FACTSHEET FOR PARTNERSHIP FIELD VALIDATION TEST

Partnership Name	Big Sky Regional Carbon Partnership		
Contacts:	Name	Organization	E-Mail
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Principal Investigator	Lee Spangler		
Field Test Information: Field Test Name	Basalt Pilot Site Characterization Test – Phase III		
Test Location	Near Wallula township in Eastern Washington State		
Amount and Source of CO_2	Tons: NA	Source:	
Field Test Partners (Primary Sponsors)	Batelle, United Power, LLC; Energy Northwest; Portland General Electric; Puget Sound Energy, Port of Walla Walla		

Summary of Field Test Site and Operations:

The goal of the Basalt Pilot Site Characterization Test is to conduct a small scale CO_2 sequestration project in Columbia River flood basalts designed to confirm the feasibility of permanently and safely sequestering large quantities of CO_2 within deep flood basalt formations. Specific technical objectives of the proposed 36 month field test include 1) assess the local, large-scale basalt reservoir and adjacent formation responses to CO_2 injection, 2) track the migration of the CO_2 within the injection reservoir, and evaluate containment of the CO_2 for comparison with reservoir modeling predictions, and 3) evaluate the rate of CO_2 mineralization for comparison with previously developed laboratory-derived predictions.

The proposed field test location is situated approximately 16 miles south of Pasco, Washington in lightly inhabited agricultural and heavy industrial-zoned land in western Walla Walla County (see Figure 1).

Figure 2 shows a satellite image that displays the immediate area of the proposed field test pilot study, which is located in the northern ~450 acre parcel of the Port of Walla Walla, Attalia Property 1, within the northern half of Section 2, Township 8N, Range 31E, and the southeast quarter of Section 34, Township 8N, Range 31E. The field test site is located ~1 to 2 miles east of the Columbia River and northeast of the Boise Cascade Corporation industrial facility.

The field test borehole network would include: 1) pilot borehole; 2) injection borehole; and 3) three shallow basalt boreholes. The injection borehole would be re-entered and two geochemical assessment coreholes drilled post-CO2 injection and after an incubation time period of 12 to 24 months. The pilot borehole would be the principal borehole for acquiring detailed hydrogeologic information for the site (i.e., hydrologic testing, hydrochemical sampling, wireline geophysical surveys) and would be drilled initially to a depth of ~4,000 ft. Based on the results obtained from the pilot borehole, an injection borehole would be drilled approximately 500-1000 ft away and completed to the targeted basalt injection zone horizon. The three shallow monitoring boreholes (i.e., one ~1800 ft and two ~900 ft deep) would be used for cross-well seismic imaging of the areal extent of the injected CO_2 within the injection reservoir. A slant or deviated corehole would be drilled using the 1800 ft monitoring well during the post-injection phase (e.g., at 1 to 2 years following injection) in order to extract core from the injection interflow zone for the purpose of assessing geochemical reactions between the injected CO_2 and host basalt rock.

After the final core samples are retrieved, a decision will be reached with the site developer whether the wells are needed to support commercial operations at the site. If so, ownership of the wells would be transferred to the site developer. If not, each well would be plugged and abandoned in accordance with Washington State Department of Ecology requirements.

Figure 1. Regional Location Map of Field Test Site

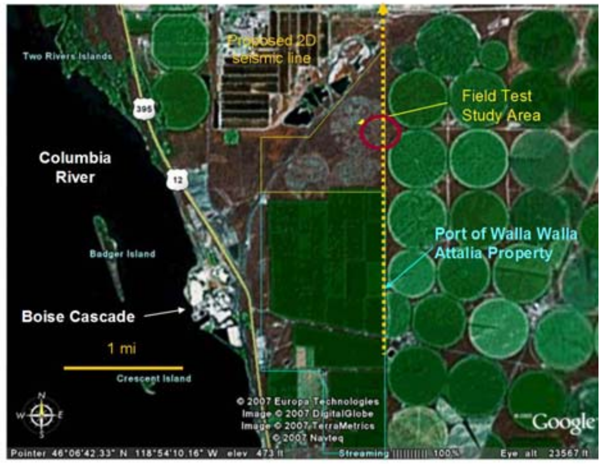
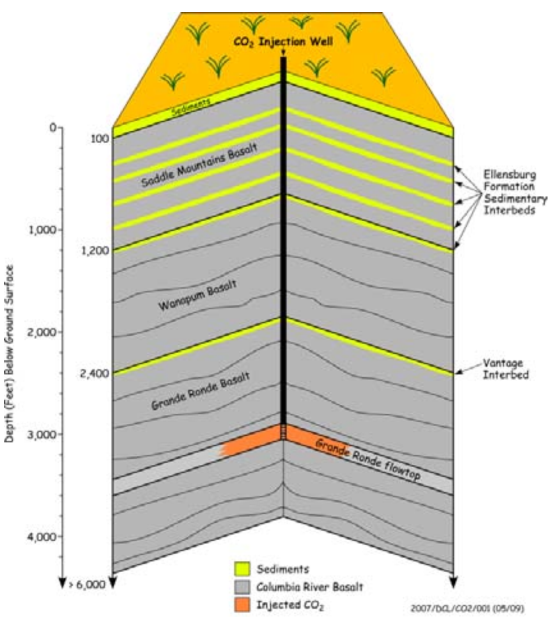


Figure 2 (at right). Google Earth View of Field Test Study Area. The red circle is the location of the proposed injection and monitoring wells. The yellow dashed line is the location of the proposed 2D seismic line, along a section line dirt road and power line right of way.

The location of the proposed field test site lies within the Columbia River Basalt province. Anticipated subsurface geologic conditions at the field test site are shown in Figure 3, and are based on extrapolations from surrounding borehole characterization information. As shown, the expected approximate subsurface formation thicknesses at the field test site (from surface) include: 100 ft of surficial alluvial deposits; 1,200 ft of combined Saddle Mountains Basalt Formation (5 basalt flows) and sedimentary interbeds of the Ellensburg Formation (4 to 5 sedimentary interbeds); 1,200 ft of Wanapum Basalt (11 basalt flows); 5 to 40 ft of Vantage interbed/paleosol horizon; >6,000 ft of Grande Ronde Basalt/undifferentiated CRB (>20 basalt flows); >1,000 ft undifferentiated sub-basalt, sedimentary formation deposits; and the underlying crystalline/metamorphic basement complex. Of particular hydrogeologic importance is the presence of the Vantage interbed/paleosol horizon that serves as a regional low permeability horizon separating groundwater within the underlying Grande Ronde and overlying Wanapum Basalts (Reidel et al., 2002). Groundwater within the Grande Ronde Basalt and below is expected to be non-potable containing high concentrations of fluoride and sulfides.

The general topography of the Pasco Basin reflects structural deformation associated with Miocene to Recent folding and uplift of the Columbia River basalts. Prominent ridges form part of the Yakima Fold Belt, a series of asymmetric, generally east-west anticlinal folds. The north limbs of the anticlines are usually steeply dipping and broken by thrust faults.



The Yakima Fold Belt upland ridge closest to the project site area is the Horse Heaven Hills, which lie about 7 miles south of the project site. This is a folded fault block range that is uplifted along the Wallula Fault Zone located on the north side of the range. The bedrock at the sequestration site is covered by alluvium, but the structural dip of the Grande Ronde basalts is expected to be near horizontal, based on regional geology and geotechnical findings (PanGeo, Inc, 2001). There is no closed structure at the site. The axis of the Cold Creek Syncline may cross near the sequestration site, from northwest to southeast. A key objective of the seismic survey is to ensure that no faults playing off the Cold Creek Syncline extend to the test site area.

Figure 3. General Stratigraphic/ Depth Relationship of Injection Zone and Overlying Formations

Research Objectives:

The overall objectives of the Basalt Site Characterization Test include:

1. Address the critical technical issues associated with the injection, and fate and transport of supercritical CO_2 in one or more interflow zones in a deep basalt formation
2. Work with industry partners to ensure that Characterization Test activities support their needs (to the extent practicable)
3. Participate in public outreach activities as required or as requested by industry partners
4. Work with state regulators and environmental NGO groups to ensure timely support of necessary permitting.

Site characterization activities undertaken under Phase II have been designed to determine acceptability of conducting drilling, injection, and monitoring phases to be supported under the Phase III cooperative agreement. The Phase II activities include: 1) installation of shallow soil gas monitoring probes and collection and analyses of gas samples from these probes to begin development of a database on variability in CO_2 and other trace gas concentrations at the site, and 2) conducting a quasi-3D seismic survey at the site to determine overall reservoir thickness (both the basalt and metamorphic strata underlying the basalt) and to identify any faults or fracture zones that must be avoided in locating an injection well at the site, 3) applying for all necessary permits to conduct drilling and CO_2 injection operations on the property.

Under Phase III, site characterization activities will include an evaluation of reservoir suitability to proceed with CO_2 injection, execution of injection of 3000 to 5000 tons of CO_2 into a selected interflow zone, monitoring plume evolution and pressure responses in overlying basalt zones, monitoring geochemical changes in pore fluids over time as a result of basalt-CO_2-water interactions, and finally extracting core samples from the injection zone (after a 1-2 year incubation period) to check for mineralization occurrence.

Summary of Modeling and MMV Efforts:

Preliminary simulations of CO_2 injection into the flow tops of two individual basalt flows in the Grande Ronde (GR) basalt formation were executed using the STOMP-H_2O-CO_2-NaCl simulator (White and Oostrom 2006). The two flows considered were the GR-5 flow and the Umtanum flow. Both flow tops have high permeabilities and are good candidates for injection. The objective of the simulations was to determine the radius of a 3000 MT CO_2 plume injected during a proposed pilot scale test needed for submission of permit documents. Two basalt flow tops in the Grande Ronde Basalt formation were considered, the RRL-2/GR-5 (unnamed flow), 26 ft thick, and the RRL-2/GR-9 (Umtanum Flow).

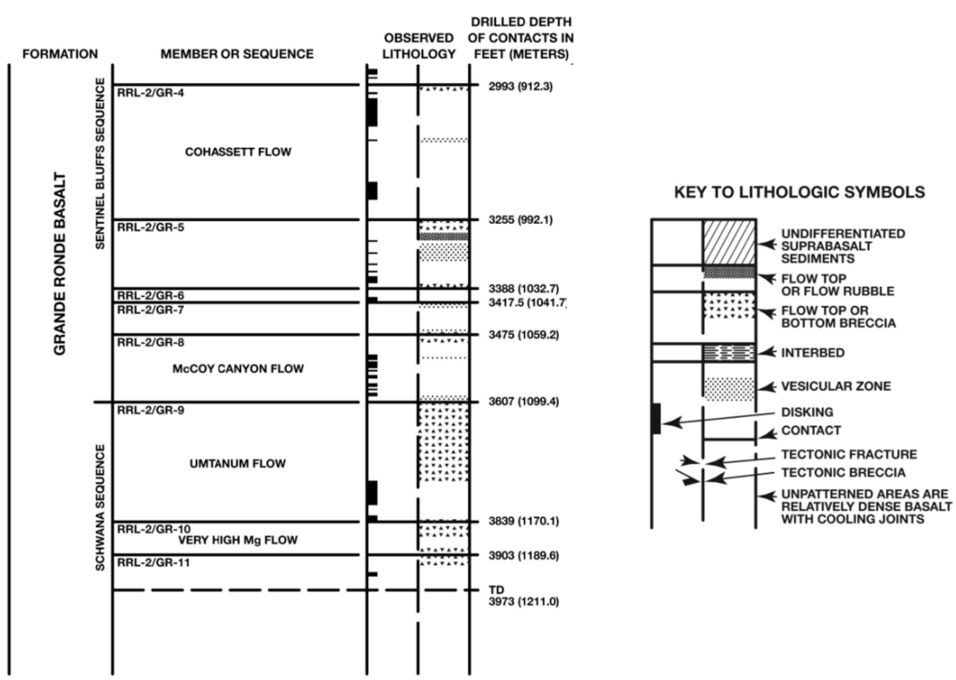


Figure 4. Lithologic Unts in the RRL-2 Corehole based on (Wintczak 1984) to estimate properties at the test site.

The transmissivity of GR-5 flow top in the RRL-2 well was determined to be 9.87 ft^2/day ($1.06x10^{-5}$ m^2/s) using hydraulic tests (Strait and Spane 1983). The transmissivity of the Umtanum flow top was determined to be 480 ft^2/day ($5.16x10^{-4}$ m^2/s) using hydraulic tests (Strait and Spane 1982). The permeabilities assumed for the basalt flow materials were $1x10^{-11}$ m/s for the dense flow interiors, $1x10^{-4}$ m/s for the GR-5 flow top breccia, $1x10^{-5}$ m/s for the Umtanum flow top breccia, $2x10^{-7}$ for rubble, and $1x10^{-7}$ for vesicular basalt. Two-dimensional simulations with a cylindrical coordinate grid were developed. Vertical grid spacing was 1 ft, while radial grid spacing was variable, ranging from 0.08 m to 5.9 m. Homogeneous layers were assumed based on the observed lithology surrounding the GR-5 flow top and the Umtanum flow top. The contacts between the layers were given a random amount of roughness to simulate the heterogeneity of those contacts.

In the Umtanum flow top simulations, the CO_2 is injected over an interval between 3607-3761 ft below ground surface (bgs) and the injected CO_2 quickly rises to the top of the formation where it is trapped by the low-permeability overlying McCoy Canyon flow. The resulting plume has a radius of 550 ft. After 2 years, 26% of the injected CO_2 has dissolved into the aqueous phase.

In the GR-5 flow top simulations, the CO_2 is injected over a smaller interval between 3255-3278 ft bgs. The injected CO_2 is trapped by the overlying Cohassett flow interior. The resulting plume has a radius of 700 ft, with higher gas concentrations than seen in the Umtanum flow top simulations. After 2 years, 21% of the injected CO_2 has dissolved into the aqueous phase. The dissolved CO_2 fraction is lower than in the Umtanum flow top simulations due to the smaller volume of the plume.

The results of the numerical modeling indicate that both the Umtanum flow top and the GR-5 flow top are good candidates for CO_2 injection due to their high permeability. There is uncertainty in the results of these simulations because the unsaturated flow properties (e.g., air entry pressure) of the basalt flow tops were estimates and the data are taken from wellbore data approximately 30 miles from the pilot injection site.

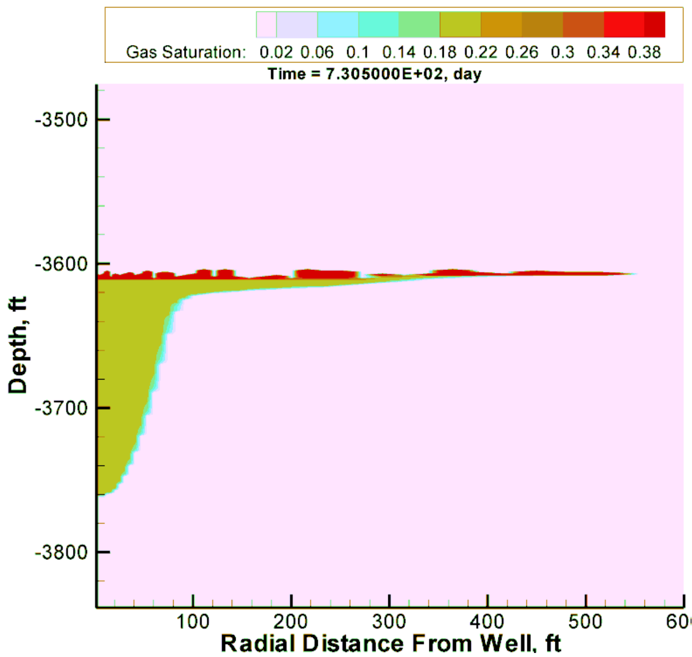


Figure 5 (at left). CO_2 Gas Saturation in the Umtanum Flow Top 2 Years Post-Injection at the Rate of 100 tonnes/day for 30 days

MMV Summary

A comprehensive MMV program has been designed for the pilot study that includes surface and shallow subsurface gas monitoring, surface and cross-well seismic, geochemical sampling, and post-injection core sample retrieval.

The MMV program for the basalt characterization test includes data collection and analysis prior to, during, and following the test. Planned MM&V methods include: 1) Atmospheric & Soil; 2) Seismic; 3) Borehole Geophysics; 4) Geochemical; and 5) Pre-closure Characterization. During these tests, parameters and characteristics of interest will be monitored using appropriate surface and/or borehole geophysical methods, as well as chemical measurements on produced and down-hole fluids. Additionally, similar pre-test measurements will be conducted to assess changes that have occurred due to the injection of CO_2. Prior to, during, and following injection, microseismicity and vadose zone gases near the injection well will be monitored.

<u>Atmospheric and Soil Monitoring</u>

Although it is highly unlikely that any CO_2 would reach the surface during or after injection, a single eddy covariance station will be installed to monitor over the expected plume footprint. The station would be installed prior to injection and removed shortly after injection terminates.

Dedicated soil gas probes will be placed at discrete points along 4 orthogonal transects extending away from the injection well. Starting at the injection well, the soil-gas probes would be spaced at 100, 200, 500, and 1,000 ft to provide complete coverage of the plume area. Vadose zone soil gas samples would begin being collected quarterly as early as possible ahead of injection (to establish background variability) and would continue on a quarterly basis until site closure. Soil-gas samples would be analyzed for CO_2 and other target analytes, including tracers co-injected with the CO_2 (e.g., perfluorohydrocarbon tracers) and stable carbon and oxygen isotopes to differentiate leaked CO_2 from other sources.

<u>Seismic</u>

2-D seismic will be conducted using closely spaced surface sensors, multiple seismic wave sources and recording both P (compressional) wave data and P-S, which is converted wave shear data. The converted wave shear data are greatly influenced by fractures in basalt. In addition some long source-receiver offset data will be acquired to benefit from the refracted or diving wave.

Geophysical monitoring will focus on crosswell seismic imaging, vertical seismic profiles (VSP), and passive seismic monitoring. These seismic methods involve placing either sources or receivers, or both, in wellbores, which reduces the amount of seismic wave scattering and increases both lateral and vertical resolution. Crosswell seismic methods will supplement surface-based methods or VSP's to better characterize the movement and extent of the plume and provide an image of subsurface structure in the vicinity of the injection zones, as well as a tomographic view of the velocities between the wells (DONG et al., 2005).

Borehole Geophysics

The wireline borehole surveys will likely include: resistivity, neutron, gamma, sonic/acoustic, density, formation micro-imager (FMI), combined gamma spectroscopy (RST-A), dynamic fluid-logging (fluid-temperature/density and flowmeter), and gravity. The smaller density contrast of supercritical gas plus the larger reservoir depths will require the gravity change due to CO_2 injection be measured using borehole gravimeters. The surveys will be used to map changes in physical and chemical properties of rocks and fluids and rapid detection of gravity changes associated with CO_2 injection. Coordination and combined analysis of the cross-well seismic and borehole gravity surveys will enable the 3-D geometry of the injected CO_2 plume to be tracked and estimation of its in situ mass and saturation.

Geochemical Monitoring

A pre-injection tracer test will be performed using a conservative tracer (KBr, PFBA, or DMP) to establish the basic hydrologic properties such as porosity, hydraulic conductivity and dispersion. During the CO_2 injection phase, pulses of different tracers will be added to the CO_2 stream. The leading chemical tracer candidates are SF_6, CH_3F, and CH_2F_2 (perfluorohydrocarbons) and noble gas tracers (Helium-3, Krypton-78, Xenon-124). Because each of these inert tracers has unique physical properties (diffusivity, solubility), the multi-tracer approach allows for the determination of CO_2/water multi phase transport parameters. Finally, changes in the aqueous concentrations/ratios of naturally occurring trace element will be monitored as a means to assess the CO_2 mineralization process.

Water chemistry analysis will be performed on samples obtained from the injection zone and in selected formations overlying the target basalt interflow zone. Critical parameters that will be measured are: pH, Eh, dissolved O_2, temperature, conductivity, major, minor, and trace elements, stable isotopes, tracers, colloids, and microbes. It is anticipated that a high frequency sampling will be maintained during the first two months after injection and then one sampling campaign approximately every 2 to 4 months (20 samples per event). A U-tube sampling device or Westbay system will be used in the Pilot Borehole to collect fluid and gas samples during the test. Analysis will employ either a traditional gas chromatograph or a new system that can continuously measure the tracers in the water samples.

Microbiological monitoring

To understand the in-situ microbial dynamics in response to CO_2 injections, a piggyback activity with the geochemical monitoring activities will allow for evaluation of the impact on the in situ microbial community in the injection reservoir. Sampling of the pre- and post-injection reservoir fluids, in conjunction with planned geochemical sampling via U-tube and/or Westbay systems, will enable determination of the rate of return of the reservoir to pre-injection conditions. It will also enable a crucial test of theoretical predictions, including any potential unanticipated microbiological dynamics such as the microbial conversion of CO_2 to methane gas.

Pre-Closure Characterization

This phase will characterize the in-situ geochemical reactions of the injected CO_2 within the reservoir host rock horizon, and assess any resultant changes to hydraulic and storage characteristics within the injection interflow zone. These activities are currently scheduled to occur 24 months after injection, but exact timing will depend upon results obtained from post-injection monitoring activities. Pre-closure characterization activities include: conducting a suite of wireline borehole geophysical surveys, performing a series of comparative hydrologic tests, and drilling deviated geochemical coreholes.

Selected wireline borehole geophysical surveys will be conducted within the Injection Borehole prior to corehole drilling. The post-injection geophysical surveys selected will be based on an evaluation of wireline survey results conducted during the pre-injection phase characterization and are expected to be very similar if not identical. The post-injection wireline geophysical information will be compared with the results obtained during the pre-injection characterization phase to evaluate potential formational property changes in the area immediately surrounding the borehole due to the CO_2 injection. Additionally, the hydrologic tests conducted during the pre-injection phase for the injection zone within the Injection Borehole will be repeated during the post-injection characterization. The associated pressure responses will be monitored in similar fashion both at Injection Borehole and within the nearby Pilot Borehole during the post-injection testing. The post-injection tests will be compared to pre-injection results to assess potential formational property changes (i.e., transmissivity, storativity, leakage) over the intermediate-scale (inter-well) distance.

Slanted or deviated geochemical coreholes will be drilled from the Injection Borehole after removal of the reservoir isolation packer system from the borehole. The coreholes will be deviated at an angle (using an installed borehole wedge) that will ensure intersecting the injection zone horizon at distances of ~50 to 100 ft from the central injection borehole. The primary objective of this post-injection characterization activity is to retrieve injection zone basalt cores and formation fluid samples for detailed geochemical characterization of potential secondary mineralization that may be associated with the CO_2 injection process.

Accomplishments to Date: Phase III work has not been authorized at this time.

Summarize Target Sink Storage Opportunities and Benefits to the Region:
Within the BSCSP region, there are several major geological provinces with high potential for geologic sequestration. One of these is the Columbia Plateau Volcanic Province, which represents the dominant regional geologic feature occupying much of Idaho, Oregon, and Washington states. The CO_2 storage potential of the Columbia River Basalt Group (CRBG) within this volcanic province has been estimated at between 50 to 100 $GtCO_2$, making it one of the most significant potential deep geological storage formations in the region. The ultimate goal of the Basalt Pilot Test is to demonstrate and validate the safe, permanent storage of CO_2 in reactive mafic formations that underlie this site and surrounding region. A successful field demonstration of CO_2 sequestration at this site has important implications for future development of a sub-bituminous coal fueled IGCC unit (nominal 700 MWe net) that has been announced for development at this site.

Cost:

Total Field Project Cost: $12,240,361.00

DOE Share: $8,992,526.00 73%

Non-Doe Share: $3,247,835.00 27%

Field Project Key Dates:

Baseline Completed: 03/30/2008

Drilling Operations Begin: NA

Injection Operations Begin: NA

MMV Events: Soil gas monitoring in progress

Field Test Schedule and Milestones (Gantt Chart):

Big Sky Carbon Sequestration Partnership Phase III - Gantt Chart

	Budget Period 3		Budget Period 4			Budget Period 5		
Site Selection	FY08	FYO9	FY10	FY11	FY12	FY13	FY14	FY15
Infrastructure Development Plan		Rcm4						
Detailed Basalt Site Characterization and Development Plan		Rcm6						
Site Characterization								
Basalt Pre-injection Characterization Report		Rcm7						
Basalt Baseline MMV Characterization Report								
NEPA Compliance and Permitting								
Submission of NEPA Questionnaires to NETL	Pm1							
Submit Class V injection well permits	Pm2							
Injection and Monitoring Operations								
Detailed Baslt Site Activity and MMV Plan		Rcm5						
Sign Well Drilling Contract			Wdm1					
Submit CO2 Procurement agreement	Omm1							
Basalt Operational Monitoring and Modeling Report			Omm2					
Injection and Post Injection Monitoring			Rcm8					
Borehole and Coring			Rcm9					
Reporting								
Final Topical Report			Pam1					

Additional Information