Water Supply Well Condition Assessments

Real-World Applications and Results

Presented by Kevin Lindsey and Phil Brown; with support of Steven Patten, Frank Nicholson, Julie West, and Jon Travis

GeoEngineers

Northwest Groundwater Services, LLC

PNWS-AWWA Annual Conference
May 3-5, 2023

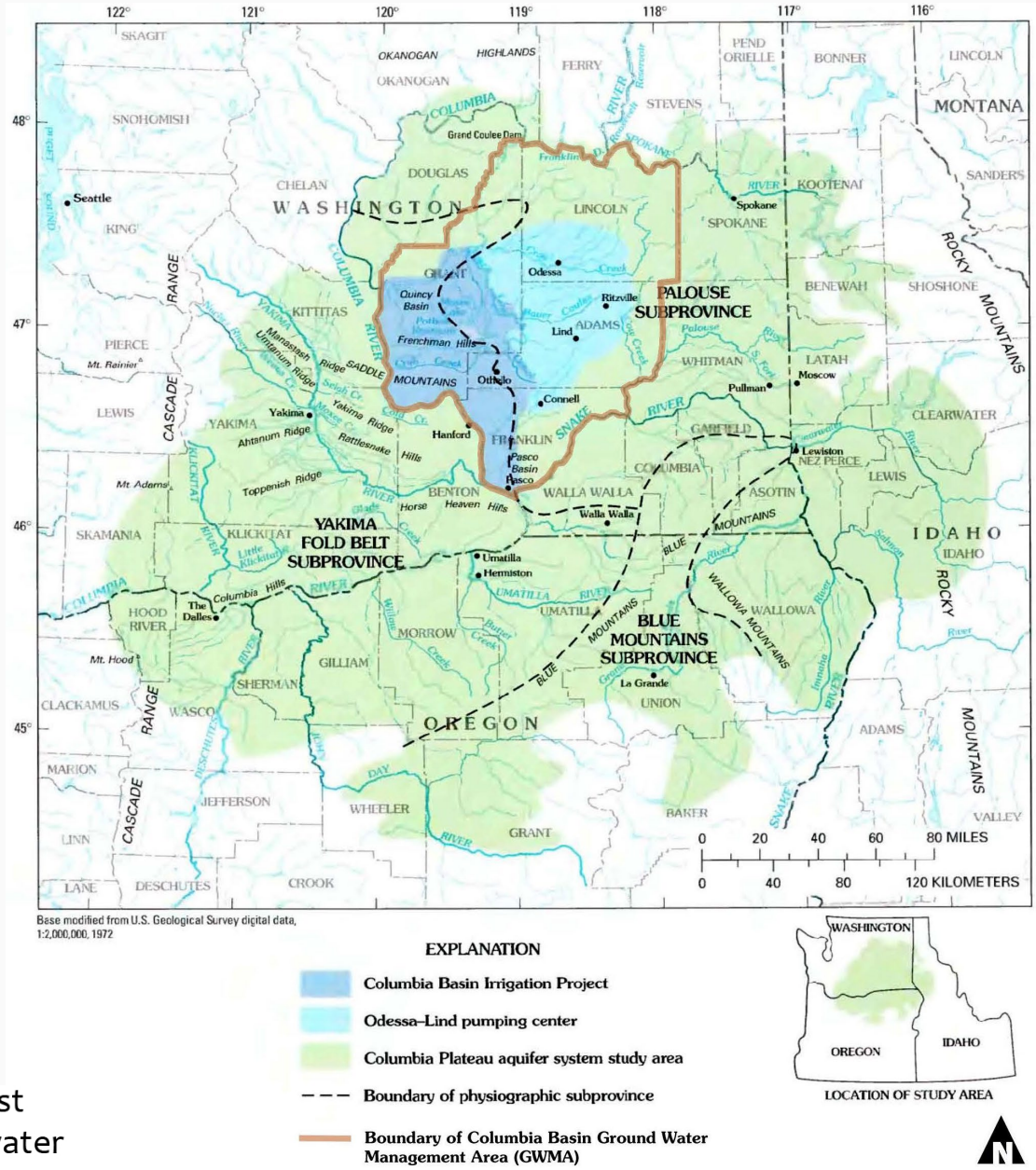
Introduction

- Purpose: Describe an Approach to Assessing Well Conditions and Look at Case Studies with Different Outcomes
- Outline:
  - Where are we
  - Types of wells
  - Methodology
  - Case studies
  - Take homes

Northwest Groundwater Services, LLC

GeoEngineers

Project Locations



Northwest Groundwater Services, LLC

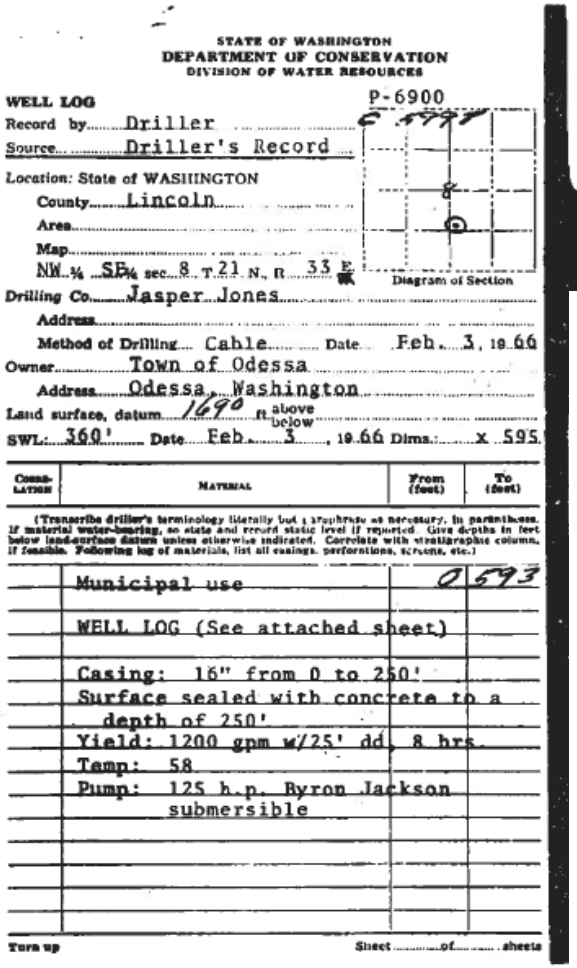
GeoEngineers

The Wells

- 7 recent/ongoing well projects
- 6 are CRBG wells
- 6 are > 30 yrs
- 3 are open basalt completions
- 3 have long-term WL declines
- 2 not purpose-built for municipal supply

Methodology: Background

- Records Review:
  - Pumping
  - Water level
  - Chemistry
  - Well logs
  - Rebuild logs
  - What's been done; History



STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES

WELL LOG P-6900

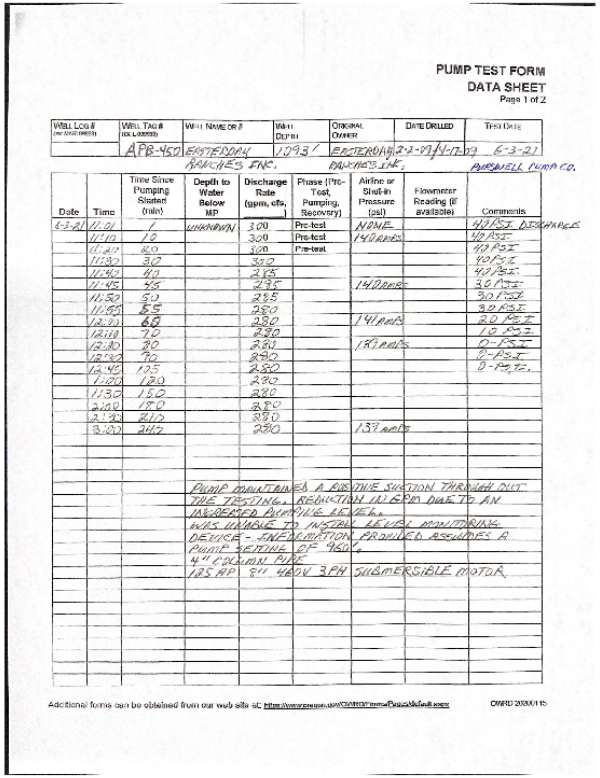
Record by Driller
Source Driller's Record

Location: State of WASHINGTON
County Lincoln
Area
Map
NW ¼ SE ¼ sec. 8 T. 21 N., R. 33 E. W.M.
Diagram of Section

Drilling Co. Jasper Jones
Address
Method of Drilling Cable Date Feb. 3, 1966
Owner Town of Odessa
Address Odessa, Washington
Land surface, datum 1690 ft above below
SWL: 360' Date Feb. 3, 1966 Diam.: x 595

Formation	Material	From (feet)	To (feet)
	Municipal use	0	593
	WELL LOG (See attached sheet)		
	Casing: 16" from 0 to 250'		
	Surface sealed with concrete to a depth of 250'		
	Yield: 1200 gpm w/25' dd, 8 hrs.		
	Temp: 58		
	Pump: 125 h.p. Byron Jackson submersible		

Turn up Sheet ... of ... sheets



PUMP TEST FORM
DATA SHEET
Page 1 of 2

Well Log #	Well Tag #	Well Name or #	Well Depth	Original Owner	Date Drilled	Test Date
	APB-450	EASTERDAY	1093'	EASTERDAY FARMS INC.	2-2-17/4-17-17	6-3-21

Date	Time	Time Since Pumping Started (min)	Depth to Water Below MP	Discharge Rate (gpm, cfs,)	Phase (Pre-Test, Pumping, Recovery)	Airline or Shut-in Pressure (psi)	Flowmeter Reading (if available)	Comments
6-3-21	11:01	1	UNKNOWN	300	Pre-test	NONE		40 PSI DISCHARGE
	11:10	10		300	Pre-test	140 PSI		90 PSI
	11:20	20		300	Pre-test			90 PSI
	11:30	30		300				90 PSI
	11:40	40		295				90 PSI
	11:45	45		295		140 PSI		30 PSI
	11:50	50		295				30 PSI
	11:55	55		290				30 PSI
	12:00	60		290		140 PSI		20 PSI
	12:10	70		290				10 PSI
	12:20	80		290		130 PSI		0 PSI
	12:30	90		290				0 PSI
	12:45	105		290				0 PSI
	1:00	120		290				
	1:30	150		290				
	2:00	180		290				
	2:30	210		290				
	3:00	240		290		139 PSI		

PUMP MAINTAINED A AIRLINE SUCTION THROUGH OUT THE TESTING. A REDUCTION IN RPM DUE TO AN INTERRUPTED PHASE REVERSAL WAS UNABLE TO INSTALL LEVEL MONITORING DEVICE - INFORMATION PROVIDED ASSUMES A PUMP SETTING OF 450'.
4" COLUMN PIPE
125 HP 511 460V 3PH SUBMERSIBLE MOTOR

Additional forms can be obtained from our web site at ... OWRD 2020/01

Northwest Groundwater Services, LLC

GeoEngineers

Methodology: Background

- Wellhead Visit
  - Physical layout
  - Can we do what we want to do?
  - How are we going to do it

Northwest Groundwater Services, LLC

GeoEngineers

Methodology: Biogeochemical Profile

- Water Systems Engineering, Inc.
- WQ Sampling: Pump-on (in-well), 1 hr (aquifer)
- Biology:
  - Aerobic, anaerobic, genus/species
  - Activity
- Geochemistry:
  - Mechanical
  - Natural

Methodology: Biogeochemical Profile

- Geochemistry:
  - ORP/LSI/Hardness
  - Iron
  - TOC/Silica
- Biology:
  - Heterotrophic plate count
  - ATP (initial/growth)
  - Anerobic/aerobic (sulfate reducing/iron oxidizing species)
  - E-coli/coliform/protozoa
- Interpretation:
  - Surface/in-well/aquifer
  - Food source(s)
  - Rehab/disinfection options

Methodology: Physical Assessment

- Specific Capacity; current vs past
- Pull pump; column/pump conditions
- Video; What's there and where is it

Northwest Groundwater Services, LLC

GeoEngineers

Methodology: Analysis

- Goal: Simple cleanout, aggressive rehab/rebuild, or replace?
- Can well be rehabbed?
- Cleaning:
  - Chlorine or Acid
  - Swab/Brush
  - Pulse/Energy
- Reconstruction; if needed is it feasible?
- WQ improvement potential
- Risk/cost/benefit rehab vs replace decision

Case studies; Recent/Ongoing projects

- Grouped wells based on outcome
  - WW-7, WR-10
  - WW-5, Lind 7
  - WR-2, WR-3, MF-9

- For each examine
  - Current conditions
  - Construction history
  - Evaluation Findings
  - Outcomes and why

Case Studies: WW 7

- 50 y.o., unused for 30 years
- History of warm water with H2S
- Power surcharge to start motor, so not exercised
- Building demolition required to pull pump
- PP&L Requested system test late 2022

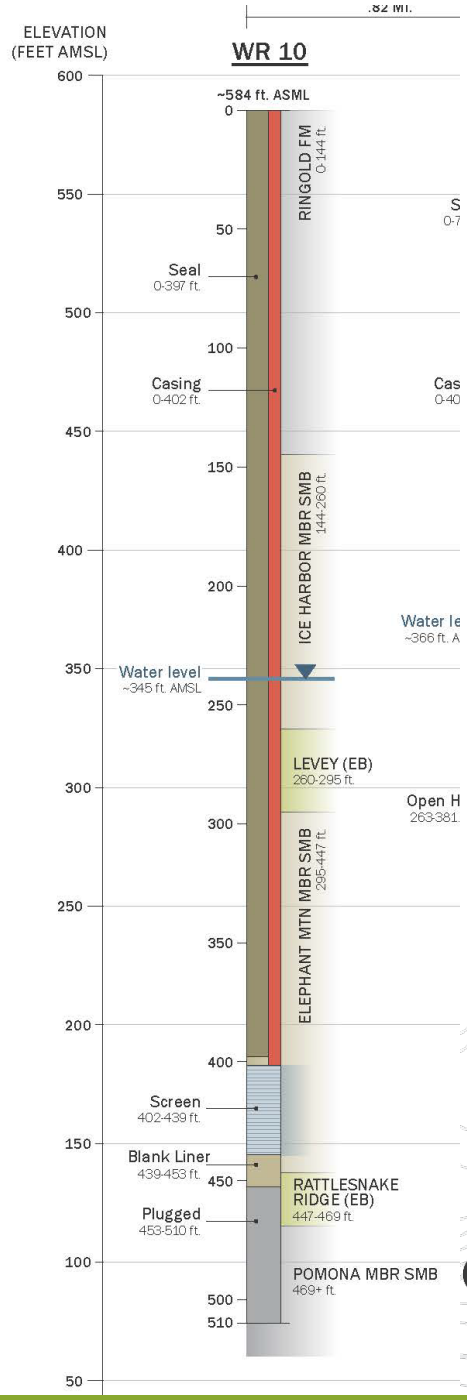
Case Studies: WW 7

- The motor ran, and water was pumped (2,700 gpm)
- Biological profile showed low activity
- H2S was not noted
- Water cleared in 5 minutes
- Specific capacity had not declined
- Take-Away: Even though this well seemed like problems were likely, it remains in good operational condition

(casing not inspected)

Case Studies: WR 10

- CRBG Well:
  - Drilled 2006, replaced failed well (2005)
  - 452 ft deep, screened 402-430 ft bgs
  - >1,000 gpm
- History/Issue
  - Failed well was grouted
  - Quickly start on 10
  - Soon developed WQ problems
  - Left in stand-by mode 15 yrs
  - In 2020, will ASR bubble push bad water away?

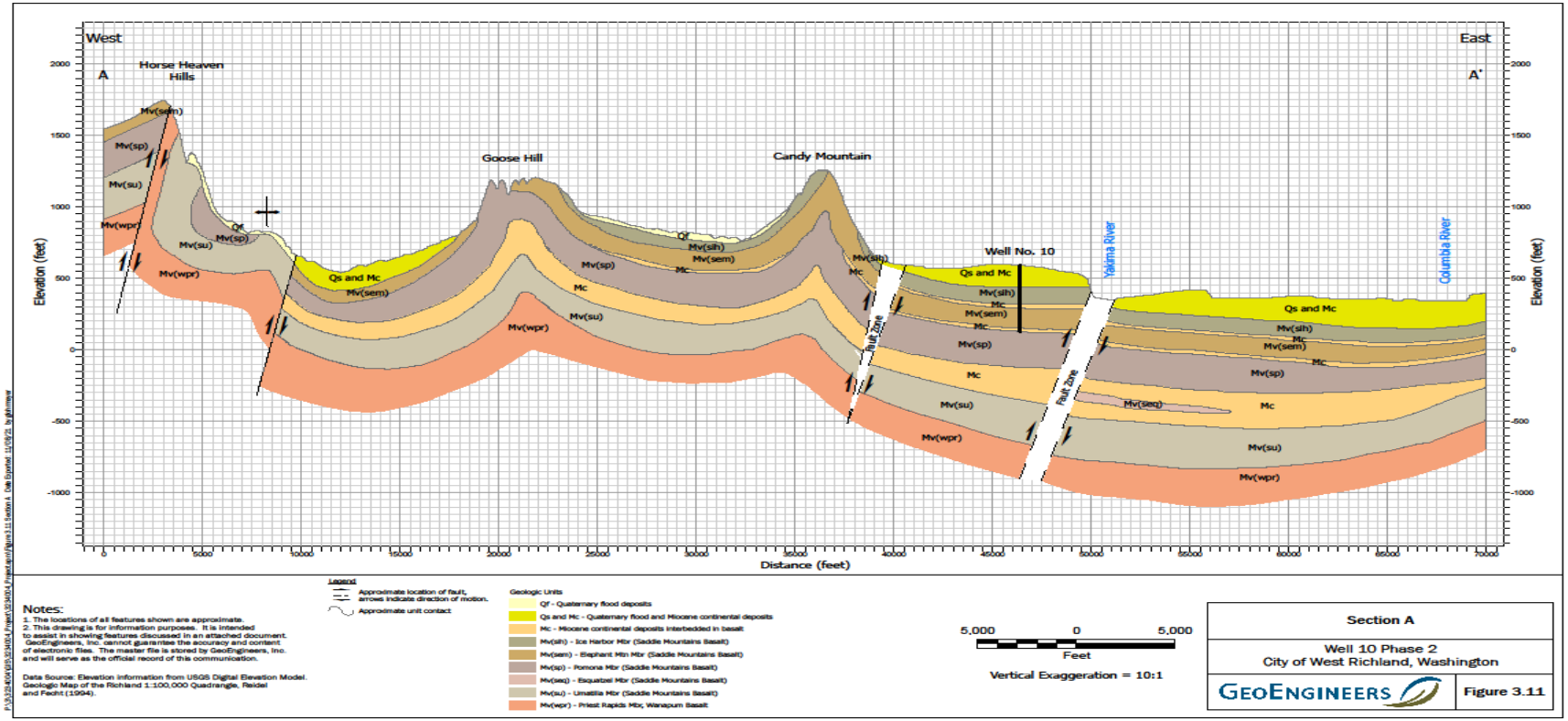


Northwest Groundwater Services, LLC

GeoEngineers

Case Studies: WR 10

- Findings: (1) Water quality had improved, (2) Screens clean, (3) Well productive, (4) Brush and disinfection only
- Outcome: (1) ASR is feasible, (2) City still needs to meet peak demand



Case Studies: WW5

- Emergency use only
- Aging infrastructure
- Suitable for ASR?
- Condition Assessment:
  - Collected Samples
  - Measured SC
  - Pulled Pump
  - Video Inspection

Northwest Groundwater Services, LLC

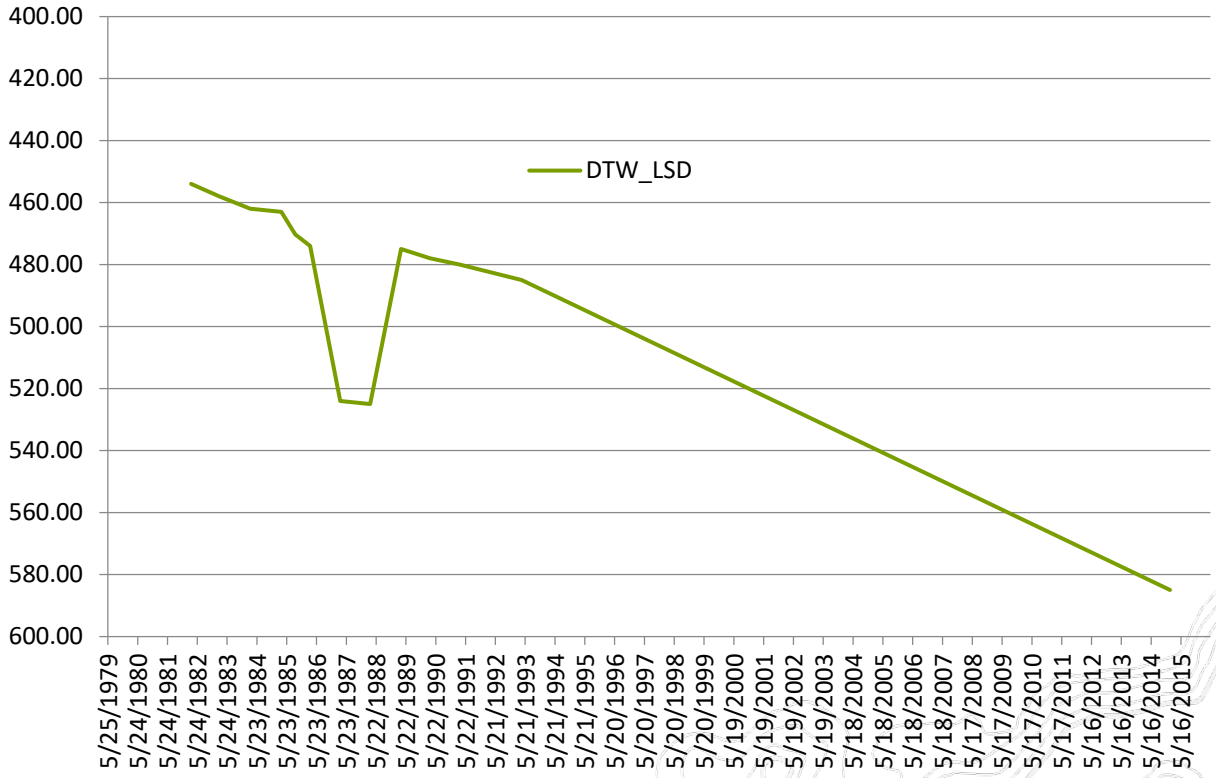
GeoEngineers

Case Studies: WW5

- Well moderately active
- Significant MIC (corrosion)
- Casing required cleaning prior to condition evaluation
- Cleaning process caused casing failure
- Well was re-built with new casing and seal
- Water was clean post-disinfection
- Well is now suitable for ASR

Case Studies: Lind 7

- CRBG Well:
  - Drilled 1980
  - 1020 ft deep, open below 515 ft bgs
- History/Issue
  - 750 gpm loss
  - 135 ft static drop
  - WQ degradation



Northwest Groundwater Services, LLC

GeoEngineers

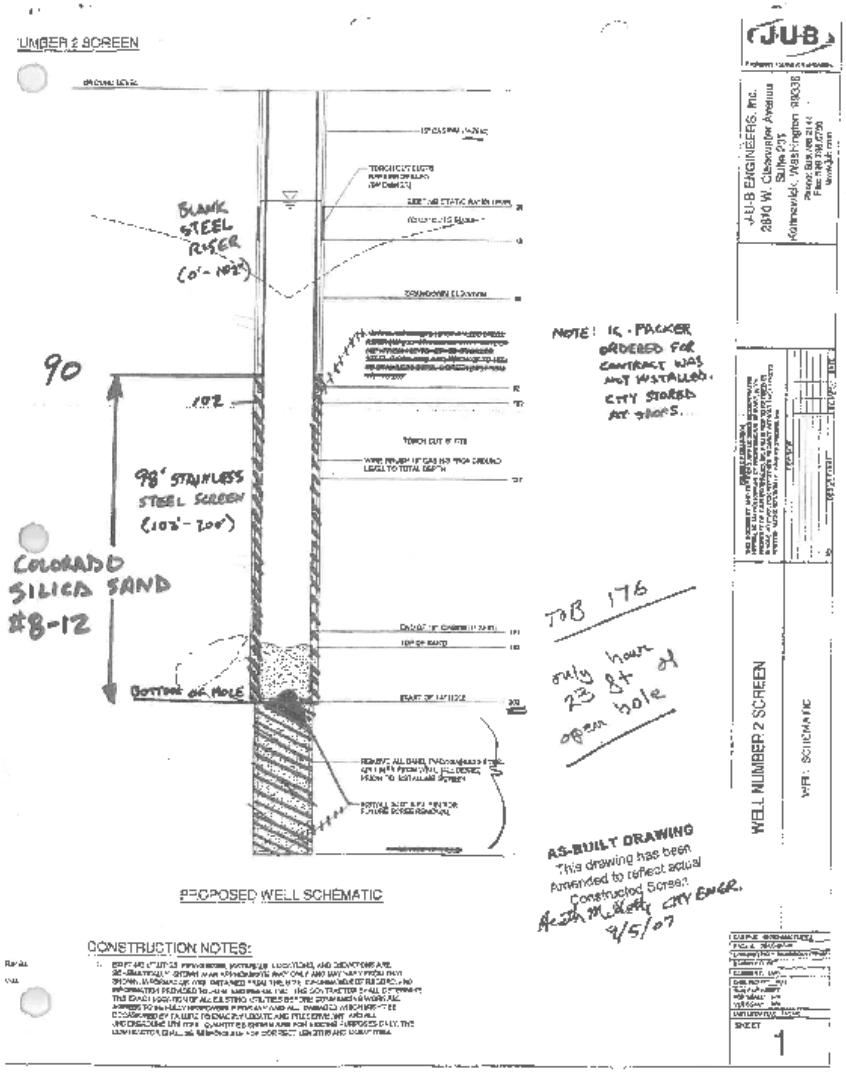
Case Studies: Lind 7

	Casing	Aquifer
Plate Ct (colonies/ml)	>1,500	>1,500
Anerobic growth (%)	<10	<10
Sulfate reducing bac	Neg	Neg
Fe/Mn oxidizing bac	Neg	Neg
E. Coli	Neg	Neg
Bac ID	Acintobacter venetianus Bacillus cereus; B. thuringiensis	
Microbe	Protozoa	

- Findings: oil feed, surface biology
- Outcome: keep it running, sample supply system, plan for new well in a few years

Case Studies: WR2

- Alluvial/CRBG Well:
  - Drilled 1962: 250 ft bgs; perfed 100-125 ft bgs in alluvial aquifer; open in basalt (>177 ft bgs)
  - Rebuild 2005: liner, screen, and perfs
  - 1,000 gpm
- History/Issue
  - Pre-Rebuild; sanding
  - Post-Rebuild; sanding, nitrate-N
  - 1,000 gpm to <250 gpm

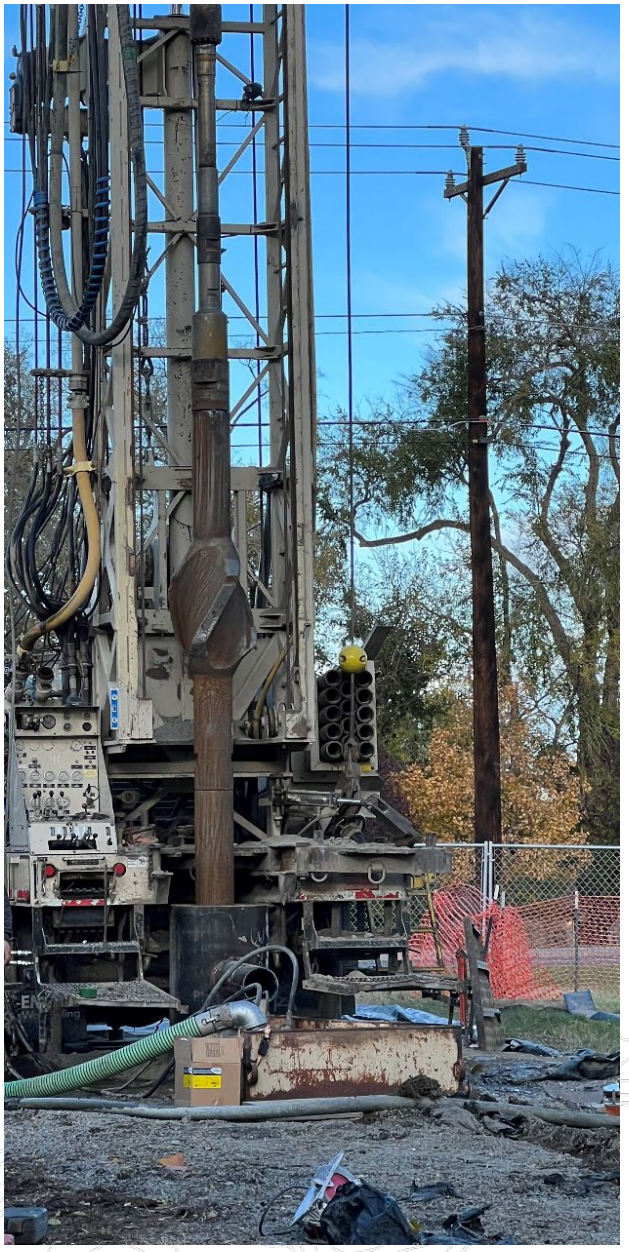


Northwest Groundwater Services, LLC

GeoEngineers

Case Studies: WR2

- Basalt Well
  - Shallow well in developed area, WQ
  - Water Rights allow deeper completion
  - Downsizing to case, seal, advance = too small
- Outcome – Decomm/Replace

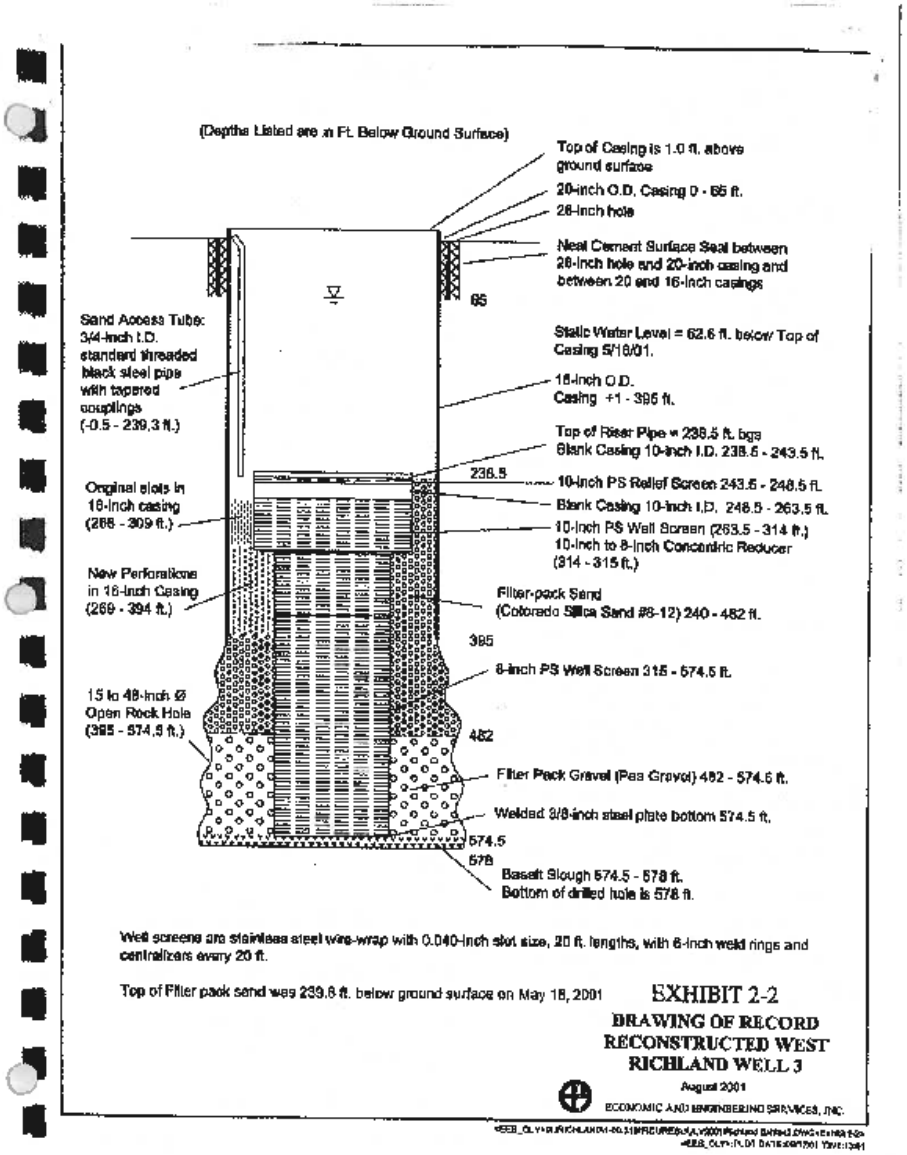


Northwest Groundwater Services, LLC

GeoEngineers

Case Studies: WR 3

- Basalt well with interbeds
  - Drilled 1981: 585 ft deep; perfed 276-316 ft bgs; open 399 to BOH (irrigation)
  - Rebuild 2001: screen and filter pack installed 238-574 ft bgs; perfed 269-394 ft bgs
- History/Issue
  - Pre-Rebuild; sanding, lower borehole collapse
  - Post-Rebuild; sanding, WA degraded
  - 2,500 gpm to <500 gpm

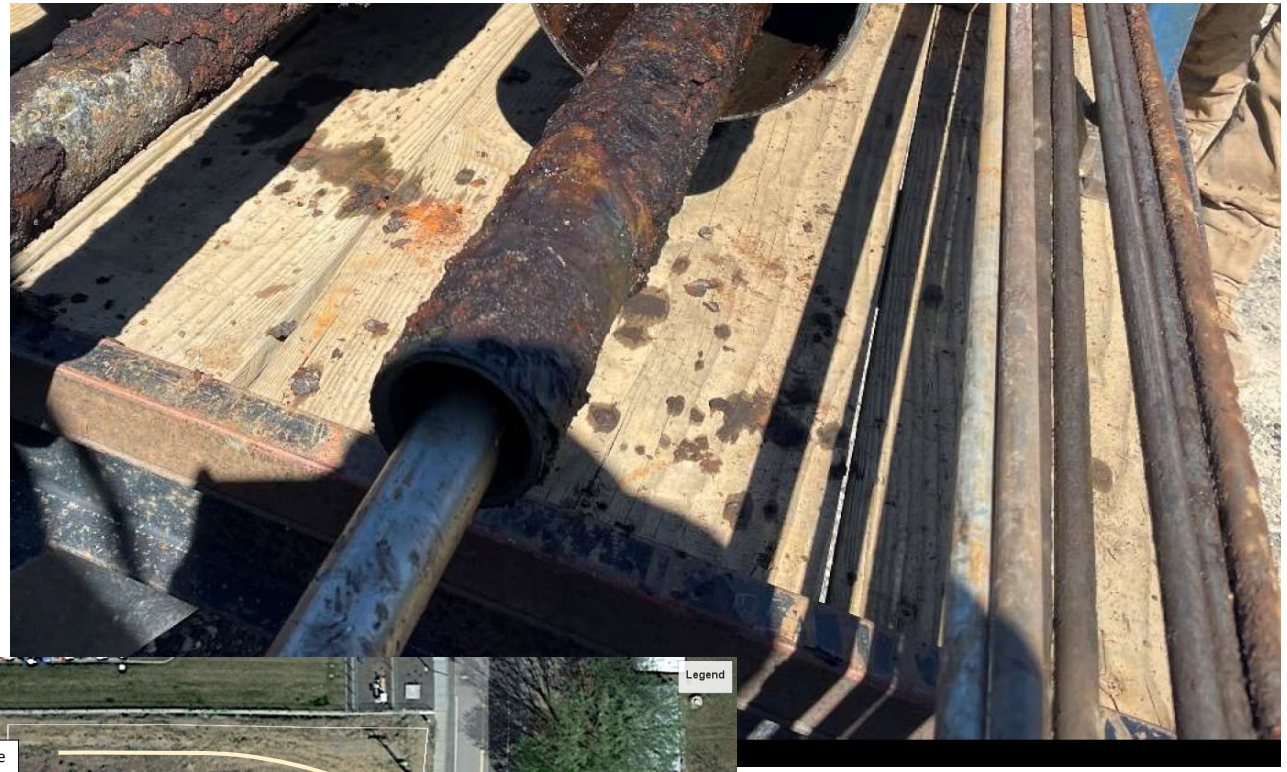


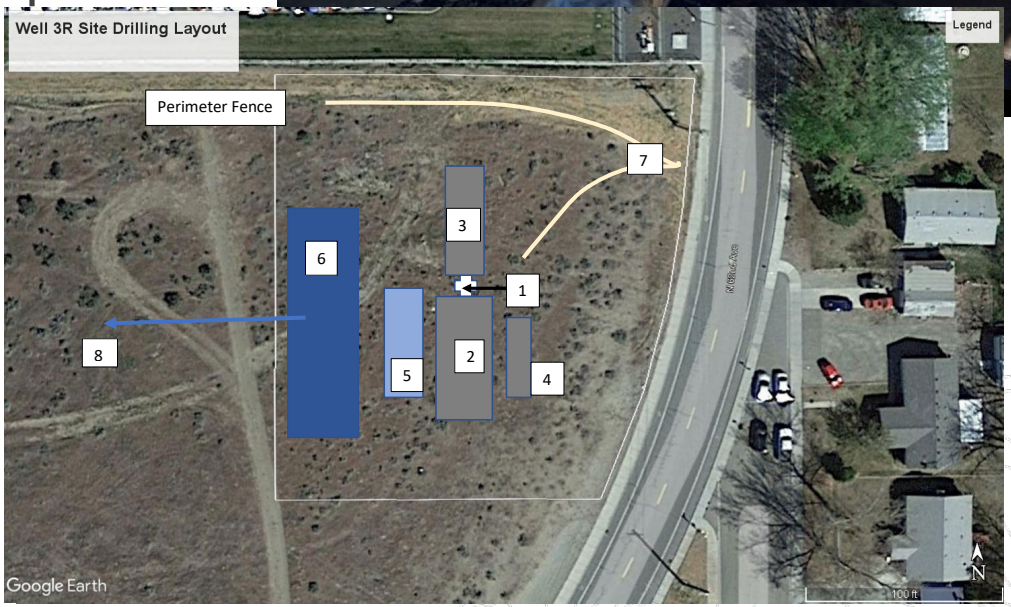
Northwest Groundwater Services, LLC

GeoEngineers

Case Studies: WR 3

- Findings: corroded, debris, last rebuild, options limited
- Outcome: decomm/replace





egend: 1 – well location; 2 – drill rig; 3 – pipe rack; 4 – compressor(s); 5 – circ tank/frac tank (as needed); 6 – cuttings and water collection pit; 7 access; 8 – Conveyance line onto land application area for discharge water.

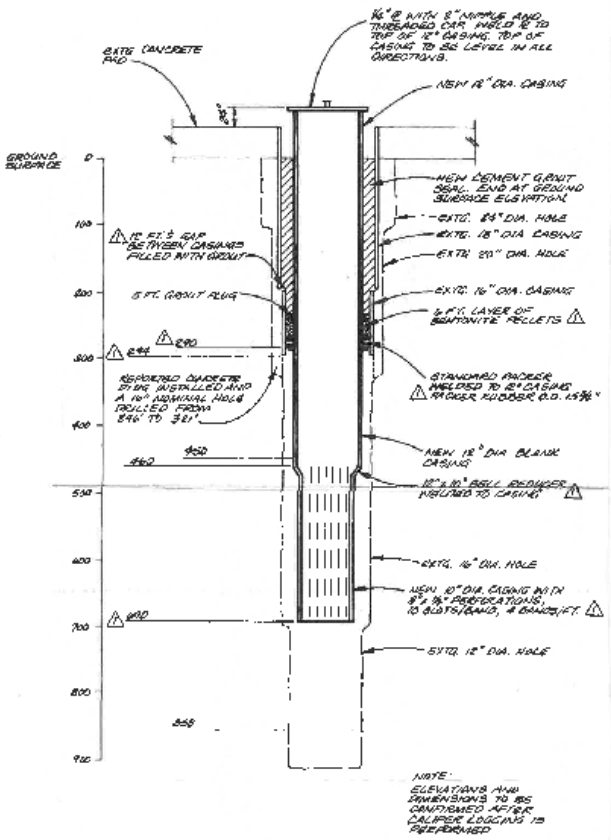
GURE: Approximate drilling site and equipment layout. Actual locations and equipment determined by selected drilling contractor in onsultation with City.

Northwest Groundwater Services, LLC

GeoEngineers

Case Studies: MF 9

- Basalt well
  - Drilled 1951: 915 ft deep; cased to 294 ft; seal (?); open to BOH (industrial)
  - Rebuild 1999: 12-inch blank liner to 460 ft; sealed (294 ft); 10-inch slotted liner to 690 ft; 12- to 10-inch bell reducer (solid pipe)
- History/Issue
  - Pre-Rebuild: 1500 gpm; 90 ft DD; Static 205 ft; some borehole collapse
  - Post-Rebuild: gradual prod and WL decline
  - Currently: <450 gpm, H_2S odor



Case Studies: MF 9

- Findings
  - ORP positive; LSI positive (high $CaCO_3$ ppt); highly active with Fe-Mg oxidizing bacteria
  - Liner broken and offset
  - Slots extremely overgrown
  - Lower borehole filled with debris and not plumb
- Outcome
  - Can't fix (broken/displaced liner) or clean (slots)
  - Replace well at better location in City

Take Homes

- Decide: maintain or run-to-failure?
- Problems are manageable if diagnosed correctly and addressed early
- Multiple rebuilds may be a **Red Flag**
- Original construction:
  - Avoid Slots
  - Telescope
  - Don’t screen/perf shallow: prevent cascading water
- M&O:
  - Measure dynamic and static WL annually
  - Periodic SC measurement to track changes
  - Sample and/or physical inspection if SC drops or WQ changes occur
- Like a 20 y.o. car, sometimes you just have to call it a day.

Thank You for Your Time

- Kevin Lindsey, Principal Hydrogeologist, GeoEngineers, 509-209-2848
- Phil Brown, Principal Hydrogeologist/Owner, Northwest Groundwater Services, 503-313-5195