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Operated for the U.S. Department of Energy by
Sandia Corporation
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Date: October 24, 2005

From: Rick Beauheim, 6822, MS1395 Rick Beauheim

To: File

Subject: IMC-461, 462, and 463

In January 2004, the Carlsbad Field Office (CBFO) of the Department of Energy (DOE) entered into an agreement (Detweiler, 2004) with IMC Potash Carlsbad, Inc. (now Mosaic), regarding the potash exploration holes IMC-461, 462, and 463 drilled west of the WIPP site (Figure 1). Under this agreement, IMC allowed Sandia to collect geophysical logs from all three holes and convert IMC-461 into a Culebra piezometer. This memorandum summarizes the results of those activities.

Geophysical logging of IMC-461, 462, and 463 was conducted by RAS Inc., under contract to Sandia. Two logging runs were made in each hole. The first run was for a three-arm caliper (tool 9065, see attached), and the second run was for natural gamma, spontaneous potential (SP), single-point resistivity, and multi-point resistivity (tool 9041, see attached). The logging tools were leased from Century Geophysical Corporation by RAS. Logging of IMC-463 was performed on January 15, 2004 using a portable logging winch owned by RAS. Logging of IMC-462 and 461 was performed on January 19 and 26, 2004, respectively, using a Century Geophysical Corporation logging truck.

Tool 9065 (three-arm caliper) was calibrated using 4-inch and 8-inch calibration rings before use. Tool 9041 (gamma and electric logs) was calibrated using a calibration assembly provided by Century before each use. The logging depth in IMC-463 (~707 ft below ground surface (bgs)) was determined by the limitations of the logging winch used. A repeat section from 354 to 497 ft bgs was logged with tool 9041 only. The logging depth in IMC-462 (~1007 ft bgs) was the total depth of the hole after IMC had cemented the bottom 300+ ft of hole. A repeat section from 219 to 465 ft bgs was logged with tool 9041 only. The logging depth in IMC-461 (~1316 ft bgs) was the total drilled depth of the hole. A repeat section from 171 to 505 ft was logged with tool 9041 only.

Generally speaking, the electric logs (SP and resistivity) provided little useful information because the extremely high conductivity of the drilling brine used by IMC overwhelmed the formation electrical properties. The caliper and gamma logs, however, provided excellent information. Stratigraphic picks made from the gamma log by Dennis Powers are given in Table 1. The picks are also shown on the attached logs.

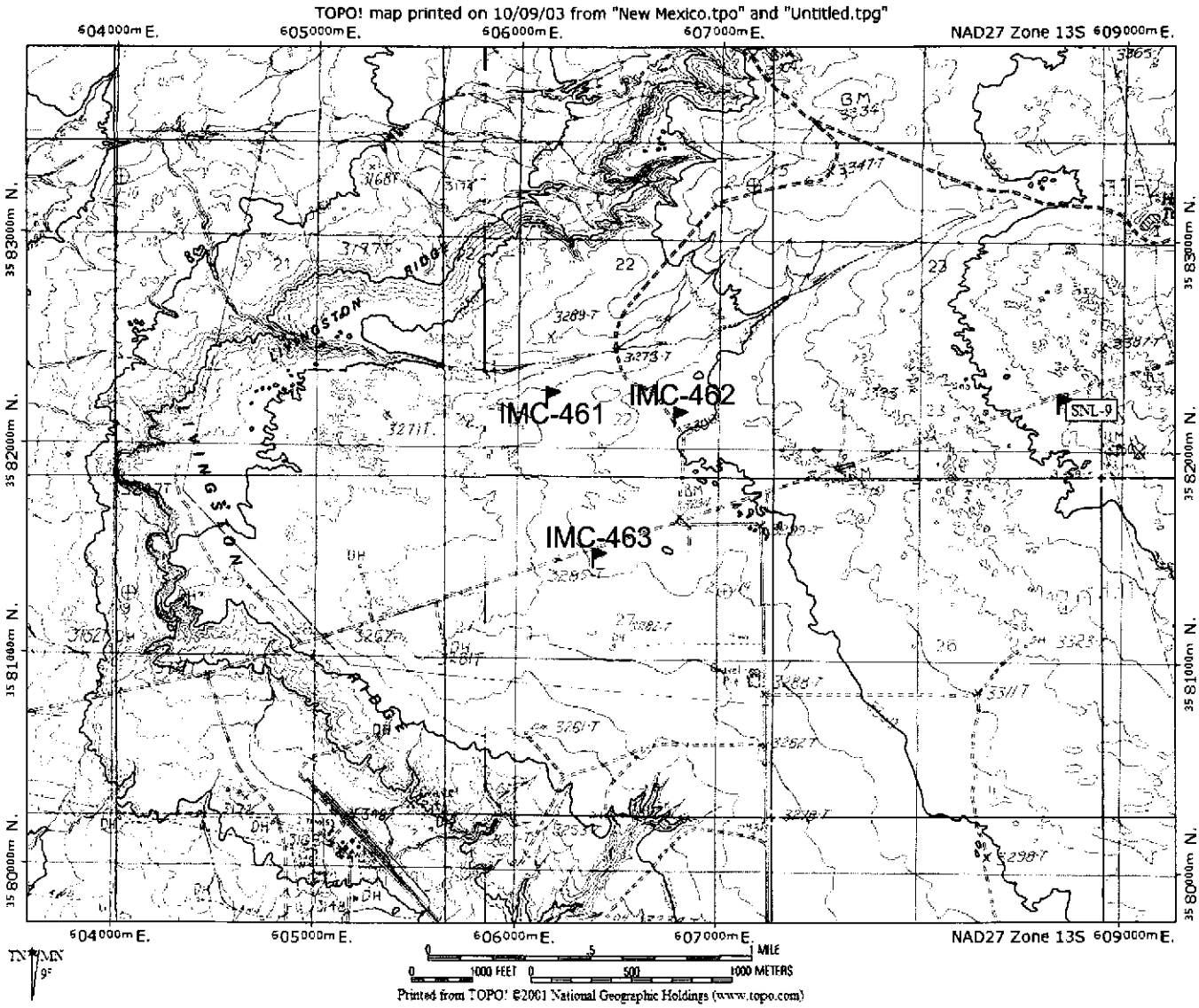


Figure 1. Locations of IMC-461, 462, and 463 west of the WIPP site.

After logging was completed in IMC-461, the hole was plugged from its total depth up to 402 ft bgs with cement by IMC's drilling contractor, Stewart Brothers Drilling Company. Stewart Brothers (under contract to Sandia) then installed a piezometer in IMC-461 under my direction on January 27, 2004. The piezometer is constructed of 2-inch Schedule 80 PVC with flush threaded joints and a 2.375-inch outside diameter (Figure 2). The drilled hole diameter was 5.125 inches. The bottom of the PVC string consists of 15.16 ft of blank PVC with an end cap. Above that is a 24.95-ft screen section with 0.01-inch slots. The upper section of the string consists of 363.08 ft of blank PVC, which extends 2.1 ft above the "ground surface" datum used for logging. Centralizers were placed ~150, ~300, and 389 ft below the top of the string. Eleven sacks of 8/12 silica sand were tremmied from the bottom of the hole up to 355 ft bgs, followed by 10 gallons of bentonite pellets. The remainder of the annulus was filled with a bentonite grout to the surface. A steel protective casing with a locking cover was cemented in place around the PVC at ground surface. Sandia commenced measuring water levels in IMC-461 on February 3, 2004.

Table 1. Stratigraphic Depths in IMC-461, 462, and 463.

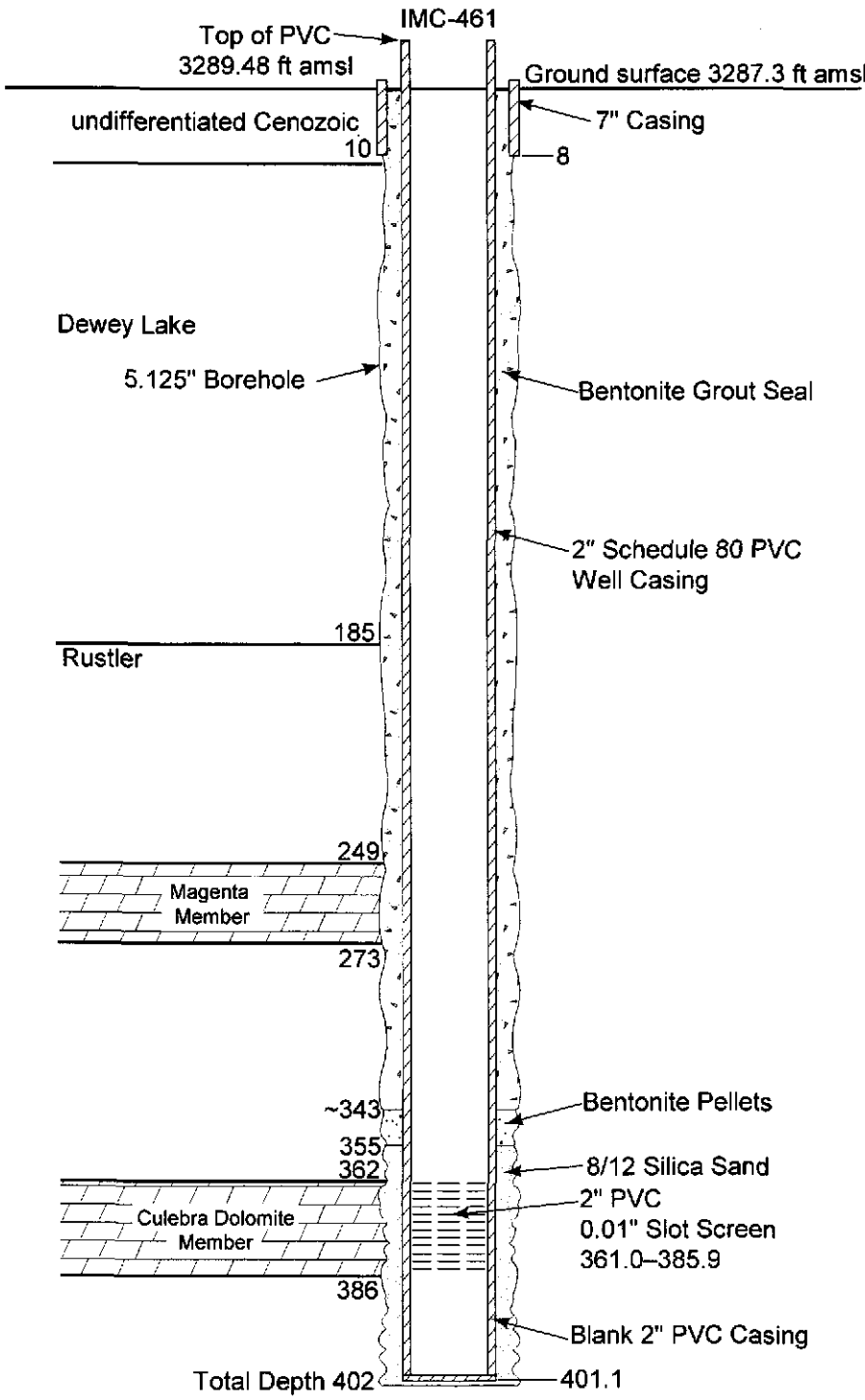
Geologic Unit	Depth in IMC-461 (ft bgs)	Depth in IMC-462 (ft bgs)	Depth in IMC-463 (ft bgs)
undifferentiated Cenozoic	0-10	0-3	0-4
Dewey Lake	10-184	3-237	4-172
Forty-niner (M4 claystone)	184-249 (216-235)	237-307 (268-286)	172-240 (205-220)
Magenta	249-273	307-329	240-267
Tamarisk (M3 claystone)	273-362 (334-346)	329-413 (388-396)	267-365 (333-349)
Culebra	362-386	413-436	365-387
Los Medaños (M2 claystone) (A1) (M1)	386-488 (386-395) (395-403) (403-488)	436-534 (436-445) (445-449) (449-534)	387-489 (387-397) (397-403) (403-489)
Salado (Vaca Triste)	488 to TD (1316) (951-960)	534 to TD (not logged)*	489 to TD (not logged)†

* IMC-462 logged depth = 1007 ft bgs
† IMC-463 logged depth = 707 ft bgs

Surveying of the borehole locations and relative elevations was performed by IMC (see attached email from Robinson). Mel Pyeatt (under contract to WRES) then surveyed the absolute elevation of a benchmark (representing ground surface) at IMC-461 as well as the top of PVC casing and top of protective casing (see attached email from Richardson), which allowed calculation of absolute elevations for IMC-462 and 463. The survey information is summarized in Table 2.

Table 2. Survey Information for IMC-461, 462, and 463.

Borehole	Township, Range, Section	Distance from East/West Line (ft)	Distance from North/South Line (ft)	Ground Surface Elevation (ft amsl)	Top of PVC Casing Elevation (ft amsl)
IMC-461	T22S, R30E, Sec. 22	1795.66 FWL	1298.39 FSL	3287.3	3289.48
IMC-462	T22S, R30E, Sec. 22	1568.94 FEL	991.14 FSL	3299.3	NA
IMC-463	T22S, R30E, Sec. 27	2804.39 FEL	1220.06 FNL	3295.6	NA



Notes:
All depths in feet below ground surface
Drawing not to scale
Centralizers at ~150, ~300, and 387 ft
Plugged back with cement from drilled depth of 1316 ft

IMC-461-0

Figure 2. As-built diagram of well IMC-461.

Reference

Detweiler, R.P. 2004. Letter from R. Paul Detweiler, Acting Manager, Carlsbad Field Office, Department of Energy, to Scott G. Vail, Manager, Environmental Services, IMC Potash Carlsbad Inc. dated January 15, 2004. CBFO:OEC:HJ:VW:04-0311:UFC:1200. Copy on file in the Sandia WIPP Records Center, Carlsbad, NM, as ERMS# 541052.

Attachments

Richardson, R. 2004. FW: well I 461, Email from Ron Richardson to Rick Beauheim, dated August 2, 2004.

Robinson, E.D. 2004. RE: surveys, Email from Eben D. Robinson to Richard L. Beauheim, dated April 28, 2004.

Century Geophysical Corp. 9065 Logging Tool, Product Description.

Century Geophysical Corp. 9041 Logging Tool, User Guide, page 1 of 1.

IMC-461 geophysical logs by RAS Integrated Subsurface Evaluation, with Stratigraphic picks by Dennis W. Powers 3/5/04.

IMC-462 geophysical logs by RAS Integrated Subsurface Evaluation, with Stratigraphic picks by Dennis W. Powers 3/5/04.

IMC-463 geophysical logs by RAS Integrated Subsurface Evaluation, with Stratigraphic picks by Dennis W. Powers 3/5/04.

Beauheim, Richard L Rick Beauheim

From: Richardson, Ron - WRES [Ron.Richardson@wipp.ws]
Sent: Monday, August 02, 2004 6:34 AM
To: Beauheim, Rick - SNL
Cc: Hughes, Dave - WRES; DeYonge, Wes - SNL; Siegel, Joel - WRES; Balderrama, Melvin - WRES
Subject: FW: well I 461

Rick:
Stuff happens....Sorry
-----Original Message-----
From: pyeatts@cavemen.net [mailto:pyeatts@cavemen.net]
Sent: Friday, July 30, 2004 10:26 AM
To: Ron Richardson
Subject: well I 461

Ron: after reviewing the elevations, we found that we used the wrong elevation for our bench mark.
top of casing should be 3289.48'
benchmark elev. is 3287.30'
latch elev is 3289.78'
We will come out and re stamp the correct elevation on our brass tablet.
Sorry. Mel

Beauheim, Richard L Rick Beauheim

From: Robinson, Eben D - Carlsbad [EDRobinson@imcglobal.com]
Sent: Wednesday, April 28, 2004 1:18 PM
To: 'Beauheim, Richard L'
Subject: RE: surveys

Rick,

We were able to shoot the holes in from section corners, but I can't find elevations for section corners in any of our files, only Northings and Eastings. We did get elevations relative to the section markers though, so if you can find an elevation for LM-3 the elevations for the holes are easy.
All vertical angles were shot to the base of the surface casing. LM-3 is the marker at the corner of sections 26,27,34,35 in T22S R30E. The new locations are:

I 461 1298.39' from S, 1795.66' from W, sec. 22, LM3 + 5.72'
I 462 991.14' from S, 1568.94' from E, sec. 22, LM3 + 17.76'
I 463 1220.06' from N, 2804.39' from E, sec. 27, LM3 + 14.01'

[Robinson, Eben D - Carlsbad]

9065 Logging Tool

Product Description

Background Information

The 9065 tool is a three-arm caliper configuration used to measure the diameter of the borehole. It can be used in both open or cased holes.

Features

Properties Measured (see diagram)

① **Three-Arm Caliper**:
Short- or long- arm configuration, motor-operated
Offset:
Short-arm: 156 cm (61.5in.)
Long-arm: 195.37 cm (76.92 in.)

Tool Specifications

Length:
Short-arm: 178 cm (64 in.)
Long-arm: 203.2 cm (80 in.)
Extra-long-arm: 5,201.92 cm (96 in.)

Temperature: 70 C (158 F)

Diameter: 43 mm (1.7 in)

Pressure: 232 kg/cm2 (4000 psi)

Weight:
Short-arm: 7.7 kg (20 lbs.)
Long-arm: 9.24 kg (24 lbs.)
Logging Speed: 9 m/min. (30 ft./min.)

Tool Voltage Required: 50 VDC

Sensor Response Ranges

Sensor	Response Limits	Accuracy
Short-Arm Caliper	5.1-50.8 cm (2-20 in.)	+/-0.38 cm (0.15 in.)
Long-Arm Caliper	10.1-101.6 cm (4-40 in.)	+/-0.64 cm (0.25 in.)

Accessories

Recommended

Calibration Ring Set

Part #2[illegible]01

Specifications subject to change without notice

Document Numbers:
Product Description #218
User Guide #308

Probes

Century GEOPHYSICAL CORP.
7517 East Pine,
Tulsa, OK 74115 USA
(918) 838-9811

Fax: (918) 838-4532
E-mail: century@ionet.net
http://www.century-geo.com

9041 Logging Tool

Primary Calibration Of The Tool

As most of the tool measures electrical properties, (ie, resistivity) the calibration of the tool is carried out with the use of resistors and the resistance to the current flow. Resistance or resistivity can be described as the "impedance of electrical flow through a material" with the mathematical equation of r = R L/A, where r is the resistance, R is the resistivity of the sample, L is the length, and A is the cross sectional area.

Therefore, a known resistance circuit can be used to simulate a tool response which then becomes the standard. The resistors used to calibrate the tool are all military spec., 1% resistors.

Primary Calibration	Standard	Response Range
Natural Gamma	0 api units	0 cps
	200 api units	180-215 cps
Spontaneous Potential	0 mv	55,000-65,000 cps
	400 mv	110,000-120,000 cps
Single Point Resistance	0 ohms	950-1,050 cps
	3000 ohms	100,000-105,000 cps
40.64 cm (16 In.) Normal	0 ohm/m	3,700-3,900 cps
	2000 ohm/m	100,000-105,000 cps
162.6 cm (64 In.) Normal	0 ohm/m	3,700-3,900 cps
	2000 ohm/m	100,000-105,000 cps
Temperature	23 C (50 F)	9,500-10,500 cps
	37 C (80 F)	5,000-5,400 cps
Fluid Resistivity	0 ohm/m	1,000 cps
	47.5 ohm/m	48,500 cps

Default Calibrations

The following parameters are sensors and responses are set-up to electronic bench testing specifications. Therefore, these "default" calibration numbers are normally used to log the tool. The sensors are the following:

Natural Gamma, Temperature, Fluid Resistivity

Optionally, the 40.64 cm (16 in.) and 162.6 cm (64 in.) normals and single point resistance will log with default calibrations but it is best if they are calibrated.

In the calibration file if the default values of 0 cps equals 0 engineering units is not changed, the tool will then automatically use the default values in the tool module for that tool.

Notes On Logging The 9041 Tool

The 9041 tool can be logged in the down or up direction. For the best results, for temperature and fluid resistivity logging, the down direction is preferred. Downward direction logs are usually made in boreholes that have been allowed to stabilize (ie. no drilling or pumping fluids) for a matter of days prior to logging. By doing this, the logs record the natural fluid temperatures and resistivity. The other electric logs will also function in the down direction but, depending on water level in the borehole, the curve may be cut off if the electric log threshold is set too low.

Electric logs must be run in non-cased, fluid-filled boreholes Correcting for borehole fluid, borehole size and bed thickness must be done to calculate such things as true resistivity, invasion profiles, and water quality.

Standard charts and correction procedures are available in most log interpretation manuals.

The depth of investigation for normal devices is based on the spacing of the current and measure electrodes. Approximately 50% of the signal measured by the measure electrode comes from a volume whose radius is twice the electrode spacing. Therefore, the 40.64 cm (16 in.) normal has 50% of its signal coming from a 81.28 (32 in.) radius around the tool, and the 162.6 cm (64 in.) normal has a 325.2 cm (128 in.) radius. Because of the large volume of investigation, the resolution of the normal devices are proportional to the electrode spacing.

Borehole conditions that affect the resistivity measurements:

- Borehole Size
- Open Hole (Fluid Filled Only)
- Mud Resistivity
- Wash-Outs

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Well logs that could not be scanned were not included in this electronic version of Beauheim 2005.