Oil & Natural Gas Technology

DOE Award No.: DE-NT0006553

Progress Report
Fourth Quarter 2008

ConocoPhillips Gas Hydrate Production Test

Submitted by:
ConocoPhillips
700 G Street
Anchorage, AK 99501

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

February 27, 2009

Office of Fossil Energy

Executive Summary

Accomplishments

- Completed Project Management Plan, including Technology Status Assessment
- Identified site selection methodology
- Short-listed 117 exchange field trial candidate sites

Current Status

- Site Identification activities are well underway with targeted completion of 3/31/09

Introduction

Work began on the ConocoPhillips Gas Hydrates Production Test (DE-NT0006553) on October 1, 2008. This report is the first quarterly report for the project and summarizes project activities from October 1, 2008 to December 31, 2008. Work during this period focused on two primary objectives: 1) drafting, review, and approval of the Project Management Plan, and 2) initial efforts to identify sites suitable for the Production Test (Site Identification).

Project Management Plan

The Project Management Plan includes a detailed description of work to be performed along with timelines, milestones, and risk management and mitigation strategies. ConocoPhillips submitted a draft Project Management Plan to NETL on November 6, 2008. After incorporating comments and feedback from NETL, ConocoPhillips submitted a final draft of the Project Management Plan on November 26, 2008.

The Project Management Plan outlines three objectives for the Production Test as follows:

1) Validation of the laboratory-proven production process whereby methane gas is produced from a hydrate structure by carbon dioxide exchange

2) Determination of the impact of injecting carbon dioxide on a hydrate-saturated reservoir & understanding the impact on permeability and production performance

3) Determination of how the carbon dioxide/methane exchange process can be advanced to the next level of testing i.e. pilot scale field evaluation

The project is divided into three phases: Site Identification (Phase 1), Field Test Planning (Phase 2), and Field Testing (Phase 3). Site Identification (Phase 1) began October 1, 2008, and is scheduled to be complete by March 31, 2009.

An important component of the Project Management Plan is the risk management plan. Risk identification, quantification, and development of mitigation steps (where appropriate) are elements of ConocoPhillips' project execution procedures. For this process, a macro-enhanced Excel tool called a Risk Register has been developed. The Risk Register for this project currently contains 27 entries.

Completion of the Project Management Plan required a Technology Status Assessment which ConocoPhillips submitted on November 26, 2008. The Assessment reviews production from methane hydrates in Russia's Messoyakha field and provides a review of recent tests at Mallik on the Mackenzie Delta and in the Milne Point Unit on Alaska's North Slope. Our Assessment also describes the experimental development of CO_2/CH_4 exchange technology.

Site Identification

Site Identification is a complex undertaking critical to the success of the Production Test. Before other attributes such as existing infrastructure, impact on continuing operations, and contractual issues can be analyzed, a site must be chosen that has high confidence of gas hydrate occurrence. As indicated on the Project Schedule/Timetable, activities during the 4th Quarter, 2008 focused on evaluation of wireline logs to identify those sites where gas hydrate presence can be inferred. A spreadsheet was built to capture ConocoPhillips' initial estimation of hydrate reservoir occurrence, thickness, and log quality comments. A graphical summary of inferred gas hydrate interval thickness is included as Chart 1.

Discussion

Approach

Gas hydrates in the Prudhoe Bay/Kuparuk River area of the Alaska's North Slope are present in the terrigenous Brookian sequence and are most prevalent in high-porosity, high permeability sandstones of the Sagavanirktok Formation. Site identification methodology utilized by ConocoPhillips has three aspects: interval recognition, criteria determination, and candidate selection.

Interval Recognition: Gas hydrate deposits occur within and below the ice-bearing permafrost on Alaska's North Slope, since the gas hydrate stability zone includes temperatures that are below and above freezing point of water. Early in our site selection process, we elected to pursue only below-permafrost targets for two reasons. First, it is very difficult to differentiate ice-bearing sandstones in the permafrost from hydrate-bearing intervals from well log or seismic data. Second, our CO_2/CH_4 exchange experiments have been conducted at 4°C and we desire to perform our initial exchange field trial at similar conditions. This temperature corresponds to approximately 400ft below the base of permafrost. The overall interval in which we searched for gas-hydrate bearing sandstone candidates started at the base of permafrost and extends downhole to the base of the gas hydrate stability zone (BGHSZ). Though the depth of permafrost has been mapped regionally, it is not a pick that can be made easily in every well. We devised a permafrost depth calculation based on well coordinates, which in turn reflects regional permafrost contours. Once the depth of permafrost was calculated, we used the publically available "CSMHYD" program to predict the depth of the BGHSZ, based on assumptions of pore water salinity, density of the hydrostatic column, gas composition, and geothermal gradient. For each well in our ConocoPhillips proprietary database, depth of permafrost and depth of BGHZ was calculated & posted on each digital log.

Criteria Determination: The primary dataset for site identification is wireline logs from existing wells. All wells drilled on the North Slope have penetrated the gas hydrate stability zone, though less than one sixth of these wells have been logged between base of permafrost and base of gas hydrate stability zone. Bob Lankston and David Schoderbek, the two primary COP investigators in this phase, met October 17 with Tim Collett, Myung Lee, Warren Agena, and several of their geophysical colleagues at USGS in Denver. The main goal of this meeting was to understand previous gas hydrate work performed by the USGS and to assure accurate calibration of ConocoPhillips site selection well log criteria to existing USGS evaluations (e.g. Collett, 1993). Interpretation of hydrate intervals is based on the concept that sandstones with gas hydrate in their pores exhibit high resistivity and high velocity (short transit time), like their ice-bearing counterparts. Collett (1993) summarized sonic & resistivity log criteria to identify gas hydrate-bearing sandstones: resistivity fifty times greater than associated water-bearing sandstones and sonic transit time forty microseconds per foot faster than adjacent wet sandstones. For our scoping site identification, we examined numerous North Slope logs and modified the aforementioned criteria into log cutoffs that allowed rapid screening of many well logs. A quick-look interpretation of the available well log data was performed with cutoffs based on the USGS criteria (Table 1). Sandstone with pore-filling gas hydrate is inferred to have gamma ray log response less than 55 API units, sonic transit time less than 140 microseconds per foot, and resistivity greater than 30 ohm-meters.

Table 1. Log Interpretation Cutoff Parameters for Hydrate Identification

Measurement	Cutoff Value
Gamma Ray (GR)	< 55 API
Resistivity (Rt)	> 30 Ohm-m
Sonic Slowness (ΔT)	< 140 μsec/ft

Our initial log review identified sandstones with variable resistivities, which may reflect variable gas hydrate saturations. A recent publication by Gomez et al (2008) describes the simultaneous calculation of both porosity and gas hydrate saturation. Once the model is appropriately parameterized, only two inputs are required: acoustic impedance (product of velocity and density) and resistivity (normalized by wet-sand resistivity). Research was initiated to determine if the method of Gomez et al (2008) added incrementally to conventional Archie-equation computations of gas hydrate saturation. Evaluation was underway at the end of Q4’08 and will be reported on in subsequent quarterly reports.

<u>Candidate Selection:</u> Of the 5700 wells present in our database, only 900 have gamma-ray, sonic, and resistivity logs over our zone of interest, base permafrost to BGHSZ. Not all 900 wells have full coverage of the zone of interest by unambiguous, high-quality logs. Using the log criteria described above, these 900 well logs were reviewed and interpreted by ConocoPhillips geoscience staff and the “top hundred” candidates were identified. Many short list wells have ambiguous sonic log response due to poor hole conditions and incomplete log overlaps. In addition, we believe partial dissociation of gas-hydrate bearing sandstones during subsequent deeper drilling may have occurred to further complicate wireline log responses. Comparison to well lists generated by historical ConocoPhillips’ in-house studies and Collett (1993) identified additional candidates, and our “top hundred” grew to 117 candidates.

Results & Discussion

Initial scoping for site identification has resulted in the 117-well list displayed below as Exhibit 1. A map of these well locations on Alaska's North Slope is included as Exhibit 2. Two well-log examples are included that illustrate the interpretive determination for inferred hydrate occurrence. Attached as Exhibit 3 are logs from Prudhoe Bay Unit L-106 and Kuparuk River Unit 3M-09.

Conclusion

Many wells exist on Alaska's North Slope with indications of gas hydrate presence. A large number of these sites lack clear-cut, unambiguous wireline log character confirming the presence of gas hydrates deposits. Reasons for this are lack of full log suites and low-quality logs due to poor borehole conditions. Borehole rugosity and washouts are widely known to contribute to poor sonic log responses, and we believe some pre-logging dissociation of hydrate-bearing sandstones may also have occurred. Our next step is to turn our data-gathering spreadsheet into a site ranking matrix. We will do this by the addition of log-quality "confidence" factors; we also plan to integrate data gathered while drilling (mudlogs) and surface seismic data to select sites with the highest confidence of gas hydrate presence.

Cost Status

Expenses incurred during this first three months of the project were below the Baseline Cost Plan as shown in Exhibit 4. There were no Federal expenses forecast in the Baseline Cost Plan and no Federal expenses were incurred. The Non-Federal Incurred Cost was below Baseline Cost Plan as a significant amount of staff time was dedicated to preparation, review, and final drafting of the Project Management Plan. This work on the Project Management Plan impacted the broad engagement of ConocoPhillips personnel in Site Identification activities.

Milestone Status

The Milestone Status Report is attached as Exhibit 5. There were no milestones planned for completion in Q4, 2008.

References:

Collett, Timothy C., 1993, Natural gas hydrates of the Prudhoe Bay & Kuparuk River area, North Slope, Alaska: AAPG Bulletin, v 77, no. 5, pp 793-812

Gomez, Carmen T., Jack Dvorkin, and Gary Mavko, 2008, Estimating the hydrocarbon volume from elastic and resistivity data: a concept: The Leading Edge, v 27, pp 710-718

Chart 1: Inferred Thickness of Individual Hydrate-bearing Sandstones

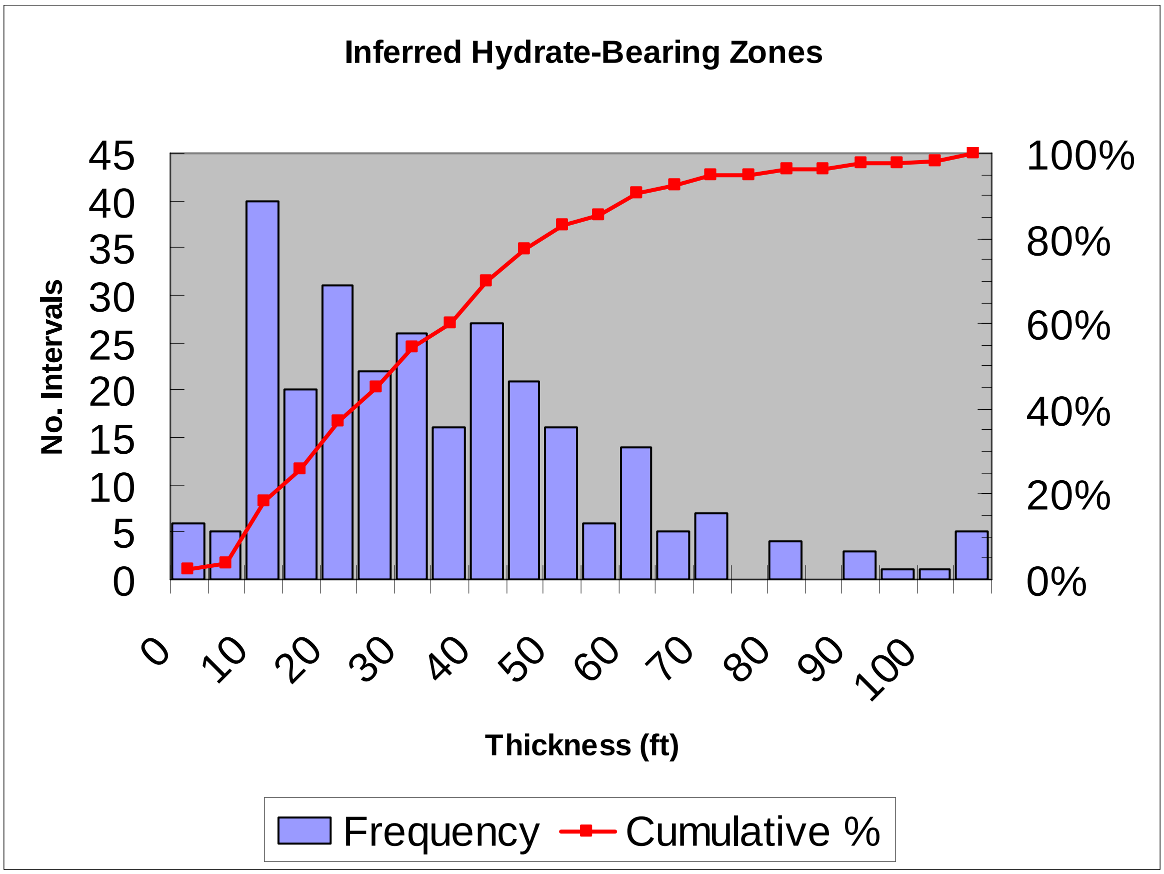

Exhibit 1: Wells with Gas Hydrate Indications

Well Name	Well Name	Well Name
_	_	_
15-11-12	KRU C-1 (1C-01)	RAVIK_STATE_1
1C-08	KRU C-4 (1C-04)	RUBY_STATE_1
1H-06	KRU C-5 (1C-05)	S-03
1J-09	KRU C-6 (1C-06)	SOCAL_33-29E
1Q-09	KRU F-5 (1F-05)	TILL_1
1Q-101	KRU_STATE_1	TOOLIK_3
2B-10	KUP_9-11-12	TW-C
2D-15	KUP_ST_1	UGNU_SWPT_1
2E-15	KUP_ST_7-11-12	V-100
2N-349	KUUKPIK_3	V-105
2P-434	L-106	V-106
3-10-12	L-114	V-107
3C-06	L-116	V-201
3J-09	MELTWATER_N_1	W_KUP_3-11-11
3K-06	MILNE_PT_18-01	W_SAK_13
3M-09	MP_1_17-11-11	W_SAK_15
3N-08	MPU_A-01	W_SAK_16
BEECHY_PT_ST_1	MPU_B-01	W_SAK_17
CASCADE_1	MPU_B-02	W_SAK_2
CHEV_18-11-12	MPU_C-01	W_SAK_20
CIRQUE_1	MPU_D-01	W_SAK_24
CIRQUE_2	MPU_K-25	W_SAK_25
COLV_DELTA_1	MPU_K-38	W_SAK_26
COLV_DELTA_2	MPU_S-15	W_SAK_3
COLV_DELTA_3	MT_ELBERT_1	W_SAK_4
FIORD_1	N_KUP_26-12-12	W_SAK_5
FIORD_2	NANUK_1	W_SAK_6
GWYDYR_BAY_S-1	NANUK_2	W_SAK_9
GWYDYR_BAY_ST_2	NANUQ_3	W_SAK_B-10
GWYDYRBAY_ST_2A	NEVE_1	W_SAK_PLT_5
HIGHLAND_1	NEW4-01 (I-PAD!)	W_SAK_PLT_7
HOT_ICE_1	NW_EILEEN_ST_1	W_SAK_PLT_8I
KALUBIK_1	NW_EILEEN_ST_2	W_SAK_SWPT_1
KAVEARAK_32-25	NWE1-01 (L-pad)	WENOMW01
KRU 1D-1 (1D-01)	NWE2-01	WETW
KRU 1D-5 (ID-05)	PBU SB-01 (S-200PB1)	WINTER_TRAILS_1
KRU 1D-8 (1D-08)	PBU SHB V-200 (V-200)	WINTER_TRAILS_2
KRU 1E-1 (1E-01)	PRUDHOE_1	WINTER_TRAILS_3
KRU 1E-1 (1E-01PB1)	Q-03	WINTER_TRAILS_4

Exhibit 2: Map of Top 117 Wells

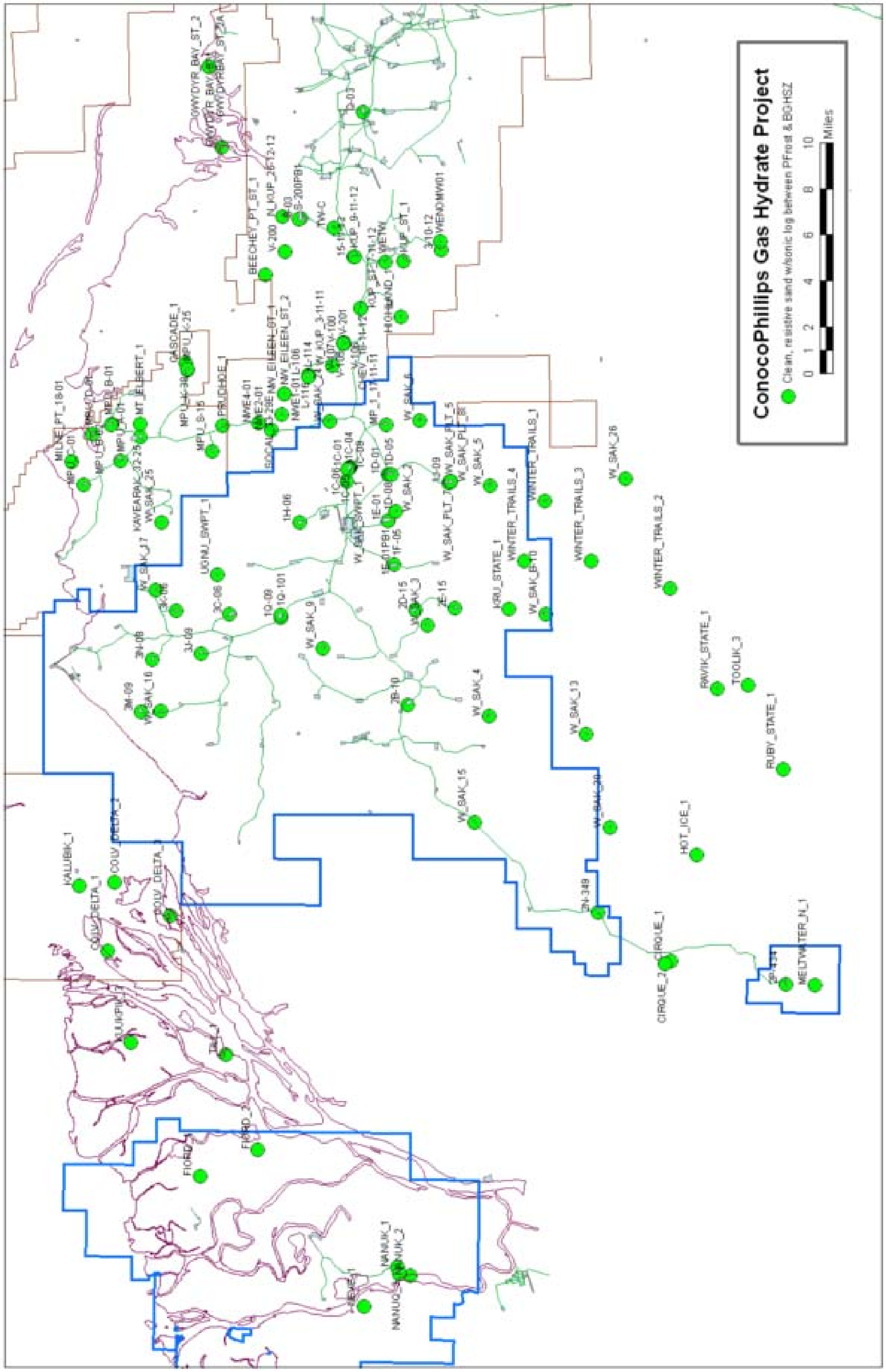

Exhibit 3A: Well-log Example for PBU L-106

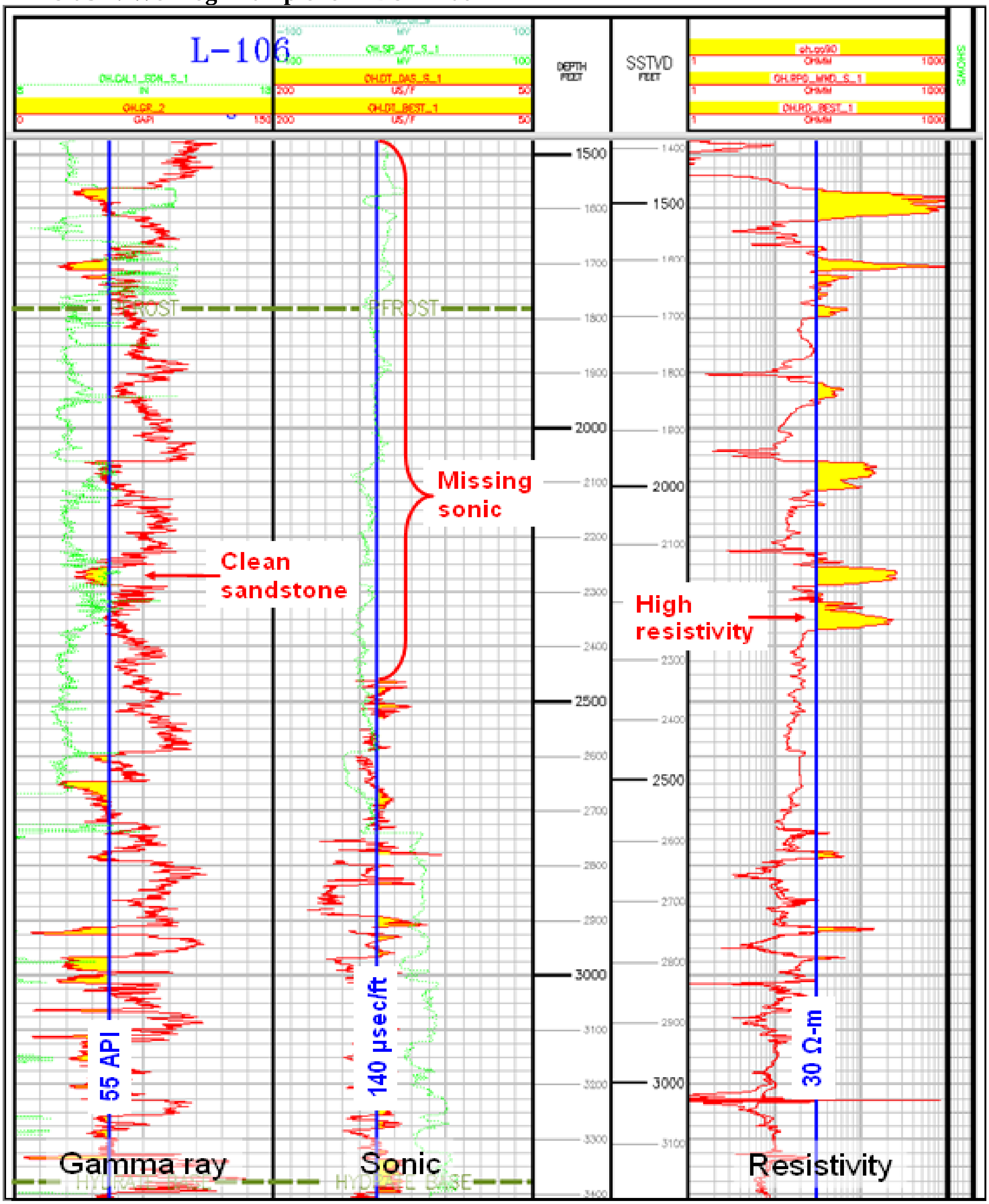

Exhibit 3B: Well-log Example for KRU 3M-09

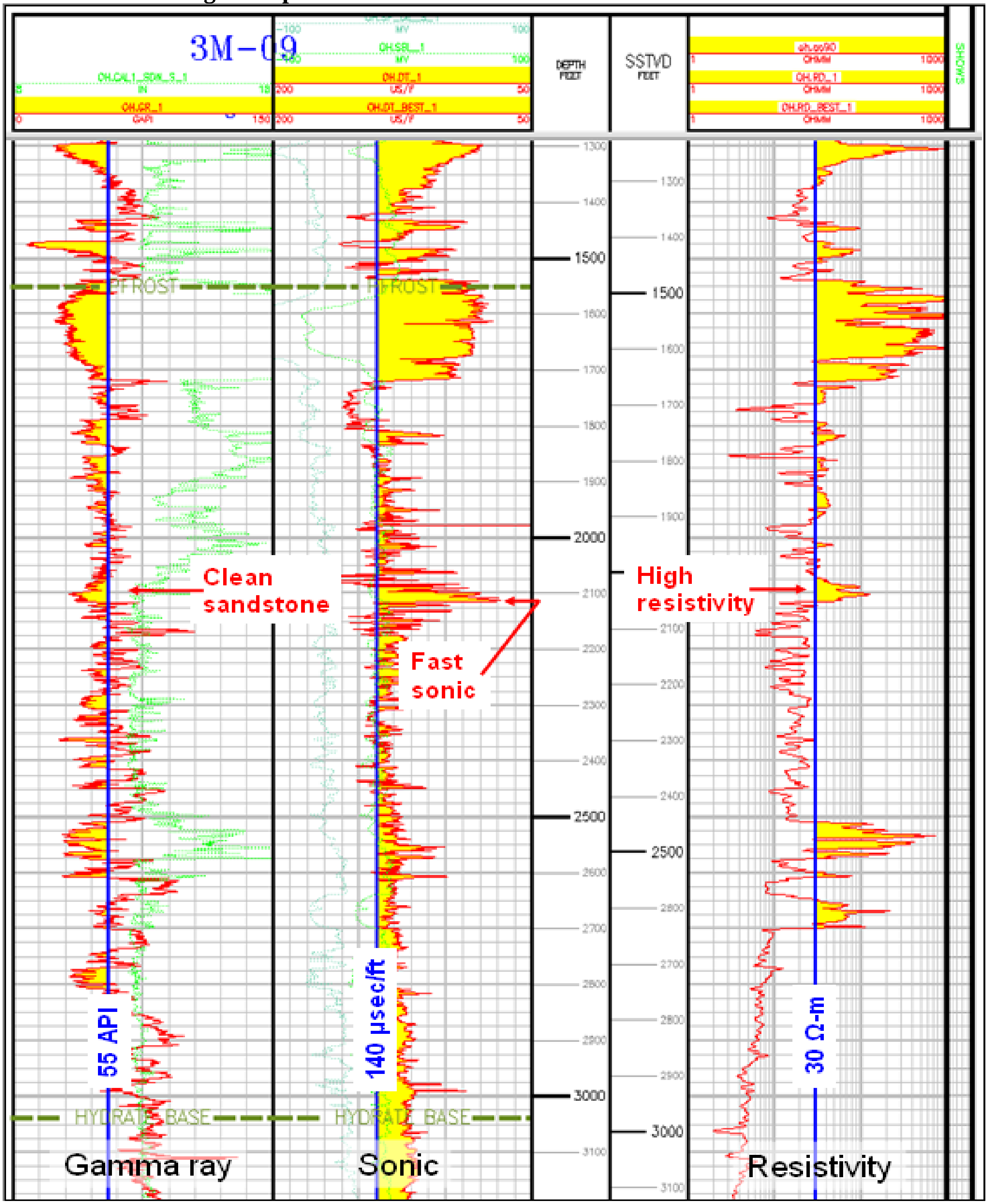

Exhibit 4 - Cost Plan/Status

COST PLAN/STATUS									
Project Phase ==>	Phase 1, Site Ident.		Phase 2, Field Test Planning			Phase 3, Field Test			
Baseline Reporting Quarter ==>	Q408	Q109	Q209	Q309	Q409	Q110	Q210	Q310	Q410
BASELINE COST PLAN									
Federal Share	0	0	60000	1450000	0	8315000	1300000	630000	0
Non-Federal Share	325100	499172	390875	333875	170699	361135	353410	348523	151351
Total Planned	325100	499172	450875	1783875	170699	8676135	1653410	978523	151351
Cumulative Baseline Cost	325100	824272	1275147	3059022	3229721	11905856	13559266	14537789	14689140
ACTUAL INCURRED COSTS									
Federal Share	0								
Non-Federal Share	121012								
Total Incurred Cost	121012								
Cumulative Incurred Cost	121012								
VARIANCE									
Federal Share	0								
Non-Federal Share	-204088								
Total Variance	-204088								
Cumulative Variance	-204088								

Exhibit 5 – Milestone Status Report

MILESTONE STATUS REPORT						
#	Task/Subtask Description	Planned Start Date	Planned End Date	Actual Start Date	Actual End Date	Comments
	Field trial site selected	1-Oct-08	31-Mar-09	1-Oct-08		Work underway
	Partner negotiations completed	15-Feb-09	31-Mar-09			
	Synergies with DOE-BP project identified	1-Mar-09	31-Mar-09			
	Well test designed and planned	1-Apr-09	30-Sep-09			
	Well and reservoir performance predicted	1-Jul-09	31-Dec-09			
	Field testing completed	1-Jan-10	31-Dec-10			
	Injection and production monitoring completed	1-Apr-10	30-Apr-10			
	Well abandonment complete	1-May-10	31-Dec-10			

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:
www.netl.doe.gov

Customer Service:
1-800-553-7681