Assessing the Origin of Groundwater Springs
and Implication for PFAS Fate and Transport at Mountain Home Air Force Base, Idaho

Michael Shultz

Battelle 6th International Symposium on Bioremediation and Sustainable Environmental Technologies

Abstract #240

Session: E9. Groundwater/ Surface Water Interactions

May 11, 2023

BURNS & McDONNELL

Knowledge Gaps Identified to Address

- Uncertainty of GW flow direction
- Continuity and connectivity of groundwater pathways
- Degree to which contaminant mass remains in vadose zone and perched water zones serves as continuing source of impact to GW
- Groundwater/surface water interaction: Nature and origin of groundwater springs to Snake River

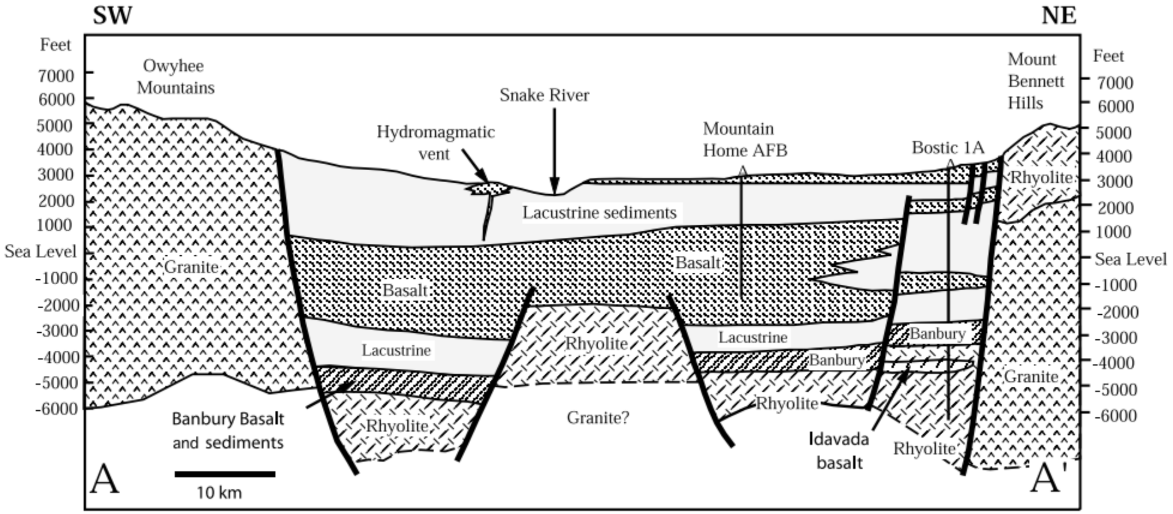
Project Accomplishments — Data Gap Resolutions

- Data Acquisition, Review, Data Gap Analysis
- Gamma and Neutron logging at 25 Existing Monitoring Wells
- Geologic Field Recon Study of Snake River Canyon Lithologic and Springs Geologic Investigation and Drone Survey
- ESS Analysis, development of geologic cross sections and basewide CSM

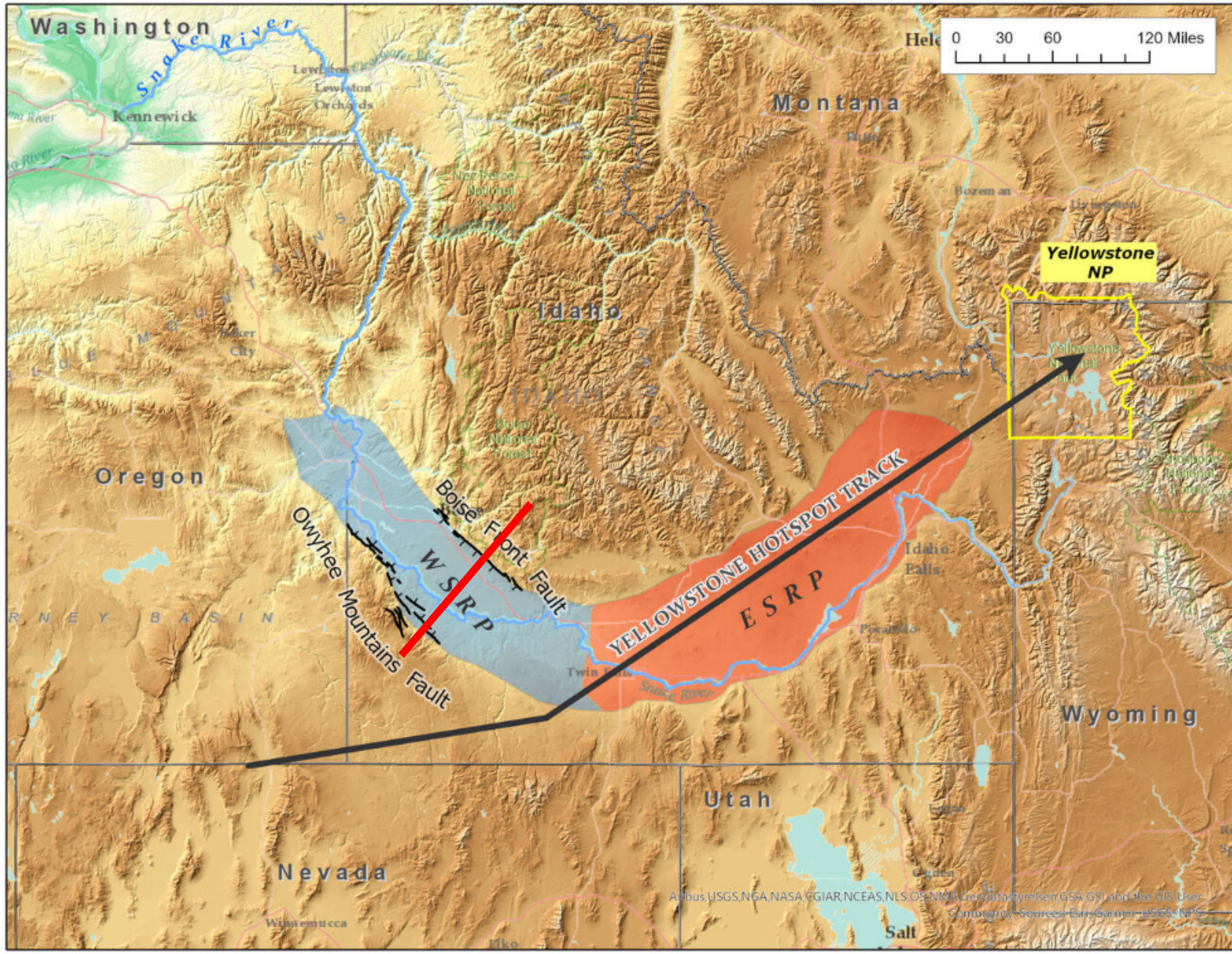
Tectonic Setting

Extensional graben related to the Yellowstone Hot Spot migration

Contains Lake Idaho Sediments, flood basalts



From Shervais, J.W., Gaurav Shroff, S.K. Vetter, Scott Matthews, B.B. Hanan, and J.J. McGee, 2002, Origin and evolution of the western Snake River Plain: Implications from stratigraphy, faulting, and the geochemistry of basalts near Mountain Home, Idaho, in Bill Bonnichsen, C.M. White, and Michael McCurry, eds., Tectonic and Magmatic Evolution of the Snake River Plain Volcanic Province: Idaho Geological Survey Bulletin 30, p. 343-361



BURNS McDONNELL

Groundwater Flow at MHAFB

- Flood basalts and interbeds are aquifers
- Interflow zones (“autobreccia”) can be prolific aquifers (K>200 ft/day in MH BPWs)
- Interflow zones can also be fine-grained, representing perching layers, contaminant “storage” areas.

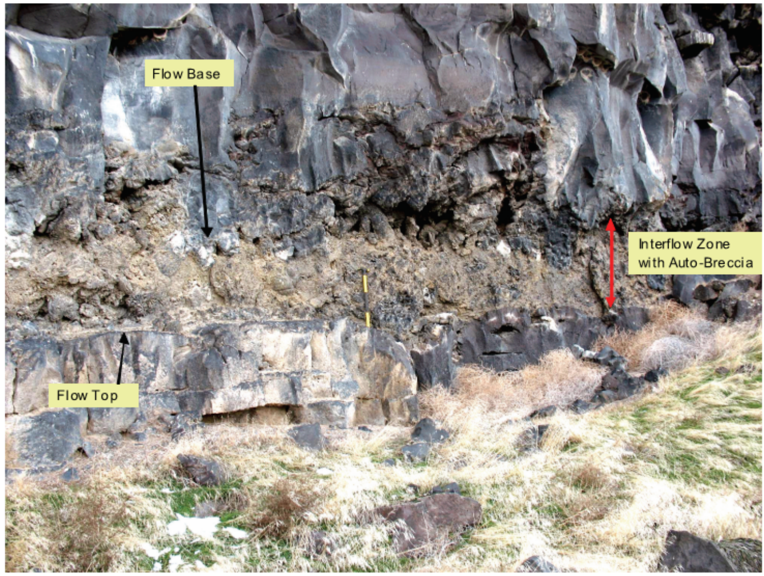
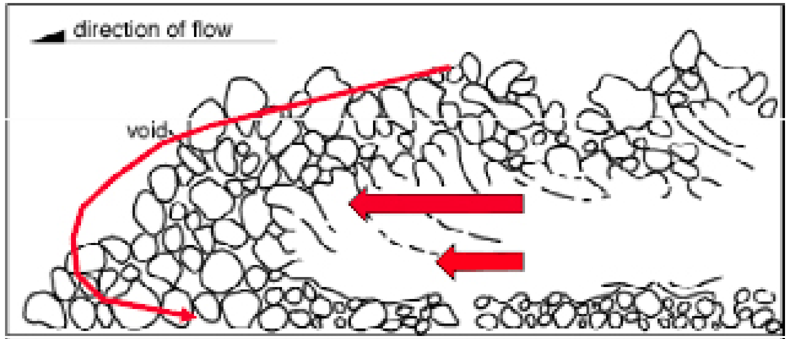


Figure 3. Photograph of an interflow zone between basalt flows. The interflow zone contains a tractor-tread auto-breccia of basalt clasts with a low permeability mud matrix that in places grades upward into clast-supported basalt breccia with cavernous porosity and high permeability. Hammer handle is 3 feet long. Middle Basalt, south of Pump Road off of Strike Dam Road, about 6 miles southwest of Mountain Home Air Force Base.



Compared to pahoehoe, aa flows are thicker and have rough, clinkery surfaces. This cross-section shows one aa flow.

http://www.luckysci.com/2014/08/types-of-volcanic-rocks-and-deposits/

Groundwater Flow at MHAFB

- Dense basalt flow interiors are fractured (columnar jointed), providing vertical flow paths
- Wellbores also provided flow paths
- Traditional thinking was that natural fracture flow was slow and wellbores were primary conduits

Perched groundwater zones are known to be present at MHAFB

The nitrate contamination to the aquifer originated from historical or modern parts of the sanitary sewage system that may have released 200 millions gallons of sewer water per year to the top of basalt for 40 or more years. Eight areas are known to contain perched water at four different altitudes above the drinking water aquifer. At least two of these perched water zones have a water chemistry consistent with sewer water. Perched water originating from the sewer system would take either a tortuous, extremely long path to the aquifer through the 400 feet of basalt lava flows and lacustrine mudstone aquitards, or a vertical fast-path via wells with annular spaces that are unsealed below the surface seal.

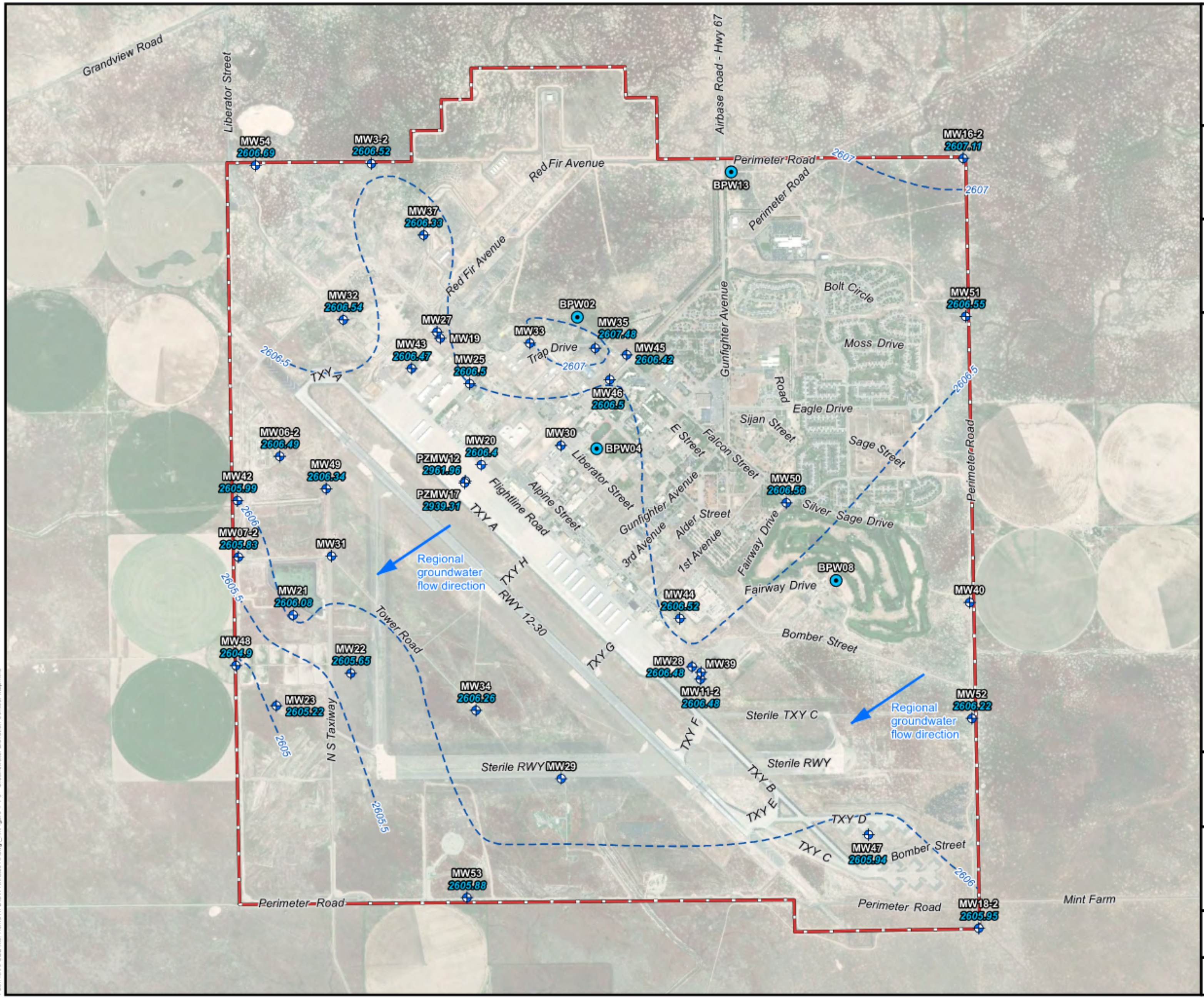


FIGURE 4.1-3
Groundwater Elevation Contour Map
May 29 & 30, 2018

Remedial Investigation Report
Nitrates at Site SD024
Mountain Home Air Force Base, Idaho

Air Force Civil Engineer Center

2261 Hughes Ave., Suite 163
JBSA Lackland, Texas 78236

Symbol Key

- Monitoring Well
- Active Production Well during Synoptic Groundwater Level Monitoring Event
- Groundwater Elevation Contour (feet, Above Mean Sea Level)*
- Mountain Home AFB Installation Boundary
- 2605.30* Groundwater Elevation (feet, Above Mean Sea Level)*

*Water levels for wells MW29, MW30, MW33, MW39, and MW40 were measured before the installation of new pumps and new measuring point elevation is not the same as the old elevation prior to the new pump installation. Perched Zone wells PZMW12 and PZMW17 are screened above the regional water table. These wells were not used for the groundwater elevation contour map.

NOTE: FOR OFFICIAL USE ONLY (FOUO). This document contains information which must be protected IAW the Privacy Act of 1974 (5 U.S.C. 552a), DoD 5400.11R, AFI 33-332, and AFI 31-401.

Project: 775408401

Date: 1/28/2019 By:SD

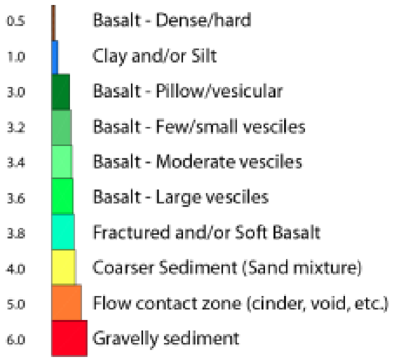
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

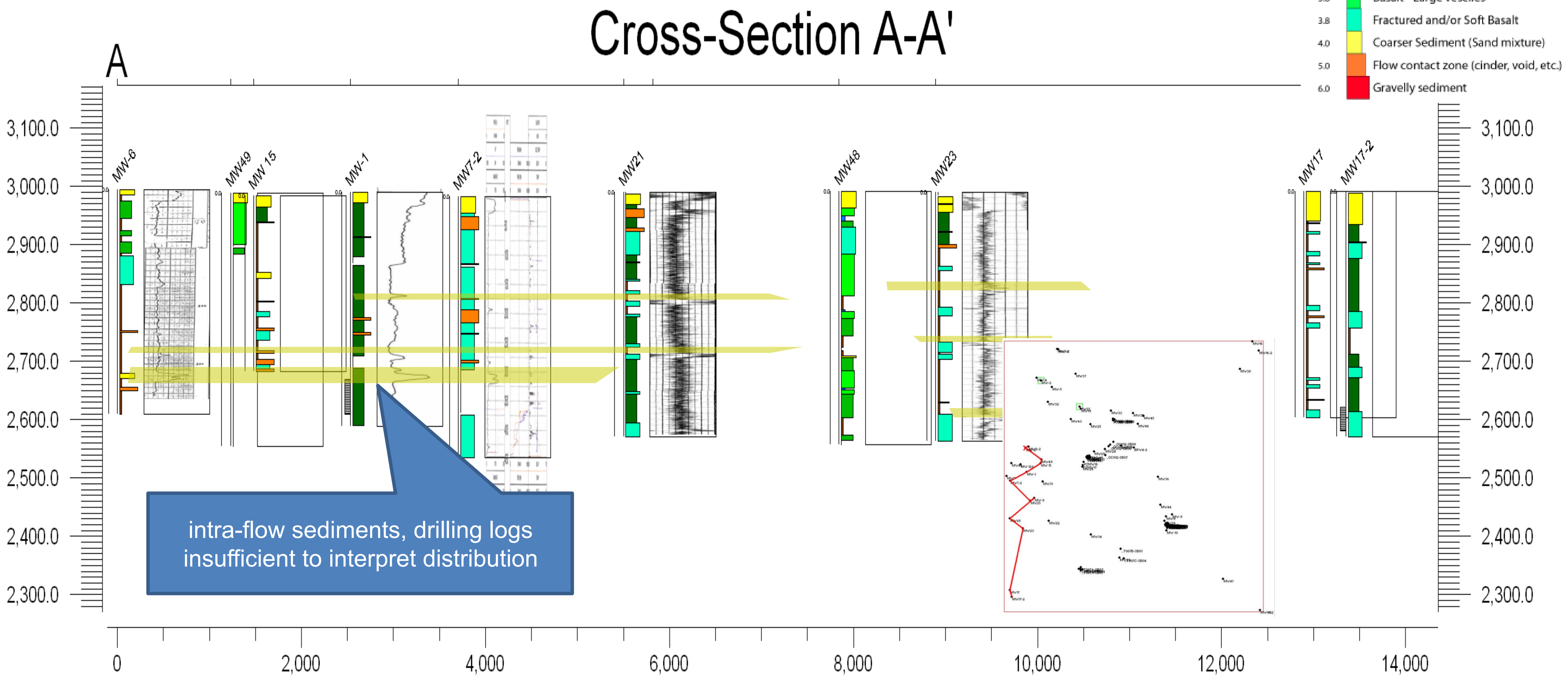
Disclaimer: For general reference purposes only. DO NOT USE to determine, certify, or verify map features, scale and/or other information.

0 1,000 2,000 4,000 Ft.

BURNS McDONNELL

Combined Gamma and Drilling Log Section



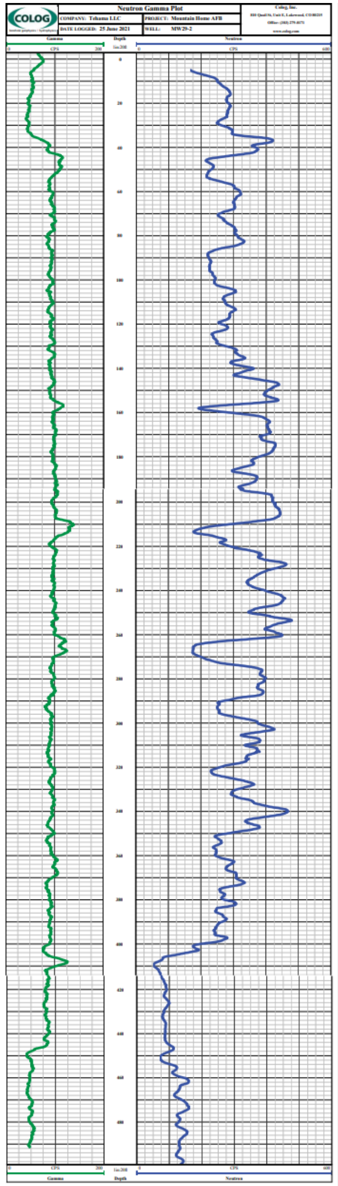


Gamma-Neutron Logging

- Well construction materials must be considered
- Natural aquifer stratigraphy interpretable (it worked through casing)

Base of surface seal

Sedimentary interbeds



Well construction diagram (left) and natural gamma ray (green curve), and neutron log (blue curve). Note increase in gamma ray response due to bentonite seal below 40' bgs, natural sedimentary interbeds, effect of water table on neutron log, and contact with sand filter pack.

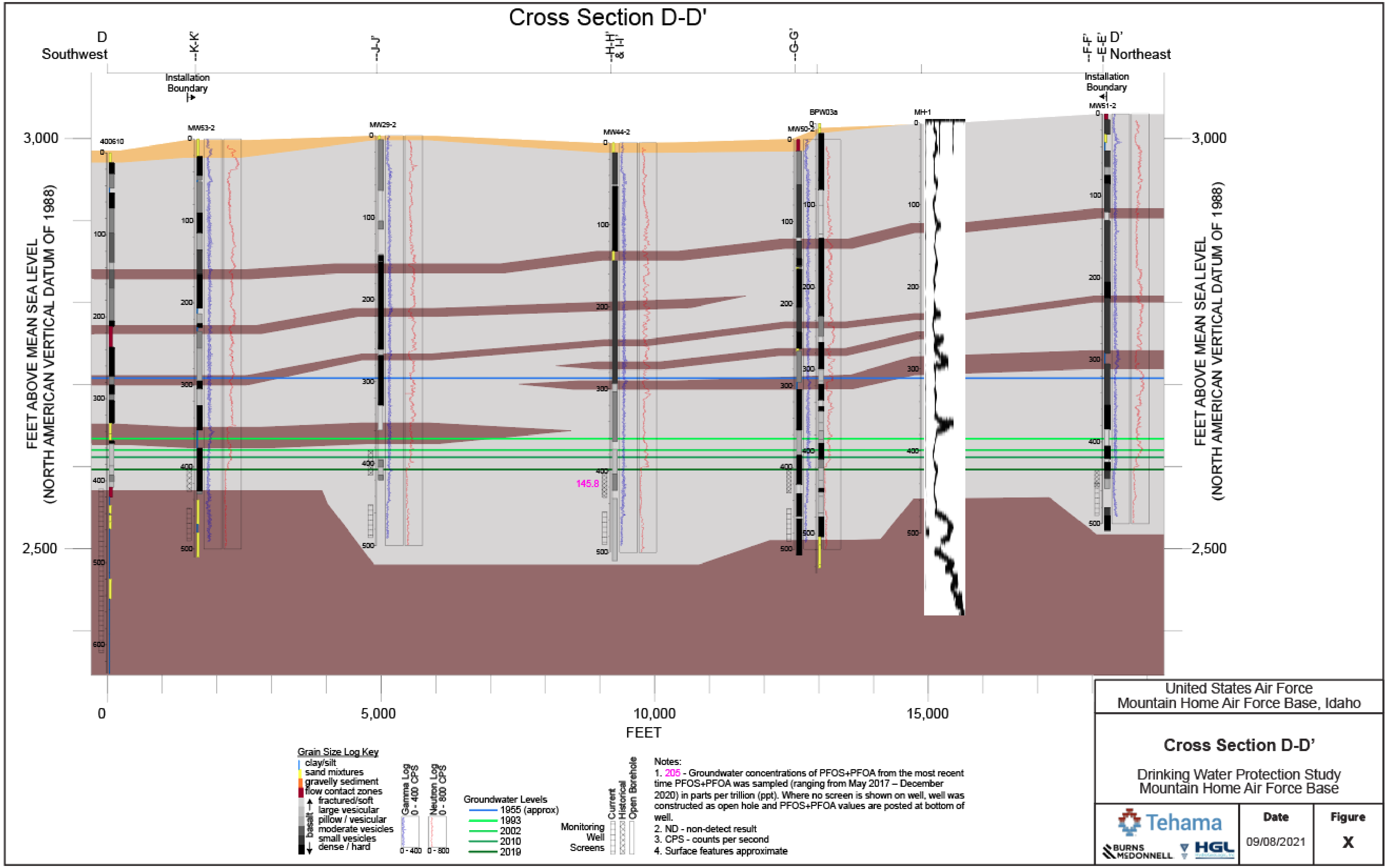
Water table

Filter pack

Tehama / Burns McDonnell / HGL	Date 09/10/2021	Response of Geophysical Logs to Natural Stratigraphic Features and Well Construction Materials, MW-29-2 MHAFB Drinking Water Protection Study	Figure 3-4

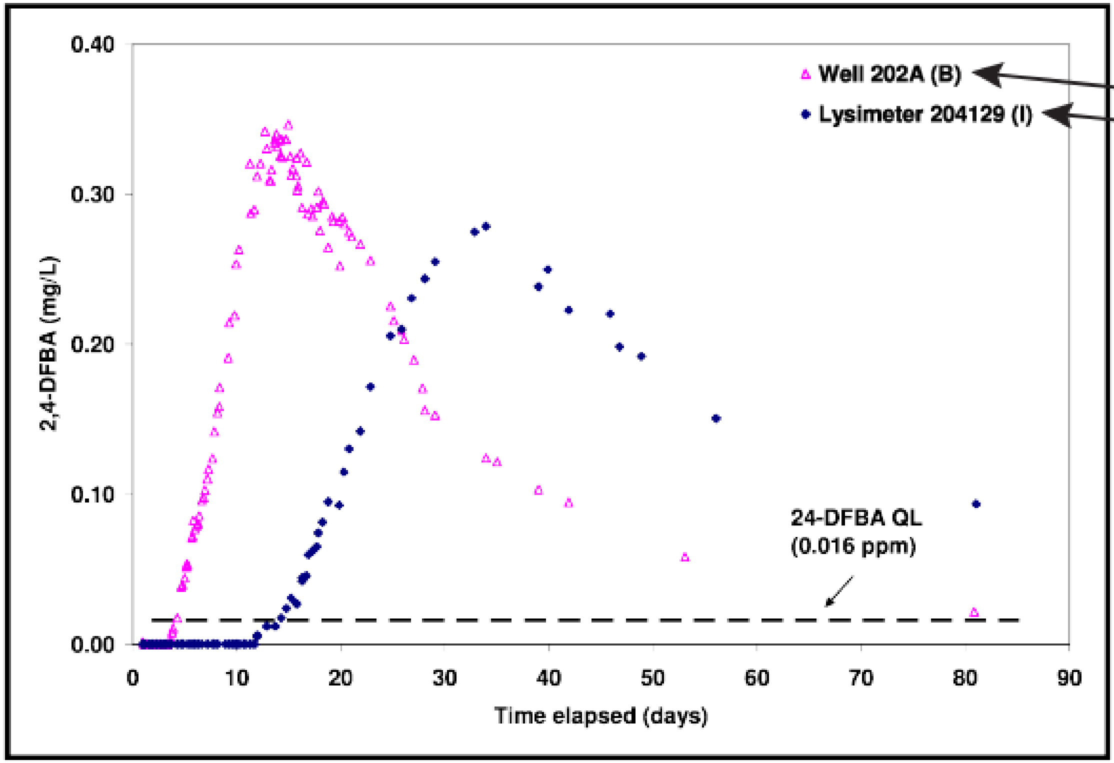
ESS Cross Section D-D’

- Geophysical logs allow confident interpretation of interbeds
- Interbeds dipping SW
- Long correlation length of interbeds
- Interbeds are mappable, perch water, and could be monitored



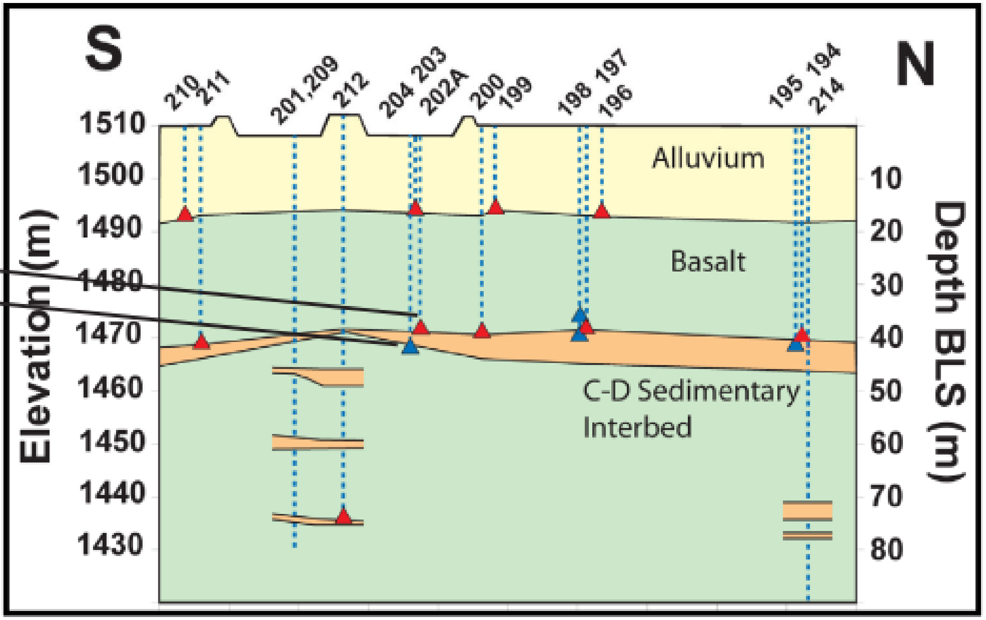
CSM GW Flow: Use of Analogue Studies from Idaho National Lab

Results from infiltration tracer tests in basalts of the eastern Snake River Plain carried out using the Vadose Zone Research Park (VZRP) at Idaho National Laboratory (INL)



Note: 24-DFBA refers to tracer 2,4-difluorobenzoate used in the study/

Figures 3 and 7; Elucidation of flow and transport processes in a variably saturated system of interlayered sediment and fractured rock using tracer tests (Duke, 2008)



United States Air Force
Mountain Home Air Force Base, Idaho

Results from INL Infiltration Tests Demonstrating Rapid Flux of Water Through Sedimentary Interbed in Vadose Zone

MHAFB Drinking Water Protection Study

Tehama / Burns McDonnell / HGL	Date	Figure
	09/10/2021	4-3

BURNS McDONNELL

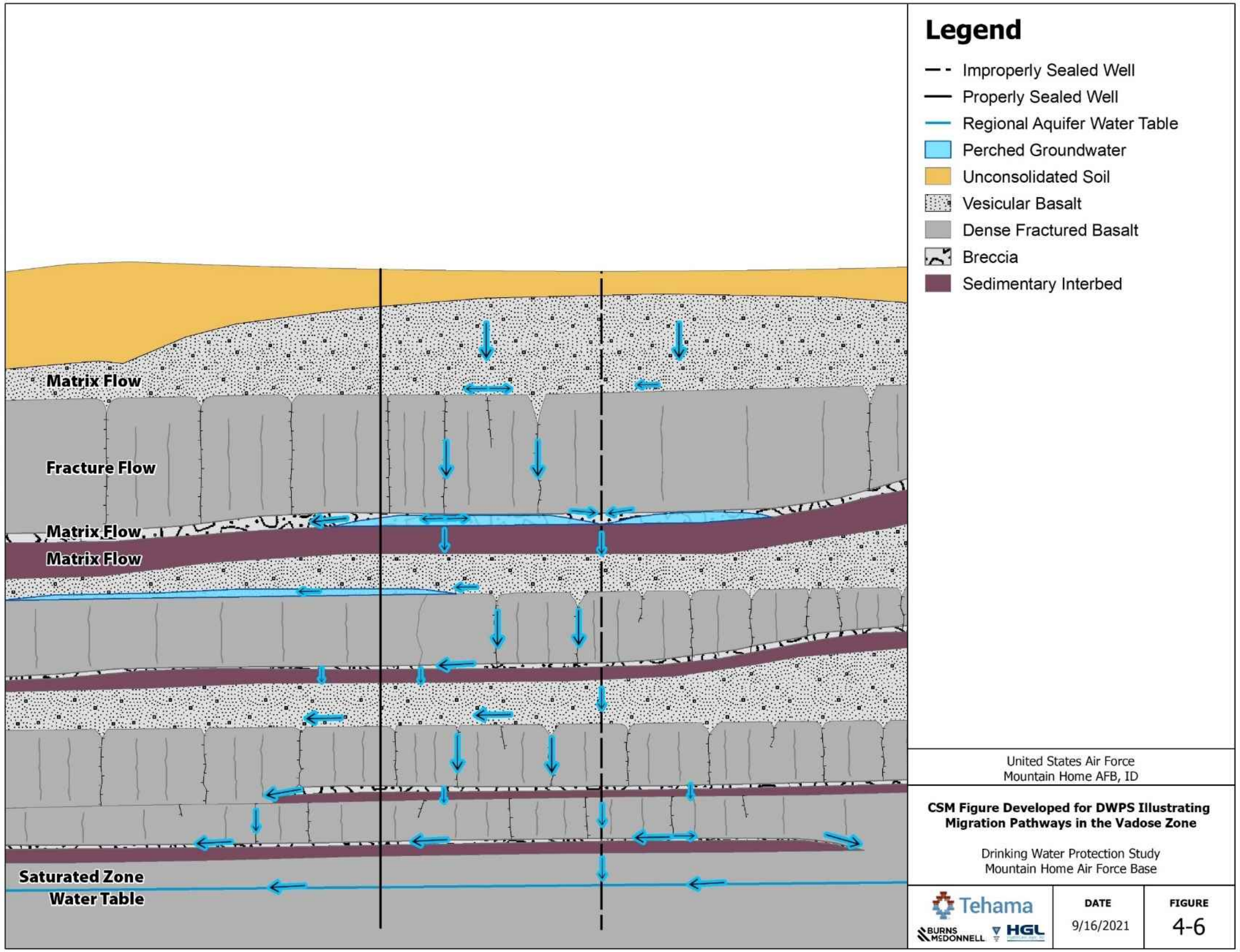
New Groundwater Flow CSM

New understanding of GW movement at MHAFB:

- GW moves vertically through the matrix
- GW moves in months, not decades
- Still very stagnant GW in center of Base not going anywhere – moves SW in winter, back NE in summer due to pumping

New understanding of contaminant migration at MHAFB:

- Nitrates and vapor concentrations didn't move (stable)
- Likely still PFAS mass in vadose zone, but no large pulses coming from that mass
- Either not migrating down much, or
- Low enough concentrations being balanced out by degradation and dilution



United States Geologic Survey, Mouth of Bruneau, Idaho, AMS 2869 IV NW-Series V893, 1946, 1:24,000 topographic sheet

Legend

Natural Spring Location

- Source - HTMC, 1952 ed.
- Source - HTMC, 1967 ed.
- Unknown

United States Air Force
MAFB Mountain Home, ID

Snake River Canyon Natural Spring Locations

Drinking Water Protection Study
Mountain Home Force Base

Tehama / Burns & McDonnell / HGL	DATE	FIGURE
	8/4/2021	1

Halls Ferry, Weatherby Springs Had Historical Significance

WATER INFORMATION BULLETIN NO. 4

GROUND-WATER RESOURCE OF THE MOUNTAIN HOME AREA, ELMORE COUNTY, IDAHO

by

Dale R. Ralston Hydrologist
and
Sheri L. Chapman Geologist

Prepared and Published by
Idaho Department of Reclamation
R. Keith Higginson
State Reclamation Engineer

JULY 1968

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

GEOLOGY

AND

WATER RESOURCES

OF THE

SNAKE RIVER PLAINS OF IDAHO

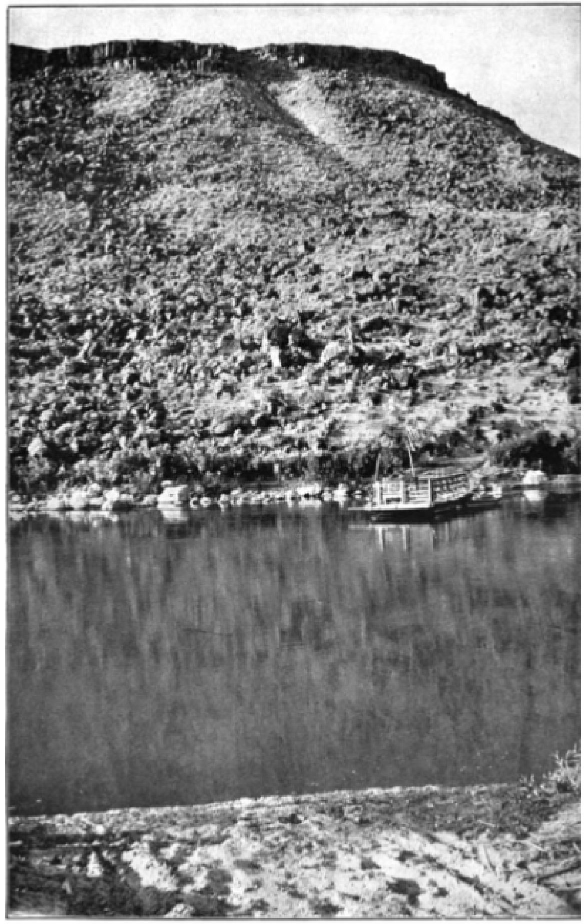
115521

BY

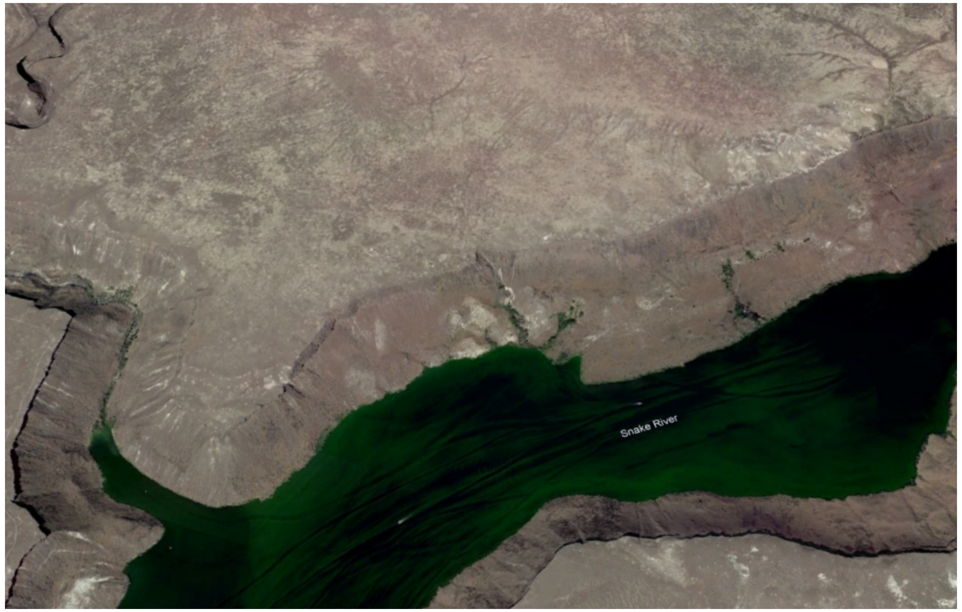
ISRAEL C. RUSSELL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1902

U. S. GEOLOGICAL SURVEY BULLETIN NO. 199 PL. VII



SOUTH WALL OF SNAKE RIVER CANYON, HALLS FERRY, IDAHO.

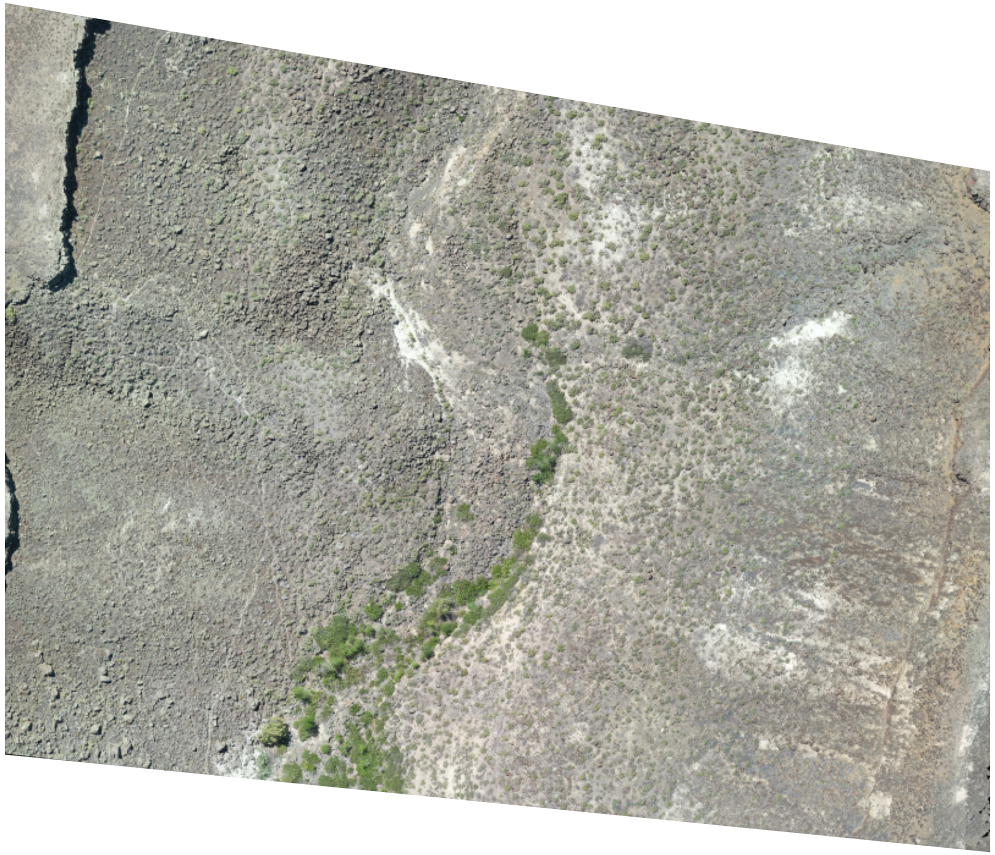


Two large springs occur in the subarea, both in the canyon of the Snake River. Halls Ferry Springs, located in sec. 14, T. 5 S., R. 5 E., approximately 50 feet above the level in C. J. Strike Reservoir, discharge approximately 800 gpm at a temperature of 66° F. A chemical analysis of the spring water is presented in a later section. The springs issue from slope wash along the Snake River

BURNS & McDONNELL

Geologic Field Mapping

Drone imagery and water transport-enabled field mapping



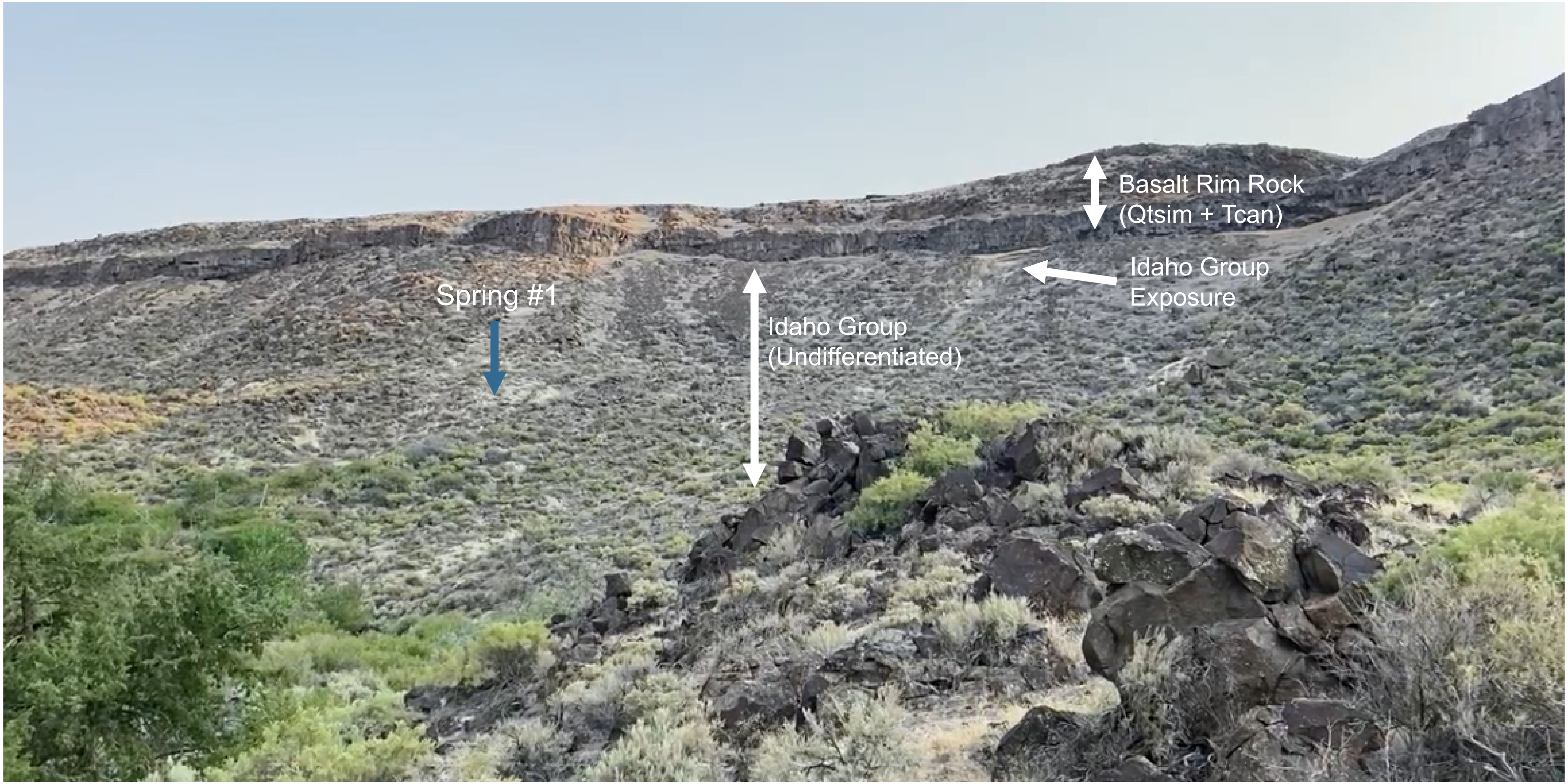


Figure 1-1: Photograph of North wall of Canyon Creek Canyon showing general stratigraphic conditions and Spring #1. Photograph looking WNW, abundant phreatophyte vegetation but no springflow observed

Sand Facies

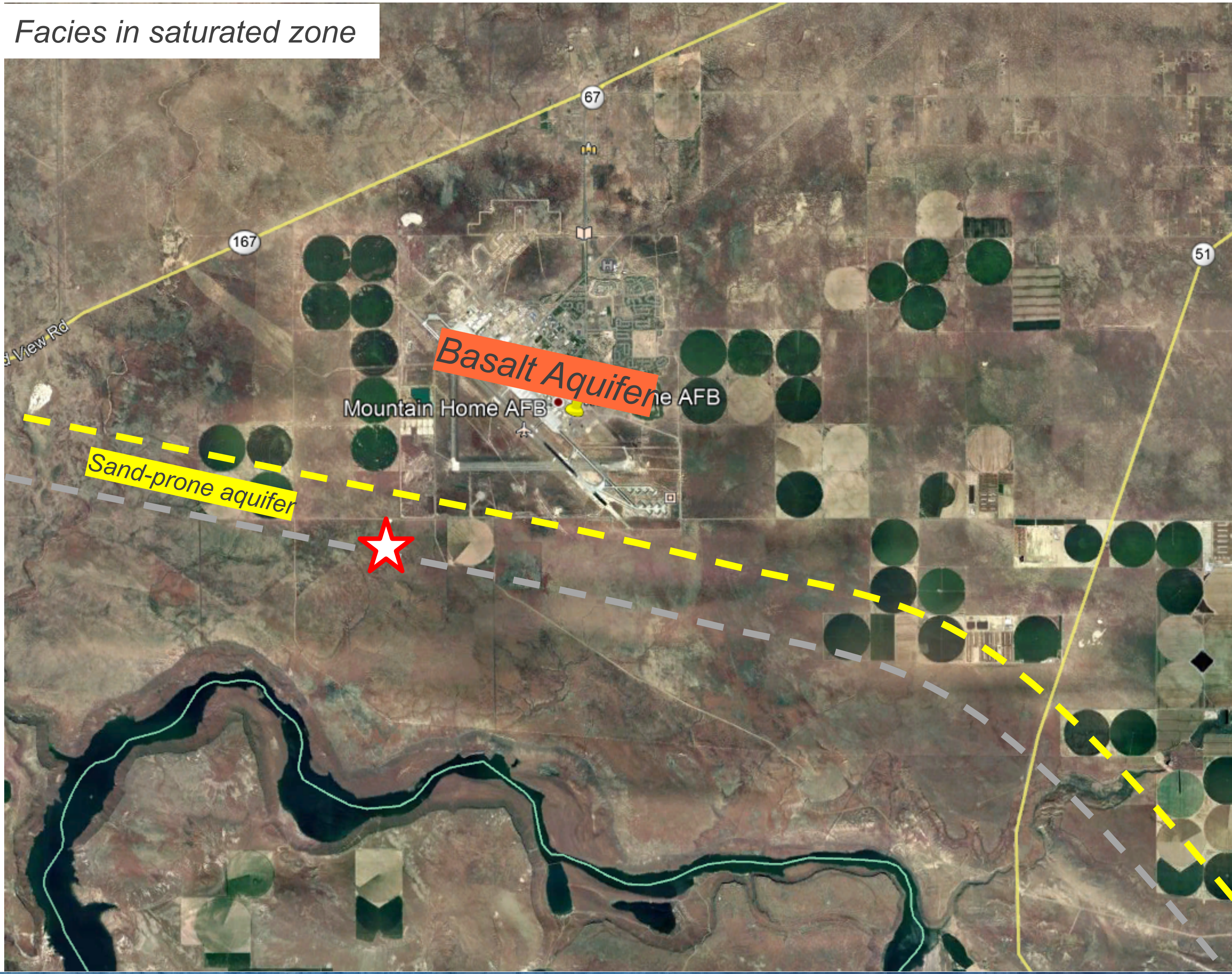
- Sand facies locally exposed in Snake River Canyon wall
- Sedimentologic observations confirm that these sands represent sediment gravity flow deposits (below wave base)

Figure 1-4: Idaho Group Strata exposed directly underneath the basalt cap rock, north wall of Canyon Creek Canyon. See text for description.

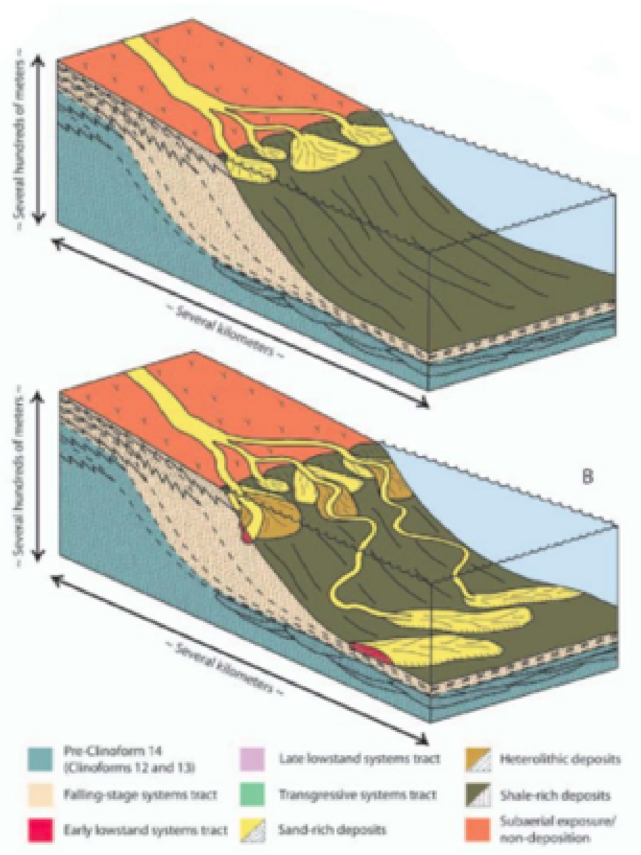
Aquifer Facies

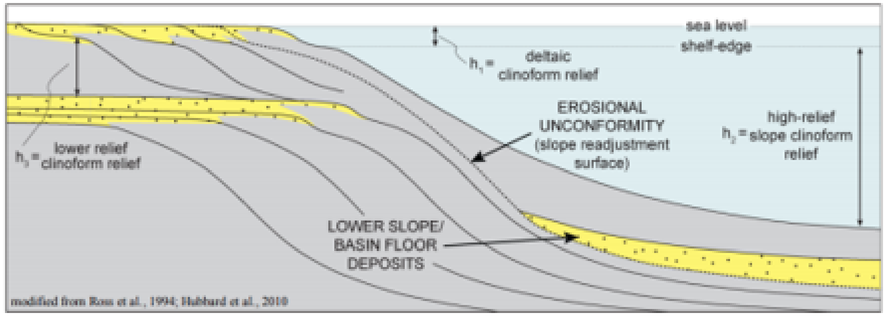
- Basalt aquifer largely replaced by Sand Aquifer in saturated zone at WF Well (star)
- Conspicuous absence of wells south of WF
- Slope and basin facies in Snake River Canyon

Bore Dia. (in)	From (ft)	To (ft)	Remarks, lithology or description of repairs or abandonment, water temp.	Water Y	Water N
16	420	430	White sticky clay		✓
	430	440	Brown Sand - Coarse	✓	
	440	442	White clay		✓
	442	450	Silty Sand	✓	
	450	459	good coarse Sand	✓	
	459	512	White Clay		✓
	512	520	Silty Clay		✓
	520	544	good Coarse Sand	✓	
	544	557	Clay		✓
	557	587	Silty Clay		✓
	587	620	Clay		✓
↓	620	635	Hard brown clay - Caves		✓



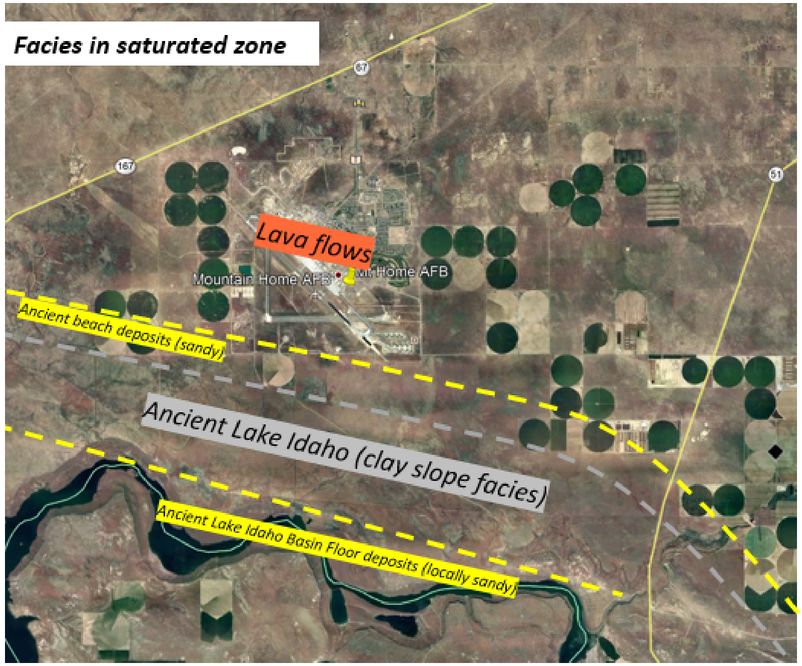
Depositional models for shelf-slope-basin systems application to MHAFB





Schematic cross section of shelf-slope-basin deposits showing preferential accumulation of sands (yellow with stipple) on the shelf and in the deep water areas, separated by a slope succession dominated by fine-grained deposits (gray), from Bower and Hubbard, 2012

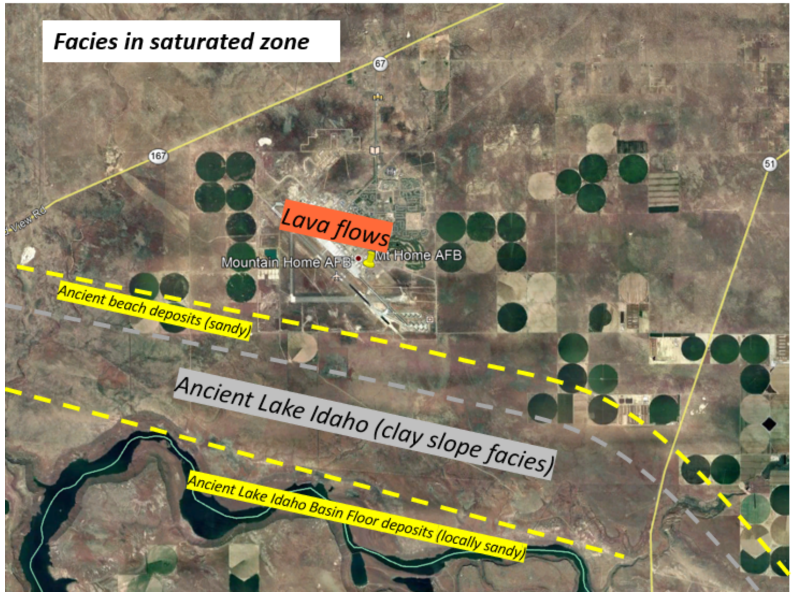
Block Diagrams depicting a delta system advancing into a standing body of water such as an ocean or lake. Sands tend to accumulate in the shallow water environment as deltas shown in top diagram. When the relative water level falls, these deposits are remobilized and the sand is transfered to the deep basin via slope channels and deposited as sublacustrine fan and channel deposits. Sand channels on slope are encased in fine-grained material and provide limited hydraulic connectivity with deltaic sands in the shallow water (Petter and Steele, 2006).

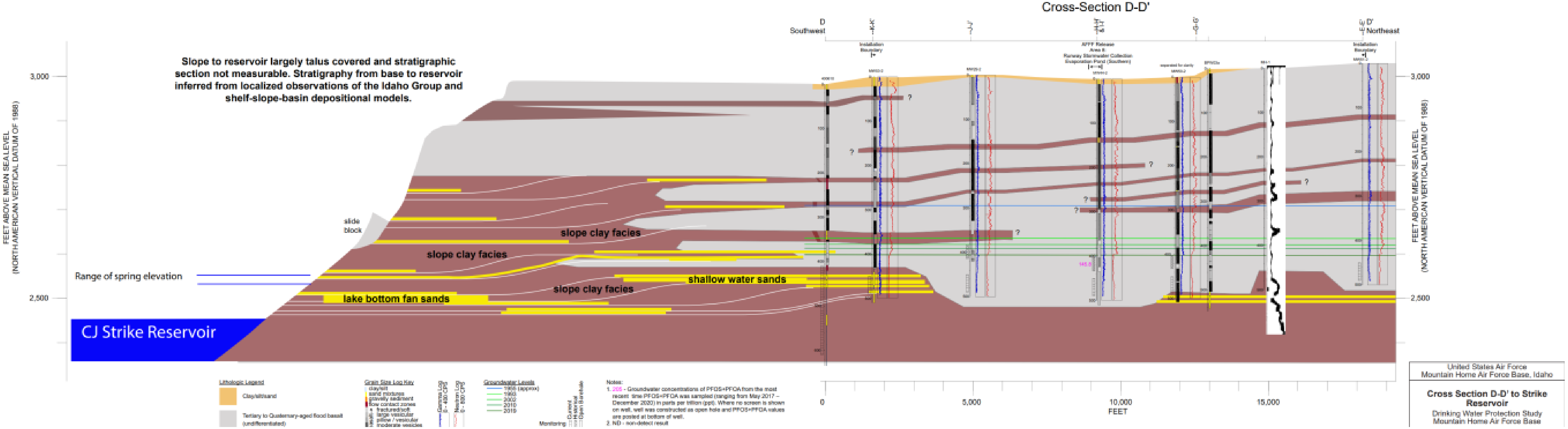


BURNS McDONNELL

Regional Conclusions

- Snake River Canyon wall consists of slope to basin lacustrine facies
- Historic springs issue from sublacustrine channel deposits which are thin and have restricted connectivity with regional groundwater basalt aquifers
- Decline in groundwater levels (100’ since 1950) reduced hydrostratic head and flow to springs greatly reduced or eliminated flow
- Slope facies resist groundwater flow, form a barrier to groundwater flow and lead to extremely flat potentiometric surface at MHAFB

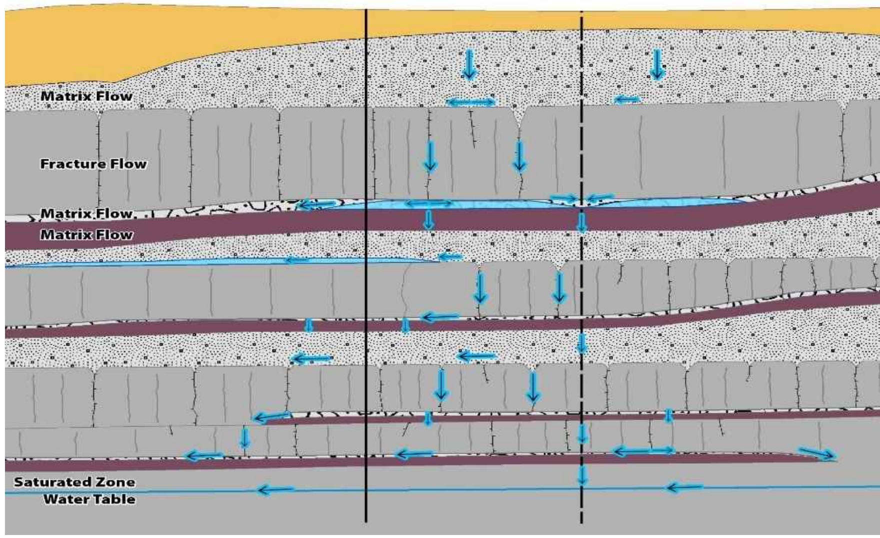


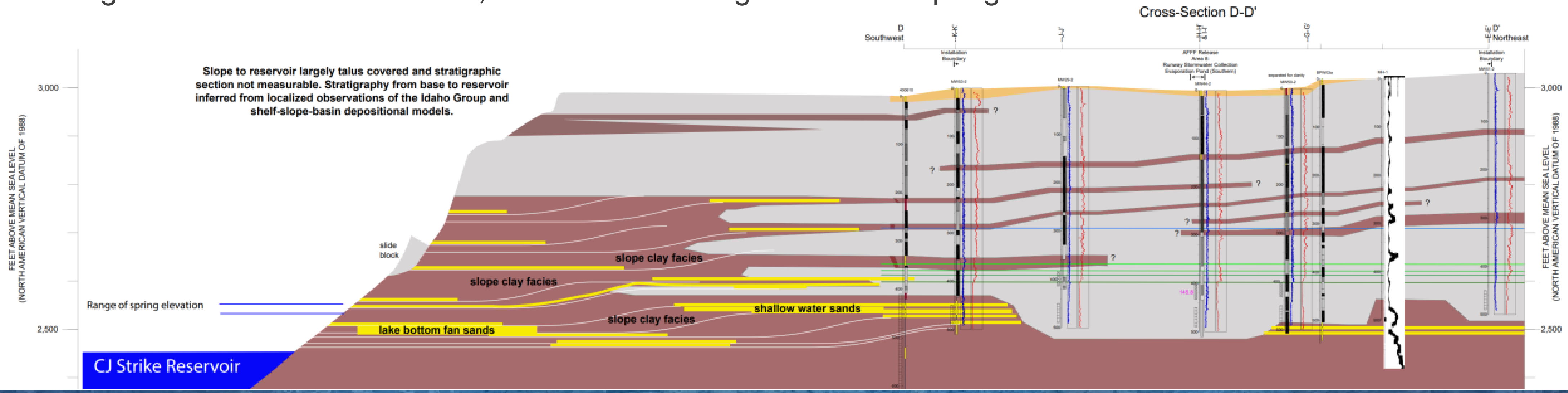


New Groundwater Flow CSM

Key Takeaways:

- Gamma and Neutron logging of existing MWs through casing is effective to identify basalt interbeds and perched groundwater
- Analogue and field observations indicate that GW moves vertically through the matrix and that GW moves rapidly downward (in months, not decades), strongly suggests no large reservoir of mass in perched zones
- Geologic field observations, depositional models enable a conceptual model with a facies change from MHAFB to the Snake River
- Facies change combined with lowered regional GW levels lead to stagnant GW in center of Base, little to no discharge at historic springs





THANK YOU