Oil & Natural Gas Technology

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Quarterly Report

April 2010 to June 2010

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

Submitted by:
Utah Geological Survey
P.O. Box 146100
Salt Lake City, UT 84114-6100

Principal Investigator: Michael D. Vanden Berg

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United States Department of Energy
National Energy Technology Laboratory

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EXECUTIVE SUMMARY

Time spent on the Utah Geological Survey's (UGS) Uinta Basin water project in the third quarter of Budget Period 2 (April to June 2010) was dominated by presentations made at two national AAPG conferences. A poster presentation at the American Association of Petroleum Geologists (AAPG) Annual Meeting held in New Orleans, LA, in April provided an overall summary of the project and its preliminary accomplishments. A second poster presentation was made at the AAPG Rocky Mountain Section (AAPG-RMS) meeting held in Durango, CO, in June. This poster focused on the preliminary results of Task 3, the geologic characterization of the Birds Nest aquifer. On display with this poster were sections of core from two nearby wells that are separated by a gilsonite vein. The core south of the gilsonite vein displays significant saline mineral dissolution resulting in extensive porosity and permeability for water transmission, while the saline minerals in the core north of the vein are intact and the zone can not transmit water. Both posters are available on the project's Web site.

Water chemistry data acquisition efforts related to Task 2 have for the most part come to an end, with analyses received for approximately 1300 wells. These data will be invaluable as "ground truth" to aid in the mapping of aquifer salinity throughout the basin scheduled to begin in Budget Period 3. In addition, several oil and gas operators have donated digitized log data from over 640 wells. These files will save large amounts of in-house digitizing time and provide the data needed to calculate the base of the moderately saline aquifer.

The UGS determined that the Birds Nest aquifer can be best characterized by studying cores that cover all or part of the interval of interest. Of the 21 cores found, 11 have been studied to date. In May 2010, as part of a separately funded project, the UGS drilled and recovered core from a new well – Skyline 16 – on the basin's eastern margin. This core recovered the ~100 foot saline interval and displayed significant saline mineral dissolution. Outcrop evaluation continued in May 2010 – excellent exposures can be found in the east near Evacuation Creek, but in the southern portion of the basin, the outcrop is highly weathered and is often a slope-former.

During May and June 2010, the Task 4 team leader collected 17 water samples from 13 previously sampled locations and four new sites. All new samples have been submitted to the Utah State Lab for chemical analysis, which should be completed in the next quarter.

Table 1. *Number of donated LAS files by company.*

Company	# of LAS files
Questar	319
Newfield	85
Enduring	75
Anadarko	50
El Paso	20
Bill Barrett	15
Berry	15
EOG	15
Gasco	7
Rosewood	7
Wind River	6
Devon	5
FIML	4
Mustang Fuel	4
Whiting Petroleum	3
Forest	2
Flying J	2
Royale	2
Anschutz	1
Bayless	1
Pendragon	1
BT Operating	1
JW Operating	1
Elk Resources	1
McElvain	1
Summit Operating	1
Total	644

PROGRESS, RESULTS, AND DISCUSSION

Task 1.0: Project Management Plan

During the month of April, the Principal Investigator (PI) wrote and submitted the project's sixth quarterly report for the period January through March 2010. This report was subsequently sent via email to all interested parties and posted on the UGS project Web site.

Task 2.0: Moderately Saline Aquifer Study

One of the most important steps in accomplishing the goals of Task 2 is to collect as many water chemistry analyses as possible from wells in the Uinta Basin. Through June 2010, the team has collected 2323 individual water analyses from over 1300 different wells (figure 1). This information has been collected from a variety of sources including oil and gas operators (719 analyses), Utah Division of Oil, Gas, and Mining well files (181 analyses), UGS databases (1247 analyses), U.S. Geological Survey databases (105 analyses), and other publications (71 analyses).

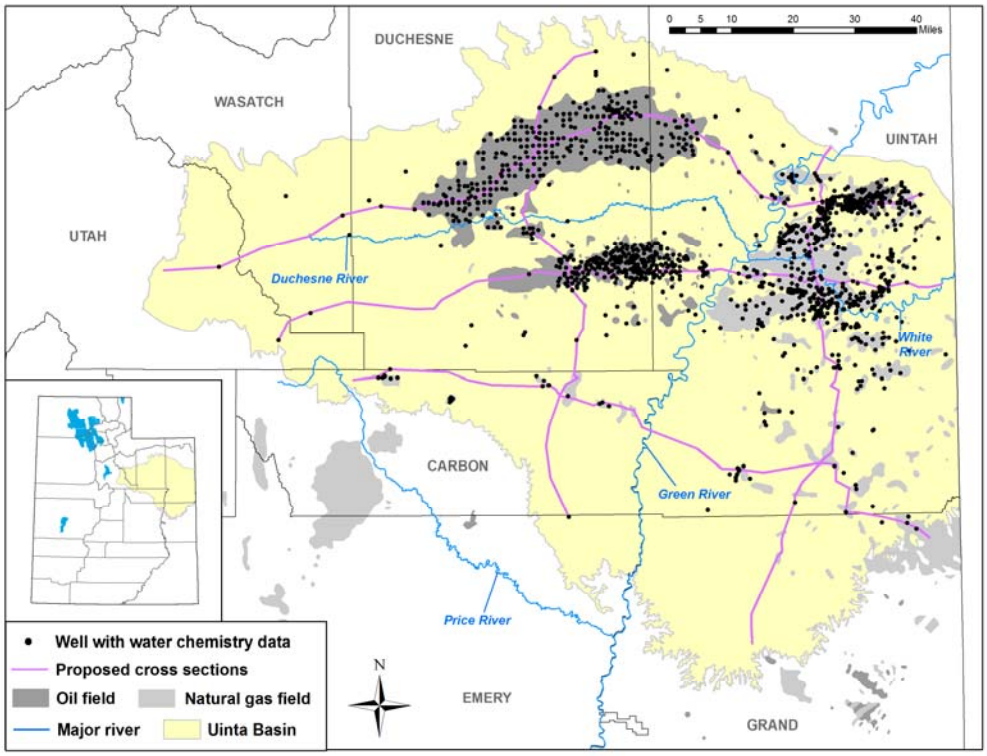

Figure 1. *Location of wells in the Uinta Basin with water chemistry data.*

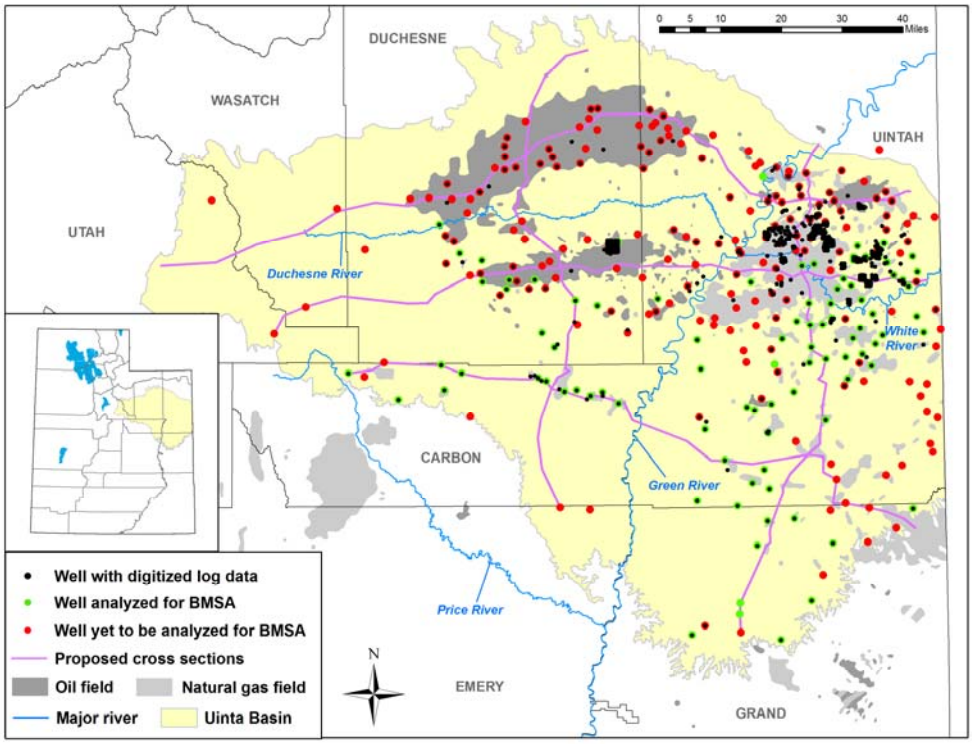

Figure 2. *Location of wells in the Uinta Basin with donated digitized geophysical logs and wells already and yet-to-be evaluated for the base of the moderately saline aquifer.*

For those areas where water chemistry data are lacking, work continues on determining the base of the moderately saline aquifer (BMSA) using geophysical logs. The Task 2 team leader has selected 281 wells spaced throughout the Uinta Basin for log interpretation. As of June 2010, the BMSA has been picked in 97 of the 281 wells (figure 2). To expedite this process, UGS has requested donations of the digital log files (LAS files) of these particular wells to aid in the picking of the BMSA. Through June 2010, UGS has received about 70% of the LAS files on the selected well list, and has overall obtained 644 digital log files from 26 different companies (many companies donated more LAS files than requested).

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.

Task 3.0: Geologic Examination of the Birds Nest Aquifer

In May 2010, as part of a separately funded project, the UGS drilled and recovered core from a new well – Skyline 16 – near the basin's eastern margin (figure 3). This core displayed a similar stratigraphy to the P-4 well, and recovered the entire Horsebench Sandstone, which sits directly on top of a ~100 foot saline interval. The saline interval also displayed significant saline mineral dissolution.

The Task 3 team leader is currently gathering all information related to the 21 wells with core that captured all or part of the Birds Nest aquifer, including geophysical well logs (both TIFF images and digital files), old lithologic logs, Fischer assays, water analyses, photographs, and any old corehole reports. This information will be posted to the project Web site during the next quarter.

The Task 3 team also spent time in May examining the Birds Nest aquifer in outcrop near Evacuation Creek. Good outcrop examples seem to be restricted to the eastern edge of the basin where the erosion-resistant Horsebench Sandstone helps create a Birds Nest cliff exposure along several stream canyons. Farther to the south, the Horsebench thins and allows for extensive weathering of the Birds Nest zone, making outcrop identification nearly impossible (also, the saline mineral crystals greatly decrease in size to the south, making them difficult to find in the weathered slope). Examining outcrop has become less of a priority due to poor exposures; instead, current focus has been primarily on examining core. Despite this fact, the Task 3 team leader hopes to examine the size and frequency of dissolved nacholite nodules seen in outcrop and quantify the changes from the White River south to Bitter Creek. Preliminary field observations indicate the frequency and size of nodules decreases to the south.

The PI created a 13-well, north-south cross section of the Parachute Creek Member of the Green River Formation through central Uintah County for display on the poster presented at the AAPG Annual Meeting in April 2010 (poster is available on the project Web site). In the center of the basin, the presence of large nahcolite beds and nodules creates spikes to low density on well logs and helps identify the saline mineral zone. However, this convention breaks down towards the basin's margins as the saline minerals become too small to be recognized by the bulk density log. To the south, the density logs no longer detect saline minerals at about Township 10 South, but cores examined south of this boundary show saline mineral deposition in the form of small nahcolite crystals (<1 inch) with significant dissolution (meaning water has passed through the zone). Unfortunately, no cores are available to help map this transition to smaller crystals to the west and north; the western and northern extent of the aquifer can only be determined by geophysical logs recording large saline nodules or beds.

Task 4.0: Baseline Water Quality and Quantity GIS Database

During May and June 2010, 17 water samples were collected from several water wells and surface-water sites. Thirteen of the samples are from repeat visits to previously sampled sites in 2009, and four are from new sample sites (table 2, figure 4). Three wells that were sampled during 2009 were no longer accessible and/or functioning wells. The four new sample sites include two USGS monitoring wells that were drilled during the 1970s, one spring, and one sample from the Green River. All new samples have been submitted to the Utah State Lab for chemical analysis.

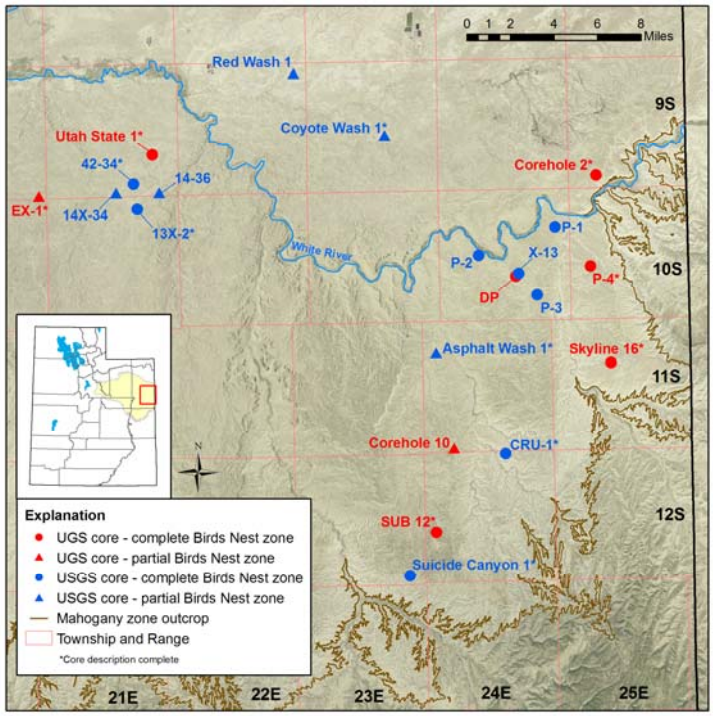

Figure 3. *Location of 21 wells in Uintah County with core that captured all or part of the Birds Nest aquifer. The cores are housed either at the Utah Core Research Center in Salt Lake City, UT, or at the USGS Core Research Center in Denver, CO.*

Table 2. *Overview of water sampling sites.*

Well ID	Depth (ft)	Level (ft)	NO_3 (mg/L) Summer 2009	NO_3 (mg/L) Fall 2009	TDS (mg/L) Summer 2009	TDS (mg/L) Fall 2009	Spring 2010[1]	Formation
Park-USGS	193+	flowing	<0.1	<0.1	796	854	sampled	Green River
Big Pack	6900	flowing	<0.1	<0.1	1298	1308	sampled	Wasatch
Willow – dom.	711	flowing	<0.1	<0.1	936	956	sampled	Green River?
Willow Creek	surface	surface	<0.1	<0.1	562	648	sampled	Alluvial
Sulfur Spring	spring	flowing	<0.1	<0.1	578	584	sampled	Green River?
Evacuation Cr.	surface	surface	<0.1	<0.1	2832	2724	sampled	Alluvial
4-star	172	70	12.6	13.5	1260	1280	sampled	Alluvial
Kings[2]	?	67?	9.5	--	2114	--	sampled	?
Windmill[3]	1382+?	flowing?	<0.1	<0.1	2394	2236		Green River?
Target[4]	53	23	10.0	--	1442	--	sampled	Alluvial
R&N[5]	60 & 80	23 & 49	7.7	7.7	1016	978		Alluvial
Batty[4,6]	83	28	18.8	--	1908	--		Alluvial
Seep Ridge	>2510	flowing	<0.1	<0.1	3056	1462	sampled	Green River
PR Spring[2]	spring	flowing	0.4	--	420	--	sampled	Green River?
South camp	98	61	--	5.8	--	1204	sampled	Green River?
White River	surface	surface	--	<0.1	--	400	sampled	Alluvial
White/Green R.[7]	surface	surface	--	<0.1	--	412		Alluvial
Green River	surface	surface	--	--	--	--	sampled	Alluvial
Sweet Water Spr.	spring	flowing	--	--	--	--	sampled	?
Bitter Cr –USGS	1497	?	--	--	--	--	sampled	Green River
Asphalt 1–USGS	2650	?	--	--	--	--	sampled	Green River

[1]Samples collected in spring 2010, but not yet analyzed
[2]No access to site in fall 2009 due to weather conditions
[3]Not operating in spring 2010
[4]Not sampled in fall 2009 due to time constraints
[5]Unable to sample in spring 2010
[6]No longer in use in spring 2010
[7]Not sampled in spring 2010

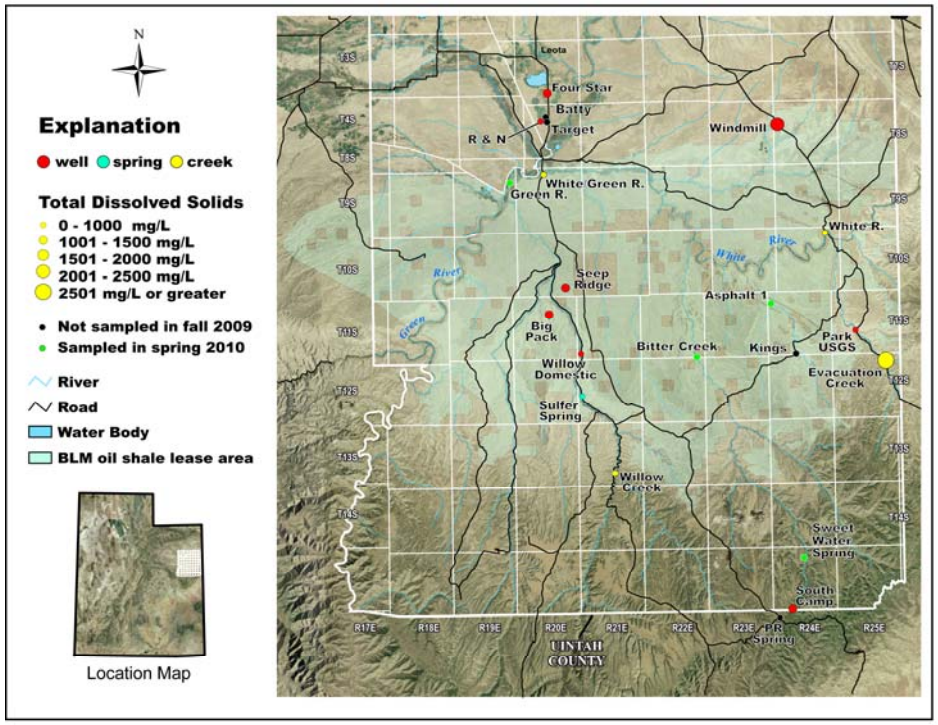

Figure 4. *Sampling sites related to Task 4, with TDS data from fall 2009 samples.*

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

This task is scheduled for Budget Period 3.

Task 6.0: Technology Transfer

- The PI wrote an article for the May 2010 issue of *Survey Notes* summarizing the project's goals and listing preliminary accomplishments. *Survey Notes* is an informative, non-technical UGS magazine with short news articles on noteworthy and interesting geologic topics in Utah, and is published three times a year.
- The PI presented a poster at the 2010 AAPG Annual meeting held in New Orleans, LA, on April 13, 2010. The poster detailed the progress made to-date on each part of the project.
- The PI presented a poster at the 2010 AAPG-RMS meeting held in Durango, CO, on June 15, 2010. 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 project Web site (http://geology.utah.gov/emp/UBwater_study) was updated with new quarterly reports, abstracts, and presentations prepared by project team members.

CONCLUSION

With the project nearing the end of its second year, the study is on schedule to achieve the goal of better understanding aquifers in the Uinta Basin to help facilitate safe and efficient saline water disposal. The Task 2 team has collected hundreds of down-hole water chemistry analyses and hundreds of digitized log files to aid in picking the base of the moderately saline aquifer; the Task 3 team has described 11 cores containing the Birds Nest aquifer; and the Task 4 team has collected three sets of water samples

from 21 sites in central Uintah County as part of a biannual sampling plan to develop baseline water quality in the area. At least one more quarter of data collection and analysis are scheduled before the final interpretation and synthesis can begin in year three.

COST STATUS

Costs in April and June were dominated by preparing for and attending two national AAPG conferences and were close to budget. Lower costs in May were the result of the PI and other members of the project team working on other projects; however, the Task 4 team leader did spend several weeks in the field collecting water samples. As displayed in figure 6, the cumulative billing through the end of June 2010 is very close (91%) to budgeted costs.

Table 3. *Project costing profile for Budget Period 2 (third quarter).*

	Apl 2010		May 2010		Jun 2010	
	Plan	Actual	Plan	Actual	Plan	Actual
UGS-personnel	$10,990	$14,522	$15,932	$2,156	$14,647	$16,628
Travel Expenses[1]	$3,580	$2,638	$3,963	$1,063	$2,842	$983
Water Chemistry						
Miscellaneous[2]		$229		$123		$91
SUBTOTALS	$14,570	$17,388	$19,895	$3,342	$17,489	$17,702
UGS OVERHEAD (32.40%)	$4,721	$5,634	$6,446	$1,083	$5,666	$5,735
SUBCONTRACTS						
P. Anderson	$6,777	$10,080	$6,777	$8,300	$6,777	$7,280
GRAND TOTALS	$26,067	$33,102	$33,117	$12,725	$29,932	$30,717

[1]April – AAPG Annual meeting, Birds Nest field work in the Uinta Basin; May – AAPG Annual meeting, water sampling in Uinta Basin; June – AAPG-RMS Annual meeting, water sampling in Uinta Basin

[2]April – Poster lamination, shipping materials to AAPG Annual meeting; May – AAPG-RMS Annual meeting exhibit booth charges, field supplies; June – poster lamination

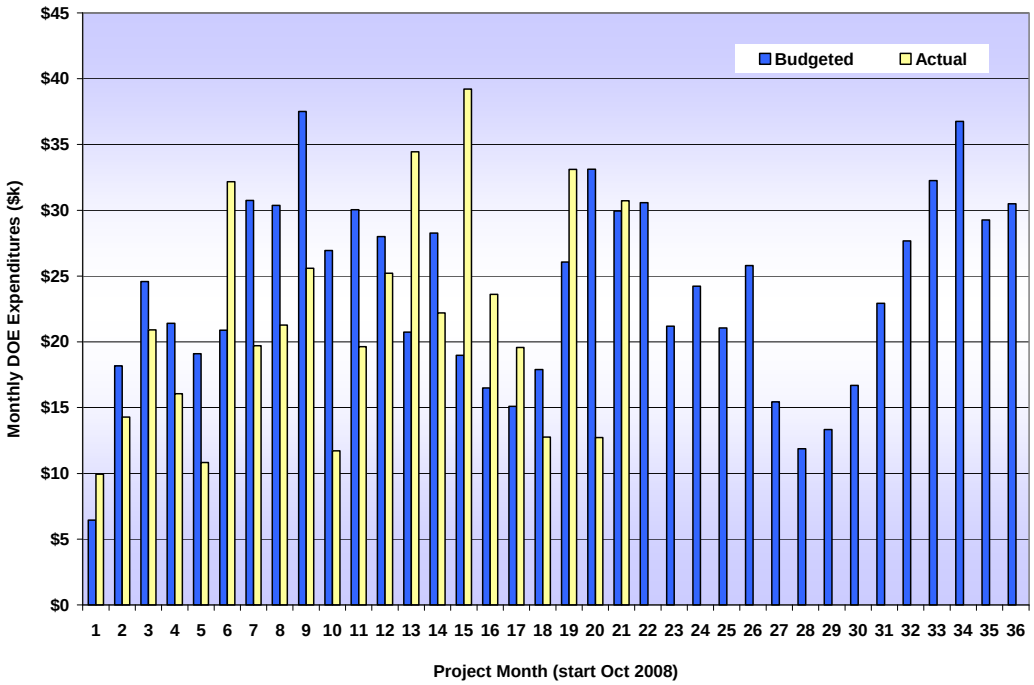

Figure 5. *Project costing profile.*

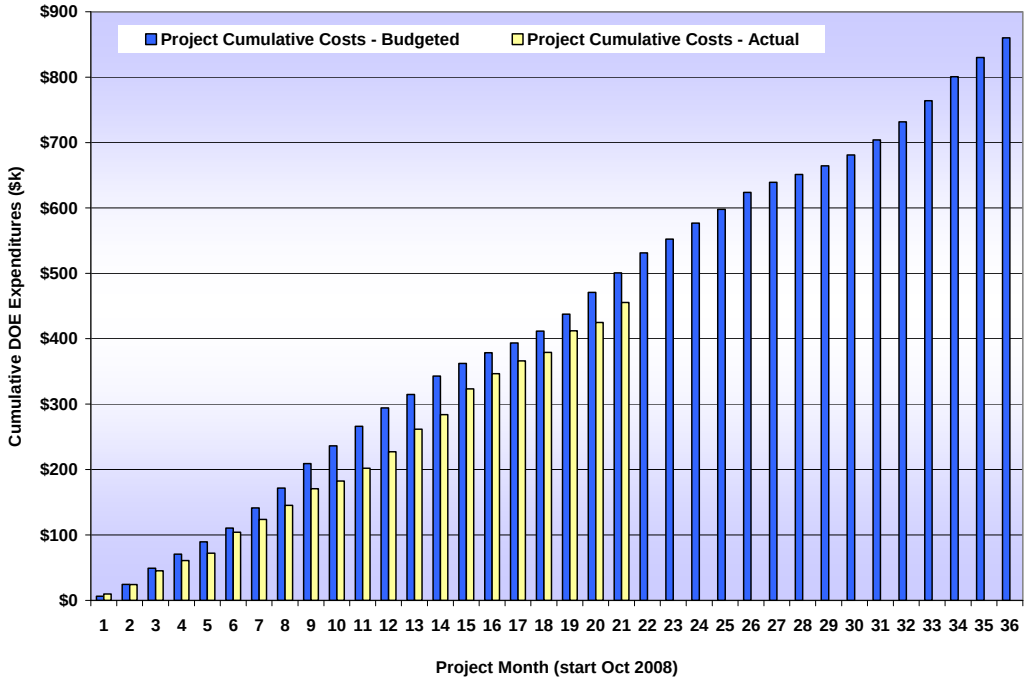

Figure 6. *Project cumulative costs.*

MILESTONE STATUS

Table 4. *Milestone log for Budget Period 2.*

	Title	Description	Related task or subtask	Completion Date	Update/comments
Milestone 2.1	Water chemistry data collection (part 2)	Collect the remaining required 1 well per township, adding additional data to areas of interest	Subtask 2.1	9/30/2010	Currently have chemistry data from 1306 wells; currently analyzing well logs in areas where no chemistry data exist (97 of 281 wells completed)
Milestone 2.2	Create Birds Nest aquifer well database	Create a database with all collected data	Subtask 3.4	9/30/2010	Evaluated Birds Nest in 11 of 21 cores; started Birds Nest well database, initially focusing on wells with core

ACCOMPLISHMENTS

- Presented poster at the AAPG Annual meeting in New Orleans, LA.
- Published article in the May 2010 *Survey Notes* summarizing project goals and results (*Survey Notes* is a UGS magazine published three times a year).
- Presented poster and displayed Birds Nest aquifer core at the AAPG-RMS meeting in Durango, CO.
- Collected and evaluated several hundred new water chemistry analyses from the U.S. Geological Survey for use in Task 2.

PROBLEMS OR DELAYS

None at this time

PRODUCTS AND TECHNOLOGY TRANSFER ACTIVITIES

- Completed sixth quarterly report
  - January 2010 through March 2010 – available on the UGS project Web site
- Updated project Web site
  - Posted various new reports, abstracts, and presentations prepared by project team members.
  - http://geology.utah.gov/emp/UBwater_study
- Published article in May 2010 addition of *Survey Notes* summarizing the project
  - *Survey Notes* is an informative, non-technical UGS magazine with short news articles on noteworthy and interesting geologic topics in Utah and is published three times a year.
  - *Survey Notes* is available on the UGS Web site.
- AAPG Annual Meeting – New Orleans, LA – April 11-14, 2010
  - The PI presented a poster in the *Environmental Remediation and Hydrogeological Characterization* session detailing the projects preliminary results and conclusions.
  - The poster is available on the UGS project Web site.
- AAPG-RMS Annual Meeting – Durango, CO – June 13-16, 2010
  - The project team presented a poster in the *Stratigraphy of Rocky Mountain Basins* session detailing the research done to-date on the Birds Nest aquifer. Two nearby cores that are

separated by a gilsonite vein were also on display; one shows extensive saline mineral dissolution and a second shows no dissolution.

- The poster is available on the UGS project Web site

National Energy Technology Laboratory

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880

One West Third Street, Suite 1400
Tulsa, OK 74103-3519

1450 Queen Avenue SW
Albany, OR 97321-2198

2175 University Ave. South
Suite 201
Fairbanks, AK 99709

Visit the NETL website at:
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