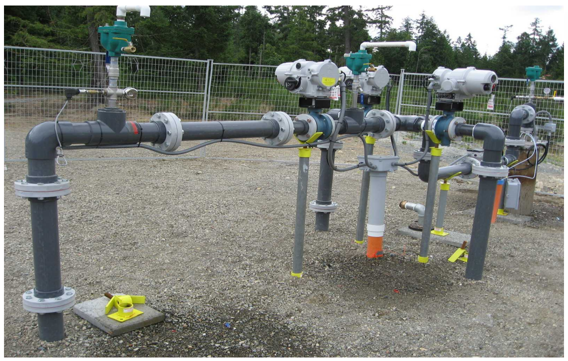
Englishman River Water Service Phase 2

Water Treatment Pilot Testing and Aquifer Storage and Recovery

Feasibility Analysis



Keith Kohut, P.Eng. M.A.Sc.

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May 16, 2014

Outline

- Background
- Water Quality Profiling
- Piloting Program
- Aquifer Storage and Recovery (ASR)
- Cost
- Recommendations

Background – Phase 1

- 2009 - Arrowsmith Water Service
- Phase 1 – Conceptual Planning, Budgeting and Scheduling
  - Revised demand projections
  - Historical river data
  - Treatment options
  - Site evaluation for intake and WTP
  - Climate change impacts
  - ASR

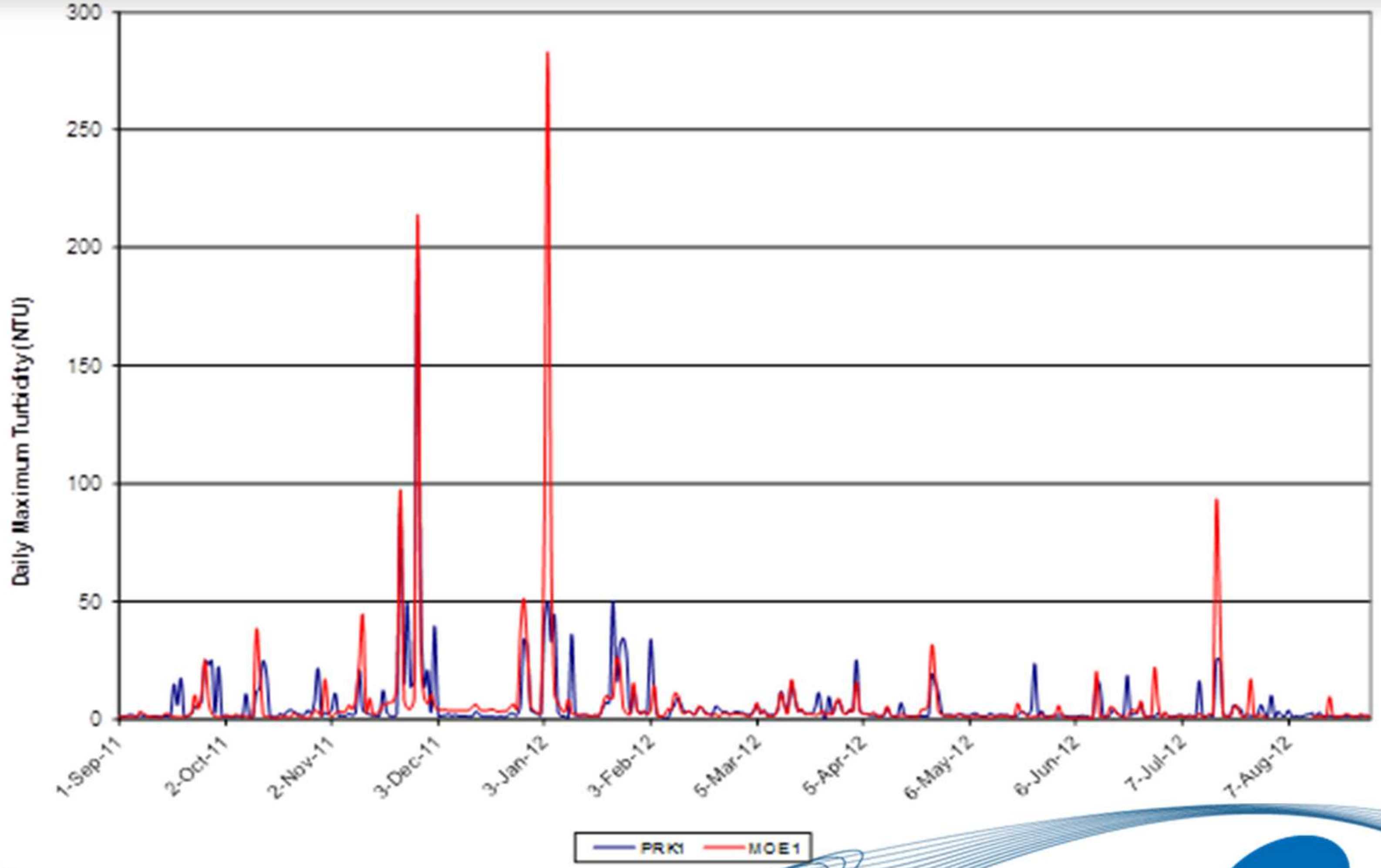
Background – Phase 2

- 2011 - Englishman River Water Service
  - Parksville and RDN
- Phase 2
  - Associated Engineering, Lowen Hydrogeology, Koers & Associates
  - Monitoring program
  - Reduced-scale field (pilot) testing
  - ASR field investigation

Water Quality Monitoring Program

- Gaps in historical data
  - Parameters of interest
  - Data for all four seasons
- 12-month monitoring program
  - On-line analyzers
  - Field measurements
  - Laboratory analysis

Monitoring - Turbidity

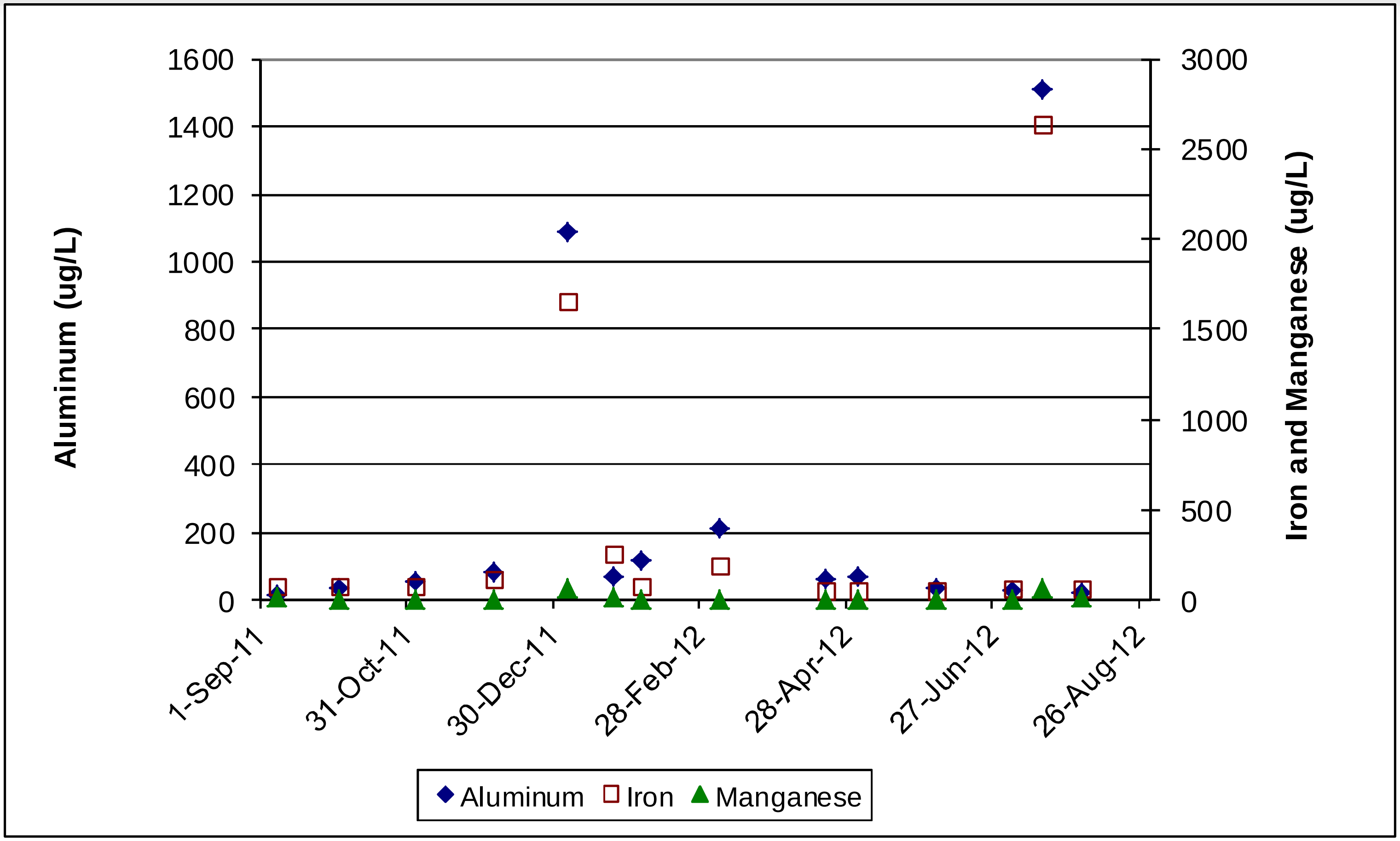


Monitoring– Other Parameters

Parameter	Objective	Average Measurement
True Colour (TCU)	≤ 15	**22**
E. Coli (counts / 100 mL)	0	20
Nitrate (mg/L as N)	≤ 10	< 0.02
Total Organic Carbon (mg/L)	-	2
Alkalinity (mg/L as $CaCO_3$)	-	17

Associated Engineering

Monitoring – Turbidity Events



Treatment Objectives

- Turbidity $\leq$ 1 (depends on treatment)
- True colour $\leq$ 15
- Microbiological protection

  - 3-log (99.9%) removal/inactivation *Cryptosporidium*
  - 3-log (99.9%) removal /inactivation *Giardia*
  - 4-log (99.99%) removal/inactivation viruses

Associated Engineering

Treatment Objectives

Can meet these treatment objectives with filtration and disinfection

Associated Engineering

Filtration Deferral / Avoidance

- Criteria includes:
  - Turbidity not exceed 5 NTU
  - *E.coli* not exceed 20 counts / 100 mL

- Do not meet filtration deferral criteria

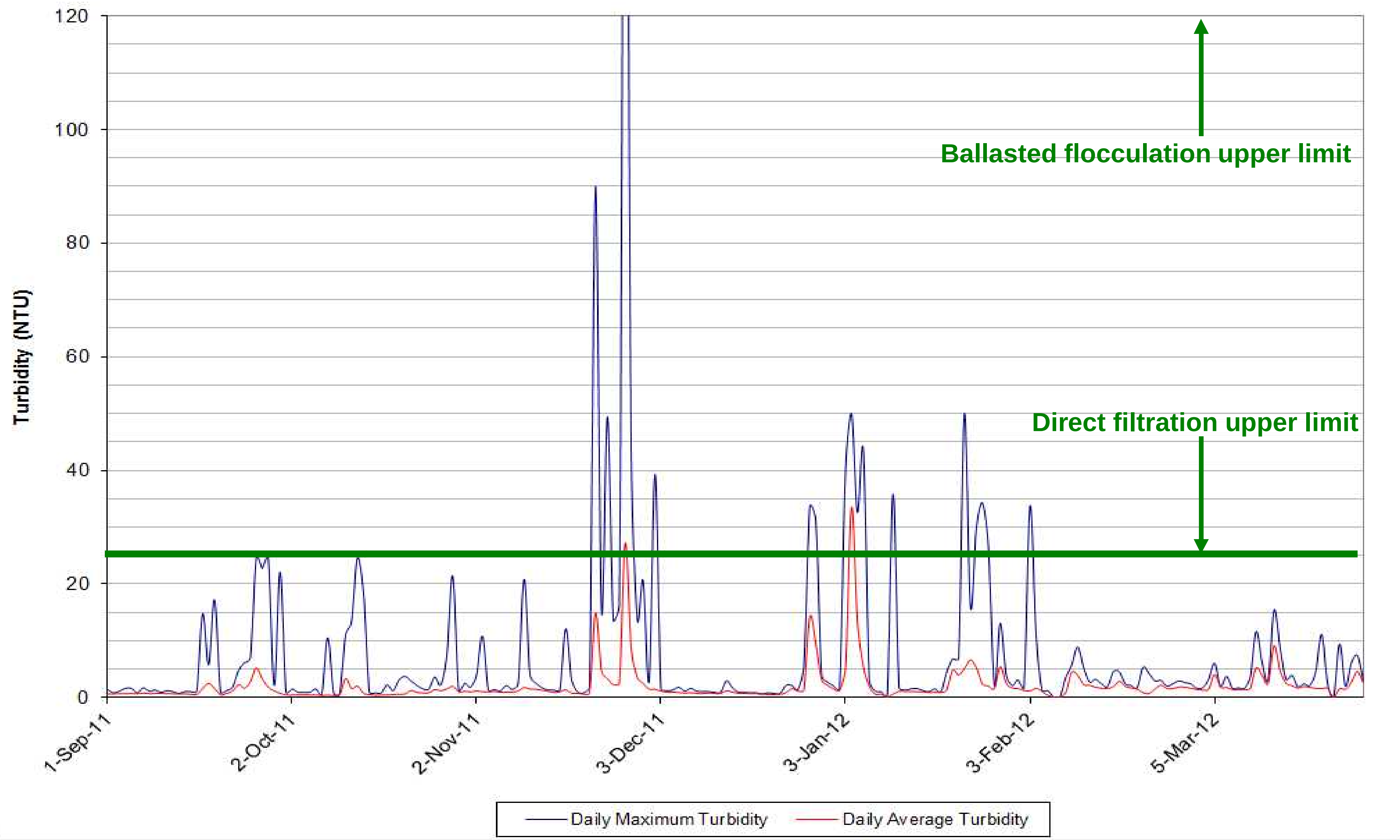
Piloting

- Each water is unique, how will treatment work?
- Objective: test performance at a reduced scale
- Pilot under most difficult conditions

Which Processes to Pilot?

- Direct filtration
- Conventional treatment
- Dissolved air flotation (DAF)
- Ballasted flocculation (ex: Actiflo®)
- Membranes

Piloting – Process Options



DAF – Can Sediment Float?

- Test at bench-scale (Pass/Fail)
- Could not make sediment float
- DAF not suitable for Englishman River water

Piloting – Process Options

- ~~Direct filtration~~ cannot handle spikes
- Conventional treatment
- ~~DAF~~ would not float
- ~~Ballasted flocculation~~ low turbidity
- Membranes

Piloting – Conventional Treatment

- Coagulation
- Flocculation
- Sedimentation
- Media filtration

Associated Engineering

Piloting – Conventional Treatment

- Hard to form settable particles
- Slow reaction to turbidity spikes
- Poor settling in settling tanks
- High filter cleaning frequency
- Could not produce consistent quality of water

- Conventional treatment not recommended

Piloting - Membrane

- Pre-filtration
- Coagulant
- Membrane ultrafiltration

Piloting - Membrane

- Consistent turbidity $\leq$ 0.01 NTU
- Need coagulant for colour removal
  - Aluminum chlorohydrate (ACH)
- Could treat turbidity events

- Membranes were successful

Piloting - Recommendations

- Treatment should consist of:
  - Pre-filtration
  - Coagulation (ACH)
  - Membrane ultrafiltration
  - Chlorination

Aquifer Storage Recovery

Englishman River Water Service

City of Parksville / Regional District of Nanaimo

Definition: Storage of water in a suitable aquifer through a well during times when water is available, and recovery of the water from the same well during times when it is needed (D. Pyne, 1995).

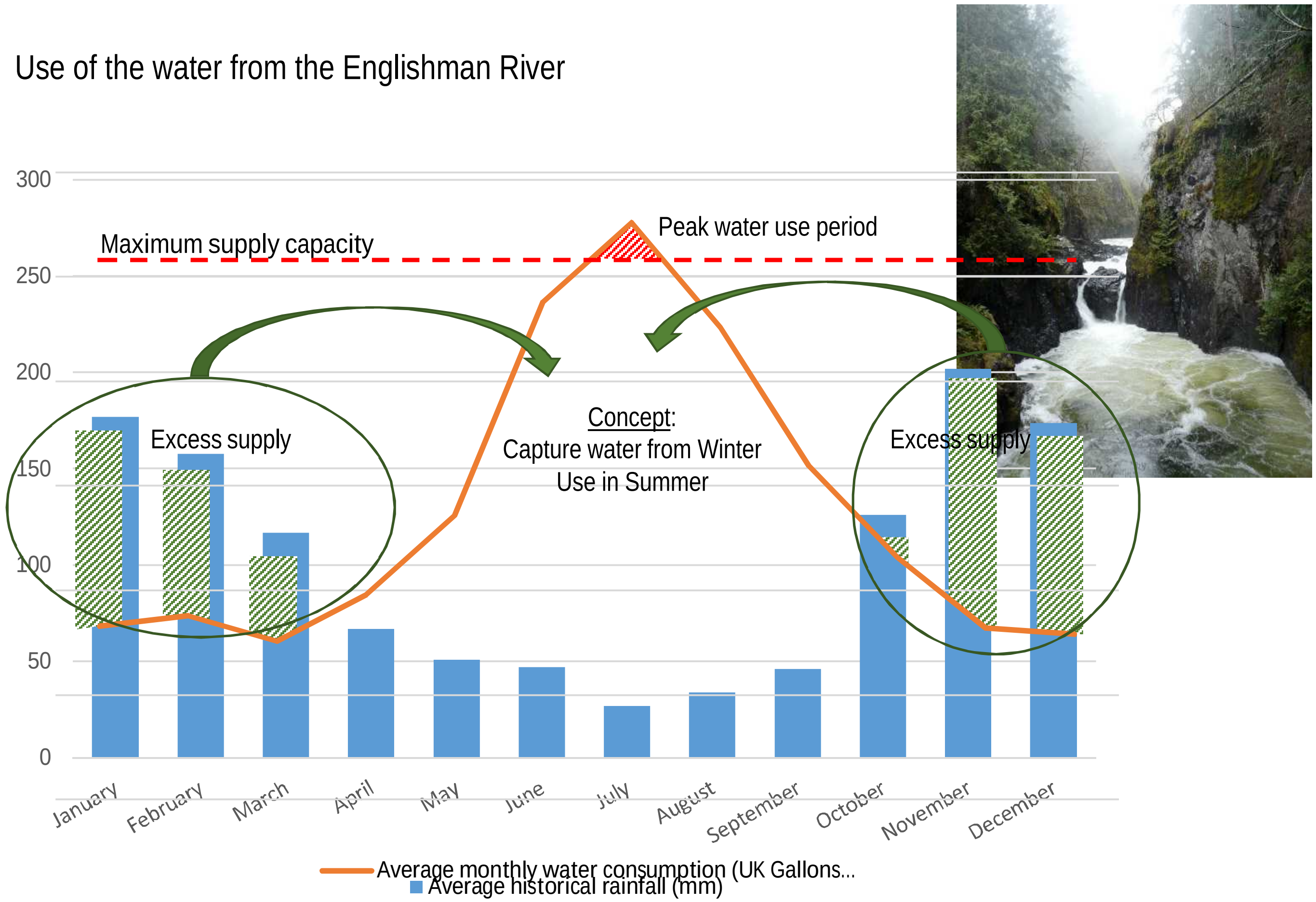
Dennis Lowen, B.Sc.G.E., P.Eng., P.Geo.

LHC Lowen Hydrogeology Consulting Ltd.

ASR Program Objectives

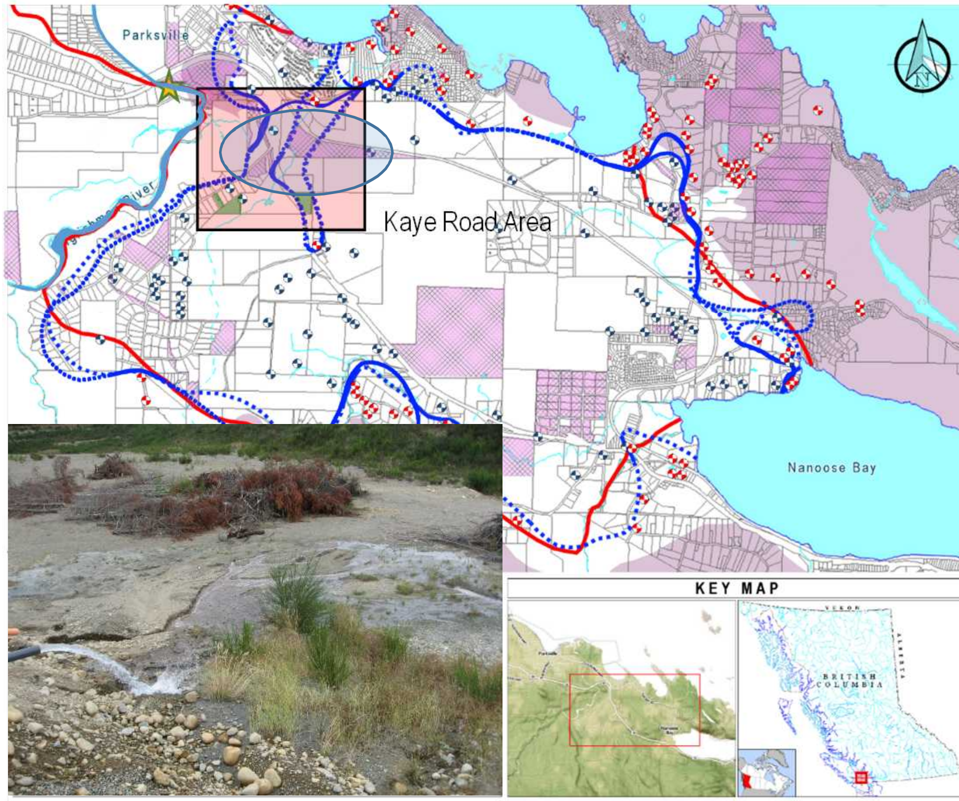
- Objectives presented in Sept.2010 Discussion Paper 5-2.
- Provide 15 ML/d (172 L/s) water supply capacity to help meet peak demands for 3.5 months.
- Total storage needed: 1,000,000 m^3.
- Engage regulators VIHA, EAO, MOE.
- After consultations with EAO, first stage objective revised to 6 ML/d (69 L/s).
- Conduct cycle testing on one well to confirm ASR feasibility.
- Refine cost estimates for ASR well field development.

Use of the water from the Englishman River



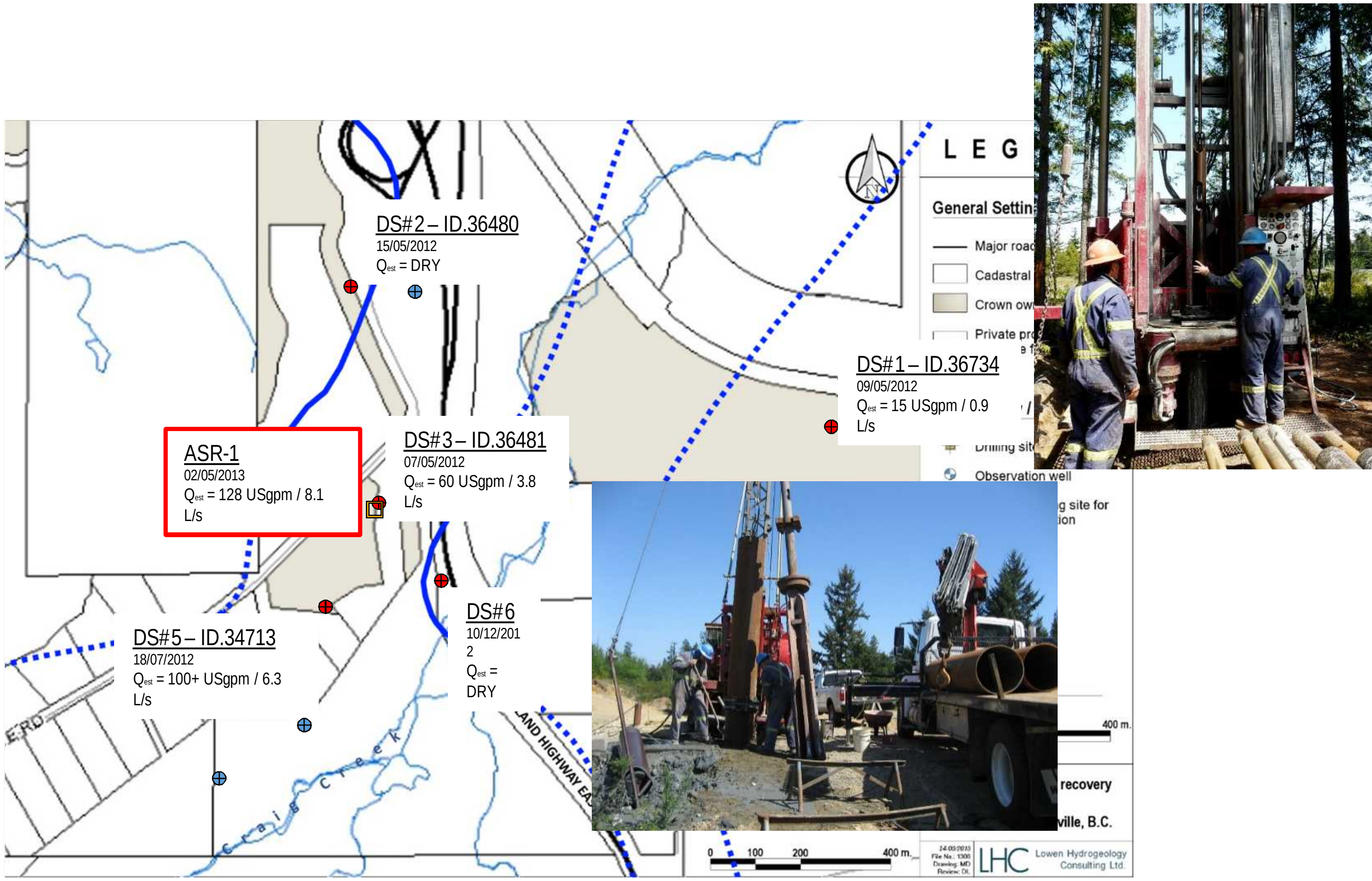
From M. Squire, ERWS, 2012

Wellfield and monitoring wells



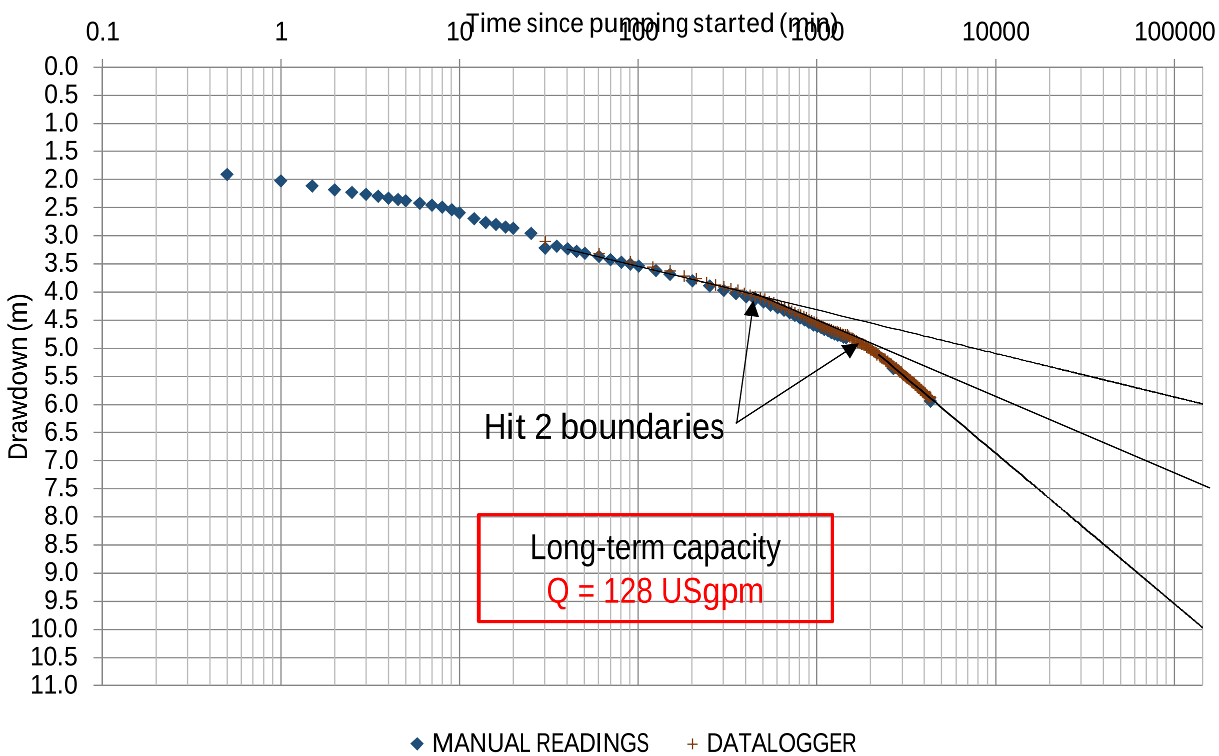
Why Kaye Road?

- Close to the future WTP
- Close to Englishman River for temporary water source
- Good aquifer thickness indicated by weight scale well
- Land owned by the RDN
- Far from existing wells = no conflicts
- Gravel pit good for back-wash disposal
- Geologic cross-section indicated favourable conditions


DS#2 – ID.36480
15/05/2012
Q_{est} = DRY
DS#1 – ID.36734
09/05/2012
Q_{est} = 15 USgpm / 0.9 L/s
ASR-1
02/05/2013
Q_{est} = 128 USgpm / 8.1 L/s
DS#3 – ID.36481
07/05/2012
Q_{est} = 60 USgpm / 3.8 L/s
DS#6
10/12/2012
Q_{est} = DRY
DS#5 – ID.34713
18/07/2012
Q_{est} = 100+ USgpm / 6.3 L/s
General Settin
Major road
Cadastral
Crown ow
Private pr
Observation well
Craig Creek
LHC Lowen Hydrogeology Consulting Ltd.

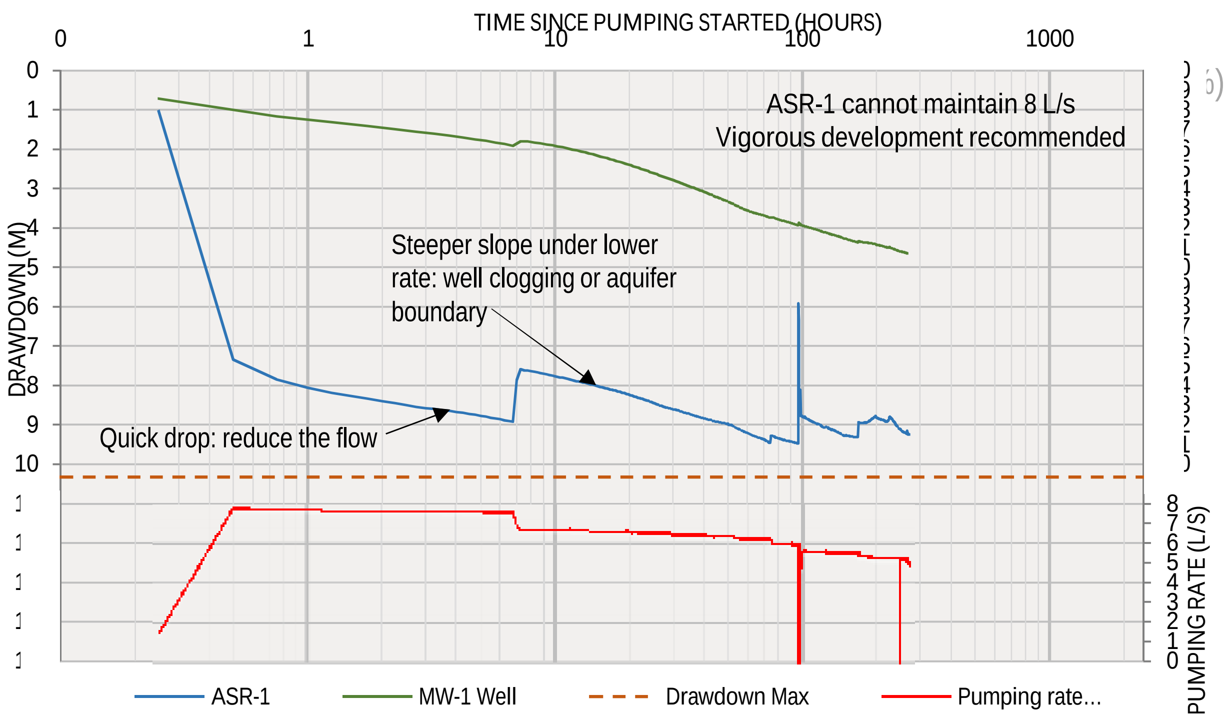
Pumping Tests at ASR-1:

- Short pumping tests during development: monitor the well capacity increase
- Step test: assess the most efficient pumping rate for the 3-day test
- 3-day pumping test: assess the long-term capacity of the well



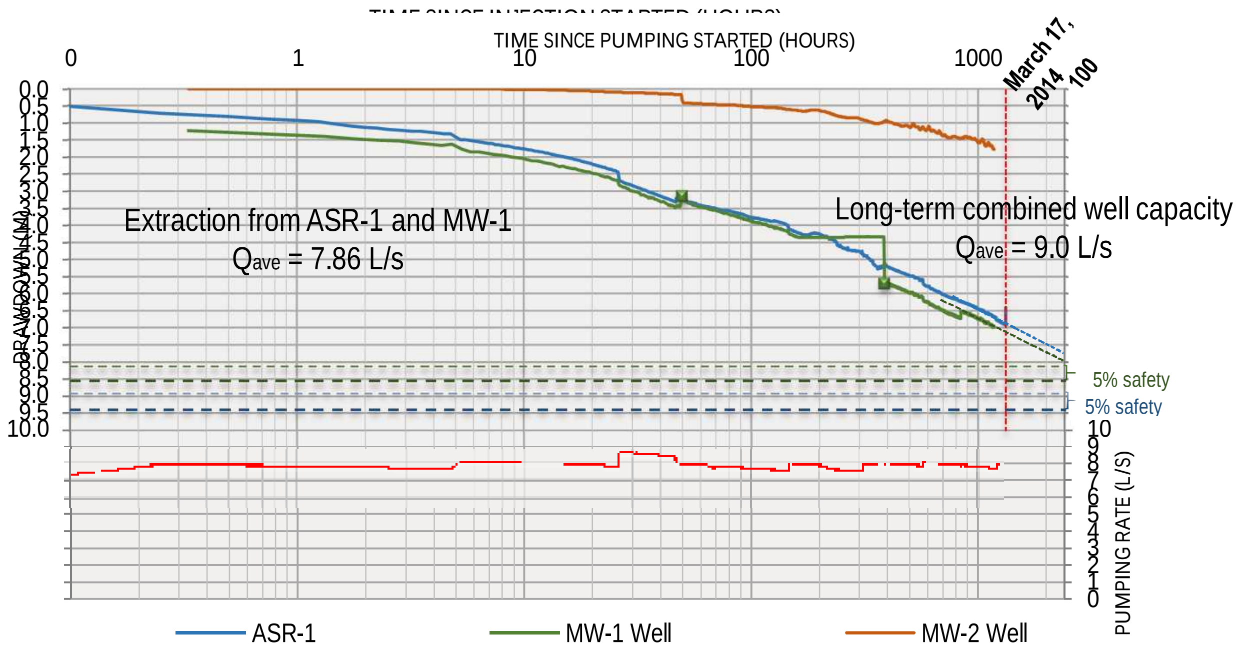
Cycle Test 1:

- Injection: 19-08-2013 to 18-09-2013 = 30 days
- Storage: 18-09-2013 to 20-09-2013 = 2 days
- Production: 20-09-2013 to 01-10-2013 = 12 days



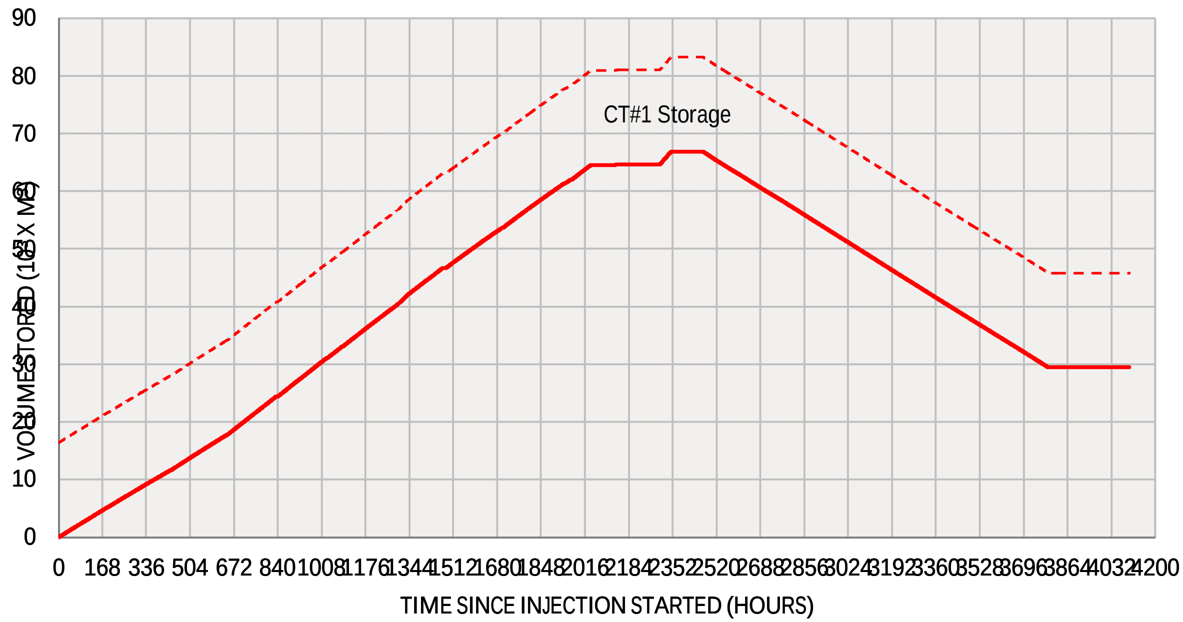
Cycle Test 2:

- Injection: 11-10-2013 to 03-01-2014 = 85 days
- Storage: 03-01-2014 to 21-01-2014 = 18 days
- Production: 21-01-2014 to 17-03-2014 = 55 days

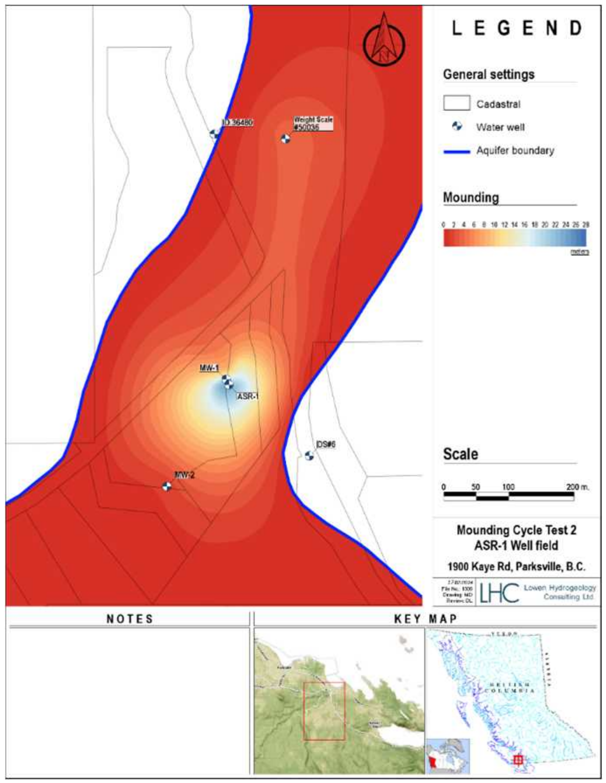


Volume injected at cycle test #1 = 16,408 m³

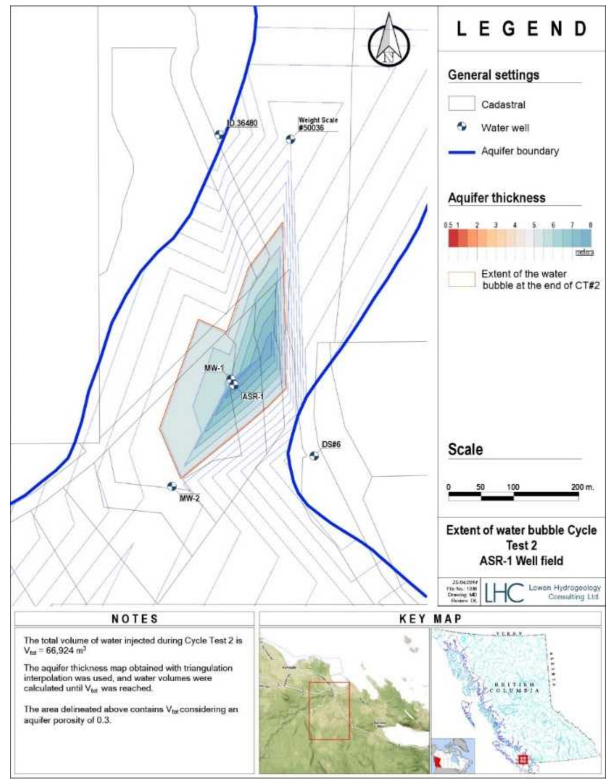
Volume injected at cycle test #2 = 66,924 m³



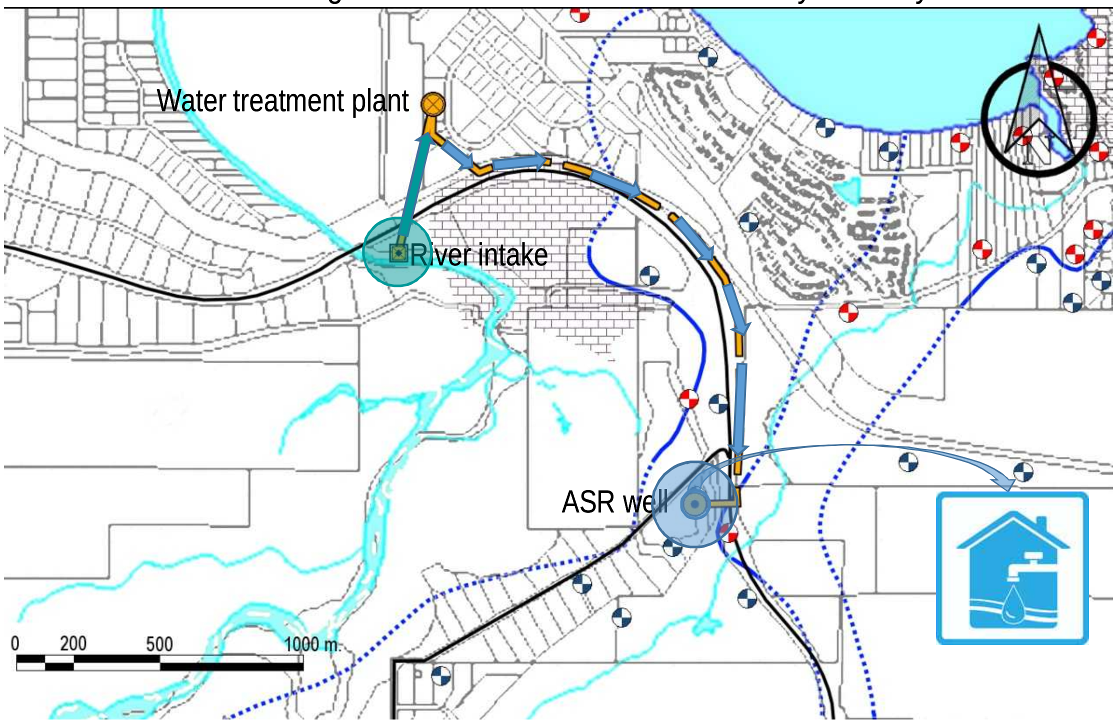
Pressure reading at the observation wells due to injection

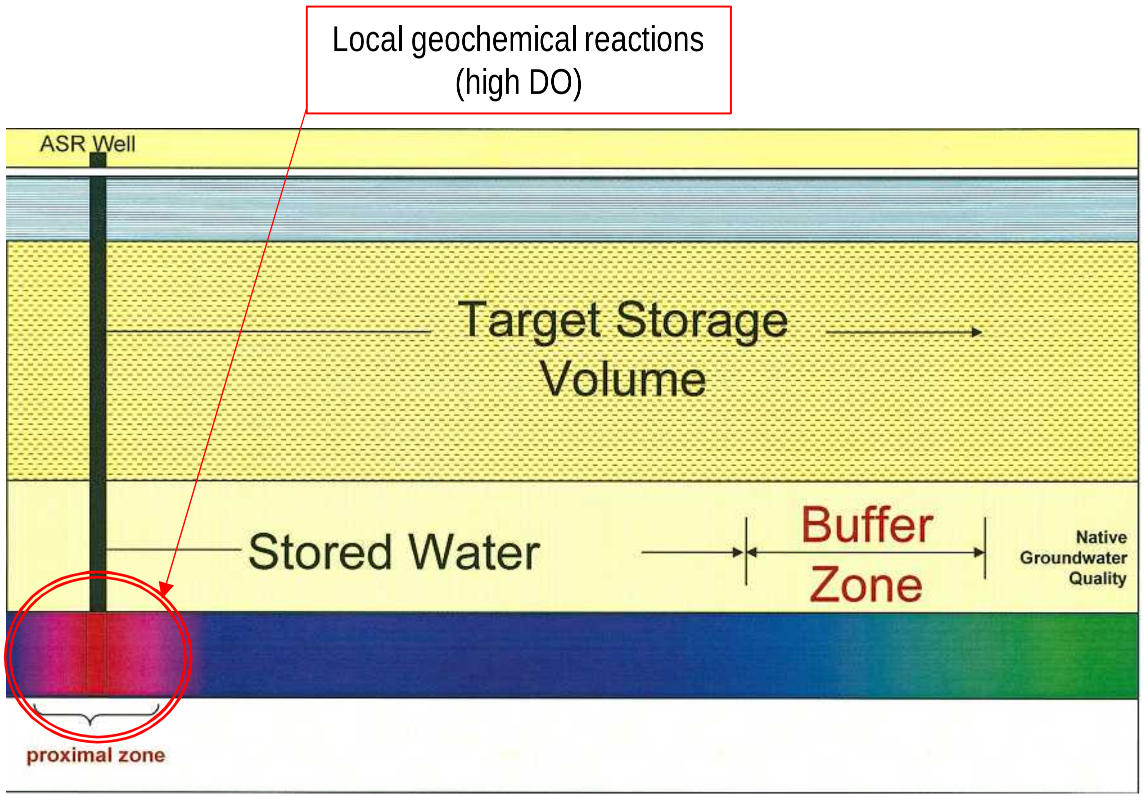


Theorized extent of the water bubble at the end of injection



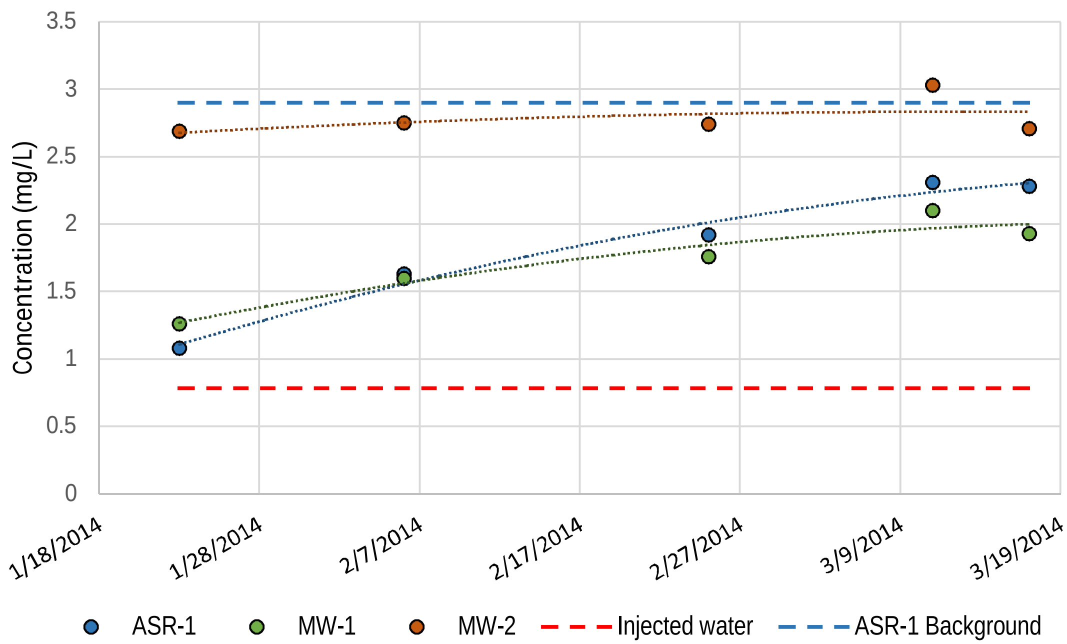
1. River water is pumped during seasonal excess;
2. Water is treated to meet the Canadian Drinking Water Quality Standards;
3. Water injected into the aquifer via ASR well;
4. Water is stored in the aquifer;
5. Water is recovered during summer and sent to the community water system.




Local geochemical reactions
(high DO)
ASR Well
Target Storage Volume
Stored Water
Buffer Zone
Native Groundwater Quality
proximal zone

<u>Tracing / conservative elements</u>: *[Elements that]* do not react with many other compounds in groundwater , and thereby are conserved in the water (R.J. Serrett, 2007)

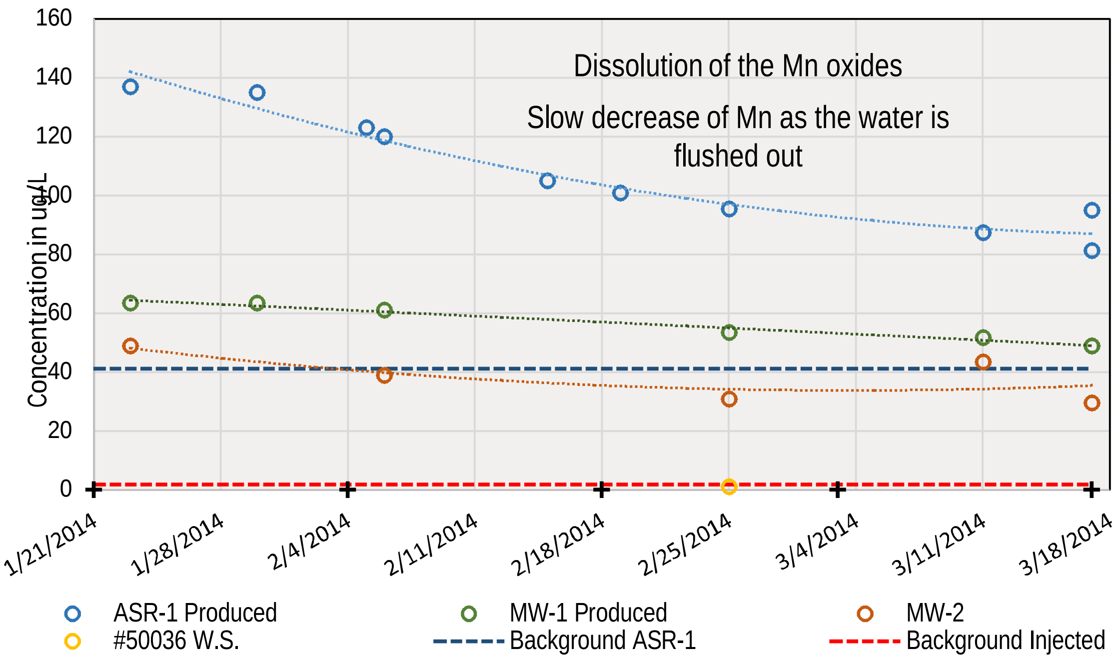
<u>Example of Potassium</u>:



Notable geochemical reactions

1/ Arsenic

2/ Manganese



Recharge and recovery rates:

- Well maximum safe capacity: Q = 9.0 L/s = 777.6 m^3/day
- Recovery period = 14 weeks (98 days)

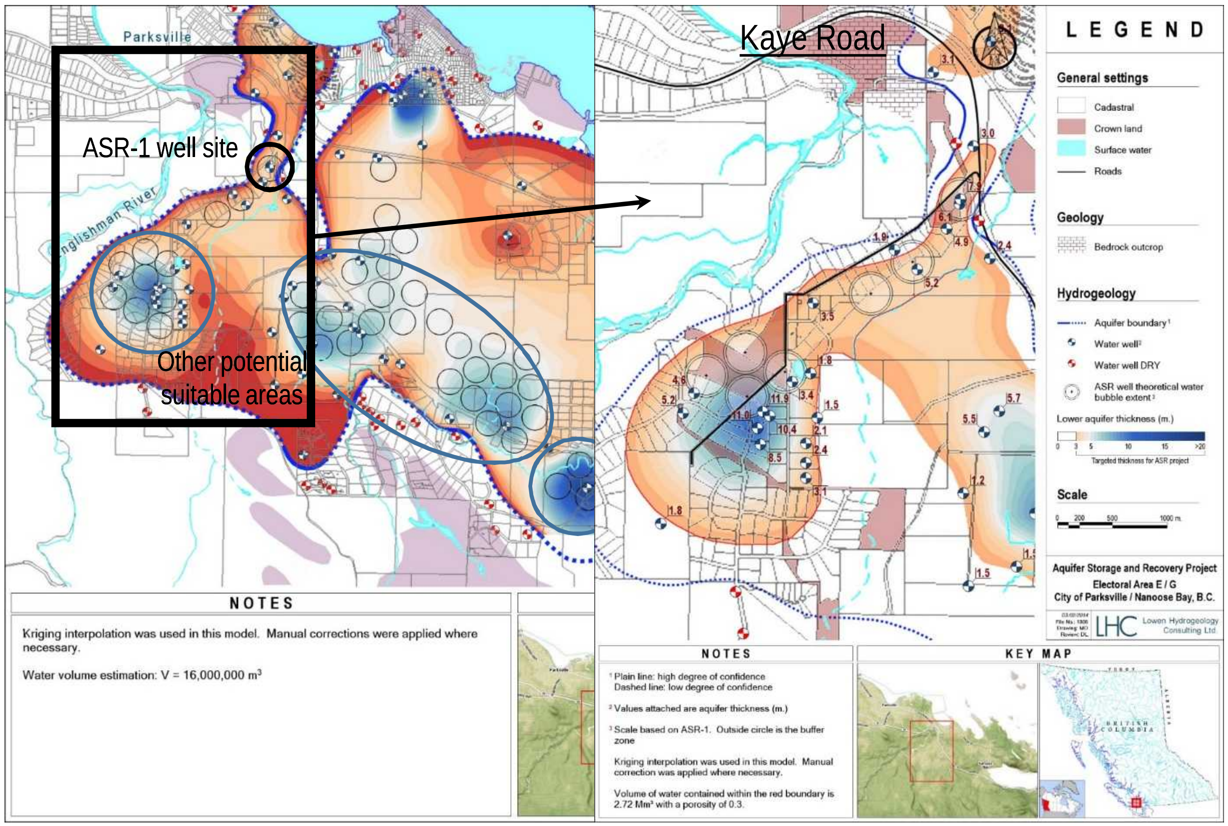
⇨ 98 days x 777.6 m^3/s = 76,205 m^3

= Yearly recharge / withdrawal rate at ASR-1 well field

Target Storage Volume (TSV) – Year 1:

- Recharge time frame: 26 weeks (182 days)
- Recommended TSV = 76,205 m^3 + BUFFER ZONE
- Buffer zone = 60 days capacity = 60 x 777.6 = 46,656 m^3
- 46,000 m^3 are already in the aquifer

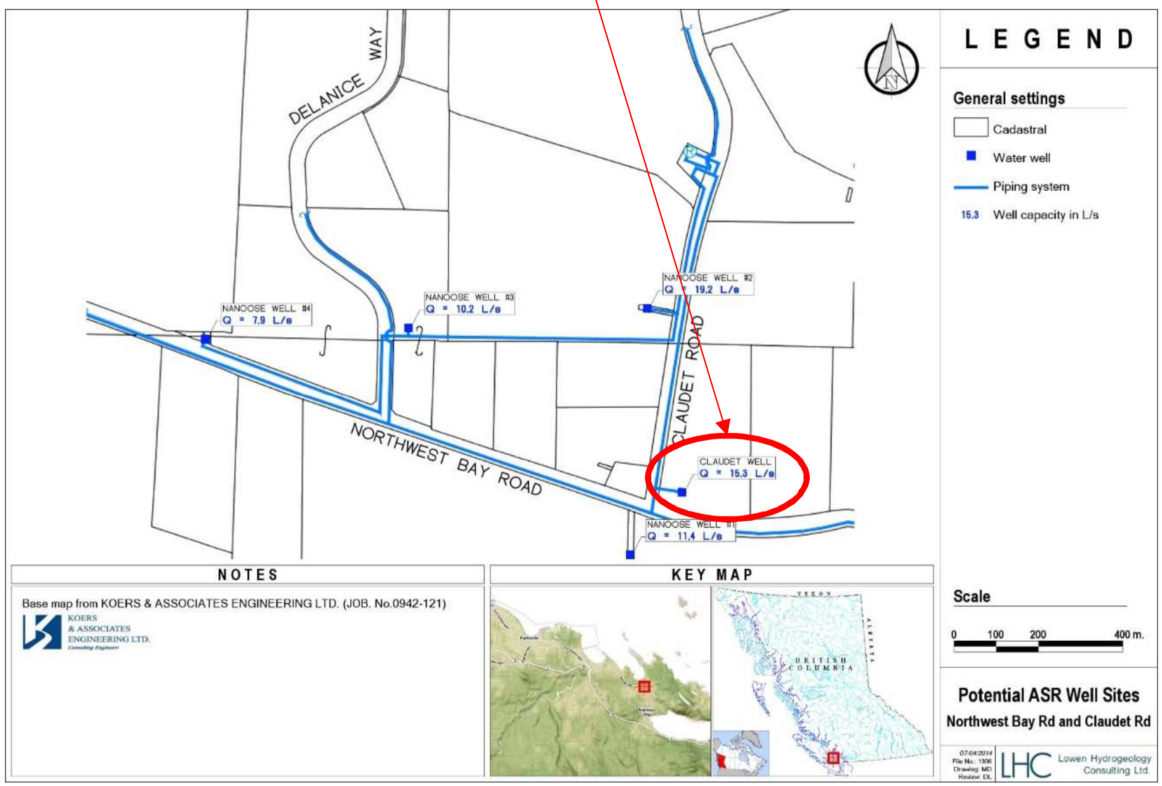
⇨ 76,205 + 46,656 – 46,000 = 76,861 m^3



Parksville
Englishman River
ASR-1 well site
Other potential suitable areas
Kaye Road
NOTES
Kriging interpolation was used in this model. Manual corrections were applied where necessary.
Water volume estimation: V = 16,000,000 m³
LEGEND
General settings
Cadastral
Crown land
Surface water
Roads
Geology
Bedrock outcrop
Hydrogeology
Aquifer boundary 1
Water well 2
Water well DRY
ASR well theoretical water bubble extent 3
Lower aquifer thickness (m.)
Scale
Aquifer Storage and Recovery Project
Electoral Area E / G
City of Parksville / Nanoose Bay, B.C.
LHC Lowen Hydrogeology Consulting Ltd
NOTES
1 Plain line: high degree of confidence
Dashed line: low degree of confidence
2 Values attached are aquifer thickness (m.)
3 Scale based on ASR-1. Outside circle is the buffer zone
Kriging interpolation was used in this model. Manual correction was applied where necessary.
Volume of water contained within the red boundary is 2.72 Mm³ with a porosity of 0.3.
KEY MAP

<u>Claudet Road</u>:

Well ID.14506 pumped for 13 days: <u>Q = 15.3 L/s</u>



- Arsenic and Manganese dissolution mostly due to different levels of Dissolved Oxygen and pH.
- Beside As and Mn issues that must be addressed, groundwater quality at ASR-1 site is good and meets all drinking water standards.
- ASR-1 well site is feasible with 9 L/s (143 USgpm) capacity.
- Kaye Road area has potential for up to 11 ASR wells.
- Preliminary assessment of Claudet Road wells – 15 L/s ASR well is feasible.
- Feasibility work remaining – resolve recovered water quality issue.
- Target capacity for first stage – 69 L/s (6 ML/d) could be met with 7 wells in Claudet Road + Kaye Road areas.
- Ultimate goal of 15 ML/d is achievable.
- Estimated cost of 7 wells plus cycle testing: $4.7 M

- Plan to address the arsenic

  As occurs in the immediate vicinity of the injection well (until DO is consumed) = small affected zone + limited quantity of As.

  - STEP 1: Short cycles to flush out As / Mn.
  - STEP 2: Observe As concentration over time
  - STEP 3: Increase volume of the stored water “buffer zone”
  - STEP 4: Temporary As / Mn removal treatment

- Construct an ASR well at the Claudet Rd well site.

- Do core-drilling for better determination of the aquifer geochemistry.

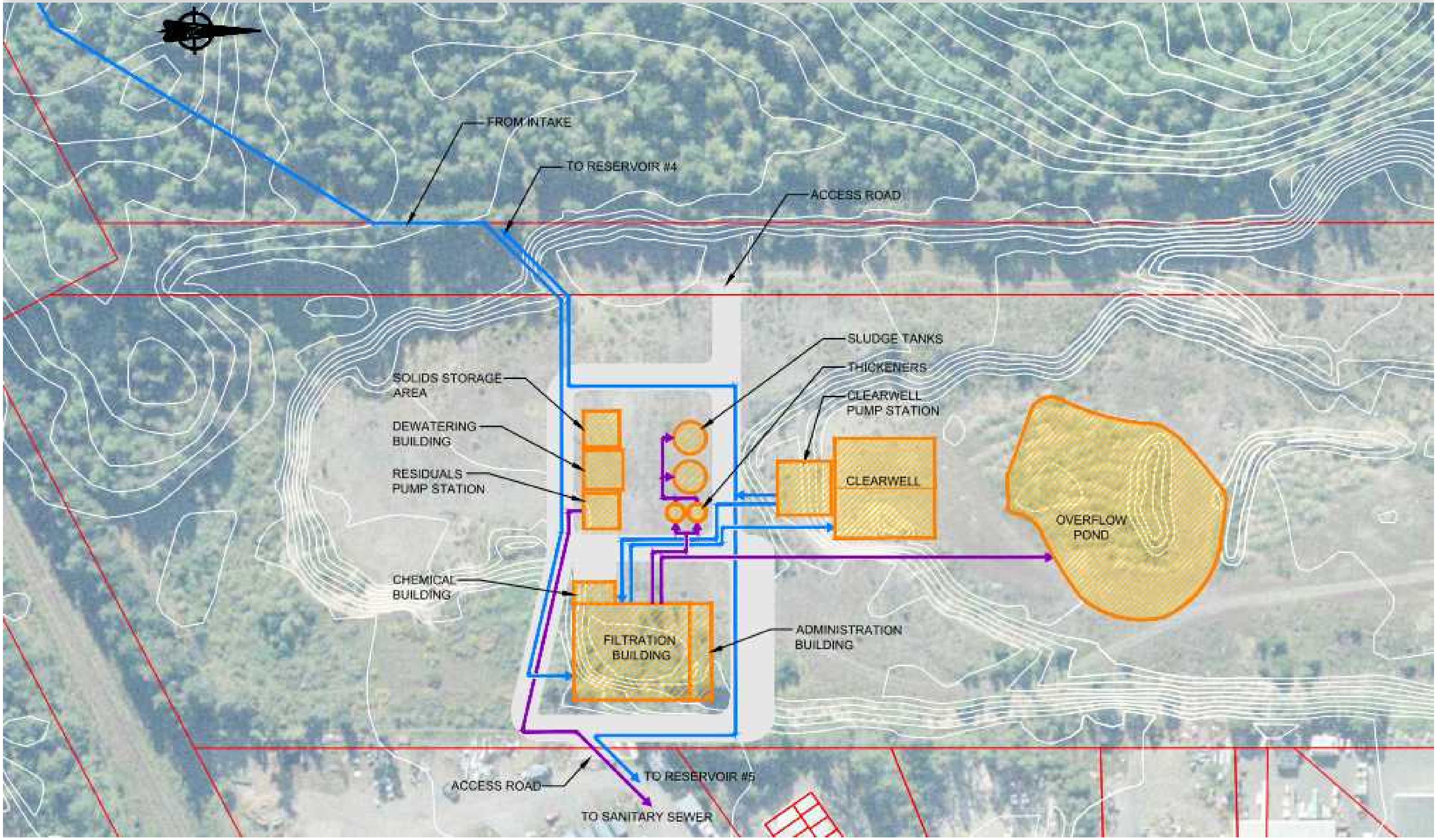
- Age date aquifer water and wood fragments to better understand the local geologic history.

Thank You

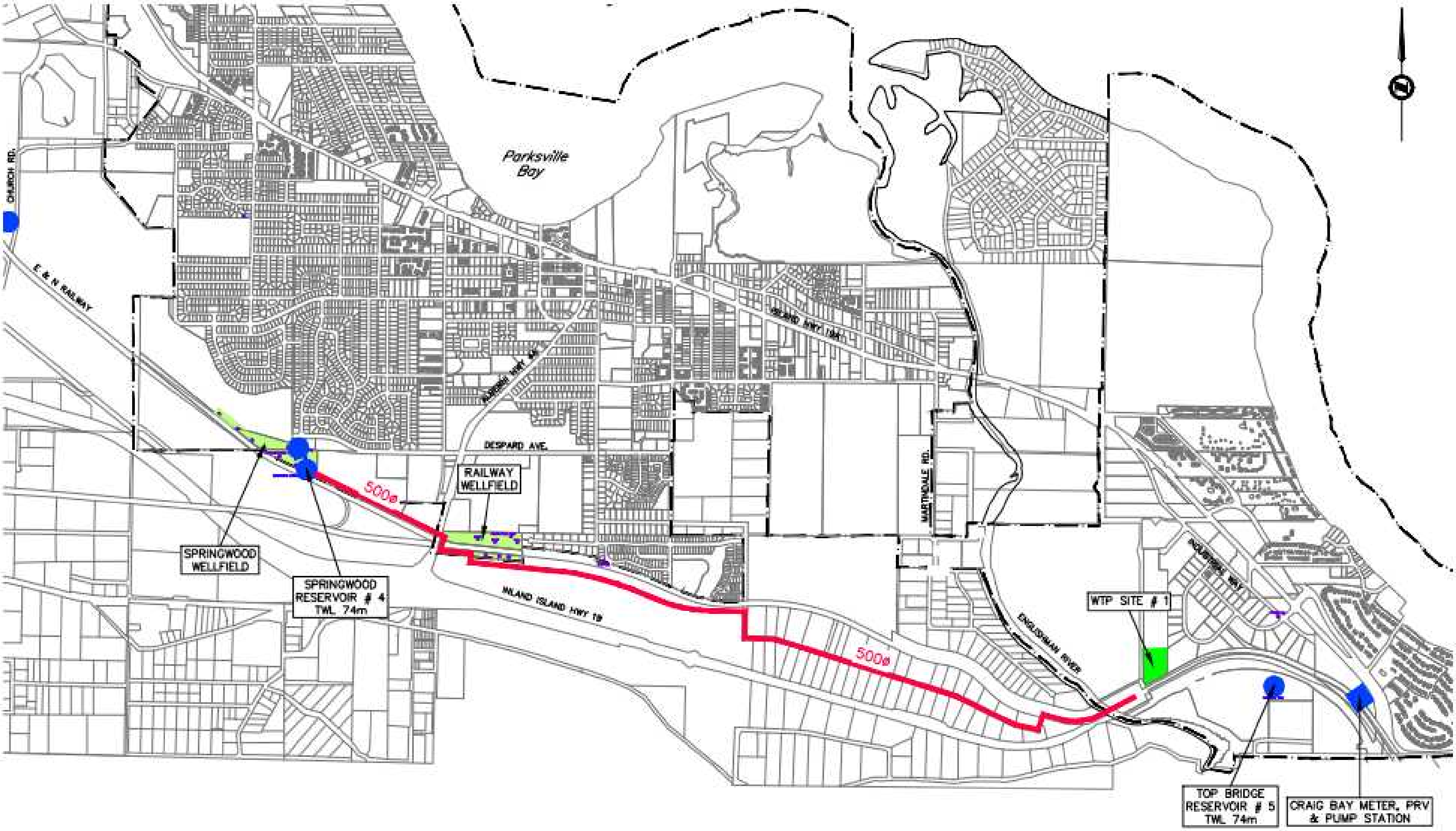
Conceptual Design – Site Plan

Conceptual Design – WTP & Intake

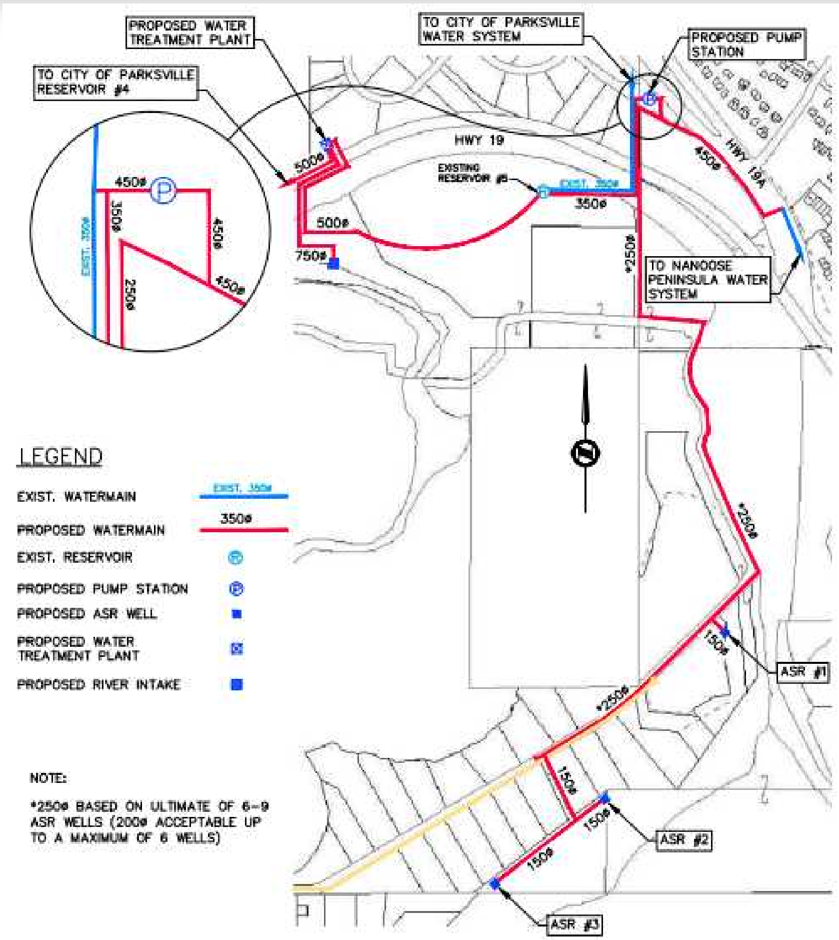
Conceptual Design – WTP



Conceptual Design– Water Mains



Conceptual Design – Water Mains



Conceptual Design – Direct Costs

(Does not include indirect costs, GST)

Water source	Cost
WTP (Phase 1)	$30.2 m
Treat Nanoose Wells	$2.0 m
ASR at Kaye Road	$3.9 m
ASR at Claudet Road	$3.3 m

Associated Engineering

Conceptual Design – Cost Analysis

Capital cost per unit of drinking water supplied

Water Source	Direct Capital Cost per Unit Capacity ($ million / ML/d)
Englishman River Water Treatment Plant (Phase 1)	0.63
ASR at Claudet Road	0.87
ASR at Kaye Road	1.33
Treatment for Nanoose Wells	1.82

Associated Engineering

Conceptual Design – Water Supply Options

- WTP lowest cost
  - Subject to: climate change, drought
  - Diversify sources to protect from risks
- ASR at Claudet next lowest cost

Water Supply Strategy

- Test Claudet
- Size WTP Phase 1: 26 ML/d
- ASR uses:
  - Improve security of supply
  - Manage climate change impacts
  - Delay need for WTP Phase 2
  - Supplement aquifers

Conceptual Design – Capital Cost

Item	Cost ($ million)
	Phase 1 2016-2035
Direct Costs	
Intake	1.7
Raw Water Pipeline	0.8
Water Treatment Plant	16.1
Water Distribution Mains (incl. Pump Stations and Reservoir Tie-ins)	5.5
ASR Development at Claudet Road	2.6
Subtotal	26.7
Contingencies – Design and Construction	6.7
Total Direct Cost	33.4
Indirect Costs	4.6
GST Allowance (5%)	1.9
Total Capital Cost	39.9

Summary

- Water Treatment Objectives
  - Turbidity
  - Microbiological control
  - Colour
- Treatment
  - Coagulation
  - Membrane
  - Disinfection

Summary

- ASR – Viable. Look for most cost effective
  - Cycle test at Claudet Road
  - Other sites near existing water infrastructure
  - Kaye Road

Next Steps

- Continue preliminary design
- ASR at Claudet Road
- Acquire property and easements for water mains
- Assess existing well inventory
- Continue dialogue with approval agencies

Thank you