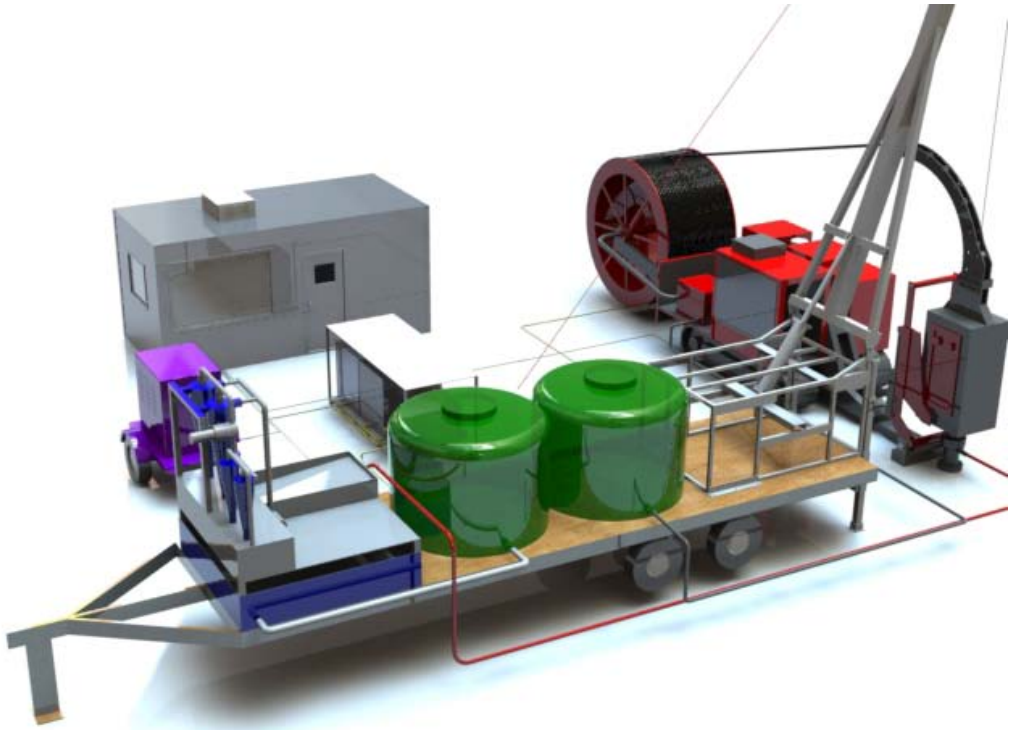


Development of a Hydrothermal Spallation Drilling System for EGS

May 19, 2010

Jared M. Potter, President

Potter Drilling, Inc.

Component R&D

PD GTP Project Overview

Potter Drilling's GTP project:

- **Timeline**
  - Initiated October 2009
  - Completion Date: May 2012
  - 20% complete to date
- **Budget**
  - $7.5 million total project budget with $5 million from the DOE
  - $3.4M in project funding in FY 2010
- **Barriers:**
  - Primary goal: improve Engineered Geothermal Systems (EGS) well construction capability
  - Secondary goals: improve site characterization & EGS reservoir creation
- **Partners:**
  - Professor Jefferson Tester, Cornell University: $600k for laboratory studies of heating technology and mineral dissolution/precipitation

Relevance/Impact of Research

Project Objective:

- Build and demonstrate a working prototype hydrothermal spallation drilling unit that will accelerate commercial deployment of EGS as a domestic energy resource

Why is this technology innovative?

- Greater ROP in hard rock: 30 ft/hr vs. <5 ft/hr using conventional methods
- Non contact: reduced bit wear and tripping
- No weight on bit: better control of trajectory
- Potential for greater well bore stability: fewer casing intervals
- Not depth limited: potential to drill to 30,000 feet with little or no performance degradation

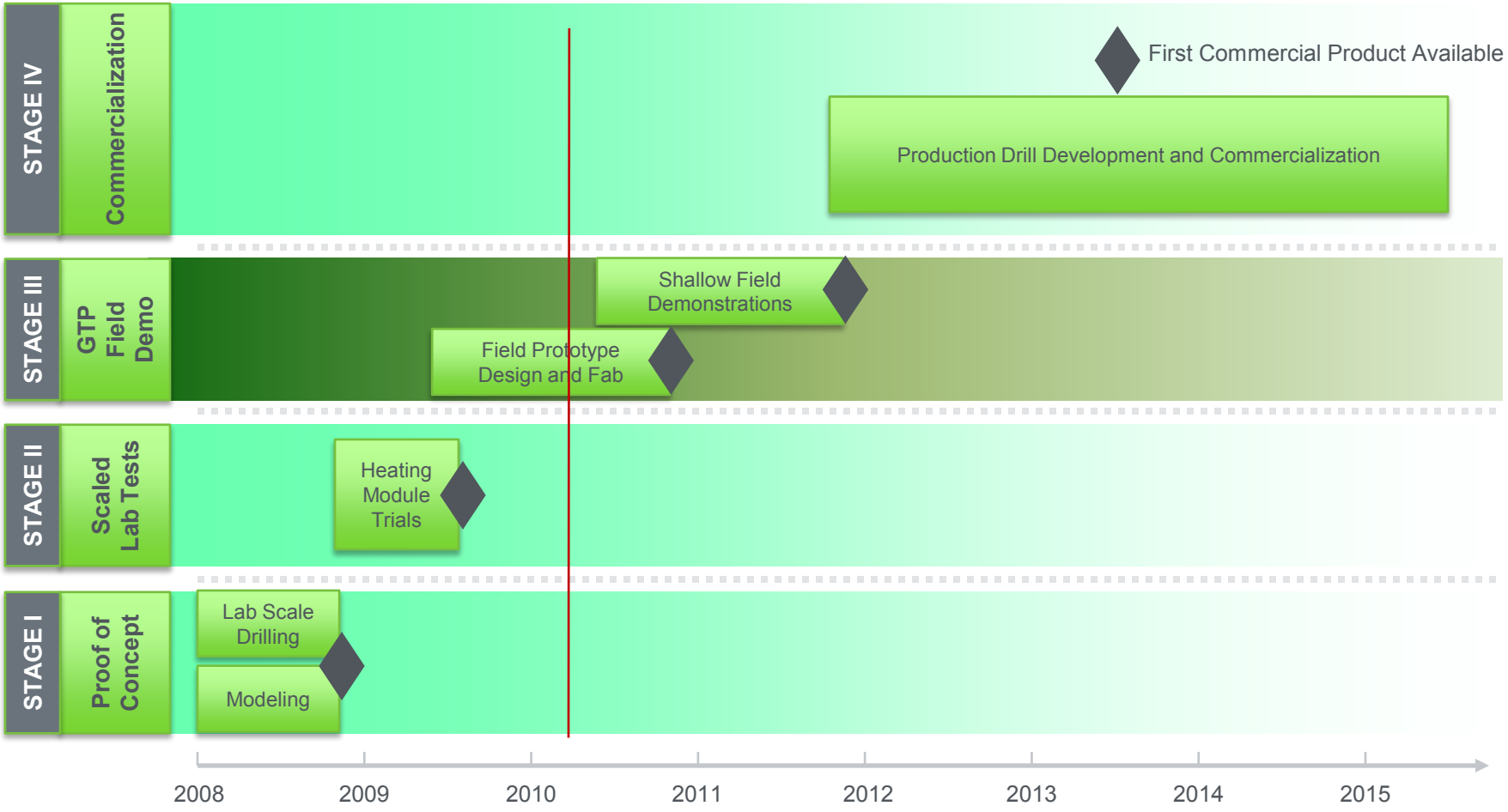
Relevance/Impact of Research

This project will impact geothermal energy development by:

- **Reducing the cost and timeframe for constructing EGS wells by 15-20%:**
  - Improved ROP
  - Reduced tripping
  - Reduced casing and completion costs
  - Enable ultra deep drilling for universal EGS development
- **Improving geothermal reservoir performance by 50 – 200%:**
  - Capability to drill directional slim holes to access stimulated zones from the main wellbore in hydrothermal and EGS production wells
  - Thermal drilling/excavation methods to remove near wellbore impedance and skin damage
- **Establishing a new site characterization technology:**
  - High angle directional drilling for improved resource-fracture identification in hard rock

Scientific/Technical Approach

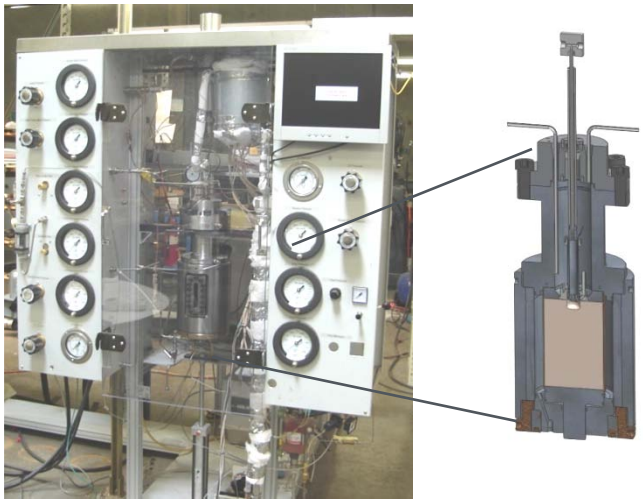
This Project is Stage 3 of a 4 Stage Development Approach



Scientific/Technical Approach

Stage I: Proof of Concept

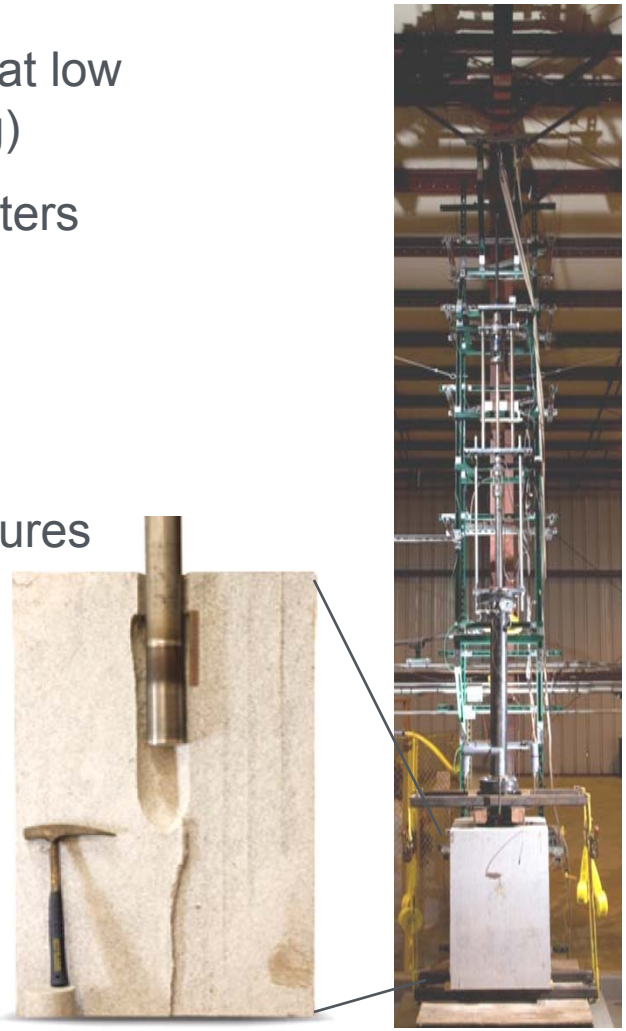
1. Demonstrated that hydrothermal spallation drilling works on small scale core samples
2. Demonstrated the process over a range of borehole pressures and stresses
3. Evaluated nozzle designs, operating temperatures and flow rates
4. Evaluated the effectiveness in a range of different rock types
5. Quantified spall size and changes in rock properties
6. Created new heat flux and ROP models



Scientific/Technical Approach

Stage II: Scaled Lab Tests

1. Demonstrated that hydrothermal spallation works at low pressures (requirement for shallow surface testing)
2. Demonstrated that process scales to larger diameters (>4” borehole)
3. Developed new chemical heating system
    - All liquid
    - “Light-off” at ambient temperatures and pressures
    - Controlled, flameless, jet temperature
4. Demonstrated ability to clear spalls
5. Continued to refine heat flux and ROP models



Scientific/Technical Approach

GTP Project Approach (Stage III):

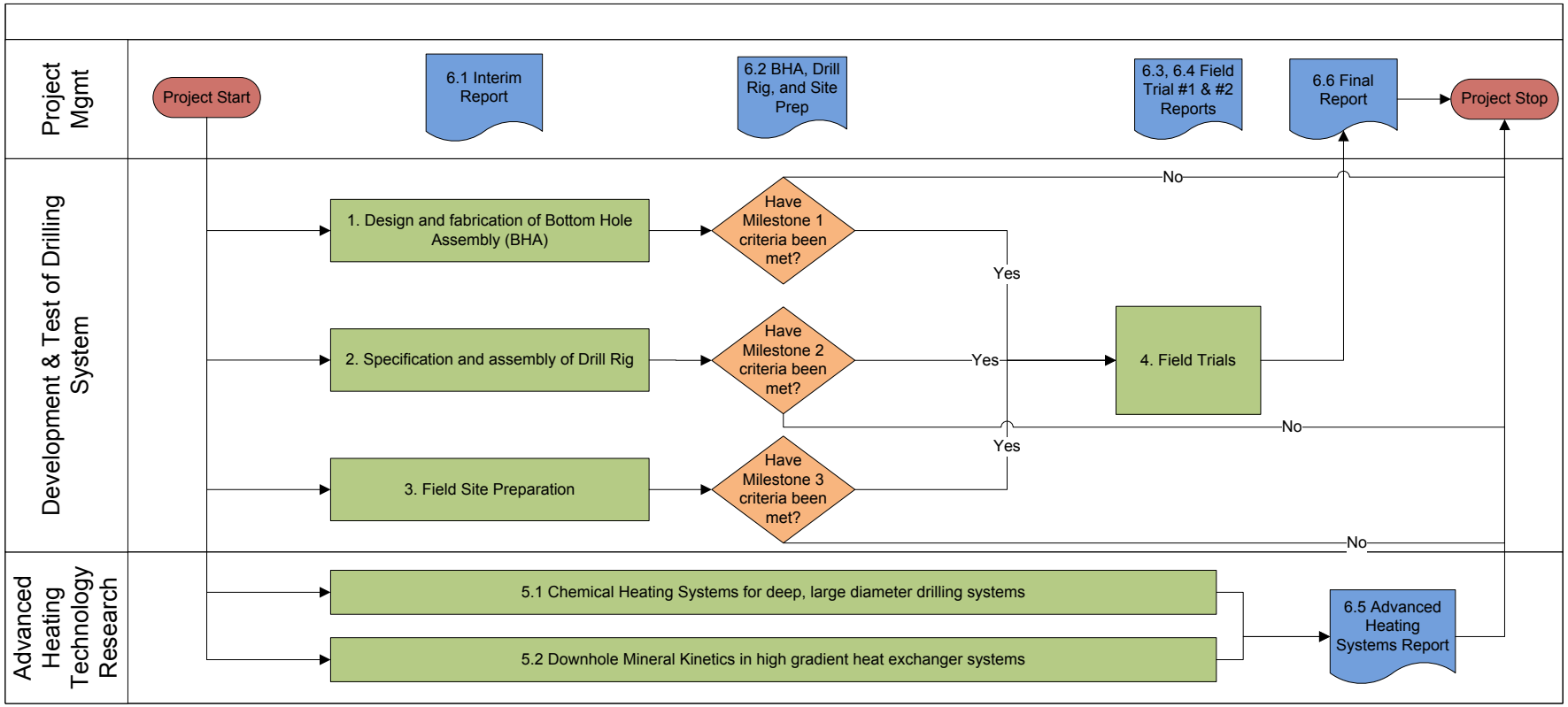
- **Task 1: Design and Fabricate Bottom Hole Assembly (BHA)**: Fully integrated and tested tool with advanced downhole instrumentation.
- **Task 2: Coiled Tube Drill Rig and support equipment:** Integrate a modified CT unit with custom hardware and software control systems.
- **Task 3: Site Preparation**: Prepare three test boreholes at the target field site in Raymond, CA.
- **Task 4: Field Trials**: The three stage iterative field test sequence will allow Potter Drilling to update and modify elements of the prototype based on experiences learned in the field.
- **Task 5- Research on Advanced Heating Technologies:** Laboratory research in conjunction with Prof. Jeff Tester at Cornell University to improve knowledge of chemical heating systems and understanding of very high temperature mineral dissolution-precipitation.
- **Task 6- Project Management and Reporting:** Reports and deliverables relevant to each task and milestone.

Scientific/Technical Approach

FY 2010 Milestones and Go/No Go Decisions

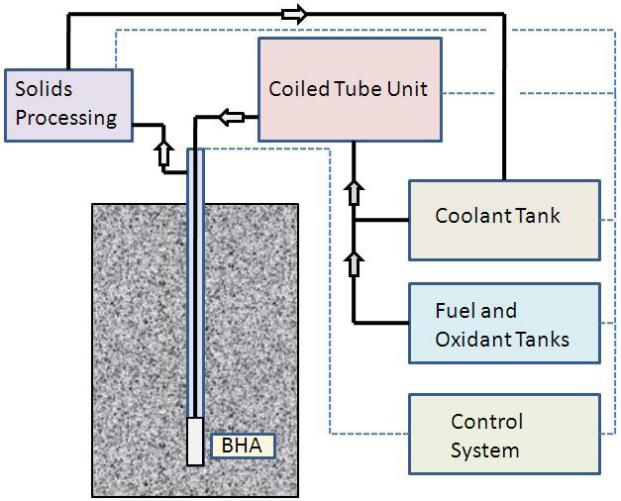
- **Complete BHA design and fabrication with bench top testing: July, 2010**
  - Flow tests at elevated temperature
  - Survival of hardware in borehole conditions
- **Complete specification and assembly of drill rig and associated support systems: July, 2010**
  - Proper flow of chemical reactants and coolant
  - Proper operation of CT injection system
  - Ability to monitor BHA using data acquisition control system
- **Complete Field Site Preparation: July, 2010**
  - Completion of 300 ft boreholes (hammer drilled and cased to spec)
  - Pressure/level tests to determine if the fluid losses/gains while drilling are acceptable.
  - Camera logging and shut in pressure decline/increase monitoring for fractures

Scientific/Technical Approach



Scientific/Technical Approach

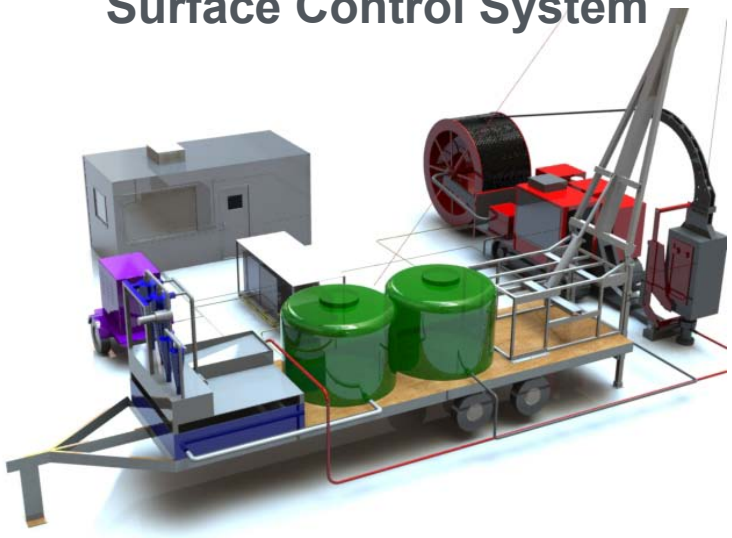
System Components



Bottom Hole Assembly

Field Site (Raymond, CA)

Surface Control System



Progress To Date:

- Completed hydrothermal spallation drilling system specification
- Completed modification and took delivery of coiled tubing unit
- Completed BHA component, sub-assembly, and electronics designs and initiated fabrication
- Completed field trial test site environmental reviews and approvals

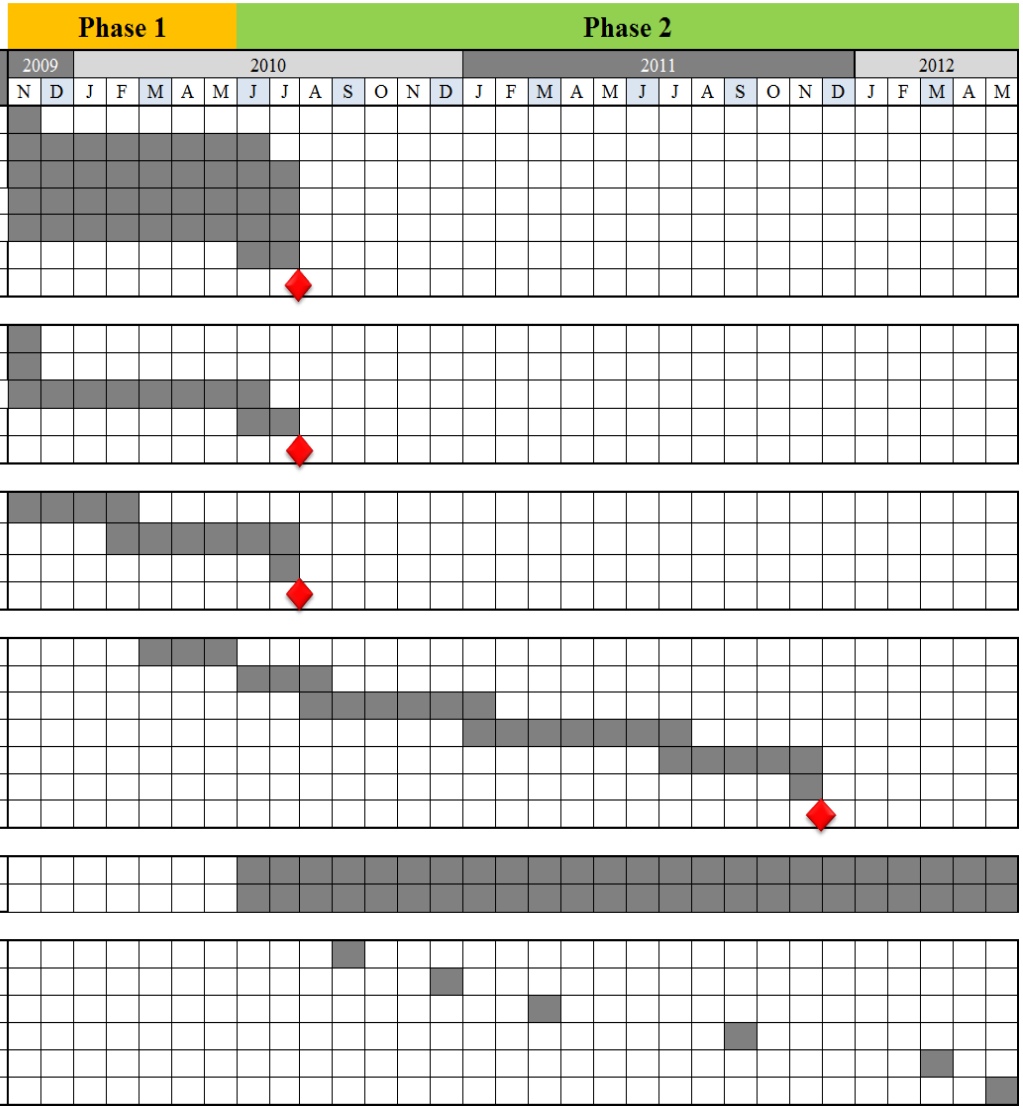
Project Management/Coordination

- **Project Plan Summary**
  - Phase 1 of work to be completed by July, 2010
    - BHA and subassemblies fabricated and wet tested
    - Drill rig and surface equipment prepared
    - Field site and starter wells prepared
  - Phase 2: Field tests commence in August, 2010
    - First field trial scheduled for August, 2010
    - Work with Cornell University commences
  - Field Trials completed in 2011
  - Project completed in May, 2012
- **Financial Plan Summary**
  - $2.0M in resources expended on Phase 1 to date
  - $4.6 M in resources to be expended in FY 2010
  - DOE ARRA resources will be completed utilized by April 2011

Project Management/Coordination

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Topic	Task	Subtask	Description
Bottom Hole Assembly	1.0	1.1	BHA Requirements Specification
		1.2	Design, Fab of Steam Generator Assembly
		1.3	Design, Fab of Dynamic Seal Assembly
		1.4	Design, Fab of Other Subassemblies
		1.5	Design, Fab of Instrumentation and Controls
	Milestone 1		Performance Assessment
	Go/No-Go 1		Go/No-Go Decision
Drill Rig and Tubing	2.0	2.1	Modification of the AmKin Drill Rig
		2.2	Modification of the Coiled Tubing
		2.3	Surface Equipment
	Milestone 2		Performance Assessment
	Go/No-Go 2		Go/No-Go Decision
Field Site Preparation	3.0	3.1	Site Requirements
		3.2	Starter Well construction
	Milestone 3		Performance Assessment
	Go/No-Go 3		Go/No-Go Decision
Field Trials	4.0	4.1	Test Plan definition
		4.2	Specify Drilling Program
		4.3	Trial#1
		4.4	Trial #2
		4.5	Demonstration
	C		Performance Assessment
	Project Closing		Project Closing Decision
Advanced Development	5.0	5.1	Chemical Heating Systems
		5.2	Downhole Mineral Kinetics
Project Management and Reporting	6.0	6.1	Interim Report: Interim update
		6.2	Report: BHA, Drill Rig, and Site Prep
		6.3	Report: Field Trial #1 Results
		6.4	Reort: Field Trials #2 Results
		6.5	Report: Advanced Development Results
		6.6	Final Report



Future Directions

- Expected Project Outcome: Field proven prototype and performance data
- Future Development Strategy:
  - Near term: Commercialize system for hydrothermal and EGS well enhancement and field characterization
  - Long term: Develop deep drilling system for EGS
- FY 2010
  - Full prototype system designed and completed by July, 2010
    - BHA performance assessment milestone
    - Drill rig performance assessment milestone
    - Site requirements milestone
  - First field trial: August, 2010
  - Second field trial: late 2010
  - Commence laboratory research at Cornell University
- FY 2011
  - Analyze results of first and second field trial
  - Iterative design and modification of system based on trial results
  - Conduct one more field trial

Summary

- Hydrothermal spallation drilling is an innovative technology with significant performance advantages in hard rock
- Application of the technology will have a considerable impact on EGS and hydrothermal well construction, reservoir performance, and site characterization
- Potter Drilling is in Stage 3 of a 4 stage development program
- The GTP has contributed $5M towards the field demonstration of our prototype drilling system
- We will have documented field test results within FY 2010