

Oil & Natural Gas Technology

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Quarterly Report

July 2009 to September 2009

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



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EXECUTIVE SUMMARY

The Utah Geological Survey's (UGS) Uinta Basin water project has finished its fourth quarter of study (Budget Period 1; July to September 2009). Water quality data acquisition efforts have for the most part come to an end, with analyses received for over 1200 wells. These data will be invaluable as "groundtruth" to aid in the mapping of aquifer salinity throughout the basin. In addition, several oil and gas operators have donated digitized log data from nearly 600 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 the study of cores which cover all or part of the interval of interest. Of the 20 cores found, two were examined in the last quarter, one near the basin's depocenter and one farther to the south near the basin margin. Saline mineral crystals in the core to the south were much smaller (1 inch to $<1/4$ inch) than the large nodules (up to a foot in diameter) and beds seen in the core from the basin's center. There is still evidence of water movement through this area (dissolved saline minerals), but the smaller nahcolite crystals can not be recognized on a geophysical log, making it difficult to trace the Birds Nest to the basin's margin (at least where there is no core).

The project team has also completed the first round of water sampling and subsequent analyses from wells on lands having the highest oil shale development potential. The overall number of adequate sample sites was reduced to 15, but the sampling frequency will increase to bi-annual.

PROGRESS, RESULTS, AND DISCUSSION

Task 1.0: Project Management Plan

During the month of July, the Principal Investigator (PI) wrote and submitted the project's third quarterly report for the period April to June 2009. This report was subsequently sent via email to all interested parties and posted on the Utah Geological Survey (UGS) project Web site. The PI also revised the Project Summary (posted to the Web site) and submitted a project continuation application.

Task 2.0: Moderately Saline Aquifer Study

The Task 2 team has focused this quarter on obtaining as many digital geophysical log files (LAS files) as possible to expedite and aid in picking the base of the moderately saline aquifer. The more LAS files donated by basin operators, the less time UGS needs to spend digitizing the logs. The Task 2 team leader has made a list of 309 key wells spaced throughout the basin, and has focused on getting these specific LAS files. Through September 2009, UGS has received about 40% of the LAS files on the key well list, and has overall obtained 580 LAS files from 21 different companies (many companies donated more LAS files than requested) (figure 1, table 1). Using the donated LAS files, the Task 2 team leader, Paul Anderson, has started picking the base of the moderately saline aquifer, comparing the results with water chemistry data where available. To date, Anderson has picked the boundary in 27 wells.

Task 3.0: Geologic Examination of the Birds Nest Aquifer

Two members of the Task 3 team traveled to the Uinta Basin in August to determine the quality of Birds Nest aquifer outcrop

Table 1. Number of donated LAS files by company.

Company	# of LAS files
Questar	315
Newfield	84
Enduring	74
Anadarko	18
Bill Barrett	17
Berry	15
EOG	15
FIML	6
Wind River	6
Devon	5
Rosewood	5
Flying J	4
Gasco	4
Mustang Fuel	3
Forest	2
Royale	2
BT Operating	1
Elk Resources	1
McElvain	1
Summit Operating	1
Whiting Petroleum	1

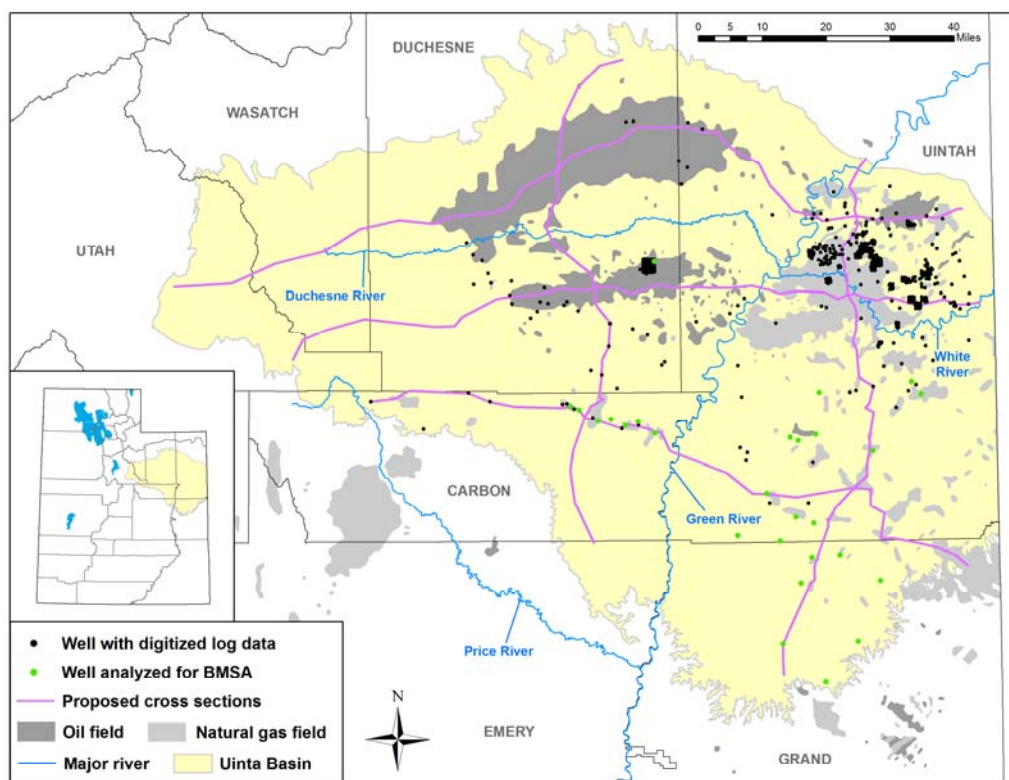


Figure 1. Map of the Uinta Basin showing the location of wells with donated digitized geophysical logs and wells evaluated for the base of the moderately saline aquifer (BMSA).

locations. The first stop was near where the Birds Nest, if present in this area, should have outcropped along the Green River; however, despite the presence of the Horse Bench Sandstone, no saline mineral deposition was visible on the surface. The next stop was near Evacuation Creek and the White River; where classic Birds Nest saline mineral dissolution cavities can be found on the vertical cliffs cut by the two streams (figure 2). This area is believed to be one of the main recharge zones for the aquifer. The Horse Bench Sandstone was also observed in this area directly above the Birds Nest zone. Farther to the south, the same saline mineral dissolution cavities can be seen on cliffs near the hamlet of Watson. Many other areas were examined, using the Horse Bench Sandstone as a marker, but these areas showed no signs of saline mineral deposition. It seems that in many cases, the Birds Nest aquifer outcrop is highly weathered and is covered with alluvium, making outcrop examination very difficult. Several more trips are planned in hopes of finding more exposures of saline deposition, but current focus will be on examining the Birds Nest in core. The 20 available cores that recovered all or part of the Birds Nest aquifer will offer a more valuable description of this zone than outcrop exposures (plate 1).

Two more cores were examined this quarter, the South Uinta Basin 12 and the EX-1. The EX-1 core (T. 9 S., R. 20 E., sec. 36) only recovered the lower 55 feet of the Birds Nest zone (the Birds Nest in this area is about 300 feet thick). The nahcolite in this lower 55 feet occurs in nodules and small beds and displays little to no dissolution. The South Uinta Basin 12 core (T. 12 S., R. 24 E., sec. 19) is located much farther south than previously examined cores, near the southern outcrop. This core displays entirely different saline mineral deposition characteristics. The entire saline zone is only 60 feet thick and is comprised of much smaller saline mineral crystals (figure 3), probably due to its proximity to the basin margin, as opposed to the large beds and nodules seen in the basin depocenter. Also, the saline minerals in this core are partially dissolved away indicating fresh water movement through the aquifer in this area.

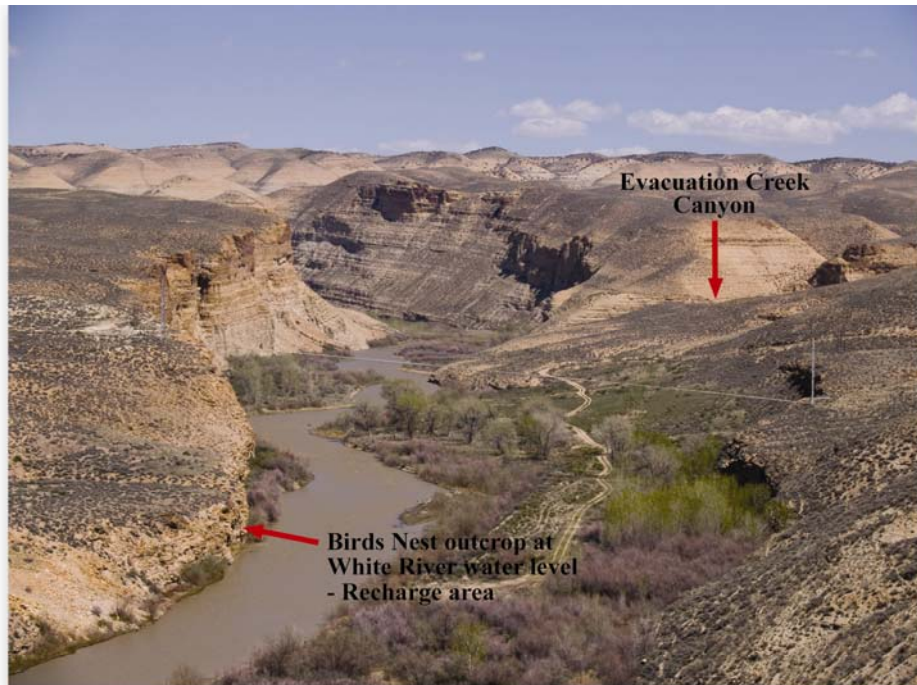


Figure 2. Core from the South Uinta Basin 12 well. Notice the smaller partially-dissolved nahcolite crystals (yellow bar equals one inch).

The Task 3 team also began examining the geophysical log signature of the Birds Nest aquifer. Near the basin depocenter, bulk density logs signal the occurrence of a large nahcolite nodule or bed, or the empty space left behind by subsequent dissolution, as a low-density spike (1.4 to 1.7 g/cm^3). These low-density spikes can be used to map the abrupt base of the saline zone in Townships 9 and 10 South. Starting in Township 11 and continuing south, the nahcolite crystals are smaller such that the density log no longer records their existence, as seen in the South Uinta Basin 12 well. This makes core examination the only way to determine characteristics of the Birds Nest aquifer in the southern part of the basin. The team has yet to look at logs/core north of Township 9 South.

Task 4.0: Baseline Water Quality and Quantity GIS Database

Nine water samples and one duplicate sample were taken from water wells and surface water sites in Uintah County during July and August. With the six samples collected in June, the list of sampling sites now consists of 11 wells, two streams, and two springs, for a total of 15 sites. Water chemistry data from the summer sampling program were received from the state laboratory in late September. Table 2 provides a summary of each site including depth of sample in the well, date sample was taken, nitrate



Figure 3. Core from the South Uinta Basin 12 well. Notice the smaller, partially-dissolved nahcolite crystals (yellow bar equals one inch).

Table 2. Overview of water sampling sites.

Well ID	Depth (ft)	Level (ft)	Month Sampled	NO ₃ (mg/L)	TDS (mg/L)	Formation
Park	750	57/350	Jun-09	<0.1	1428	Birds Nest
Park-USGS	193+	flowing	Jun-09	<0.1	796	Green River
Big Pack	6900	flowing	Jun-09	<0.1	1298	Wasatch
Willow - domestic	711	flowing	Jun-09	<0.1	936	Green River?
Willow Creek	surface	Surface	Jun-09	<0.1	562	Alluvial
Sulfur Spring Evacuation	spring	flowing	Jun-09	<0.1	578	Green River?
Creek	surface	Surface	Jul-09	<0.1	2832	Alluvial
4-star	172	70	Jul-09	12.6	1260	Alluvial
Kings	?	67?	Jul-09	9.5	2114	?
Windmill	1382+?	flowing?	Jul-09	<0.1	2394	Green River?
Target	53	23	Jul-09	10.0	1442	Alluvial
R&N	60 & 80	23 & 49	Jul-09	7.7	1016	Alluvial
Batty	83	28	Jul-09	18.8	1908	Alluvial
Seep Ridge	>2510	flowing	Aug-09	<0.1	3056	Green River
PR Spring	spring	flowing	Aug-09	0.4	420	Green River?

concentration (NO₃), total dissolved solids (TDS), and the formation from which the water was derived (if known). TDS values for all samples range from 420 to 3056 mg/L and nitrate concentrations range from less than 0.1 mg/L to 18.8 mg/L. Nitrate concentrations exceeding the 10 mg/L EPA drinking water quality standard are located mostly in areas adjacent to irrigated fields in the northwestern part of the study area (figure 4). Each site will be resampled in the fall of 2009.

Information on the “Park” sample was unknown at the time of sampling and does not represent aquifer conditions; this well will not be resampled due to the time required to obtain a representative sample (pumping would exceed 24 hours). This well will be replaced with another site to be sampled in the fall of 2009.

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 presented a poster at the Water/Energy Sustainability Symposium at the Ground Water Protection Council’s annual forum in Salt Lake City, UT on September 12, 2009. The poster was well received and the PI obtained valuable feedback from members of the U.S. Bureau of Land Management and the U.S. Environmental Protection Agency, two key customers of this research project.

Also in September, the PI submitted an abstract to the 2010 American Association of Petroleum Geologists annual meeting to be held in New Orleans, LA. The abstract details the progress made on each part of the project.

The project Web site (http://geology.utah.gov/emp/UBwater_study) was updated with new quarterly reports, newly submitted abstracts, and our poster presentation from the Ground Water conference.

CONCLUSION

With the first year of the project now over, the study is well on its way to achieving its goals of understanding the aquifers in the Uinta Basin to help facilitate safe saline water disposal. The Task 2 team has collected hundreds of down-hole water chemistry analyses and hundreds of digitized log files to

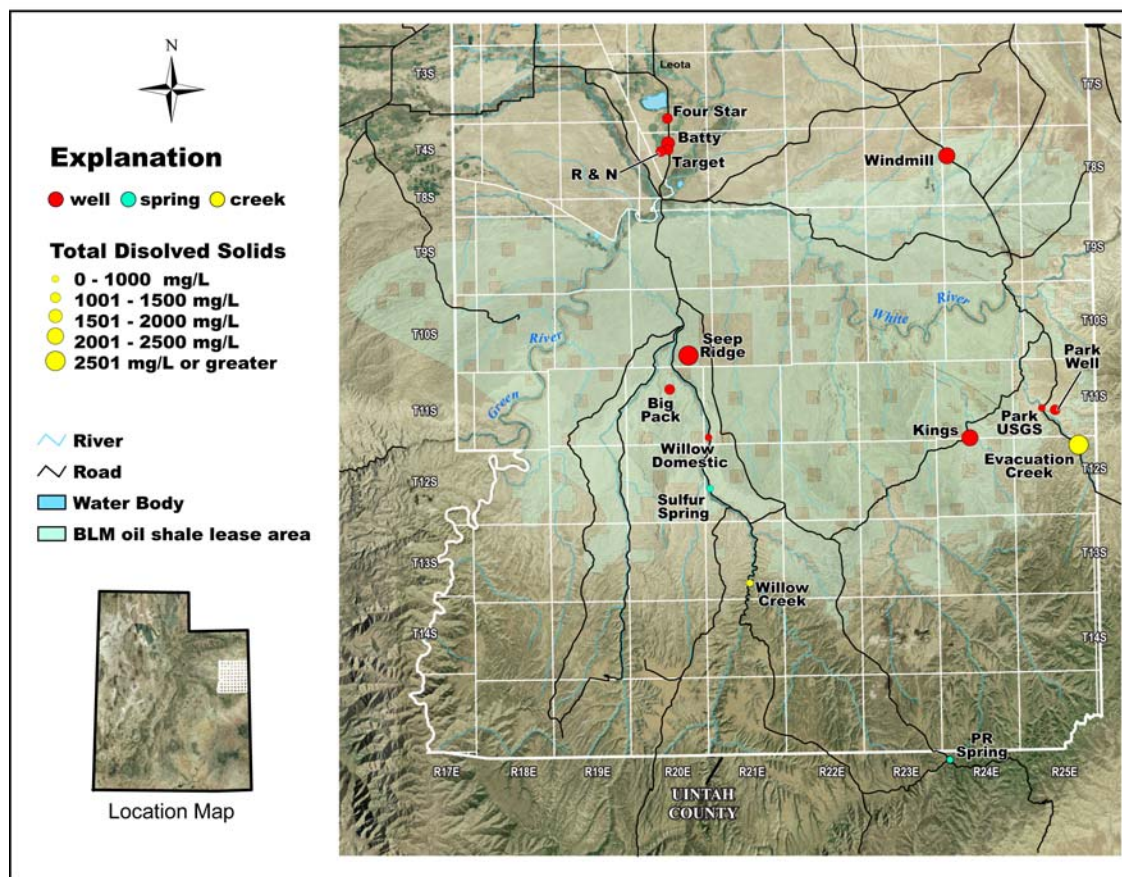


Figure 4. Map of sampling sites related to Task 4.

aid in picking the base of the moderately saline aquifer; the Task 3 team has described five cores containing the Birds Nest aquifer and found core is the best way to observe the zone's regional characteristics; and the Task 4 team has located, collected, and analyzed water samples from 15 sites in central Uintah County as a start of a bi-annual sampling plan to develop baseline water quality in the area. During year two, the project team will continue gathering and interpreting the data needed to accomplish the overall goals of the project.

COST STATUS

The water sampling and subsequent water chemistry analyses were delayed due to difficulty identifying suitable sampling locations. The first batch of water chemistry analyses will be billed in October 2009, with additional testing scheduled for December 2009. Also, personnel time in July was under budget because of employee vacations and other project obligations. Personnel time will be closer to budget in the next quarter.

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

	Jul 2009		Aug 2009		Sep 2009	
	Plan	Actual	Plan	Actual	Plan	Actual
UGS-personnel	\$8,815	\$2,274	\$10,016	\$9,312	\$14,891	\$12,541
Travel Expenses ¹		\$421	\$1,136	\$443	\$106	\$693
Water Chemistry	\$5,394		\$5,394			
Miscellaneous ²		\$105		\$875		\$67
SUBTOTALS	\$14,209	\$2,800	\$16,547	\$10,631	\$14,997	\$13,301
UGS OVERHEAD (32.40%)	\$4,604	\$907	\$5,361	\$3,444	\$4,859	\$4,310
SUBCONTRACTS						
P. Anderson	\$8,132	\$8,000	\$8,132	\$5,560	\$8,132	\$7,600
GRAND TOTALS	\$26,945	\$11,707	\$30,040	\$19,635	\$27,988	\$25,211

¹July - trip to the Uinta Basin for water sampling; August - trip to the Uinta Basin for water sampling; September - trip to the Uinta Basin for water sampling and Birds Nest outcrop examination

²July - field supplies; August - field supplies, registration for the 29th Oil Shale Symposium (\$400), registration for the Ground Water Protection Council (GWPC) meeting (\$195), exhibit booth rental fee for the AAPG 2010 annual meeting; September - purchase of maps, parking for GWPC meeting, and lamination of poster

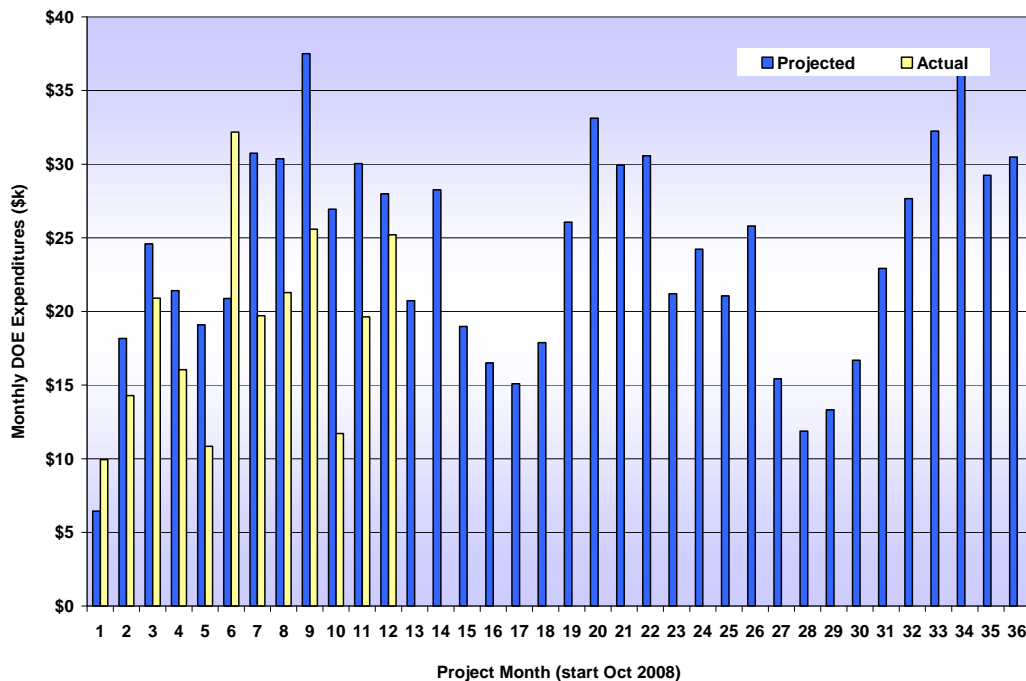


Figure 5. Project costing profile.

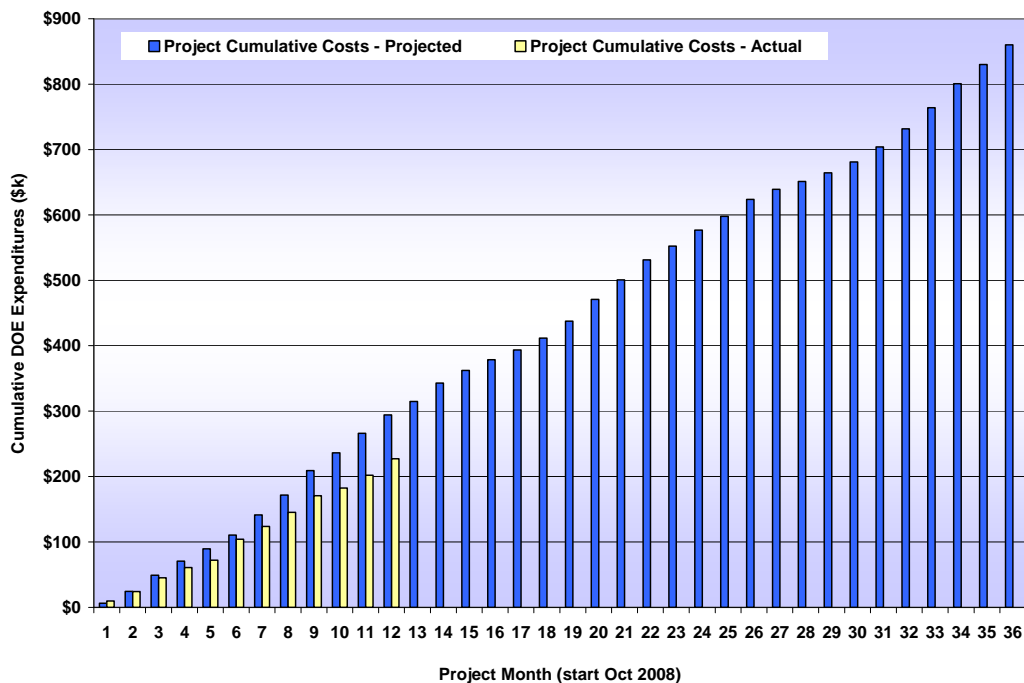


Figure 6. Project cumulative costs.

MILESTONE STATUS

Table 4. Milestone log for Budget Period 1.

	Title	Description	Related task or subtask	Completion Date	Update/comments
Milestone 1.1	Water chemistry data collection (part 1)	Collect at least half of the required 1 well per township	Subtask 2.1	9/30/2009	Data collection is in progress; currently have data from 1146 wells, still communicating with several operators to get more data, began analyzing well logs in areas where no chemistry data exists (27 completed)
Milestone 1.2	Evaluation of the Birds Nest in core and outcrop	Examine the Birds Nest in core and find at least five outcrop exposures to describe	Subtask 3.2, 3.3	6/30/2009	Evaluated 4 cores: Utah State 1, Utah State 42-34, South Uinta Basin 12, EX-1, and P-4; plan to look at more core in Oct 2009, completed one trip to the Uinta Basin to study outcrop
Milestone 1.3	Completion of the Quality Assurance Project Plan	Locate 50 sites suitable for water chemistry analyses	Subtask 4.2	12/15/2008	Completed, water sampling has commenced

ACCOMPLISHMENTS

- Revised Project Summary
- Completed first Birds Nest outcrop examination trip
- Examined and described EX-1 and South Uinta Basin 12 cores
- Attended and presented poster at the Water/Energy Sustainability Symposium at the Ground Water Protection Council's annual forum in Salt Lake City.
- Completed first round of water sampling and analysis from 15 sites in Uintah County.

PROBLEMS OR DELAYS

Our first trip into the Uinta Basin to examine the Birds Nest aquifer in outcrop revealed that this task might be more difficult than originally thought. The Birds Nest zone is prominently displayed near Evacuation Creek and along the White River, but in other places in the basin this zone is highly weathered and is most often not exposed. Further field investigations are planned, but examination of the Birds Nest in core seems to be the most valuable way to examine and characterize this zone.

With the difficulty finding suitable sites for water sampling described in the last quarterly report, water chemistry analyses were delayed. The budget for these tests was scheduled to be billed for in August and September, but this billing has been delayed to October 2009.

PRODUCTS AND TECHNOLOGY TRANSFER ACTIVITIES

- Completed third quarterly report
 - April 2009 to June 2009 – available on the UGS project Web site
- Revised Project Summary – available on the UGS project Web site
- Wrote and submitted project continuation application
- Updated project Web site
 - Posted various reports, abstracts, and presentations
 - http://geology.utah.gov/emp/UBwater_study
- Poster Presentation – Water/Energy Sustainability Symposium at the Ground Water Protection Council's annual forum – Salt Lake City, UT – September 13-17, 2009
 - The PI presented a poster which detailed the project objectives, with particular emphasis on the Birds Nest aquifer and its relationship to oil and gas development.
 - The poster is available on the UGS project Web site.
- Abstract – AAPG Annual Meeting – New Orleans, LA – April 11-14, 2010
 - An abstract was submitted to the 2010 AAPG Annual meeting detailing progress made on all aspects of the project.
 - The abstract is available on the UGS project Web site.

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Plate 1. Birds Nest aquifer reference map.



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September 2009

- Explanation**
- ◇ Water disposal well
 - UGS core - complete Birds Nest zone
 - UGS core - partial Birds Nest zone
 - USGS core - complete Birds Nest zone
 - USGS core - partial Birds Nest zone
 - ★ Cross section well
 - ▲ Well with Birds Nest water chemistry (TDS)
 - Cross section (see GWPC poster on Web site)
 - Mahogany zone outcrop
 - Horse Bench sandstone outcrop
 - Gilsonite vein
 - 10,000 TDS line
 - Major river
 - Prelim. structure contour - base of BN (ft)
 - BLM RD&D oil shale lease (OSEC)
 - Natural gas field
 - Oil field
 - Township and Range

