

# Well Maintenance and Effective Well Field Protection Plans

*Fracflow Consultants Inc.*

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*March 22, 2016*



# Outline

- Large Production Screened wells
- Construction Procedures and Well Development
- Evaluating well performance and Restoring Well Yields
- Modelling Flow Systems to Identify Long term Risks to Water Supplies – Well Field Protection Plan
- Controlling or Mitigating Risks to Well Fields
- Recommendations

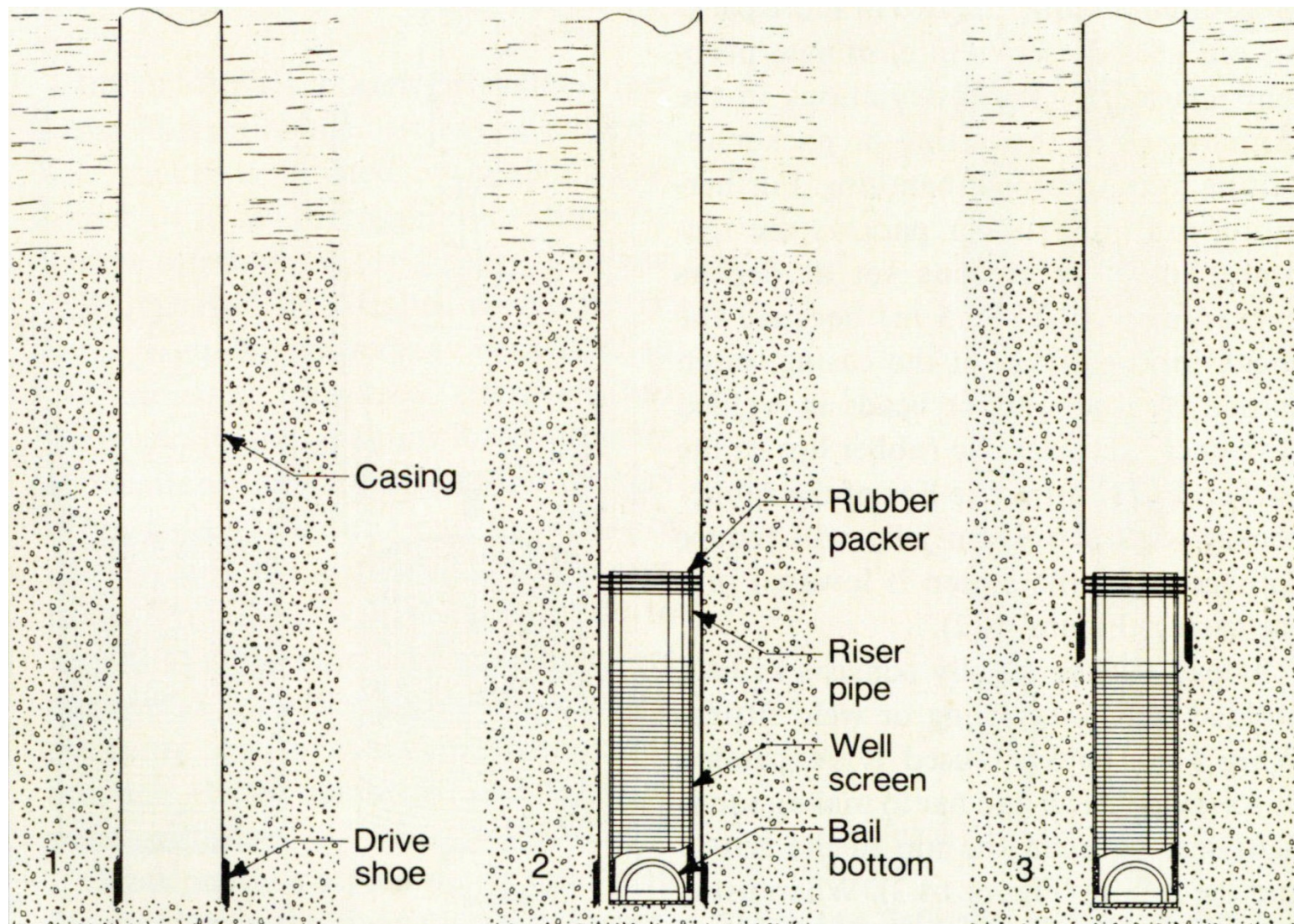


# Design and Construction of Screened Production Wells

- K-Packer design
  - Requires Development of a Natural Gravel pack
  - Requires Excavation around the Well Casing and Placement of Layered Surface/Well Seals.
  - Selection of Screen Slot size is Critical
  - Cost Effective but prone to Surface Impacts
- Screened Wells with Artificial Gravel Packs
  - Gravel pack is sized to screen slot size and sediment grain size distribution curves.
  - Can be Sealed Effectively using a Surface Casing
  - More expensive to construct.



# Typical K-Packer Design



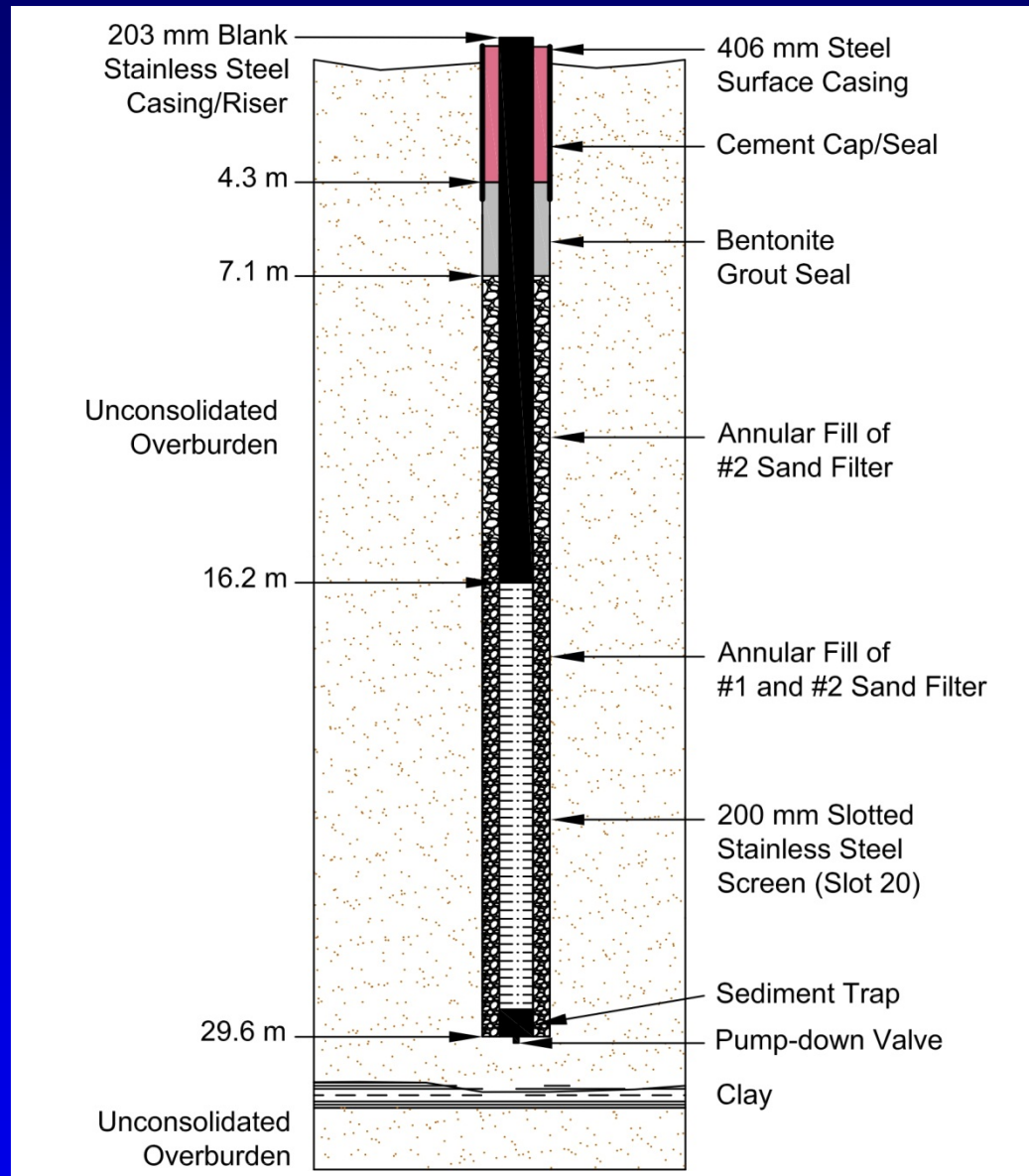
From Driscoll (1986)



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# Typical Screened Well –Artificial Gravel Pack



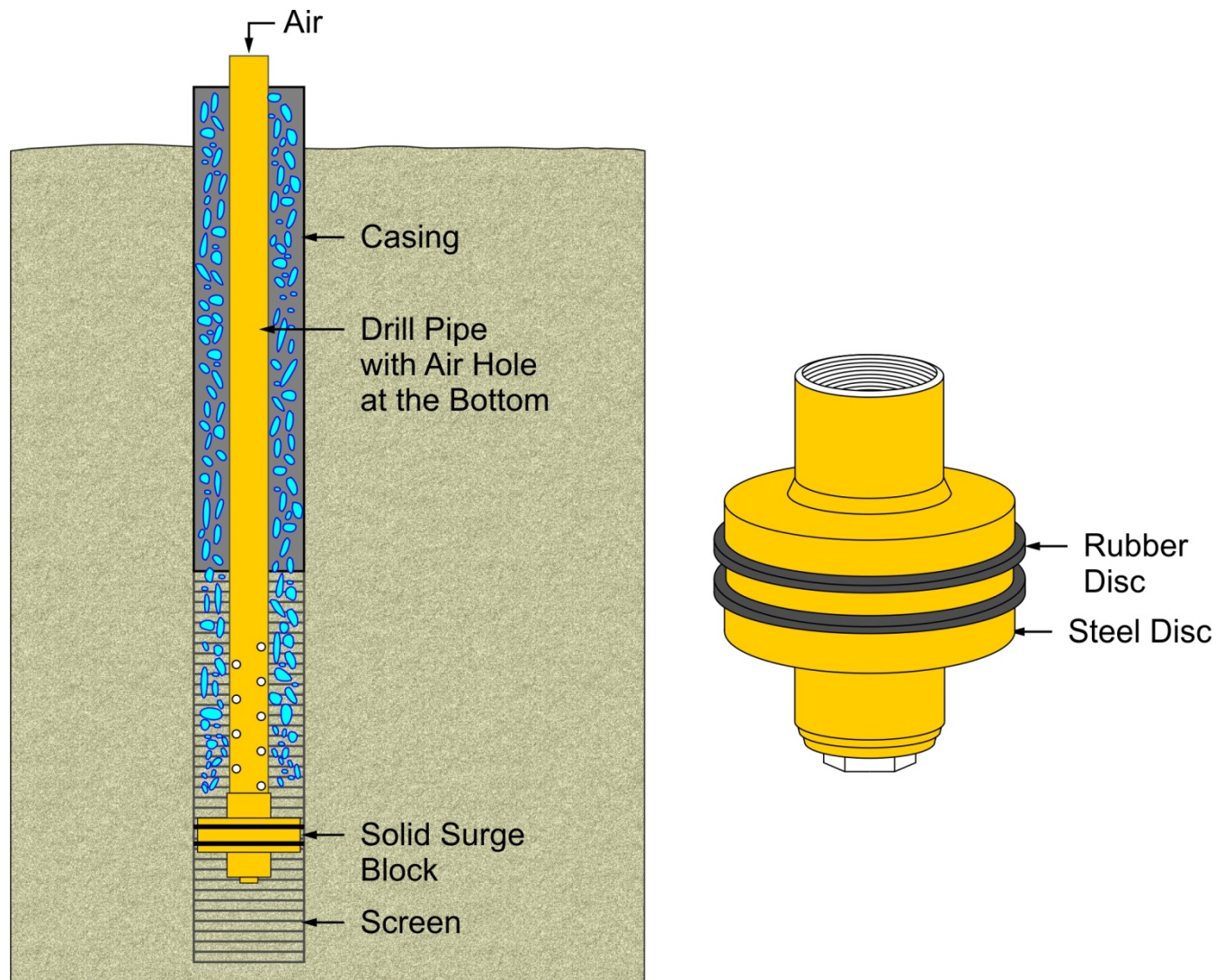
# WELL DEVELOPMENT AND WELL CLEANING



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# Well Development

## – Simultaneous Surging and Air Lifting





# Well Development



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# Well Development (avi)



# Well Development



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# Well Development



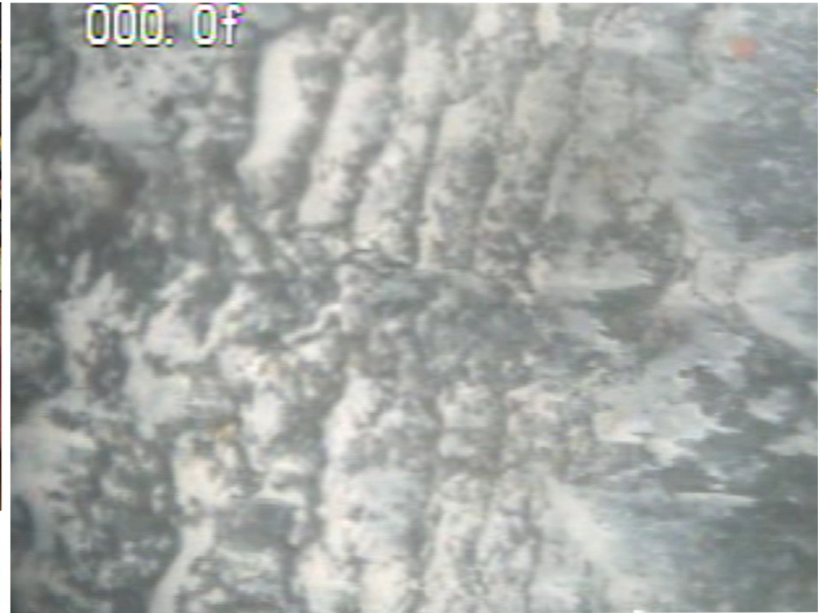
## Well Evaluation – Well Performance

- BART– Biological Activity Reaction Tests
  - Various forms of bacteria including iron forming bacteria
  - Simple and Cost Effective – First Screening Tool
- Specific Capacity Tests
  - Same as Step-Drawdown Test
  - Determines Well Efficiency
  - Compares Changes over Time
  - Provides a Reference Benchmark





# Well Cleaning-Maintenance



# Well Cleaning - Maintenance (avi)



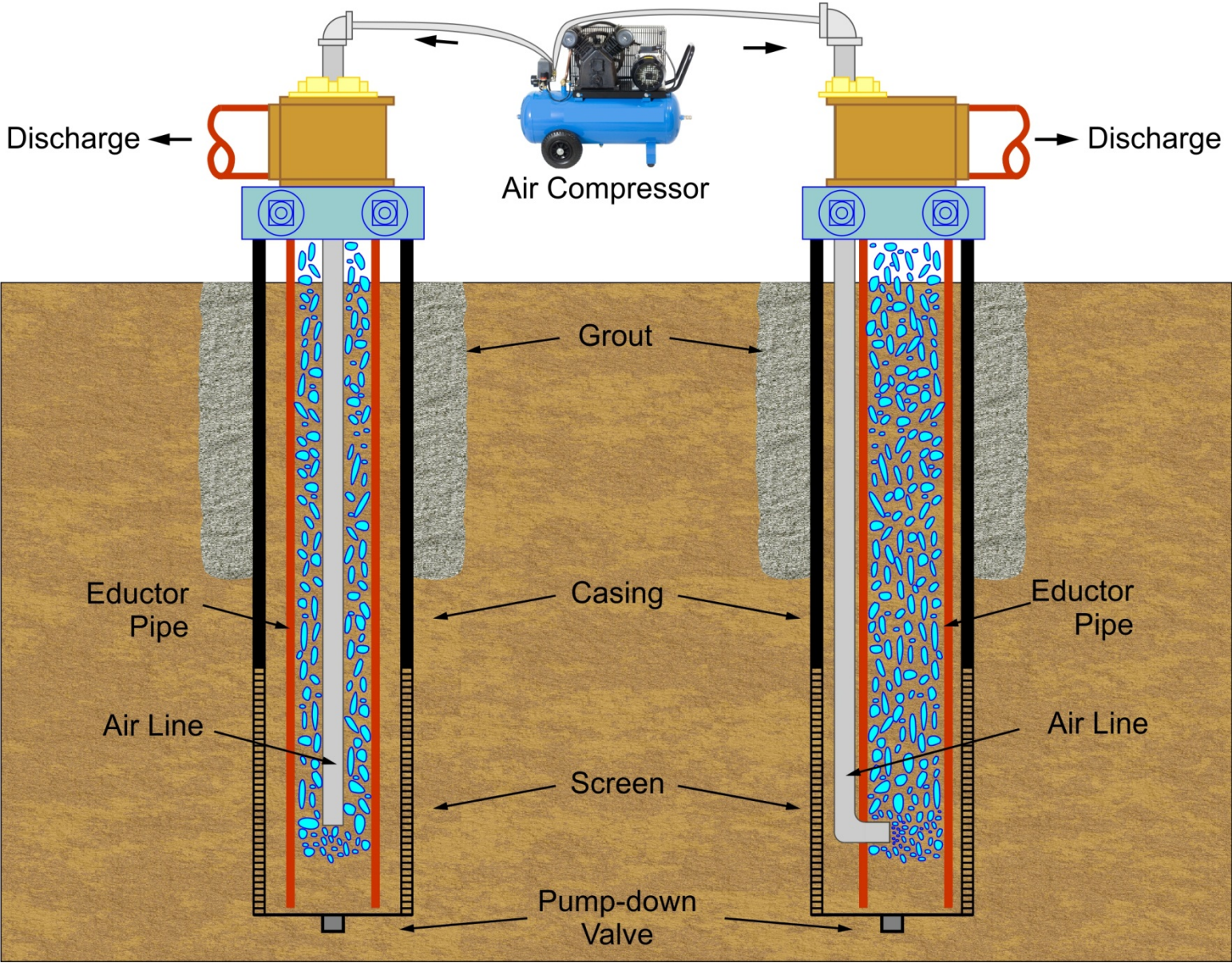
**Blocked Screen**



**Screen After Acid  
(Sulfamic) Treatment**



# Well Cleaning – Well-Within-a-Well



# Well Performance

- Stephenville
  - K-Packer Design for most wells
  - Both bedrock and overburden aquifers
  - BARTS and Specific Capacity Tests
  - Significant decreases in Well Yield over a 10 year period
  - Changes in Well Yield due to Dewatering aquifer and Plugging of Well Screens
  - Significant Increase in Well Yields with Redevelopment.





# Specific Capacity - Stephenville

Well ID	1999			June 2009			September 2009		
	Specific Capacity (L/min/m)		Static Water Level (m)	Specific Capacity (L/min/m)		Static Water Level (m)	Specific Capacity (L/min/m)		Static Water Level (m)
	Min.	Max.	--	Min.	Max.	--	Min.	Max.	--
Well 2	1172.97	1292.00	68.80	--	--	--	345.77	431.12	53.55
Well 4	1481.58	1711.11	65.57	529.96	607.47	61.53	474.92	496.64	47.31
Well 5	73.29	91.80	65.57	33.78	37.26	57.80	51.14	62.08	58.10
Well 6	67.45	120.00	65.60	26.44	29.03	57.83	44.42	48.83	58.13
Well 7	121.86	147.85	81.25	36.78	37.62	82.61	79.67	88.69	81.86
Well 8	136.76	229.15	81.43	--	--	82.19	73.62	93.69	81.58
Well 9	118.31	177.37	85.23	--	--	--	162.36	191.56	84.70
Well 10	98.17	154.09	86.95	--	--	--	60.77	97.42	87.53



## Well Performance

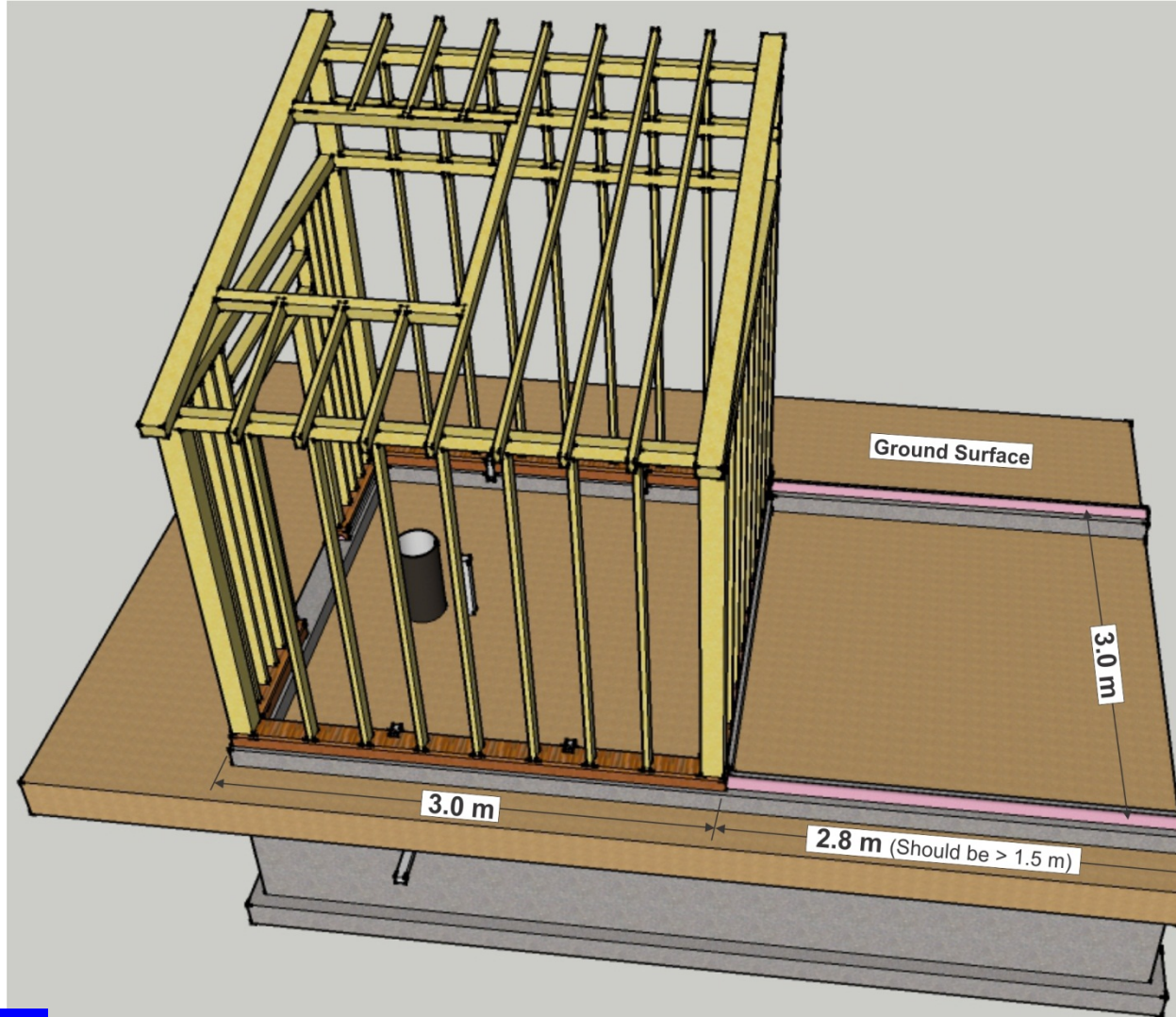
- Happy Valley Goose Bay
  - Production Wells Drilled Using Reverse Circulation
  - Artificial Gravel Pack – Slot 40
  - Original well Efficiency – 100%
  - High Specific Capacity
- Specific Capacities After 10 years of Production
  - Five wells
  - Three wells equaled original specific Capacity required jetting only
  - Two wells required Redevelopment –Surge Block



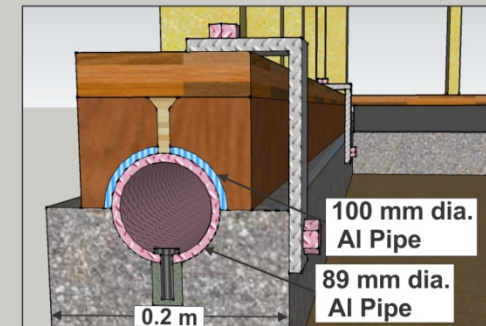
# Specific Capacity – HVGB

<i>Well ID</i>	Specific Capacity (L/min/m)			
	1996		2013	
	Min.	Max.	Min.	Max.
<i>Well No. 1</i>	70.8	78.1	77.5	139.2
<i>Well No. 2</i>	111.4	120.6	88.3	92.0
<i>Well No. 3</i>	41.2	42.1	42.4	44.7
<i>Well No. 4</i>	38.4	43.4	39.6	50.8
<i>Well No. 5</i>	34.6	36.9	35.6	37.0

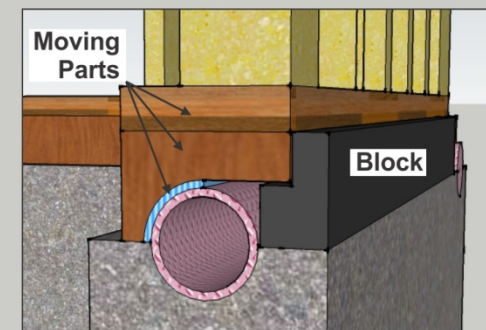
# Pump House Design for Well Cleaning



Foundation - Side

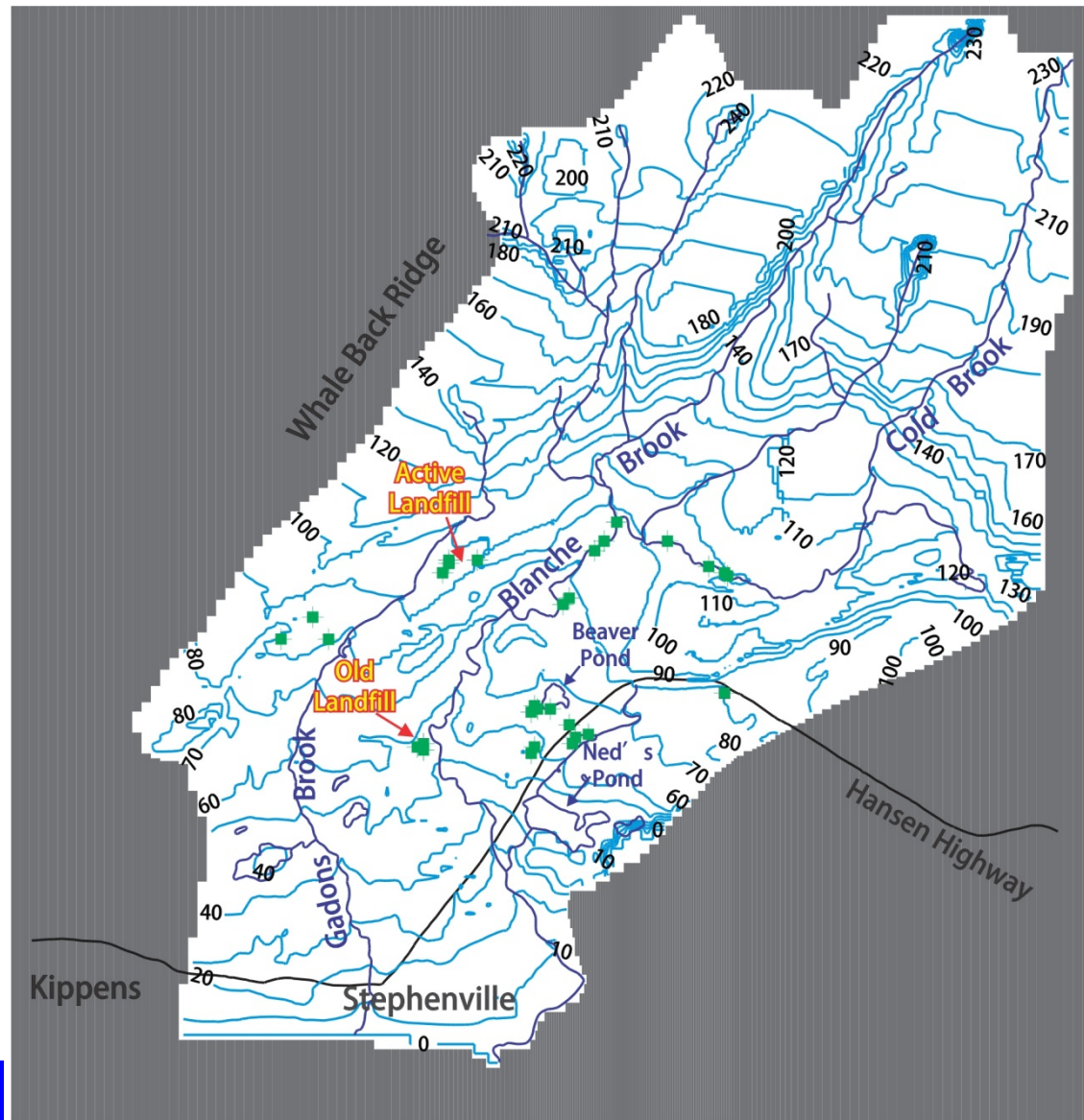


Foundation - Front & Back





# Kippens & Stephenville Model – Water Table



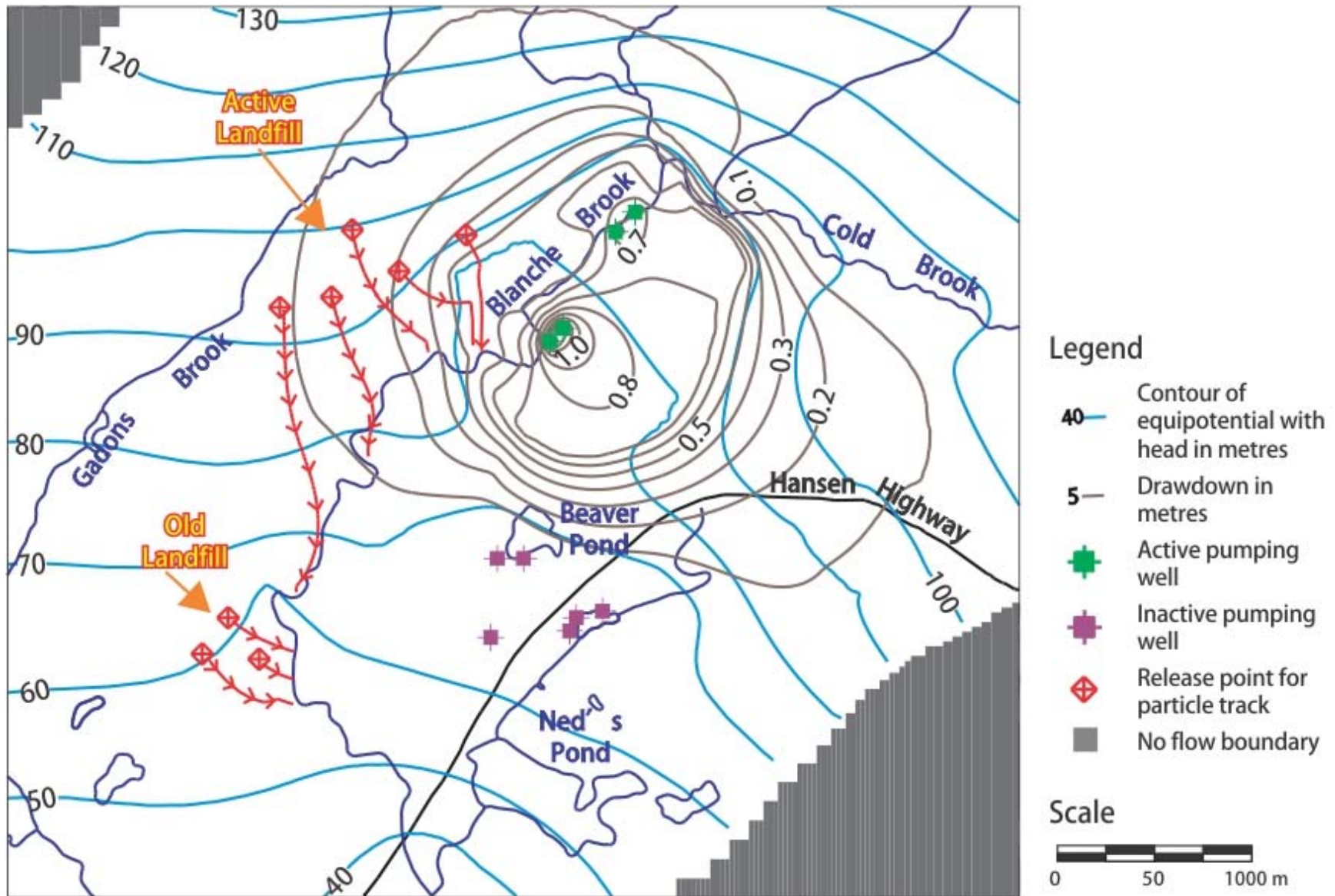
## Legend

- 40 — Contour of water table in metres
- Observation / pumping well
- No flow boundary

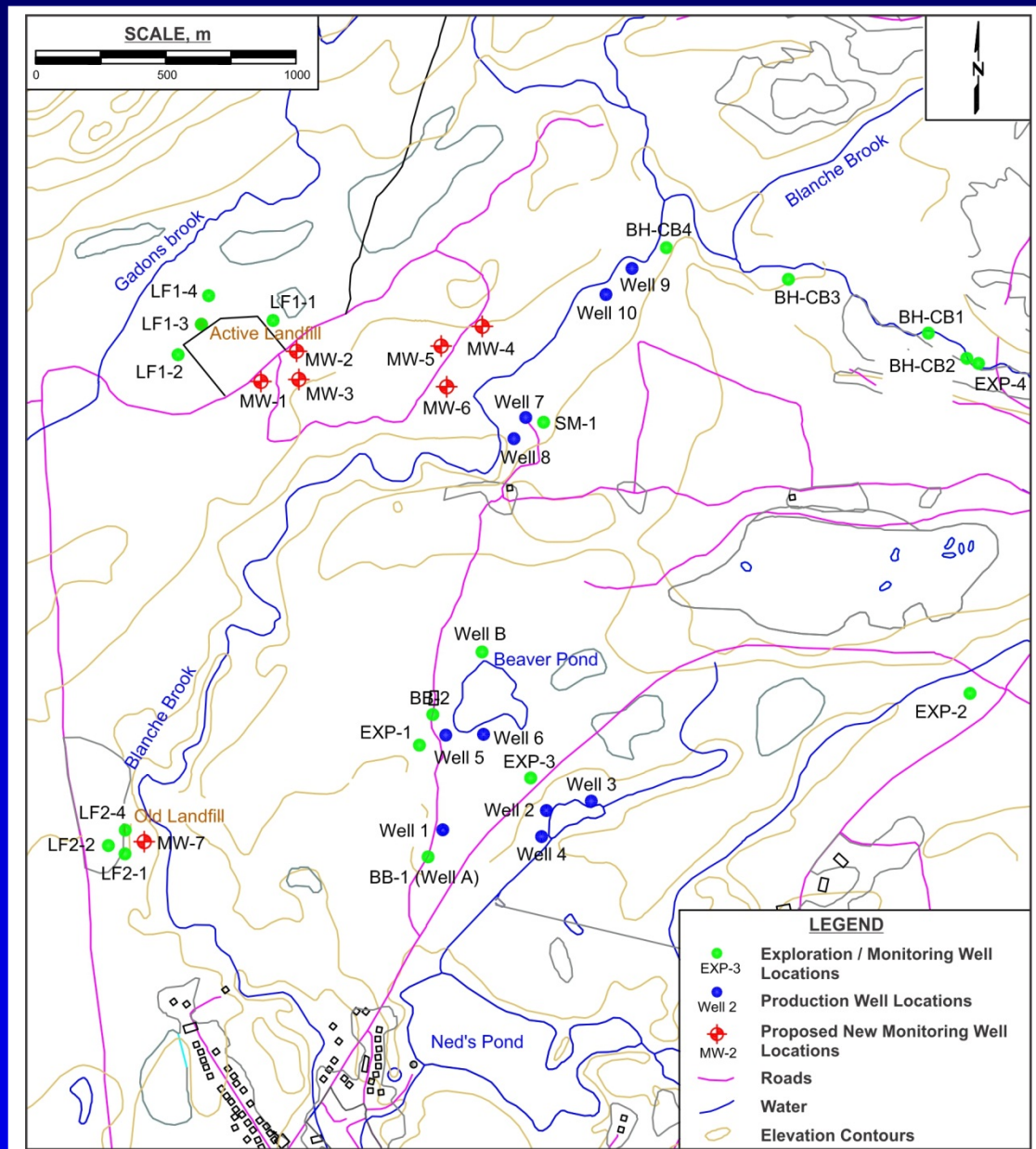
## Scale



# Stephenville - Particle Tracks (Pumping)

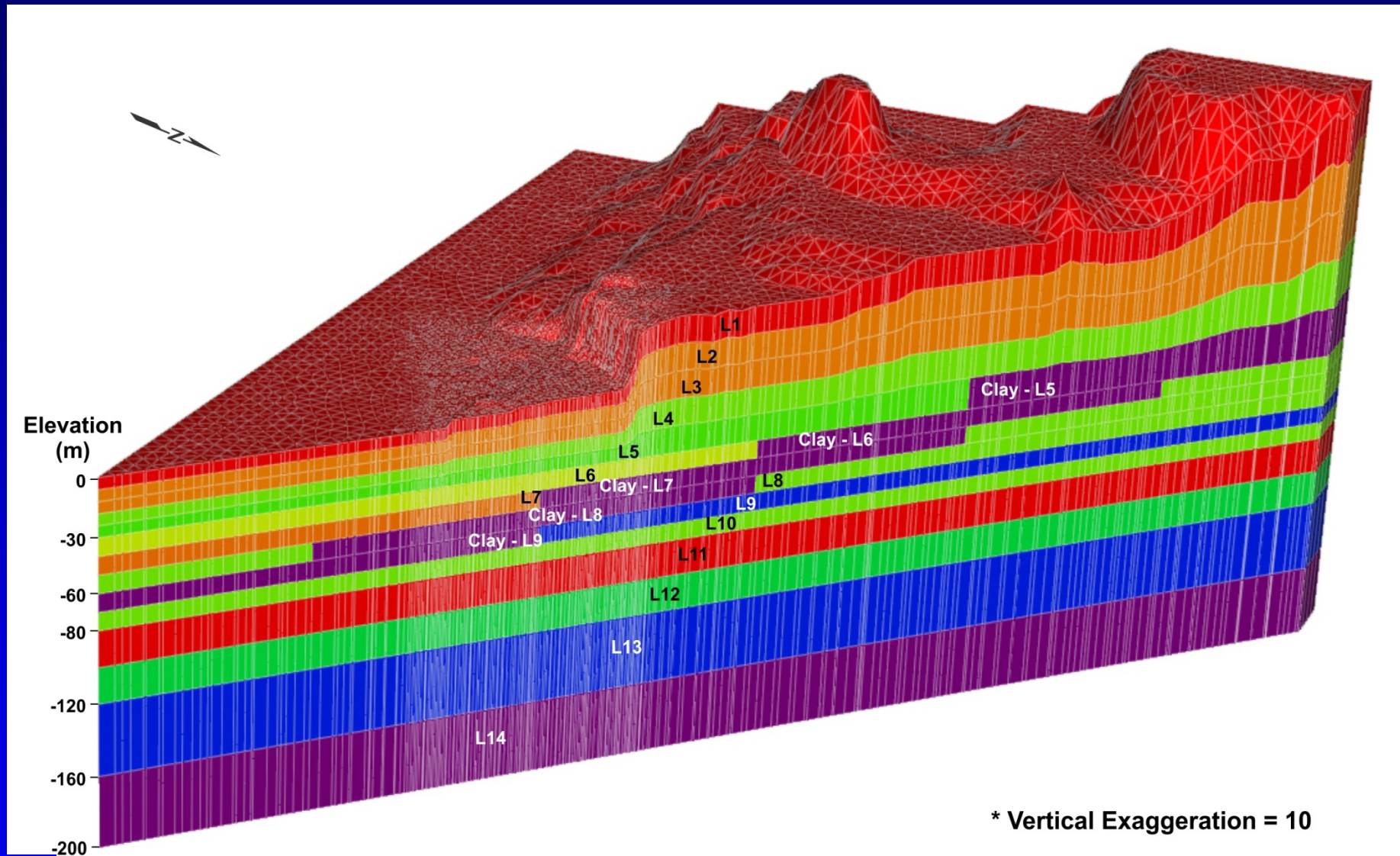


# Stephenville Well Field Protection M. Wells

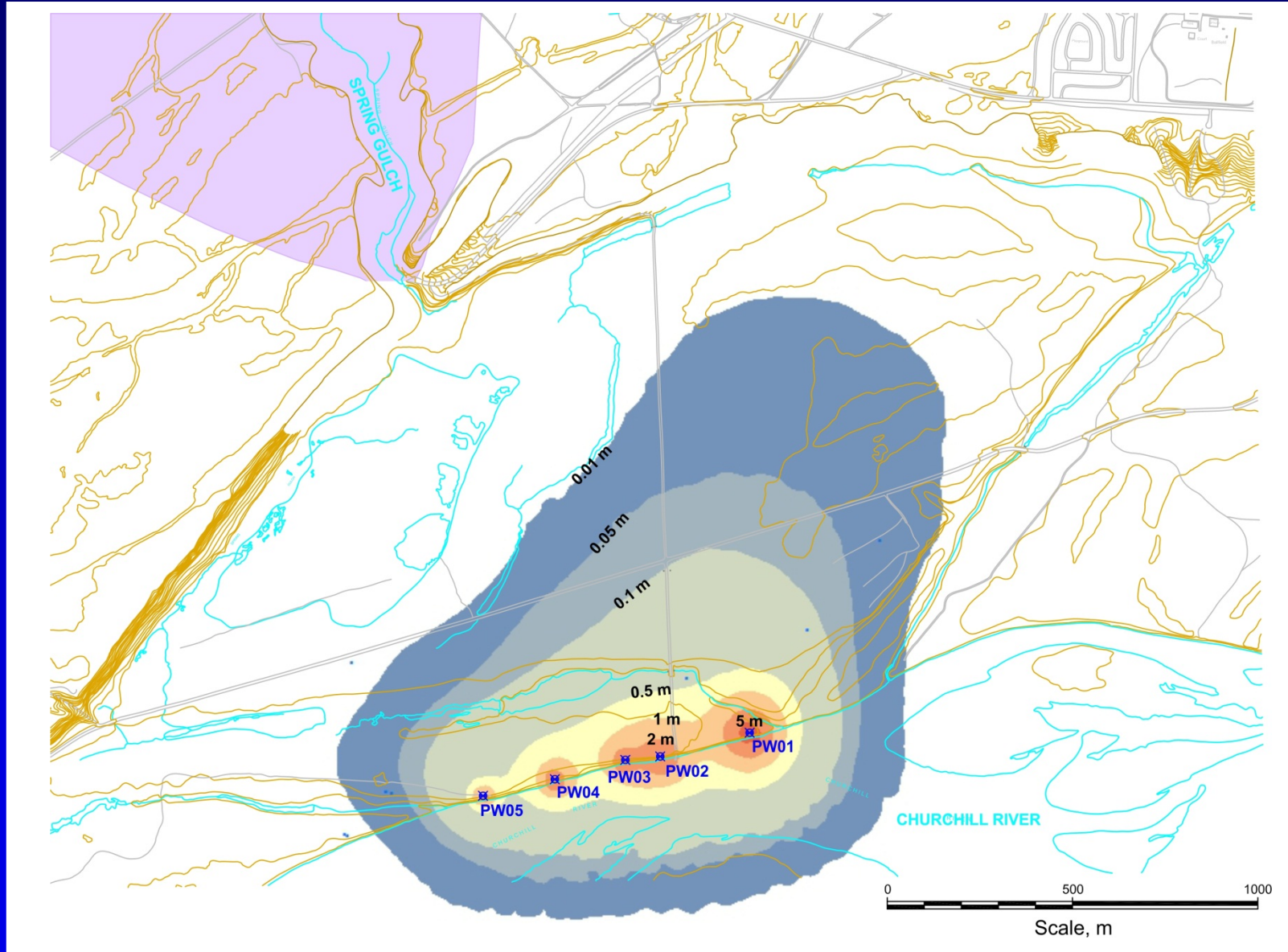




# HVGB Cross-Section of 3D Flow Model

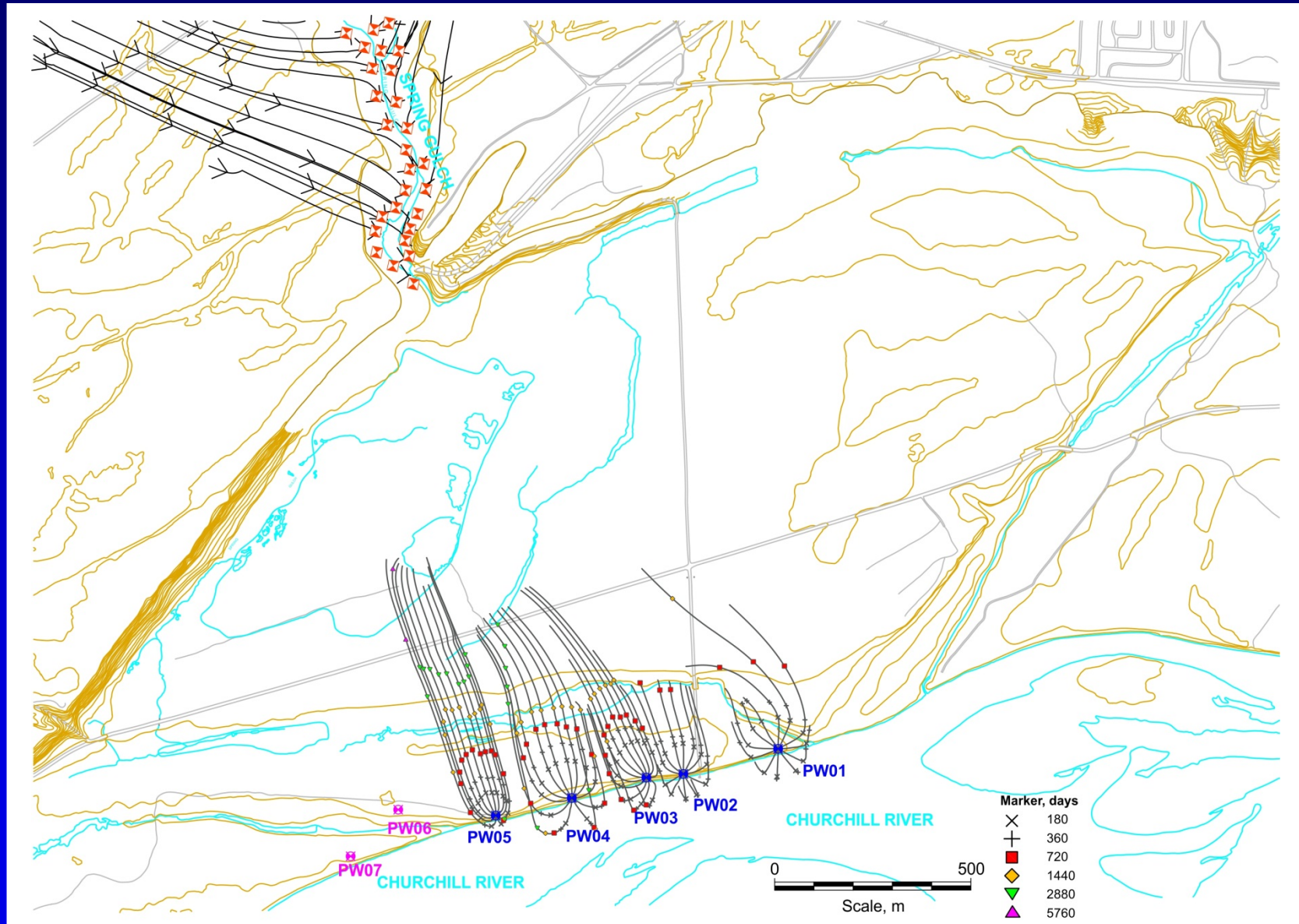


# Capture Zones – Spring Gulch and Five Wells





# Particle Tracks Spring Gulch and Five Wells





## Recommendations

- Regular – every two years – BARTS and Specific Capacity Tests
- Need easy access to well heads
- Maintain a current 3D flow and transport model of the well field flow system
- Need proper monitoring wells along flow lines with semi-annual to yearly water sampling
- Have an approved mitigation procedure in place to block impacted groundwater, ie a functional Well Field Protection Plan



## Risks to Well Fields

- Old and Active Landfills
- Over production – Mining the water
- Lack of Regular Well Maintenance
- Lack of a Well Field Protection Plan supported by a current 3D flow and transport model of the well field flow system
- Lack of proper monitoring wells along flow lines with semi-annual to yearly water sampling
- No approved mitigation procedures in place



Thank you and we will attempt to  
answer any questions you might have.

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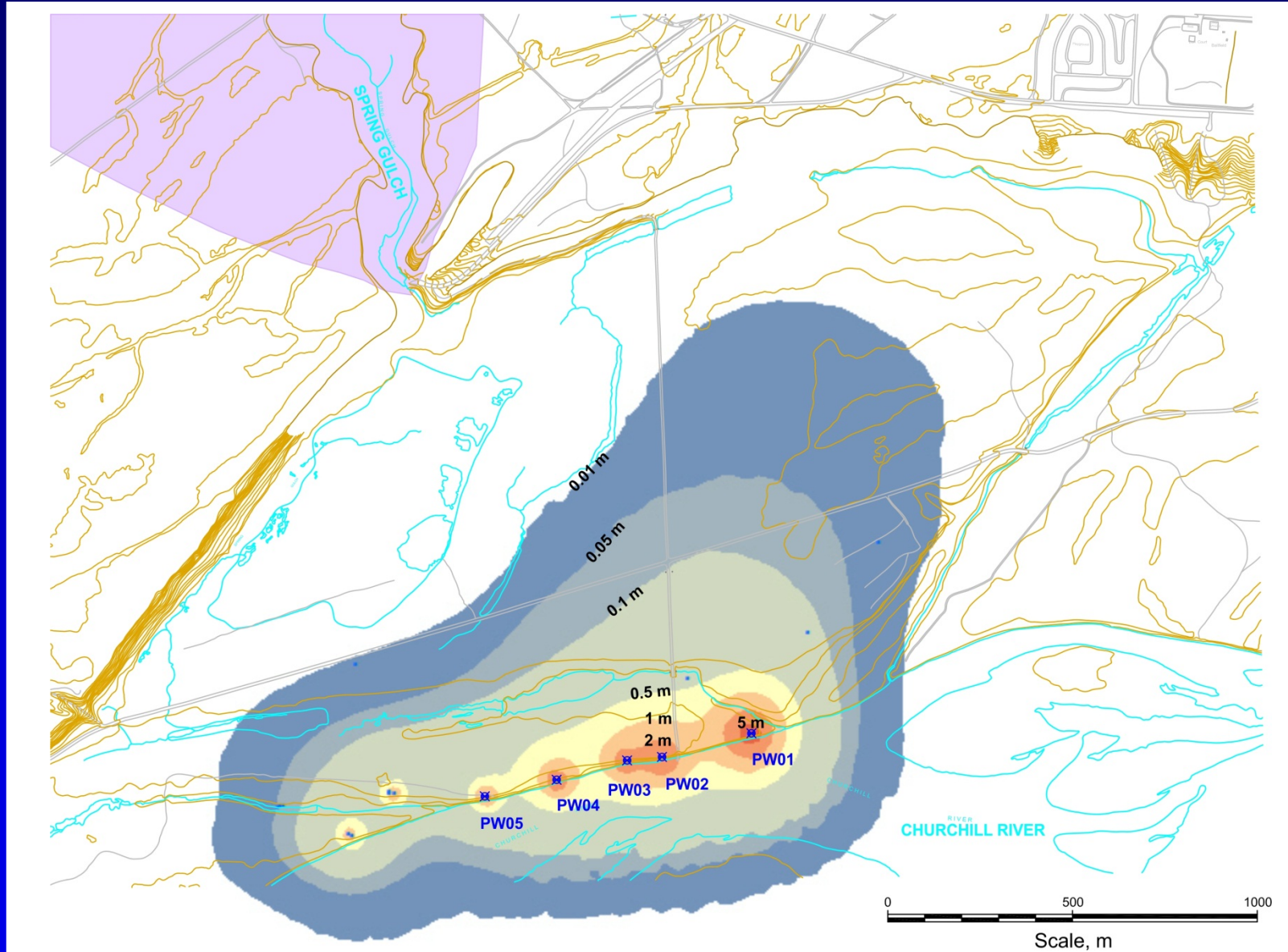
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*March 22, 2016*

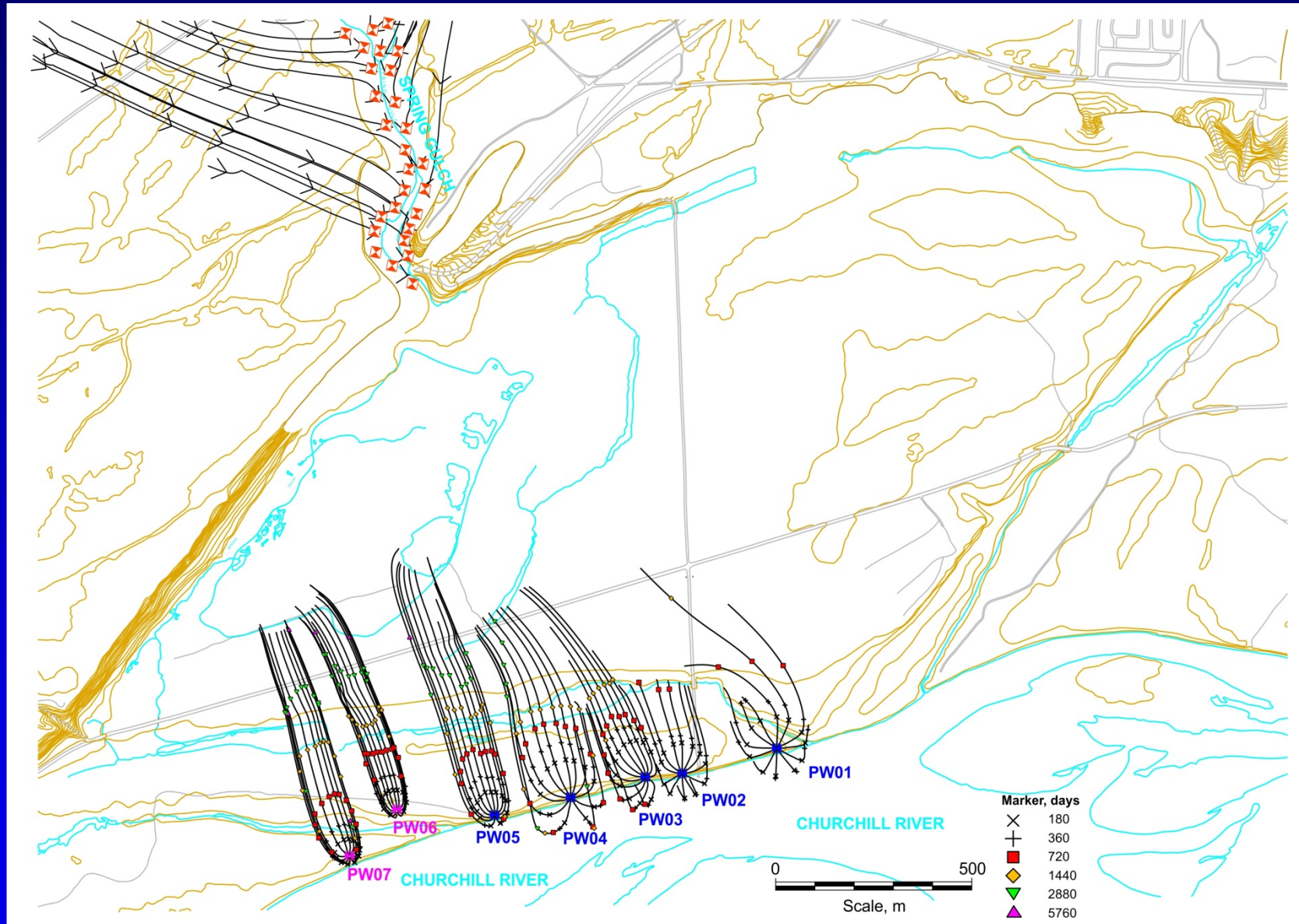




# Capture Zone Spring Gulch and Seven Wells

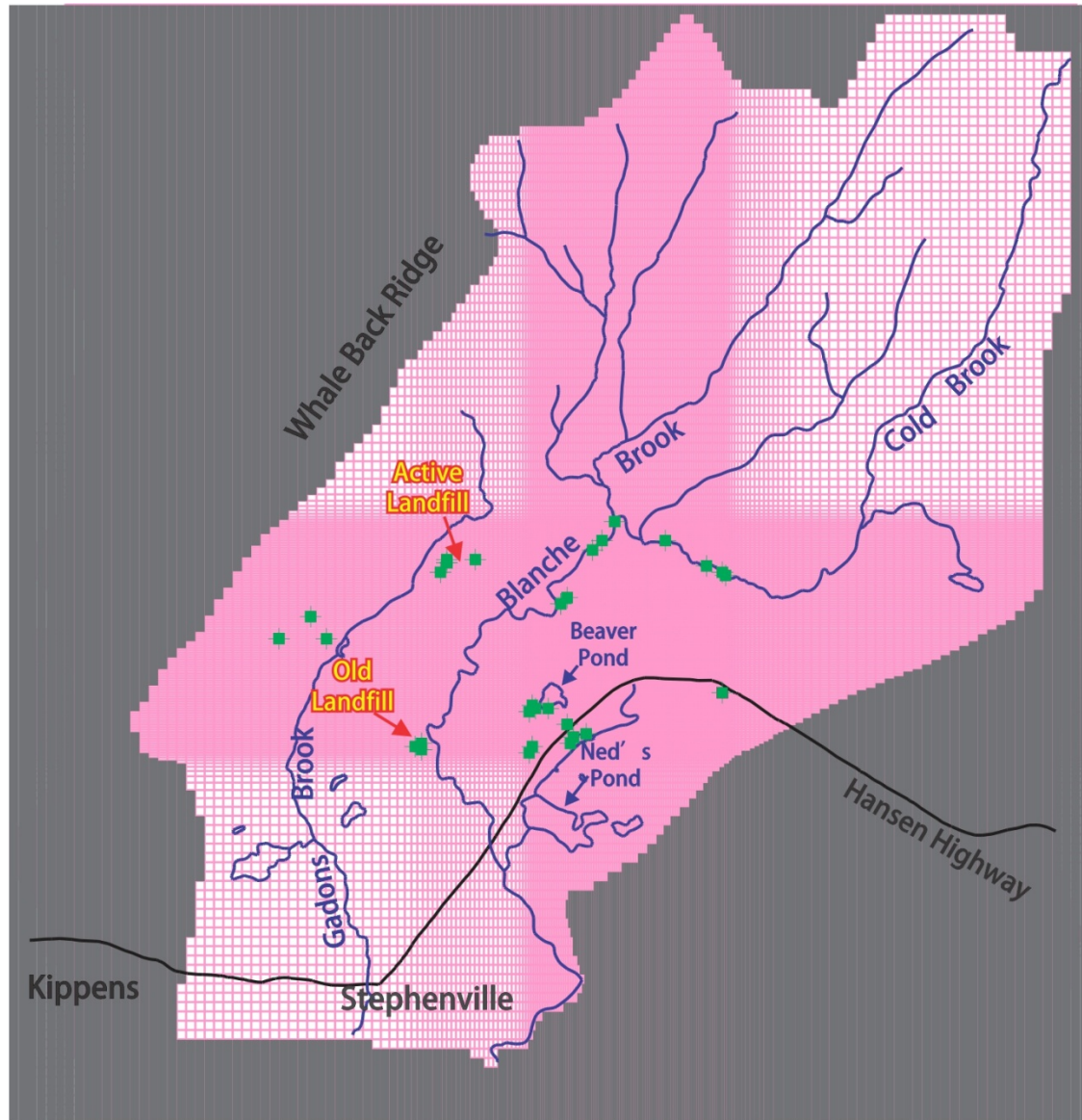


# Particle Tracks Spring Gulch and Seven Wells





# Flow Model – Grid



## Legend

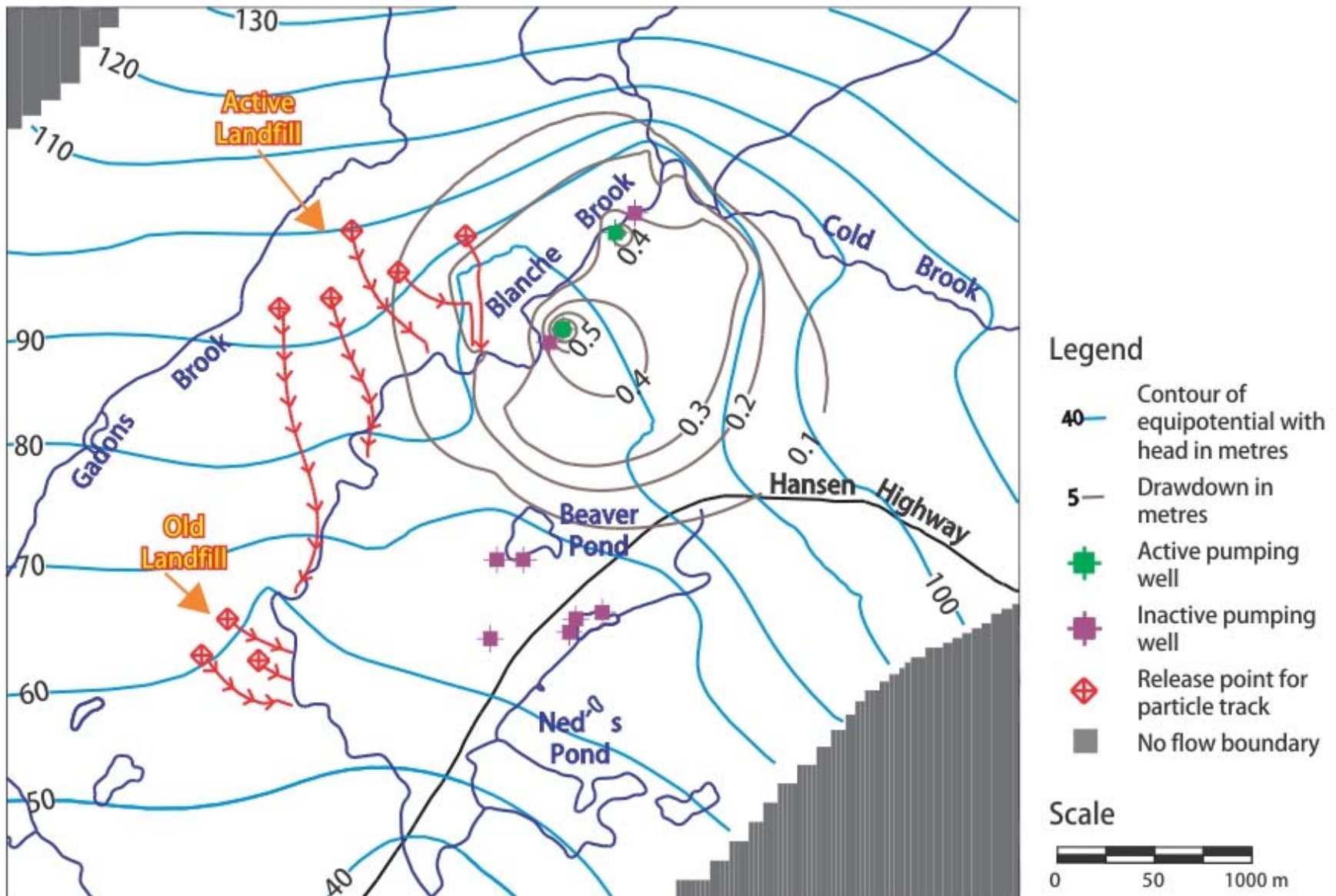
- Grid
- Observation / pumping well
- No flow boundary

## Scale

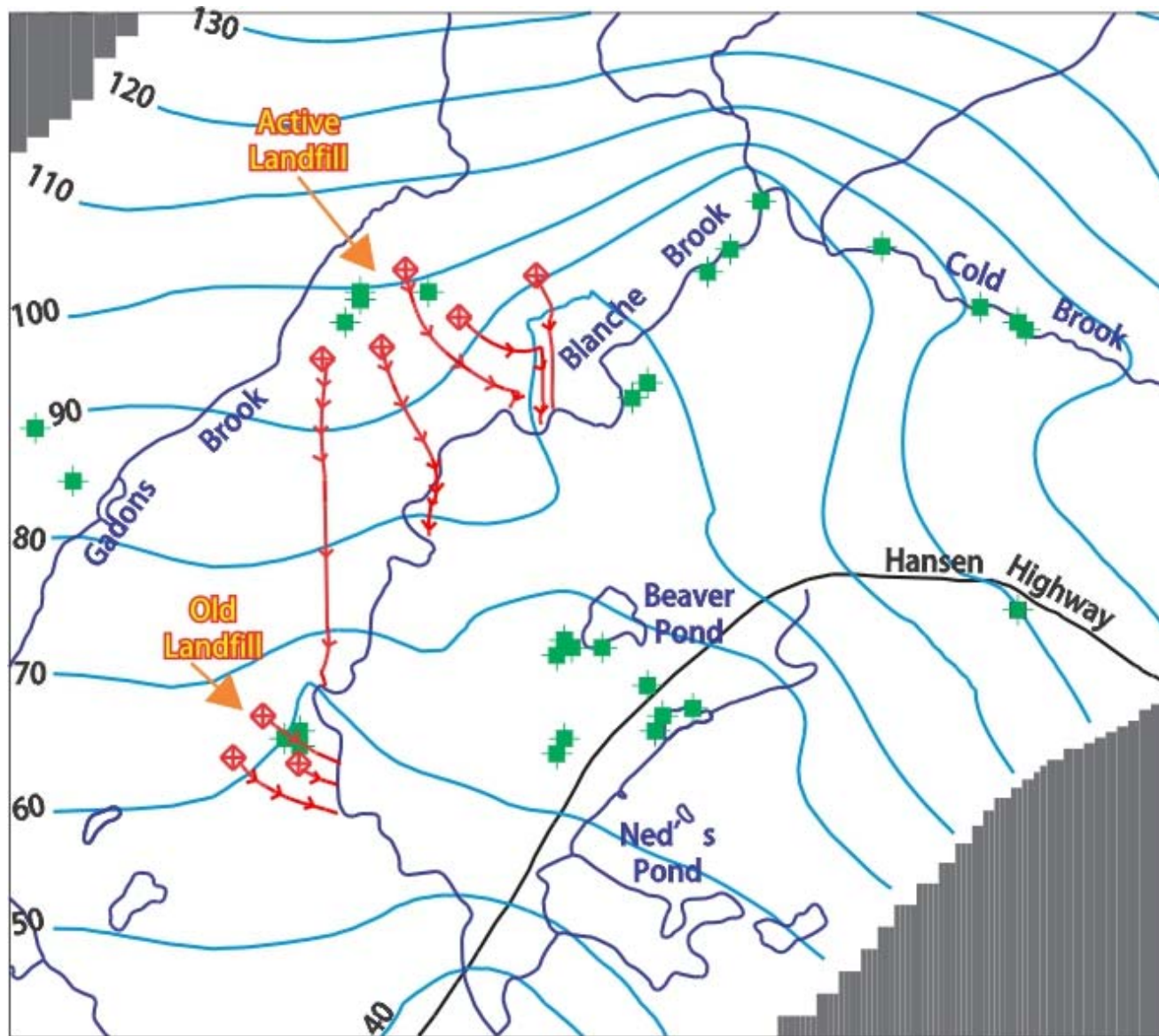




# Stephenville - Particle Tracks (Pumping)



# Particle Tracks (Non-Pumping Condition)



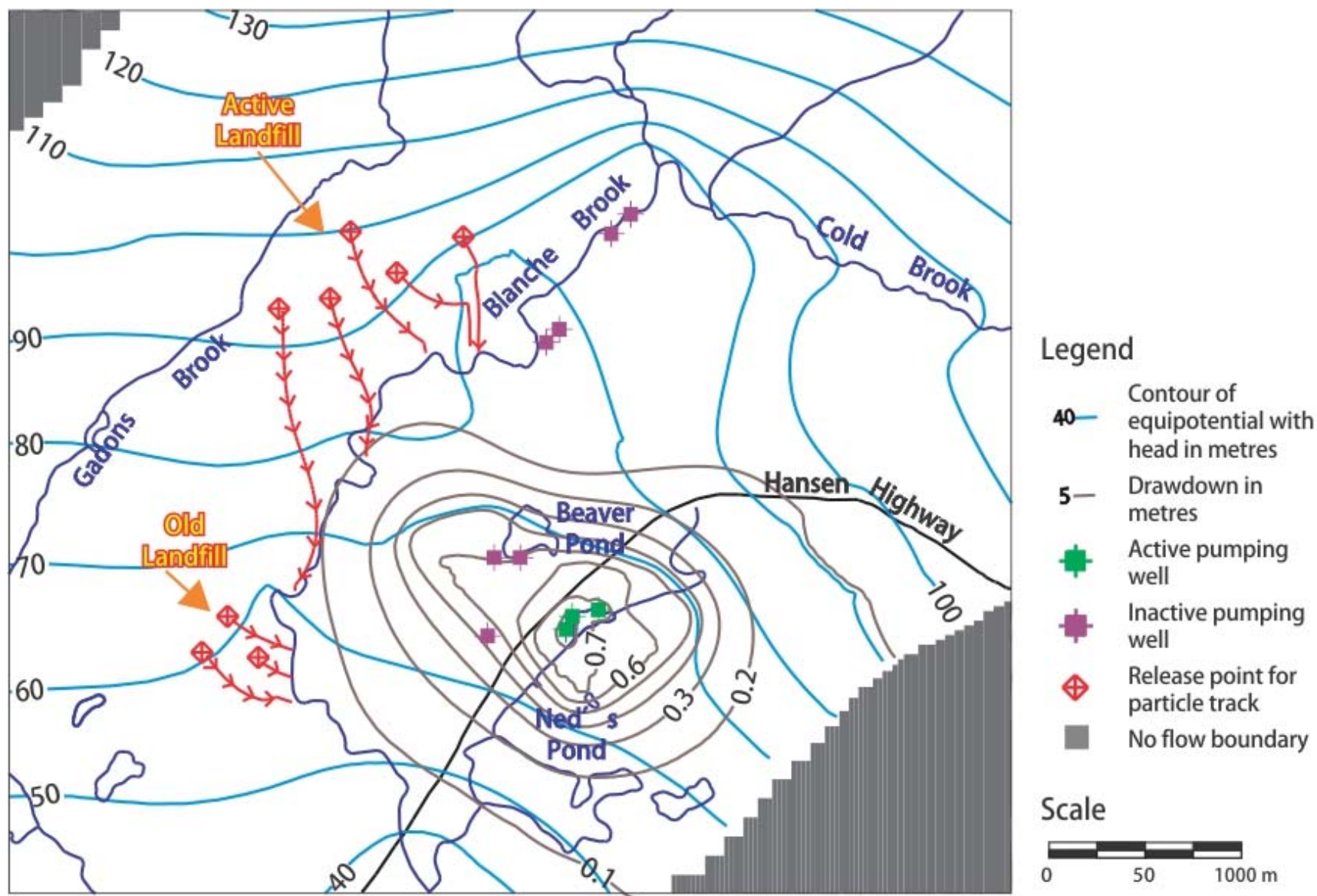
## Legend

- 40 — Contour of equipotential with head in metres
- Observation / pumping well
- ◆ Release point for particle track
- No flow boundary

## Scale



# Particle Tracks (Pumping – Selected Wells)





# Particle Tracks (Pumping – All Available Wells)

