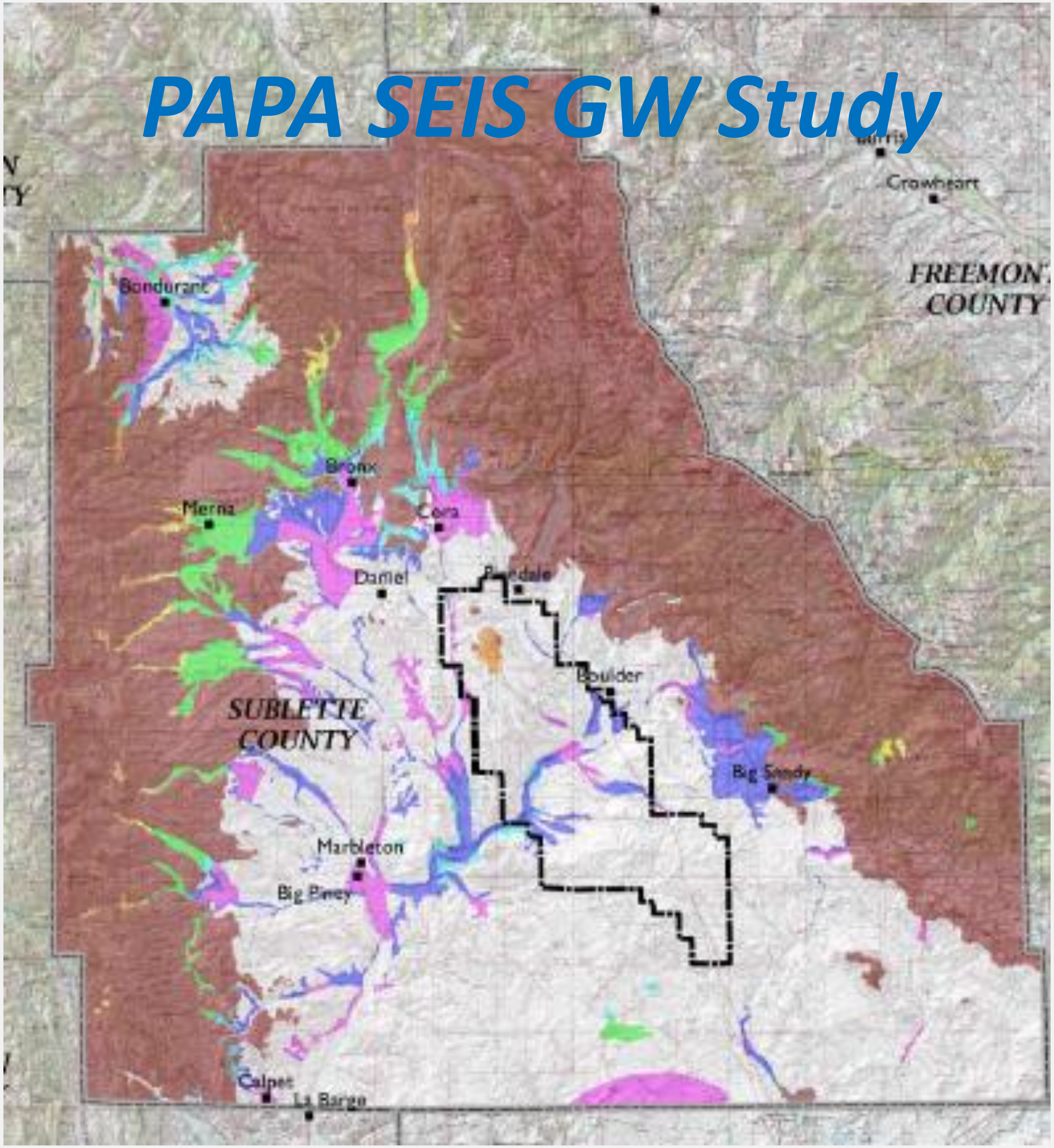
PAPA SEIS GW Study



http://www.blm.gov/wy/st/en/field_offices/Pinedale/anticline/resources/water.html

Implementation: ROD Section 4.0

SEIS ROD Section 4.2 Groundwater Resources

The BLM, in coordination with the WDEQ, EPA and the Operators, to develop both an Interim and Final Groundwater/Aquifer Prevention, Mitigation and Monitoring plan and funding strategy in accordance with the BLM's Regional Framework for Water Resources Monitoring Related to Energy Exploration and Development.

- ROD specifies that we complete the following tasks:
  - Characterization of the Groundwater Resources
  - Identify and develop mitigation for potential sources of groundwater contamination
  - Modification of the existing Groundwater monitoring system.

SEIS Programmatic Mitigation

- Interim Groundwater/Aquifer Pollution Prevention, Monitoring and Mitigation Plan within 3 months of ROD signature.
  - BLM, DEQ, EPA
  - Completed on December, 2008
    - Requires a number of Plans of Study be developed and implemented
- Final Groundwater/Aquifer Pollution Prevention, Monitoring and Mitigation Plan within 6 months of Interim Plan completion.
  - BLM, DEQ, EPA, SEO, WOGCC
  - Expected completion date 11/2011

Interim Plan: Plans of Study

- Data Gaps
  - Aquifer Characterization
  - Hydrostratigraphic Unit Definition and Communication
  - Surface/Groundwater Interaction
- Low Level Hydrocarbon Study
  - Source Assessment/Rainbow Matrix
  - Biogenic vs. Thermogenic Origin of Headspace Gas
- Standard Operating Procedures Evaluation
- Vulnerability/Risk Assessment
- Mitigation Identification

Study Wells for Aquifer Characterization

- Network Assessment
- Credibility Determination

- Well Permitting and Installation
  - Combination of Private, State and BLM
  - 30 Piezometers
  - 30 Study Wells (30’ to 800’)
    - 4 on private land
    - 10 on native range
    - 16 on existing disturbance
  - Unable to secure permission for one site on Green River

BLM
Pinedale Field Office

BLM

Pinedale Field Office

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Hydrogeologic Data Gaps

The BDE and Operators approved the POS in May 2009. The POS was developed to guide collecting and analyzing the additional field data to complete the following eight tasks:

- Task 1 – Establish contemporaneous water elevation data.
- Task 2 – Determine gain-loss characteristics of New Fork River.
- Task 3 – Evaluation surface water / groundwater interconnection.
- Task 4 – Determine hydraulic properties for each hydrostratigraphic unit (Alluvial, Shallow Wasatch and Regional Wasatch).
- Task 5 – Establish Data Collection System needed to generate hydrographs.
- Task 6 – Characterize Mesa, Antelope, and Paradise springs.
- Task 7 – Investigate hydraulic connection between each HSU.
- Task 8 – Revise hydrogeologic conceptual model.

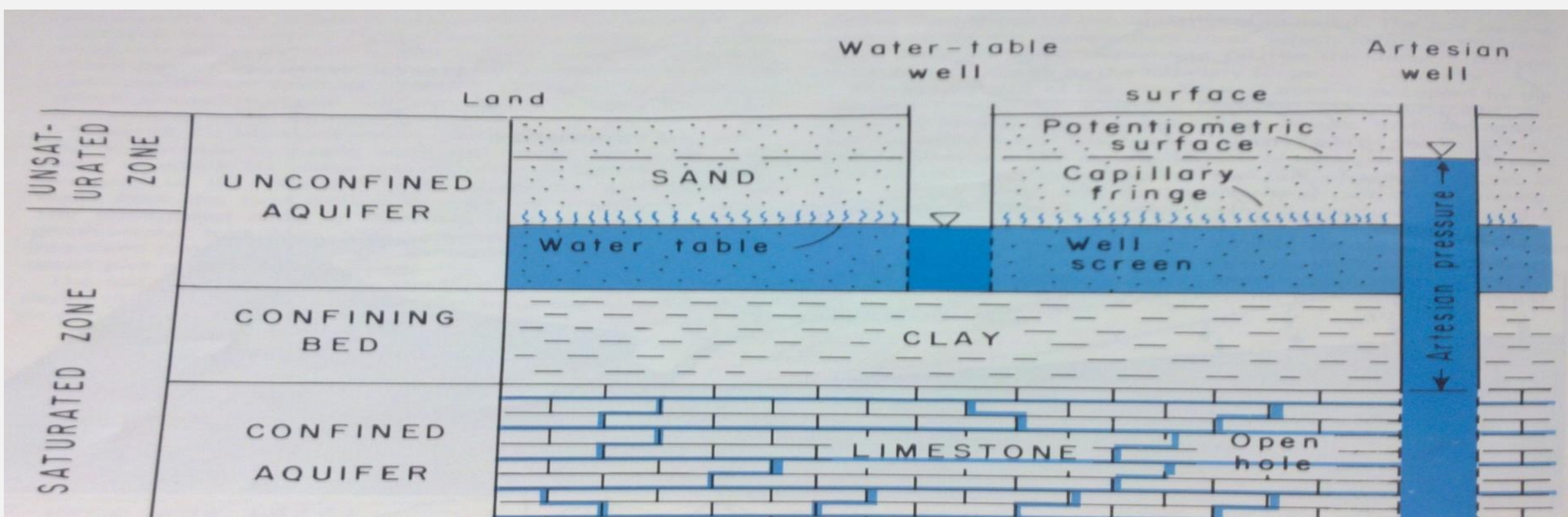
Investigative work commenced in October 2009 and concluded in June 2011. Besides obtaining groundwater data (i.e. water elevations, water quality data, and aquifer testing data), synoptic flow studies and surface water quality analysis in the New Fork River were completed, and two springs in the PAPA were characterized.

Aquifer vs. Hydrostratigraphic Unit (HSU)

A unit of rock or an unconsolidated deposit is called an **aquifer** when it can yield a usable quantity of water.

A **Hydrostratigraphic Unit** is generally defined by its flow conditions (transmissivity, storage, etc.) so that an Aquifer may contain 1 or more HSUs

- HSU analysis integrates chemical, hydraulic, geologic, and geophysical data to produce a comprehensive three-dimensional model of the subsurface based on fluid flow characteristics.
- Fluid flow pathways are requirements for impact characterization and remediation activities.



BLM
Pinedale Field Office

HSU Utility

HSU assists decision making in:

1. **Locating and designing** characterization boreholes and monitor wells,
2. **Prioritizing** the construction and phased startup of remediation systems,
3. **Managing** extraction of subsurface contaminants,
4. **Finding** sources of past contaminant releases,
5. **Tracking** the migration of subsurface contaminants,
6. **Evaluating** the subsurface effectiveness of the remediation systems.

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Initial Determinations

1) Initial results indicate that it may take groundwater 100 days to travel in alluvium the same distance that it would take 10 years in a sandstone unit of the Wasatch Formation.
2) Of the total flow in the New Fork River, approximately 42% is attributed to groundwater discharge during baseflow. Based on groundwater balance calculations, about 90% of groundwater flux (underflow) into the PAPA eventually discharges to surface water in the study area.

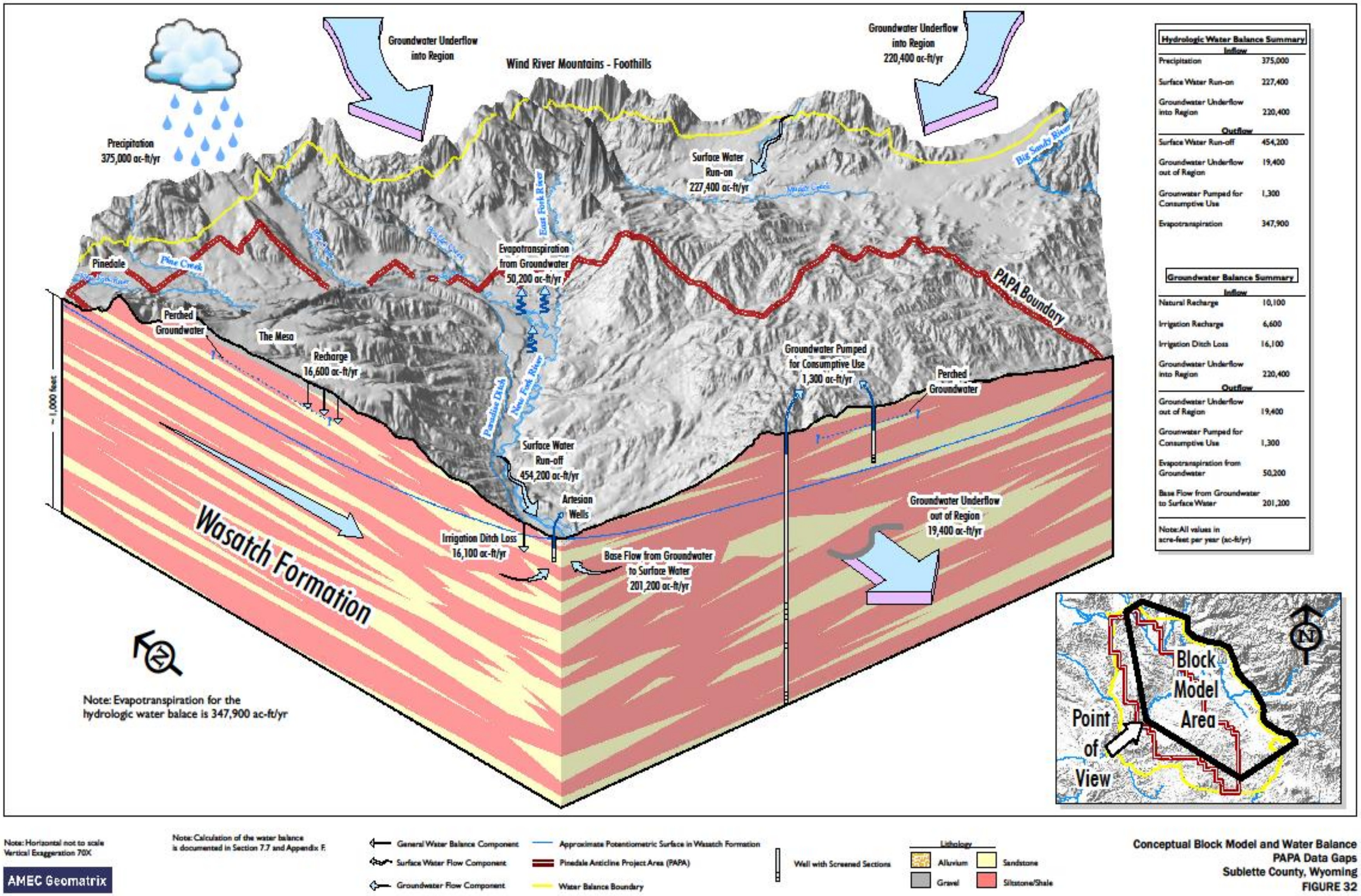
Well Type*	Total Number of Wells	HSU					
		Alluvial		Shallow Wasatch		Regional Wasatch	
		Total Number	Avg. Depth (feet)	Total Number	Avg. Depth (feet)	Total Number	Avg. Depth (feet)
Domestic	81	6	77	0	--	75	118
Stock	26	0	--	14	219	12	172
Industrial	156	0	--	2	189	154	651
Study	30	4**	40	6	185	18	422

* Well type designated by SCCD with exception of the Interim Plan Study wells.
** Study wells T-2a-G and T-2b-G are completed in unsaturated gravel on the Mesa.

HSU	Average Hydraulic Conductivity (Kh, ft/day)	Effective Porosity (n_e)	Average Gradient (dh/dl, ft/ft)	Average Velocity (ft/day)	Average Velocity (ft/decade)
Alluvium	446	0.28	0.0014	2.23	8,140
Wasatch Fm.*	2.7	0.27	0.0070	0.07	256

*estimate for saturated sandstone units within either the Shallow or Regional Wasatch HSUs.

GW budget



Pine

BLM

Modeling

2008 PAPA Conceptual model: Used to identify Data Gaps for the Aquifer Characterization requirement

- is the synthesis of existing data into a graphical representation of the hydrogeologic system that explains the current understanding of the flow system.
- currently being updated based on hydrogeologic data gaps investigation
- Draft Report received in December 2011; comments being incorporated and finalized

A mathematical model simulates groundwater flow indirectly using equations that represent physical flow processes. Mathematical models fall into two categories: analytical and numerical.

- Analytical models are useful for addressing simple problems, like the velocity of groundwater in a homogeneous, isotropic aquifer.

Numerical Model

Operators proffered to complete a numerical model in March 2011

- Numerical models are best suited to simulate groundwater flow and contaminant transport in complex geological environments.
- Purpose is to provide a tool that will support the water resources monitoring plan being developed for the PAPA.
- The model has been calibrated to site-specific data to demonstrate the model's ability to accurately simulate groundwater flow.
- The model will then be used to evaluate the fate and transport of potential contaminants and to help determine the most appropriate monitoring locations for resulting water resources monitoring program.

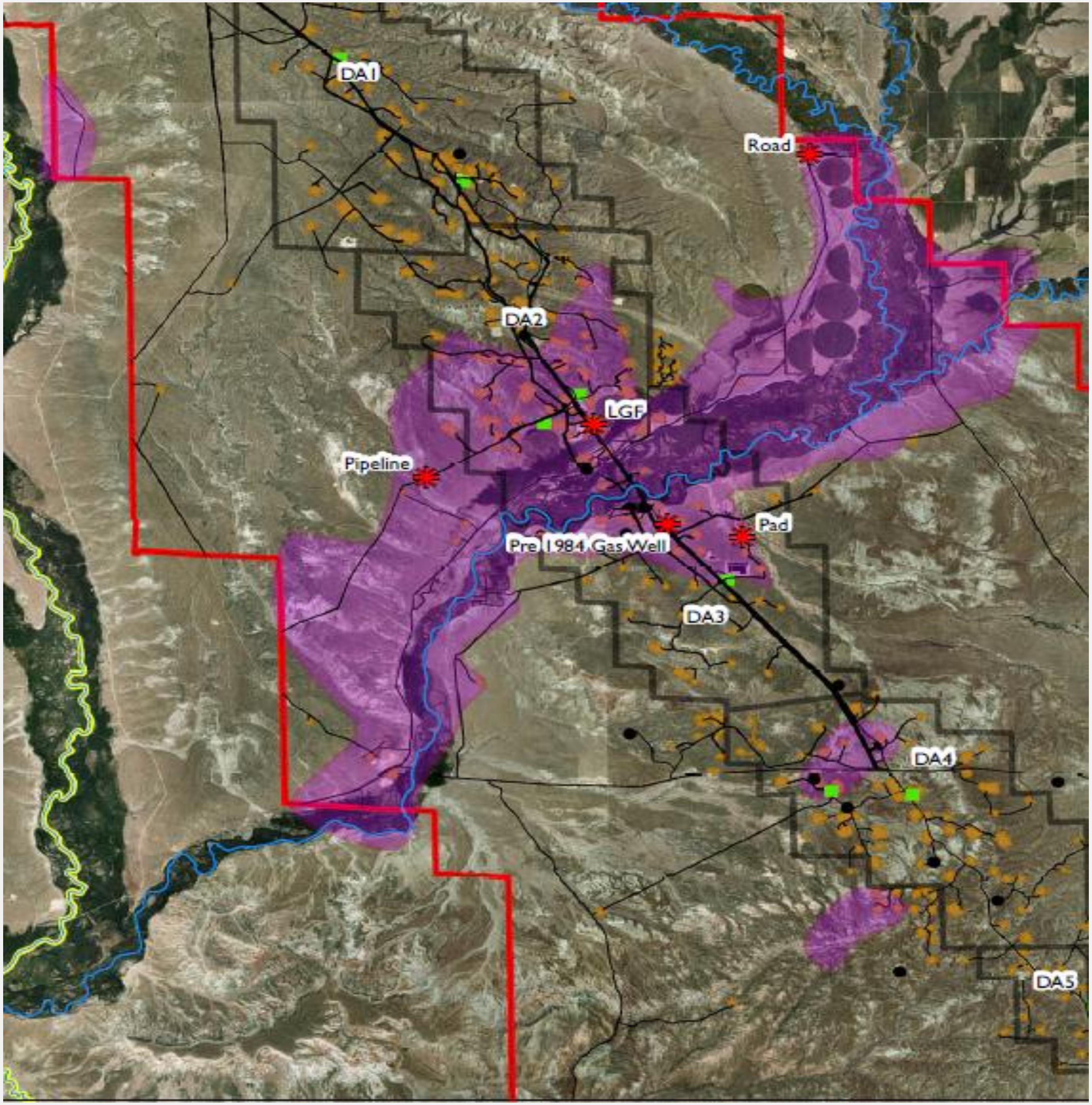
Solute and Particle Tracking

Reverse particle tracking

- Used to identify if specific existing receptors are at risk of contamination from potential source areas. Particles will be run in reverse for a specified period to determine the portion of the aquifer contributing water to the receptor.

Solute Transport Modeling

- Used to assess potential impacts to the aquifer and potential receptors from releases. Transport of volatile organic compounds such as benzene, toluene, ethylbenzene and xylenes from hypothetical sources or source areas will be simulated.
- Solute transport simulations will be run for a specified period of time for at least one hypothetical source in each of several selected development areas or zones.
- Simulation will result in plume maps and visualizations and those portions of the aquifer predicted to be affected by hypothetical releases will be considered in selection of monitoring locations.
- The model will also be used to estimate transport times for selected compounds that ay reach the aquifer in hypothetical groundwater contamination scenarios. Time series plots will be developed from predictive runs showing the rate of movement through different portions of the aquifer.



BLM

Pinedale Field Office

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Final Groundwater/Aquifer Plan

Will incorporate results of the:

- Final Data Gaps report (2/12)
- Numerical Model Transport scenario's (2/12)
- Operators SOP analysis (Current practices identified)
- Low Level Hydrocarbon Detection Investigation (4/12)
  - Operators are choosing to have this document peer-reviewed prior to submittal to the agency for review.

Final Plan will recommend for Agency consideration:

- Monitoring Network Design w/ proposed Sampling and Analysis Plan
  - How, where, when, what
  - Industrial, Stock and Domestic well Monitoring Schedule
  - Triggers for action
  - Response plan
- Mitigation Measures Identified for Implementation

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Future tasks

- Current Considerations include:
  - Goals and Purpose of the monitoring program
  - Any new Data Gaps identified?
  - Mitigation Implementation
    - Schedule, Authority
- Monitoring Program Implementation
  - Program Roll-out
  - Network Access
  - Sampling contractor
  - Reporting
    - How
    - When
    - Who

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

What have we learned?

1. Identified area's most susceptible to contamination
2. Project is significantly over budget; Operators continue to fund
3. Saturated soil conditions in spring 2009 and 2010 inhibited well access for sampling/aquifer testing
4. Negotiating access took longer than expected
5. Water and cuttings disposal was very expensive and unaccounted for in the ROD budget.
6. Numerical model has added significant time to the project
7. MOU will likely be developed for future monitoring to explicitly define roles, responsibilities, and funding procedures.

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT