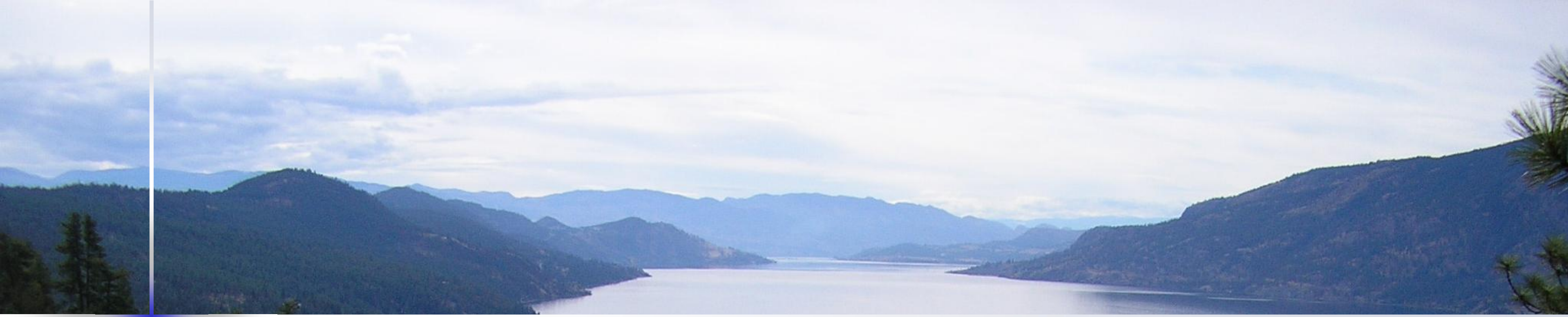


Understanding Threats to Groundwater in Okanagan Basin: Vulnerability and Sustainability

Diana M. Allen

Simon Fraser University, Burnaby, BC, Canada

Water Supply in Okanagan Basin

Total population in 1971= 115,000

Total population in 2001= 317,000

Total population in 2031 = 450,000

- Okanagan Basin is among the highest water users (domestic) in Canada and the world
- In addition, agriculture generally demands as much as 70% of total water use in the Okanagan Valley.

MAJOR CHANGES IN LAND USE ACTIVITIES 1971-2001

Growth Indicators	1971	2001	% Increase
Population	115'000	317'000	175%
Golf Courses	7	50	600 %
Ski Resorts	4	8	100 %
Wineries	< 12	82	580 %
Grape Production Area	955 ha	2286 ha	240%
Water Storage Systems	81	147	81%

Courtesy of H. Schreier, UBC

The Growing Demand on Water

- Number of streams "fully recorded" = 235 of 300
- Groundwater is becoming an attractive resource to meet the growing water needs of this region

BUT

- Little is currently known about the resource
- As the demand for groundwater increases, it will become increasingly important to consider the threats to this resource

Overview

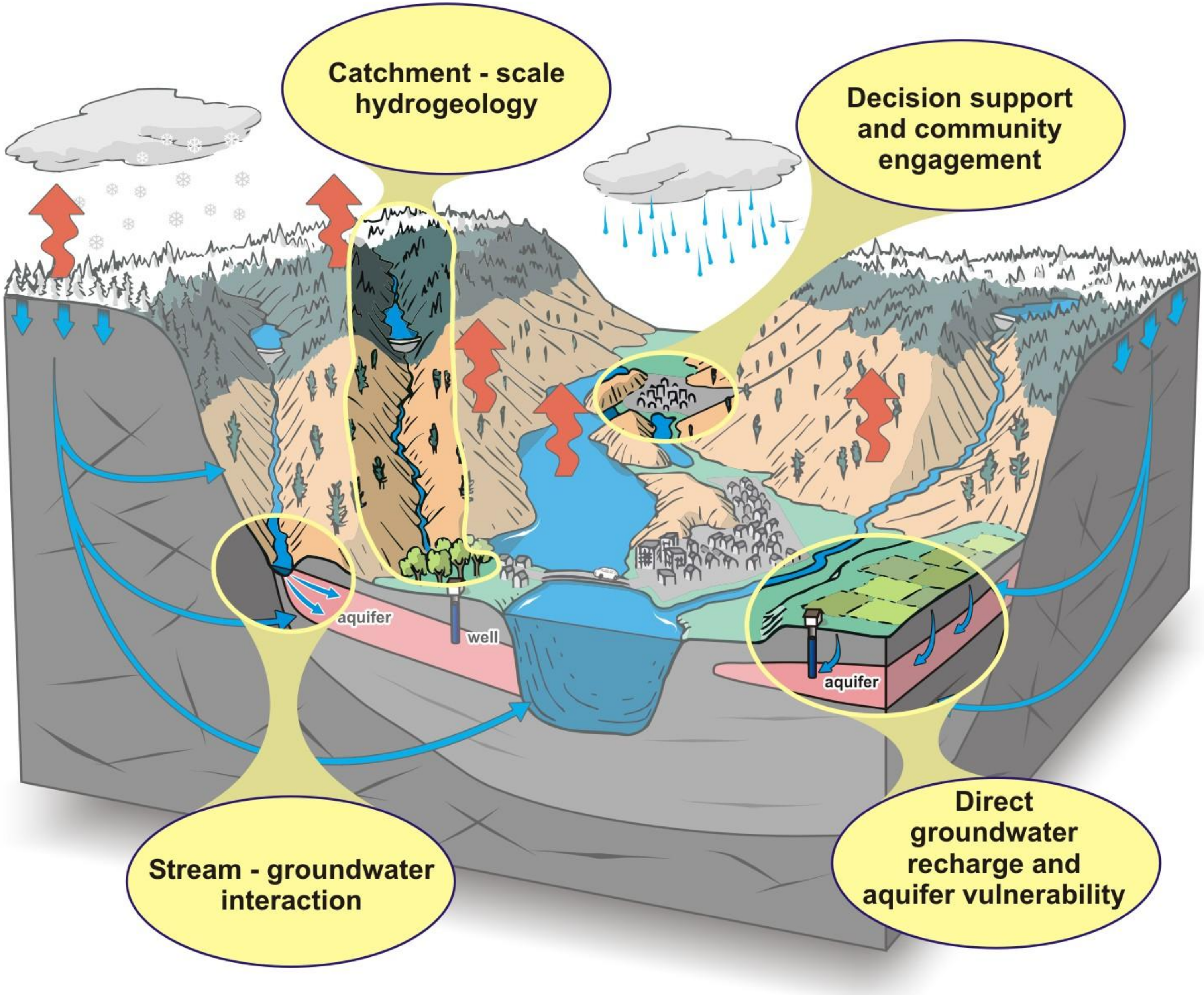
- The Goals of our Canadian Water Network Project
- Main threats to groundwater:
  - Vulnerability to Contamination
  - Sustainability of the Resource
- Examples from the Oliver Region

Goals of CWN Project

- CWN researchers are contributing to science knowledge about groundwater, particularly groundwater recharge
- The PATHWAYS researchers in our CWN project have partnered with Smart Growth on the Ground in Oliver to ensure that this knowledge is effectively transferred to local decision makers.

"A Basin Approach to Groundwater Recharge in the Okanagan: Bridging the Gap Between Science and Policy"

Canadian Water Network projects



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Project Researchers

- Diana Allen (SFU) – Jessica Liggett, Mike Toews, Hendrik Voeckler
- Steve Grasby (GSC) – Brian Smerdon
- Adam Wei and Jeff Curtis (UBC-O)– Natasha Neumann
- Murray Journeay, Shannon Denny (GSC)
- Nick Hedley (SFU)– Cyrille Medard de Chardon
- Craig Forster (U Utah)
- Alge Merry (Waterloo Hydrogeologic Inc.)

Vulnerability of Aquifers to Contamination

- All aquifers are susceptible to contamination, some more than others
- The degree to which an aquifer can become contaminated depends on two main factors:
  - Is there a source of contamination?
  - How susceptible is the aquifer to that contamination?

Sources of Contamination

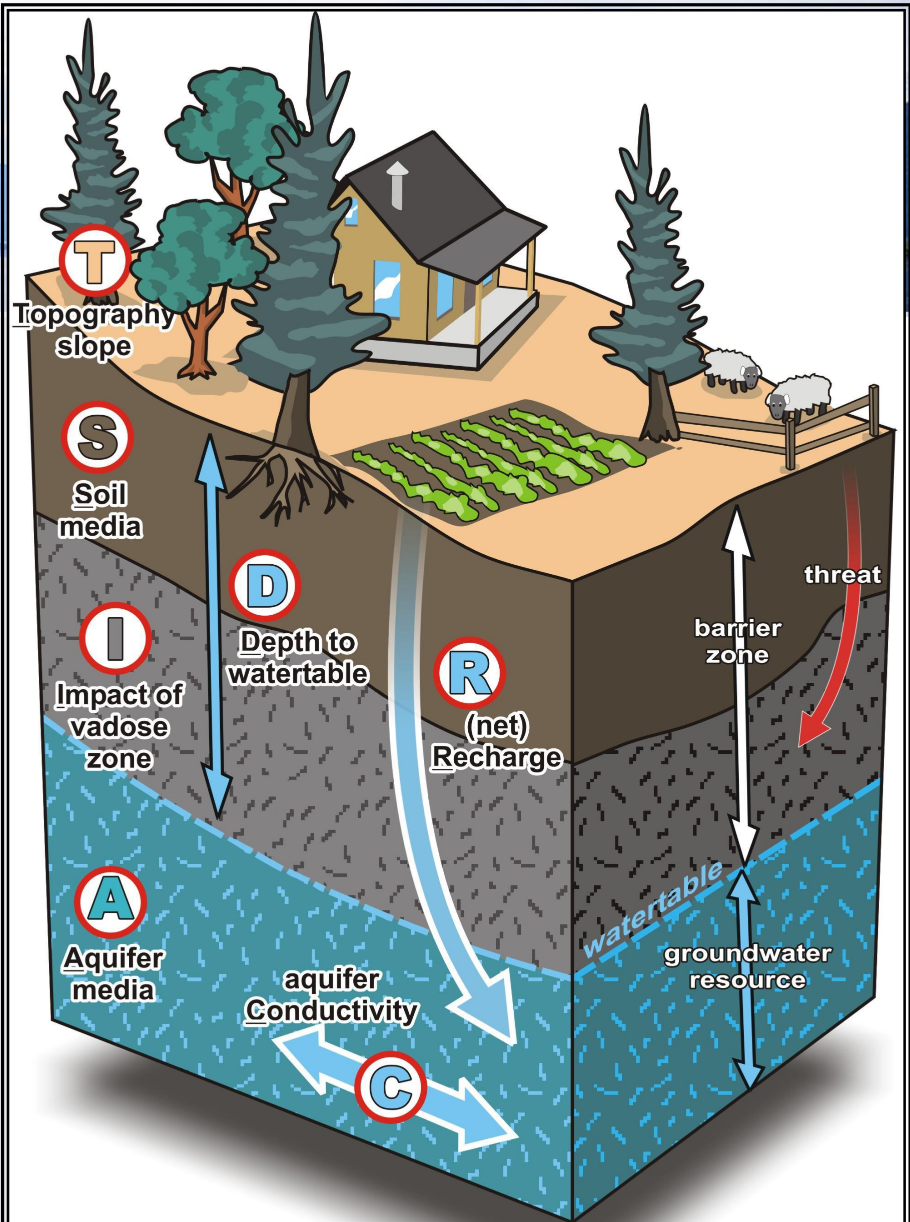
- There are a number of potential sources of contamination.
  - Agriculture-related (pesticides, herbicides, manure, fertilizer)
  - Waste disposal sites (e.g., Landfills, septic)
  - Industrial-related (e.g., storage tanks)
  - Transportation Routes (salt, hazardous spills)
- A map or listing of all potential sources of contamination form a hazard inventory

Susceptibility to Contamination

- Depends on the intrinsic properties of the aquifer, such as:
  - the permeability of the overlying soils and aquifer media,
  - whether the aquifer is confined or unconfined,
  - depth of water table,
  - how much water enters the aquifer - recharge
- We can map these properties to show areas that are more susceptible to contamination than others.
- These are called aquifer susceptibility maps, or more generally, aquifer vulnerability maps.

Vulnerability Mapping using DRASTIC

- DRASTIC developed by US EPA (1987) to evaluate relative vulnerability
- Assumptions:
  - Downwards movement of contaminant
  - Contaminant is conservative
  - Contaminant moves with same rate as water
- Spatially distributed vulnerability

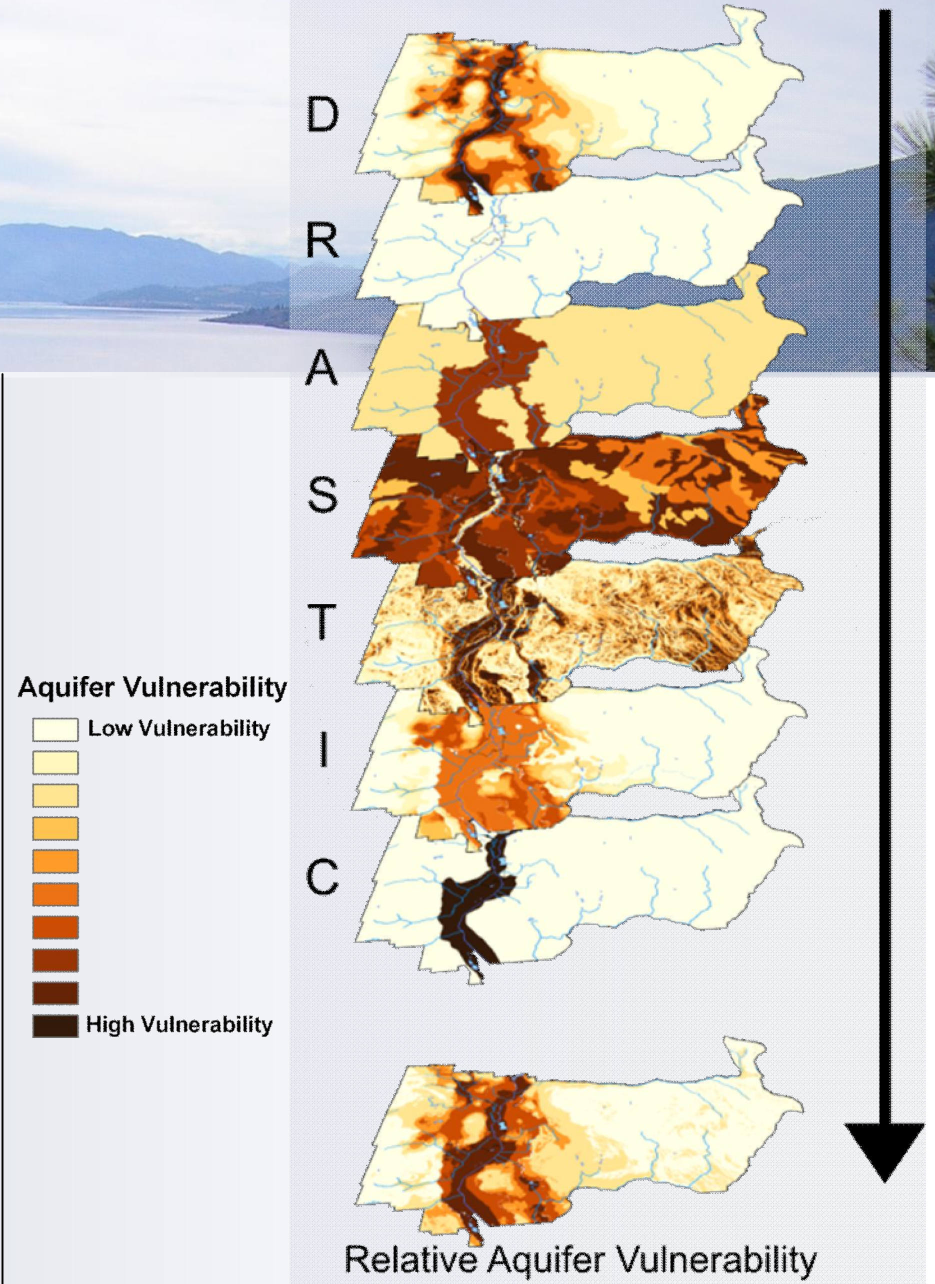


Courtesy of B. Turner, and R. Franklin (GSC). Modified by C. Médard de Chardon

DRASTIC

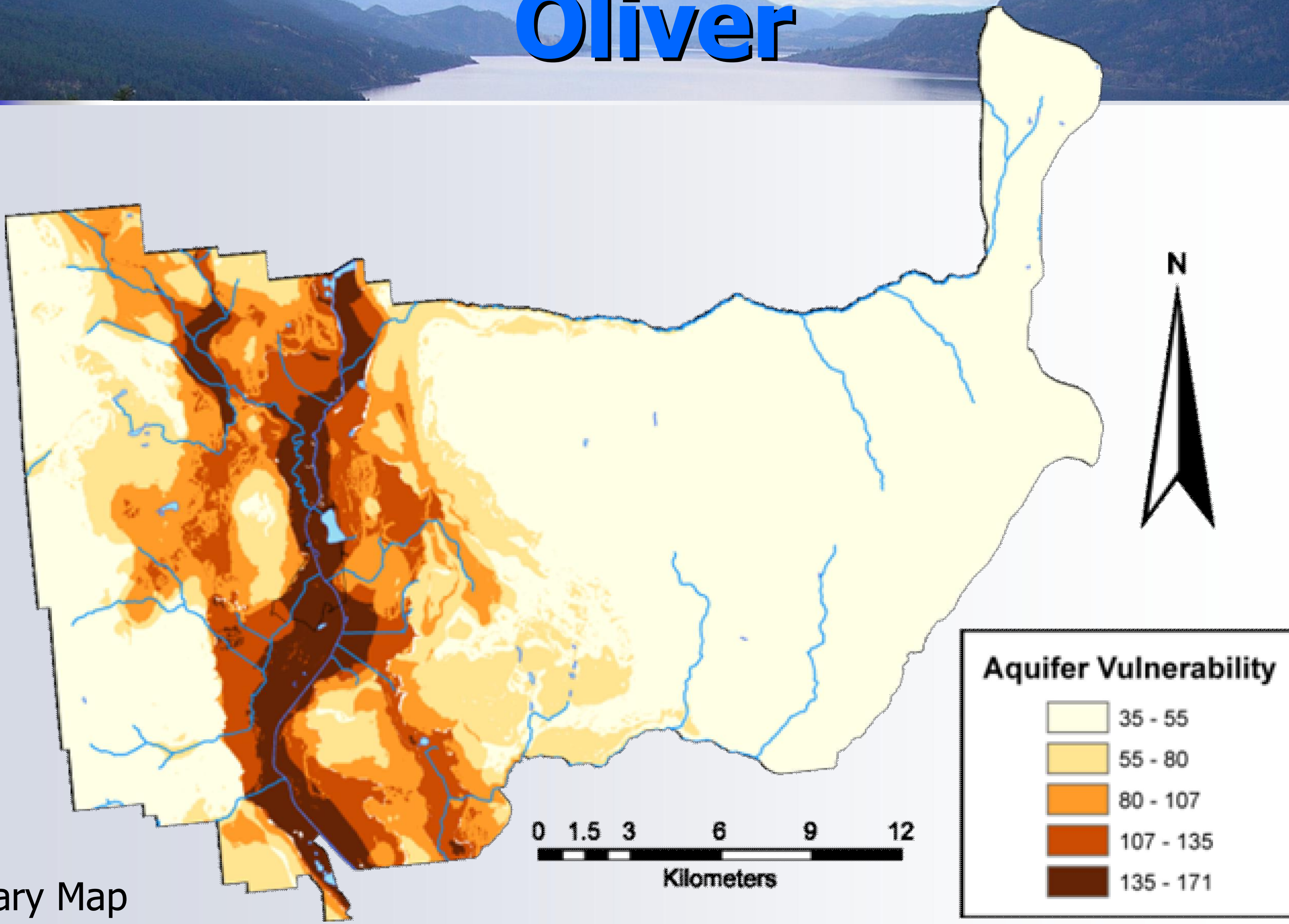
Example:

Depth to water range (m)	Rating
0 - 1.5	10
1.6 - 4.6	9
4.7 - 9.1	7
9.2 - 15.2	5
15.3 - 22.9	3
23 - 30.5	2
30.6 +	1



Vulnerability = (5)D + (4)R + (3)A + (2)S + (1)T + (5)I + (3)C

Aquifer Vulnerability in Oliver



Preliminary Map

An Integrated Assessment Framework

Hazard Assessment

1. **Hazard inventory**
   past event: catalog
2. **Hazard potential**
   future event:
   probability, location

Vulnerability Assessment

1. **Exposure to damage**
2. **Susceptibility to damage**

environment, human, facility

Risk Assessment

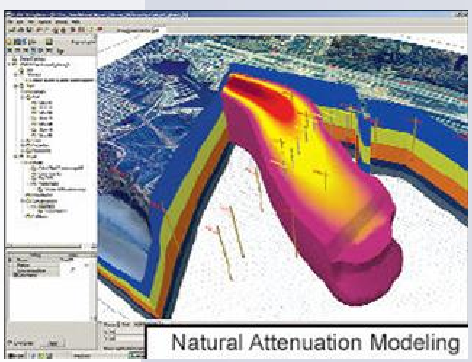
1. **Losses**
2. **Costs**

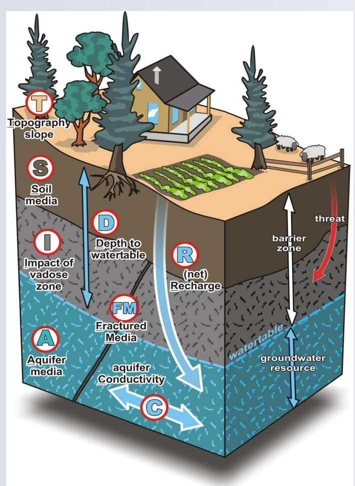
environment, human
facility, economy

Strategic Planning

1. **Land use scenario**
2. **Other scenarios**
   - economic,
   - demographic, etc.

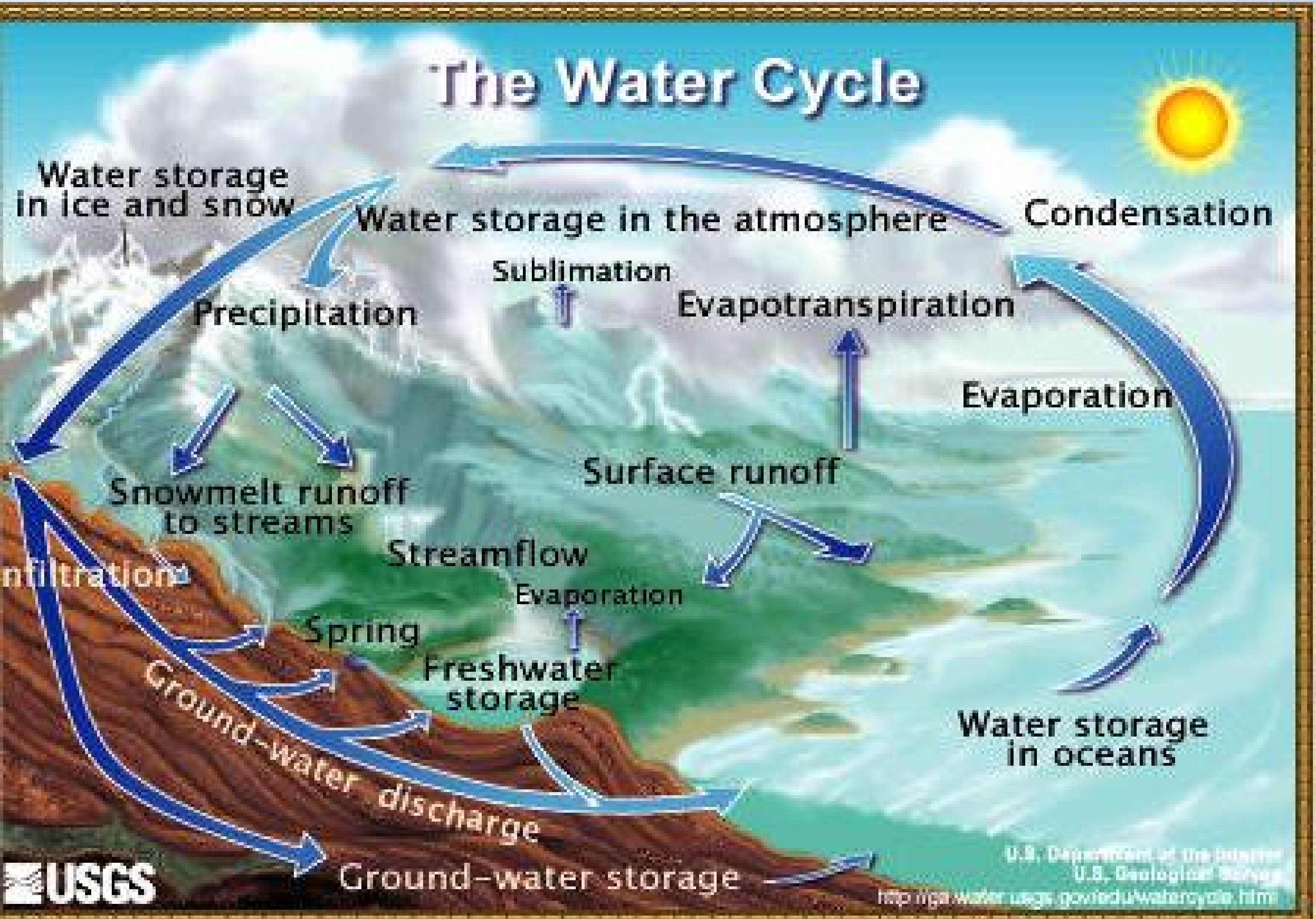
current and future





Groundwater Sustainability

- Groundwater is an important component of the hydrologic cycle



The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Surface runoff
Snowmelt runoff to streams
Streamflow
Infiltration
Evaporation
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
USGS
Ground-water storage

Groundwater and Surface Water are Connected

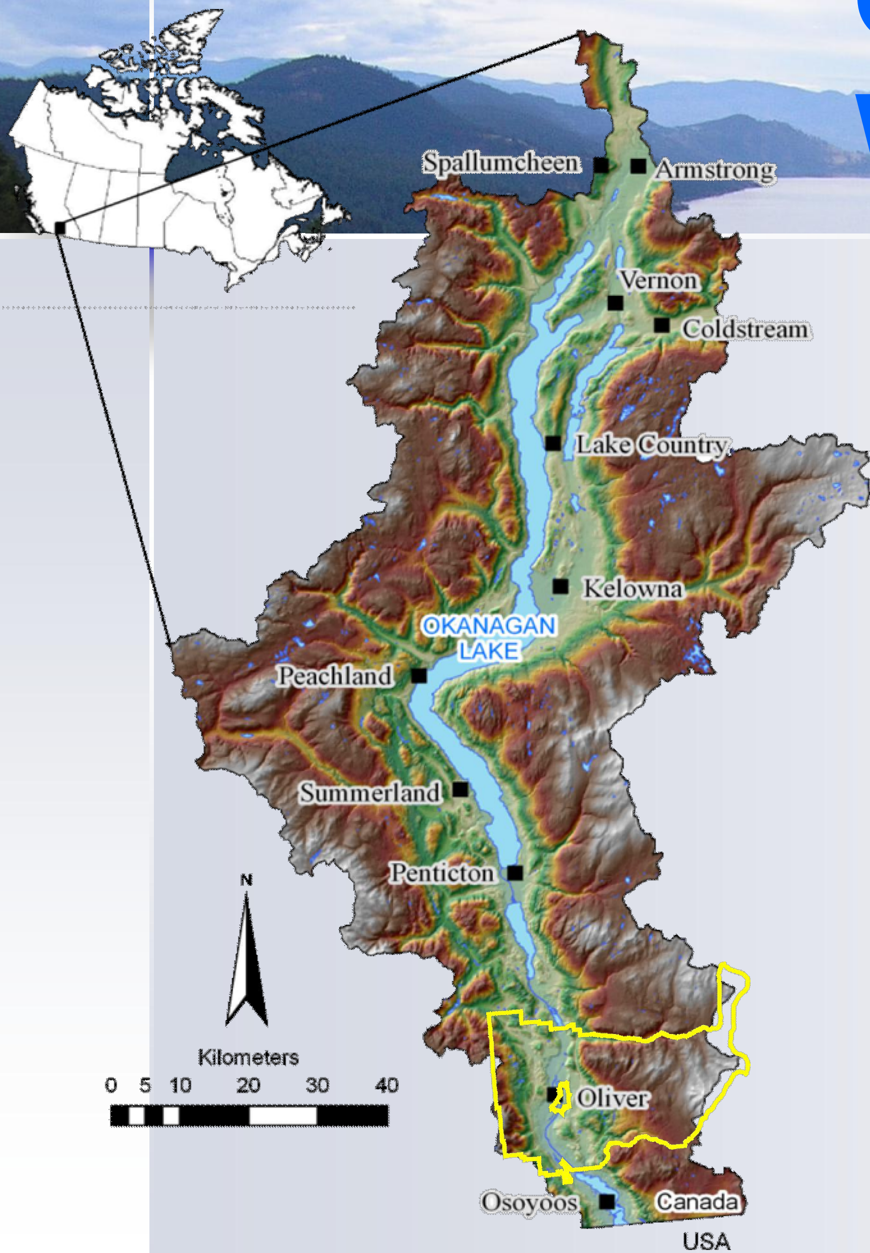
- Surface streams in the Okanagan interact with groundwater.
  - Streams supply water to the subsurface at the edges of the valley
  - Some streams gain water from groundwater
- Take away from one, and you take away from the other
- Placing a well near a stream effectively takes water from that stream

Long Term Sustainability

- A full accounting of water supply in Okanagan Basin must consider groundwater
  - How much groundwater is there in storage?
  - How much is replenished each year?
  - How much is available for use?
- How will increased demand affect the resource?

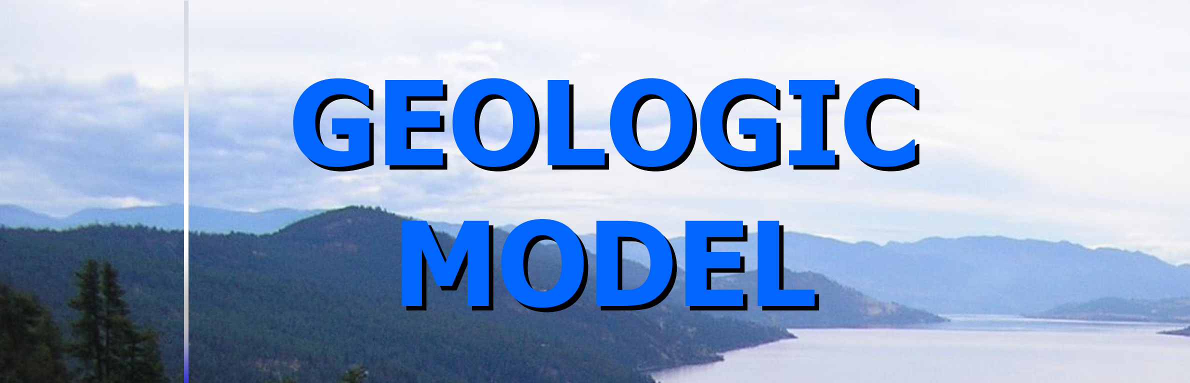
  More wells, more chances for conflict both between well users and with surface water
- How will climate change affect the resource?

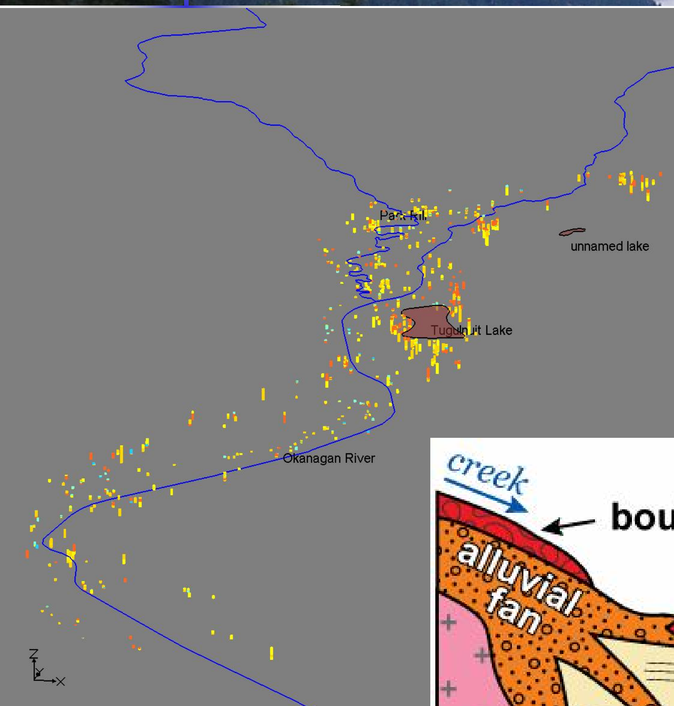
Oliver Water Supply

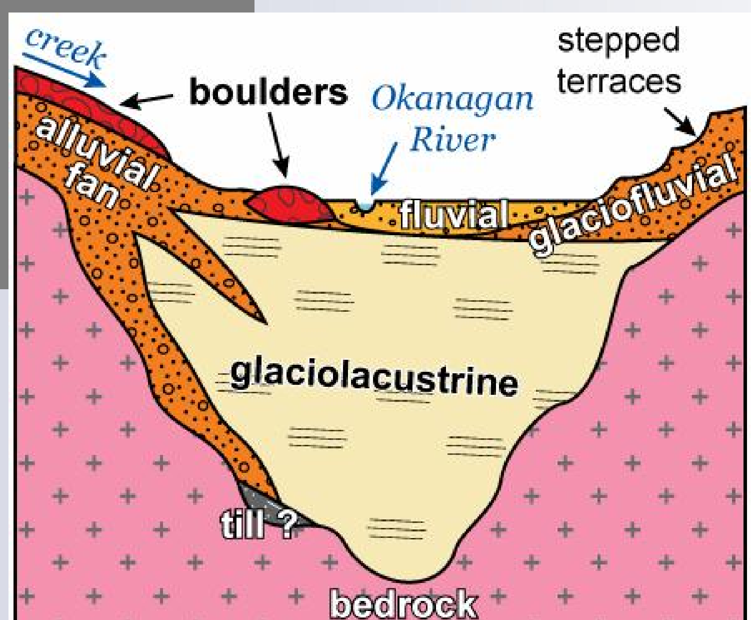


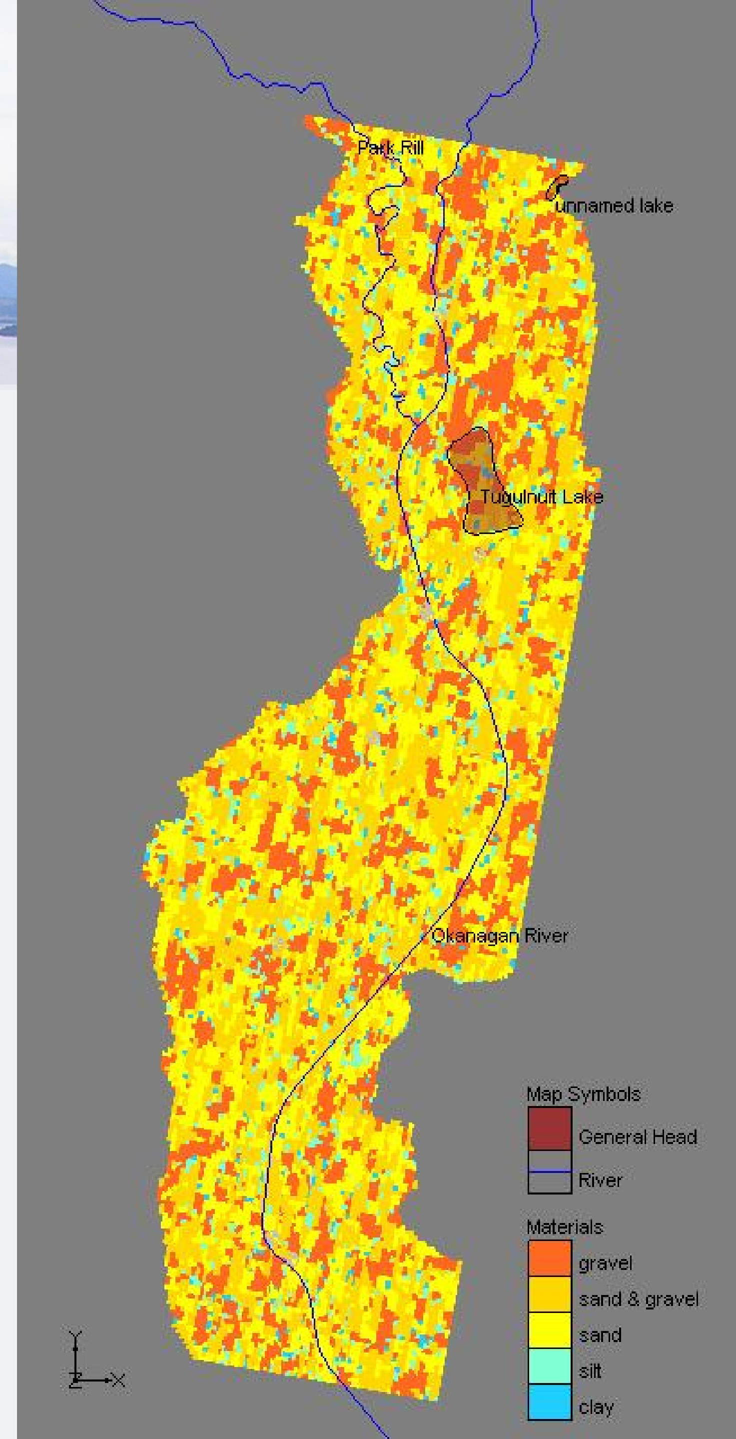
- Oliver is situated in the very dry southern Okanagan
- Oliver municipal water supply is comprised of six water wells and a reservoir
- The "Ditch" continues to supply irrigation and domestic water to Oliver's rural residents
- Oliver's municipal water system tends to operate at or near capacity

GEOLOGIC MODEL

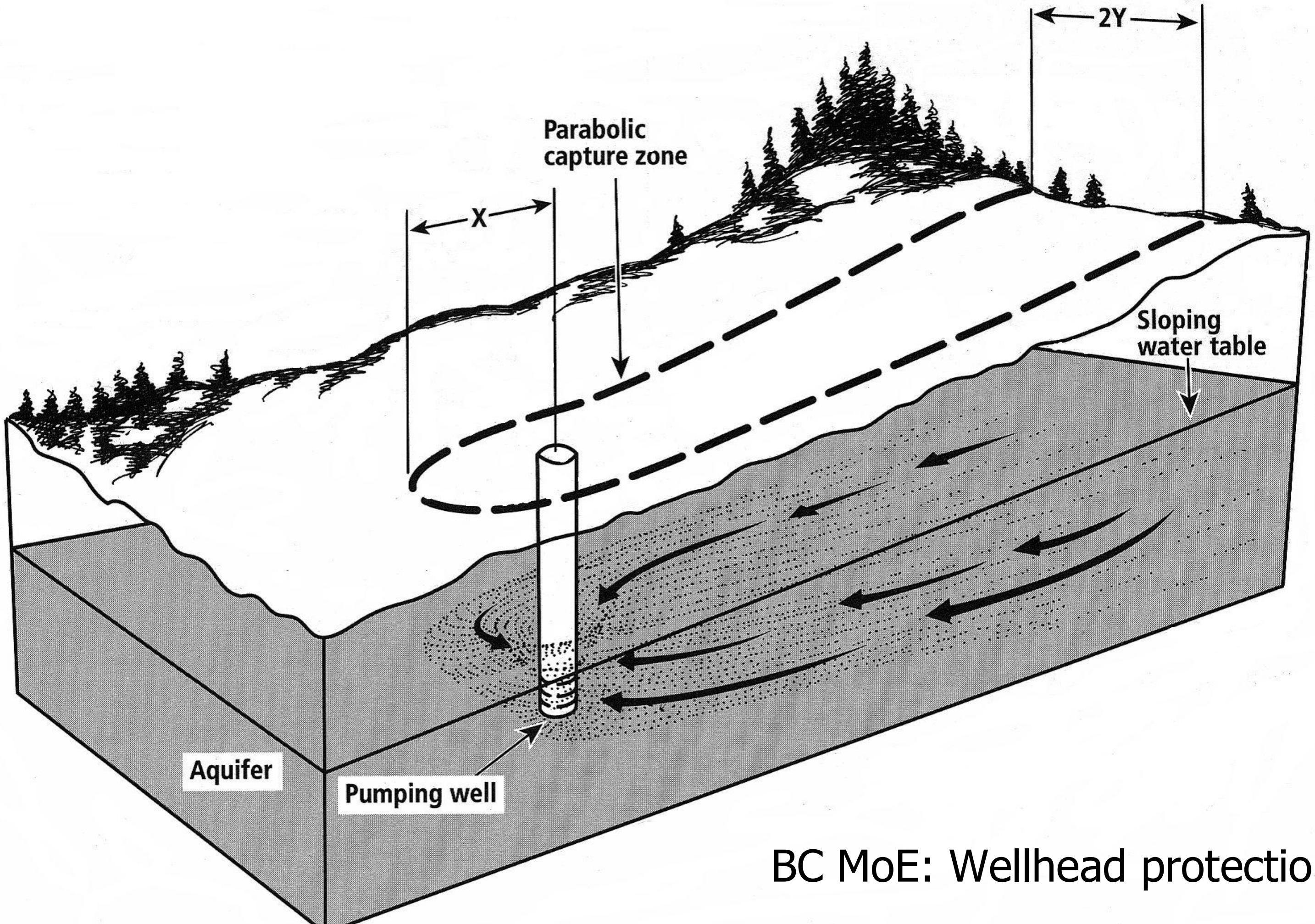








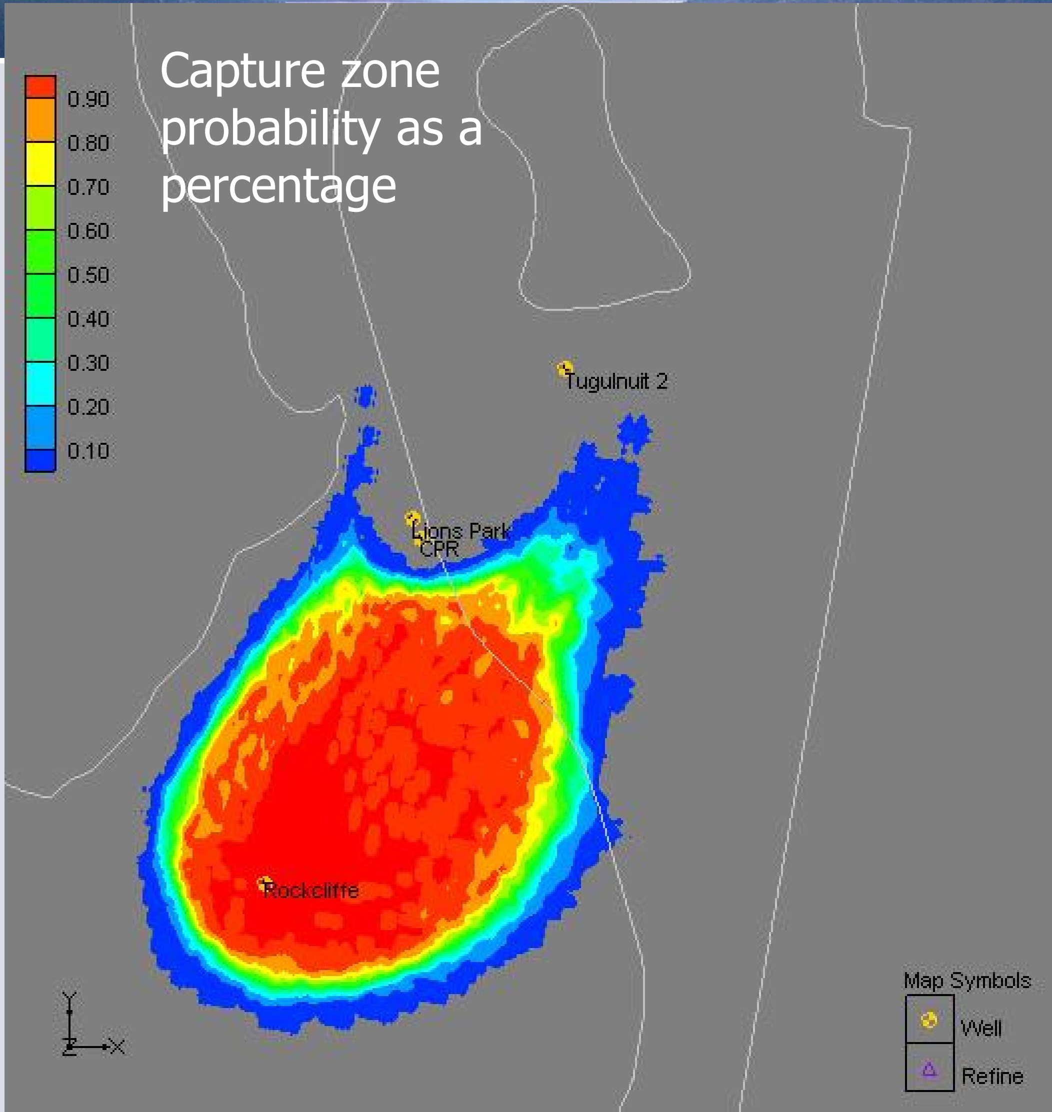
WELL CAPTURE ZONE



BC MoE: Wellhead protection toolkit

WELL CAPTURE ZONES

Approx. 10 year capture zone



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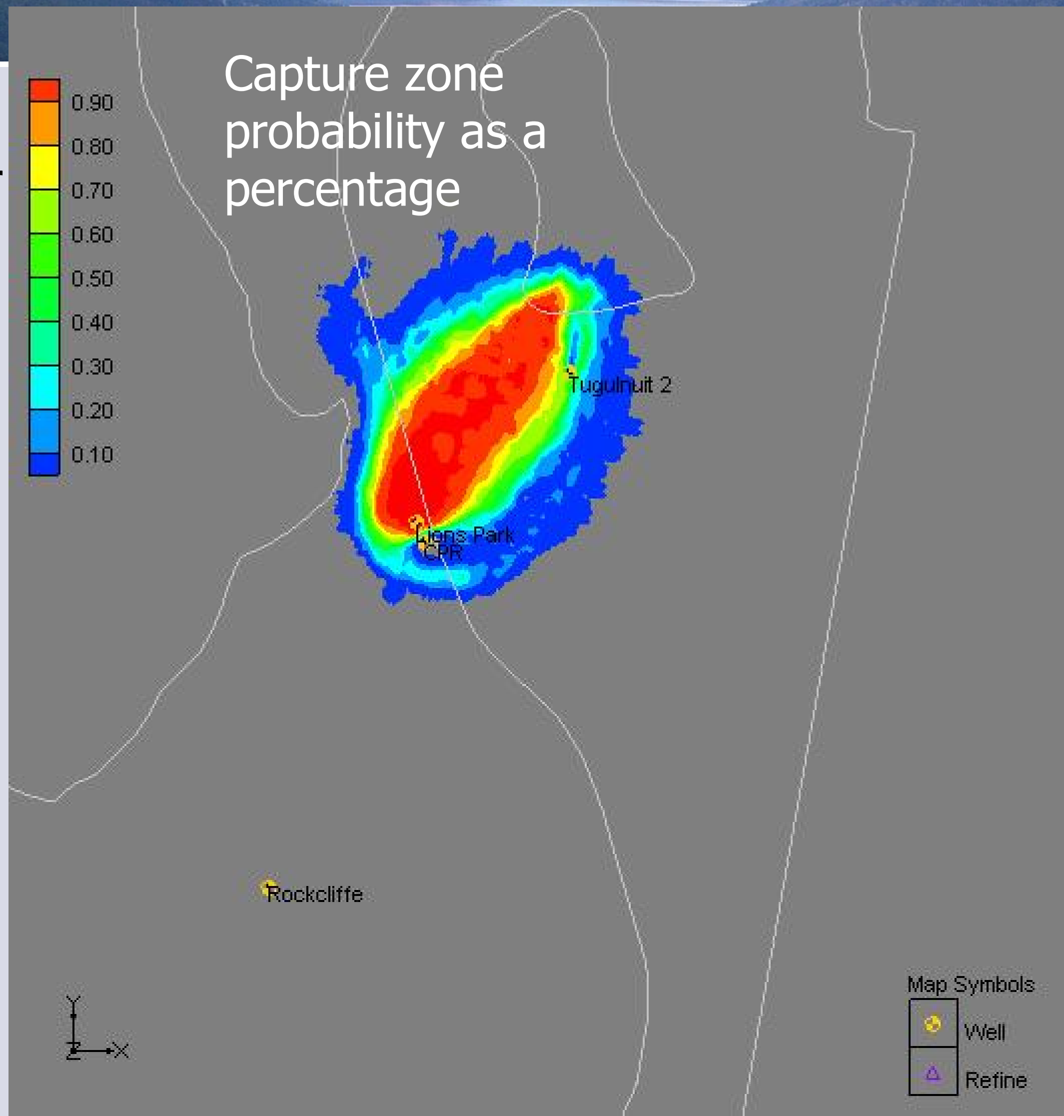
Approx. 10 year capture zone



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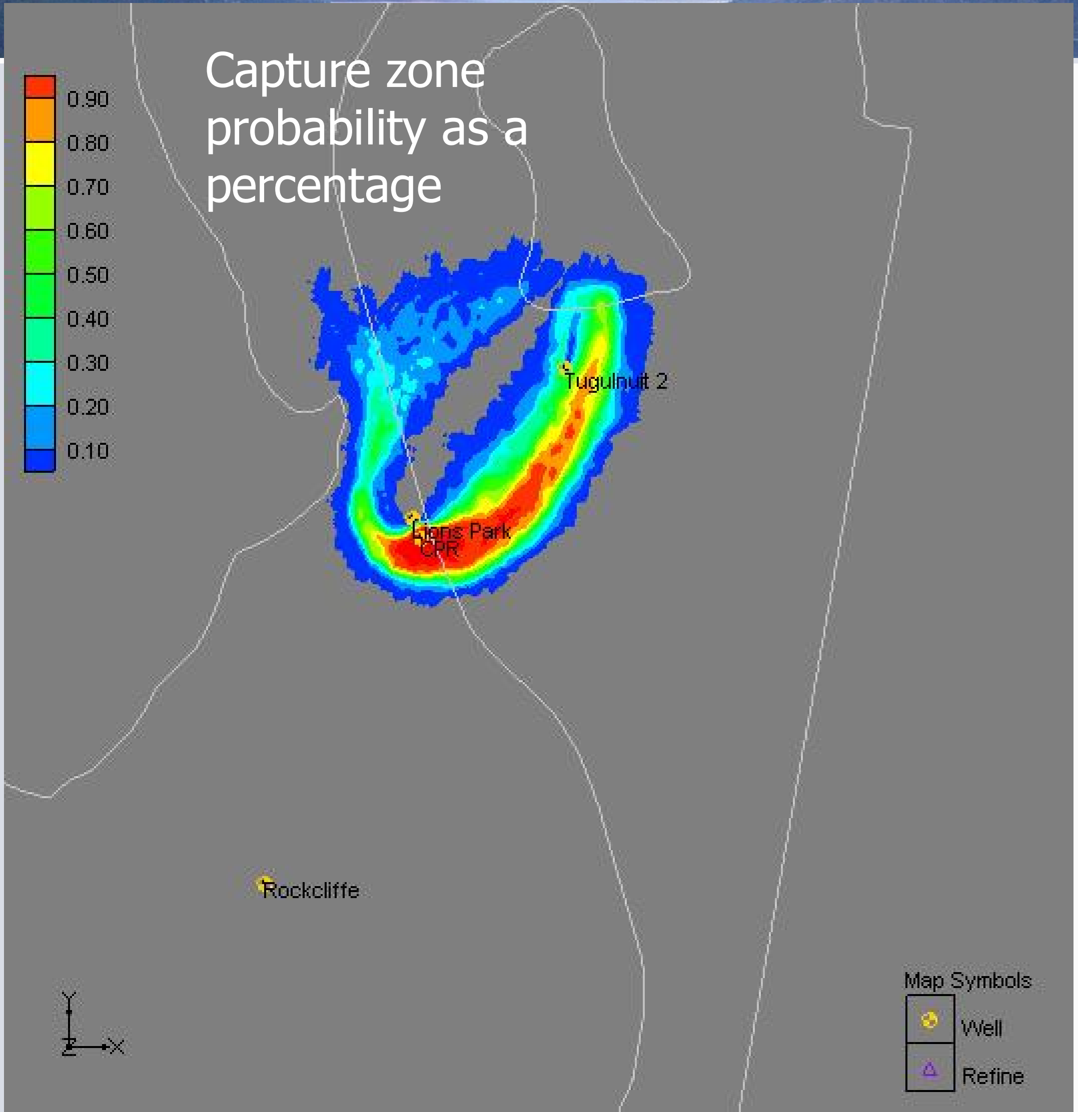

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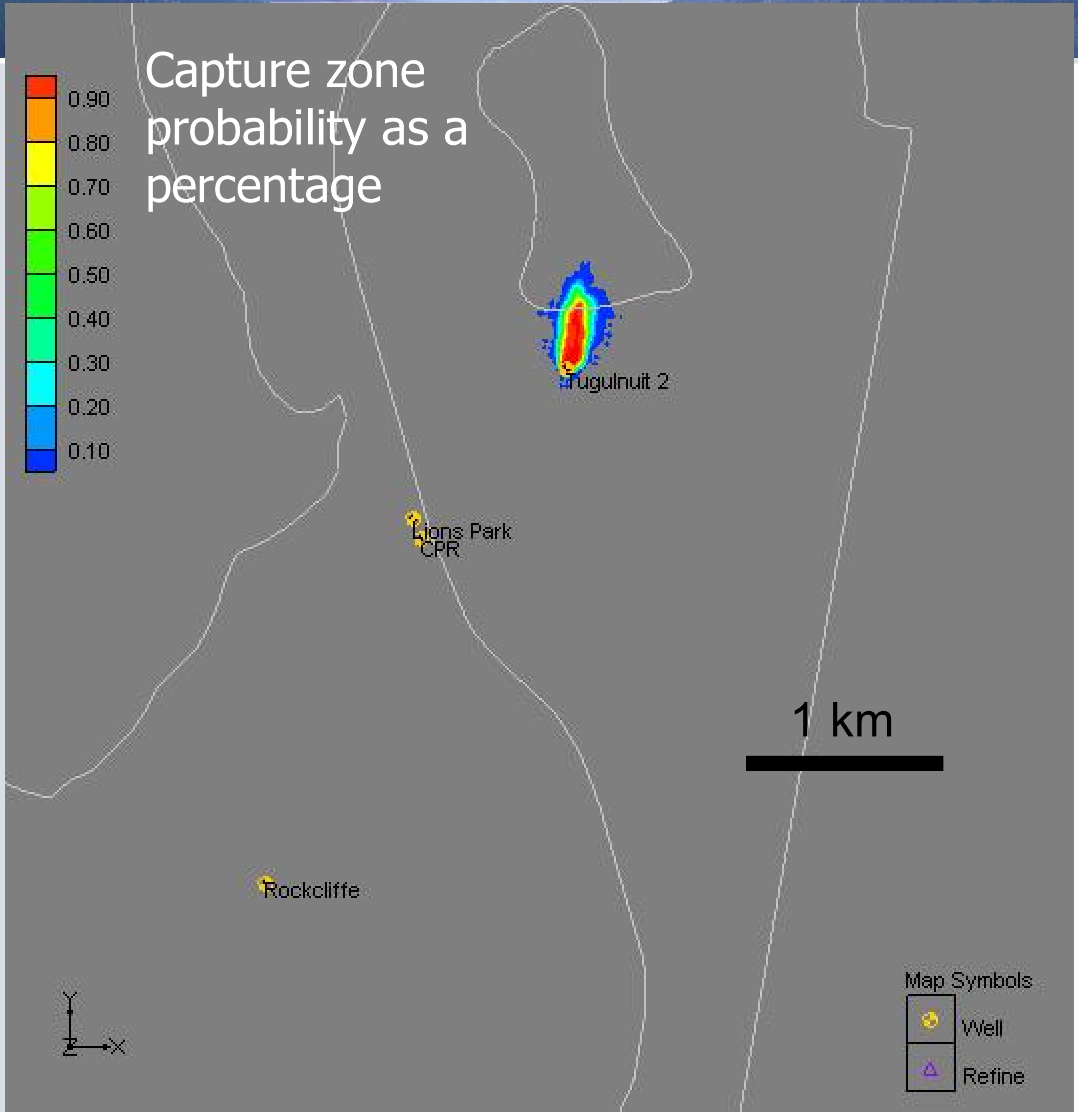
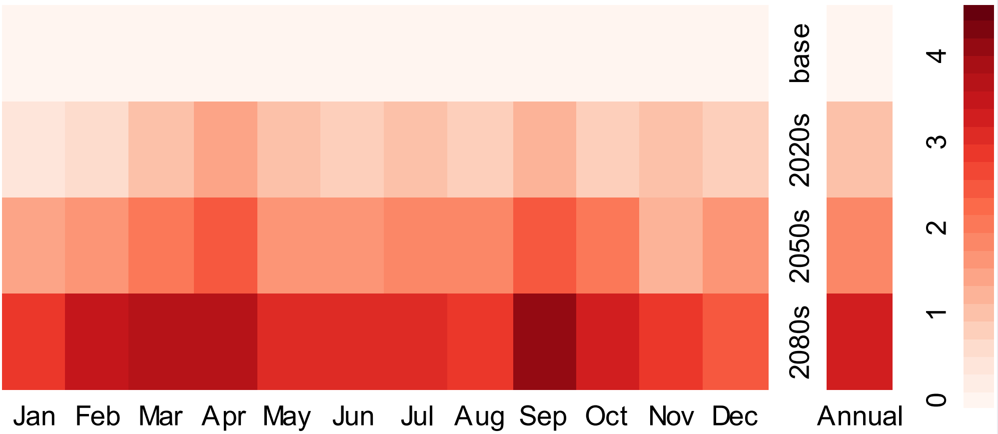
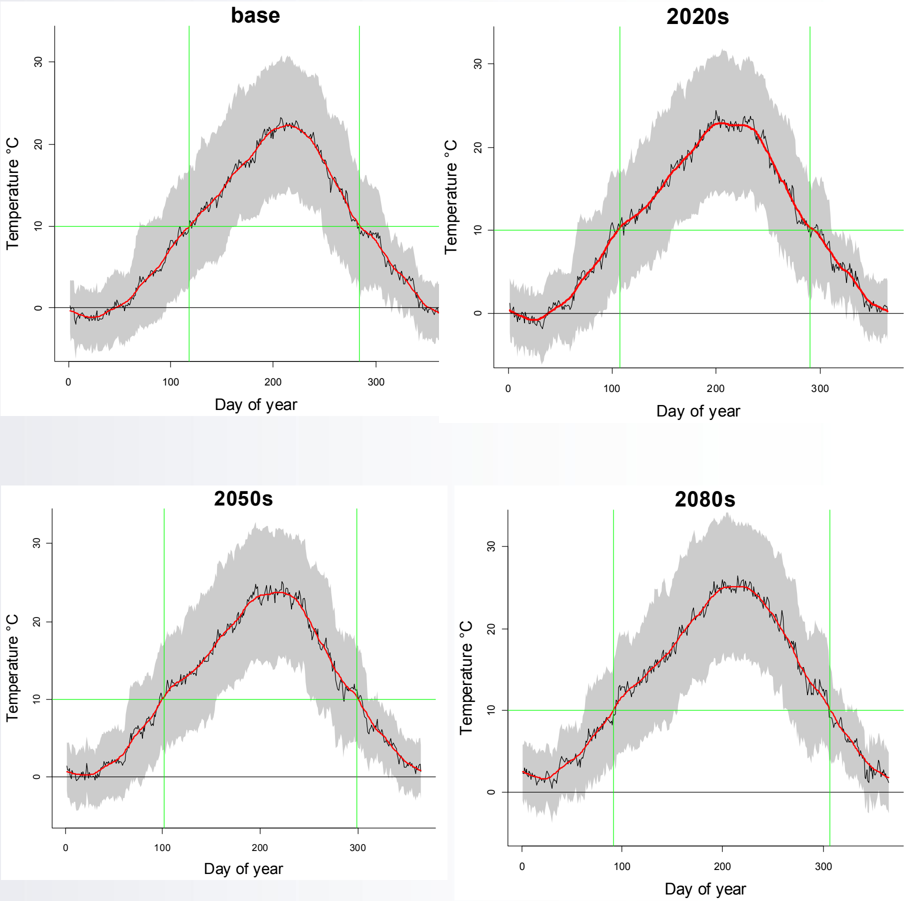


Climate Change

Temperature

Absolute change in *mean temperature*





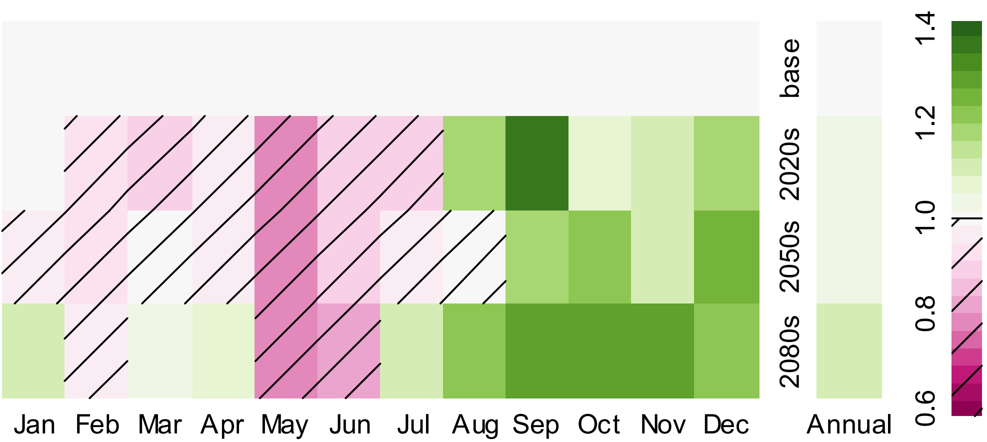
Changes in growing days (10°C)

State	Start	End	Total days
base	117 (27 Apr.)	284 (11 Oct.)	167
2020s	107 (17 Apr.)	290 (17 Oct.)	183
2050s	101 (11 Apr.)	299 (26 Oct.)	198
2080s	91 (1 Apr.)	307 (3 Nov.)	216

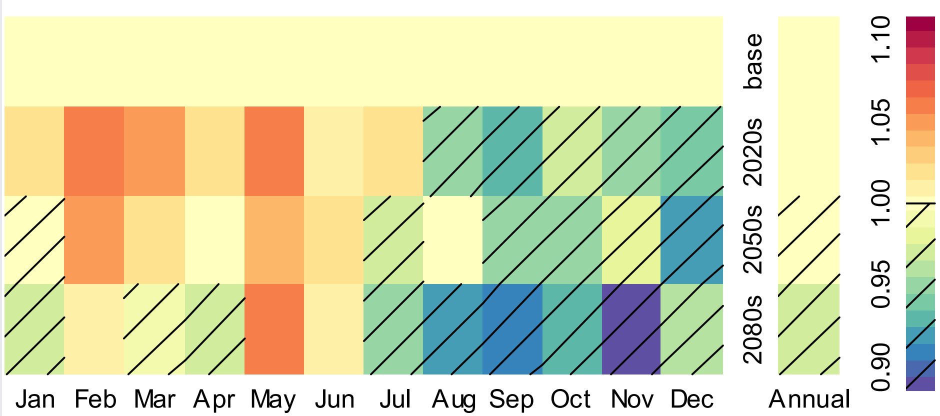
Climate Change

Precipitation and Solar Radiation

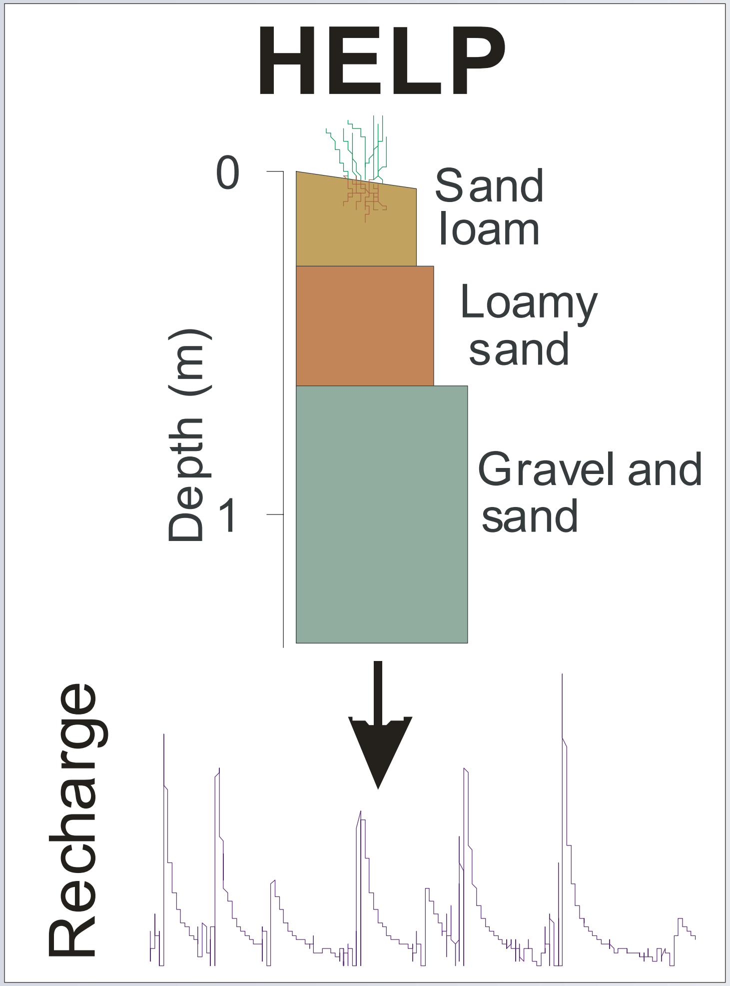
Relative change in monthly *precipitation*

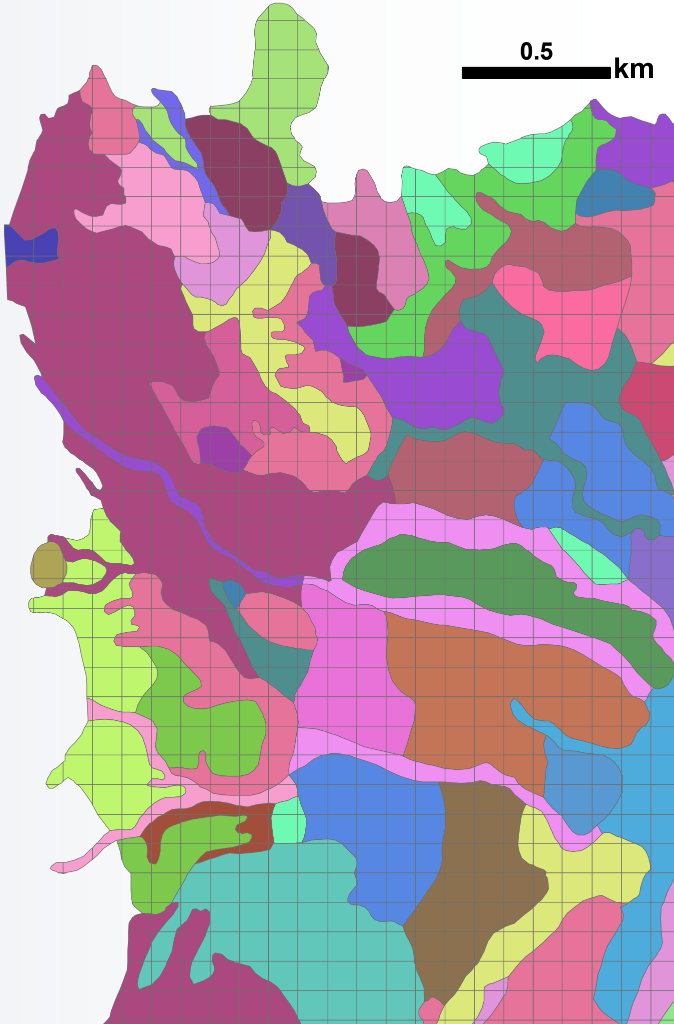


Relative change in *solar radiation*



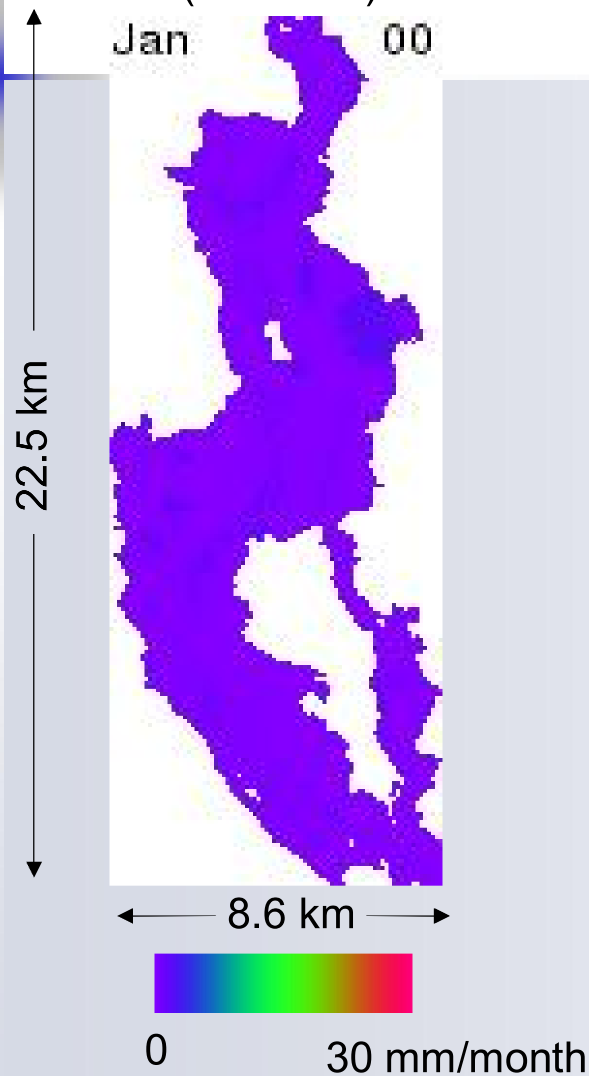
Groundwater Recharge

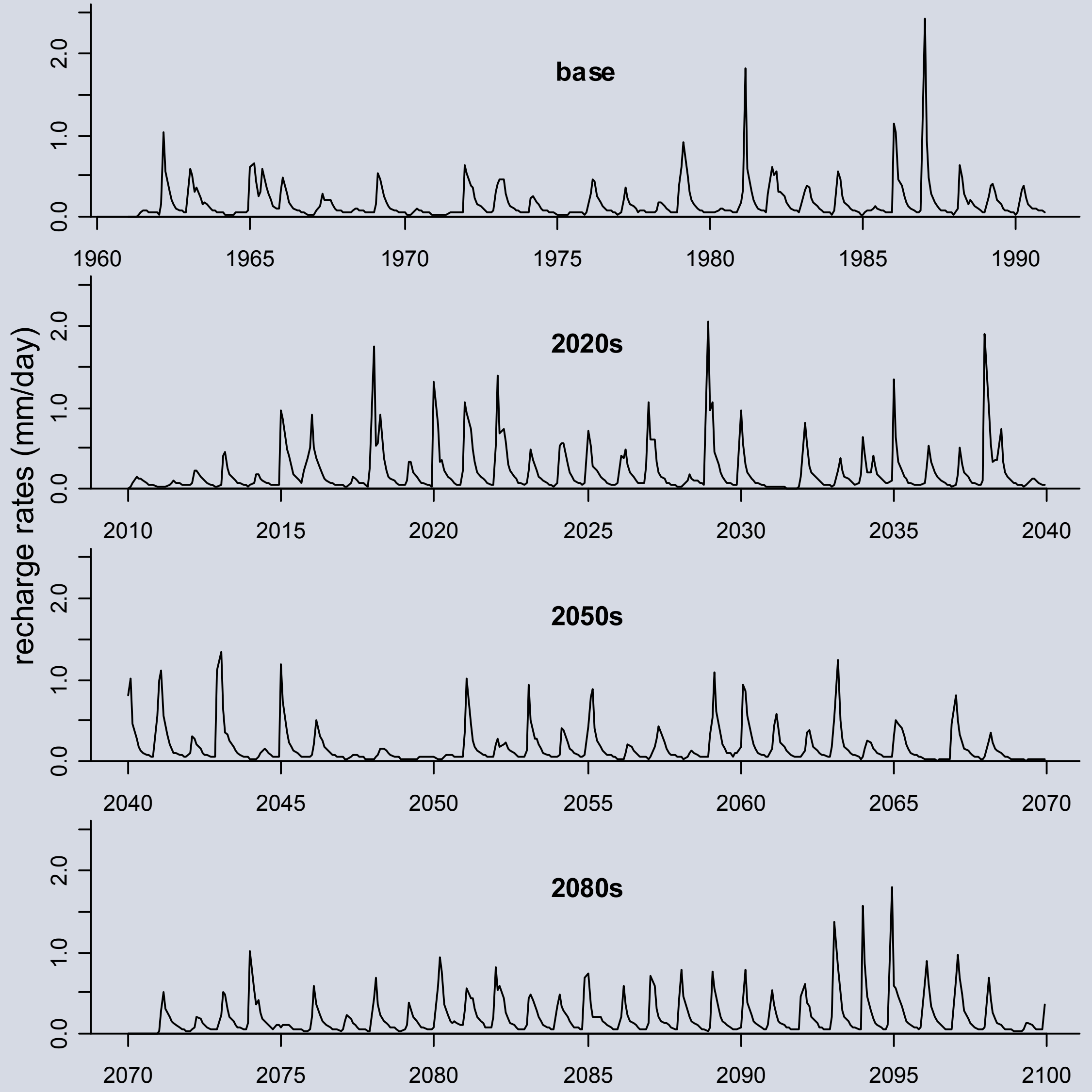




Recharge modelling results: seasonal

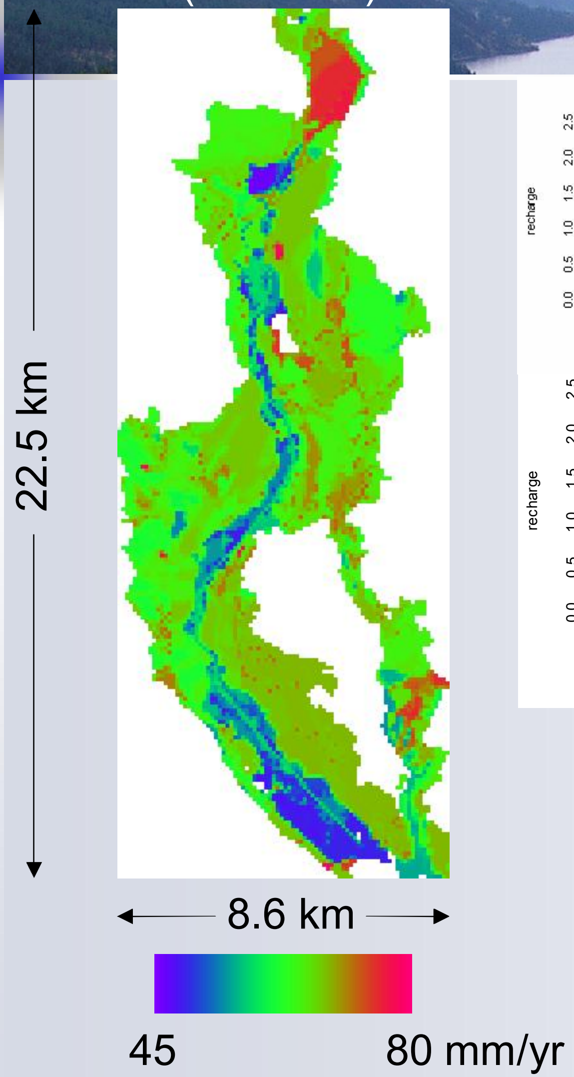
Monthly recharge rates (historical)

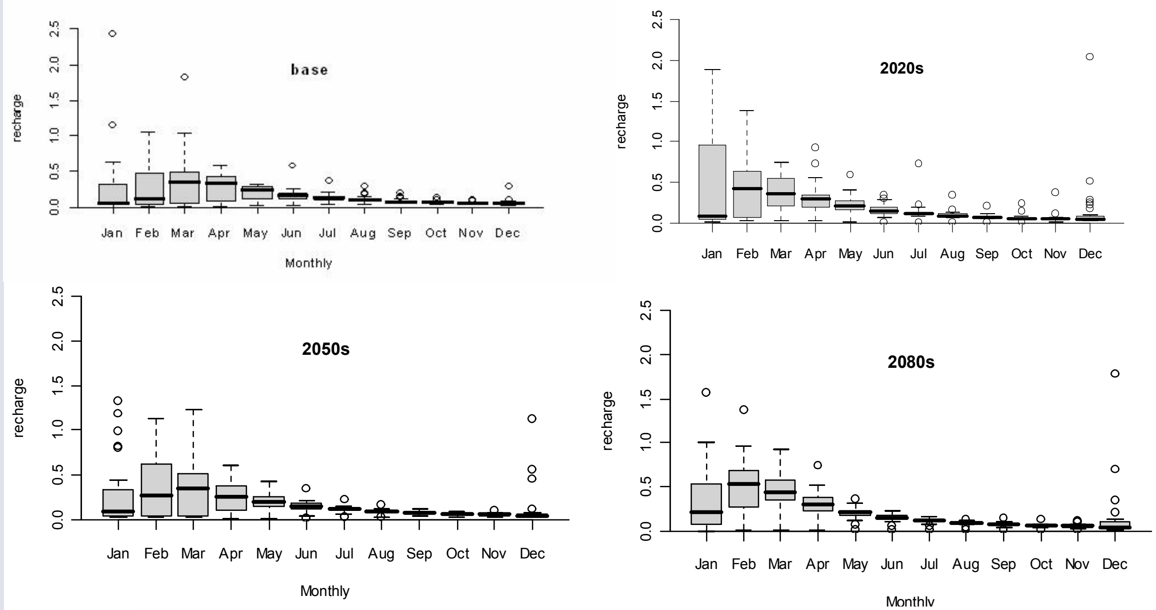




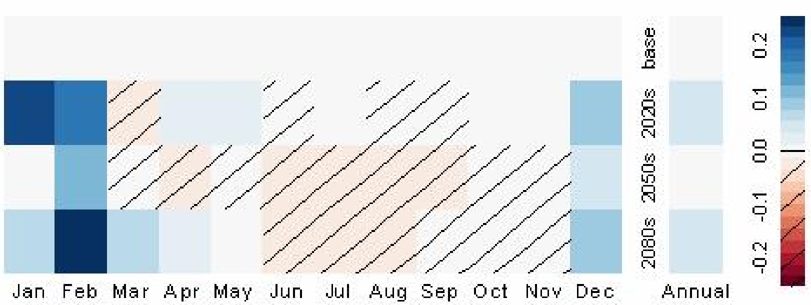
Recharge modelling results: seasonal

Annual recharge rates (historical)





Absolute change in daily recharge rates



Groundwater Sustainability

- Minor increase of recharge with future-predicted climate change
  - Due to earlier timing of recharge (less evapotranspiration)
- More potential evapotranspiration earlier in season
  - Irrigation methods would be less efficient
  - Also less precipitation early in the season
- Longer growing season
  - More stress on irrigation demands

Use of Science for Local Decision Making

- Aquifer Vulnerability (AV) has been mapped for Oliver region
- Land Use Allocation Model (LUAM) was developed to help identify areas of desirable growth
- LUAM incorporated into SGOG to form a sustainable development plan for the Greater Oliver Area
- Preliminary AV maps incorporated into LUAM
- Well capture zones have been modelled for use in wellhead protection planning as identified in the new Oliver OCP
- Climate change impacts on groundwater recharge have been assessed

Acknowledgements

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CANADA
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