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Quarterly Progress Report
(January – March 2009)

DRILLING AND PRODUCTION TESTING THE METHANE HYDRATE RESOURCE POTENTIAL ASSOCIATED WITH THE BARROW GAS FIELDS

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Prepared for:
United States Department of Energy
National Energy Technology Laboratory

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Office of Fossil Energy

TENTH QUARTERLY PROGRESS REPORT

JANUARY – MARCH 2009

CHARACTERIZATION AND QUANTIFICATION OF THE METHANE HYDRATE RESOURCE POTENTIAL ASSOCIATED WITH THE BARROW GAS FIELDS

DOE Project Number: DE-FC26-06NT42962

Awarded to

North Slope Borough, Alaska

Project Director/Manager: Kent Grinage

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Principle Investigator

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DISCLAIMER

EXECUTIVE SUMMARY

Phase 2 of this project commenced December 1, 2008, followed immediately on December 2 with a kick-off meeting in Barrow between the Petrotechnical Resources of Alaska (PRA) technical team and North Slope Borough project management team. In this, the second quarter of Phase 2, and the tenth project quarter, the team visited Barrow to review logistics and permitting issues; attended a project kick-off meeting with DOE-NETL in Morgantown, W. Virginia; completed work on the revised Project Management Plan; completed the Technology Status Assessment; modeled production from a horizontal gas production well with associated hydrate dissociation due to reservoir depressurization; designed and initiated a procurement plan for services and equipment required to complete the project; and made significant progress on well design for a pilot/monitoring well and a horizontal production well, including publication of a topical report describing the well design effort.

PROGRESS, RESULTS AND DISCUSSION

TASK 1: Project Management Plan (PMP) and Project Reporting

The revised PMP was submitted during the kick-off meeting in Morgantown, January 22, 2009, and based on discussion between NETL and the project technical team after the kick-off meeting, further revisions were agreed and incorporated in the final PMP. Final revisions to this document were completed February 4, 2009. This document spells out the details of the project activities, deliverables, milestones, budget, and schedule for the five-year project term, and considerable dialogue between the North Slope Borough, DOE-NETL and PRA representatives contributed to the final document.

TASK 2: Establish Technical Advisory Group

A technical advisory group was established to:

- Provide ad-hoc technical advice to the project team
- Assist in peer review of key project plans and decisions
- Advocate on behalf of the project as appropriate

A list of TAG candidates was compiled by DOE-NETL and the project PI, and a solicitation letter was sent out on February 27, 2009. A group of seven individuals were confirmed as TAG members:

Bob Fisk, BLM
Bruce Hermann, MMS
David Schoderbek, COP
Tim Collett, USGS
Brian Anderson, WVU
Carolyn Ruppert, USGS
Paul Hanson, BP

The first TAG teleconference/WebEx meeting was held April 6, 2009 to discuss well design and instrumentation plans. Five of the seven members of the TAG participated in the meeting (Schoderbek, Collett, Anderson, Ruppert, and Hanson), as well as Ray Boswell, Rick Baker and Rob Vagnetti from DOE; Steve MacRae and Kent Grinage from the North Slope Borough, and Tom Walsh, Pete Stokes, Julia Belli, Mike Cook, and Mike Dunn from PRA.

After an introduction by DOE project officer Rob Vagnetti, Tom Walsh provided an overview of Phase 1 of the project, and an intro to plans and preliminary work done on Phase 2. Mike Dunn presented detail of the fine scale modeling that was done early in Phase 2 to determine how a monitoring well would be capable of detecting hydrate dissociation and how the model results were used to modify the design of well plans for monitoring and production wells.
Dunn also described the temperature monitoring that would be accomplished through DTS instrumentation of the observation well, as the modeling predicts will be observed over time as hydrates dissociate. He discussed the fact that the location of the hydrate test well at East Barrow was changed from the EB19 well site to the EB18 site due to well log analysis done by the USGS showing that the EB19 well logs did not indicate hydrates while the EB18 well logs did indicate hydrates.

Mike Cook reviewed details of the well construction and completion designs of the observation well and the horizontal producing well.

Round table discussion focused on details of drilling operations, including build angles to get horizontal at shallow target depth in unconsolidated lithologies; coring and core analysis details; decision point criteria and timing; reservoir modeling input parameters, specifically initial water, free gas and hydrate saturations in the hydrate stability zone; and distance between a production and monitoring well at Walakpa optimized to detect changes in the HSZ in such a large gas container. The discussion was very helpful to the project technical team, and the following action items were agreed:

1) Send minutes from the call to the TAG.
2) Send out follow up discussions on the simulation saturations to the TAG.
3) Prepare and send out a straw man of the coring analysis, staffing and decision matrix for comment by the TAG.

Action item 1 has been completed, and discussions are ongoing regarding item 2. The straw man coring and analysis plan is scheduled to go out to the TAG by May 17, 2009 for comment prior to publication of the Request for Proposals for solicitation of project services and equipment.

TASK 3: Design optimized well drilling and completion

Well design work was a key activity during this quarter, with progress made in a variety or areas. Fine grid reservoir simulation modeling was completed in order to address the question of whether or not we are able to dissociate hydrates through depressurization of the reservoir, and if we are able to detect measurable changes in temperature in a monitoring wellbore near the horizontal producer in order to detect the changes in the hydrate stability zone. Significant changes in the program design occurred as a result of further review of the surveillance aspect of the research. Originally, we had planned to drill a vertical pilot well to core and log the Barrow Sandstone interval, and if successful in proving the existence of in-situ hydrates, we would sidetrack that wellbore to drill a horizontal production wellbore, equipped with distributed temperature survey (DTS) instrumentation to monitor changes in temperature of the reservoir. After initial discussions of this plan, we decided that the production of gas in the wellbore would compromise the value of our temperature observations, and we have now shifted to a two well program, with one pilot/monitoring well, and a separate horizontal producer nearby. Specification of the mudlogging, LWD and wireline logging, and coring and core analysis are progressing, and fairly detailed specification of all aspects of the program will be included in the request for proposals to be published May 24, 2009, after technical advisory group review of all specifications.

Fine Scale Modeling:

At the East Barrow Field, two potential locations were evaluated as optimal hydrate test well sites, based on geosciences data, reservoir issues, surface constraints, and logistical considerations. Both proposed subsurface locations are expected to intersect the modeled base of the hydrate stability zone within the Barrow sandstone, and both are located near seismic lines. As shown in Figure 1, these two primary candidate areas are 1.) at the crest of the structure near well No. 19, and 2.) near the crest of the structure adjacent to wells No. 18 and No. 21.

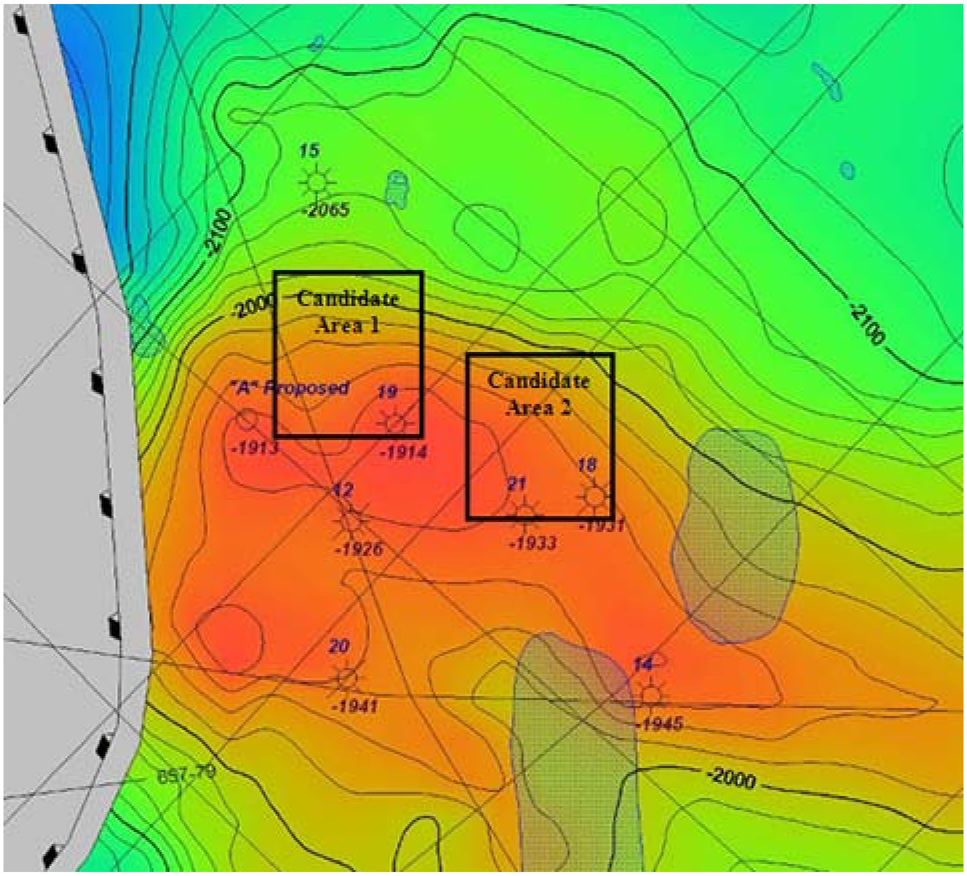

Figure 1: Map of East Barrow Gas Field with Candidate Hydrate Test Well Locations

One of the fundamental factors to consider when determining whether and where to place the observation and producer wells is: what changes are expected to occur within the hydrate interval over the course of the production test. To answer this question, a fine gridded reservoir model was developed over one of the areas (candidate area No. 1), to predict how the hydrate zone would dissociate due to downdip free-gas production.

As a result of the simulation work to predict the status of the hydrate zone at current time, and how the current hydrate interval is expected to change over 5 years of production, several observations and conclusions are noted, as listed below:

- The expected case shows hydrate decomposition occurs from below (from the original free gas/hydrate interface), and away from the overburden and underburden. At the time the observation well is drilled, at least one interface is expected.
- As a practical matter, other possible scenarios may be found at the observation well including 2.) A full column of hydrate, with no interface. Or, 3.) Very little to no hydrate.
- The full column of hydrate case was artificially created by turning off thermal properties of the overburden and underburden. This could have also been created by adjusting other input values such as reducing the percent of free gas phase, which would reduce pressure transmission through

the hydrate. The smaller column of hydrate was created by using a higher temperature of overburden and underburden, leading to more hydrate dissociation. This could also have been created by reducing the thickness of the hydrate zone, or decreasing the hydrate saturation below the figure that resulted in the best history match.

- Uncertainty surrounding the actual location of hydrates and the exact depth of the hydrate/free-gas interface must be acknowledged and considered when choosing the optimal location of the observation well and producer well.
- This work suggests that an observation well near the crest of the structure is a good location and is expected to see adequate hydrate and an interface to monitor.
- This work suggests that a horizontal well in the free gas leg, producing at 1 MMscfpd, will cause enough pressure lowering to cause hydrates at the observation well to dissociate.

Fine-Grid Simulation Modeling – Temperature Modeling

The fine-grid simulation has determined that if a hydrate column is present near the crest of the structure, there will be dissociation of hydrates at the location of an observation well due to production from a downdip high angle producer. The question then becomes, what measurements can be taken to prove that dissociation is occurring, and, and what can be done to measure hydrate behavior over time. Given the endothermic nature of hydrate dissociation, it was postulated that continuous monitoring of temperature could be used to meet these objectives.

To test this theory, the temperature of the grid-blocks at the wellbore was recorded over time. The result is the plot shown in Figure 2 below.

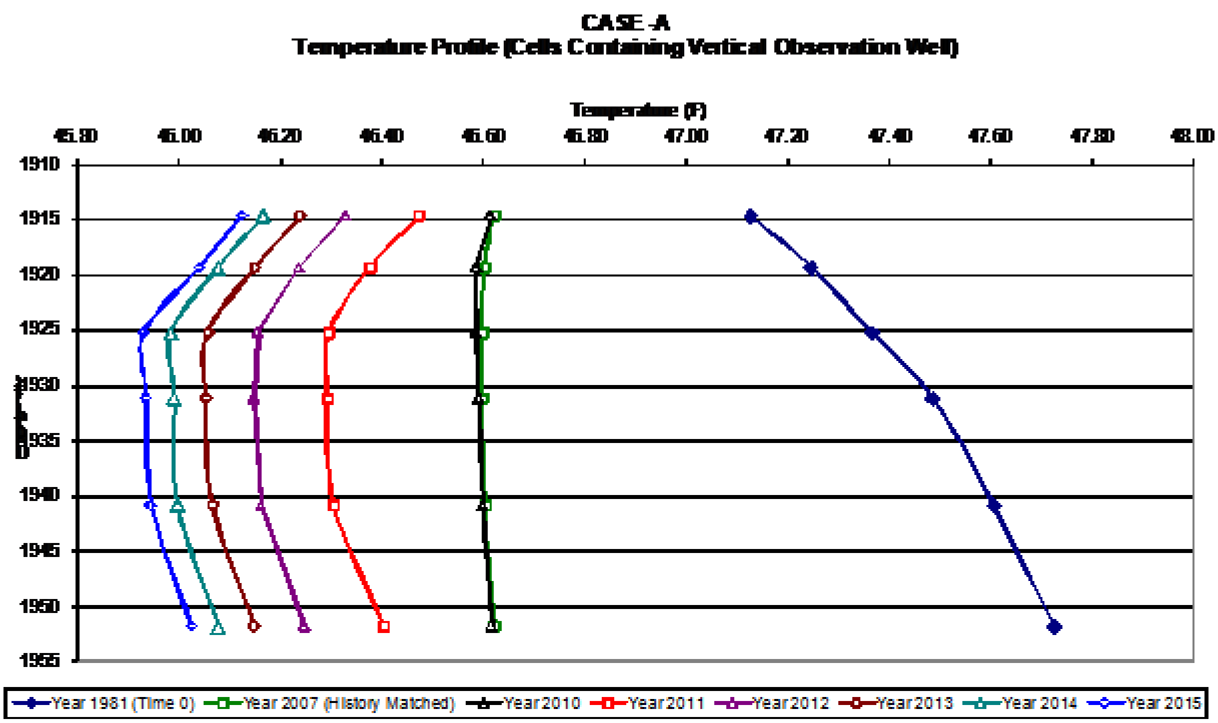

Figure 2: Case A, Simulated Temperature Response over Barrow Sand, span of 5 years of production

The results of this work indicate that continuous temperature monitoring with distributed temperature survey (DTS) will be an acceptable way of proving that hydrates are present, and that hydrates are dissociating due to downdip production and resulting depressurization.

Basic Well Design

Based on the work to date, including the fine-grid reservoir modeling, wellbore temperature modeling, and evaluation of optimal drilling locations, a design has been selected to optimize trade-offs and provide the necessary data to measure and monitor the hydrate zone.

Several well designs were considered. To provide a framework for the evaluation, a set of objectives and priorities was established. It was determined that the well configuration had to meet the following minimum requirements:

1. The stratigraphic test well had to provide physical evidence that if hydrates were present, they could be confirmed with core and/or electric logs.
2. If hydrates are present, the stratigraphic test well should be able to be completed as an observation well for long term monitoring.
3. The observation well should not be disturbed by production, so that it can provide a “quiet” monitoring site to measure the temperature response of a hydrate zone undergoing pressure induced dissociation from an offset production.
4. The high-angle or horizontal well should provide a way to drill (sample) as much reservoir rock as possible, while travelling from a zone with hydrates, toward a zone of free gas.
5. The producer well should provide a production well bore that would allow for significant enough rate to cause a pressure reduction and dissociation at the nearby observation well.

Given these requirements, the well design that was selected for the East Barrow Field is shown in Figure 3

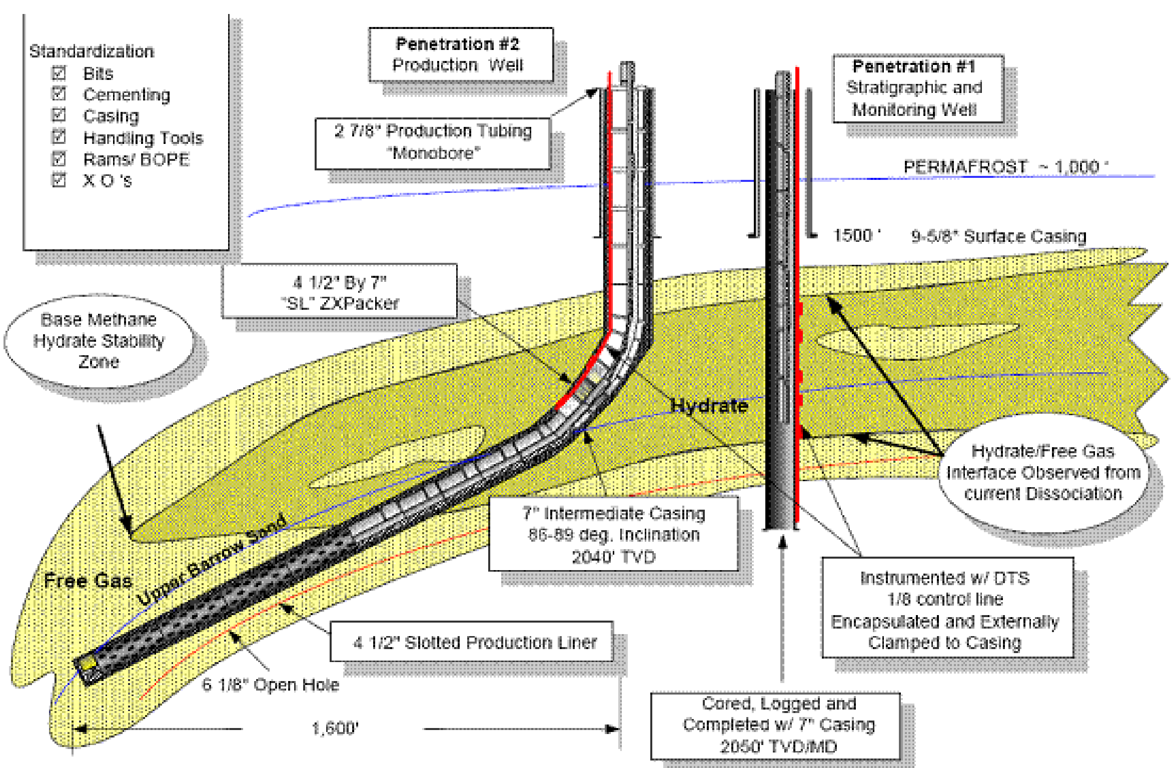

Figure 3: Pilot/Monitoring Well and Horizontal/High Angle Production Well Design

TASK 4: Design surveillance program and "smart well" components and conduct Phase IIA surveillance and monitoring

Preliminary design work and specification was outlined in this quarter, to identify the objectives, scope, equipment, and expectations for surveillance to detect changes in the hydrate stability zone as a function of free gas production and depressurization.

After data has been captured during the drilling phase, and assuming hydrates are confirmed and an observation well and producer well are completed, there is a comprehensive, long-term data gathering effort planned for the two wells. The primary objective of this data program is to measure how the hydrate behaves over time, as it is de-pressured by production from the down-dip free gas leg.

The production-phase data gathering program consists of two main categories – real time temperature monitoring of the wellbore, and analyses of produced fluids. A high-level discussion of these plans is given in the following two sections.

Distributed Temperature Survey

Distributed temperature survey (DTS) was first used on hydrate wells at the Mallik project in 2004 (Henninges, 2005). This project proved that DTS is an excellent way to measure and monitor the endothermic nature of hydrate dissociation. A similar program is planned for the Barrow Gas Fields.

DTS uses a continuous fiber-optic cable to measure the exact temperature, over time, along the wellbore where the cable has been installed. The fiber-optic distributed temperature measurement uses an industrial laser to launch nanosecond bursts of light down the optic fiber. During each passage of light packet, a small amount is back-scattered from molecules in the fiber. This back-scatter is a function of the temperature of the fiber, and therefore can be analyzed to determine the exact temperature along the entire length of the fiber. Spectrum acquisition times can be varied from as little as few seconds, to hours, which defines the accuracy and resolution of the measured temperature log. Typical resolution of 0.1 degrees Celsius is used for downhole reservoir surveillance applications. A graphical plot of the temperature along the well is generated, and which can be analyzed over time.

DTS cable is planned for both the observation well and the horizontal producer well. The DTS in the observation well will be used to monitor the change in temperature as the hydrates dissociate and lose heat, due to the endothermic reaction as hydrates dissociate to free water and gas. DTS is planned for the producer well to monitor temperature at the producing sand face to measure temperature change that may be a result of Joule-Thompson cooling. Given the relatively low cost to install the line, and valuable, long term data that is expected, there is no reason to limit DTS to the observation well.

The DTS fiber optic cable is typically installed inside a ¼” stainless steel control line, similar to control lines that are installed for control of sub-surface safety valves. Clamps and procedures that have been developed for other control-line installations are used to install DTS cables. There are at least two companies that manufacture and install their own systems. There are also several oilfield service companies that purchase these systems from the original manufacturers and install these systems all over the world. The system has become a common and reliable way to conduct reservoir surveillance in many different types of oil and gas production wells, and is not limited strictly to hydrate test wells.

Geochemical Analysis of Produced Fluids

Indirect evidence in the form of petrophysical, geophysical, geochemical, pressure, and temperature data will be gathered to support the presence of hydrate and measure its properties and behavior. Geochemical detection involves analysis of formation water and gas composition and isotopic fractionation to determine the presence of hydrate gas, the source of the gas, and the processes leading to the formation and dissociation of the hydrate. Pore water freshening, coupled with presence of large amounts of methane has been documented as an indicator of hydrate occurrence (Hesse and Harrison, 1981). Gas samples from the Barrow Gas Fields have been collected and analyzed on several occasions, and compositional and isotopic analysis of samples from 9 wells (three from each field) has been completed. Additional samples will be collected and tested as part of this program. Samples will be analyzed and compared to older samples to determine whether geochemical changes are taking place as a result of hydrate dissociation.

TASK 5: Prepare Request for Proposals and evaluate contractor bids

The procurement process is well underway, including: identification of all services and equipment necessary to complete the project; publication of a Request for Unpriced Technical Offer/Request for Qualifications; creation of an index of service companies and equipment providers, and their contact info; and organizing and hosting a meeting of all interested vendors.

Interested vendors are required to respond to the RUTO/RFQ by May 1, 2009, and interested and qualified respondents will be sent a Request for Proposals packet beginning May 24. The RFP packet will include fairly detailed specification of all aspects of the project.

TASK 6: Permitting

Extensive effort has been ongoing throughout this quarter to establish permitting requirements for the project, and engage with agencies regarding project activities which trigger permitting action. The following outline was established to keep track of key permitting deliverables.

Task 6 Permits to Drill & Complete Well
6.1 Compile listing of all required permits
6.1.1 Permit Scoping Document outlining surface use proposed, routes/drill locations, water needs, power needs, camp/support facilities, power generation equipment, proposed waste management.
6.1.2 Finalize research on eiders and lake level recovery.
6.1.3 Determine if additional lake study data is available for east gas field water sources
6.1.4 Determine BLM right-of-way applicability and timeline
6.1.5 Determine Spill contingency applicability and timeline
6.1.6 Research NSB permit history
6.1.6.1 Evaluate need for garvel placement
6.1.7 Solicit and incorporate input into Draft Scoping Document for a final working draft.
6.1.8 If appropriate, utilize technical consultants to identify any long lead time air permitting
6.1.9 Develop list of permits and permit schedule
6.1.10 Conduct agency outreach to validate permit list and schedule and to solicit input on issues of concern/study needs

6.2 Prepare and submit required permits to agencies
6.2.1 Research and advance permitting for summer studies

6.2.2 Prepare and review drilling permit applications
6.2.3 Submit permit applications for East Barrow and Walakpa wells
6.3 Monitor permit status and provide Agency Follow-up
6.3.1 Conduct application meeting with agencies
6.3.2 Respond to agency questions/clarifications
6.3.3 Attend public meetings/ respond to agency questions
6.3.4 Track permit review
6.3.5 Obtain permits (must be 130 days from application submittal above)

6.4 Plan and Monitor Field Operations and Post Well Follow-up
6.4.1 Prepare field compliance manual
6.4.2 Conduct training for drilling operations
6.4.3 Track field work and provide support on permit compliance - East Barrow Well

6.4.4 Track field work and provide support on permit compliance - Walakpa
6.4.5 Follow up on permitting post wells

Numerous teleconferences and meetings have taken place between the DOE, NSB, PRA, USFWS, and USACE, and significant progress has been made toward the goal of securing all permits necessary to complete the project.

Project Milestones:

Table 1. Milestone Plan for NSB Methane Hydrate Phase II Project

Task	Milestone	Due date	Comments
1	Updated Project Management Plan	1/12/09	Compl 2/4/09
1	Technology Status Assessment Report	2/6/09	Compl 2/26/09
2	TAG Members Confirmed	2/13/09	Compl 2/27/09
3	Well Drilling and Completion Plan Review submitted to TAG	3/16/09	Compl 3/16/09
3	RFP Specification Review submitted to TAG	5/1/09	On schedule
4	Well Instrumentation Plan Review submitted to TAG	3/16/09	
5	Request for Unpriced Technical Offer/Request for Qualifications Document	3/27/09	
5	Request for Proposal (RFP) with Specifications Documents	5/12/09	*
5	List of Prime Contractor selected for contracted service, equipment and materials	9/18/09	
6	Permits required for Drilling Methane Hydrate Test wells at E. Barrow and Walakpa Fields	2/9/10	
7	Approval for Drilling and Authority for Expenditure Topical Report	9/30/09	*
	Proceed to Budget Period 4	**12/1/09**	
8	Updated Project Management Plan	12/21/09	
9	Contracts between NSB and all Prime Contractors providing services, equipment and materials	4/30/10	
10	Hydrate Test Well Drilled, cored and logged at East Barrow	11/30/10	*
10	****DECISION POINT** Complete or Abandon Hydrate Test Well Drilled at East Barrow**	11/30/10	
10	Technical Presentation on Drilling of Hydrate Production Test Well	11/18/10	
11	Hydrate Production Test Well and Reservoir Surveillance Data and Analysis Topical Report	8/6/10	
	****DECISION POINT** Proceeding to Task 12 requires the written authorization of the DOE and the NSB**	**12/1/10**	
12	Updated Project Management Plan	12/22/10	
13	Hydrate Test Well Drilled, cored and logged at Walakpa	6/30/11	*
13	****DECISION POINT** Complete or Abandon Hydrate Test Well Drilled at Walakpa**	6/30/11	

Accomplishments

- Updated Project Management Plan
- Completed Technology Status Assessment
- Established and teleconferenced with Technical Advisory Group
- Designed and initiated procurement process
- Completed Fine Scale Reservoir Modeling
- Significantly matured well design
- Established and initiated permitting process
- Completed topical report on well design

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