Water Budget Project — Phase 1
Gabriola, DeCourcy, and Mudge Islands

Presentation of Results, DRAFT Final Report
Dec 13, 2012, Nanaimo, BC

SRK Consulting (Canada) Inc.

Thurber Engineering Ltd.

Prepared for

Regional District of Nanaimo

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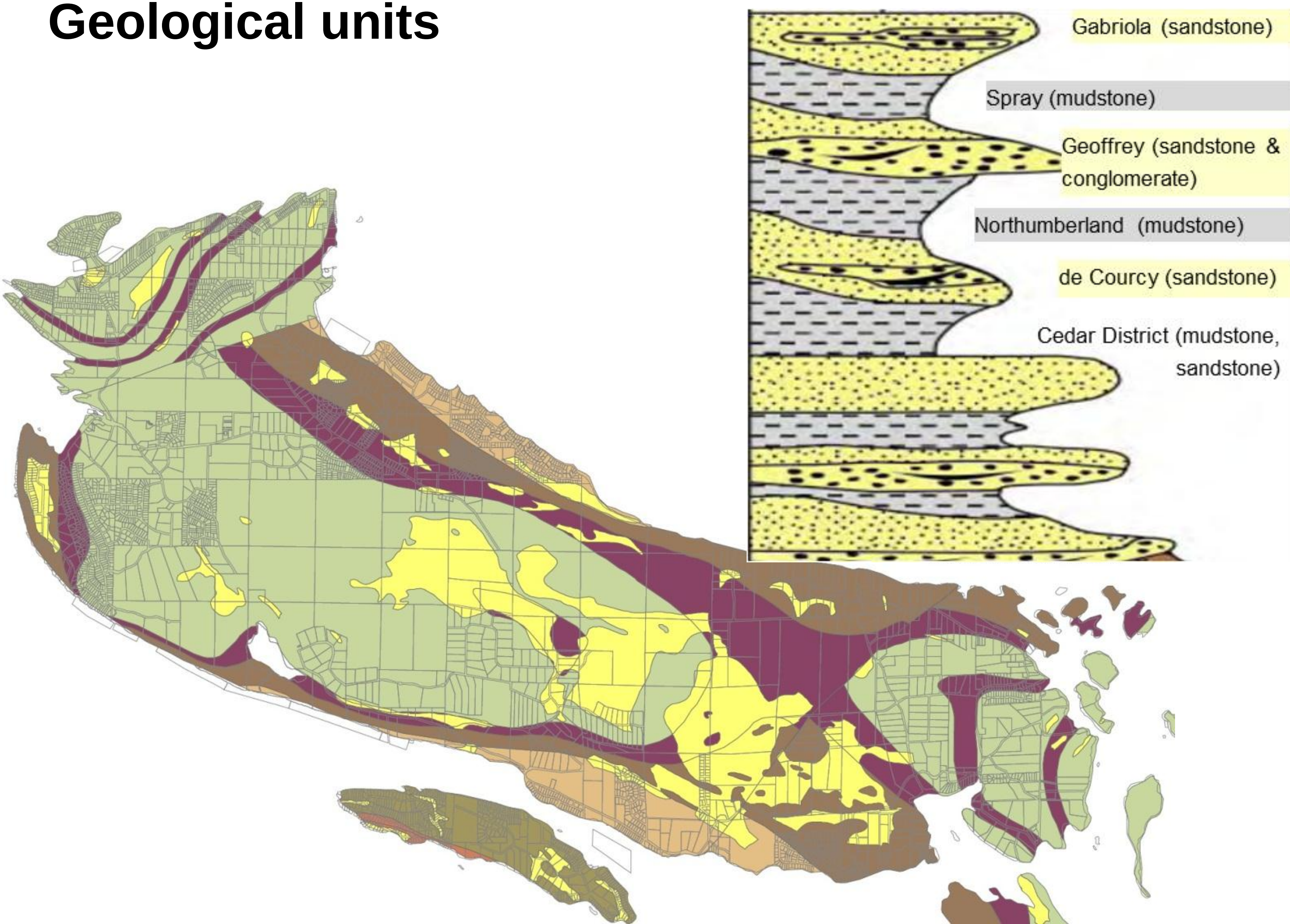
srk consulting THURBER ENGINEERING LTD.

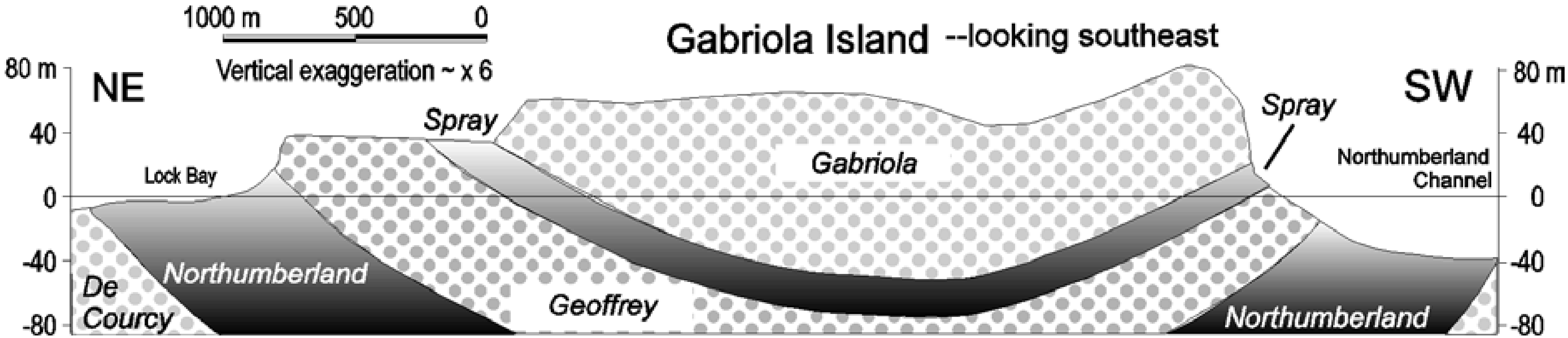
Objectives:

- review existing hydrogeological information
- develop one **3D conceptual hydrogeological model**
- calculate **water budget** and assess groundwater extraction rates
- assess **groundwater extraction “stress”** on aquifers
- identify **data gaps** in conceptual model and water budget
- identify additional requirements for expansion of long term groundwater observation well network

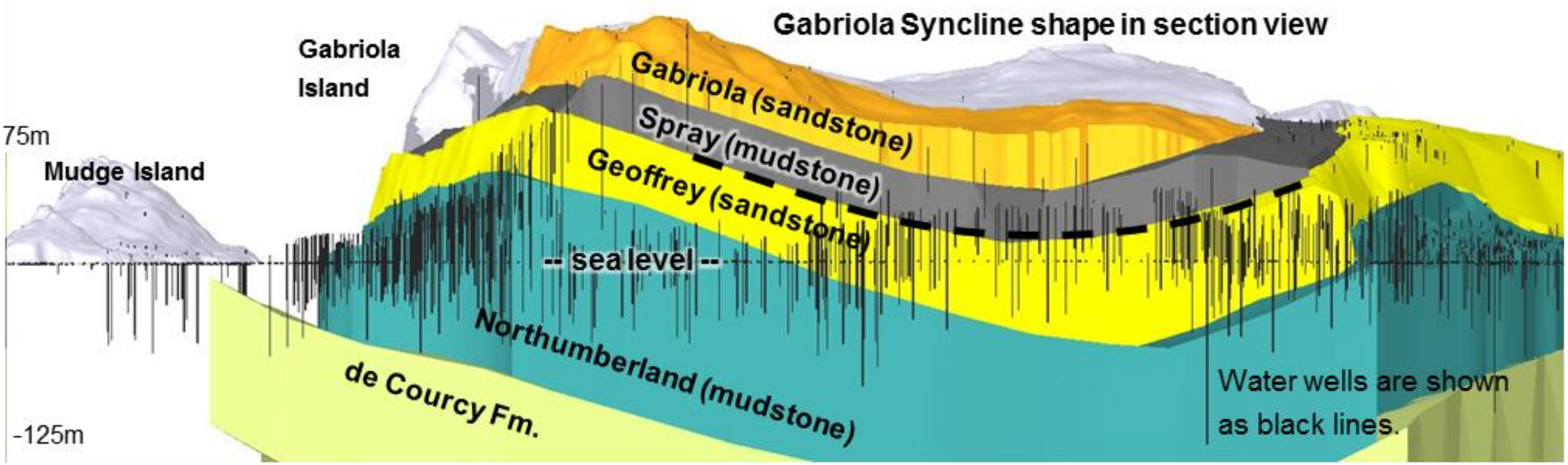
Geological units

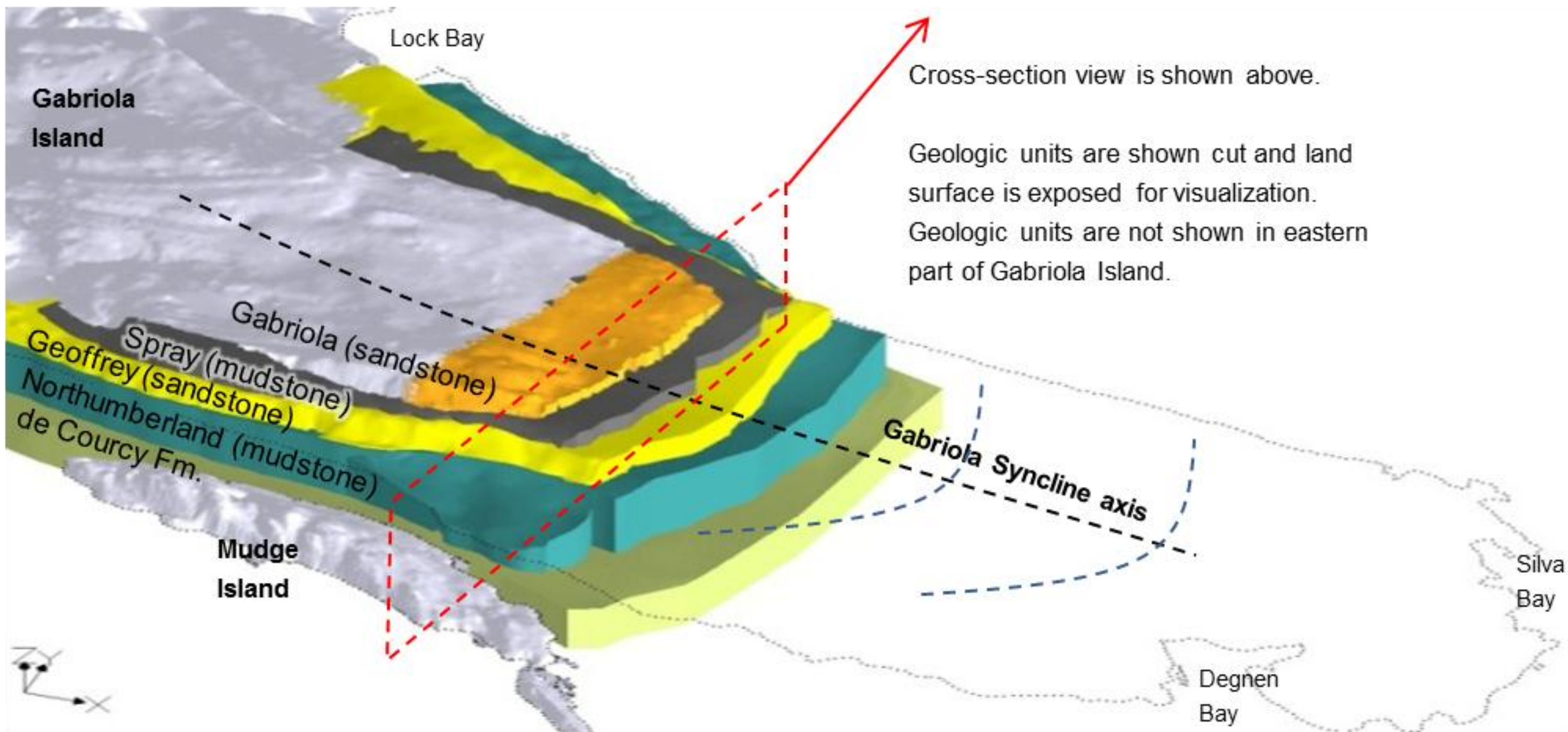


Section done by Earle & Krogh (2004)

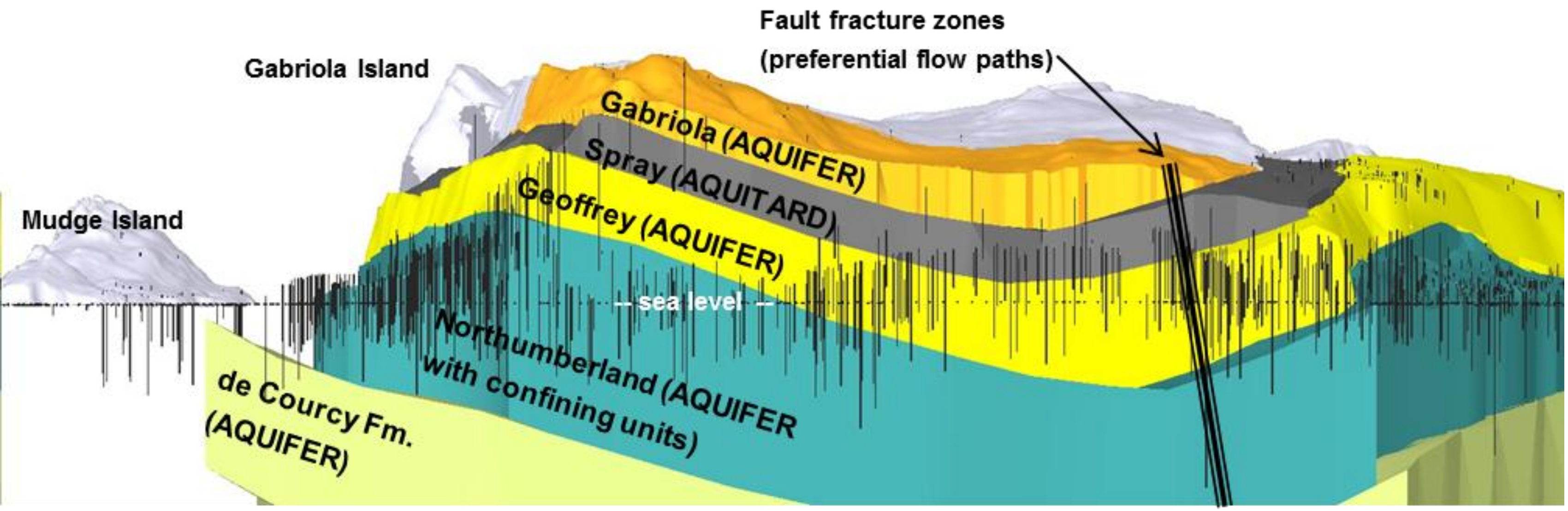


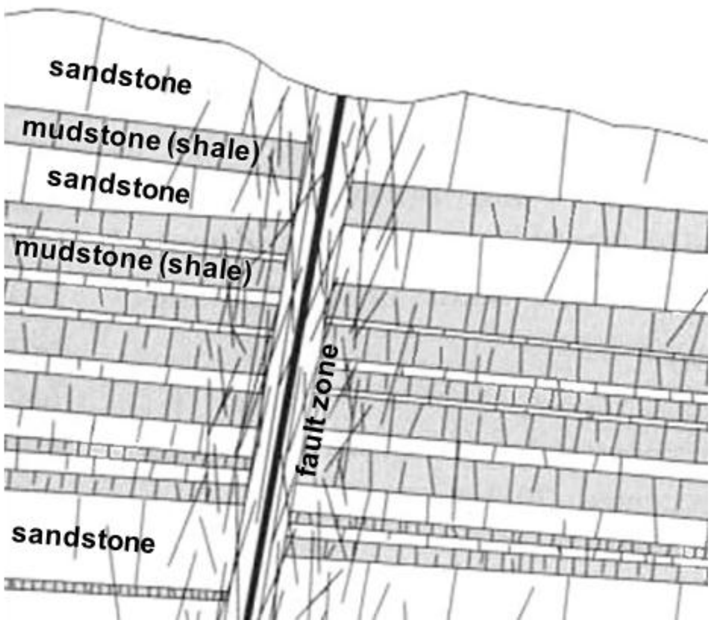
Geological units and structure

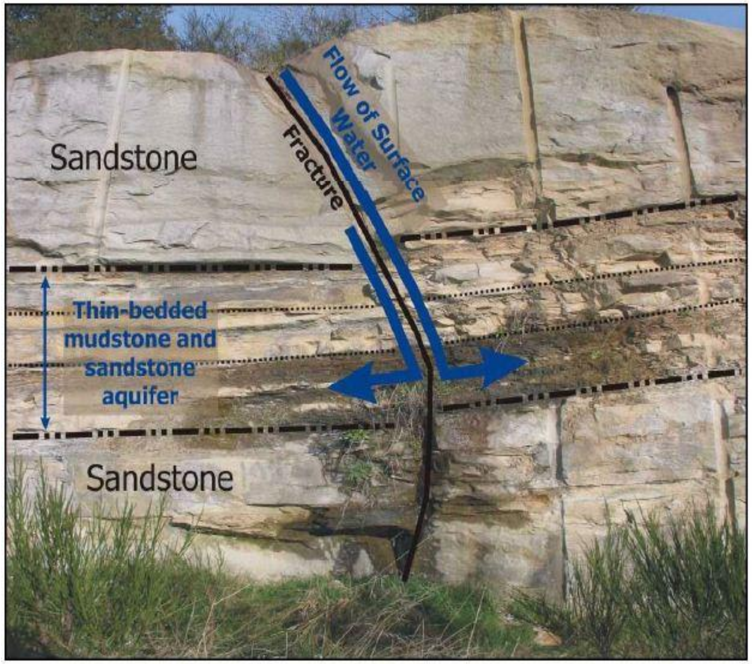




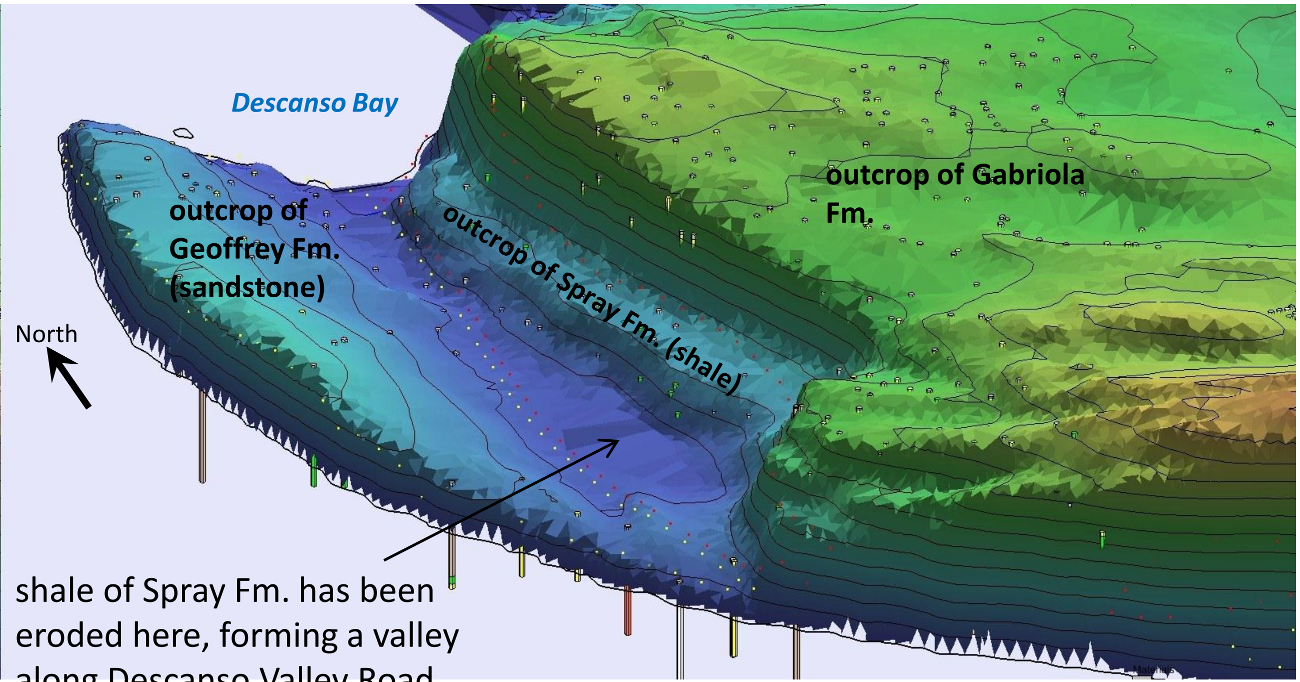
Hydro-Geological units (fractured rock)

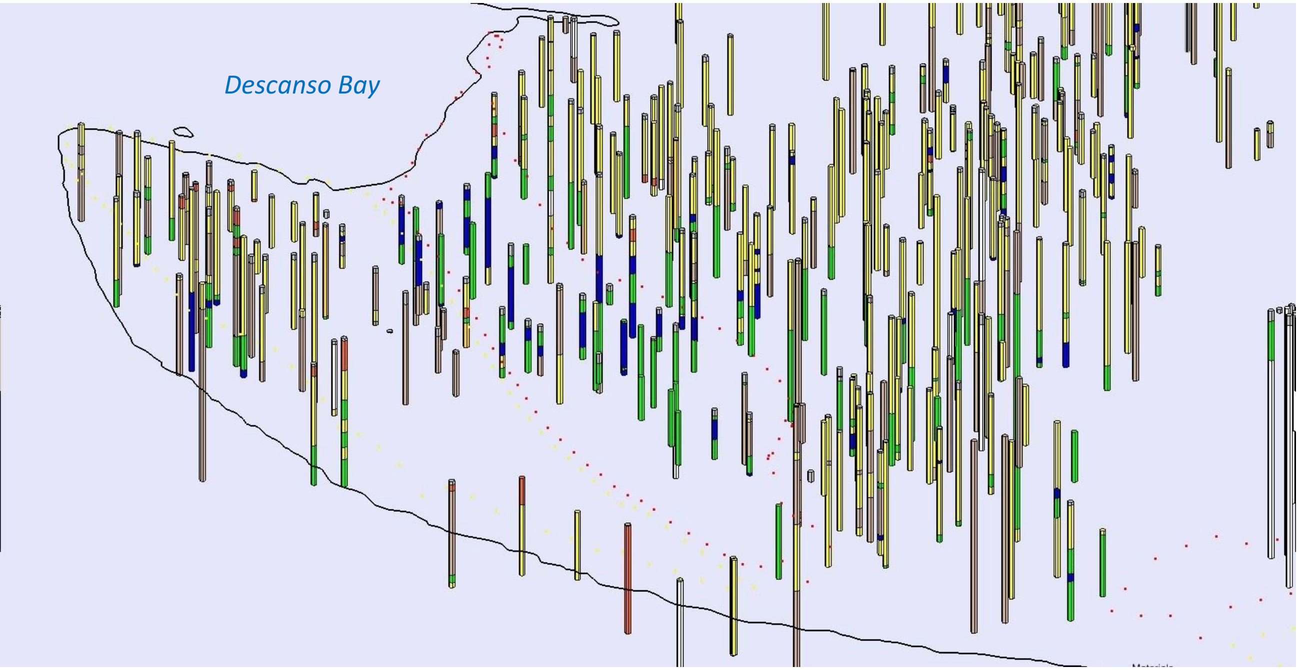




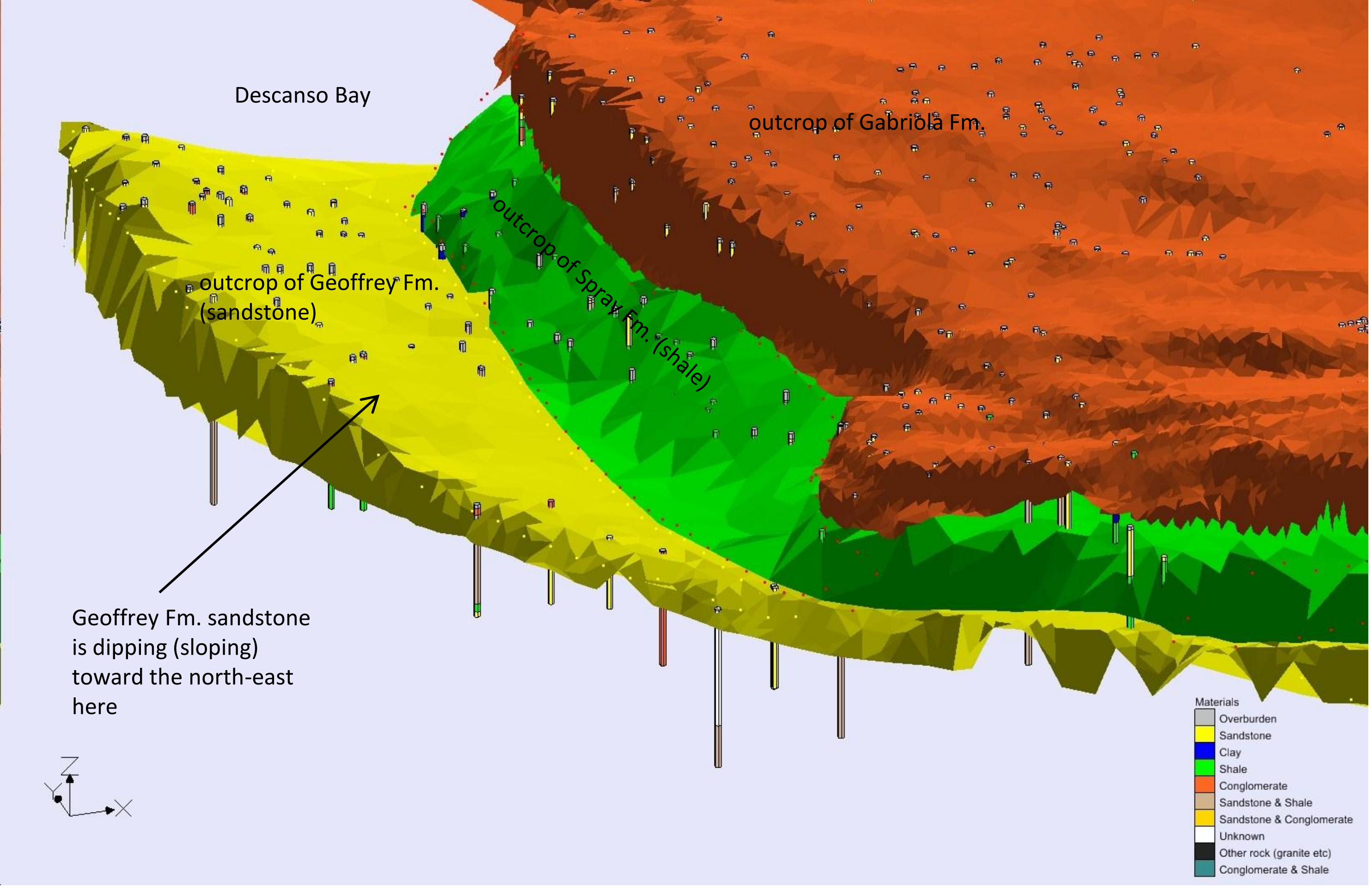


Example of geologic data near Descanso Bay





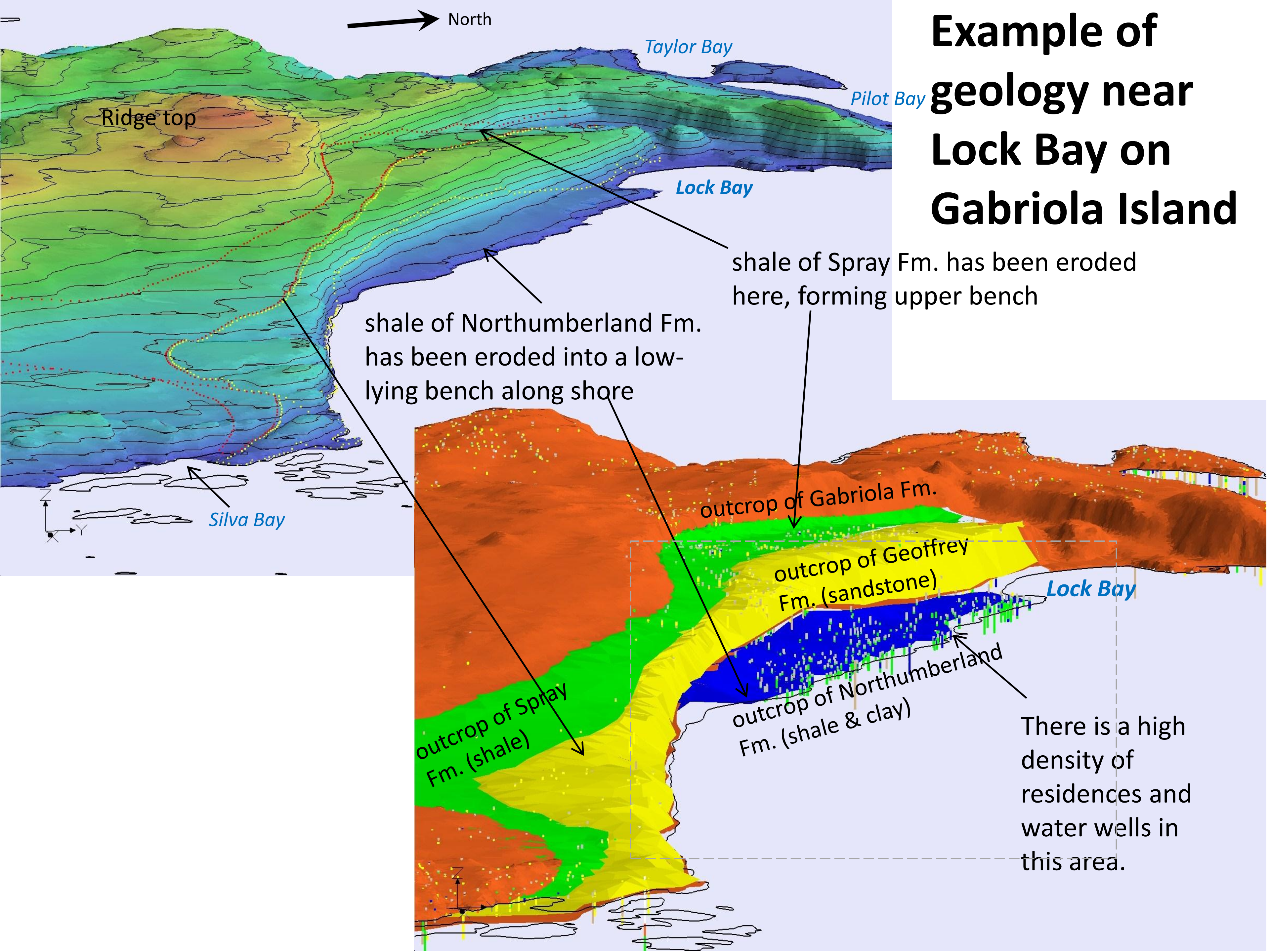
- well lithologs from WELLS database
- variable quality of logs and positional accuracy

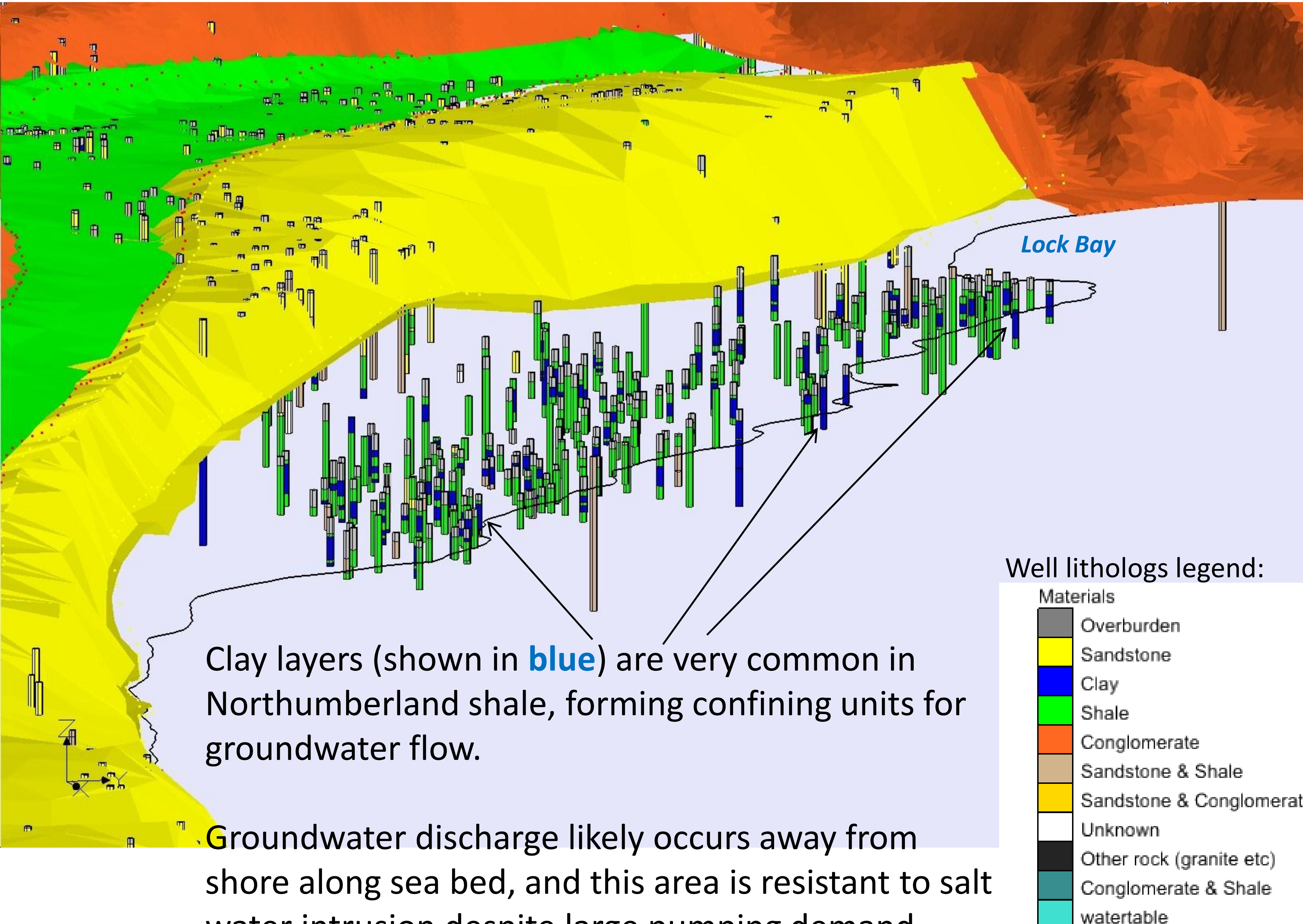


Simple 3D model can be built from geologic unit outcrops from surficial geology and ground surface model

- well logs are of limited value
- too much variability in log quality

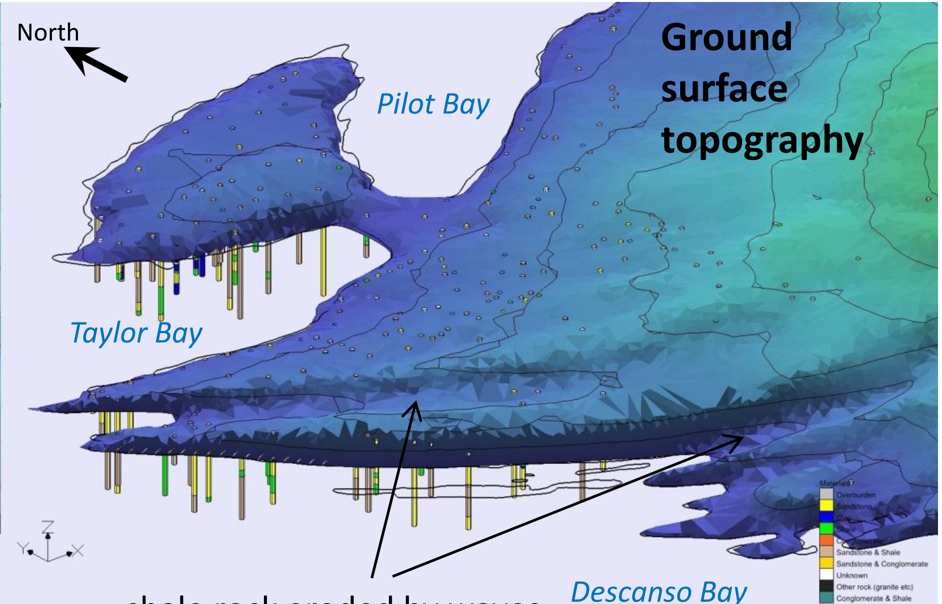
Example of geology near Lock Bay on Gabriola Island



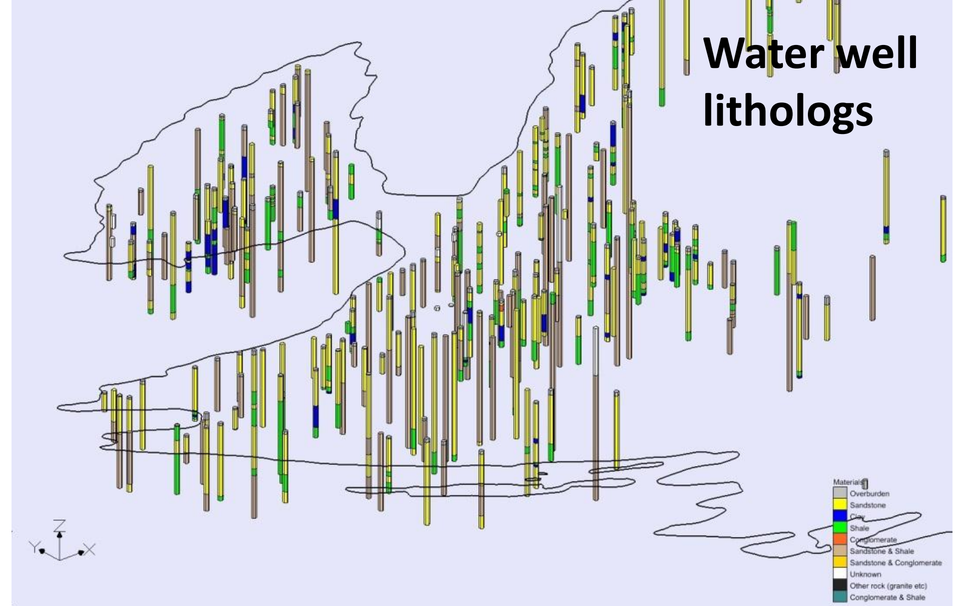


Clay layers (shown in **blue**) are very common in Northumberland shale, forming confining units for groundwater flow.

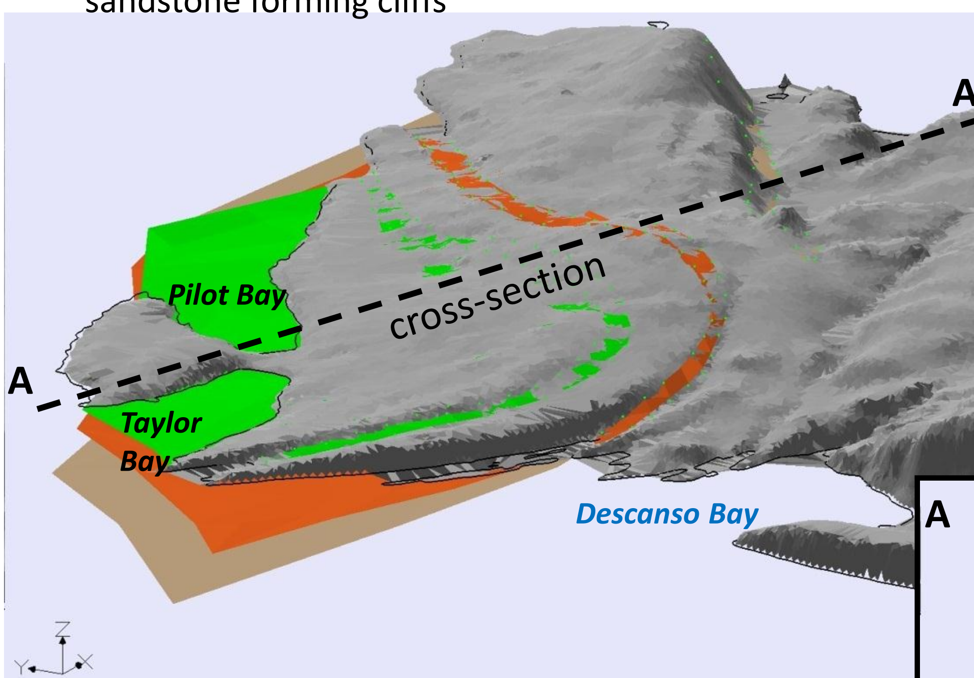
Groundwater discharge likely occurs away from shore along sea bed, and this area is resistant to salt water intrusion despite large pumping demand.



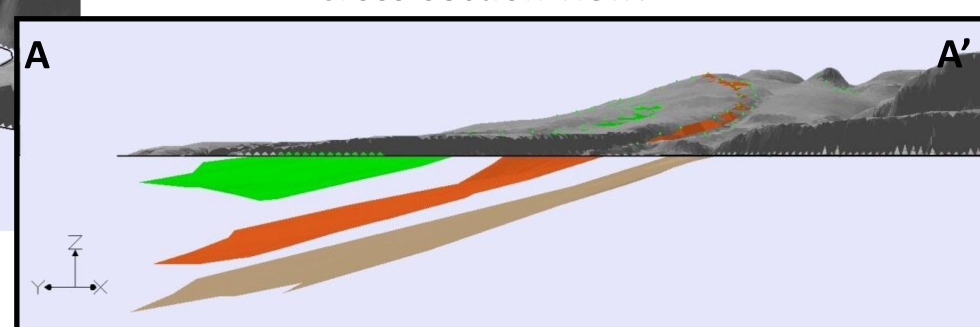
shale rock eroded by waves, sandstone forming cliffs



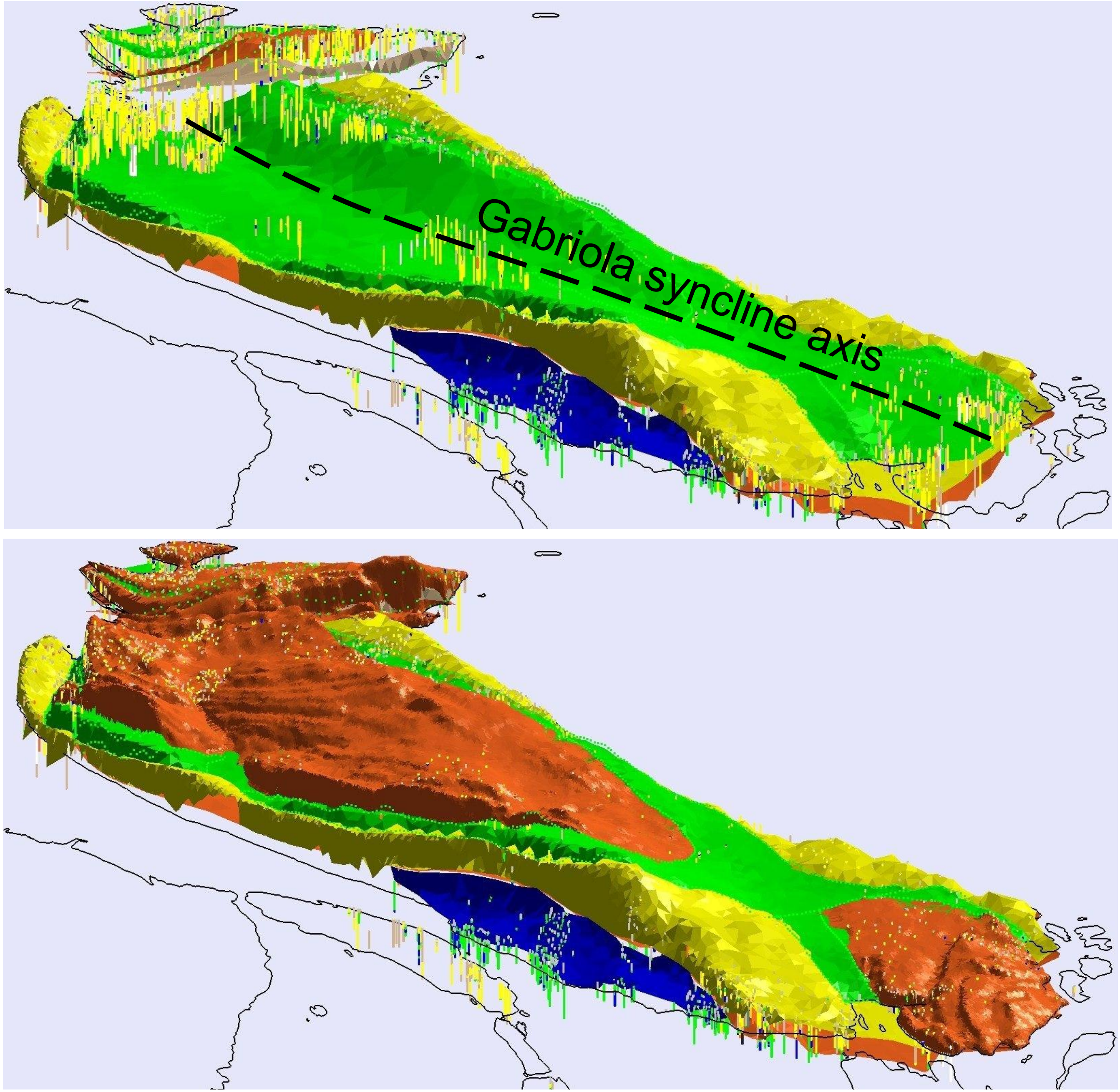
Shale rock layers in west part of Gabriola Island



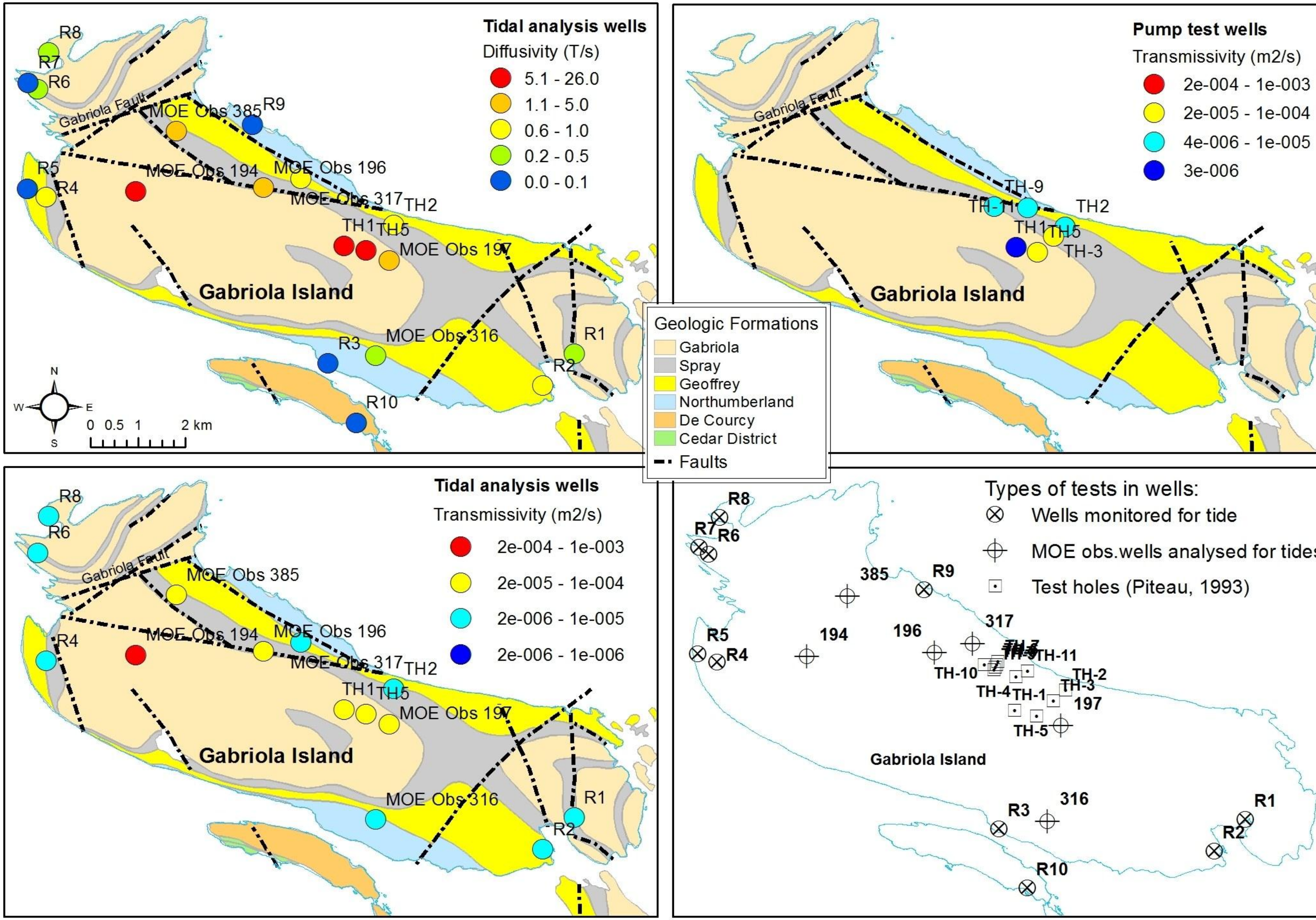
Cross-section view:



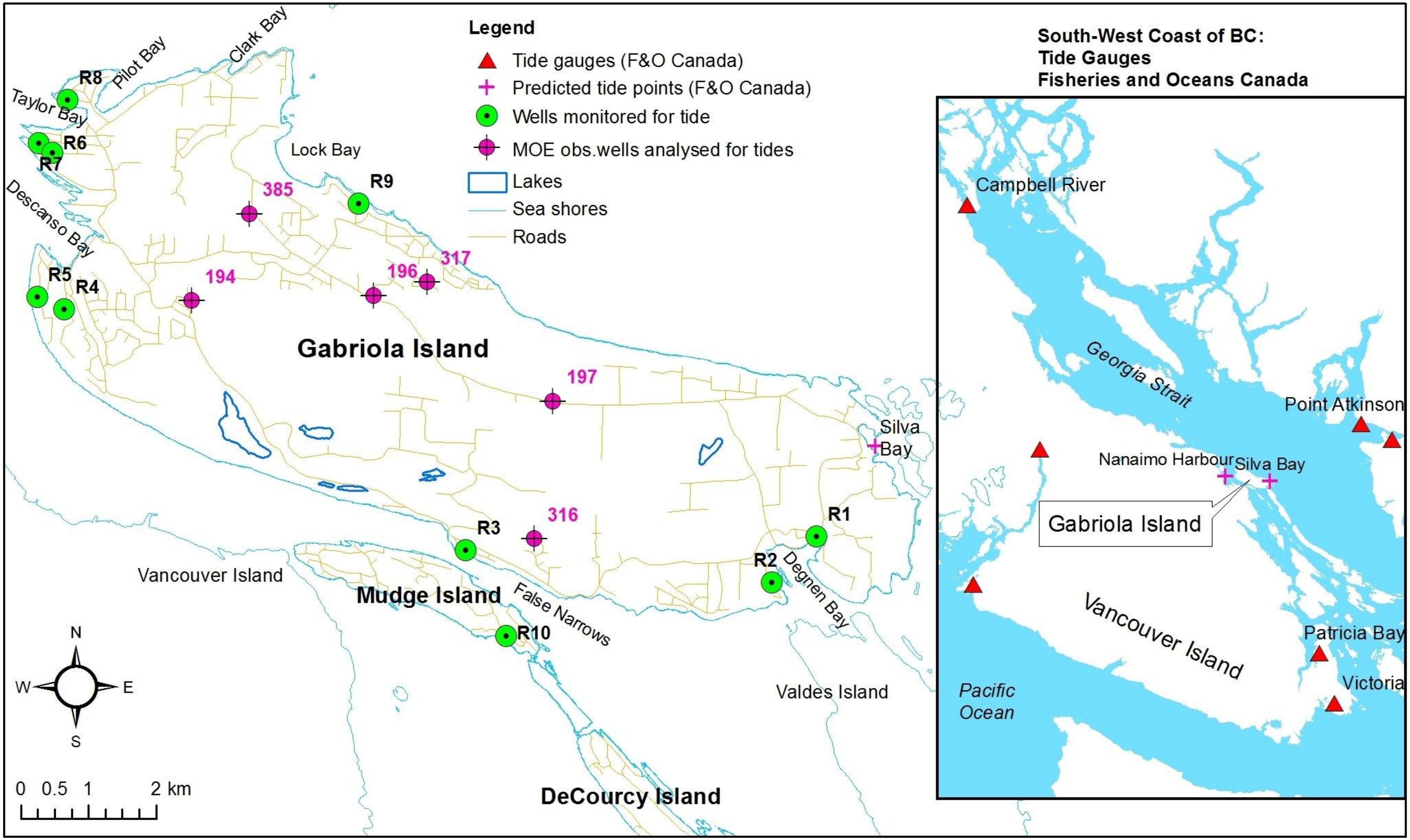
3D geological model fitted to all data



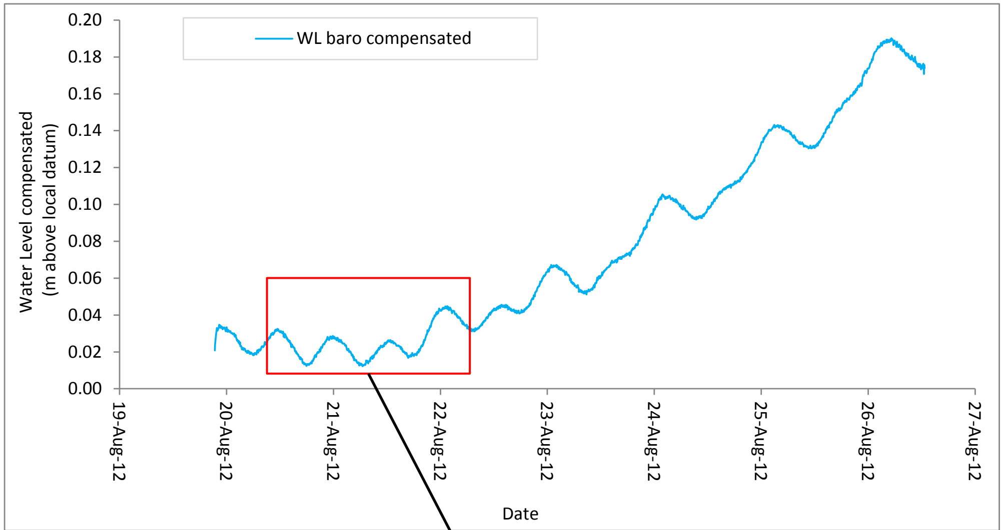
Hydro-Geological units: properties

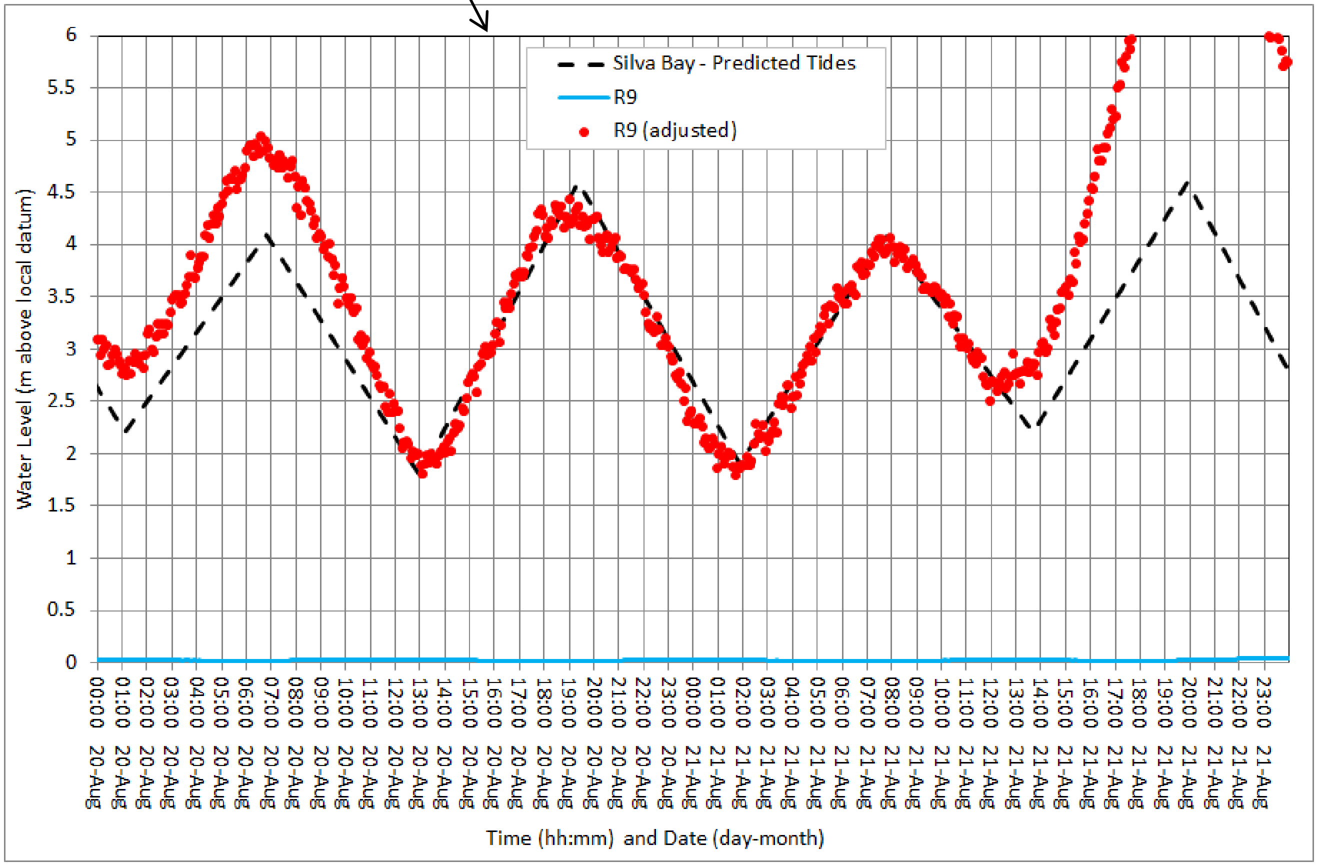


2012 tidal monitoring in 10 residential wells

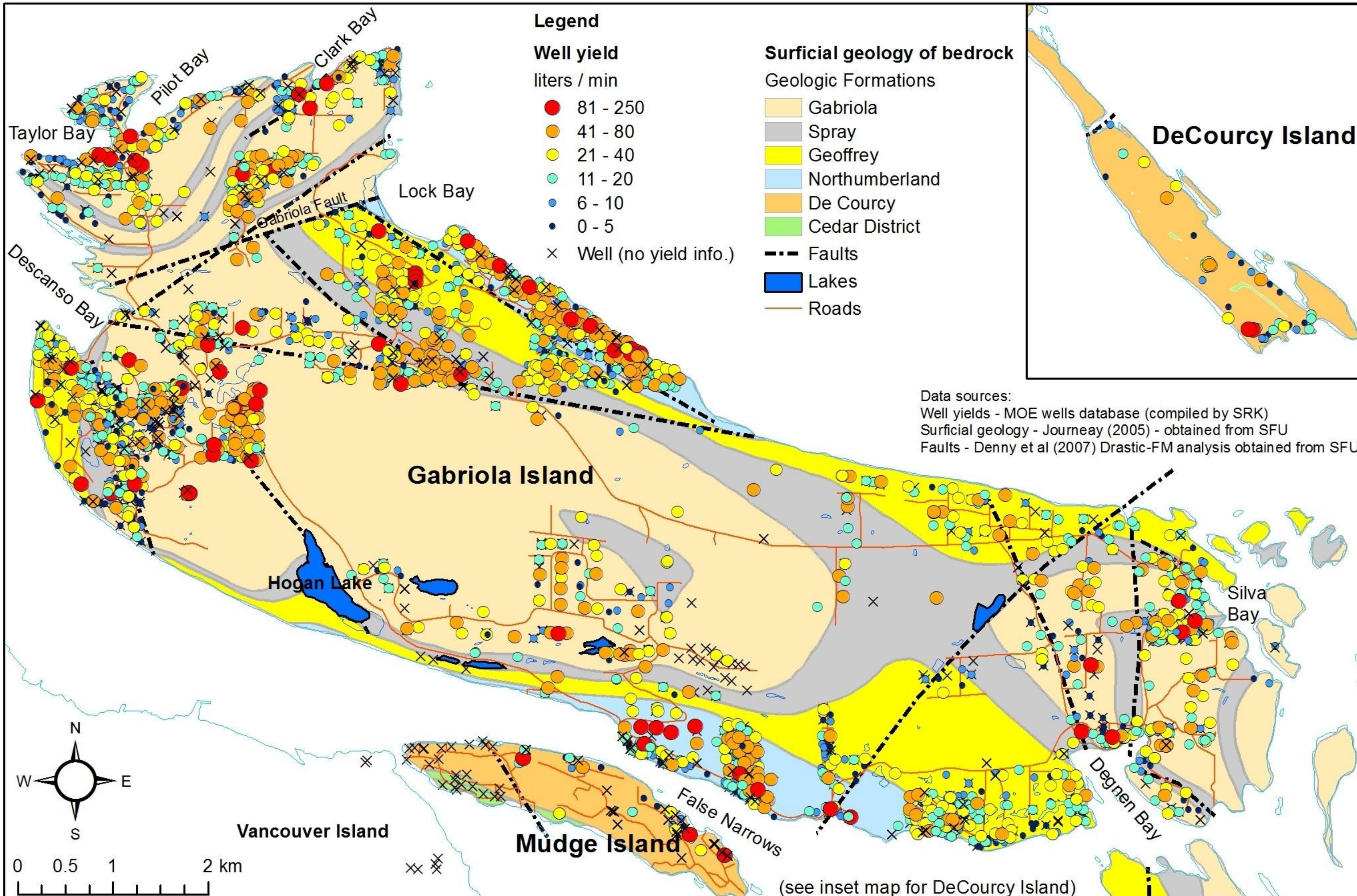


Example of results

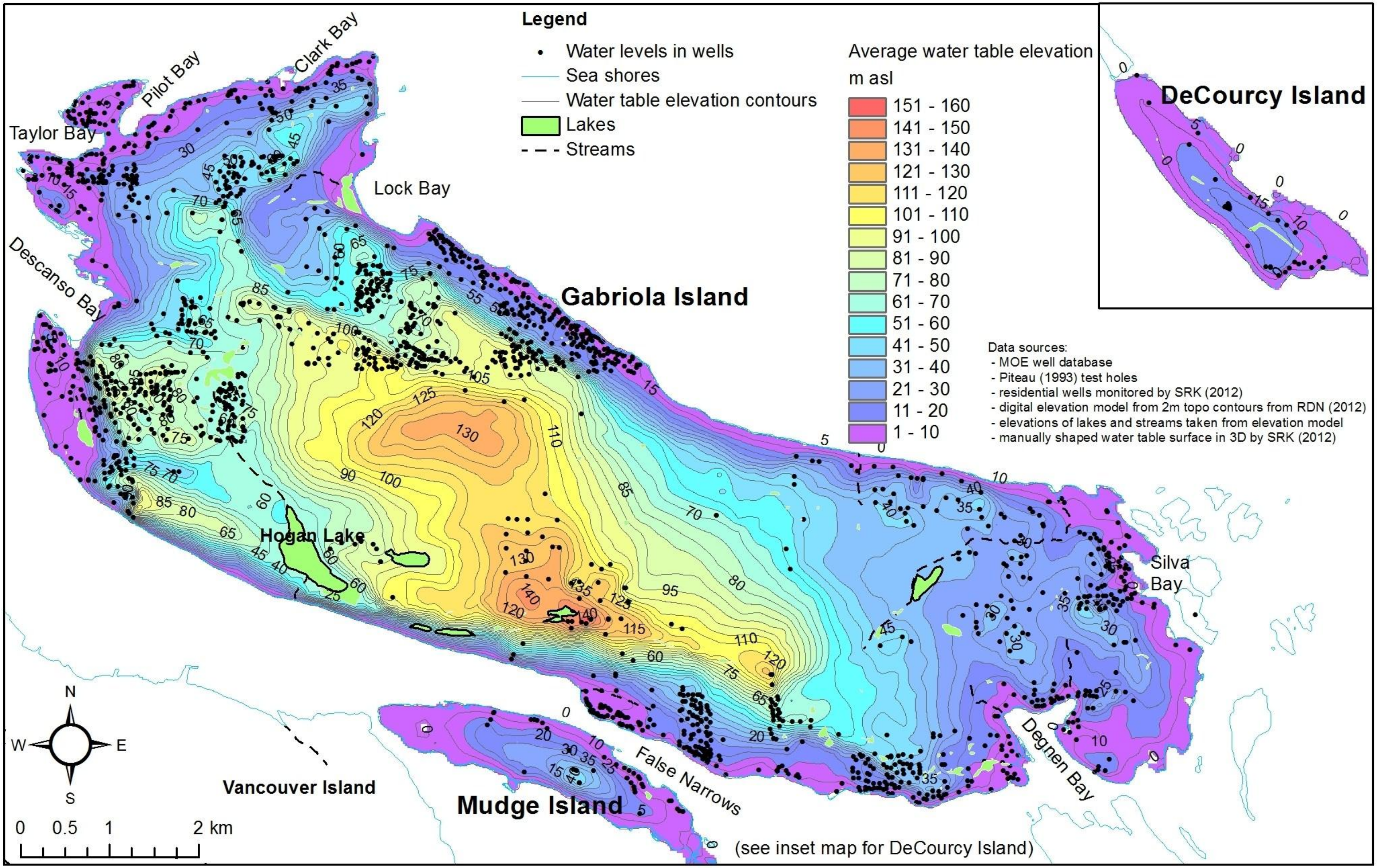




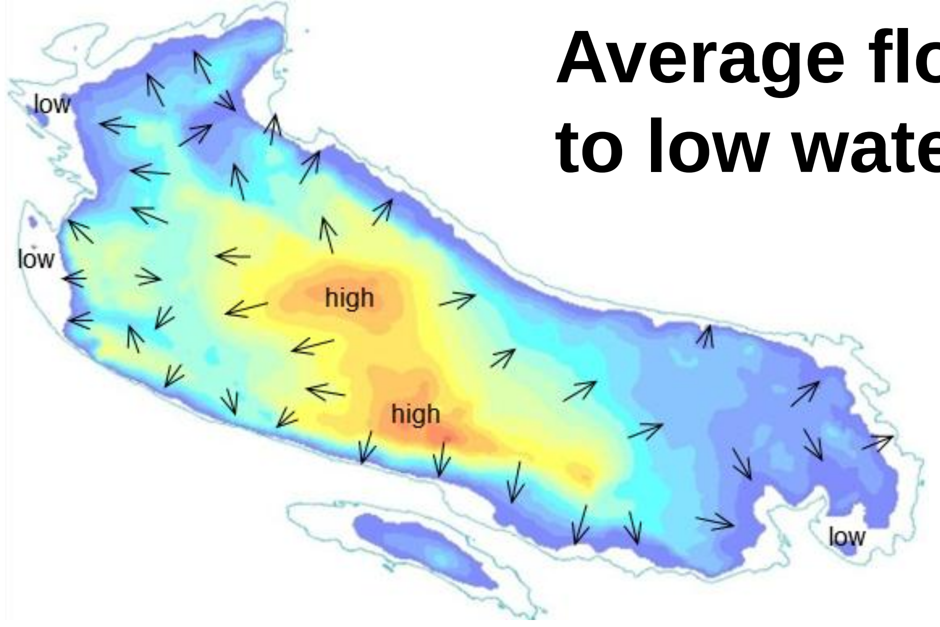
Aquifer productivity (well yields)



Average water levels on islands



Average flow directions from high to low water levels



Actual flow is complicated (example of one conceptual picture) (from GSC poster by Denny et al 2007)

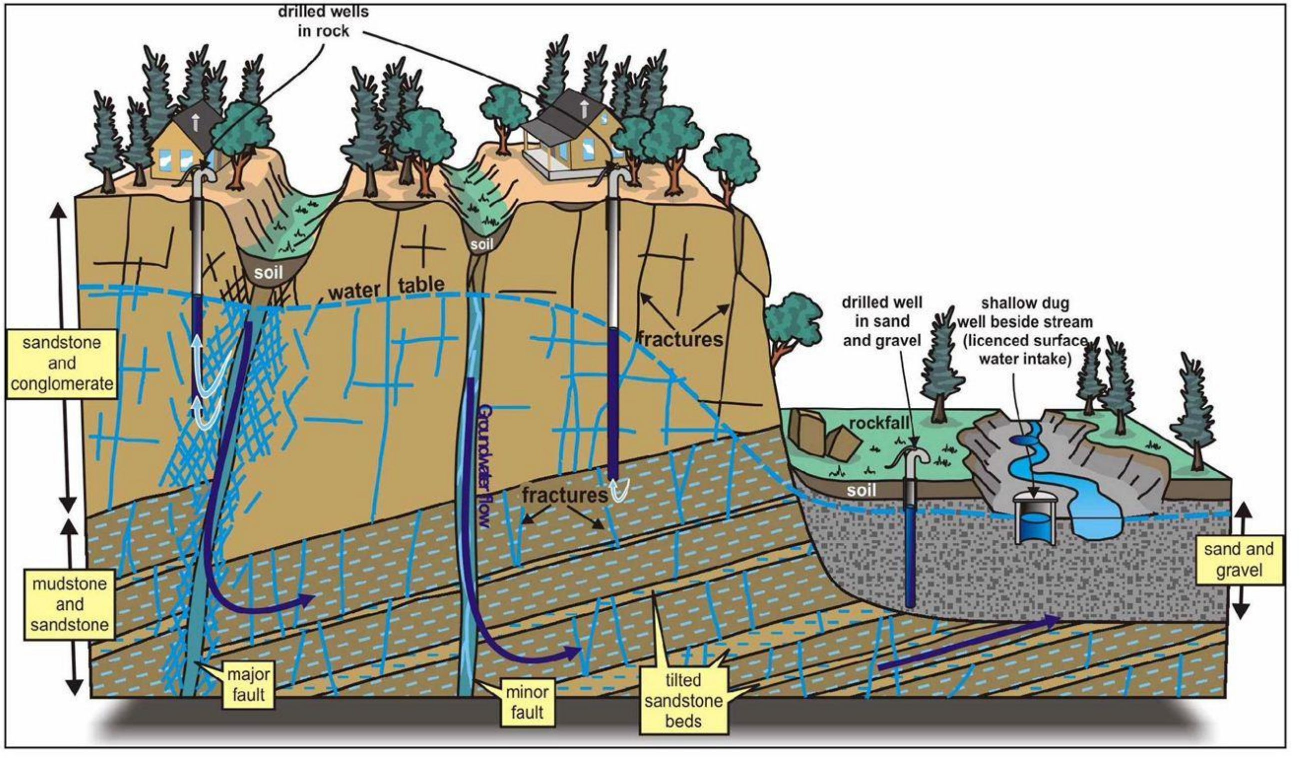
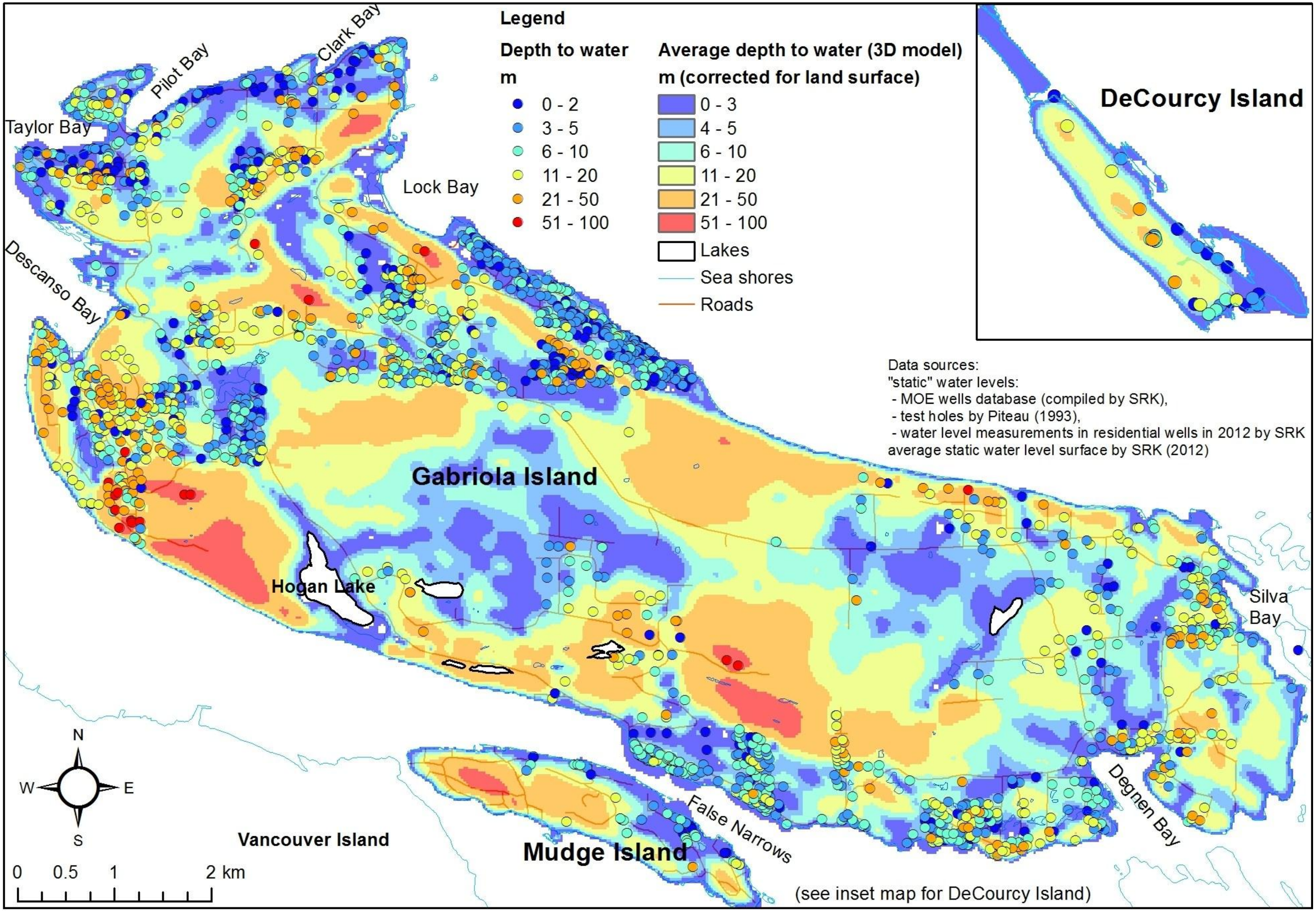
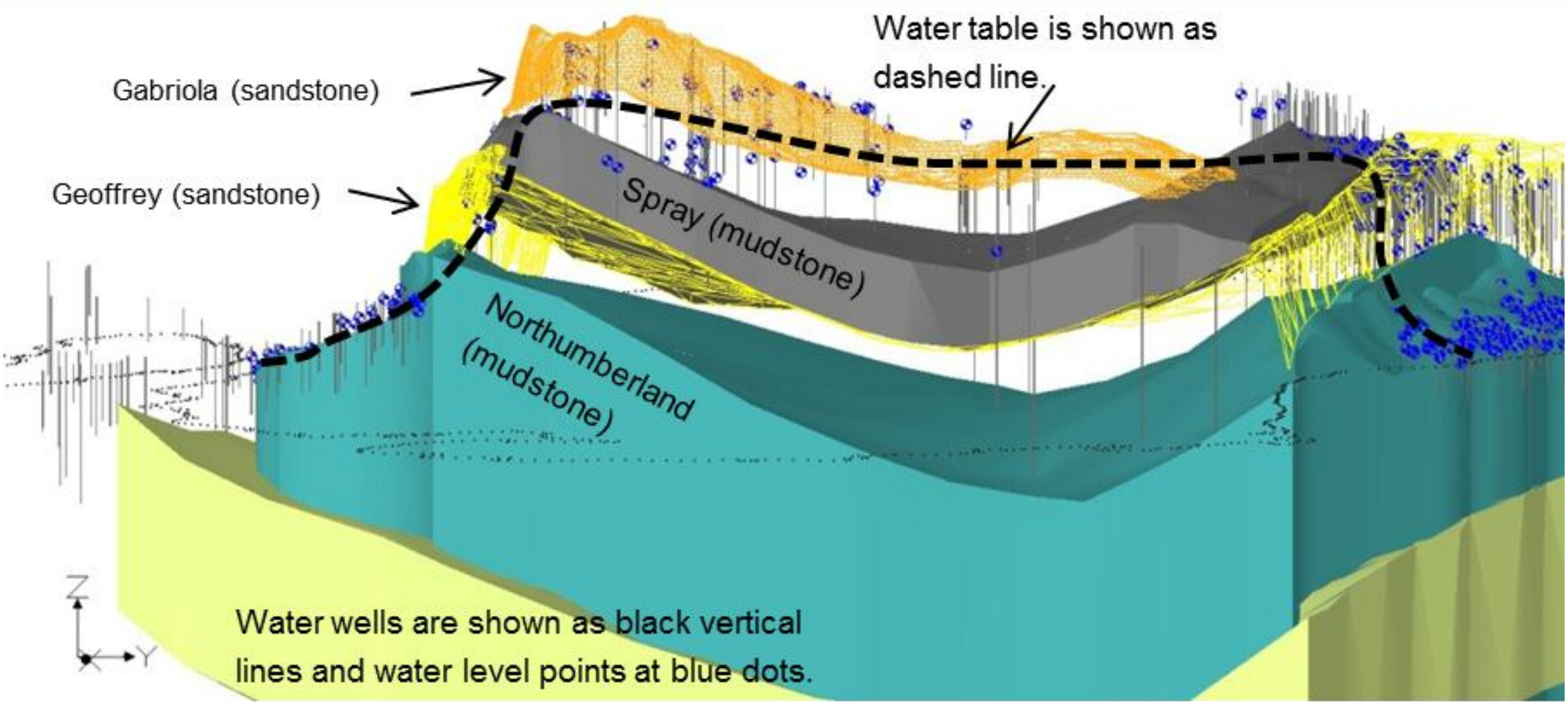


Figure 1. Ground water fills cracks and pores below the water table.

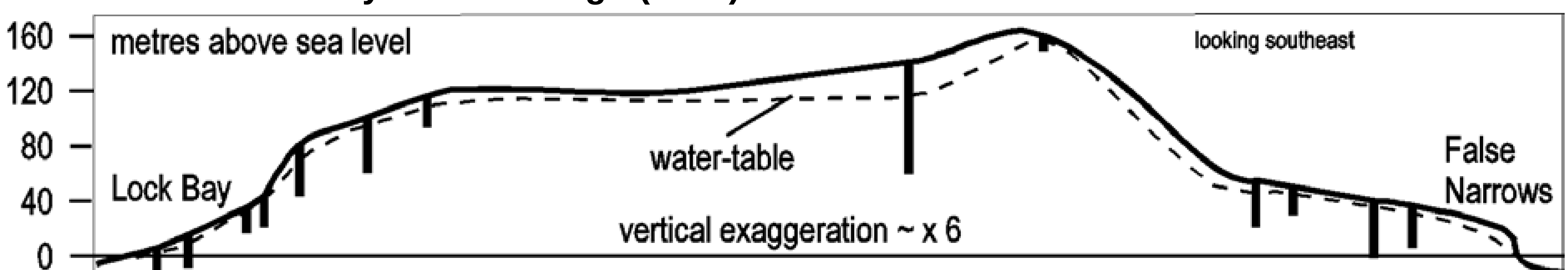
Depth to water



Water table in cross-section

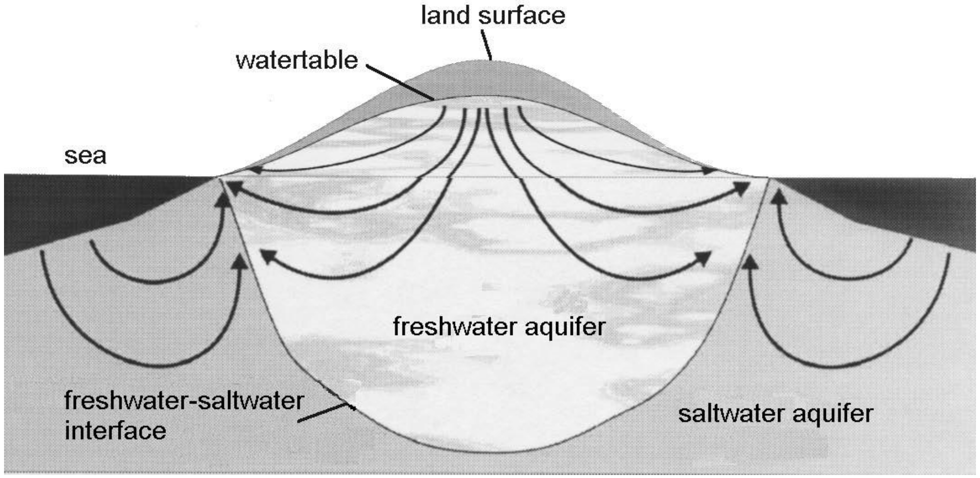


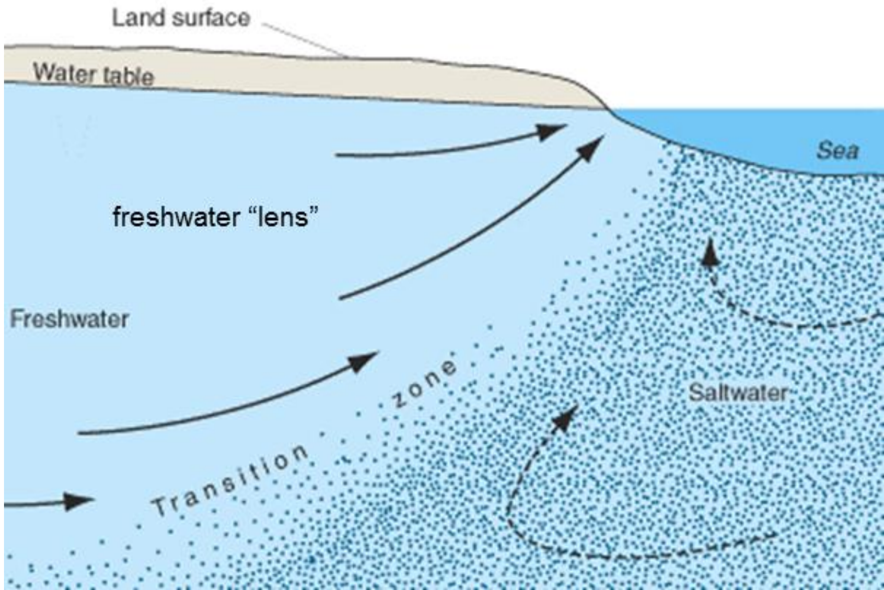
Section done by Earle & Krogh (2004)



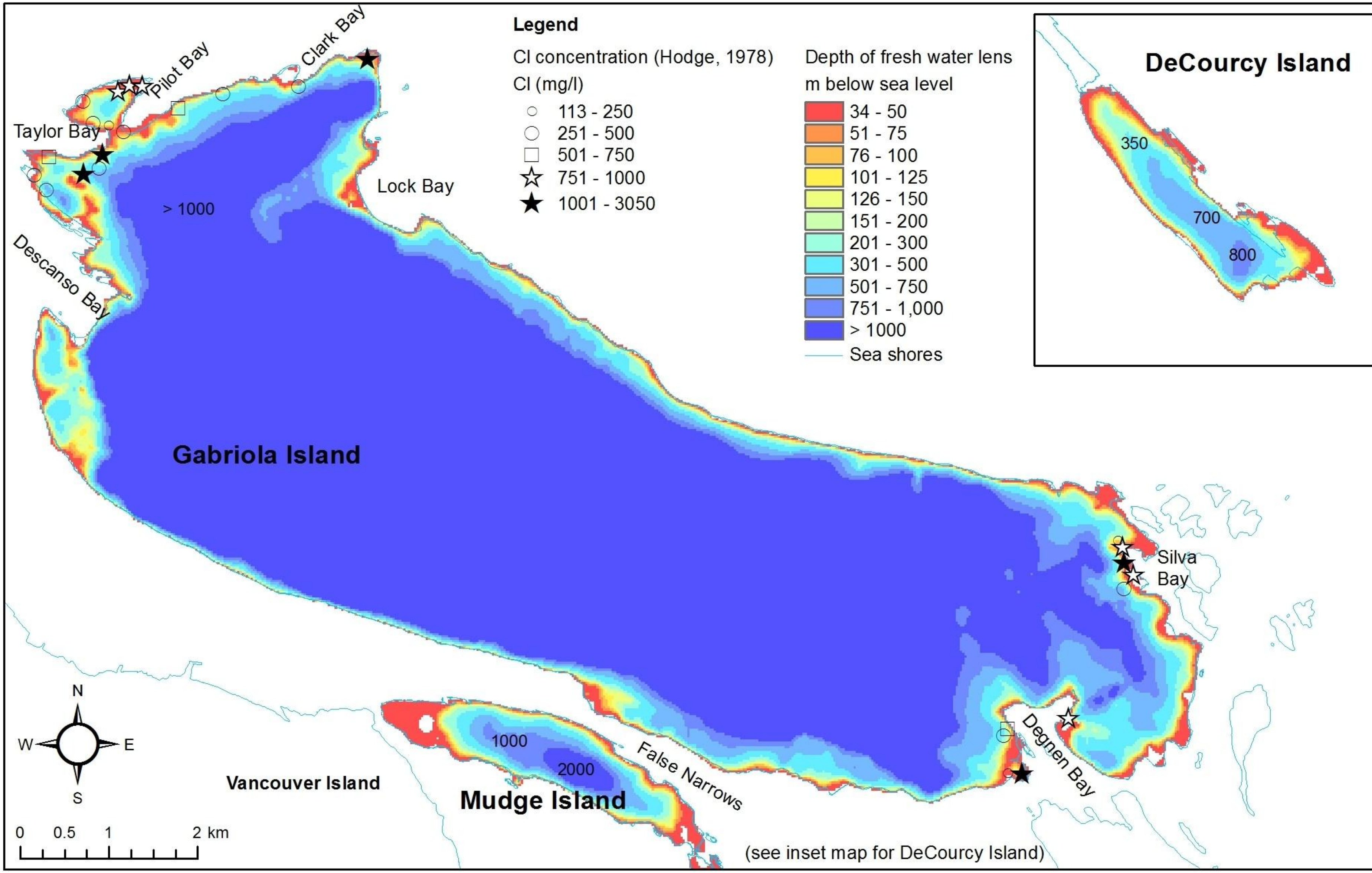
Fresh water lens – how deep?

freshwater lens concept for “small” island, used in many reports

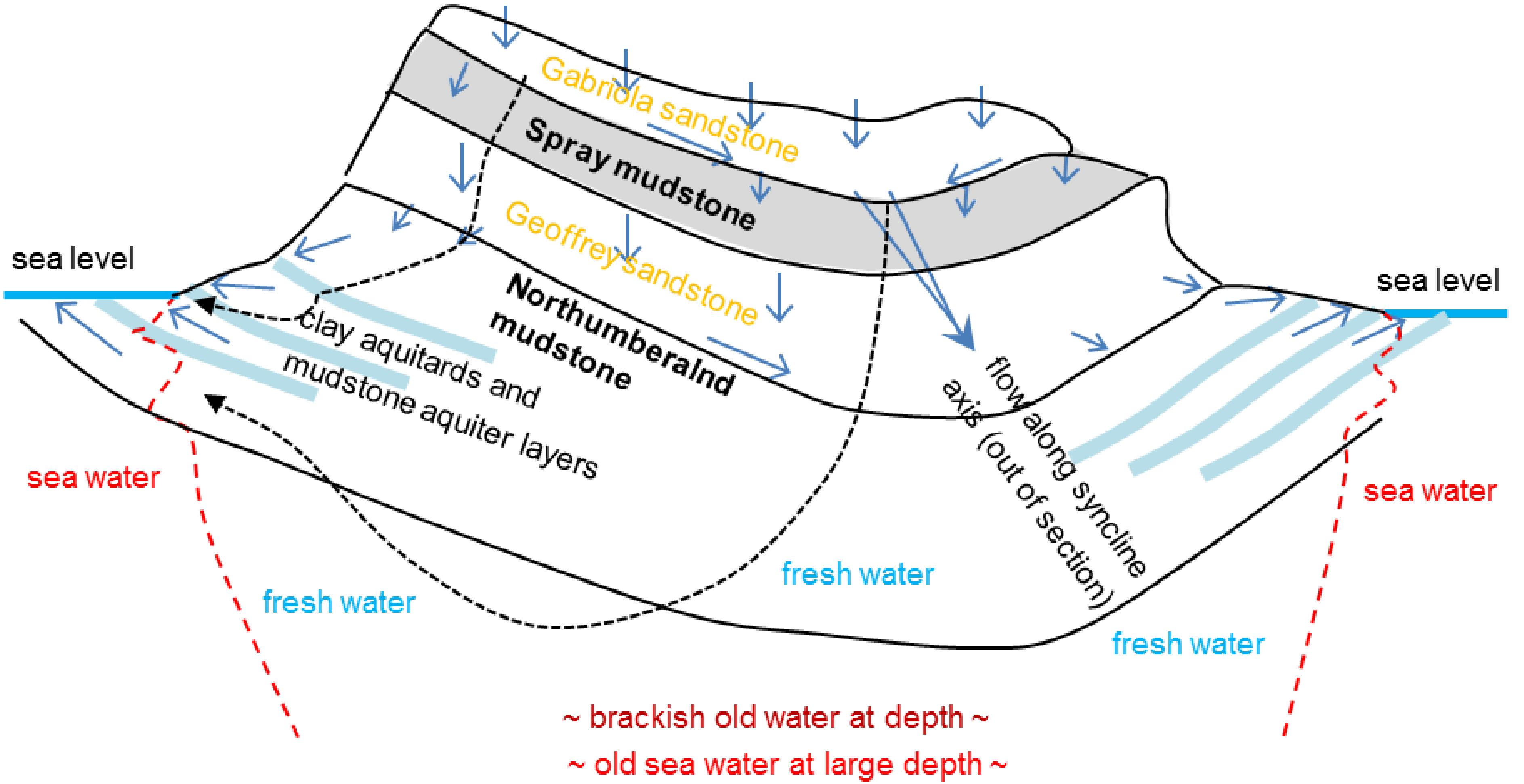




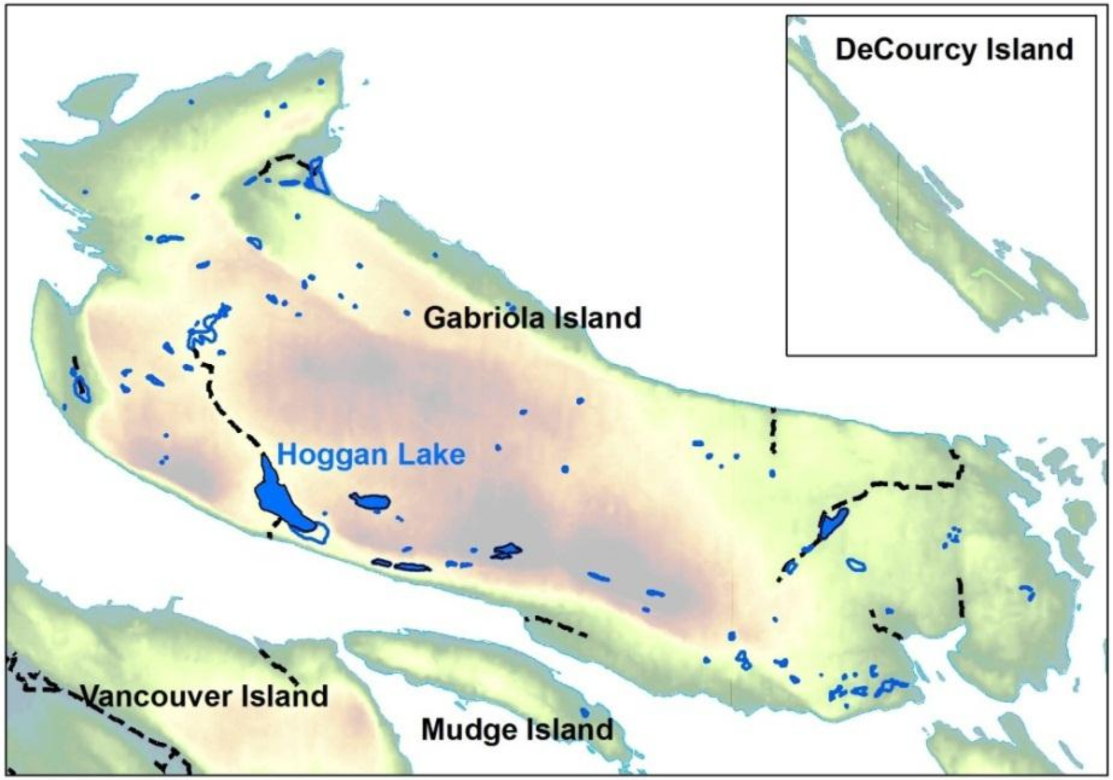
Fresh water lens – how deep?



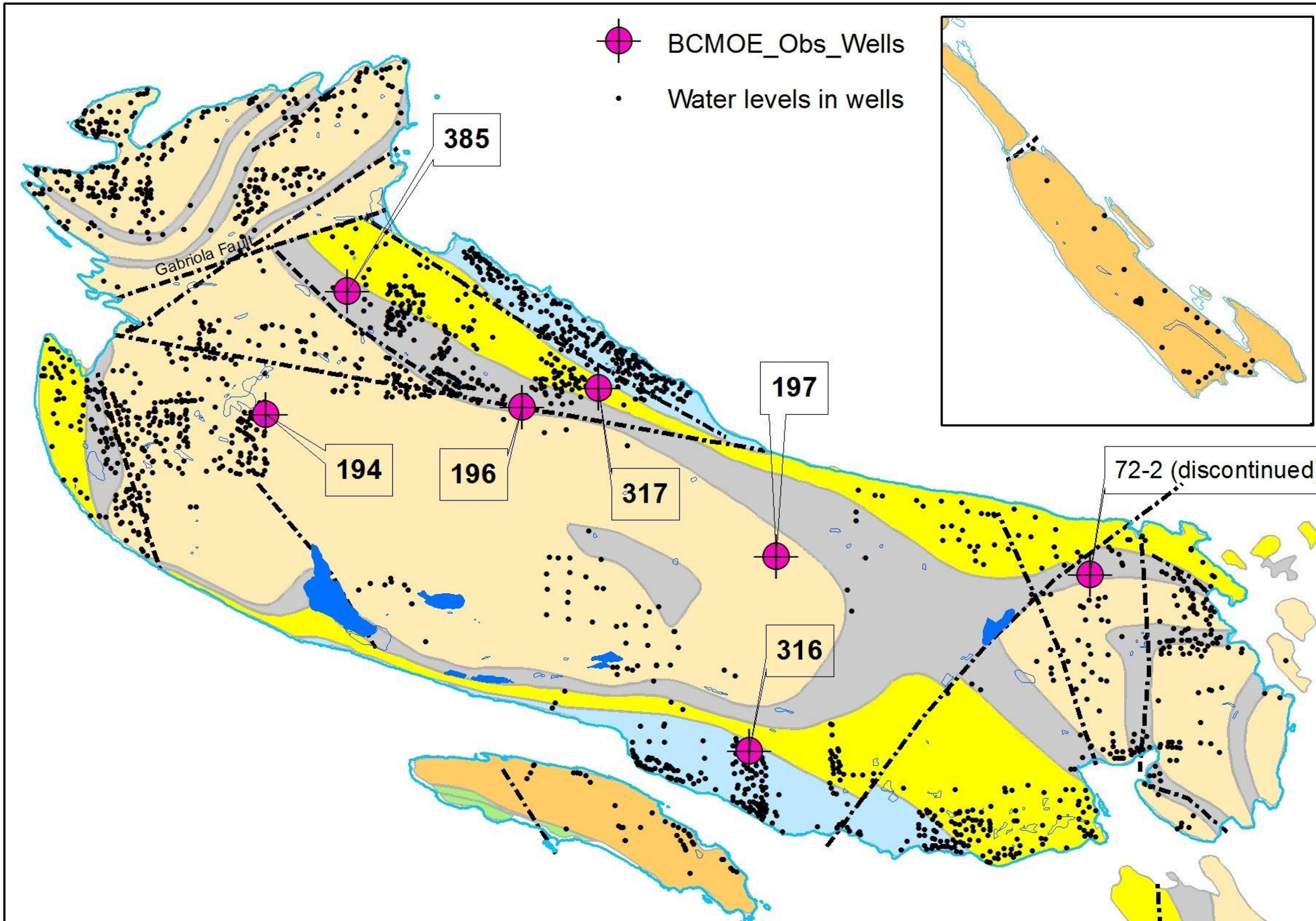
Flow of groundwater



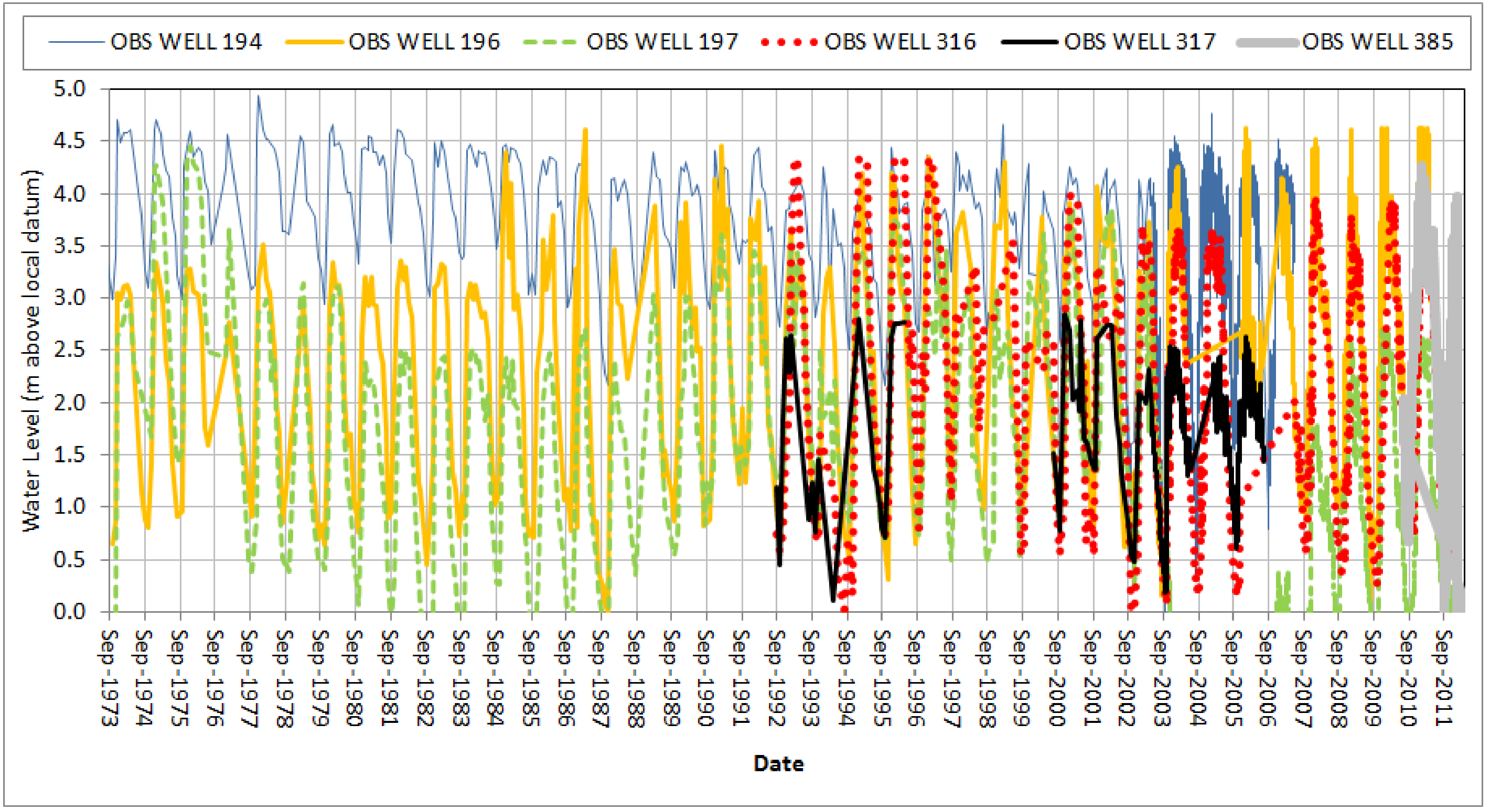
Surface water

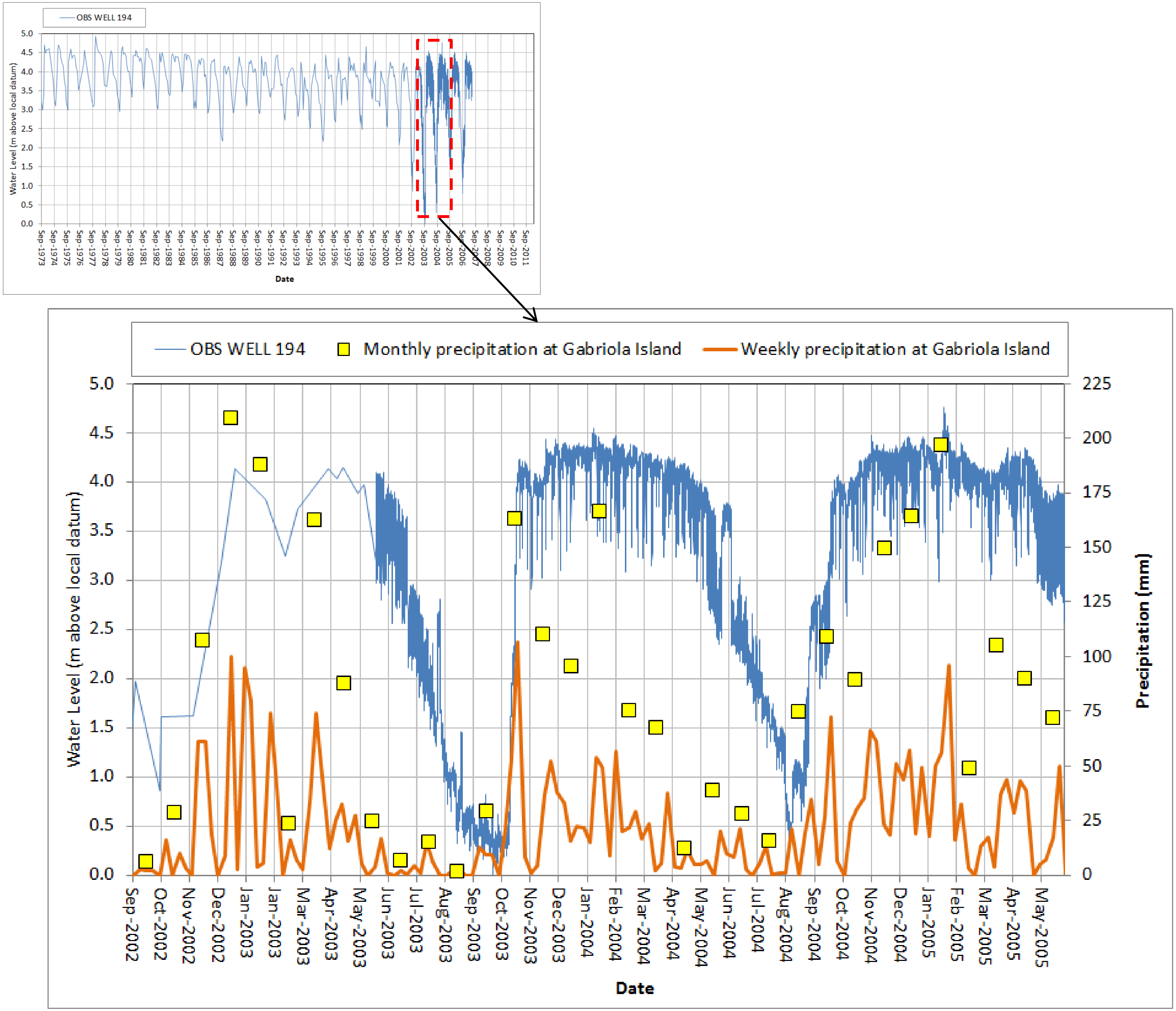


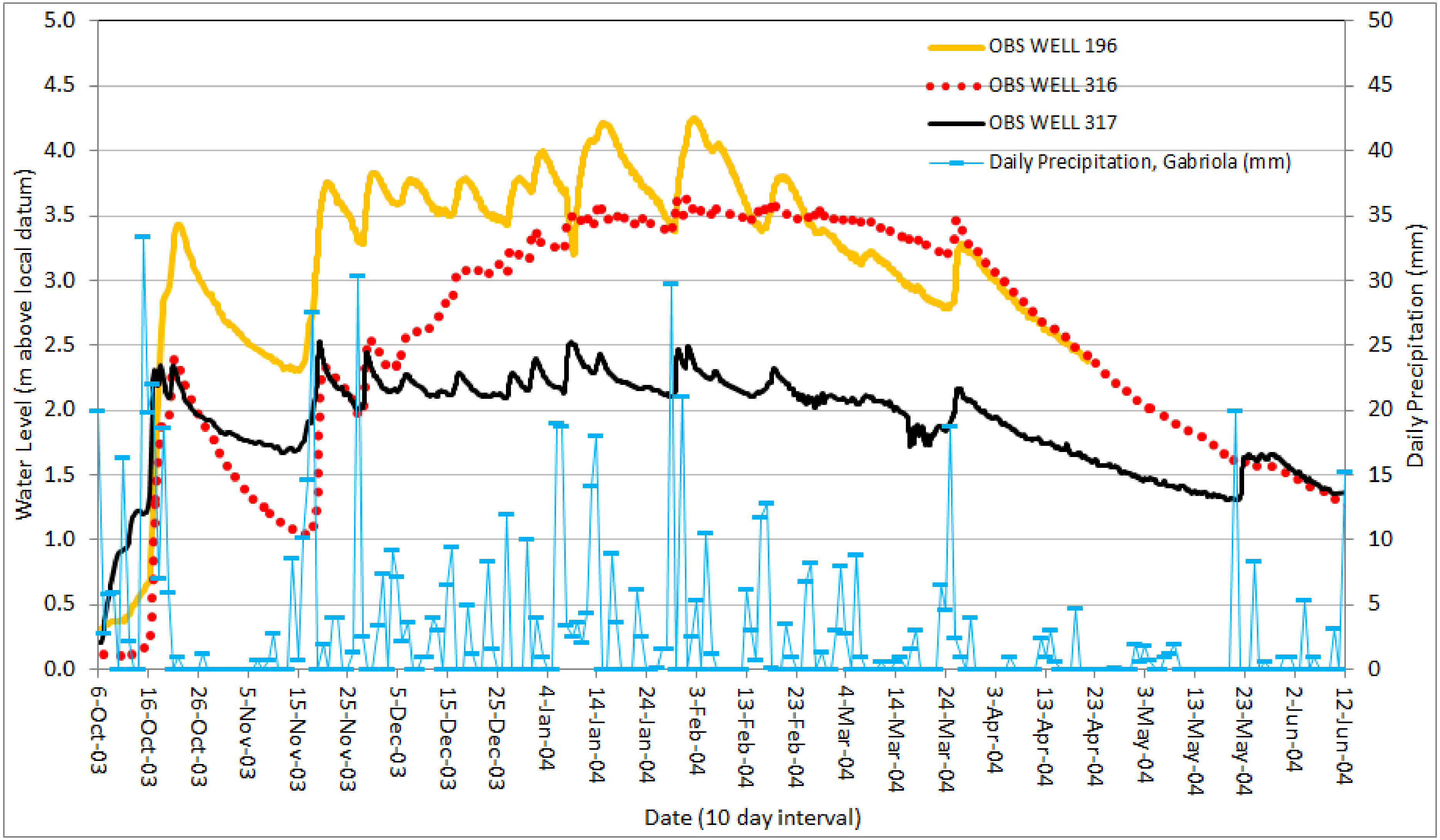
Existing water level monitoring wells



Water level seasonal / annual variation




OBS WELL 194
Water Level (m above local datum)
Date
OBS WELL 194
Monthly precipitation at Gabriola Island
Weekly precipitation at Gabriola Island
Water Level (m above local datum)
Precipitation (mm)
Date



OBS WELL 196
OBS WELL 316
OBS WELL 317
Daily Precipitation, Gabriola (mm)
Water Level (m above local datum)
Daily Precipitation (mm)
Date (10 day interval)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
50
45
40
35
30
25
20
15
10
5
0
6-Oct-03
16-Oct-03
26-Oct-03
5-Nov-03
15-Nov-03
25-Nov-03
5-Dec-03
15-Dec-03
25-Dec-03
4-Jan-04
14-Jan-04
24-Jan-04
3-Feb-04
13-Feb-04
23-Feb-04
4-Mar-04
14-Mar-04
24-Mar-04
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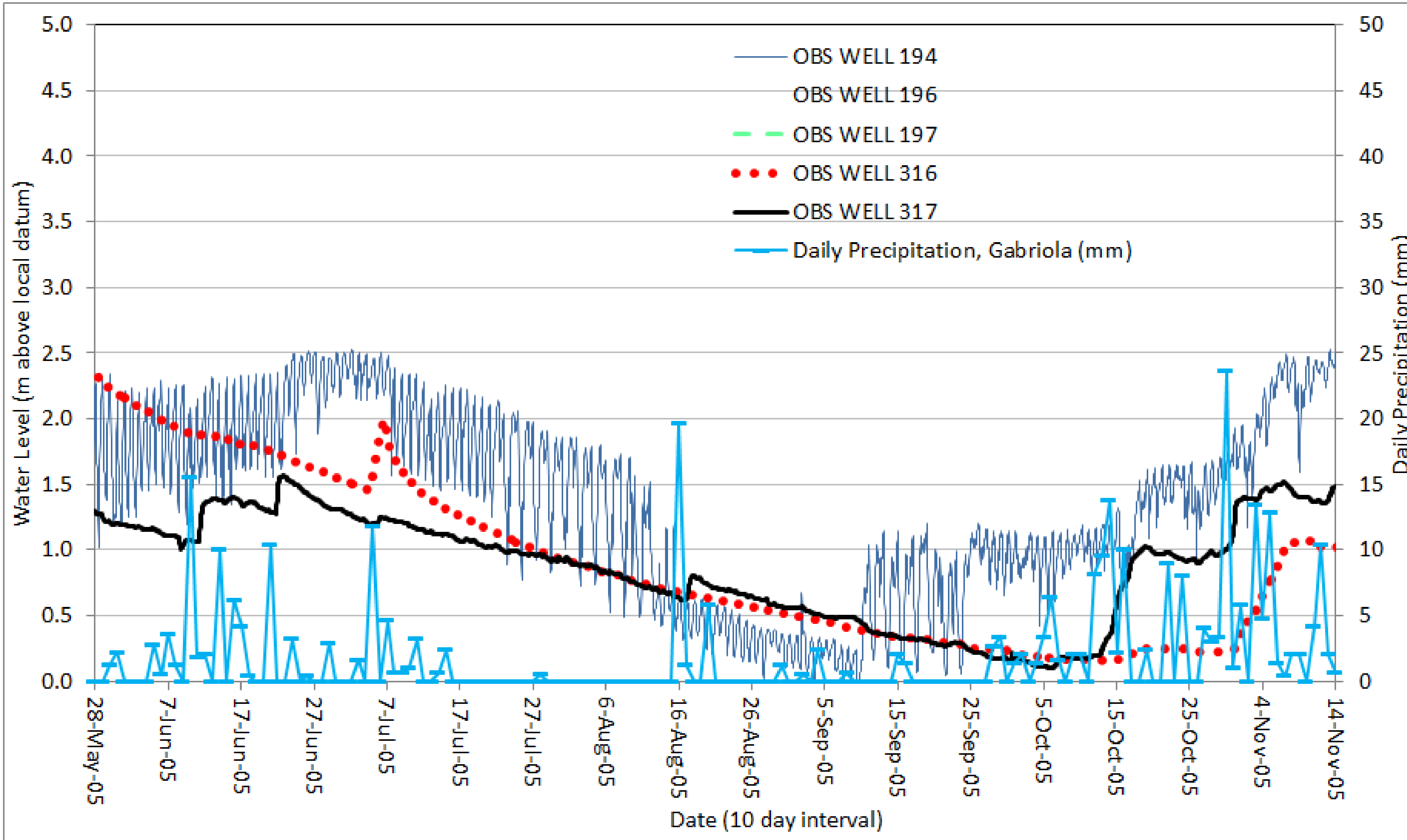
23-May-04
2-Jun-04
12-Jun-04


OBS WELL 194
OBS WELL 196
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OBS WELL 316
OBS WELL 317
Daily Precipitation, Gabriola (mm)
Water Level (m above local datum)
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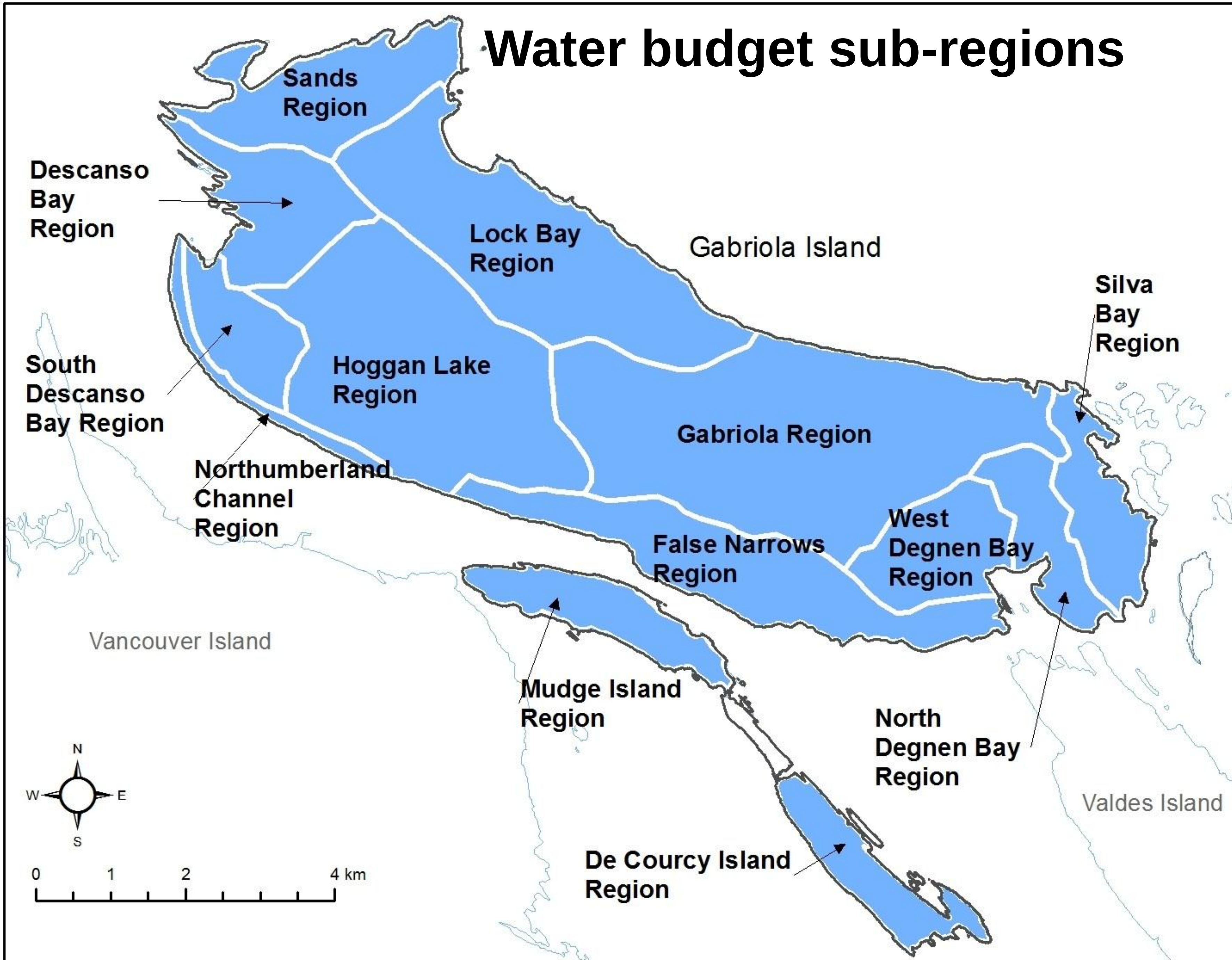
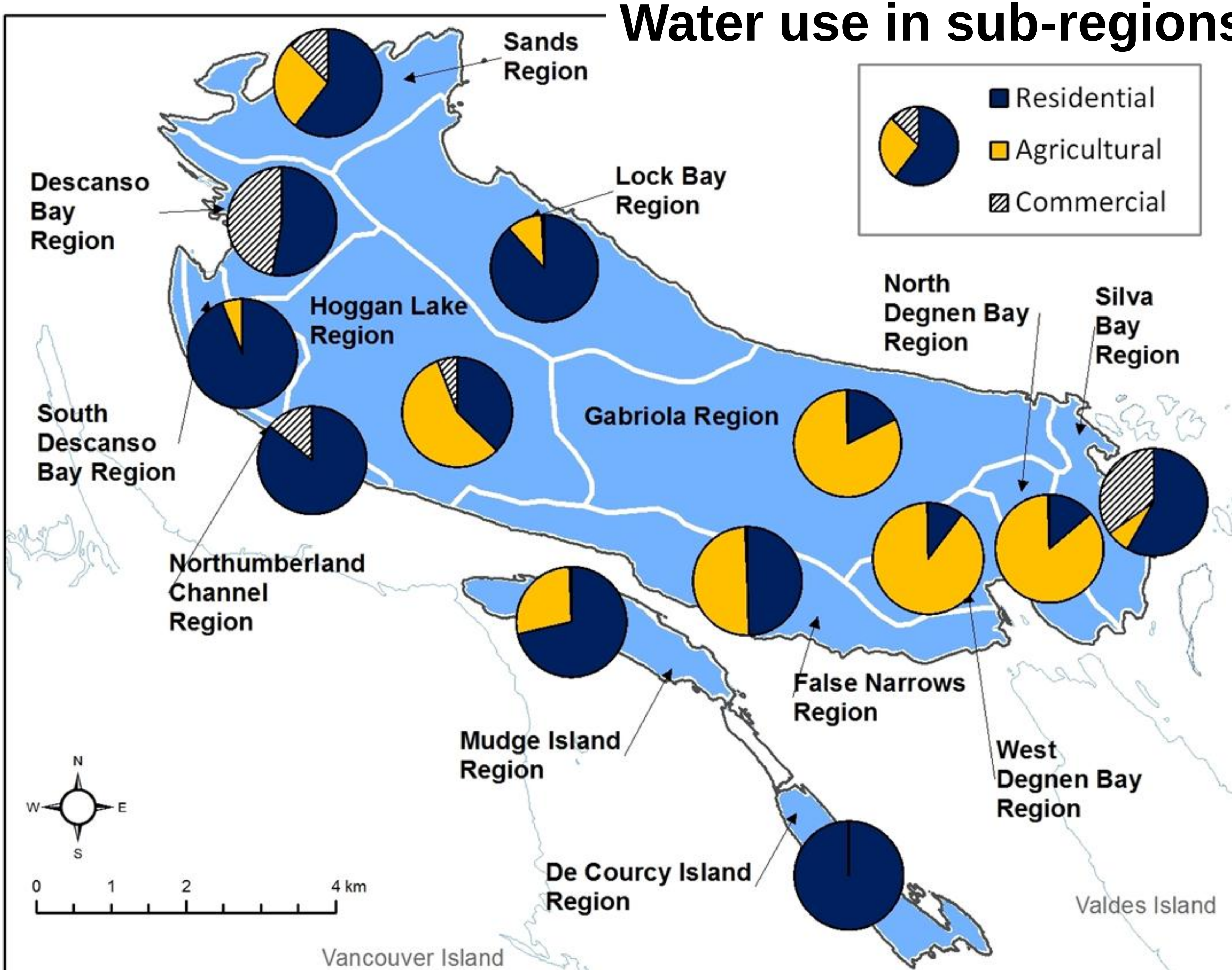
Date (10 day interval)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
50
45
40
35
30
25
20
15
10
5
0
28-May-05
7-Jun-05
17-Jun-05
27-Jun-05
7-Jul-05
17-Jul-05
27-Jul-05
6-Aug-05
16-Aug-05
26-Aug-05
5-Sep-05
15-Sep-05
25-Sep-05
5-Oct-05
15-Oct-05
25-Oct-05
4-Nov-05
14-Nov-05

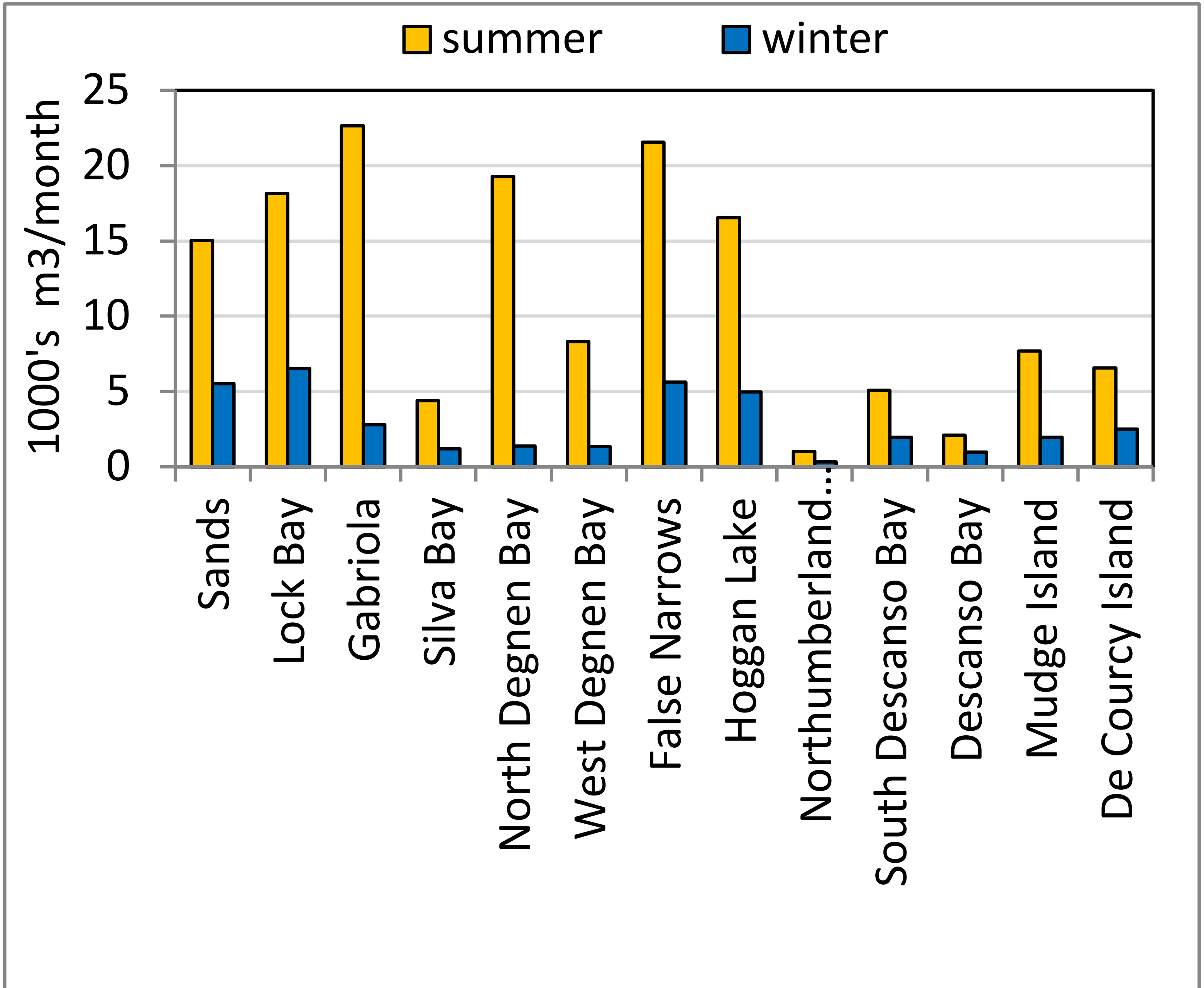
Water budget sub-regions



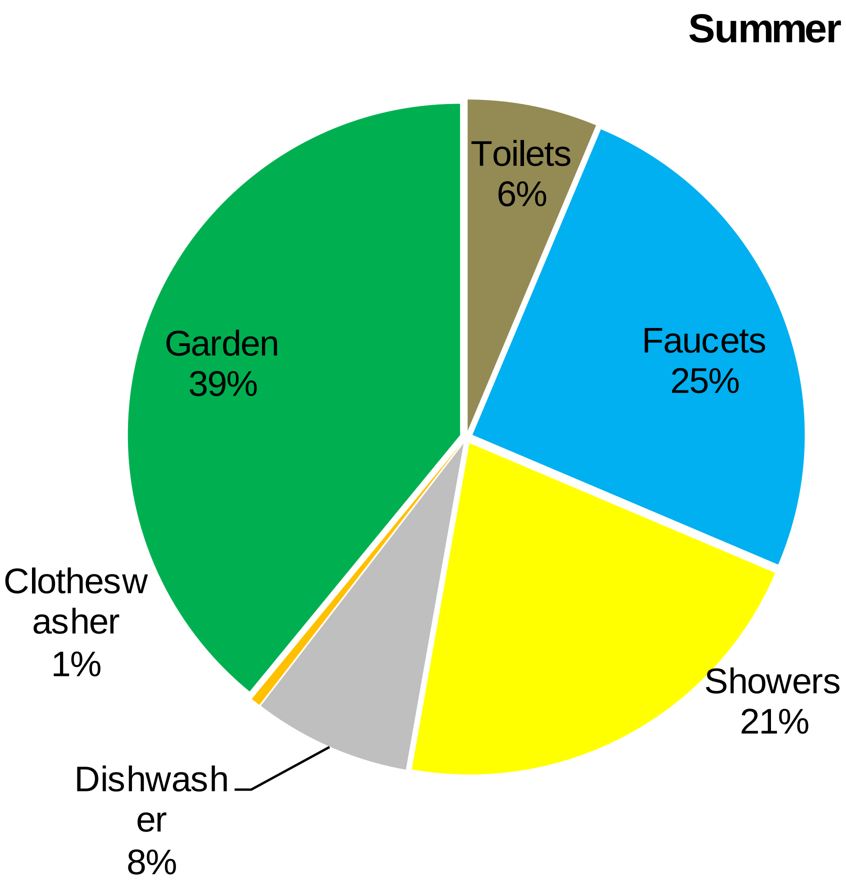
Water use in sub-regions

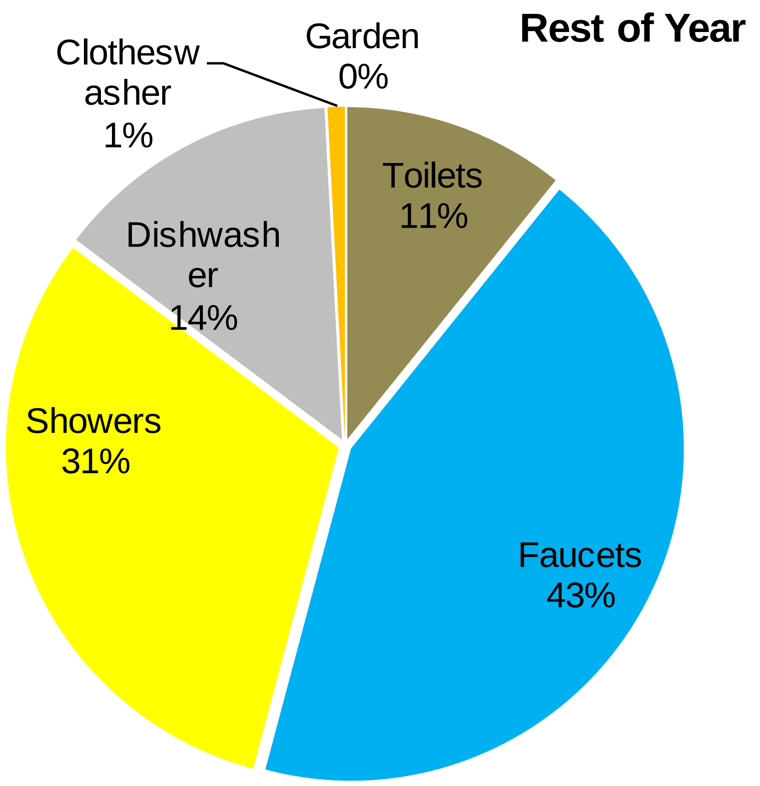


Seasonal difference in water demand



Residential water use type & seasonal differences



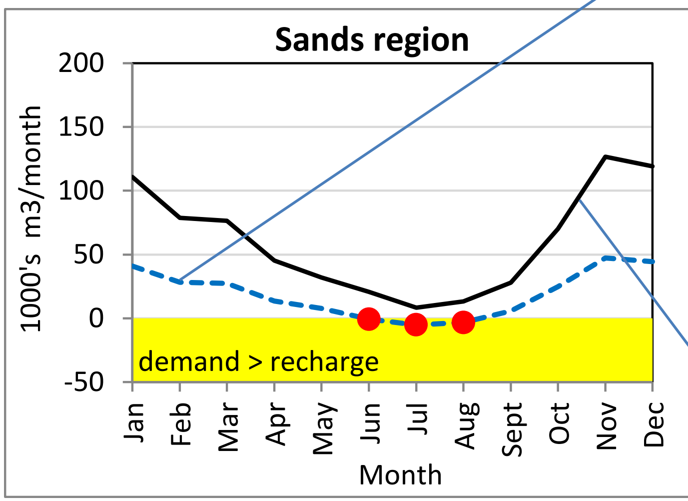


Calculating water "stress"

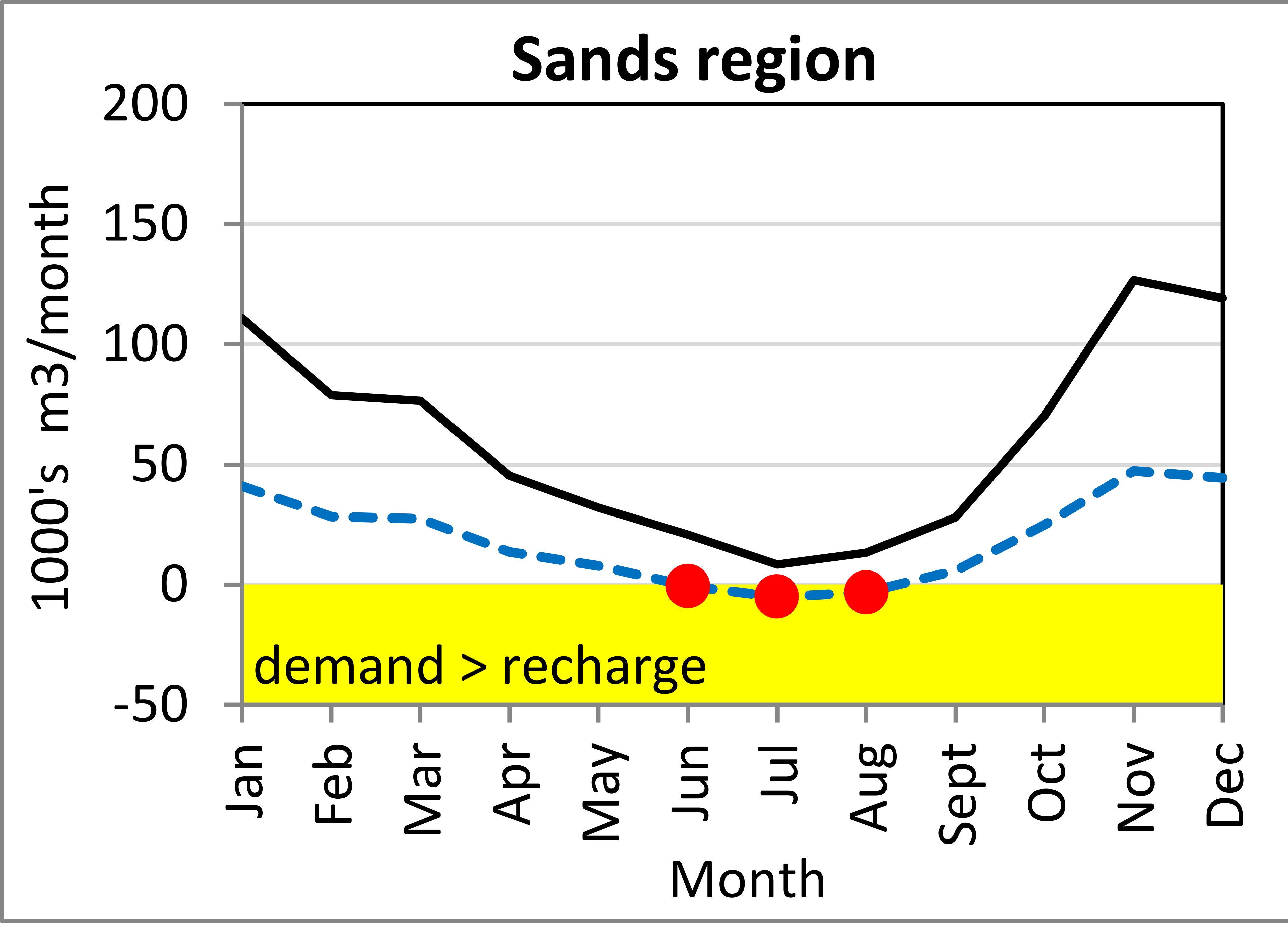
The categories of aquifer "stress" due to groundwater extraction were:

- low stress = surplus is large > 10,000 m^3
- moderate stress = surplus is 0 to 10,000 m^3
- higher stress = deficit

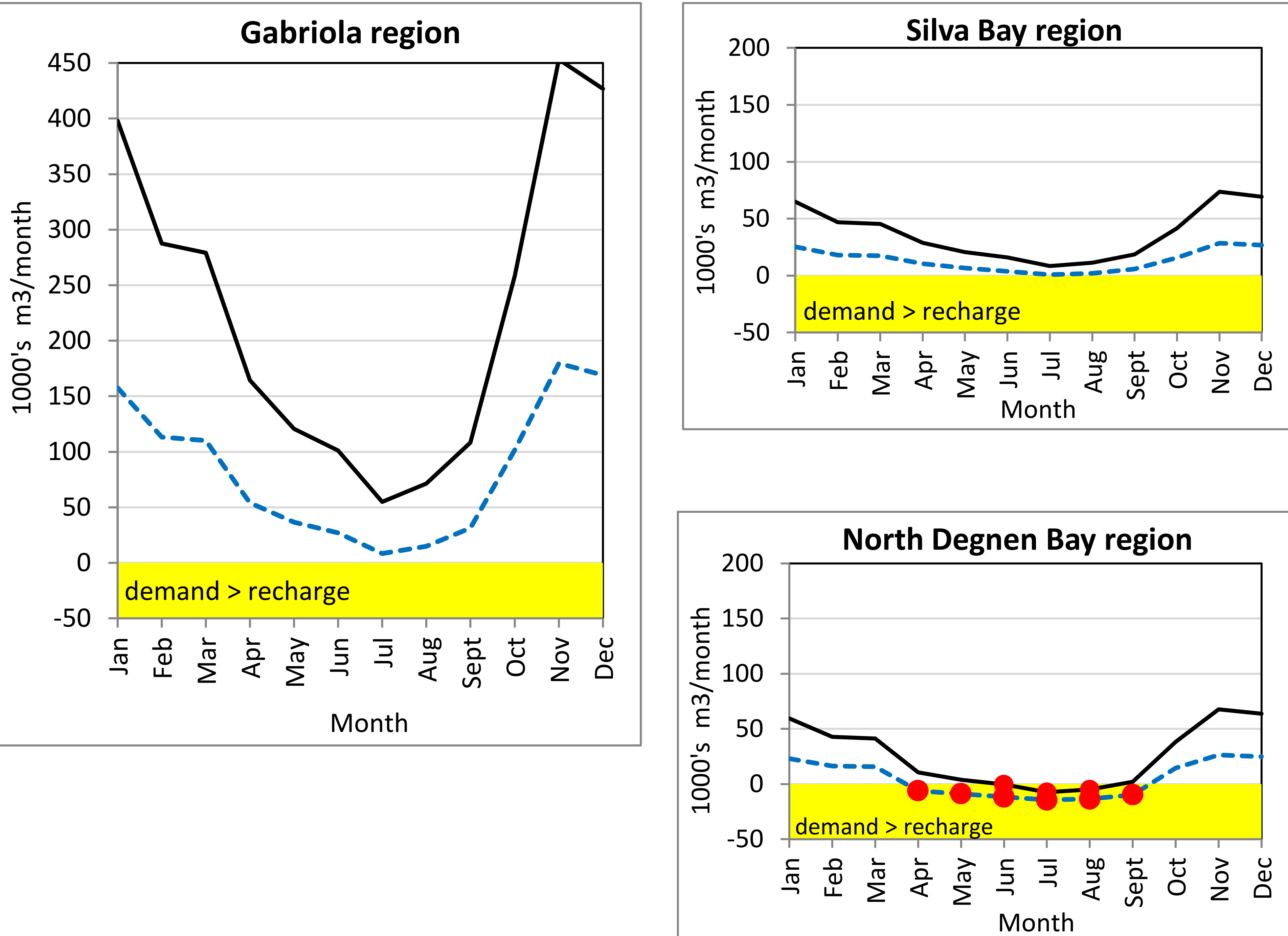
Monthly water surplus (recharge-demand) and water stress categories by water sub-region



	Water sub-regions	Monthly surplus (recharge - demand) in 1000's m^3/month and category of water stress											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
10% recharge scenario	Sands	41.0	28.3	27.3	13.4	7.7	-0.7	-5.1	-3.2	5.7	24.6	47.3	44.5
	Lock Bay	93.6	66.0	63.9	38.3	27.4	12.7	1.2	5.3	24.0	58.6	107.2	100.7
	Gabriola	157.5	113.3	110.0	54.1	36.6	26.8	8.3	14.9	31.2	101.7	179.6	169.1
	Silva Bay Region	25.3	18.0	17.4	10.5	6.6	3.8	0.7	1.8	5.7	15.6	28.5	26.8
	North Degnen Bay	22.9	16.2	15.7	-6.1	-8.9	-11.8	-14.6	-13.6	-9.8	14.5	26.3	24.7
	West Degnen Bay	30.5	21.7	21.1	7.4	3.9	1.5	-2.2	-0.9	2.4	19.4	34.9	32.8
	False Narrows	60.3	42.1	40.8	16.5	9.2	-1.2	-8.8	-6.1	6.3	37.3	69.4	65.1
	Hoggan Lake	115.1	82.0	79.4	43.4	30.3	20.5	7.5	12.5	25.8	73.2	131.6	123.7
	Northumberland Channel	9.7	6.9	6.7	4.3	3.0	2.1	0.9	1.3	2.7	6.2	11.0	10.4
	South Descanso Bay	21.5	15.0	14.5	8.8	6.2	2.2	-0.5	0.4	5.4	13.3	24.7	23.2
	Descanso Bay	36.4	26.1	25.3	16.1	11.8	9.4	5.1	6.7	10.7	23.3	41.5	39.0
	Mudge Island	24.7	17.4	16.8	8.1	5.2	0.6	-2.5	-1.4	4.4	15.4	28.4	26.6
	De Courcy Island	21.8	15.1	14.6	8.6	6.0	0.9	-1.9	-0.9	5.3	13.3	25.1	23.5
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
25% recharge scenario	Sands	110.8	78.8	76.4	45.4	32.1	20.9	8.3	13.1	28.1	70.1	126.7	119.3
	Lock Bay	243.7	174.7	169.4	107.1	79.8	59.0	30.2	40.5	72.1	156.3	278.0	261.6
	Gabriola	398.0	287.5	279.1	164.3	120.6	101.0	54.8	71.3	108.2	258.3	453.3	426.8
	Silva Bay Region	65.0	46.8	45.4	28.7	20.5	16.0	8.4	11.1	18.4	41.5	73.7	69.3
	North Degnen Bay	59.4	42.6	41.3	10.6	3.9	-0.5	-7.5	-5.0	1.9	38.2	67.7	63.7
	West Degnen Bay	78.3	56.3	54.7	29.3	20.6	16.2	7.1	10.3	17.7	50.5	89.3	84.0
	False Narrows	159.2	113.8	110.3	61.8	43.7	29.3	10.3	17.1	38.0	101.8	181.9	171.1
	Hoggan Lake	295.1	212.4	206.1	125.9	93.2	73.0	42.3	54.7	83.4	190.5	336.5	316.7
	Northumberland Channel	24.6	17.7	17.2	11.1	8.3	6.7	3.8	4.8	7.5	15.9	28.0	26.4
	South Descanso Bay	56.7	40.5	39.3	24.9	18.5	13.0	6.3	8.7	16.7	36.2	64.8	60.9
	Descanso Bay	92.3	66.6	64.6	41.8	31.3	26.7	15.9	19.8	28.6	59.8	105.2	99.1
	Mudge Island	64.7	46.3	44.9	26.5	19.2	12.9	5.2	8.0	17.2	41.5	73.9	69.5
	De Courcy Island	58.2	41.5	40.2	25.3	18.7	12.2	5.2	7.7	16.9	37.1	66.6	62.6



Sands region
200
150
100
50
0
-50
1000's m3/month
demand > recharge
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
Month


Gabriola region
1000's m3/month
450
400
350
300
250
200
150
100
50
0
-50
demand > recharge
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
Month
Silva Bay region
1000's m3/month
200
150
100
50
0
-50
demand > recharge
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
Month
North Degnen Bay region
1000's m3/month
200
150
100
50
0
-50
demand > recharge
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
Month

Data Gaps and Recommended Data Collection

Priority	Data Type
1	Water-use surveys in all regions
2	Long-term observation wells in residential areas
3	Drawdown in residential wells around large production wells
4	Short-duration monitoring of water levels in residential wells
5	Survey and measurements of surface water flows
6	Additional hydraulic tests in representative locations in different hydrogeological units
7	Improved geological map along island steep slopes/cliffs
8	Data quality control of existing wells database.
9	Deep water levels and water quality

Conclusions:

Hydrogeological conceptual model:

- shared groundwater resource
- recharge from precipitation 10 to 25% of m.a. P.
- water levels show quick and small rise in water level after each rainy period (2 – 4m)
- water levels has repeating seasonal cycle
- large groundwater storage volume, used during dry season and recharged during wet season

Conclusions:

Groundwater system response to extraction:

- no consistent or significant long term trends
- locally large temporary drawdowns of groundwater level
- dense residential development along shores; narrow land penninsulas are most sensitive because of low recharge and shallower depth of fresh water
- geologic conditions and shallow depth of fresh water increases the chances of saltwater intrusion in some shore areas

Conclusions:

Groundwater system response to extraction:

- annual time scale → no significant water stress

  → recharge is sufficient to meet demand

- monthly time scale → “higher stress” during dry season

  → more water extracted than recharged

  → aquifer recharged easily in autumn

- no evidence from water levels of long term decline caused by increase of demand over time

Conclusions:

Limitations of water budget results:

- results are indicative, good initial assessment
- recharge can only be estimated (likely range is 10% to 25%)
- pumping demand uncertain (+/- ___% ?)
- water-use surveys are a small sample of users, those most interested in groundwater resource and conservation...
- few actual hard numbers on which to base estimates in commercial wells
- almost every resource is regulated and measured, why not groundwater?

Conclusions:

Recommened management plan:

- groundwater regulation (hopefully in future), for now voluntary water use reporting – increase community involvement
- issues: population growth, water use change, climate change, water quality
- increased monitoring and data collection but in cost-effective way
- increase awareness of occurrence of saltwater intrusion
- simple groundwater numerical model can be used to improve conceptual model and run scenarios, but these are not black boxes which give answers, completely depend on conceptual model and data available - see latest BC MOE guidelines for groundwater modeling in natural resource extraction

Guidelines for Groundwater Modelling to Assess Impacts of Proposed Natural Resource Development Activities

British Columbia
Ministry of Environment

Water Protection & Sustainability Branch

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