RIVERTON DOME GAS EXPLORATION AND STIMULATION TECHNOLOGY DEMONSTRATION, WIND RIVER BASIN, WYOMING

Fourth Quarterly Technical Progress Report

Reporting Period Start Date:: July 1, 1998
Reporting Period End Date: September 30, 1998

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Department of Energy Contracting Officer: Ms. Mary Beth Pearse

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Disclaimer

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Contractor Name and Address: Institute for Energy Research
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& Principal Investigators: Ronald C. Surdam & Thomas L. Dunn

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Objectives

This project will provide a full demonstration of an entirely new package of exploration technologies that will result in the discovery and development of significant new gas reserves now trapped in unconventional low-permeability reservoirs. This demonstration includes the field application of these technologies, prospect definition and well siting, and a test of this new strategy through wildcat drilling. In addition this project includes a demonstration of a new stimulation technology that will improve completion success in these unconventional low permeability reservoirs which are sensitive to drilling and completion damage. The work includes two test wells to be drilled by Snyder Oil Company on the Shoshone/Arapahoe Tribal Lands in the Wind River Basin. This basin is a foreland basin whose petroleum systems include Paleozoic and Cretaceous source beds and reservoirs which were buried, folded by Laramide compressional folding, and subsequently uplifted asymmetrically. The anomalous pressure boundary is also asymmetric, following differential uplift trends.

Scope of the Work

The Institute for Energy Research has taken a unique approach to building a new exploration strategy for low-permeability gas accumulations in basins characterized by anomalously pressured, compartmentalized gas accumulations. Key to this approach is the determination and three-dimensional evaluation of the pressure boundary between normal and anomalous pressure regimes, and the detection and delineation of areas of enhanced storage capacity and deliverability below this boundary. This new exploration strategy will be demonstrated in the Riverton Dome—Emigrant Demonstration Project (RDEDP) by completing the following tasks: 1) detect and delineate the anomalous pressure boundaries, 2) delineate surface lineaments, fracture and fault distribution, spacing, and orientation through remote sensing investigations, 3) characterize the internal structure of the anomalous pressured volume in the RDEDP and determine the scale of compartmentalization using produced water chemistry, 4) define the prospects and well locations as a result on this new exploration technology, and 5) utilize new completion techniques that will minimize formation damage and optimize production.

Summary of Technical Progress

Task 1. Detect and Delineate the Anomalous Pressure Boundaries Using Analysis of 2D & 3D Seismic Data and Sonic Log Velocity Analysis

Sonic Analysis. For third quarter of the Riverton Dome project in 1998, our work focused on: (1) detection, delineation, and visualization of regional pressure boundaries and gas-saturated sweet spots and (2) tests of the validity and universality of the newly developed exploration paradigm, technology, and tools specifically designed to exploit anomalously pressured gas accumulations. The new, process-oriented conceptual model, innovative technology, and diagnostic tools developed by Surdam and associates at the Institute for Energy Research (IER) were applied to the sonic and seismic velocity analyses of the Riverton Dome Project. Three sonic logs and 1620 CDP profiles from the Riverton Dome 3D survey were processed and the anomalous velocity for each log and CDP was computed. A three-dimensional anomalous sonic velocity model was constructed for the Riverton Dome Area. The results show that significantly anomalous velocities exist in the Frontier Formation and formations below it (Figures 1 and 2). Potential gas-saturated sweet spots can be identified and delineated on the 3-D anomalous sonic velocity model. Next quarter, we will check the seismic velocity uncertainties. In addition, more faults and formation tops will be introduced to the 3-D anomalous velocity model.

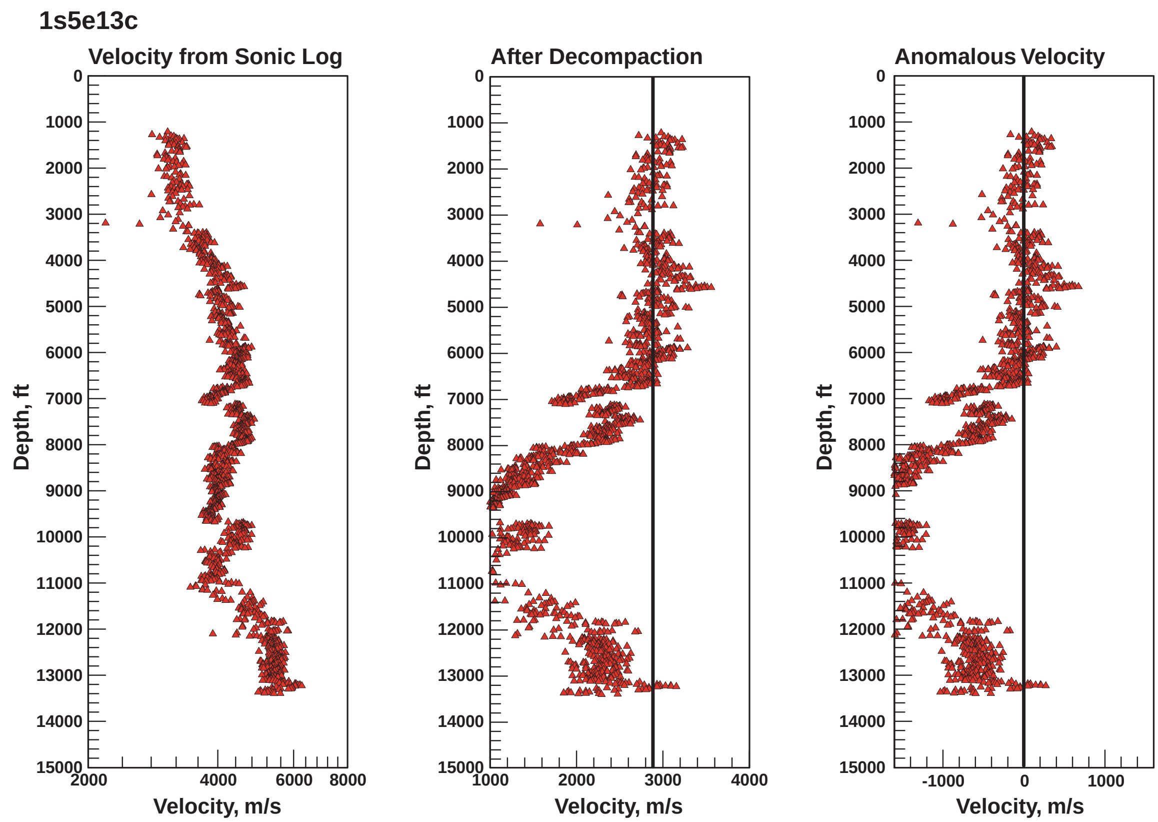


Figure 1A-C. A. Semilogarithmic plot of a sonic log for the Tribal 8 well within the Riverton Dome 3-D survey. B. The plot of velocity vs. depth for the same sonic log shown in A, but with the velocity corrected for normal compaction. C. Plot of anomalous velocity vs. depth for the same sonic log shown in A; anomalous velocity is the difference between the measured velocity profile and the velocity-depth profile for normally compacted rocks.

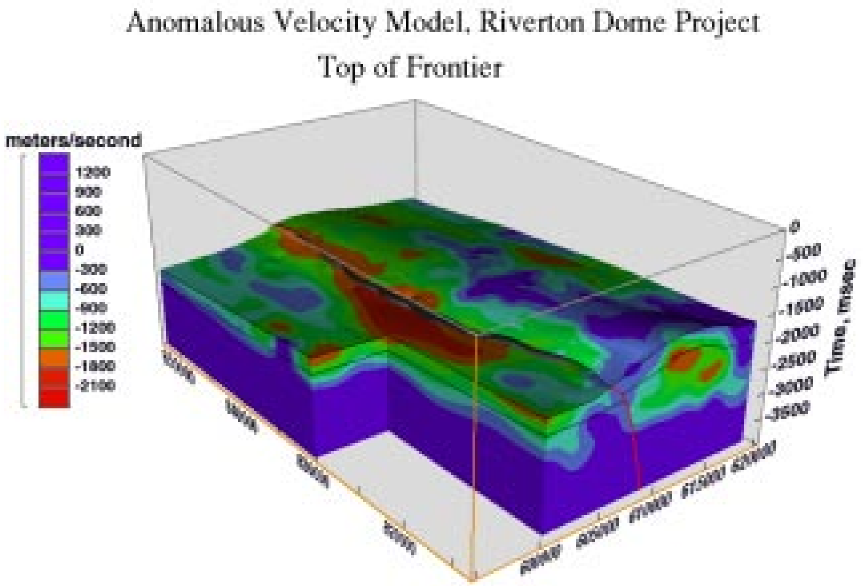
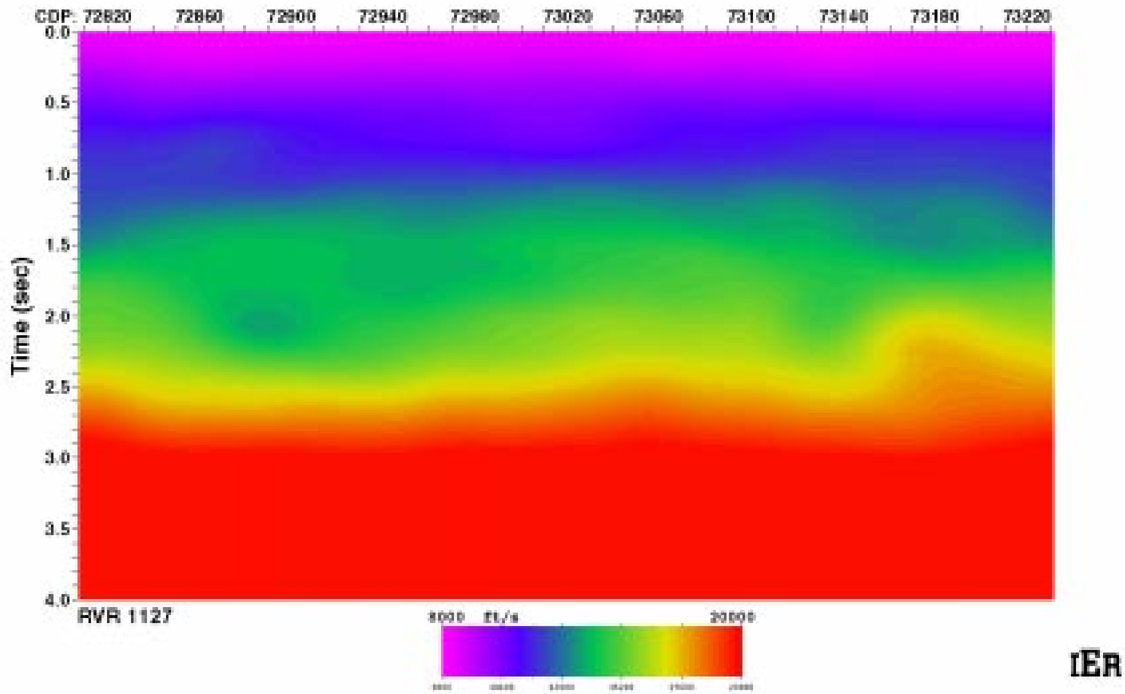


Figure 2. A 3-D anomalous velocity model for the Riverton Dome 3-D survey, showing the anomalous velocity/gas-saturated rock distribution of the Frontier Formation. The water-saturated rock volumes are shown in blue, and gas-saturtaed rock volumes are shownin green, orange, and red.

Seismic Analysis. The Riverton Dome 3-D seismic data arrived from the processing company at the beginning of August. After loading the archived ProMAX database and processing flows that we received from the processors, we were able to begin our detailed velocity analysis. To illustrate what we mean by detailed, the processing company performed velocity analysis along every 25th in-line, at every 50th cross-line. For the acquisition parameters of this seismic survey these velocity analysis points are situated at 5,500 foot intervals along lines separated by 2,500 ft. Our detailed velocity analysis is done along every 10th in-line, at every 9th cross-line. This will produce a fairly uniform grid of velocity analysis points at every 990 feet along lines separated by 1,000 ft. This results in about 150 fold increase in velocity data for the 3-D volume. Both we and the processing company are able to pick the velocities at about 100 ms intervals. A primary reason for the processing company to perform such a spatial coarse velocity analysis is due to the time required to do the analysis. They may have spent a week doing the analysis for this whole volume, whereas we will end up taking more than two months. For what the processing company is hired to do, a week will suffice. For the spatial resolution we want for our velocity data, we need much greater detail. We expect that we will be finished with the velocity analysis sometime during the next quarter.

Plots of interval velocity from one in-line and a couple of velocity semblance plots are included in order to illustrate the data quality and some preliminary results. The stack superimposed on the interval velocity field is not migrated. A velocity inversion is indicated between CDP 72850 and CDP 72920 in the interval from about 1.6 s to 2.3 s (Figure 3A,B). The individual velocity semblance plots show both the traces at the particular CDP as well as a velocity-time plot of the CDP with color-coded semblance contours of the velocity function (Figure 4). The semblance contours are a statistical measure of the multichannel coherence (energy) of the data at a particular velocity and time. In picking the velocities the semblance contours are used as an unbiased guide to the overall velocity function. In other words, the distribution of the semblance peaks gives a rough guide to the velocity function determined by the seismic data at the individual CDP. These semblance velocity plots indicate the lateral variability of the velocity data over a distance of 6,600 ft. Instead of having just one data point over this interval, we have nine. The kind of data and analyses indicated here are the basis for the velocity data used in our analysis and interpretation.

A.



B.

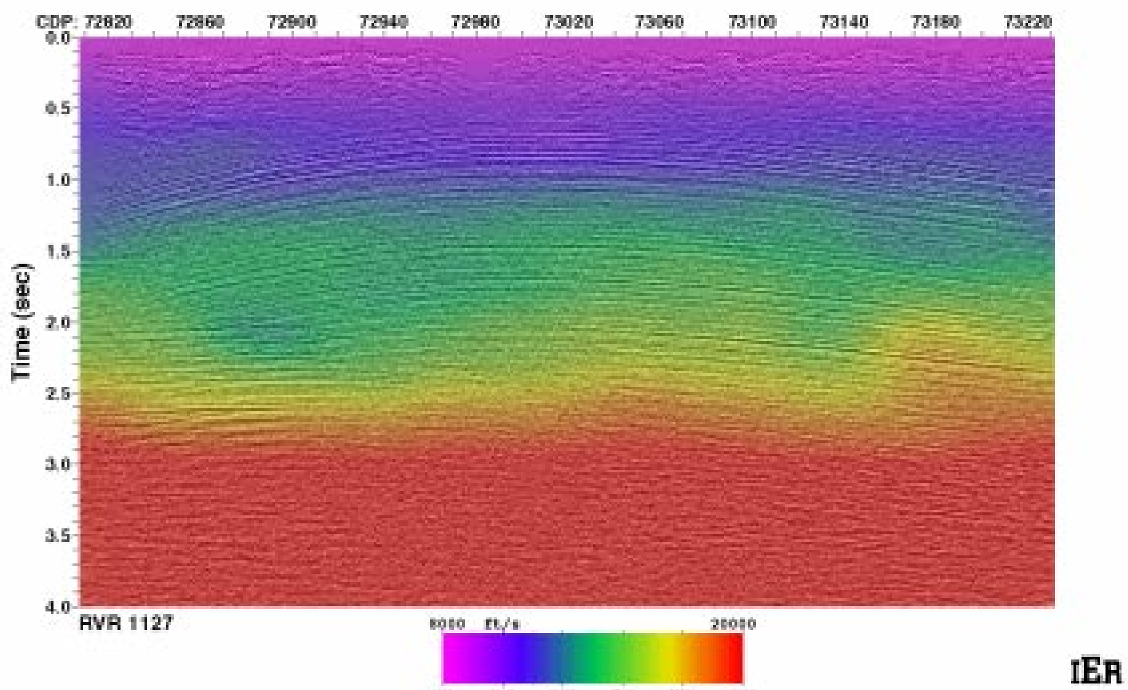


Figure 3A,B. In-line 1127. (A) Interval velocity field determined from the seismic data. (B) Interval velocity field superimposed on stack of in-line 1127. Data are not migrated.

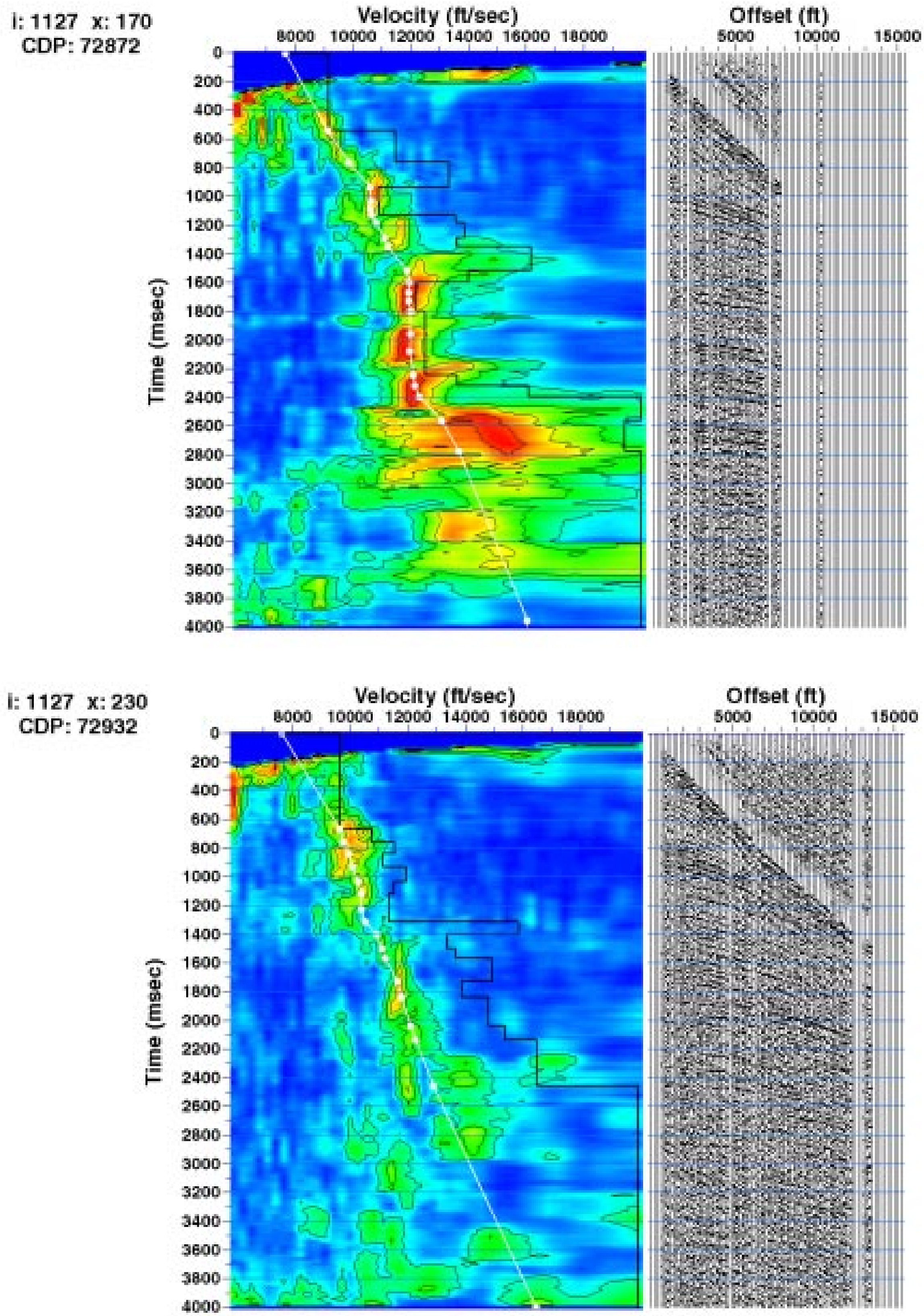


Figure 4. Velocity semblance plots for two CDPs along in-line 1127. See text for discussion of semblance and its use in velocity analysis. Data points are separated by 6,600 ft along the in-line

Task 2. Delineate Surface Fracture and Fault Distribution, Spacing, and Orientation Lineaments Through Remote Sensing Analysis

Preliminary work has demonstrated that there are several significant east-west regional linears characterizing the structural setting to the north of the 3-D seismic study area.

Task 3. Characterization of the Internal Structure of the Anomalous Pressured Volume in the RDEDP & Determination of Compartmentalization Using Produced Water Chemistry and Petrography

Seven cores were obtained from Riverton Dome:

- **Arco Mary B. O'Connor #1; 2S-4E-1**
- **Arco Tribal #2; 1S-4E-36**
- Arco Tribal #5; 1S-4E-36
- **Arco Tribal #6; 1S-5E-30**
- **Arco Tribal #8; 1S-5E-31**
- **Arco Tribal #9; 1S-5E-31**
- Arco Tribal #10; 1S-4E-25

Preliminary core descriptions have been performed on the five cores in bold. A summary of the cores, which includes depths and formations, is shown in Table 1. The preliminary core description includes basic lithology, grain size, cementation, and internal structures. In addition, natural fractures were recognized, but have not fully been described. A full core description, which will include interpretations of depositional environments and facies, and a fractured core description, which will include a summary of the cementation patterns within the fractures will be performed shortly.

Table 1. Riverton Dome Core Summary.

Well Name & Number	Twnsp., Range, Sec.	Depths (ft)	Formations
Arco Mary B. O'Connor #1	2S-4E-1	4572-4612 7956-8760	Cody Frontier
Arco Tribal #2	1S-4E-36	9732-9733 9744-9745 11397-11540 11750-12008	Morrison Morrison Dinwoody & Phosphoria Tensleep
Arco Tribal #5	1S-4E-36	2837-5185	Cody
Arco Tribal #6	1S-5E-30	9580-9604	Lakota
Arco Tribal #8	1S-5E-31	4611-4712 9612-9631	Cody Lakota
Arco Tribal #9	1S-5E-31	8371-9018 9934-10111	Frontier Dakota
Arco Tribal #10	1S-4E-25	9439-9474 10217-10292	Dakota Nugget

Task 4. Play and Prospect Definition and Wildcat Wells Location Determination: New Exploration Technology Demonstration

This portion of the study is of course contingent upon the above mentioned progress.

Task 5. Well Demonstrations: Exploration Technology and New Stimulation

This portion of the study is of course contingent upon the above mentioned progress and is scheduled for the latter portion of the study.

Task 6. Project Integration and Technology Transfer: Workshops, Briefings, and Publications

We have no activity to report at this time.