

# Oil & Natural Gas Technology

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## Quarterly Report

April 2011 - June 2011

### Water-related Issues Affecting Conventional Oil and Gas Recovery and Potential Oil-Shale Development in the Uinta Basin, Utah



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**TABLE OF CONTENTS**

Executive Summary ..... 1  
Progress, Results, and Discussion..... 1  
Conclusion ..... 7  
Cost Status ..... 7  
Milestone Status..... 9  
Accomplishments..... 9  
Problems or Delays..... 9  
Products and Technology Transfer Activities..... 9

**LIST OF FIGURES**

Figure 1: Location of wells in the Uinta Basin with available water chemistry data and wells analyzed for the BMSA..... 2  
Figure 2 Areal extent of the Birds Nest aquifer ..... 4  
Figure 3: Isopach of the lower Birds Nest aquifer zone..... 5  
Figure 4: Isopach of the upper Birds Nest aquifer zone..... 5  
Figure 5: Isopach of the interburden between the base of the lower Birds Nest aquifer and Big Three oil shale beds..... 6  
Figure 6: Isopach of the interburden between the base of the lower Birds Nest aquifer and Mahogany oil shale zone..... 6  
Figure 7: Project costing profile ..... 8  
Figure 8: Project cumulative costs ..... 8

**LIST OF TABLES**

Table 1: Project costing profile for Budget Period 3 (third quarter)..... 7  
Table 2: Milestone log for Budget Period 3..... 9

## **EXECUTIVE SUMMARY**

Various data collection activities for all areas of the Utah Geological Survey's (UGS) Uinta Basin water project are nearly complete. The focus has now shifted towards synthesizing all the collected data, creating a wide variety of maps and figures, and forming preliminary conclusions. A one quarter no-cost extension has been requested to allow for additional time to address all the project's goals.

A new, preliminary map of the base of the moderately saline aquifer has been created. The focus of the Task 2 team will now be to reconcile the over 2600 water chemistry analyses collected throughout the basin with the preliminary map and make appropriate changes to resolve data conflicts.

The Task 3 team has analyzed the Birds Nest zone in over 250 wells and has mapped the aquifer's areal extent and thickness in central Uintah County. These maps will greatly aid in determining potential Birds Nest aquifer saline water disposal areas. The Principal Investigator (PI) has also finished examining core containing the Birds Nest zone, which provides crucial ground truth to interpret the geophysical logs from wells lacking core. During the next quarter, the team plans to continue refining the preliminary maps by looking at additional wells, especially in the northwest, and additional outcrop areas.

The Task 4 team has nearly completed all water sampling and is awaiting results from the final round of water chemistry analyses. Within the next few months, the team will begin synthesizing the data and formulating final conclusions.

## **PROGRESS, RESULTS, AND DISCUSSION**

### **Task 1.0: Project Management Plan**

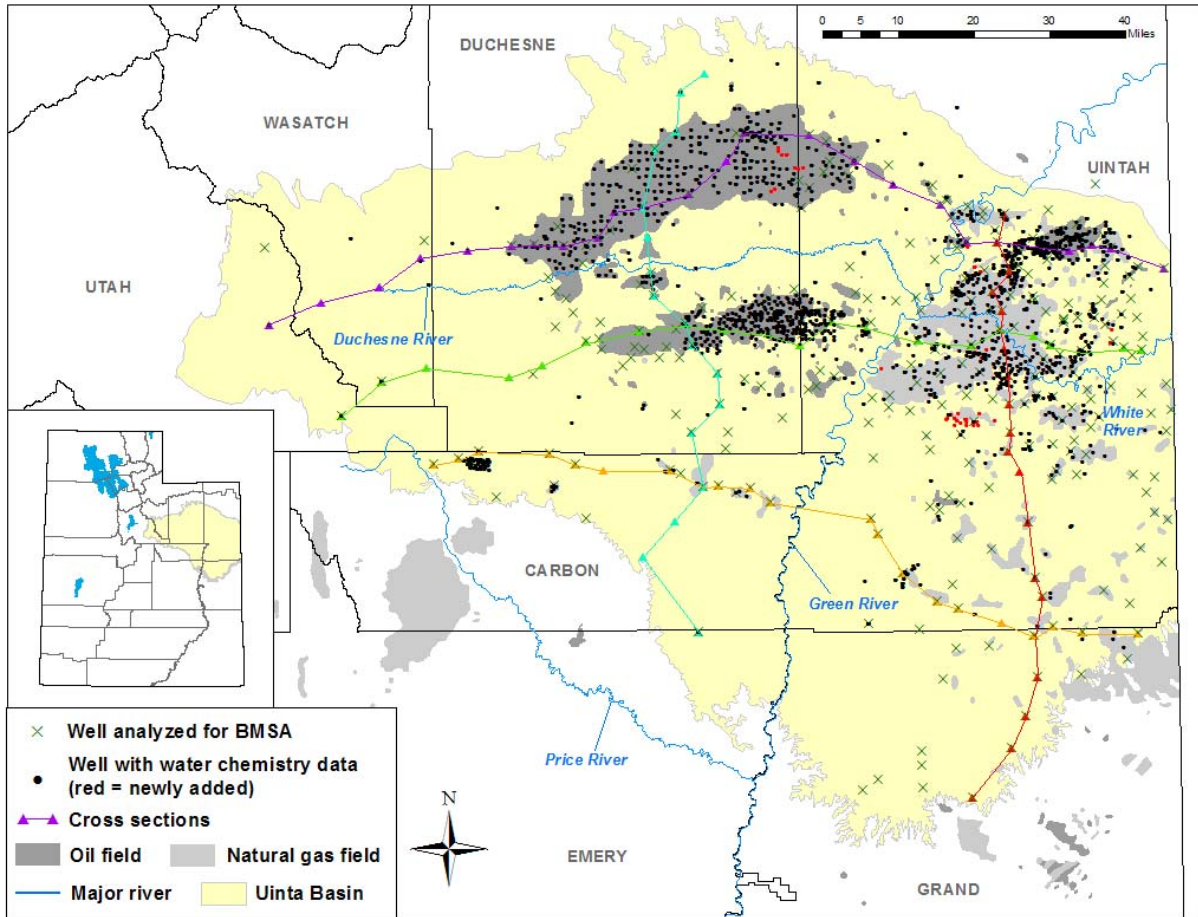
During the month of April, the PI wrote and submitted the project's tenth quarterly report for the period January through March 2011. This report was subsequently sent via email to all interested parties and posted on the UGS project website.

### **Task 2.0: Moderately Saline Aquifer Study**

Even as the project begins to wind down, water chemistry analyses keep trickling in from several sources. Through June 2011, the Task 2 team has collected 2609 individual water analyses from 1441 different wells (figure 1). This information has been collected from a variety of sources including oil and gas operators or service companies (783 analyses); Utah Division of Oil, Gas, and Mining (DOGGM) well files (404 analyses); UGS databases (1251 analyses); U.S. Geological Survey databases (103 analyses); and other publications (68 analyses). An Access database has been populated with all the incoming data, facilitating its manipulation and retrieval. The database will continue to be updated as new data are acquired from operators or generated by project researchers.

A significant Task 2 milestone was reached in May; the Task 2 team leader created the first draft of the new base of the moderately saline aquifer (BMSA) map using the interpretations made from geophysical logs from 259 selected wells (figure 1). Current work now focuses on comparing the preliminary map to the collected water chemistry data, reconciling conflicts between the two datasets. The Task 2 team leader has also consulted with several operators to verify that the BMSA mapping conforms to observations in their specific field areas.

In order to add a third dimension to the mapping effort, five regional cross sections, two north-south sections and three east-west sections, were constructed (figure 1). When finished, these cross sections will highlight the general geology, water-bearing formations, formations that act as seals, and the level of the BMSA.



*Figure 1. Location of wells in the Uinta Basin with available water chemistry data and wells analyzed for the BMSA.*

### **Task 3.0: Geologic Examination of the Birds Nest Aquifer**

Over the past two quarters, the Task 3 team evaluated geophysical logs from ~250 wells in order to map the areal extent of the Birds Nest aquifer with potential for large-scale saline water disposal. This oval-shaped area, representing the depocenter of Eocene Lake Uinta, is defined by the presence of large saline mineral nodules and thin beds recorded on geophysical logs as spikes to low density in two distinct zones (figure 2).

As ancient Lake Uinta began to recede, its waters became hyper-saline, depositing large saline nodules and thin saline mineral beds, 20 to 120 feet thick, forming the more extensive and thicker lower Birds Nest zone (figure 3). An influx of fresh water, represented by volcanoclastic debris flows recorded in rocks on the east side of the basin (Horsebench Sandstone), decreased the lake’s salinity for a period of time, greatly reducing saline mineral deposition. However, as the lake continued to shrink, it once again returned to its hyper-saline state, depositing a less extensive upper Birds Nest zone centered farther to the west than the lower zone (figure 4).

The northwestern extent of the upper and lower Birds Nest zones, as defined by the presence of large saline nodules, is poorly defined due to lack of wells and appropriate geophysical logs in the area (figures 3 and 4). During the next quarter, the Task 3 team will conduct an additional search for wells, focusing on this northwestern transition zone.

The Task 3 team also created an isopach map showing the thickness of the “interburden” between the base of the lower Birds Nest aquifer and the top of the economic oil shale deposits, picked at the top of the Big 3 oil shale beds (figure 5). There is concern that large volumes of water disposed within the Birds Nest zone could impact future potential oil shale development. The thicker the interburden, which is made up of impermeable lean oil shale, the less likely water could travel vertically down to the rich oil shale beds. However, fractures and possibly gilsonite veins could act as vertical conduits for water flow between these two otherwise hydraulically-isolated zones. Current oil shale development is concentrated close to the oil shale outcrop areas, southeast and up-dip of current Birds Nest water disposal. However, future underground mining or in-situ oil shale development could be located closer to the basin’s paleo-depocenter, near current disposal activities. An isopach of the interburden between the base of the lower Birds Nest zone and the Mahogany oil shale zone shows a thickening of sediments from near the outcrop in the southeast (~220 ft thick) to deeper in the basin in the northwest (~460 ft thick) (figure 6).

#### **Task 4.0: Baseline Water Quality and Quantity GIS Database**

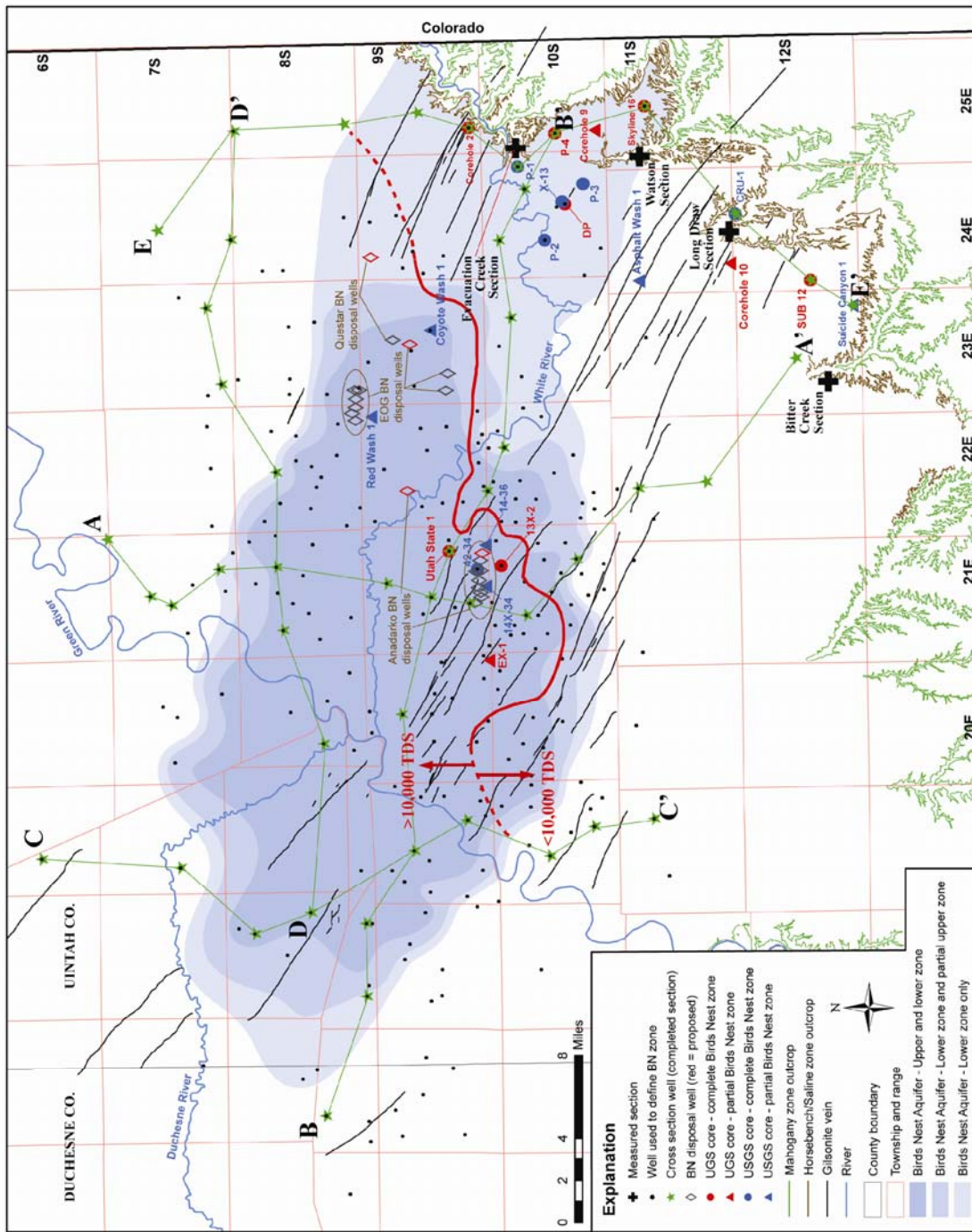
The Task 4 team leader collected the final round of water samples from 14 of the previously sampled sites. Due to severe flooding in the area that closed several roads, the remaining sites will be sampled in July.

#### **Task 5.0: Integration of Analysis of Produced Water from Simulated In-situ Oil Shale Extraction Technologies**

As stated in the previous quarterly report, researchers in the Department of Chemical Engineering at the University of Utah have completed laboratory experiments simulating in-situ oil shale extraction with two overall objectives in mind: (1) determine the presence and species of dissolved organics in the water phase post-pyrolysis, and (2) determine the effect of the presence of water on retorting and its products. A detailed report/paper is currently being prepared by Dr. Milind Deo and his graduate students.

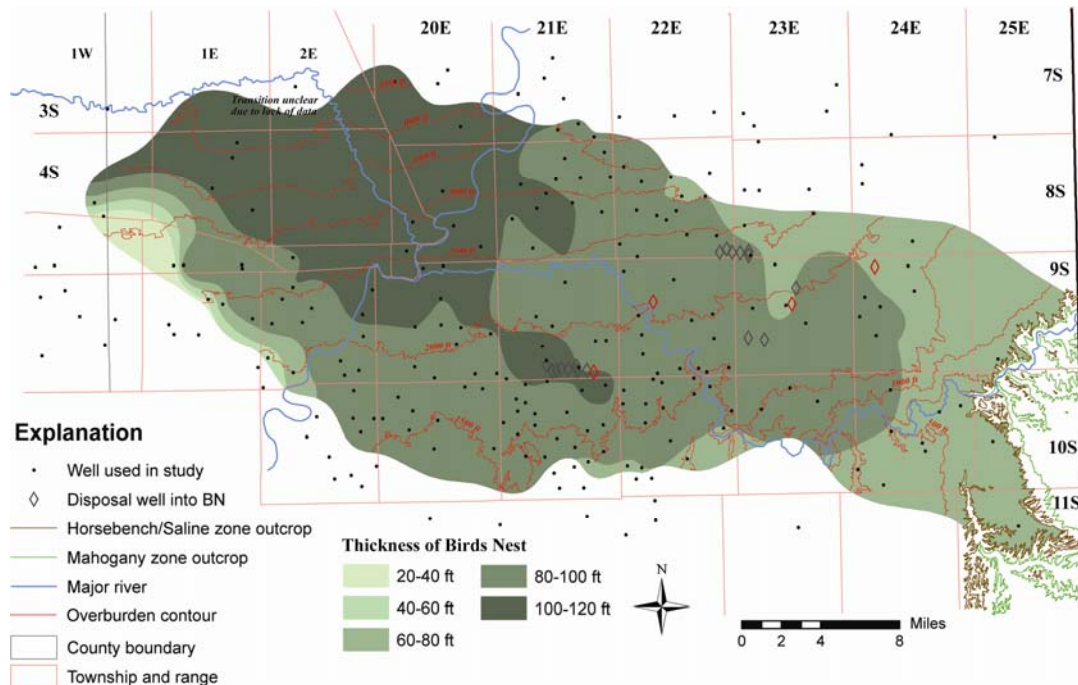
#### **Task 6.0: Technology Transfer**

- The PI presented a poster at the 2011 American Association of Petroleum Geologists (AAPG) Annual meeting held in Houston, TX, on April 11, 2011. The poster detailed the progress made to-date on each part of the project and included a display of core from the Birds Nest aquifer.
- The PI presented a poster at the 2011 AAPG - Rocky Mountain Section (RMS) meeting held in Cheyenne, WY, on June 27, 2011. The poster presentation focused on the Birds Nest aquifer portion of the study and featured two cores from the Birds Nest zone, one displaying saline mineral dissolution and a second showing no dissolution.
- The Task 4 team leader presented at the Geological Society of America - Rocky Mountain Section (RMS-GSA) meeting held in Logan, UT on May 19, 2011. The presentation focused on the progress and preliminary results of the Uinta Basin seasonal water sampling program.
- The PI led a field trip to the Uinta Basin for the University of Utah’s 2011 Unconventional Fuels Conference, which included a stop at Evacuation Creek to discuss the Birds Nest aquifer and the purpose of this research project.
- The project website ([http://geology.utah.gov/emp/UBwater\\_study](http://geology.utah.gov/emp/UBwater_study)) was updated with new quarterly reports, abstracts, and presentations prepared by project team members.

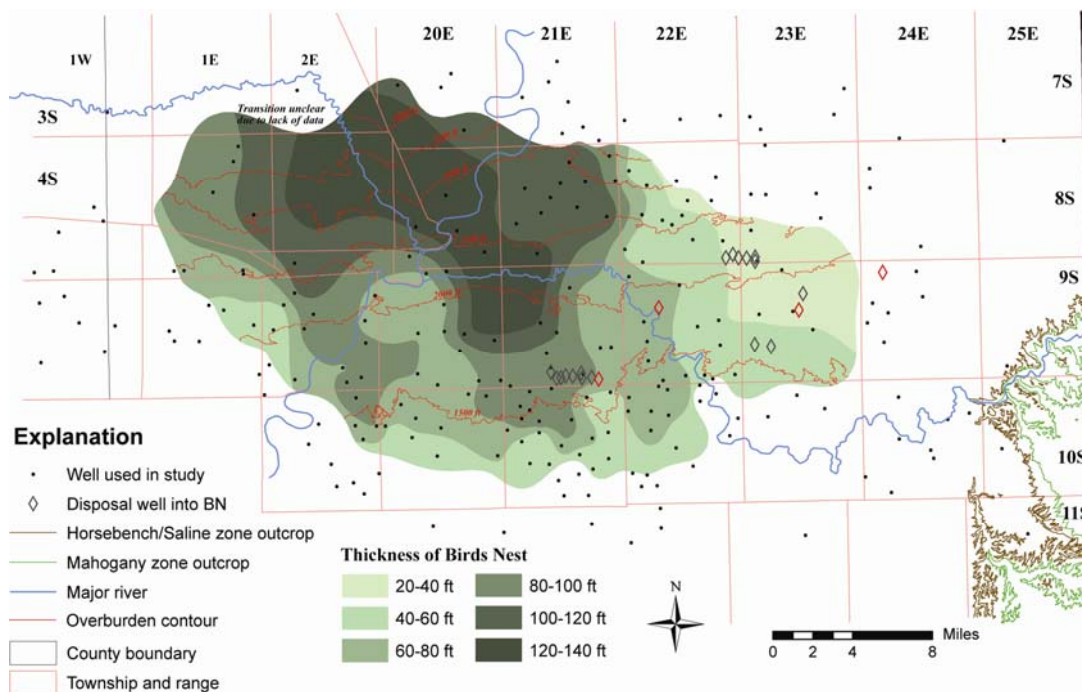


**Figure 2.** Areal extent of the Birds Nest aquifer with potential for saline water disposal (location of large saline nodules or beds) as determined using geophysical logs. Dark blue represents the area where both an upper and lower Birds Nest zone exist, medium blue represents an area with the lower zone but only a partial upper zone, and the lightest blue represents an area where only the lower zone exists. Five cross sections have been constructed to illustrate the aquifer's spatial and stratigraphic extent (A' and B-B' are available on the 2010 AAPG poster, C-C' and D-D' are available on the 2011 AAPG poster, and E-E' are available on the 2011 AAPG-RMS poster).

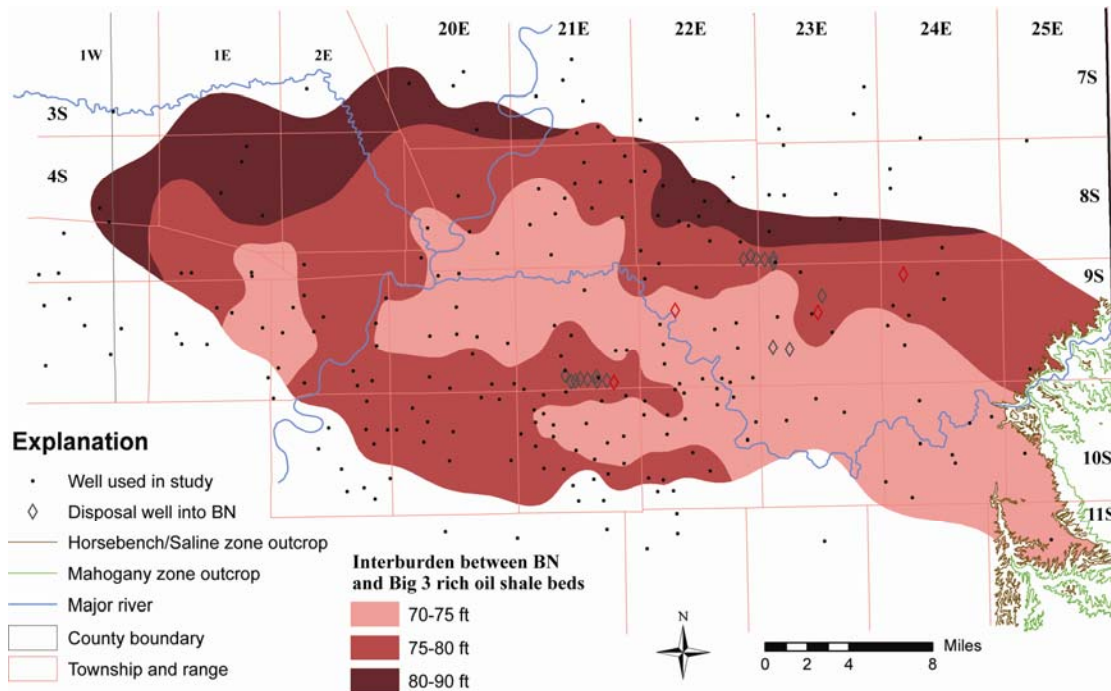




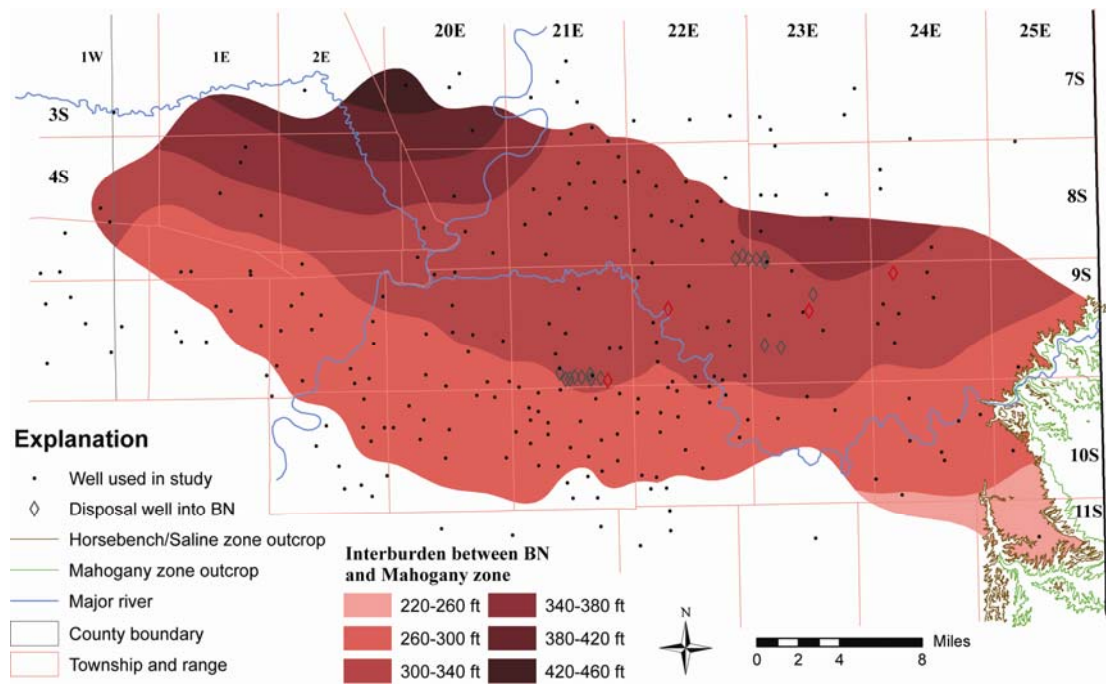
**Figure 3.** Isopach of the lower Birds Nest aquifer zone. This map only records where large saline mineral nodules/beds are present based on geophysical logs and core descriptions; the dissolution of such nodules creates the space for potential large-scale water disposal.



**Figure 4.** Isopach of the upper Birds Nest aquifer zone. This map only records where large saline mineral nodules/beds are present based on geophysical logs and core descriptions; the dissolution of such nodules creates the space for potential large-scale water disposal.



*Figure 5. Isopach of the interburden between the base of the lower Birds Nest aquifer to the top of economic oil shale, picked at the top of the Big 3 oil shale beds.*



*Figure 6. Isopach of the interburden between the base of the lower Birds Nest aquifer to the top of the Mahogany oil shale zone.*



## CONCLUSION

The majority of the data collection and research activities are now finished and the project team has begun to synthesize the data and formulate preliminary conclusions. The Task 2 team has completed a preliminary BMSA map and will spend the next few months refining the contours to match all existing data. The Task 3 team has created many preliminary maps and cross sections and will now focus on finalizing the products and formulating conclusions/recommendations. The Task 4 team is nearly finished with the water sampling and upon receiving the final water chemistry dataset, will start preparing the final report. A requested one quarter no-cost extension will provided additional time to finalize research on all goals of the project.

## COST STATUS

Costs incurred during the past quarter were near or under budget (table 1 and figure 7). An accounting error from the previous quarter was corrected, adding \$3,544 to the total budget (applied in the June 2011 billing month) (table 1). Also, an accounting adjustment was made to account for costs incurred during “month 13” from 2009 and 2010 (month 13 refers to costs incurred that did not appear during the previous fiscal year until after the books were closed). These costs were billed for in spring 2011, but were applied to the June 2009 and June 2010 billing month (see revised versions of figures 7 and 8). After making the above mentioned adjustments, the overall project spending is within 98.3% of the projected budget (figure 8).

**Table 1.** Project costing profile for Budget Period 3 (third quarter).

	Apl 2011		May 2011		Jun 2011	
	Plan	Actual	Plan	Actual	Plan	Actual
UGS-personnel	\$8,612	\$14,438	\$14,674	\$7,713	\$15,850	\$9,194
Travel Expenses <sup>1</sup>	\$3,590	\$1,086	\$1,101		\$3,390	\$1,900
Water Chemistry						
Miscellaneous <sup>2</sup>		\$120		\$1,500		\$54
<b>SUBTOTALS</b>	\$12,202	\$15,643	\$15,775	\$9,214	\$19,240	\$11,148
<b>UGS OVERHEAD (32.40%)</b>	\$3,954	\$5,068	\$5,111	\$2,985	\$6,234	\$3,612
<b>SUBCONTRACTS</b>						
P. Anderson <sup>3</sup>	\$6,777	\$2,320	\$6,777	\$0	\$6,777	\$8,500
Accounting adjustment <sup>4</sup>						(\$3,544)
<b>GRAND TOTALS</b>	\$22,933	\$23,032	\$27,663	\$12,199	\$32,251	\$19,716

<sup>1</sup>April – AAPG Annual meeting in Houston, TX; June –trip to Vernal for water sampling, AAPG-RMS Annual meeting in Cheyenne, WY

<sup>2</sup>April – poster lamination; May – software registration; June – office and field supplies

<sup>3</sup>June billing includes May

<sup>4</sup>Accounting correction

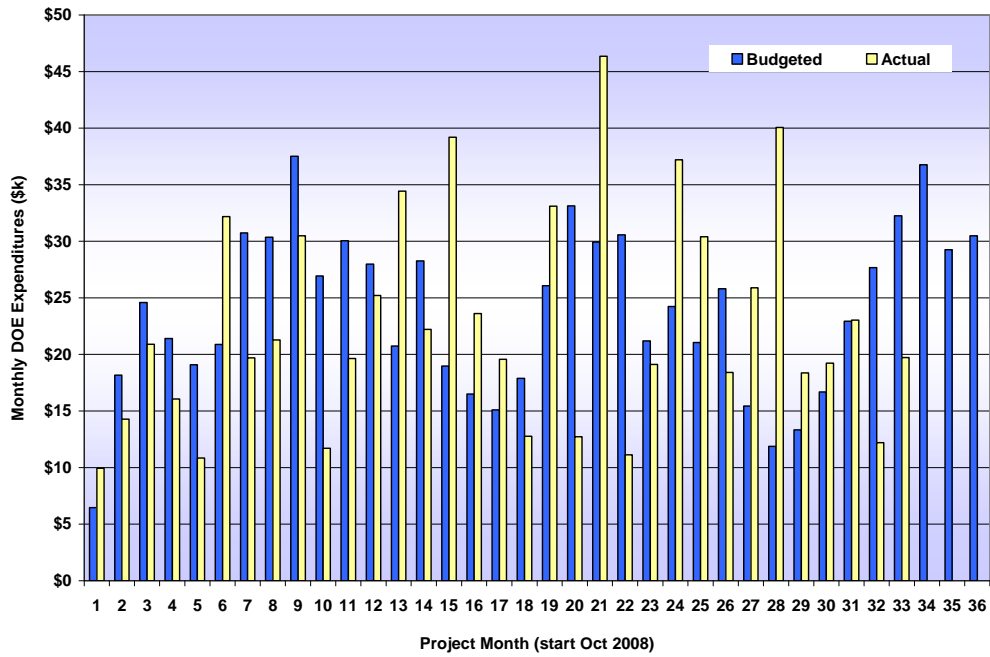


Figure 7. Project costing profile.

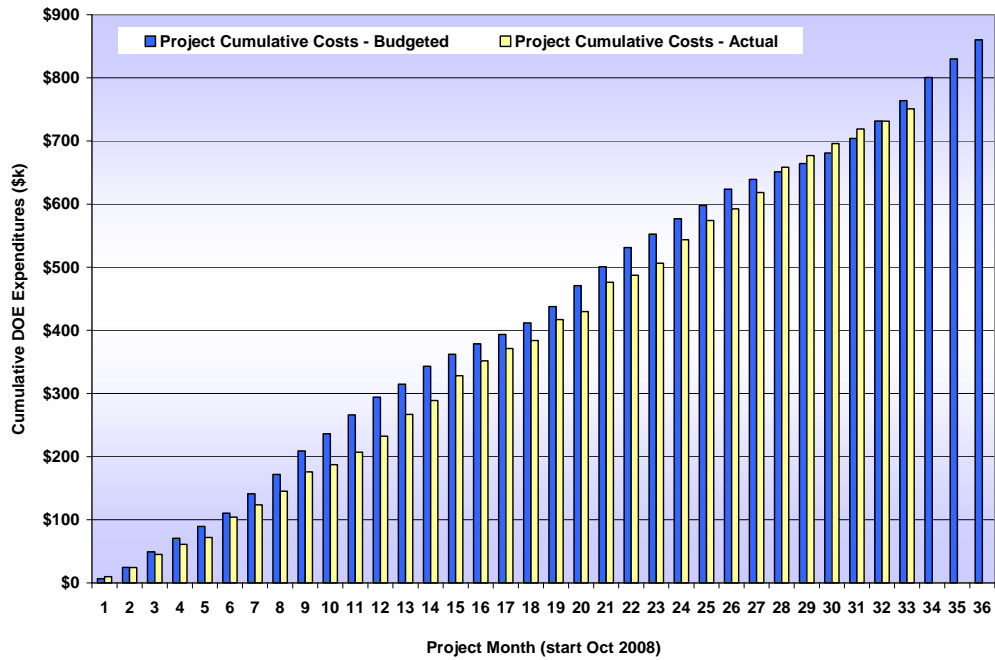


Figure 8. Project cumulative costs.

## MILESTONE STATUS

*Table 2. Milestone log for Budget Period 3.*

	<b>Title</b>	<b>Description</b>	<b>Related task or subtask</b>	<b>Completion Date</b>	<b>Update/comments</b>
Milestone 3.1	Map the base of the moderately saline aquifer	Re-map the base of the moderately saline aquifer, including cross-sections, based on data collected during the previous two years	Subtask 2.2	3/31/2011	Currently have 2609 individual water analyses from 1441 wells; determined the BMSA using geophysical logs in all 259 wells, first draft of map completed
Milestone 3.2	Creation of Birds Nest aquifer maps	Map the thickness, extent, and water chemistry of the Birds Nest aquifer	Subtask 3.5	6/30/2011	Preliminary maps are now completed
Milestone 3.3	Water quality and quantity analysis	Combine all collected water data and combine into a final report	Subtask 4.4	9/30/2011	Final round of water sample collection is completed, awaiting chemistry results
Milestone 3.4	Integration analysis	Model transfer of oil and water to adjacent aquifers and beyond	Task 5	6/30/2011	Researchers at the University of Utah have completed this part of the project and are in the process of preparing a final report

## ACCOMPLISHMENTS

- Presented at the AAPG Annual meeting in Houston, TX, the AAPG-RMS meeting in Cheyenne, WY, and the GSA-RMS meeting in Logan, UT
- Created first draft of the BMSA map
- Completed maps displaying the areal extent, thickness, and overburden of the Birds Nest aquifer

## PROBLEMS OR DELAYS

The PI requested a one quarter no-cost extension to the project. This would push the official project ending date to December 31, 2011. An additional three months will allow more time to review preliminary maps and data and seek input from industry and regulatory agencies, helping the project team to create a more useful final product. The project is currently under budget, leaving sufficient funds for an additional three months.

## PRODUCTS AND TECHNOLOGY TRANSFER ACTIVITIES

- Completed tenth quarterly report
  - January 2011 through March 2011 – available on the UGS project website
- Updated project website
  - Posted various new reports, abstracts, and presentations prepared by project team members
  - [http://geology.utah.gov/emp/UBwater\\_study](http://geology.utah.gov/emp/UBwater_study)

- Poster presentation – AAPG Annual Meeting – Houston, TX – April 10-13, 2011
  - The poster detailed research performed on the Birds Nest aquifer and included a display of Birds Nest zone core
  - The poster is available on the UGS project website
- Oral presentation – GSA-RMS Annual Meeting – Logan, UT – May 18-20, 2011
  - The presentation detailed preliminary results of the seasonal water sampling in the eastern Uinta Basin (Task 4)
  - The presentation is available on the UGS project website
- Poster presentation – AAPG-RMS Annual Meeting – Cheyenne, WY – June 26-29, 2011
  - The poster detailed research performed on the Birds Nest aquifer and included a display of Birds Nest zone core
  - The poster is available on the UGS project website
- The PI led a field trip to the Uinta Basin for the University of Utah’s 2011 Unconventional Fuels Conference, which included a stop at Evacuation Creek to discuss the Birds Nest aquifer and the purpose of this research project
- The PI completed descriptions of 21 cores (of 22) containing the Birds Nest aquifer (the DP core will not be analyzed due to its poor condition and its very close proximity to the X-13 core)
- The PI completed preliminary maps of the areal extent, thickness, and overburden of the Birds Nest aquifer
- The PI completed 5 regional cross sections through the Birds Nest interval

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