provide guidance to the Contractor.



## PART 9. FINDINGS & RECOMMENDATIONS

We have summarized the key findings of this study below:

### 1. Existing System Review

- The Fulford Water System contains approximately 2,330m of AC watermain in the supply system and 1,775m of AC watermain in the distribution system.
- The existing AC watermain has been broken into six (6) segments which have been ranked in priority for replacement (through a Criticality Assessment). Depending on funding allocation for each “Phase” of replacement, the segments could be combined or constructed individually.
- Generally, the Fulford Water System cannot achieve sufficient flow for residential or commercial fire protection in accordance with the CRD, MMCD, or FUS guidelines.
- Sections of existing PVC watermain in the system have not been sized to achieve sufficient flow (while maintaining required system pressures & velocities) for residential or commercial fire protection in accordance with the CRD, MMCD, or FUS guidelines.

### 2. Supply System Watermain Review

- Four (4) AC watermain replacement options were reviewed including:
  - Option A - The conceptual replacement alignment runs from Weston Lake along Beaver Point Road and connects to South Ridge Drive through private property.
    - Requires new lake intake, new pump station, supply watermain through MOTI right-of-way, and supply watermain through private property.
    - Connection through private property could have significant impact on schedule and cost. As such, this is not considered the preferred option.
  - Option B – The conceptual replacement alignment runs from Weston Lake along Beaver Point Road and connects to the existing supply system at the intersection of Beaver Point Road and South Ridge Drive.
    - Requires new lake intake, new pump station, and supply watermain through MOTI right-of-way.
    - Although this connection requires longer section of supply watermain, it is considered the preferred option.
    - This option could also allow for the installation of the roadside Multi-Use Path above the proposed watermain to provide connection from Fulford Harbour to Stowell Lake and Weston Lake.

- Option C – The conceptual replacement alignment runs from Weston Lake west, through private property to Reynolds Road, then runs south along Reynolds Road and connects to South Ridge Drive through private property (2 properties minimum).
  - Requires new lake intake, new pump station, supply watermain through MOTI right-of-way, and supply watermain through private property.
  - Although this connection requires shorter section of supply watermain, connection through private properties could have significant impact on schedule and cost. As such, this is not considered the preferred option.
- Option D – The conceptual option review considered replacement of the supply watermain along the existing route which generally follows the creek that outlets from Weston Lake to the south.
  - Based on our site walk as well as desktop review for suitability, ease of construction (access, water control, technologies, risk, etc.), construction cost, and environmental permitting requirements this replacement option is not considered the preferred option.

### 3. Distribution System Watermain Review

- Three (3) scenarios were reviewed including:
  - Option 1 – This option includes replacing all existing AC watermains with 150mm Dia. PVC watermain and revisions to pressure zones including increasing the lower pressure zone by ~15 psi and looping the system by addition of a second pressure control station.
    - This option provides PVC watermains (AC watermains replaced), improved hydraulic capacity, and improved fire flows, however the available fire flows do not meet CRD, MMCD, or FUS guidelines.
  - Option 2 – This option investigates the required upgrades to provide a typical design fire flow of 60 L/s (MMCD). This option includes replacing all existing watermains with 200mm Dia. PVC watermain (the looped section through “downtown” could be 150mm Dia.) and revisions to pressure zones including increasing the lower pressure zone by ~15 psi and looping the system by addition of a second pressure control station.
    - This option provides replaced AC watermains, improved hydraulic capacity which provides a typical design fire flow of 60 L/s (MMCD Design Guideline (2014) minimum fire flow requirements for Single/Two Family Residential without sprinklers).
    - This option requires replacement of existing undersized PVC watermain including approximately 1,170m of 100mm diameter and 320m of 150mm diameter PVC watermain.
    - Order of magnitude cost to replace these existing sections of PVC piping with adequately sized piping (for fire flows) is approximately \$1,000 per meter or about \$1.5M.

- Option 3 – This option investigates the required upgrades to provide a design fire flow of 64 L/s @ the Ocean Estuary Development (Design Fire Flow Provided by Developer). This option includes replacing all existing watermains from the reservoir towards the development with 200mm Dia. PVC watermain. The development would also require a 200mm Dia. PVC watermain to be extended outside of the existing Water Service Area.
  - Based on our initial review the minimum watermain size of 200mm dia. is required to provide 64 L/s fire flow while maintaining velocities within maximum of 3.0 m/s.
  - We note that a 300m section of 150mm dia. PVC watermain, from the reservoir towards the development, wouldn't need to be replaced to provide target fire flow, if the maximum velocity requirement was revised from 3.0m/s to 3.7m/s.
  - It is understood that this option would be led by the developer only if the District agrees to expand the Water Service Area.
  - Reservoir storage requirements related to this design fire flow were not reviewed as part of this study.

We have the following recommendations based on the findings in our investigation, analysis, and criticality assessment of the existing system as well as analysis, option review, and recommendations to support the AC watermain replacement in the Fulford Water System:

- Supply System – Develop conceptual design, replacement program, and cost estimate(s) for the AC watermain replacement within the supply system.
  - **Option B Recommended**
- Distribution System – Develop conceptual design, replacement program, and cost estimate(s) for the AC watermain replacement within the distribution system.
  - **Option 1 Recommended**
- Develop detailed design for the replacement program which is to be broken into phases to strategically replace the AC watermain replacement in accordance with the watermain replacement prioritization (criticality assessment).



## PART 10. CLOSURE

We trust that the information provided in this document is sufficient for your requirements. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Sincerely,

McElhanney Ltd.

EGBC Permit No. 1003299

Prepared by:

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Date	Status	Revision	Author
January 30, 2023	Draft for Client Review	Revision 00	S. O'Connor
March 10, 2023	Issued for Client Review	Revision 01	S. O'Connor

# **APPENDIX A – WATER MODEL SCENARIO COMPARISON TABLES**

Table A-1: Peak Hour Pressures Comparison

Node	Approximate Location	~ Elevation (m)	Existing System			Proposed System (Existing WSA) - Option #1			Proposed System (Existing WSA) - Option #2			Proposed System (WSA Expansion) - Option #3		
			Demand (l/s)	Pressure (psi)	Pressure (psi)	Demand (l/s)	Pressure (psi)	Pressure (psi)	Demand (l/s)	Pressure (psi)	Pressure (psi)	Demand (l/s)	Pressure (psi)	Pressure (psi)
J-2	203 South Ridge Drive	62.7	0.11	43	43	0.18	43	43	0.18	43	43	0.18	43	43
J-3	132 Beaver Point Road	40.0	0.03	75	75	0.06	75	75	0.06	75	75	0.06	75	75
J-4	169 Sunnyside Drive	40.0	0.07	75	75	0.12	75	75	0.12	75	75	0.12	75	75
J-5	154 Sunnyside Drive	39.2	0.40	76	76	0.65	76	76	0.65	76	76	0.65	76	76
J-6	132 Sunnyside Drive	28.4	0.44	92	91	0.24	92	91	0.24	92	92	0.24	92	92
J-7	172 Morningside Road	14.7	0.11	64	64	0.18	64	64	0.18	64	64	0.18	64	64
J-8	191 Morningside Road	16.0	0.00	62	62	0.00	62	62	0.00	62	62	0.00	62	62
J-9	254 Morningside Road	14.7	0.33	64	64	0.54	64	64	0.54	64	64	0.54	64	64
J-10	247 Morningside Road	16.0	0.03	62	62	0.06	62	62	0.06	62	62	0.06	62	62
J-11	266 Morningside Road	23.0	0.00	62	62	0.00	62	62	0.00	62	62	0.00	62	62
J-12	280 Morningside Road	26.8	0.26	47	47	0.42	47	47	0.42	47	47	0.42	47	47
J-13	116 Beaver Point Road	40.0	0.00	75	75	Removed	75	75	Removed	75	75	Removed	75	75
J-14	116 Beaver Point Road	40.0	0.00	75	75	Removed	75	75	Removed	75	75	Removed	75	75
J-15	116 Beaver Point Road	40.0	0.00	75	75	0.00	75	75	0.00	75	75	0.00	75	75
J-16	117 Beaver Point Road	40.0	0.07	75	75	0.12	75	75	0.12	75	75	0.12	75	75
J-17	112 Beaver Point Road	36.7	0.03	88	88	0.06	88	88	0.06	88	88	0.06	88	88
J-18	2900 Fulford-Ganges Road	16.9	0.22	108	108	0.36	108	108	0.36	108	108	0.36	108	108
J-19	2901 Fulford-Ganges Road	12.3	0.44	67	67	0.24	67	67	0.24	67	67	0.24	67	67
J-20	2915 Fulford-Ganges Road	2.3	0.26	81	81	0.42	81	81	0.42	81	81	0.42	81	81
J-21	117 Morningside Road	10.0	0.14	70	70	0.24	70	70	0.24	70	70	0.24	70	70
J-22	122 Morningside Road	7.8	0.26	73	73	0.42	73	73	0.42	73	73	0.42	73	73
J-23	158 Morningside Road	14.9	0.22	63	63	0.36	63	63	0.36	63	63	0.36	63	63
J-24	164 Morningside Road	16.0	0.07	62	62	0.12	62	62	0.12	62	62	0.12	62	62
J-25	117 Beaver Point Road	30.6	0.00	88	88	0.00	88	88	0.00	88	88	0.00	88	88
J-26	2823 Fulford-Ganges Road	23.5	0.00	98	98	0.00	98	98	0.00	98	98	0.00	98	98
J-27	2825 Fulford-Ganges Road	17.3	0.07	107	107	0.12	107	107	0.12	107	107	0.12	107	107
J-28	2807 Fulford-Ganges Road	14.1	0.18	112	112	0.30	112	112	0.30	112	112	0.30	112	112
J-29	131 Orchard Road	25.8	0.00	95	95	0.00	95	95	0.00	95	95	0.00	95	95
J-30	127 Orchard Road	24.9	0.00	97	97	0.00	97	97	0.00	97	97	0.00	97	97
J-31	120 Orchard Road	26.4	0.11	94	94	0.18	94	94	0.18	94	94	0.18	94	94
J-32	120 Orchard Road	20.0	0.07	103	103	0.12	103	103	0.12	103	103	0.12	103	103
J-33	101 Morningside Road	0.0	0.63	85	85	0.06	85	85	0.06	85	85	0.06	85	85
J-34	125 Sunnyside Drive	28.6	0.00	91	91	0.00	91	91	0.00	91	91	0.00	91	91
J-35	108 Hilltop Road	25.8	0.00	95	95	0.00	95	95	0.00	95	95	0.00	95	95
J-36	120 Hilltop Road	26.8	0.00	94	94	0.00	94	94	0.00	94	94	0.00	94	94
J-37	117 Hilltop Road	34.9	0.44	82	82	0.24	82	82	0.24	82	82	0.24	82	82
J-38	156 Hilltop Road	40.0	0.00	75	75	0.00	75	75	0.00	75	75	0.00	75	75
J-39	140 Hilltop Road	40.0	0.22	75	75	0.36	75	75	0.36	75	75	0.36	75	75
J-40	110 Tahouney Road	29.4	0.63	43	43	0.06	43	43	0.06	43	43	0.06	43	43
J-41	252 Morningside Road	24.7	0.14	50	50	0.24	50	50	0.24	50	50	0.24	50	50
J-42	110 Orchard Road	19.4	0.00	67	67	0.00	67	67	0.00	67	67	0.00	67	67
J-43	2895 Fulford-Ganges Road	16.5	0.00	61	61	0.00	61	61	0.00	61	61	0.00	61	61
J-100	2795 Fulford-Ganges Road	15.3	0.00			0.00			0.00			0.00		
J-101	2683 Fulford-Ganges Road	6.6												
J-102	2681 Fulford-Ganges Road	1.0												
J-103	2661 Fulford-Ganges Road	1.4												
J-104	2621 Fulford-Ganges Road	3.3												

Pressures below the acceptable design minimum of 41.4 kPa (60 psi) have been highlighted in red.  
 Pressures above the maximum allowable pressure (MWD Design Guideline, 2016) of 850 kPa (123 psi) have been highlighted in yellow.\*  
 \* The guidelines also note that subject to approval of the local authority, the maximum allowable pressure may be increased to .035 MPa (150 psi) for systems with multiple pressure zones.

Capital Regional District  
 Fulford Water - AC Watermain Replacement: Investigation, Analysis, Criticality Assessment, Option Review  
 WATER MODEL SCENARIO COMPARISON TABLES (AVAILABLE FIRE FLOW)

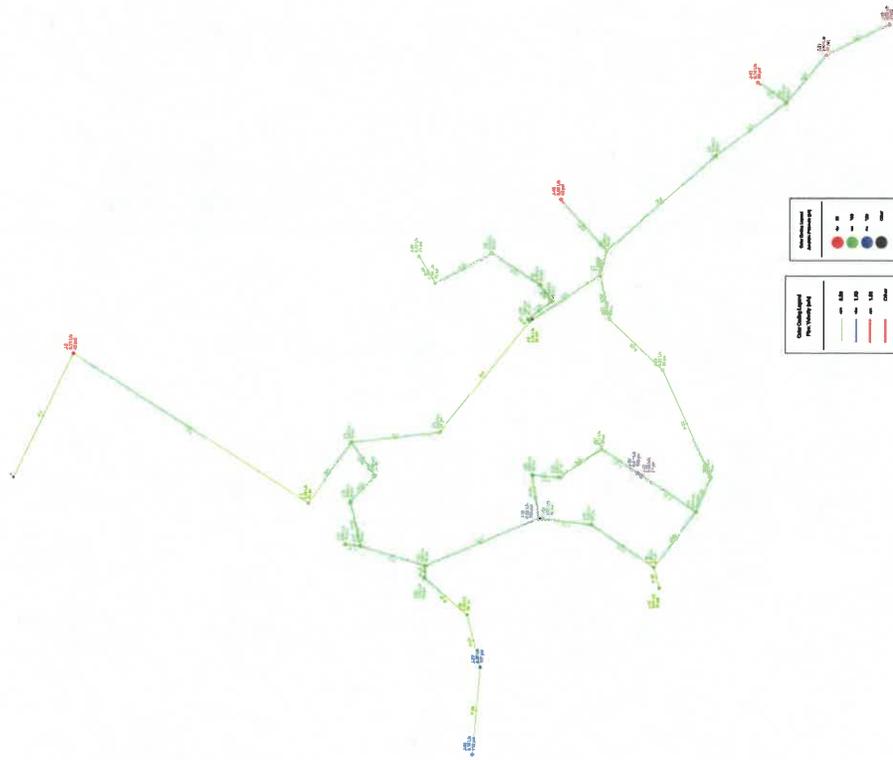
Table A-2: Available Fire Flow (MDD + Fire Flow) Comparison

Node	Approximate Location	~ Elevation (m)	Existing System Fire Flow (L/s)	Proposed System (Existing WSA) - Option #1 Fire Flow (L/s)	Proposed System (Existing WSA) - Option #2 Fire Flow (L/s)	Proposed System (WSA Expansion) - Option #3 Fire Flow (L/s)
J-2	203 South Ridge Drive	62.7	52	50	90	89
J-3	132 Beaver Point Road	40.0	52	50	90	89
J-4	169 Sunnyside Drive	40.0	52	50	90	54
J-5	154 Sunnyside Drive	39.2	52	50	90	54
J-6	122 Sunnyside Drive	28.4	49	49	90	54
J-7	172 Morningside Road	14.7	49	50	90	67
J-8	191 Morningside Road	16.0	23	50	90	23
J-9	254 Morningside Road	14.7	22	50	90	22
J-10	247 Morningside Road	16.0	18	50	90	18
J-11	266 Morningside Road	23.0	16	50	90	16
J-12	280 Morningside Road	26.8	14	49	90	15
J-13	116 Beaver Point Road	40.0	23	Removed	Removed	Removed
J-14	116 Beaver Point Road	40.0	23	Removed	Removed	Removed
J-15	116 Beaver Point Road	40.0	23	50	90	89
J-16	117 Beaver Point Road	40.0	23	50	90	89
J-17	112 Beaver Point Road	30.7	23	50	90	89
J-18	2900 Fulford-Ganges Road	16.9	23	50	77	21
J-19	2901 Fulford-Ganges Road	12.3	17	50	79	21
J-20	2915 Fulford-Ganges Road	2.3	19	50	82	21
J-21	117 Morningside Road	10.0	21	50	85	21
J-22	122 Morningside Road	7.8	22	50	90	21
J-23	158 Morningside Road	14.9	23	50	89	45
J-24	164 Morningside Road	16.0	23	50	76	41
J-25	117 Beaver Point Road	30.6	23	90	27	89
J-26	2823 Fulford-Ganges Road	23.5	23	27	80	89
J-27	2825 Fulford-Ganges Road	17.3	23	27	90	89
J-28	2807 Fulford-Ganges Road	14.1	23	27	90	89
J-29	131 Orchard Road	25.8	23	50	79	21
J-30	127 Orchard Road	24.9	23	50	79	21
J-31	127 Orchard Road	26.4	23	50	81	21
J-32	120 Orchard Road	20.0	23	50	82	21
J-33	101 Morningside Road	0.0	6	24	82	6
J-34	125 Sunnyside Drive	28.6	27	27	90	27
J-35	108 Hilltop Road	25.8	27	27	90	27
J-36	120 Hilltop Road	26.8	27	27	90	27
J-37	117 Hilltop Road	34.9	23	27	90	23
J-38	136 Hilltop Road	40.0	23	27	90	23
J-39	140 Hilltop Road	40.0	23	27	90	23
J-40	110 Talhouny Road	29.4	6	6	6	6
J-41	252 Morningside Road	24.7	18	50	53	5
J-42	110 Orchard Road	19.4	6	50	83	7
J-43	2895 Fulford-Ganges Road	16.5	16	50	64	21
J-100	2795 Fulford-Ganges Road	15.3				
J-101	2688 Fulford-Ganges Road	6.6				
J-102	2681 Fulford-Ganges Road	1.0				
J-103	2661 Fulford-Ganges Road	1.4				
J-104	2621 Fulford-Ganges Road	3.3				

Available fire flows, while maintaining minimum residual pressure in system of 140 kPa (20 psi), less than a typical design fire flow of 60 L/s (MMKCD Design Guideline (2014)) have been highlighted in red  
 Available fire flows greater than the design fire flow of 64 L/s have been highlighted in green.

# **APPENDIX B – WATER MODEL FIGURES**

Scenario: PID - 3.32 L/e  
**Model Figure A**

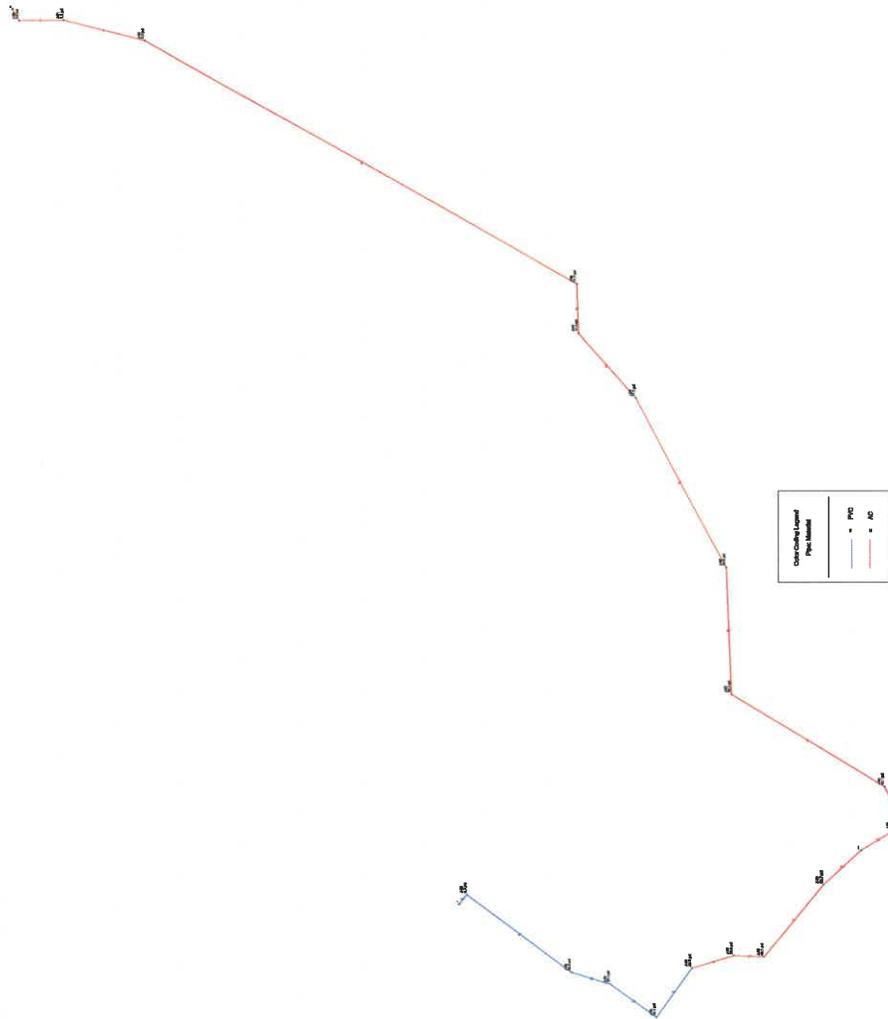


**\*Model Figures Scaled for Electronic Viewing Only  
Refer to Model Scenario Tables for summarized Results**

Scenario: 2020 - 2,000 L/s + Five Flows  
**Model Figure B**

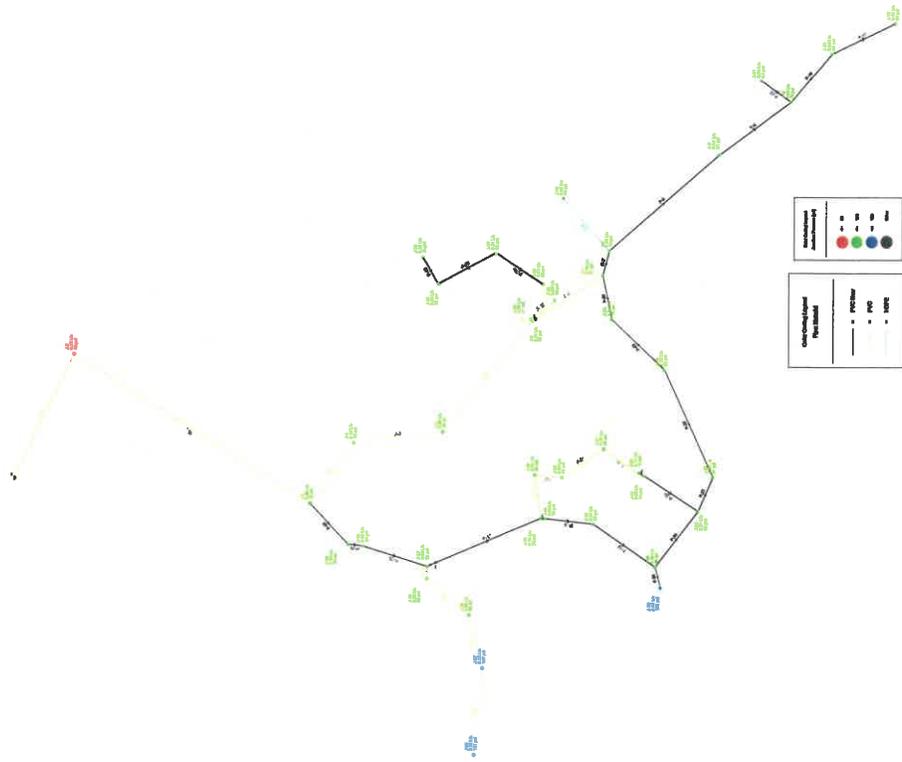


Scenario: Base  
**Model Figure C**

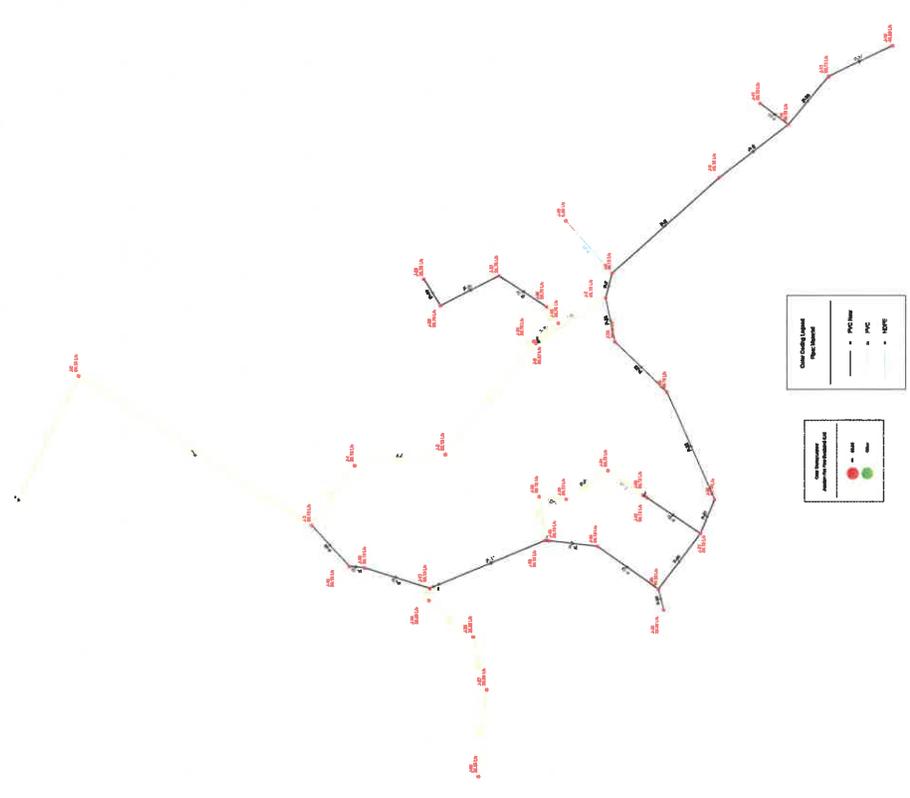


\*Model Figures Scaled for Electronic Viewing Only  
 Refer to Model Scenario Tables for summarized Results

Scenario: 1970 - 5.4M Lbs  
**Model Figure D**

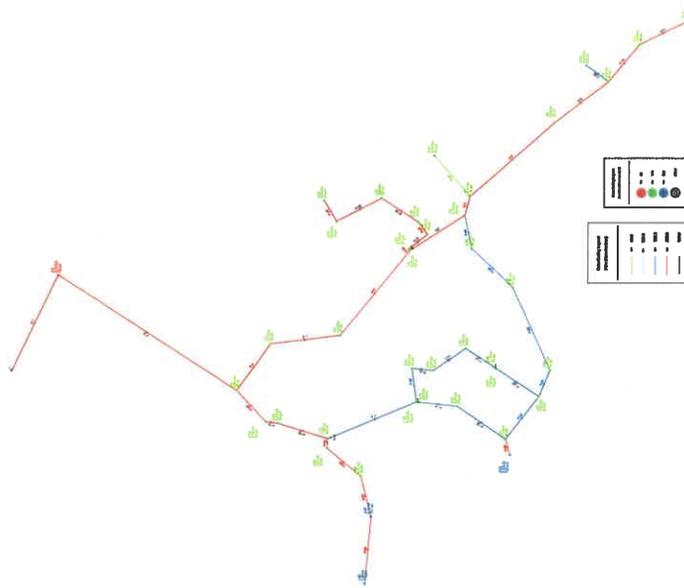


Scenario: MDD - 4.60 L/s + Fire Flow  
**Model Figure E**



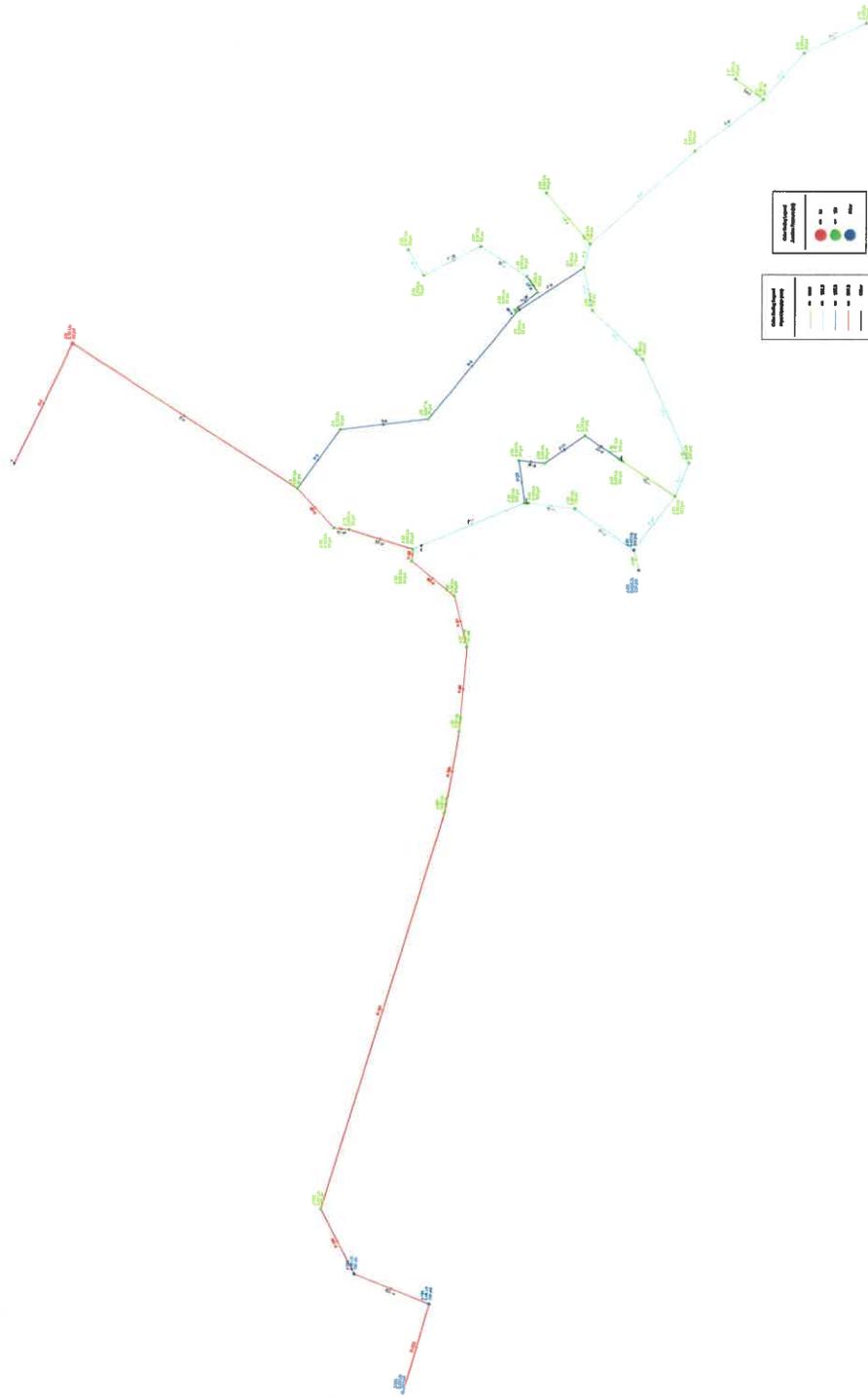
\*Model Figures Scaled for Electronic Viewing Only  
 Refer to Model Scenario Tables for summarized Results

Scenario: FWS - S.A.1.6  
**Model Figure F**



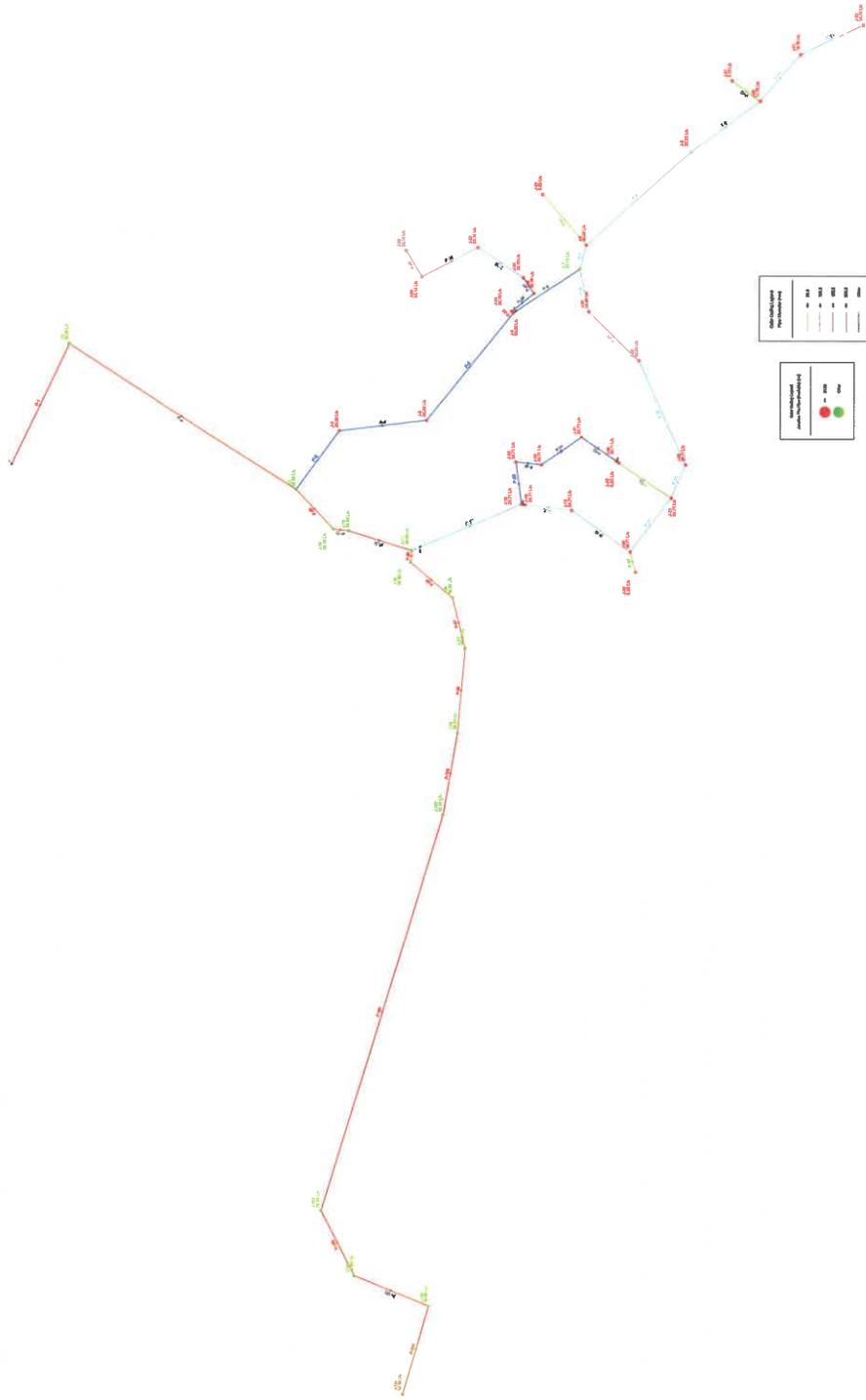


Scenario: P10 - 7.50 L4  
**Model Figure H**



\*Model Figures Scaled for Electronic Viewing Only  
Refer to Model Scenario Tables for summarized Results

Scenario: MDD - S.40 Ls + Fine Flow  
**Model Figure I**



**\*Model Figures Scaled for Electronic Viewing Only  
Refer to Model Scenario Tables for summarized Results**

# **APPENDIX C – CRITICALITY ASSESSMENT MATRIX**

Section	Segment	Approx. Location	System	Existing Watermain Details			Stop Hole	Diameter (mm)	Material	Leaks and Breaks	Service Connections	Remaining Useful Life	Components for Watermain Rehabilitation Analysis		Day-to-Day Condition Assessment	Sensitivity Areas	Redundancy	
				Label	Length (m)	Start/End							Complaints	General Land Use				
1	N/A	203 South Ridge Drive	Distribution	P-1	166	R-1	J-2	150	PVC		3	Unknown	Unknown	Unknown	Key logging section			
		132 Beaver Point Road	Distribution	P-2	335	R-2	J-3	150	PVC		1	Unknown	Unknown	Unknown	Key logging section			
		169 Samydside Drive	Distribution	P-3	90	J-3	J-4	150	PVC		2	Unknown	Unknown	Unknown	Key logging section			
		154 Samydside Drive	Distribution	P-4	109	J-4	J-5	150	PVC		11	Unknown	Unknown	Unknown	Key logging section			
2	Priority #5	172 Samydside Drive	Distribution	P-5	372	J-5	J-6	150	PVC	1	0	Unknown	Unknown	Unknown	Key logging section			
		172 Samydside Drive	Distribution	P-6	100	J-6	J-7	150	PVC		3	0	Unknown	Unknown	Unknown	Key logging section		
		181 Morningdale Road	Distribution	P-7	31	J-7	J-8	100	AC		0	0	Unknown	Unknown	Unknown	Key logging section		
		254 Morningdale Road	Distribution	P-8	174	J-8	J-9	100	AC		9	0	Unknown	Unknown	Unknown	Key logging section		
		247 Morningdale Road	Distribution	P-9	206	J-9	J-10	100	AC		1	0	Unknown	Unknown	Unknown	Key logging section		
		268 Morningdale Road	Distribution	P-10	76	J-10	J-11	100	AC		0	0	Unknown	Unknown	Unknown	Key logging section		
		280 Morningdale Road	Distribution	P-11	85	J-11	J-12	100	AC		7	0	Unknown	Unknown	Unknown	Key logging section		
		252 Morningdale Road	Distribution	P-12	43	J-12	J-13	100	AC		0	0	Unknown	Unknown	Unknown	Key logging section		
		116 Beaver Point Road	Distribution	P-13	49	J-13	J-14	100	AC		0	0	Unknown	Unknown	Unknown	Key logging section		
		117 Beaver Point Road	Distribution	P-14	54	J-14	J-15	100	AC		0	0	Unknown	Unknown	Unknown	Key logging section		
3	Priority #2	117 Beaver Point Road	Distribution	P-15	19	J-15	J-16	100	AC	1	2	Unknown	Unknown	Unknown	Key logging section			
		112 Beaver Point Road	Distribution	P-16	82	J-16	J-17	100	AC		1	1	Unknown	Unknown	Unknown	Key logging section		
		2900 Falford-Gangee Road	Distribution	P-17	249	J-17	J-18	100	AC		6	6	Unknown	Unknown	Unknown	Key logging section		
		2901 Falford-Gangee Road	Distribution	P-18	63	J-18	J-19	100	AC		2	4	Unknown	Unknown	Unknown	Key logging section		
		2902 Falford-Gangee Road	Distribution	P-19	90	J-19	J-20	100	AC		1	7	Unknown	Unknown	Unknown	Key logging section		
		2915 Falford-Gangee Road	Distribution	P-20	84	J-20	J-21	100	AC		1	4	Unknown	Unknown	Unknown	Key logging section		
		117 Morningdale Road	Distribution	P-21	45	J-21	J-22	100	AC		7	0	Unknown	Unknown	Unknown	Key logging section		
		132 Morningdale Road	Distribution	P-22	342	J-22	J-23	100	AC		6	2	Unknown	Unknown	Unknown	Key logging section		
		158 Morningdale Road	Distribution	P-23	83	J-23	J-24	100	AC		2	6	Unknown	Unknown	Unknown	Key logging section		
		104 Morningdale Road	Distribution	P-24	54	J-24	J-25	100	AC		1	1	Unknown	Unknown	Unknown	Key logging section		
4	Priority #3	120 Orchard Road	Distribution	P-25	84	J-25	J-26	50	AC		0	0	Unknown	Unknown	Unknown	Key logging section		
		101 Morningdale Road	Distribution	P-26	26	J-26	J-27	50	AC		1	1	Unknown	Unknown	Unknown	Key logging section		
		117 Beaver Point Road	Distribution	P-27	14	J-27	J-28	100	PVC		0	0	Unknown	Unknown	Unknown	Key logging section		
		2823 Falford-Gangee Road	Distribution	P-28	68	J-28	J-29	100	PVC		2	2	Unknown	Unknown	Unknown	Key logging section		
		2825 Falford-Gangee Road	Distribution	P-29	65	J-29	J-30	100	PVC		2	0	Unknown	Unknown	Unknown	Key logging section		
		2807 Falford-Gangee Road	Distribution	P-30	105	J-30	J-31	100	PVC		5	3	Unknown	Unknown	Unknown	Key logging section		
		131 Orchard Road	Distribution	P-31	33	J-31	J-32	150	PVC		0	0	Unknown	Unknown	Unknown	Key logging section		
		127 Orchard Road	Distribution	P-32	61	J-32	J-33	150	PVC		3	3	Unknown	Unknown	Unknown	Key logging section		
		120 Orchard Road	Distribution	P-33	52	J-33	J-34	150	PVC		2	2	Unknown	Unknown	Unknown	Key logging section		
		125 Samydside Drive	Distribution	P-34	3	J-34	J-35	100	PVC		0	0	Unknown	Unknown	Unknown	Key logging section		
5	Priority #4	108 Hilltop Road	Distribution	P-35	36	J-35	J-36	100	PVC		0	0	Unknown	Unknown	Unknown	Key logging section		
		120 Hilltop Road	Distribution	P-36	24	J-36	J-37	100	PVC		0	0	Unknown	Unknown	Unknown	Key logging section		
		117 Hilltop Road	Distribution	P-37	24	J-37	J-38	100	PVC		0	0	Unknown	Unknown	Unknown	Key logging section		
		136 Hilltop Road	Distribution	P-38	68	J-38	J-39	100	AC		4	4	Unknown	Unknown	Unknown	Key logging section		
		140 Hilltop Road	Distribution	P-39	79	J-39	J-40	100	AC		6	6	Unknown	Unknown	Unknown	Key logging section		
		110 Tahmany Road	Distribution	P-40	38	J-40	J-41	100	AC		0	0	Unknown	Unknown	Unknown	Key logging section		
		285 Reynolds Road	Supply	P-41	84	R-4	J-40	50	HDPE		4	4	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		285 Reynolds Road	Supply	P-42	20	R-2	J-50	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		285 Reynolds Road	Supply	P-43	66	J-50	J-51	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		285 Reynolds Road	Supply	P-44	125	J-51	J-52	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
6	N/A	120 Tahmany Road	Supply	P-45	729	J-52	J-53	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		120 Tahmany Road	Supply	P-46	73	J-53	J-54	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		120 Tahmany Road	Supply	P-47	129	J-54	J-55	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		120 Tahmany Road	Supply	P-48	283	J-55	J-56	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		120 Tahmany Road	Supply	P-49	187	J-56	J-57	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		105 Tahmany Road	Supply	P-50	260	J-57	J-58	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		105 Tahmany Road	Supply	P-51	49	J-58	J-59	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		172 Morningdale Road	Supply	P-52	22	J-59	J-60	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		184 Samydside Drive	Supply	P-53	57	J-60	J-61	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		154 Samydside Drive	Supply	P-54	75	J-61	J-62	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
7	N/A	154 Samydside Drive	Supply	P-55	136	J-62	J-63	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		154 Samydside Drive	Supply	P-56	44	J-63	J-64	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		159 Samydside Drive	Supply	P-57	63	J-64	J-65	100	AC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		132 Beaver Point Road	Supply	P-58	90	J-65	J-66	100	PVC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		143 South Ridge Drive	Supply	P-59	84	J-66	J-67	100	PVC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		155 South Ridge Drive	Supply	P-60	61	J-67	J-68	100	PVC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		169 South Ridge Drive	Supply	P-61	193	J-68	J-69	100	PVC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate
		203 South Ridge Drive	Supply	P-62	18	J-69	T-1	100	PVC		0	0	Unknown	Unknown	Unknown	Key supply main for all water	Watercourse	No Alternate

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**McElhanney**







Making a difference...together

Fulford Water Service

**GROWTH AND DEVELOPMENT ANALYSIS**

C. Sunderland

August 2011

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## 1. PURPOSE

This report serves the following purposes:

- To determine the implications for the Fulford Water Service of growth and development in the Fulford community.
- To provide a basis for staff recommendations regarding requests by land owners for inclusion of property in the Fulford Water Service Area.
- To provide a basis for staff recommendations regarding proposed development or land use changes referred to the CRD by the Islands Trust and Ministry of Transportation and Infrastructure.

## 2. GROWTH FORECAST

### 2.1 Growth in Number of Users

The Islands Trust Salt Spring Island Official Community Plan (OCP) includes the Fulford Village in the Island Villages Development Permit Area (DPA). The OCP provides the following rationale for the Island Villages DPA:

The villages of Salt Spring Island function as commercial, social and cultural centres of the community. Existing zoning means there is considerable potential for these activities to continue to grow in village areas.

Development Permit designation will guide the community's most significant, concentrated and visible new development so that it is compatible with existing buildings, with the natural environment and with community objectives for villages.

Zoning within the Area allows a high density of development which is expected to result in the creation of large new areas of impervious surfaces. In the past, such development has changed natural patterns of stormwater drainage and resulted in flooding or erosion of downslope properties.

Outside the Island Villages DPA, subdivision and development of more than two dwelling units per parcel are unlikely to occur. The current boundaries of the CRD Fulford Water Service Area (WSA) and the Fulford Village DPA are similar (Figure 1). There are three large parcels in the WSA (including the Fulford School and Childcare Centre) that fall outside the DPA, and there are five parcels (about 5 ha total) in the DPA but outside the WSA boundary.

Growth and development density in the Fulford Village area are constrained by the lack of sewer infrastructure. Of the 108 folios in the WSA, only 19 are larger than 0.5 ha and 9 are larger than 1 ha. For new development, it is unlikely that lots smaller than 1 ha can support onsite wastewater systems for more than two dwelling units or equivalent, and that lots smaller than 0.5 ha can support more than one dwelling unit.

The CRD Board may expand the boundaries of the Fulford WSA, if the owners of land near the service area petition to be included. Although the potential for growth due to expansion of the service area is difficult to estimate, such growth is entirely within the control of the CRD Board.

There are currently 104 single family dwelling unit equivalents (SFE) connected to the Fulford Water System. An estimate of the maximum probable growth in connected dwelling units (or

equivalent) is provided in Table A. It is estimated that 84 additional SFE could be connected to the water system, bringing the total to 188 SFE.

**Figure 1. Fulford Water Service Area and Development Permit Area Boundaries**



Based on the limited available historical data, the Fulford WSA has grown little, if at all, in the past decade. However, land owners in the Fulford area have recently expressed interest in inclusion and development, suggesting that there is significant near-term potential for growth. For the purpose of this analysis, it is estimated that on average, one SFE will be added annually until the area reaches 130 SFE in 2037, and that growth will slow after that date. The rate of growth will be largely governed by the decisions and recommendations of the Fulford Water Service Commission.

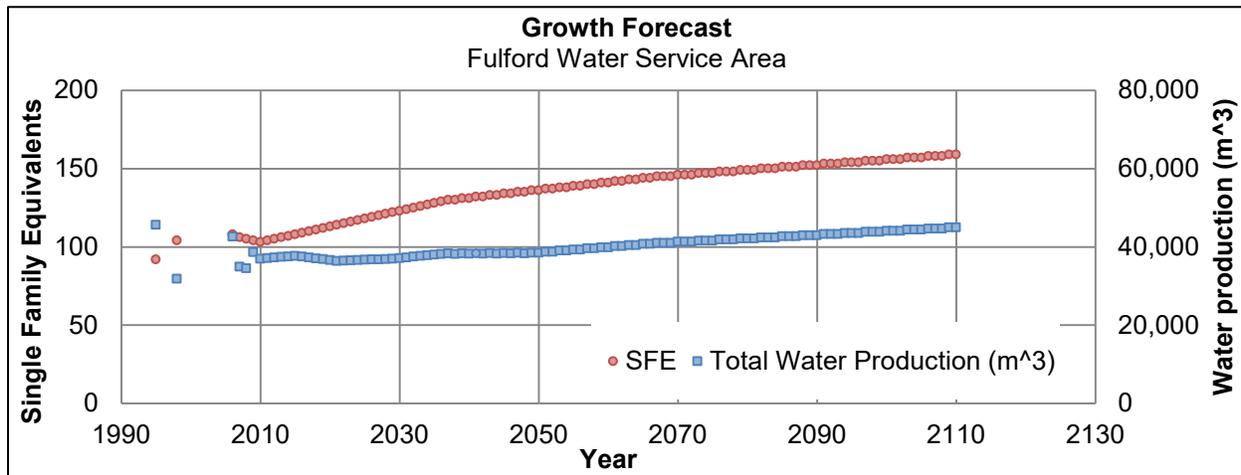
1.1 Growth in Water Demand

Customer water demand is expected to decrease steadily over the next two decades as older household fixtures and appliances are replaced with newer, more efficient ones. Leakage losses will also decline when water mains are replaced. It is assumed that the oldest water mains in the system will be replaced between 2016 and 2020. Due to these factors, overall water demand is expected to remain roughly constant until about 2050, after which it is assumed that water use per customer will remain constant and overall water use will increase proportionally with growth in the number of users. The resulting forecasts of growth in SFE and total annual water demand are shown in Figure 2.

**Table A. Estimate of Maximum Probable Growth of the Fulford Water Service**

Category	Potential SFE	Note
Unconnected lots	23	18 lots including school and Childcare Society. Assume 1 SFE per lot, except 4 for school and 3 for Childcare Society.
Secondary suites	10	Legal suites will be limited by land area and site conditions for onsite sewage systems. Assume parcels between 0.5 ha and 1 ha with >2 SFE currently (10 total) will develop suites.
Subdivision and/or redevelopment of existing parcels	36	Development will be limited by land area and site conditions for onsite sewage systems. Assume potential of 4 additional SFE per parcel larger than 1ha (9 total).
Expansion of the service area to adjacent property	15	There are 5 parcels, about 5 ha total in Islands Trust Fulford Village DPA but outside Fulford WSA. Other nearby lots may also be connected.
<b>TOTAL NEW SFE</b>	<b>84</b>	<b>(probable maximum build-out 188 SFE)</b>

**Figure 2. Growth Forecast**



**2. WATER SUPPLY CAPACITY**

The capacity of the Fulford water system to supply water to users is constrained by the source (Lake Weston and catchment lands), pumps and treatment (the treatment plant and pump stations), supply and distribution mains, pressure reducing valves and storage. The capacity of each component is assessed as follows.

**2.1 Water Source**

The Water source for the Fulford Water Service is Lake Weston, for which the CRD holds two licenses to divert a total of up to 291.6 cubic metres per day, and to store up to 49,339.6 cubic metres of water for the Fulford Water Service. A dam has not been developed; therefore none of the licensed storage is utilized and maximum day demand (MDD) directly impacts the dry season discharge flow rate from Lake Weston. MDD (calculated as total annual demand x 2.5 / 365) is not forecast to exceed 291 cubic metres before 2080.

Hydrologic parameters for Lake Weston are reported in the Salt Spring Island Water Allocation Plan published by MOE in 1993. The catchment area for Lake Weston is 170 ha, yielding about 622,000 cubic metres of inflow between November and April based on historic rainfall. Lake Weston has an estimated surface area of 18.5 hectares and volume of 1,090,000 cubic metres. During the dry summer months, there is no significant inflow to Lake Weston. Although there is no historical record to verify the natural hydrology of Lake Weston, evaporation would likely result in a natural drawdown of roughly 0.3m, and zero discharge flow from the lake between June and October.

The diversion of water for the Fulford Water Service between June and October increases the extent of drawdown of Lake Weston. On average, roughly 20,000 cubic metres are diverted between June and October, increasing the extent of drawdown by about 0.11m. Weston Lake drawdown is not expected to change significantly in the foreseeable future based on forecast growth in water demand.

**2.2 Pumps and Treatment**

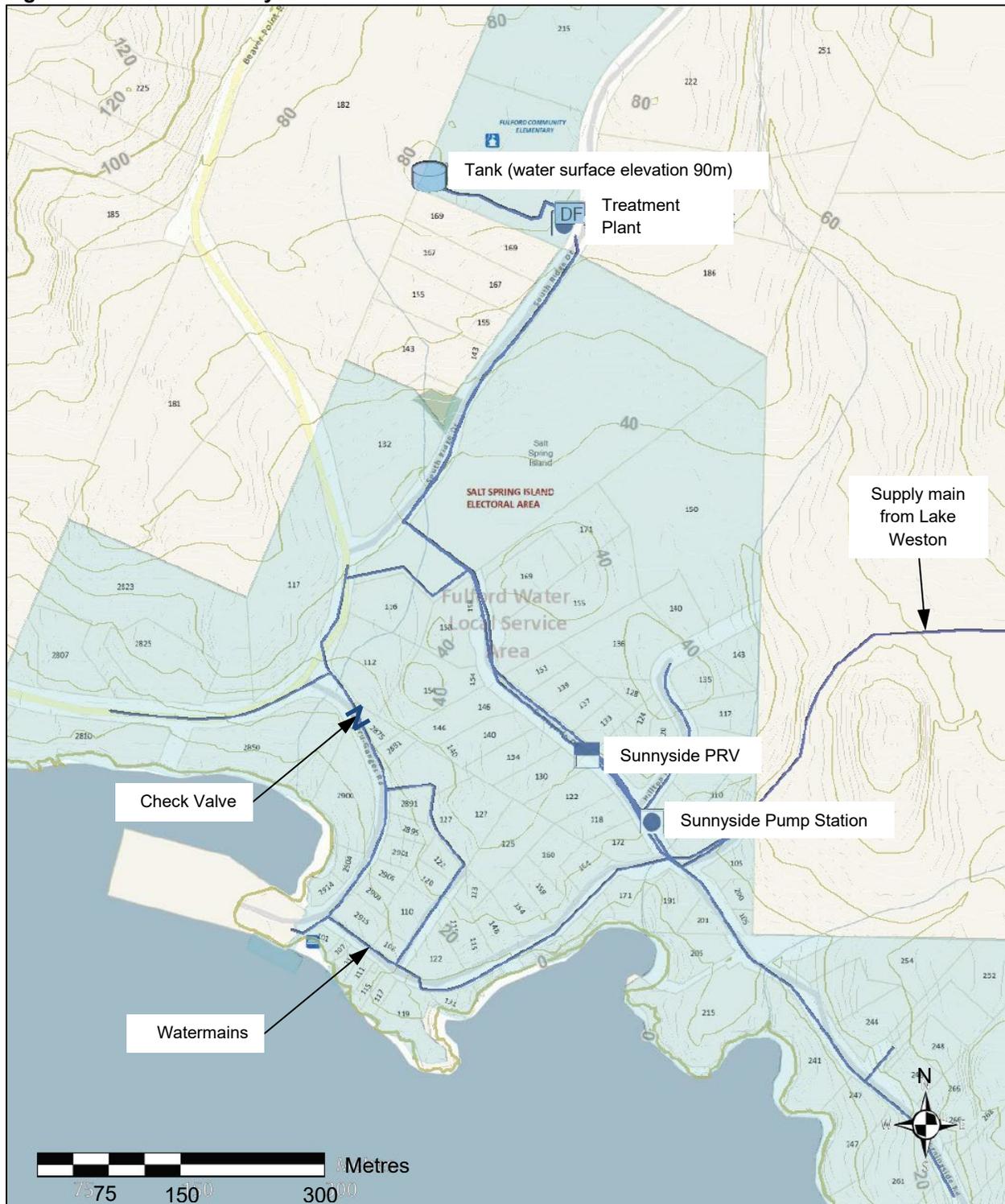
The Fulford water treatment plant, commissioned in November 2009, has a design treatment capacity of 4.5 litres per second in continuous operation. All pumps and process equipment in the plant and in the Sunnyside Drive raw water pump station are sized for the treatment flow rate. Allowing for filter backwashing, the plant has a maximum treatment capacity of at least 300 cubic metres per day, capable of meeting forecast MDD for at least several decades.

### 2.3 Supply and Distribution Mains

The raw water supply pipeline consists of about 2 kilometres of 100mm asbestos-cement (AC) pipe from Lake Weston to the Sunnyside pump station, and another 750m of AC and plastic (PVC) pipe from the pump station to the treatment plant. At the design treatment flow rate of 4.5 litres per second, the total head loss through the raw water pipeline would be an acceptable 8 metres (12 psi).

Although the Fulford water system has not been hydraulically modeled in its current configuration, all the distribution mains are likely of adequate size to meet current and projected domestic water demands with acceptable residual pressure. Some infrastructure may require upgrading to provide adequate firefighting capacity.

Figure 3. Fulford Water System Infrastructure



The Fulford distribution system was modeled for existing and potential water supply scenarios by Bullock Baur Associates Ltd. in 1998. The existing distribution arrangement is a substantial improvement over any of the modeled scenarios:

- Upon completion of upgrades on Sunnyside Drive this year, water will be delivered through a 150mm watermain from the elevated storage tank at the Fulford School (operating elevation about 90m) to the Sunnyside Drive pressure reducing valve (PRV). This main will likely be sufficient to meet current and future domestic demands, and provide recognized fire hydrant protection for residential insurance grading purposes, for the entire system. Based on the 2010 Fire Underwriters' Survey report for Salt Spring Island, this main may not be adequately sized for hydrants recognized for commercial insurance grading purposes.
- The upper pressure zone consists of relatively short 100mm branches (less than 500m) from the 150mm main on Beaver Point, Fulford-Ganges and Hilltop Roads, at elevations ranging from about 15-40m. These mains will have adequate capacity to accommodate forecast growth in domestic demand for the foreseeable future, but do not have adequate capacity for recognized fire hydrant protection.
- For the lower zone, pressure is decreased at the Sunnyside PRV (elevation 30m) from about 90psi to 45psi. This zone primarily consists of a 650m branch extending southwest along Morningside Road, and an 800m branch extending southeast along Morningside to the Village centre, and north along Fulford-Ganges Road to a check valve near Beaver Point Road. The latter includes a small loop on Orchard Road. Both branches are predominantly 100mm AC mains, at elevations of 20m or lower. The Morningside branch will have adequate capacity to accommodate growth for the foreseeable future, but does not have adequate capacity for recognized fire hydrant protection.
- The Village centre branch includes all the current commercial and institutional demands in the area, and the highest density of residential demand. This branch may not be adequately sized for future domestic demand, and does not have adequate capacity for recognized fire hydrant protection.

#### 2.4 Pressure Reducing Valves

There is currently a single pressure reducing valve (PRV) station on Sunnyside Drive, which supplies water to the entire lower pressure zone. The Sunnyside PRV manifold piping is 150mm, but the main valve is 100mm and may need to be replaced with a 150mm valve in order to meet future firefighting needs in the Village centre.

The upper and lower pressure zones are isolated at Fulford-Ganges Road by a check valve, which prevents flow from the upper zone to the lower zone but allows flow from the lower to the upper zone should the upper zone main in Beaver Point Road require isolation. In order to meet future demands in the Village Centre, and particularly to supply water for fire protection, a second PRV should be installed to replace the check valve.

#### 2.5 Storage

A 360 cubic metre treated water tank was constructed at the Fulford School in 2007, and entered service in 2009. The tank has ample capacity for balancing and emergency storage for current and long-term forecast demands, and is adequate for recognized residential fire hydrant protection. However, the storage capacity may not be adequate to provide hydrant protection recognized for commercial insurance grading purposes.

The potential water supply constraints to growth in the Fulford Village area are summarized in Table B.

**Table B. Potential Water Supply Infrastructure Constraints to Growth**

Existing Asset (2011)	Proposed Future Asset	Notes
AC main Morningside w/o Sunnyside (450m - 100mm)	150mm PVC	Necessary for fire protection, and may also be required for high peak flows from commercial facilities such as fire sprinkler systems, kitchen equipment and toilets. Existing main is near end of useful life.
AC main Fulford-Ganges east of Beaver Point (269m - 100mm)	150mm PVC	As above
AC main Orchard Rd (80m - 50mm)	150mm PVC	Short section of 50mm main should be replaced to enable Orchard Road to meet Village core demands when Fulford-Ganges is isolated for maintenance. Existing main is near end of useful life.
PVC main PRV to Hiltop (100m - 100mm)	150mm PVC	Necessary for fire protection in the lower pressure zone, and may also be required for high peak flows from commercial facilities such as fire sprinkler systems, kitchen equipment and toilets. Existing main was installed in 2005.
Sunnyside PRV station (100mm valve)	150mm valve	Necessary for fire protection in the lower pressure zone, and may also be required for high peak flows from commercial facilities such as fire sprinkler systems, kitchen equipment and toilets. Existing valve was installed in 2005.
Fulford-Ganges Road check valve	Fulford-Ganges Rd PRV station	Necessary for redundancy and likely also required for commercial hydrant protection.

Hydraulic modeling of the distribution system would be required to accurately predict the capacity of current and upgraded infrastructure to meet domestic and firefighting demands. Commercial, institutional or multi-family residential development will almost certainly be constrained by the lack of capacity for building sprinkler systems until watermains are upgraded to 150mm.

### 3. INFRASTRUCTURE EXPANSION AND REPLACEMENT COSTS AND FUNDING

The Fulford water system will require capital funding in the future to accommodate growth, and to replace aging infrastructure to sustain service to existing users. To assign costs fairly an asset replacement plan is required. Some assets of the Fulford Water Service, including 4.3 km of asbestos-cement watermains, will require replacement in the near future to maintain an acceptable level of service to existing customers. Newer assets, including the treatment plant and tank, have adequate capacity to accommodate forecast growth for at least the next 25 years. Few of the assets require upgrading to accommodate forecast growth, and those that do are generally also due for replacement.

### 3.1 Estimated Costs of Asset Replacement and Expansion

A conceptual analysis of asset replacement cost and timing is provided in Appendix A. The replacement cost of all the existing assets is estimated to be \$7.2 million, including \$4.5 million for watermains (including engineering and contingency). It is estimated that \$3.4 million will need to be expended between 2012 and 2027, of which \$2.6 million is for replacement of watermains. Some of these mains will also require replacement with larger mains to accommodate growth, primarily to provide adequate water supply for fire protection in the Village core. Since the mains will require replacement before larger mains are likely to be required for new development, it is assumed that only a small proportion of the replacement cost (5 percent) may reasonably be attributed to new users.

Replacement or construction of other assets will likely be driven largely by growth and development, including:

- 100mm PVC watermain between Sunnyside PRV and Hilltop intersection, serving the low pressure zone, installed 2005 but inadequately sized to provide fire hydrant protection to the low pressure zone
- 100mm main PRV in the Sunnyside PRV station. The building and manifold piping are sized for a 150mm PRV. The main PRV assembly would need to be upgraded to 150mm to provide recognized fire hydrant protection for commercial and institutional structures in the Village core.
- 100mm check valve at Fulford-Ganges Road will likely require replacement with a 150mm PRV to provide commercial hydrant protection in the Village core.

It is assumed that the value of these upgrades is equally shared between new development and existing users, so 50 percent of the cost is attributed to new users.

Based on the foregoing, the estimated cost of capital projects necessary to accommodate growth between 2012 and 2027 in the Fulford water system is \$130,000, including engineering and contingency. This represents 1.8 percent of the total capital expenditure anticipated in the same timeframe. The remainder is associated with replacing assets at the end of their useful life, for the benefit of existing users.

### 3.2 Cost Recovery for Development and Service Area Expansion

The options available for recovering capital costs related to growth and development (development cost charges, or DCCs) are governed by Division 10 of the *Local Government Act*. DCCs may be levied to recover all or a portion of the costs of infrastructure projects required to accommodate growth. DCC revenue may not be applied to projects that are not required due to growth. Growth estimates, capital plans and budgets must be prepared for a specific timeframe. DCCs may be levied upon on approval of subdivision, or issuance of a building permit. Separate DCC categories are permitted for different land uses, but are subject to several restrictions and exclusions. DCC revenues and expenditures must be accounted separately from other revenues and expenditures of the service, and must be reported annually.

The economic, social and environmental impacts, of a proposed DCC must be considered. A DCC should not deter the development of social housing or low environmental impact development. DCCs may be reduced or waived for development of these types.

Charges may also be imposed at the time a land owner petitions the Regional District for inclusion in a service area. If a DCC is implemented, the cost of expanding the infrastructure

to accommodate the *existing* use of parcels to be included in the service area must also be considered (not proposed future uses). Any future development of the included property would then be subject to a DCC. Charges negotiated as a condition of inclusion should consider the following costs:

- The equivalent to the DCC, based on existing use of the land to be included.
- The cost of the inclusion process, including analysis, preparation and presentation of reports, and preparation of Bylaws.
- The costs of infrastructure extension and connection to provide service to each parcel of land to be included (in accordance with Fee and Charge and Regulation Bylaws).

#### 4. ALTERNATIVES

The following alternatives are considered fair and reasonable approaches to sharing capital costs between existing and new users of the Fulford Water Service:

##### 4.1 Implement a Development Cost Charge and Inclusion Charge

Charges may be imposed for development within the service area, and for inclusion of new users in the service area, in accordance with the following or similar structure:

• DCC planning timeframe	2012-2027
• Forecast single-family residential growth (SFE)	12
• Forecast other growth (SFE)	4
• Total estimated cost of projects attributed to growth	\$129,376
• Cost per SFE	\$8,086
• Discount – single family residential	50%
• <b>DCC – residential, per SFE</b>	<b>\$4,043</b>
• <b>DCC – other, per SFE</b>	<b>\$8,086</b>
• Total estimated DCC revenue, 2012-2027	\$80,860

A DCC would be imposed when a building permit is issued within the service area. DCCs in the “other” category would be assigned based on an estimate of SFE by the General Manager. For land included in the service area, a charge equivalent to the DCC based on existing use, plus the actual cost of staff services related to the inclusion, would be levied.

For new residential SFE added to the service area, a 50% discount on the DCC is suggested to avoid a deterrent effect. A DCC in the range of \$8,000 per SFE is assumed to be less likely to deter commercial or institutional development.

##### 4.2 Status Quo

The annual cost of service during the DCC planning timeframe is forecast to be in the range of \$4,000 (of which \$2,800 is capital expense to replace aging infrastructure). Given that the Fulford source and most of its infrastructure have unused capacity there is a strong financial incentive to increase the number of users to share the burden of operating and asset replacement costs.

There will be an added cost to implement and administer a DCC, which must be recovered in the annual cost of service. Given the small size of the service area and the small proportion of capital expense attributable to growth, it is likely that the reduction in annual cost achieved

by the DCC (about \$60 per parcel per year) would be largely offset by increased administrative costs. A decision to implement a DCC may be deferred until it is more clearly necessary. In the interim, a water distribution hydraulic model and formal asset management plan may be completed to better define the costs attributable to growth and development.

## 5. CONCLUSIONS

The following conclusions are drawn from this analysis:

- Growth in the Fulford water system is forecast to occur at a rate of about one SFE per year in the next 15 years.
- Reductions in water demand due to watermain replacement and household fixture and appliance replacement will likely offset the addition of new users, resulting in no significant change in overall annual demand in the next 15 years.
- The water source, supply main, treatment plant, pumps and tank are adequately sized to accommodate growth and development for at least the next 15 years.
- Some distribution mains and valves will likely require upgrading in the next 15 years to accommodate peak flows due to new development. In particular, adequate water supply for fire protection will likely be a condition of approval for commercial, institutional or multi-family residential development.
- Since the need to replace most watermains in the next 15 years is primarily driven by their age and condition, only five percent of the replacement cost of old AC mains should be attributed to new development.
- The total project cost attributable to growth and development in the next 15 years is estimated to be about \$130,000. A Development Cost Charge and Inclusion Charge in the range of \$4,000 to \$8,000 per SFE could be implemented to recover the anticipated costs of growth and development over the next 15 years.
- There is a strong economic incentive for existing users to increase the user base of the Fulford Water Service, in order to share fixed capital and operating costs among more users, and a DCC and inclusion charge may deter growth. Added to the deterrent effect that a DCC and inclusion charge may have, the administration cost of a DCC program may outweigh its benefit to existing users.

## 6. RECOMMENDATIONS

- Defer implementation of a Development Cost Charge and Inclusion Charge to recover infrastructure costs, and revisit the need for such charges in two to five years.
- Require applicants for inclusion of land in the Fulford Water Service Area to pay the following costs, including a deposit in advance based on an estimate:
  - The cost of the inclusion process, including analysis, preparation and presentation of reports, and preparation of Bylaws.
  - The costs of infrastructure extension and connection to provide service to each parcel of land to be included (in accordance with Fee and Charge and Regulation Bylaws).
- Complete a hydraulic model of the water distribution system as a basis for design of upgrades to meet anticipated water supply capacity constraints, including fire flows; and incorporate the findings of the hydraulic model in an asset replacement plan and cost recovery model.

**APPENDIX A – CONCEPTUAL ASSET REPLACEMENT ANALYSIS**

**CONCEPTUAL ASSET REPLACEMENT ANALYSIS**

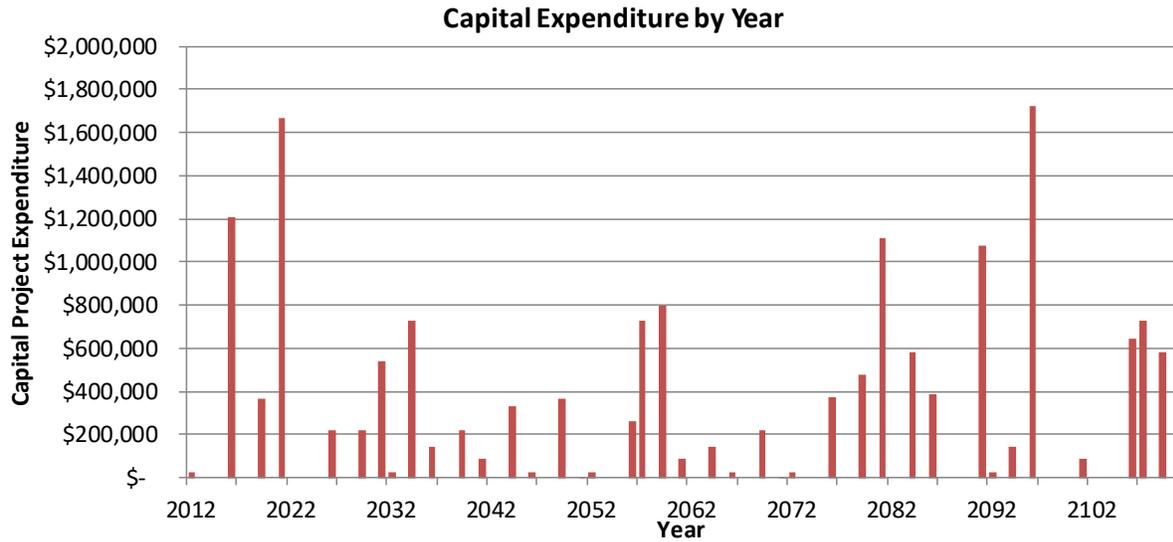
August 2011

Fulford Water Service, Salt Spring Island

**Assumptions**

- Assets are replaced when they reach the end of their useful life
- Reserves above the minimum balance are contributed directly to capital costs as they occur
- The balance of annual capital costs after reserve funding is financed over 15 years through MFA (assume 6% interest)
- Annual cost of service is held constant at a level sufficient to pay operating and debt costs and maintain reserves
- Pipe lifespans are from CRD Juan de Fuca water service asset database; other asset lifespans are per PSAB 3150 standard
- Remaining lifespans are based on known or estimated asset age, and service history where available

Existing Asset (2011)	Estimated remaining lifespan (years)	Proposed Future Asset	Qty	Estimated lifespan (years)	Estimated Replacement Cost (\$ 2011)	Proportion of cost related to capacity	Cost of work required for capacity increase
AC raw waterline to PS (2026m - 100mm)	10	150mm PVC	2,026	75	\$ 810,400	0%	\$ -
AC raw waterline Sunnyside (283m - 100mm)	10	150mm PVC	283	75	\$ 141,500	0%	\$ -
PVC raw waterline Sunnyside to WTP (463m - 100mm)	70	150mm PVC	463	75	\$ 231,500	0%	\$ -
AC main Morningside s/o Sunnyside (465m - 100mm)	20	150mm PVC	465	75	\$ 232,500	0%	\$ -
AC Main Sunnyside PRV to end Hilltop (278m - 100mm)	10	150mm PVC	278	75	\$ 139,000	0%	\$ -
AC main Morningside w/o Sunnyside (450m - 100mm)	5	150mm PVC	450	75	\$ 450,000	5%	\$ 22,500
AC main Fulf-Gang e/o Bvr Pt (269m - 100mm)	5	150mm PVC	269	75	\$ 134,500	5%	\$ 6,725
AC main Bvr Pt N to Sunnyside (269m - 100mm)	20	150mm PVC	269	75	\$ 134,500	0%	\$ -
AC main Orchard Rd (222m - 100mm)	5	150mm PVC	222	75	\$ 111,000	0%	\$ -
AC main Orchard Rd (80m - 50mm)	5	150mm PVC	80	75	\$ 40,000	5%	\$ 2,000
PVC main tank to Sunnyside (645m - 150mm)	70	150mm PVC	645	75	\$ 322,500	0%	\$ -
PVC main Sunnyside w/o PRV (192m - 150mm)	75	150mm PVC	192	75	\$ 96,000	0%	\$ -
PVC main PRV to Hilltop (100m - 100mm)	70	150mm PVC	100	75	\$ 50,000	50%	\$ 25,000
PVC main Hilltop to Morningside (40m - 150mm)	70	150mm PVC	40	75	\$ 20,000	0%	\$ -
PVC main WTP to tank (167m - 100mm)	70	150mm PVC	167	75	\$ 83,500	0%	\$ -
PVC main Orchard Rd (47m - 150mm)	65	150mm PVC	47	75	\$ 23,500	0%	\$ -
PVC main Fulf-Gang w/o Bvr Pt (241m - 100mm)	75	150mm PVC	241	75	\$ 120,500	0%	\$ -
HDPE long service Tahouney (46m - 50mm)	75	50mm PVC	68	75	\$ 34,000	0%	\$ -
PVC long service 248-252 Morningside (46m - 50mm)	45	50mm PVC	46	75	\$ 23,000	0%	\$ -
6" Hydrant (3)	15	6" hydrant	3	20	\$ 15,000	0%	\$ -
Standpipe / 4" Hydrant (14)	10	6" hydrant	8	20	\$ 40,000	0%	\$ -
Tank (360m <sup>3</sup> bolted steel)	33	Tank (360m <sup>3</sup> bolted steel)	1	35	\$ 230,000	0%	\$ -
Sunnyside pump station	15	Sunnyside pump station	1	50	\$ 75,000	0%	\$ -
Sunnyside PRV station	45	Sunnyside PRV station	1	50	\$ 60,000	5%	\$ 3,000
Fulford-Ganges Rd check valve	15	Fulford-Ganges Rd PRV station	1	50	\$ 60,000	50%	\$ 30,000
Lake Weston intake structure	10	Lake Weston intake structure	1	20	\$ 20,000	0%	\$ -
Reynolds Rd Chlorinator station	1	Reynolds Rd screen station	1	20	\$ 15,000	0%	\$ -
Curb stop (85)	5	Meter assembly	85	20	\$ 85,000	0%	\$ -
Meter assembly (11)	5	Meter assembly	11	20	\$ 12,100	0%	\$ -
Air valve (5)	20	Air valve (5)	5	20	\$ 5,000	0%	\$ -
Treatment plant buildings	46	Treatment plant buildings	1	50	\$ 500,000	0%	\$ -
Treatment process equipment	23	Treatment process equipment	1	25	\$ 400,000	0%	\$ -
Controls and instrumentation	8	Controls and instrumentation	1	10	\$ 150,000	0%	\$ -
SCADA system	8	SCADA system	1	15	\$ 100,000	0%	\$ -
Engineering and Contingency	45%	of construction cost			\$ 2,234,250	2%	\$ 40,151
Grant funding							
Total Estimated Asset Replacement Cost					\$ 7,199,250		\$ 129,376

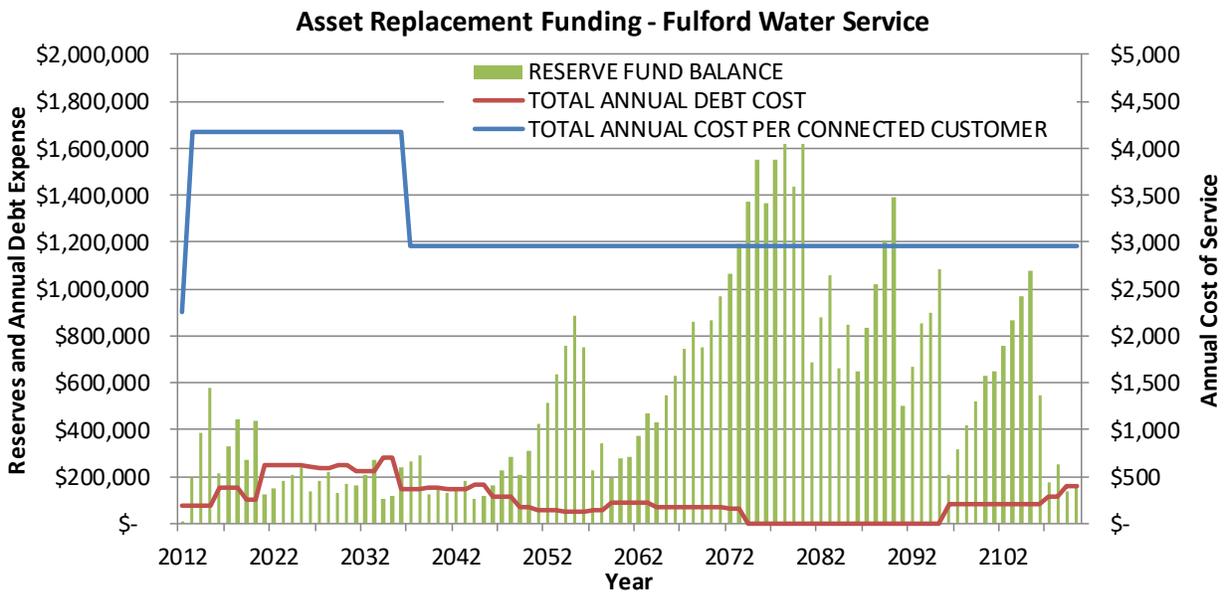


**Inclusion/Development Cost Charge Parameters**

DCC plan timeframe	<b>2012</b>	to	<b>2027</b>
Capital expense required to service 120 SFE (2027):	<b>\$ 129,376</b>		
Total SFE added:	16		
Assist Factor	<b>50%</b>		
Cost per SFE added (DCC/inclusion charge):	<b>\$ 4,043</b>		

**Annual Cost of Service Parameters** (total annual cost per connected single-family residential parcel)

Asset Renewal Phase (years)	<b>25</b>	Minimum Reserve Fund Balance	<b>\$ 100,000</b>
Target Annual Cost (asset renewal phase)	<b>\$ 4,170</b>	Target Annual Cost (long term)	<b>\$ 2,950</b>
		Is Target Sustainable?	<b>YES</b>



**APPENDIX B – REFERENCES**

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## REFERENCES

1. Hendren, Gary and Richard Edwards. Fulford Harbour Waterworks District, Salt Spring Island, BC (Feasibility Study for Conversion). Capital Regional District. April 2004.
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5. Fire Underwriters Survey Final Report – Salt Spring Island Fire Protection District. Fire Underwriters Survey. February 5, 2010.
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9. Salt Spring Island Official Community Plan Bylaw No. 434, 2008. Islands Trust. Adopted October 2, 2008.
10. Budget documents and Bylaws of the Fulford Water Service. Capital Regional District. Viewed August 2011.