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Prepared in cooperation with the U.S. Department of Energy

Geophysical Logs and Water-Quality Data Collected for Boreholes Kimama-1A and -1B, and a Kimama Water Supply Well near Kimama, Southern Idaho

Data Series 622

**U.S. Department of the Interior
U.S. Geological Survey**

Cover: View of U.S. Geological Survey logging van setup while logging at the Kimama drill site, Kimama, Idaho. (Photograph taken by Linda C. Davis, October 4, 2010.)

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U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

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Conversion Factors and Datum

Conversion Factors

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Flow rate		
foot per day (ft/d)	0.3048	meter per day (m/d)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
Radioactivity		
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8.$$

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius ($\mu\text{S}/\text{cm}$ at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter ($\mu\text{g}/\text{L}$).

Datum

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Altitude, as used in this report, refers to distance above the vertical datum.

Abbreviations, Acronyms, and Symbols

μm	micrometer
BLS	Below Land Surface
DOE	U.S. Department of Energy
DOSECC	Drilling, Observation and Sampling of the Earth's Continental Crust
ESRP	Eastern Snake River Plain
INL	Idaho National Laboratory
KWS	Kimama Water Supply
LT-MDL	Long-term method detection level
LRL	Laboratory reporting level
MDL	Method detection level
N	Nitrate
NWQL	USGS National Water Quality Laboratory
P	Phosphorus
RESL	Radiological and Environmental Sciences Laboratory
USGS	U.S. Geological Survey

Geophysical Logs and Water-Quality Data Collected for Boreholes Kimama-1A and -1B, and a Kimama Water Supply Well near Kimama, Southern Idaho

By Brian V. Twining and Roy C. Bartholomay

Abstract

In September 2010, a research consortium led by scientists from Utah State University began drilling the first of three continuously cored boreholes on the Snake River Plain in southern Idaho. The goals of this effort, the Snake River Scientific Drilling Project, are to study the interaction between the Earth's crust and mantle, to identify potential geothermal energy sources, and to track the evolution of the Yellowstone hotspot on the Snake River Plain.

The first borehole, located near Kimama, Idaho, is about 50 miles southwest of the U.S. Department of Energy's Idaho National Laboratory. Because geohydrologic data are scarce for that area of the central Snake River Plain, the Kimama borehole, completed in January 2011, provided a unique opportunity to collect geophysical and water-chemistry data from the eastern Snake River Plain aquifer system, downgradient of the laboratory. Therefore, in conjunction with the Snake River Scientific Drilling Project, scientists from the U.S. Geological Survey's Idaho National Laboratory Project Office conducted geophysical logging and collected water samples at the Kimama site. Wireline geophysical logs were collected for the diverging borehole, Kimama-1A and -1B, from land surface to 976 and 2,498 feet below land surface (BLS), respectively. Water samples were collected from Kimama-1A at depths near 460 and 830 feet BLS, and from the Kimama Water Supply (KWS) well located about 75 feet away.

Geophysical log data included a composite of natural gamma, neutron, gamma-gamma dual density, and gyroscopic analysis for boreholes Kimama-1A and -1B. Geophysical logs depicted eight sediment layers (excluding surficial sediment)

ranging from 4 to 60 feet in thickness. About 155 individual basalt flows were identified, ranging from less than 3 feet to more than 175 feet in thickness (averaging 15 feet) for borehole Kimama-1B (0 to 2,498 feet BLS). Sediment and basalt contacts were selected based on geophysical traces and were confirmed with visual inspection of core photographs. Temperature logs from the water table surface (about 260 feet BLS) to the bottom of borehole Kimama-1B (2,498 feet BLS) were nearly isothermal, ranging from about 62 to 64 degrees Fahrenheit. Gyroscopic data revealed that borehole Kimama-1B begins to separate from borehole Kimama-1A near a depth of 676 feet BLS. Drillhole azimuth and horizontal deviation at total logged depth for boreholes Kimama-1A and -1B were 172.6 and 188.3 degrees and 25.9 and 82.0 feet, respectively.

Water samples were collected and analyzed for common ions; selected trace elements; nutrients; isotopes of hydrogen, oxygen, and carbon; and selected radionuclides. One set of water samples was collected from the KWS well and the two other sample sets were collected from borehole Kimama-1A near 460 and 830 feet BLS. With one exception, data for all three zones sampled near Kimama generally indicated that the water chemistry was similar. The exception was found in the deepest zone in borehole Kimama-1A (830 feet BLS) where concentrations probably were affected by the drilling mud. A comparison of the inorganic, organic, and stable chemistry data between the KWS well and the 460-foot zone in borehole Kimama-1A indicated similar chemistry of the aquifer water, except for some variability with nitrate plus nitrite, orthophosphate, iron, zinc, and carbon-14. Radionuclide concentrations were either less than reporting levels or at background levels for the eastern Snake River Plain aquifer.

Introduction

Since 1949, scientists of the U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, have studied the hydrology, geology, and geophysics to provide baseline data about the disposition and migration of radioactive and chemical wastes in the eastern Snake River Plain (ESRP) aquifer at the Idaho National Laboratory (INL). The USGS continues to collect and report data related to the movement of water contained within ESRP aquifer. Numerical modeling of groundwater flow at the INL (Ackerman and others, 2010) indicates that periodic influences of recharge can lead to non-uniform changes in the water table at the INL. Because of these non-uniform changes, and because some wastewater constituents have been found recently at reportable concentrations in deeper zones of water at the INL boundary (Bartholomay and Twining, 2010), more data downgradient of the INL may be useful in understanding water movement in the ESRP aquifer.

The Kimama site ([fig. 1](#)) is the first of three scientific drill sites proposed by a consortium of universities collaborating with government agencies and the nonprofit research corporation DOSECC (Drilling, Observation and Sampling of the Earth's Continental Crust). The Kimama site was established as part of the Project Hotspot initiative to study the interaction between the Earth's crust and mantle, to identify potential geothermal energy sources, and to track the evolution of the Yellowstone hotspot on the Snake River Plain. More information about the project is available at http://www.usu.edu/geo/shervais/Shervais-USU-Geology/Project_Hotspot.html (last visited June 9, 2011).

Although the drill site does not lie directly downgradient from the INL as mapped by Lindholm and others (1988; [fig. 1](#)) whether or not water from the INL is contributing to the area remains unknown because data are scarce for the central part of the ESRP. Therefore, the Kimama Water Supply (KWS) well and borehole(s) Kimama-1A and -1B, provided a unique opportunity to collect geophysical and water-chemistry data from the ESRP aquifer system downgradient of the INL.

Purpose and Scope

This report presents geohydrologic data collected from wireline geophysical logging and from water sampling at the Kimama scientific drilling site. Geophysical logging was conducted twice during October and November 2010 at boreholes Kimama-1A and -1B. Water sampling of the KWS well from the upper part of the aquifer and of borehole Kimama-1A from two deeper zones (460 and 830 ft BLS) was conducted during October 2010. Wireline geophysical logs were run through a drill casing in order to obtain natural gamma, neutron, gamma-gamma (long- and short-spaced)

density, temperature, and gyroscopic deviation logs. Water samples were collected from the KWS well and from the two discrete depths within borehole Kimama-1A. These samples were analyzed for common ions; selected trace elements; nutrients; isotopes of hydrogen, oxygen, and carbon; and selected radionuclides.

Geohydrologic Setting

The Kimama site is located in the west-central part of the ESRP, about 50 mi southwest of the INL ([fig. 1](#)). The ESRP is a northeast-trending structural basin about 200 mi long and 50–70 mi wide. The basin, bounded by faults on the northwest and by downwarping and faulting on the southeast, has been filled with basaltic lava flows interbedded with terrestrial sediments. These basaltic rocks and sedimentary deposits combine to form the ESRP aquifer, which is the main source for groundwater in the ESRP.

The ESRP aquifer is one of the most productive aquifers in the United States (U.S. Geological Survey, 1985, p. 193). Water in the aquifer generally moves from northeast to southwest, and eventually discharges at springs along the Snake River downstream of Twin Falls, Idaho—about 100 mi southwest of the INL ([fig. 1](#)). The Kimama drill site is located midway between the INL southern boundary and Thousand Springs area, to which the ESRP aquifer discharges ([fig. 1](#)). Across the INL, the water-table altitude in boreholes ranges from about 4,560 to 4,400 ft ([fig. 1](#)); near Kimama, the altitude of the water table is about 4,050 ft. The velocity of groundwater near the top of the ESRP aquifer southwest of the INL is about 15 to 25 ft/d (Plummer and others, 2000). The ESRP aquifer water moves horizontally through basalt interflow zones and vertically through joints and interfingering edges of interflow zones. The geology of the area plays a significant role in controlling groundwater flow. Infiltration of surface water, heavy pumping, geologic conditions, and seasonal fluxes of recharge and discharge affect the movement of groundwater locally (Garabedian, 1986).

Drilling and Completion of the Kimama Wells

The Kimama scientific drilling site was determined by the Project Hotspot initiative (Shervais and others, 2006). Project personnel worked with the Bureau of Land Management to determine a suitable location and to secure the necessary permits. The Kimama site is located along the axis of the ESRP to meet project goals of continuously coring through rock and sediment and documenting the record of volcanism and sedimentation through time at a single geographic point within the ESRP system. Cores were pulled from the ground and examined for physical, petrographic, geochemical, and isotopic characteristics.

Figure 1. Location of the Kimama drill site, water-table contours, and the direction of groundwater flow moving through the eastern Snake River Plain aquifer and discharging near the Thousand Springs area, southern Idaho (modified from Ackerman and others, 2006).

Prior to core drilling, the KWS well was constructed and completed in August 2010 by Eaton Drilling and Pump Service (Permit No. 859768). The KWS well was constructed to supply water during coring; it also served as a source of potable water during the daily operations.

The drilling organization DOSECC was selected for coring at boreholes Kimama-1A and -1B. Core drilling was conducted from September 2010 through January 2011, reaching a total borehole depth of 6,275 ft BLS. A rotary drilling rig, outfitted with HQ- and NQ-size core systems, was used to core, ream, and set casing strings during borehole construction.

DOSECC attempted to core as deep as possible without using drilling mud to meet project objectives of collecting groundwater samples from various depths in the aquifer. After swelling clays continued to cause borehole stabilization problems, DOSECC began using drilling mud [a mixture of high yield bentonite, Aqua-solve 45, NDFX-233 (proprietary drilling fluid), and soda ash] on October 2, 2010, near a depth of 649 ft BLS (John Shervais, Utah State University, written commun., October 2, 2010). Drilling mud was continuously injected at rates between 25 and 30 gal/min from a depth of 649 ft BLS through the completion depth (6,275 ft BLS).

Final borehole construction consisted of Kimama-1A and -1B, with both boreholes originating from the same surface location. Borehole Kimama-1A was drilled from land surface to a total depth of 1,097 ft BLS from September 24, 2010, through October 9, 2010. Borehole Kimama-1B was drilled from about 676 to 6,275 ft BLS from October 10, 2010, through January 31, 2011. While drilling borehole Kimama-1A, the HQ-size core system [inside

diameter (ID) 3.06-in./outside diameter (OD) 3.50-in.] lost the ability to rotate at about 795 ft BLS due to swelling clay material. After failed attempts to pull out the drill stem, project personnel decided to continue drilling until they reached a stopping point for setting a permanent well casing. Core drilling continued to 1,097 ft BLS using a smaller diameter NQ-size core system (ID 2.38-in./OD 2.75-in.). The ID and OD tolerance between both HQ- and NQ-size core systems allows the smaller diameter system to pass through the larger diameter system.

Based on core and geophysical logs, project personnel decided to ream out the borehole Kimama-1A to 6.5-in. and set a 4.5-in. steel casing from land surface to 900 ft BLS. During reaming, the drill bit was redirected after hitting an obstruction in borehole Kimama-1A near 676 ft BLS, resulting in a second borehole (Kimama-1B), deviating slightly to the west (Chris Delahunty, DOSECC, oral commun., November, 2010). Thus, the original borehole Kimama-1A, from about 676 to 1,097 ft BLS, was abandoned during reaming. After reaming to 900 ft BLS, a 4.5-in. steel casing was placed on the bottom of Kimama-1A, and the casing annular space was pressure-grouted and sealed. HQ-size coring for the second borehole, Kimama-1B, started near 900 ft BLS, resulting in geologic unit overlaps between 900 and 1,097 ft BLS. DOSECC continued coring Kimama-1B, reaching a final borehole depth of 6,275 ft BLS. Location and drilling information for the Kimama site are summarized in [table 1](#). Specific details about the drill rig, daily progress, and coring systems used are available at the DOSECC website: <http://www.dosecc.org> (accessed June 9, 2011).

Table 1. Location and general information for the Kimama water supply well and boreholes Kimama-1A and Kimama-1B, Kimama, southern Idaho.

[Location of water-supply well and boreholes are shown in [figure 1](#). **Abbreviations:** BLS, below land surface; NAD 27, North American Datum of 1927; NGVD 29, National Geodetic Vertical Datum of 1929. ft, foot; in., inch; NA, not available]

Well or borehole information	Kimama water supply well	Borehole Kimama-1A	Borehole Kimama-1B
Site identifier ¹	425023113474401	425023113474301	425023113474302
Longitude (NAD 27, decimal seconds)	113°47'44.74"	113°47'43.93"	113°47'43.93"
Latitude (NAD 27, decimal seconds)	42°50'23.09"	42°50'23.17"	42°50'23.17"
Land-surface altitude (ft, NGVD 29)	4,285	4,284	4,284
Aquifer thickness (ft, BLS) ²	3,300	3,300	3,300
Drilled borehole depth at time of geophysical logging	NA	976	2,496
Completion depth (ft, BLS)	300	1,097	6,275
Borehole diameter (in.)	8	NA	NA
Casing diameter (in.)	6	NA	NA
Top open interval (ft BLS)	260	NA	NA
Bottom of open interval (ft BLS)	300	NA	NA
Depth to water (ft BLS) ³	260	260	260

¹Unique numerical identifier used to access well data (<http://waterdata.usgs.gov/nwis>).

²Estimated based on temperature inflection data collected during drilling subtracted from the water table at the time of drilling (John Shervais, written commun., November 18, 2010).

³Estimated from the borehole Kimama-1A neutron log.

Geophysical Logs and Geologic Descriptions

The suite of borehole geophysical data included natural gamma, neutron, gamma-gamma (long- and short-spaced) density, temperature, and gyro-deviation logs run through a drill casing. The USGS collected geophysical logs for borehole Kimama-1A prior to DOSECC reaming and setting a 4.5-in. casing during the week of October 6, 2010. Geophysical logs for borehole Kimama-1B were collected through the casing during the week of November 3, 2010. Logging data were analyzed from 0 to 996 ft BLS for borehole Kimama-1A and from 0 to 2,498 ft BLS for borehole Kimama-1B. Geophysical logs were not collected for the KWS well.

Geologic descriptions of core are not included in this report. However, photographs of core were visually inspected and compared against geophysical logs to verify the presence of sediment layers and/or to identify potential basalt flow contacts. Where depth discrepancies existed between contacts of sediment and basalt layer tops and bottoms, geophysical

log depths were used for reporting. No attempts were made to correct core photograph data to geophysical data because depths marked on core photographs could not be verified. Basalt and sediment layers were examined only for borehole Kimama-1B because of the overlap between the two boreholes.

Geophysical Log Descriptions

The wireline geophysical logs collected for boreholes Kimama-1A and -1B are shown in [table 2](#). Geophysical data were collected using Century Geophysical Corporation™ logging equipment, and data files were processed using Advanced Logic Technology's WellCAD™ analytical software. A composite of natural gamma, neutron, gamma-gamma dual density, and temperature logs along with general lithology from land surface to total depth are included in [figures 2](#) and [3](#). Raw borehole geophysical data for Kimama-1A and -1B are available upon request in Log ASCII Standard (LAS) format by contacting the USGS INL Project Office at <http://id.water.usgs.gov/projects/INL/about/contact.html>.

Table 2. Summary of geophysical logs collected at boreholes Kimama-1A and Kimama-1B, Kimama, southern Idaho.

[All files in LOG/LAS format. Borehole refers to abbreviation for borehole Kimama-1A or -1B. Probe ID refers to the Century™ tool number. Hole condition specifies the status of the hole prior to logging. Log direction refers to well probe direction. Comments: HQ and NQ refer to drill rod nominal size, 3.06 and 2.38-in. inside diameter, respectively. **Abbreviations:** ft, feet; BLS, below land surface]

Log type	Borehole	Probe ID	Depth (ft BLS)		Date	Hole condition	Log direction	Comments
			Top	Bottom				
Neutron	1A	9057A	0	985	10/06/2010	Drilling	up	HQ rods near 785 ft BLS NQ rods near 1,007 ft BLS
	1B	9057A	0	2,497	11/04/2010	Drilling	up	4.5-in. casing near 900 ft BLS HQ rods near 2,515 ft BLS
Gamma-gamma dual density	1A	0024A	0	991	10/06/2010	Drilling	up	HQ rods near 785 ft BLS NQ rods near 985 ft BLS
	1B	0024A	0	2,498	11/04/2010	Drilling	up	4.5-in. casing near 900 ft BLS HQ rods near 2,515 ft BLS
Natural gamma	1A	9057A	0	985	10/06/2010	Drilling	up	HQ rods near 785 ft BLS NQ rods near 985 ft BLS
	1B	9057A	0	2,497	11/04/2010	Drilling	up	4.5-in. casing near 900 ft BLS HQ rods near 2,515 ft BLS
Temperature	1A	9057A	260	985	10/06/2010	Drilling	up	HQ rods near 785 ft BLS NQ rods near 985 ft BLS
	1B	9057A	260	2,497	11/04/2010	Drilling	up	4.5-in. casing near 900 ft BLS HQ rods near 2,515 ft BLS
Gyro deviation	1A	9095	0	976	10/06/2010	Drilling	down/up	HQ rods near 785 ft BLS NQ rods near 985 ft BLS
	1B	9095	0	2,490	11/04/2010	Drilling	down/up	4.5-in. casing near 900 ft BLS HQ rods near 2,515 ft BLS

Figure 2. Geophysical and lithologic logs from total depth to land surface for borehole Kimama-1A, Kimama, southern Idaho.

Figure 3. Geophysical and lithologic logs from total depth to land surface for borehole Kimama-1B, Kimama, southern Idaho.

The four geophysical logs described in [figures 2](#) and [3](#) are:

- *Natural gamma*—A measure of the gamma radiation emitted by the naturally occurring radioisotopes within the rock material comprising the borehole wall; elevated natural gamma readings suggest the presence of a sedimentary layer.
- *Neutron*—A measure of the rock’s hydrogen content, which can be directly related to the porosity of the porous medium. A high neutron porosity indicates the presence of highly fractured basalt or sediment under saturated conditions, whereas a low neutron porosity indicates an area of dense basalt.
- *Short-spaced and long-spaced gamma-gamma dual density*—Also known as the induced gamma-density, this is a measure of the bulk density of a rock material in the vicinity of a borehole wall. The bulk density of a rock material is inversely related to its porosity, where lower density material (fractured rock) shows an elevated counting rate on the gamma-gamma response.
- *Temperature*—Recorded in degrees Fahrenheit, it reflects vertical changes in temperature gradient.

Geophysical data (natural gamma, neutron, and gamma-gamma dual density) were visually examined to a depth of 2,498 ft BLS, as were core photographs, to identify sediment and basalt contacts in boreholes Kimama-1A and -1B.

The natural gamma trace depicted tops of sediment layers near 387, 605, 763, 1,045, 1,486, 1,737, 1,803, and 2,409 ft BLS (not including surficial sediment extending from land surface to about 40 ft BLS). Natural gamma, neutron, and density logs indicated about 155 individual basalt flows ranging from less than 3 ft to more than 175 ft thick (mean = 15 ft).

Elevated neutron response (below the water table at 260 ft BLS) is explained by the presence of cement observed in borehole Kimama-1B ([fig. 3](#)) between the intervals: 10–440 ft BLS; 730–750 ft BLS; and 790–900 ft BLS. After reaming and setting a 4.5-in. casing, the annular space was cemented. The elevated neutron response represents reduced hydrogen content, so these areas are believed to be those where cement had settled out.

Temperature logs were run during a break in coring activity. The logs show that the aquifer from the water table (near 260 ft BLS) to 2,498 ft BLS is isothermal, ranging from about 62 to 64°F. Subtle variations in water temperature occur in the vicinity of fractured basalt, and these variations are likely related to increased horizontal groundwater flow entering the borehole along fractured media. No attempts were made to correct for residual drilling effects in the temperature data presented.

Borehole gyroscopic deviation surveys were run on October 10, 2010, for borehole Kimama-1A, and on November 4, 2010, for borehole Kimama-1B ([table 3](#)). The gyroscopic deviation surveys were collected through the drill casing to total drilled depth using USGS procedures (USGS INL Project Office, Setup and Operation of the 9095 Gyro Tool, written commun., May 1, 2009). Prior to logging, sighting azimuth and casing stickup data were collected and used to orient the gyroscopic deviation tool during warmup procedures ([table 3](#)). Processed gyroscopic deviation surveys are presented in [figure 4](#). Data indicate a 25.9- and 82.0-ft horizontal deviation from vertical with 1.5 and 1.9 degree deviation from vertical within Kimama-1A and -1B, respectively. Gyro-deviation logs show the point at which Kimama-1A and -1B separate near 676 ft BLS ([fig. 4](#)).

Table 3. Summary of gyroscopic deviation data collected at boreholes Kimama-1A and Kimama-1B, Kimama, southern Idaho.

[Borehole locations are shown in [figure 1](#). Survey performed using a Century Geophysical Corporation™ 9095 logging tool. A landing plate or tripod was used to hold the tool vertical during warmup. During warmup, the following information was noted: reference sighting azimuth, land surface drilling datum height, and magnetic declination. **Abbreviations:** ft, foot]

Gyroscopic deviation data	Boreholes	
	Kimama-1A	Kimama-1B
Total depth logged (ft)	976	2,490
Horizontal deviation from vertical taken at total logged depth (ft)	25.9	82.0
Deviation from vertical taken at total logged depth (degrees)	1.5	1.9
True drillhole length at total logged depth (ft)	975.6	2,488.6
Drillhole azimuth at total logged depth (degrees from True North)	172.6	188.3
Sighting Azimuth at land surface (degrees from True North)	210	217
Casing stickup at land surface (ft)	2.3	6.1

Figure 4. Gyroscopic deviation data collected for boreholes Kimama-1A and Kimama-1B, Kimama, southern Idaho.

Geologic Descriptions

Sparsely vegetated eolian deposits were visually described as the uppermost geologic unit at the Kimama scientific drilling site. Surficial sediments were at least 40 ft thick, and they were composed of silt to fine sand loess deposits, yellowish-brown in color.

At least eight sediment layers, excluding surficial sediment, were detected in Kimama-1B from 0 to 2,498 ft BLS. Sediment layers that ranged from less than 4 ft to greater than 60 ft thick mostly consisted of fine sand, silt, and clay. Sediment layers deeper than 2,498 ft BLS are not summarized in this report.

Basalt, primarily olivine tholeiite, represented about 95 percent of the core recovered from borehole Kimama-1B. Basalt flows ranged from less than 3 ft to more than 175 ft thick, varied from highly fractured to dense, had high to low vesiculation, was light to dark gray in color, and had aphanitic to fine-grained texture. Basalt flows deeper than 2,498 ft BLS are not described in this report.

Water-Quality Data

Sample Collection Methods

Water sample collection at the Kimama scientific drilling site generally followed guidelines that are documented in the USGS National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated) and in Knobel and others (2008). Water samples were collected from the KWS well from a submersible pump at a hydrant near the well. Samples were collected from pre-cleaned Tygon™ tubing installed off piping at the hydrant after field measurements were stable. Water samples from borehole Kimama-1A were collected using a pre-cleaned stainless steel thief sampling bottle that was lowered to about 460 and 830 ft BLS, and then filled with formation water. The stainless-steel bottle was then brought to the surface and emptied into a pre-cleaned container from which samples were processed to fill appropriate bottles for different analyses. Field measurements of pH, specific conductance, water temperature, dissolved oxygen, and alkalinity were taken from the pre-cleaned container and are presented in [table 4](#).

Field processing of samples differed depending on the constituents for which analyses were requested. Samples analyzed by the USGS National Water Quality Laboratory (NWQL) and the USGS Menlo Park Tritium Laboratory were placed in containers and preserved in accordance with laboratory requirements specified by Knobel and others (2008, appendix A). Containers and preservatives used were supplied

by the NWQL, and they had undergone a rigorous quality-control procedure (Pritt, 1989, p. 75) to minimize sample contamination. Samples requiring filtration were filtered through a disposable 0.45-μm cartridge that had been pre-rinsed with at least 1 L of deionized water. Samples analyzed by the Radiological and Environmental Sciences Laboratory (RESL) at the INL were placed in containers and preserved in accordance with laboratory requirements specified by Bodnar and Percival (1982), and by Knobel and others (2008, appendix A). Samples for isotopes of oxygen and hydrogen were containerized in bottles provided by the USGS Reston Stable Isotope Laboratory - Isotope Fractionation Project in Reston, Virginia. The samples also were analyzed at the Reston laboratory. Samples for isotopes of carbon were containerized in bottles provided by the NWQL, and these samples were analyzed at the National Oceanic Sciences Accelerator Mass Spectroscopy Laboratory in Woods Hole, Massachusetts.

Three water samples were collected; one from the KWS well, and two from borehole Kimama-1A at about 460 and 830 ft BLS. Water samples were collected from the KWS well after it had been used for more than a month as a water supply well for coring. The KWS well was completed in the upper 40 ft of the aquifer ([table 1](#)). The samples collected from Kimama-1A from approximately 460 ft BLS were collected from a 40-ft open interval between 436 and 476 ft BLS that was created when two 20-ft core rods were removed to create the opening. A break in the core rods at 476 ft helped to create the opening. The sample from 830 ft BLS represented water from about 715 to about 976 ft BLS, which was the bottom of the hole at the time of collection. Analyses for several of the constituents from the 830-ft level were affected by the drilling mud. Therefore, these data should be used with caution ([table 4](#)). Material data safety sheet (MSDS) forms for the drilling mud can be found in [appendix A](#). Water chemistry data for the three samples collected from different zones in the two wells, and a second sample set collected for tritium at the 830-ft level in Kimama-1A are shown in [table 4](#).

Analytical Methods

Analytical methods used by the USGS for selected organic, inorganic, and radionuclide constituents are described by Goerlitz and Brown (1972), Thatcher and others (1977), Wershaw and others (1987), Fishman and Friedman (1989), Faires (1993), Fishman (1993), and McCurdy and others (2008). Analytical methods used for selected isotopic constituents were summarized by Busenberg and others (2000). A discussion of procedures used by the RESL for the analysis of radionuclides in water is provided by Bodnar and Percival (1982), Sill and Sill (1994), and the U.S. Department of Energy (1995).

Table 4. Concentrations of selected radiochemical and chemical constituents in water from Kimama water supply well and borehole Kimama-1A, near Kimama, southern Idaho.

[Well and borehole locations are shown in [figure 1](#). Samples analyzed at the USGS National Water Quality Laboratory unless otherwise indicated. Uncertainty of radiochemical constituents is 1 standard deviation (s). Uncertainty of deuterium and oxygen-18 is ± 1.5 per mil. Uncertainty of carbon-13 is ± 0.3 per mil. Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in boldface type. **Abbreviations:** $\mu\text{S}/\text{cm}$, microsiemens per centimeter; mg/L , milligrams per liter; CaCO_3 , calcium carbonate; pCi/L , picocuries per liter; N, nitrogen; P, phosphorus; E, estimated. NC, not collected. NA, not applicable. NS, not sampled. <, less than. *, concentration or measurement probably affected by bentonite gel drilling solution]

Constituent or measurement	Kimama water supply well		Borehole Kimama-1A	
	10/06/2010 ¹	10/06/2010 ²	10/07/2010 ³	10/07/2010 ⁴
Time	1315	1930	1600	1820
Water temperature ($^{\circ}\text{C}$)	15.6	15.6	15.0	13.8
Air Temperature ($^{\circ}\text{C}$)	19.0	16.4	17.1	16.4
pH	7.85	*9.35	8.05	8.75
Specific conductance ($\mu\text{S}/\text{cm}$) (field)	292	*946	328	638
Specific conductance ($\mu\text{S}/\text{cm}$) (lab)	293	*1,115	328	NC
Dissolved oxygen (mg/L)	7.83	8.14	9.55	8.35
Alkalinity (mg/L as CaCO_3)	114	NS	118	NA
Total dissolved solids (mg/L)	194	NC	210	NA
Calcium (mg/L)	26.1	25.1	30.7	NA
Magnesium (mg/L)	12.9	9.74	13.1	NA
Potassium (mg/L)	3.24	*12.9	3.22	NA
Silica (mg/L)	32.1	26.5	31.1	NA
Sodium (mg/L)	15.2	*193	16.8	NA
Bromide (mg/L)	0.026	*0.102	0.032	NA
Chloride (mg/L)	11.8	*82.3	15.3	NA
Fluoride (mg/L)	0.485	*0.923	0.6	NA
Sulfate (mg/L)	20.8	*76.5	23.4	NA
Ammonia as N (mg/L)	<0.010	<0.01	<0.01	NA
Nitrite as N (mg/L)	<0.001	0.001E	<0.001	NA
Nitrate plus nitrite as N (mg/L)	0.513	0.318	0.681	NA
Orthophosphate as P (mg/L)	0.03	0.025	0.243	NA
Aluminum ($\mu\text{g}/\text{L}$)	5.06	*45.6	3.52	NA
Antimony ($\mu\text{g}/\text{L}$)	0.096	0.733	0.112	NA
Arsenic ($\mu\text{g}/\text{L}$)	2.27	3.18	2.09	NA
Barium ($\mu\text{g}/\text{L}$)	7.94	28.7	15.6	NA
Beryllium ($\mu\text{g}/\text{L}$)	<0.10	<0.10	<0.10	NA
Boron ($\mu\text{g}/\text{L}$)	29.2	40.4	36.1	NA
Cadmium ($\mu\text{g}/\text{L}$)	0.026E	0.058	<0.016	NA
Chromium ($\mu\text{g}/\text{L}$)	3.58	2.42	2.4	NA
Cobalt ($\mu\text{g}/\text{L}$)	0.023E	2.84	0.087	NA
Copper ($\mu\text{g}/\text{L}$)	<0.5	*10.3	<0.5	NA
Iron ($\mu\text{g}/\text{L}$)	3.42E	*54.9	29.6	NA
Lead ($\mu\text{g}/\text{L}$)	0.547	0.247	0.020E	NA
Lithium ($\mu\text{g}/\text{L}$)	13.1	38	18.9	NA
Manganese ($\mu\text{g}/\text{L}$)	0.819	5	1.39	NA
Molybdenum ($\mu\text{g}/\text{L}$)	3.02	7.54	2.86	NA
Nickel ($\mu\text{g}/\text{L}$)	0.223	3.3	0.448	NA
Selenium ($\mu\text{g}/\text{L}$)	0.826	1.33	0.681	NA
Silver ($\mu\text{g}/\text{L}$)	<0.005	0.053	<0.005	NA
Strontium ($\mu\text{g}/\text{L}$)	141	203	157	NA
Thallium ($\mu\text{g}/\text{L}$)	<0.01	0.013E	<0.01	NA
Tungsten ($\mu\text{g}/\text{L}$)	0.337	*309	1.05	NA
Uranium ($\mu\text{g}/\text{L}$)	1.5	5.69	1.54	NA
Vanadium ($\mu\text{g}/\text{L}$)	10.3	9.04	8.21	NA
Zinc ($\mu\text{g}/\text{L}$)	70.2	9.2	8.38	NA

Table 4. Concentrations of selected radiochemical and chemical constituents in water from Kimama water supply well and borehole Kimama-1A, near Kimama, southern Idaho.—Continued

[Well and borehole locations are shown in [figure 1](#). Samples analyzed at the USGS National Water Quality Laboratory unless otherwise indicated. Uncertainty of radiochemical constituents is 1 standard deviation (s). Uncertainty of deuterium and oxygen-18 is ± 1.5 per mil. Uncertainty of carbon-13 is ± 0.3 per mil. Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in boldface type. **Abbreviations:** $\mu\text{S}/\text{cm}$, microsiemens per centimeter; mg/L, milligrams per liter; CaCO_3 , calcium carbonate; pCi/L, picocuries per liter; N, nitrogen; P, phosphorus; E, estimated. NC, not collected. NA, not applicable. NS, not sampled. <, less than. *, concentration or measurement probably affected by bentonite gel drilling solutions]

Constituent or measurement	Kimama water supply well		Borehole Kimama-1A	
	10/06/2010 ¹	10/06/2010 ²	10/07/2010 ³	10/07/2010 ⁴
Total organic carbon (mg/L)	0.368E	*425	0.482E	NA
Tritium (pCi/L) ⁵	1.06 $\pm$ 2.04	0 $\pm$ 2.01	-0.7 $\pm$ 2	1.08 $\pm$ 2.07
Tritium (pCi/L) ⁶	50 $\pm$ 50	810$\pm$70	240$\pm$50	70 $\pm$ 50
Rerun	NA	16.1 $\pm$ 50.5	180$\pm$50	NA
Strontium-90 (pCi/L) ⁶	0.5 $\pm$ 0.7	1.5 $\pm$ 0.7	0.3 $\pm$ 0.6	NA
Cesium-137 (pCi/L) ⁶	15 $\pm$ 9	8 $\pm$ 8	12 $\pm$ 8	NA
Gross alpha (pCi/L) ⁶	0.0 $\pm$ 1.0	18$\pm$6	-1 $\pm$ 2	NA
Rerun	NA	33$\pm$10	8 $\pm$ 3	NA
Gross beta (pCi/L) ⁶	3.8$\pm$0.8	14.4$\pm$1.2	4.3$\pm$0.8	NA
Rerun	NA	18.0$\pm$1.5	5.1$\pm$0.9	NA
Americium-241 (pCi/L) ⁶	-0.01 $\pm$ 0.002	0.003 $\pm$ 0.013	0.006 $\pm$ 0.012	NA
Plutonium-238 (pCi/L) ⁶	-0.005 $\pm$ 0.013	-0.003 $\pm$ 0.01	-0.003 $\pm$ 0.009	NA
Plutonium-239,240 (pCi/L) ⁶	-0.005 $\pm$ 0.009	0.003 $\pm$ 0.007	0.009 $\pm$ 0.008	NA
Carbon-13/Carbon-12 (per mil) ⁷	-9.20	NC	-9.38	NA
Carbon-14 (percent modern) ⁷	58.2 $\pm$ 0.24	NC	64.48 $\pm$ 0.25	NA
Deuterium (per mil) ⁸	-136.4	-136.7	-138	NA
Oxygen-18 (per mil) ⁸	-17.91	-17.97	-17.98	NA

¹Samples collected from pumped well.

²Samples collected from a bailed sample from 830 ft BLS.

³Samples collected from a bailed sample from 460 ft BLS.

⁴Bailed at about 830 ft BLS.

⁵Samples analyzed at the USGS Menlo Park Tritium Laboratory in Menlo Park, CA.

⁶Samples analyzed at the Radiological and Environmental Sciences Laboratory, INL.

⁷Samples analyzed at the National Oceanic Sciences Accelerator Mass Spectroscopy Laboratory in Woods Hole, MA.

⁸Samples analyzed at the USGS Reston Stable Isotope Laboratory - Isotope Fractionation Project in Reston, VA.

Guidelines for Interpretation of Analytical Results

Concentrations of radionuclides are reported with an estimated sample standard deviation, s , which is obtained by propagating sources of analytical uncertainty in measurements. McCurdy and others (2008) provided details on interpreting radiological data used by the USGS. The guidelines for interpreting analytical results are based on an extension of a method proposed by Currie (1984) and are given in Davis (2010). In this report, radionuclide concentrations less than $3s$ are considered to be less than a “reporting level.” The reporting level should not be confused with the analytical method detection limit, which is based on laboratory procedures.

Concentrations of inorganic and organic constituents are reported with reference to laboratory reporting levels (LRLs). Childress and others (1999) provide details about the approach used by the USGS regarding detection levels and reporting levels. USGS Office of Water Quality Technical Memorandum 2010.07 (U.S. Geological Survey, 2010) outlines changes to data reporting by the NWQL for the inorganic and organic constituents. The method detection limit is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the concentration is greater than zero. The LRL is the concentration at which the false negative error rate is minimized to be no more than 1 percent of the reported results. The LRL generally is equal to twice the yearly determined long-term method detection level (LT-MDL), which is a detection level derived by determining the standard deviation of a minimum of 24 MDL spike-sample measurements over an extended time. The LT-MDL controls

false positive error—it is the concentration at which the false positive risk is minimized to be no more than 1 percent of the reported values (Childress and others, 1999). These reporting levels may be described as preliminary for a developmental method if the levels have been based on a small number of analytical results. These levels also may vary from sample to sample for the same constituent, and the same method, if matrix effects or other factors arise that interfere with the analysis. Concentrations measured between the LT-MDL and the LRL are described as estimated values. For most of the constituents in this report, reported concentrations generally are greater than LRLs, but some concentrations are given as less than the LRL, and some concentrations are estimated. As a matter of convention, concentrations of stable isotopes are reported as relative isotopic ratios (Toran, 1982). Busenberg and others (2000) described stable isotope data in more detail.

Inorganic Chemistry Data

Water samples collected from the KWS well and from borehole Kimama-1A (460 and 830 ft BLS) were sent to the NWQL to be analyzed for dissolved concentrations of cations of calcium, potassium, magnesium, and sodium; anions of bromide, chloride, fluoride, and sulfate; and trace elements of aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, molybdenum, nickel, selenium, silver, strontium, thallium, tungsten, uranium, vanadium and zinc. In addition, samples were collected and sent to the NWQL to be analyzed for dissolved concentrations of ammonia as nitrogen (N), nitrite as N, nitrate plus nitrite as N, and orthophosphate as phosphorus (P) (table 4).

A comparison of the data between the upper zone in the KWS well and borehole Kimama-1A 460-ft BLS zone indicates very similar chemistry of the aquifer water. A few exceptions include some variability with nitrate plus nitrite as N (0.513–0.681 mg/L), orthophosphate as P (0.03–0.243 mg/L), iron (estimated 3.42–29.6 µg/L), and zinc (70.2–8.38 µg/L) (table 4). The water chemistry of a few of the constituents such as calcium, magnesium, silica, and several trace elements from borehole Kimama-1A 830-ft BLS zone also were quite comparable to the upper two zones, but several of the other constituents appeared to have been affected by the drilling mud. Because of time constraints needed for drilling, we were unable to wait for the deeper part of the aquifer to clear before sample collection.

Organic Chemistry Data

Water samples collected from the KWS well and from borehole Kimama-1A (460 and 830 ft BLS), were analyzed for total organic carbon at the NWQL. Data were comparable between the KWS well and borehole Kimama-1A 460-ft BLS zone; the deepest zone (830-ft BLS) was contaminated with the bentonite gel (table 4).

Stable Isotope Data

Water samples collected from KWS well, and from Kimama-1A (460 and 830 ft BLS) were analyzed for relative concentrations of stable isotopes of hydrogen (H), oxygen (O), and carbon (C). Because the absolute measurement of isotopic ratios is analytically difficult, relative isotopic ratios were measured instead (Toran, 1982). For example, $^{18}\text{O}/^{16}\text{O}$ of a sample is compared with $^{18}\text{O}/^{16}\text{O}$ of a standard:

$$\Delta^{18}\text{O} = (R_{\text{sample}}/R_{\text{standard}} - 1) \times 1,000, \quad (1)$$

where

R_{sample} is the $^{18}\text{O}/^{16}\text{O}$ ratio in the sample,
 R_{standard} is the $^{18}\text{O}/^{16}\text{O}$ ratio in the standard, and

$\Delta^{18}\text{O}$ is the relative concentration, in units of parts per thousand (per mil).

$\Delta^{18}\text{O}$ is referred to as delta notation; it is the value reported by isotopic laboratories for stable isotope analysis. $^2\text{H}/^1\text{H}$ and $^{13}\text{C}/^{12}\text{C}$ are defined in a similar manner with the respective ratios replacing $^{18}\text{O}/^{16}\text{O}$ in R_{sample} and R_{standard} . The standard used for determining $\Delta^{18}\text{O}$ and $\Delta^2\text{H}$ in water is standard mean ocean water as defined by Craig (1961). The Pee Dee Belemnite reference standard was used to determine $\Delta^{13}\text{C}$ in water (Timme, 1995, p. 71). The carbon-14 was measured by accelerator mass spectroscopy, and concentrations are given as percent modern carbon.

The data for stable isotopes of samples collected for deuterium, oxygen-18, and carbon-13 were similar for all the different zones sampled for this study (table 4). The percent modern carbon in the sample from borehole Kimama-1A 460-ft BLS zone was slightly greater (64.48 ± 0.24) than in the sample from the KWS well (58.2 ± 0.24).

Radionuclide Data

Water samples were collected from the KWS well and from borehole Kimama-1A (460 and 830 ft BLS), and analyzed for tritium; strontium-90; gross alpha, beta, and gamma radioactivity; plutonium-238 and plutonium-239, -240 (undivided); and americium-241 at the RESL. In addition, samples were collected for tritium and analyzed by the USGS Menlo Park Tritium Laboratory in Menlo Park, California, using a lower MDL than the RESL. The MDL for tritium analyzed at the RESL is about 200 pCi/L, and the MDL for tritium at the USGS lab is about 5.7 pCi/L (Bartholomay and Twining, 2010).

Except for gross beta concentrations, the concentrations from all water samples from the KWS well were less than the reporting level of three times the sample standard deviation (table 4). The gross beta concentration of 3.8 ± 0.8 pCi/L in the KWS well is representative of background concentrations in the ESRP aquifer that range from 0 to 7 pCi/L (Knobel and others, 1992).

Concentrations of radionuclides from borehole Kimama-1A 830-ft BLS zone were less than the reporting level for all samples, except for one gross alpha concentration (18 ± 6 pCi/L), which was right at the reporting level. Concentrations of gross beta and tritium from initial analyses were greater than the reporting level for RESL samples; rerun analyses indicated that concentrations were still greater than the reporting level for the gross beta concentration, but the tritium concentration was less than the reporting level at 16.1 ± 50.5 pCi/L (table 4). Tritium concentrations in samples collected the next day (October 7, 2010) were less than the reporting level for analyses from both laboratories.

Except for the gross beta analyses and one tritium sample, concentrations in the water samples from borehole Kimama-1A 460-ft BLS zone were less than the reporting level of three times the sample standard deviation (table 4). The one tritium sample had a concentration slightly above the reporting level at 240 ± 50 pCi/L (a rerun had a concentration of 180 ± 50 pCi/L) (table 4). The gross beta concentration of 4.3 ± 0.8 pCi/L is representative of background concentrations in the ESRP aquifer that range from 0 to 7 pCi/L (Knobel and others, 1992). All the tritium data from the USGS Menlo Park Tritium Laboratory were less than the reporting level, and concentrations were near zero (table 4).

Summary

In 2010, the U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy (DOE), conducted geophysical logging and water sampling activities at a scientific drilling site near Kimama, southern Idaho. Wireline geophysical logs were collected for boreholes Kimama-1A and -1B from land surface depths of 976 and 2,498 feet below land surface (BLS), respectively. Water samples were collected from borehole Kimama-1A at depths near 460 and 830 ft BLS using a thief sampler, and from the Kimama Water Supply (KWS) well from a dedicated submersible pump. The Kimama scientific drilling site was established as part of the Project Hotspot initiative to study the interaction between the Earth's crust and mantle, to identify potential geothermal energy sources, and to track the evolution of the Yellowstone hotspot on the eastern Snake River Plain (ESRP). The USGS participated with geophysical logging and water-quality sampling to gain a better understanding of the geology and hydrology of the ESRP aquifer downgradient of the DOE's Idaho National Laboratory, which is located about 50 miles northeast of the study site.

Geophysical log data included a composite of natural gamma, neutron, gamma-gamma dual density, and gyroscopic analysis for boreholes Kimama-1A and -1B. Geophysical logs depicted eight sediment layers (excluding surficial sediment) ranging from 4 to 60 feet thick. Approximately 155 individual basalt flows were identified, ranging from less than 3 feet to

more than 175 feet thick (mean = 15 feet) for Kimama-1B (0–2,498 feet BLS). Sediment and basalt contacts were selected based on geophysical traces, and they were confirmed by visual inspection of core photographs. Temperature logs from the water table surface (about 260 feet BLS) to the bottom of borehole Kimama-1B (about 2,498 feet BLS) were nearly isothermal, ranging from about 62 to 64 degrees Fahrenheit; however, temperature data were not compensated for effects of recent drilling activity. Gyroscopic data reveal that borehole Kimama-1B begins to separate from borehole Kimama-1A near a depth of 676 feet BLS. Drillhole azimuth and horizontal deviation at total logged depth for boreholes Kimama-1A and -1B were 172.6 and 188.3 degrees and 25.9 and 82.0 feet, respectively.

Water samples were collected and analyzed for common ions; selected trace elements; nutrients; isotopes of hydrogen, oxygen, and carbon; and selected radionuclides from the KWS well and from two discrete zones (460 and 830 ft BLS) in borehole Kimama-1A. Data for the three zones sampled generally indicated that the water chemistry was similar for all zones except for concentrations in the deepest zone that probably was affected by the drilling mud. A comparison of the inorganic, organic, and stable chemistry data between the upper zone and the 460-ft zone indicated similar chemistry of the aquifer water, except for some variability with nitrate plus nitrite as N, orthophosphate as P, iron, zinc, and carbon-14. Radionuclide concentrations were either less than reporting levels or at background levels for the ESRP aquifer.

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**Appendix A. Material Safety Data Sheets for Drilling Products Used at the
Kimama Scientific Drilling Site: Bentonite, Ndfx 233, and Soda Ash**

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MATERIAL SAFETY DATA SHEET

SECTION I: IDENTIFICATION OF PRODUCT

COMPANY: **Diversity Technologies Corp.**
8750 – 53rd Ave.
Edmonton, AB T6E 5G2

DATE: June 27, 2010
PHONE: 780-468-4064
FAX: 780-469-1899

PRODUCT NAME: **Extra High Yield Bentonite**

PRODUCT USE: Drilling fluid & cement additive

CHEMICAL FAMILY: Bentonite clay CAS#: 1302-78-9

WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS)

WHMIS CLASSIFICATION: D2A

WORKPLACE HAZARD: Potential carcinogen; contains crystalline silica

TRANSPORTATION OF DANGEROUS GOODS (TDG)

PROPER SHIPPING NAME: Not regulated under TDG

TDG CLASSIFICATION: Not applicable

UN NUMBER (PIN): Not applicable

PACKING GROUP: Not applicable

SECTION II: HAZARDOUS INGREDIENTS

INGREDIENT	% (w/w)	CAS NUMBER	LD ₅₀ Oral-Rat	LC ₅₀ Inhal-Rat	ACGIH-TLV
Crystalline silica; quartz	2 – 6	14808-60-7	Not available	Not available	0.025 mg/m ³

SECTION III: HEALTH HAZARDS

ROUTE OF ENTRY: [] EYE CONTACT [] SKIN [XX] INHALATION [] INGESTION

EYE CONTACT: May cause mechanical irritation.

SKIN CONTACT: Possible drying resulting in dermatitis.

INGESTION: No adverse effects expected.

INHALATION: Inhalation may cause irritation of the nose, throat and respiratory passages. Long-term inhalation may cause silicosis, a progressive, disabling and, sometimes, fatal lung disease. Chronic inhalation exposure to crystalline silica quartz has been observed to cause lymph node effects, kidney effects and auto-immune disease.

CARCINOGENICITY: Bentonite is not listed as a carcinogen. Crystalline silica when inhaled in the form of quartz or cristobalite from occupational sources is carcinogenic to humans: The IARC has concluded that this chemical is carcinogenic to humans (Group 1). The ACGIH has designated this chemical as a suspected human carcinogen (A2). The US NTP has listed this chemical as a known human carcinogen.

TERATOGENICITY: No information available.

REPRODUCTIVE

TOXICITY: No information available.

MUTAGENICITY: Crystalline silica has been shown to cause mutagenic effects in human cells in-vitro.

SYNERGISTIC

PRODUCTS: No information available.

SECTION IV: FIRST AID MEASURES

SKIN CONTACT: If irritation occurs or when shift ends, wash with soap and water until clean.

EYE CONTACT: Flush with water until irritation ceases. If irritation persists, contact a physician.

INGESTION: No first aid required; material is non-toxic.

INHALATION: Move to area free from dust. Apply oxygen or artificial respiration if required. If breathing difficulties, or distress, continue obtain medical attention.

SECTION V: PHYSICAL DATA

APPEARANCE AND ODOUR: Pale grey to buff powder, granule or tablet; no odour

SPECIFIC GRAVITY: 2.45 – 2.55

BOILING POINT (° C): Not applicable

MELTING POINT (° C): 1450° C (approx)

SOLUBILITY IN WATER: Insoluble pH: 8-10 (5% aq. suspension)

PERCENT VOLATILE BY VOLUME: Not available

EVAPORATION RATE: Not applicable

VAPOUR PRESSURE (mmHg): Not applicable

VAPOUR DENSITY (air = 1): Not applicable

BULK DENSITY: 55 lb/ft³

SECTION VI: FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: Not applicable

FLAMMABLE LIMITS: Not applicable

EXTINGUISHING MEDIA: Use media suitable for and packaging and surrounding fire. Product becomes very slippery when wet, avoid using water as fire-fighting agent.

SPECIAL FIRE FIGHTING PROCEDURES: Self-contained breathing apparatus required for fire fighting personnel.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None known.

SECTION VII: REACTIVITY DATA

STABILITY: STABLE [XX] UNSTABLE []

INCOMPATIBILITY (CONDITIONS TO AVOID): None known.

CONDITIONS OF REACTIVITY: Not available

HAZARDOUS DECOMPOSITION PRODUCTS: None known

HAZARDOUS POLYMERIZATION: WILL NOT OCCUR [XX] MAY OCCUR []

SECTION VIII: PREVENTATIVE MEASURES

SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION: NIOSH/MESA approved respirators for silica bearing dust.

VENTILATION: Use local ventilation, process enclosure or other engineering controls to maintain airborne concentration of dust below TLV.

PROTECTIVE GLOVES: Generally not necessary; personal preference.

EYE PROTECTION: Suggest goggles.

OTHER PROTECTIVE EQUIPMENT (Specify): Ensure emergency eye wash station and safety shower are available.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING

Avoid breathing dust; wear approved respiratory protection. Practice reasonable caution and personal cleanliness. Avoid eye contact. Store in cool, dry area. Empty packages contain residual hazardous material and should be handled as if full.

STEPS TO BE TAKEN IN CASE THE MATERIAL IS SPILLED OR RELEASED

Avoid breathing dust; wear an approved respirator. Vacuum to avoid generating airborne dust. Avoid using water. Product slippery when wet. Collect uncontaminated material for repackaging. Collect contaminated material in an approved container for disposal.

WASTE DISPOSAL METHOD

Dispose in accordance with federal, provincial and local regulations. It is the responsibility of the end-user to determine if material meets the criteria of hazardous waste at the time of disposal. Empty packaging must be disposed of in accordance with local regulations.

SECTION IX: PREPARATION

THE INFORMATION CONTAINED HEREIN IS GIVEN IN GOOD FAITH,
BUT NO WARRANTY, EXPRESSED OR IMPLIED, IS MADE.

DATE ISSUED:	June 27, 2010	BY: Product safety committee
SUPERSEDES:	June 27, 2007	PHONE: 780-440-4923

**Diversity Technologies Corp. is the parent company of
Canamara-United Supply, Hollimex Products, The Drilling Depot and
Westcoast Drilling Supplies.**

Newpark Drilling Fluids, LLC PRODUCT INFORMATION

410 17th STREET

■ SUITE 460 ■

DENVER, COLORADO 80202 ■

(303) 623-2205 ■

FAX (720) 904-7970

NDFX 233

PRODUCT DESCRIPTION

NDFX 233 was formulated specifically for mining applications. It is a proprietary blend of New 100N, New Ease 203, and Deep Drill Inhibitor in proper formulation.

APPLICATION

The product provides penetration rate enhancement, highly effective lubricity, and shale stability. It is effective in **ANY** type of water base formulation and is extremely effective in high angle holes where highly reactive clays are encountered. The product is environmentally safe in any and all applications.

BENEFITS

- *Reduces torque in lower concentrations.
- *Provides borehole stability by reducing water activity and by attaching itself to shale surfaces.
- *Inhibits clays by providing a semi permeable membrane on the shale interface to help minimize undesirable diffusion and osmotic effects of the clays.
- *Increases penetration and bit life.
- *Environmentally safe.

TREATMENT RECOMMENDATIONS

Lower concentrations of 2-4 qts per 300 gallons of mix will provide initial and consistent torque reduction. For torque increases due to deviation and/or high angle hole, 4-6 qts per 300 gallons may be required. For clay inhibition/shale stabilization, 4-12 quarts depending on the reactivity of the clay/shale encountered.

PACKAGING

NDFX 233 is available only in 5 gallon pails. It can be made available in drums or bulk quantities with prior notification.

SAFETY DATA SHEET

North American Version

SODA ASH (Sodium Carbonate)

1. PRODUCT AND COMPANY IDENTIFICATION

1.1. Identification of the substance or preparation

Product name : SODA ASH (Sodium Carbonate)
Product grade(s) : Dense Soda Ash
Chemical Grade Soda Ash
Chemical Name : Sodium carbonate
Synonyms : soda salt, soda crystal, disodium carbonate
Molecular formula : Na_2CO_3
Molecular Weight : 106 g/mol

1.2. Use of the Substance/Preparation

Recommended use : - Glass industry
- Metallurgy
- Detergent
- Chemical industry
- Pulp and paper
- Ion exchange resins regenerating agent
- Purifying flue gas

1.3. Company/Undertaking Identification

Address : SOLVAY CHEMICALS, INC.
3333 RICHMOND AVENUE
HOUSTON TX 77098-3099
United States

1.4. Emergency and contact telephone numbers

Emergency telephone : 1 (800) 424-9300 CHEMTREC® (USA & Canada)
01-800-00-214-00 (MEX. REPUBLIC)

Contact telephone number : US: +1-800-765-8292 (Product information)
(product information): US: +1-713-525-6500 (Product information)

2. HAZARDS IDENTIFICATION

2.1. Emergency Overview:

NFPA : H= 2 F= 0 I= 0 S= None
HMIS : H= 2 F= 0 R= 0 PPE = Supplied by User; dependent on local conditions

General Information

Appearance : granules, powder
Colour : white
Odour : odourless

Main effects

- This substance is classified and labelled according to Annex I of Directive 67/548/EEC, as amended.
- Irritating to eyes.

2.2. Potential Health Effects:

Inhalation

- Product dust may be irritating to eyes, skin and respiratory system.
- Irritating to mucous membranes
- Repeated or prolonged exposure: Risk of sore throat, nose bleeds.
- (in case of higher concentration): Cough.

Eye contact

- Severe eye irritation
- Lachrymation
- Redness
- Swelling of tissue
- May cause irreversible eye damage.

Skin contact

- When in contact with damp skin, irritation.
- Itching
- Repeated exposure may cause skin dryness or cracking.

Ingestion

- Severe irritation
- Irritation of the mouth and throat.
- Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhoea.

Other toxicity effects

- See section 11: Toxicological Information

2.3. Environmental Effects:

- See section 12: Ecological Information

3. COMPOSITION/INFORMATION ON INGREDIENTS

Sodium carbonate

CAS-No.	:	497-19-8
Concentration	:	>= 99,8 %

4. FIRST AID MEASURES

4.1. Inhalation

- Remove the subject from dusty environment and let him blow his nose.
- If symptoms persist, call a physician.

4.2. Eye contact

- Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes.
- Consult with an ophthalmologist immediately in all cases.

4.3. Skin contact

- Remove and wash contaminated clothing before re-use.
- Wash off with plenty of water.
- If symptoms persist, call a physician.

4.4. Ingestion

- Call a physician immediately.

If victim is conscious:

- If swallowed, rinse mouth with water (only if the person is conscious).
- Do NOT induce vomiting.

If victim is unconscious but breathing:

- Artificial respiration and/or oxygen may be necessary.

5. FIRE-FIGHTING MEASURES

5.1. Suitable extinguishing media

- Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

5.2. Extinguishing media which shall not be used for safety reasons

- None.

5.3. Special exposure hazards in a fire

- Not combustible.

5.4. Hazardous decomposition products

- none

5.5. Special protective equipment for fire-fighters

- No special precautions required.

6. ACCIDENTAL RELEASE MEASURES

6.1. Personal precautions

- Refer to protective measures listed in sections 7 and 8.

6.2. Environmental precautions

- Do not flush into surface water or sanitary sewer system.
- If the product contaminates rivers and lakes or drains inform respective authorities.

6.3. Methods for cleaning up

- Sweep up and shovel into suitable containers for disposal.
- Avoid dust formation.
- Keep in properly labelled containers.
- Keep in suitable, closed containers for disposal.
- Treat recovered material as described in the section "Disposal considerations".

7. HANDLING AND STORAGE

7.1. Handling

- Use only in well-ventilated areas.
- Keep away from Incompatible products.

7.2. Storage

- Keep in a dry place.
- Store in original container.
- Keep container closed.
- Keep away from Incompatible products.

7.3. Packaging material

- Polyethylene
- Woven plastic material + PE.

7.4. Other information

- Avoid dust formation.
- Refer to protective measures listed in sections 7 and 8.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1. Exposure Limit Values

Sodium carbonate

- SAEL (Solvay Acceptable Exposure Limit) 2007
TWA = 10 mg/m³

Particles not otherwise specified (PNOS)

- Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2) 04 2004
time weighted average = 3 mg/m³
Remarks: Respirable particles.
- Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2) 04 2004
time weighted average = 10 mg/m³
Remarks: Total particulate.
- Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) 07 2006
time weighted average = 10 mg/m³
Remarks: Total dust
- Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended) 07 2006
time weighted average = 3 mg/m³
Remarks: respirable dust fraction
- Canada. Ontario OELs. (Ministry of Labor - Control of Exposure to Biological or Chemical Agents) 03 2006
time weighted average = 3 mg/m³
Remarks: Respirable particles.
- Canada. Ontario OELs. (Ministry of Labor - Control of Exposure to Biological or Chemical Agents) 03 2006
time weighted average = 10 mg/m³
Remarks: Inhalable particulate.
- Canada. Quebec OELs. (Ministry of Labor - Regulation Respecting the Quality of the Work Environment) 2006
time weighted average = 10 mg/m³
Remarks: Total dust
- US. ACGIH Threshold Limit Values 2008
time weighted average = 10 mg/m³
Remarks: Inhalable particles.

8.2. Engineering controls

- Ensure adequate ventilation.
- Provide appropriate exhaust ventilation at places where dust is formed.
- Refer to protective measures listed in sections 7 and 8.
- Apply technical measures to comply with the occupational exposure limits.

8.3. Personal protective equipment

8.3.1. Respiratory protection

- In case of insufficient ventilation, wear suitable respiratory equipment.
- Use only respiratory protection that conforms to international/ national standards.
- Use NIOSH approved respiratory protection.
- Respirator must be worn if exposed to dust.

8.3.2. Hand protection

- Take note of the information given by the producer concerning permeability and break through times, and of special workplace conditions (mechanical strain, duration of contact).
- Wear suitable gloves.
- Suitable material: Neoprene, Natural Rubber

8.3.3. Eye protection

- Dust proof goggles, if dusty.

8.3.4. Skin and body protection

- long sleeved clothing
- dust impervious protective suit
- Rubber or plastic boots.
- Rubber or plastic apron

8.3.5. Hygiene measures

- Use only in an area equipped with a safety shower.
- When using do not eat, drink or smoke.
- Handle in accordance with good industrial hygiene and safety practice.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1. General Information

Appearance	: granules, powder
Colour	: white
Odour	: odourless

9.2. Important health safety and environmental information

pH	: 11,1 <i>Concentration: 4,016 g/l</i> <i>Temperature: 25 °C (77 °F)</i>
Boiling point/boiling range	: <i>Remarks: not applicable</i>
Flash point	: <i>Remarks: not applicable</i>
Flammability	: <u>Lower explosion limit:</u> <i>Remarks: not applicable</i>
Explosive properties	: <u>Explosion danger:</u> <i>Remarks: not applicable</i>
Relative density / Density	: 2,5
Bulk density	: from 0,5 - 0,8 kg/dm ³ <i>Method: Free flow</i>
Solubility	: Water = 71 g/l <i>Temperature: 0 °C (32 °F)</i> : = 215 g/l <i>Temperature: 20 °C (68 °F)</i>
Partition coefficient: n-octanol/water	: <i>Remarks: not applicable</i>

9.3. Other data

Melting point/range	: 851 °C (1.564 °F)
Granulometry	: 95 - 100 % < 180 µm 0 - 5 % > 180 µm
Decomposition temperature	: <i>Remarks: not applicable</i>

10. STABILITY AND REACTIVITY

10.1. Stability

- Stable under recommended storage conditions.

10.2. Conditions to avoid

- Exposure to moisture.

10.3. Materials to avoid

- Finely divided aluminium

10.4. Hazardous decomposition products

- none

11. TOXICOLOGICAL INFORMATION

Toxicological data

Acute oral toxicity

- LD50, rat, > 2.000 mg/kg

Acute inhalation toxicity

- LC50, 2 h, rat, 2,3 mg/l

Acute dermal irritation/corrosion

- LD50, rabbit, 2.000 mg/kg

Skin irritation

- rabbit, No skin irritation

Eye irritation

- rabbit, irritant effects

Chronic toxicity

- Inhalation, rat, Target Organs: Lungs, NOEL: 0,07 mg/l, observed effect

Genetic toxicity in vitro

- *Remarks: no observed effect*

Teratogenicity

- Oral route (gavage), 10 days, Various species, 179 mg/kg, Did not show teratogenic effects in animal experiments.

Remarks

- Irritating to eyes.

12. ECOLOGICAL INFORMATION

12.1. Ecotoxicity effects

Acute toxicity

- Fishes, *Lepomis macrochirus*, LC50, 96 h, 300 mg/l
- Fishes, *Gambusia affinis*, LC50, 96 h, 740 mg/l
- Crustaceans, *Ceriodaphnia dubia*, EC50, 48 h, 200 - 227 mg/l

Chronic toxicity

- Phytoplankton, EC50, biomass, 7 Days, 14 mg/l

12.2. Mobility

- Air
Remarks: not applicable
- Water
Remarks: Solubility
- Water
Remarks: Mobility
- Soil/sediments
Remarks: not significant

12.3. Persistence and degradability

Abiotic degradation

- Water, hydrolyses
Result: acid/base equilibrium as a function of pH
Degradation products: carbonic acid/bicarbonate/carbonate

Biodegradation

- Remarks: The methods for determining the biological degradability are not applicable to inorganic substances.

12.4. Bioaccumulative potential

- Result: not applicable

12.5. Other adverse effects

- no data available

12.6. Remarks

- Ecological injuries are not known or expected under normal use.

13. DISPOSAL CONSIDERATIONS

13.1. Waste from residues / unused products

- Contact waste disposal services.
- If recycling is not practicable, dispose of in compliance with local regulations.
- or
- Dilute with plenty of water.
- Neutralise with acid.
- In accordance with local and national regulations.

13.2. Packaging treatment

- To avoid treatments, as far as possible, use dedicated containers.
- or
- Clean container with water.
- Dispose of rinse water in accordance with local and national regulations.
- The empty and clean containers are to be reused in conformity with regulations.
- or
- Must be incinerated in a suitable incineration plant holding a permit delivered by the competent authorities.

13.3. RCRA Hazardous Waste

- Listed RCRA Hazardous Waste (40 CFR 302) - No

- Unlisted RCRA Hazardous Waste (40 CFR 302) - No

14. TRANSPORT INFORMATION

U.S. Dept of Transportation

Class (Subsidiary)

Remarks:

It is recommended that ERG Guide number 111 be used for all non-regulated material.

- Sea (IMO/IMDG)
- not regulated
- Air (ICAO/IATA)
- not regulated
- U.S. Dept of Transportation
- not regulated
- It is recommended that ERG Guide number 111 be used for all non-regulated material.
- Canadian Transportation of Dangerous Goods
- not regulated

15. REGULATORY INFORMATION

15.1. Inventory Information

Australian Inventory of Chemical Substances (AICS)	:	-	In compliance with inventory.
Canadian Domestic Substances List (DSL)	:	-	In compliance with inventory.
Korean Existing Chemicals List (ECL)	:	-	In compliance with inventory.
EU list of existing chemical substances (EINECS)	:	-	In compliance with inventory.
Japanese Existing and New Chemical Substances (MITI List) (ENCS)	:	-	In compliance with inventory.
Inventory of Existing Chemical Substances (China) (IECS)	:	-	In compliance with inventory.
Philippine Inventory of Chemicals and Chemical Substances (PICCS)	:	-	In compliance with inventory.
Toxic Substance Control Act list (TSCA)	:	-	In compliance with inventory.
New Zealand Inventory (in preparation) (NZ)	:	-	One or more components not on composite list considered for transfer.
Schweizer Giftliste-1 (GL-1)	:	-	In compliance with inventory.

15.2. Other regulations

US. EPA Emergency Planning and Community Right-To-Know Act (EPCRA) SARA Title III Section 313 Toxic Chemicals (40 CFR 372.65) - Supplier Notification Required

- no.

US. EPA CERCLA Hazardous Substances (40 CFR 302)

- not regulated.

US. New Jersey Worker and Community Right-to-Know Act (New Jersey Statute Annotated Section 34:5A-5)

- not regulated.

US. Pennsylvania Worker and Community Right-to-Know Law (34 Pa. Code Chap. 301-323)

- not regulated.

US. California Safe Drinking Water & Toxic Enforcement Act (Proposition 65)

- not regulated.

15.3. Classification and labelling

Canada. Canadian Environmental Protection Act (CEPA). WHMIS Ingredient Disclosure List (Can. Gaz., Part II, Vol. 122, No. 2)

- D2B Toxic Material Causing Other Toxic Effects

Remarks: This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

EC Label

- This substance is classified and labelled according to Annex I of Directive 67/548/EEC, as amended.

Symbol(s)	Xi	Irritant
R-phrases(s)	R36	Irritating to eyes.
S-phrases(s)	S 2	Keep out of the reach of children.
	S22	Do not breathe dust.
	S26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

16. OTHER INFORMATION

Ratings :

NFPA (National Fire Protection Association)

Health = 2 Flammability = 0 Instability = 0 Special =None

HMIS (Hazardous Material Information System)

Health = 2 Fire = 0 Reactivity = 0 PPE : Supplied by User; dependent on local conditions

Further information

- System maintenance
- Distribute new edition to clients

Material Safety Data Sheets contain country specific regulatory information; therefore, the MSDS's provided are for use only by customers of the company mentioned in section 1 in North America. If you are located in a country other than

Canada, Mexico or the United States, please contact the Solvay Group company in your country for MSDS information applicable to your location. The previous information is based upon our current knowledge and experience of our product and is not exhaustive. It applies to the product as defined by the specifications. In case of combinations or mixtures, one must confirm that no new hazards are likely to exist. In any case, the user is not exempt from observing all legal, administrative and regulatory procedures relating to the product, personal hygiene, and integrity of the work environment. (Unless noted to the contrary, the technical information applies only to pure product). To our actual knowledge, the information contained herein is accurate as of the date of this document. However, neither the company mentioned in section 1 nor any of its affiliates makes any warranty, express or implied, including merchantability or fitness for use, or accepts any liability in connection with this information or its use. This information is for use by technically skilled persons at their own discretion and risk and does not relate to the use of this product in combination with any other substance or any other process. This is not a license under any patent or other proprietary right. The user alone must finally determine suitability of any information or material for any contemplated use, the manner of use and whether any patents are infringed. This information gives typical properties only and is not to be used for specification purposes. The company mentioned in section 1 reserves the right to make additions, deletions or modifications to the information at any time without prior notification. Trademarks and/or other products of the company mentioned in section 1 referenced herein are either trademarks or registered trademarks of the company mentioned in section 1 or its affiliates, unless otherwise indicated.

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

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