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Sandia National Laboratories

Operated for the U.S. Department of Energy

by

Sandia Corporation

Carlsbad, New Mexico 88220

date: February 17, 2015

to: Records Center

from: Patricia Johnson, SNL Contractor

subject: 2014 Calculated Densities

The groundwater densities for the WIPP Culebra monitoring wells were calculated for 2014 as described in the Activity/Project Specific Procedure (SP) 9-11 *Calculation of Densities for Groundwater in WIPP Wells*. The derivation of the data is explained in the following sections and the supporting data are attached.

1. Calculation Process:

As stated in SP 9-11, for each calculation the observed water pressure is divided by the height of the water column. Specifically, the measured pressure value minus the closest corresponding barometric pressure was divided by the pressure gauge depth minus the closest corresponding depth to water (from or adjusted to the same measurement point elevation), and that result was then divided by 0.4335 (psi to feet of water conversion at 4°C, at which temperature the density of pure water is 1.000 g/cm³). The individual calculated density results for each well were then averaged for a final density value.

The density data are included in the *2014 Calc Densities.xlsx* spreadsheet file created in Excel. Within that spreadsheet, the worksheet *2014 Calc Dens* summarizes the resulting density values and supporting information for the calculated densities, and the worksheet *2014 Calc Dens Formulas* provides the formulas in the worksheet. In addition, the Excel file contains individual well worksheets that include the data used for the calculations and plots of the pressure gauge pressure data. The columns in the worksheets and their contents are described below:

- A – Monitor Well – Well name
- B – 2014 Avg Calc Dens (g/cm³) – Average Calculated Density Value for 2014
- C – 2013 Avg Calc Dens (g/cm³) – Average Calculated Density Value for 2013
- D – 2014 - 2013 Diff (g/cm³) – Difference between 2014 and 2013 densities (Column B - Column C)
- E – # of Dens Averaged – number of density values averaged to get the final value

WIPP: 4.4.2.3.1: TD: QA-C: RECERT: 541153

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- F – 2014 Timeframe of Data – Time period for pressure data used in calculations
- G – Pressure Gauge File Name (Gauge SN if INW) – File name for pressure data and INW gauge SN (in parentheses) if applicable
- H – Pressure Gauge Install Depth (ft BTOC/BTEC/BTOT) – Depth below primary measuring point at which the pressure gauge was installed
- I – Pressure Gauge Ideal Install Depth (ft BTOC/BTEC/BTOT) (ERMS 553781) – Mid-Culebra depth below top of referenced casing
- J – Length Off Ideal Depth (ft) – Depth in feet that the pressure gauge is installed below or above the ideal (Column I - Column H)
- K – Date of Install – Date the pressure gauge was installed or reinstalled into the well
- L – Installation Logbook Page – Reference to the logbook and page where the pressure gauge installation was documented
- M – Comments/Explanations – Comments and/or explanations regarding data

The spreadsheet entries were verified by Michael Schuhen, Organization 6212.

2. Identification/Listing of Input, Input sources, and Output:

- Excel spreadsheet including the data – 2014 Calc Densities.xls
 - Worksheet 1 – 2014 Calc Dens
 - Worksheet 2 – 2014 Calc Dens_Formulas
 - Worksheet 3 – Baro Data
 - Worksheet 4 – AEC-7R
 - Worksheet 5 – C-2737
 - Worksheet 6 – ERDA-9
 - Worksheet 7 – H-2b2
 - Worksheet 8 – H-3b2
 - Worksheet 9 – H-4bR
 - Worksheet 10 – H-5b
 - Worksheet 11 – H-6bR
 - Worksheet 12 – H-7b1
 - Worksheet 13 – H-9bR
 - Worksheet 14 – H-10c
 - Worksheet 15 – H-11b4R
 - Worksheet 16 – H-12R
 - Worksheet 17 – H-15R
 - Worksheet 18 – H-16
 - Worksheet 19 – H-17
 - Worksheet 20 – H-19b0
 - Worksheet 21 – IMC-461
 - Worksheet 22 – SNL-1
 - Worksheet 23 – SNL-2
 - Worksheet 24 – SNL-3
 - Worksheet 25 – SNL-5

- Worksheet 26 – SNL-6
- Worksheet 27 – SNL-8
- Worksheet 28 – SNL-9
- Worksheet 29 – SNL-10
- Worksheet 30 – SNL-12
- Worksheet 31 – SNL-13
- Worksheet 32 – SNL-14
- Worksheet 33 – SNL-15
- Worksheet 34 – SNL-16
- Worksheet 35 – SNL-17A
- Worksheet 36 – SNL-18
- Worksheet 37 – SNL-19
- Worksheet 38 – WIPP-11
- Worksheet 39 – WIPP-13
- Worksheet 40 – WIPP-19

3. Data Qualification for Compliance Decision Analysis:

Data sources provided in Column G (Pressure Gauge File Name(s)), Column L (Installation Logbook Page), and in the References Section.

4. Software Used:

Intel® Xeon® CPU, Microsoft Windows 7, Microsoft Office Professional Plus 2010 Excel

5. Reviews:

Technical: Michael Schuhen, 6212

QA: Shelly Nielsen, 6210

6. References:

- Pressure gauge installation data and SNL water level data from the following logbooks (package ERMS 543277):
Long-Term Monitoring Notebook (LTM)-20
Long-Term Monitoring Notebook (LTM)-21
- WRES Water Level Data submitted to SNL in monthly memoranda (package ERMS 525178)
- Johnson, Patricia B., Culebra Center Depths for Use in Calculating Equivalent Freshwater Heads of the Culebra Dolomite Member of the Rustler Formation near the WIPP Site, Revision 3, June 10, 2010 (ERMS 553781)

7. List of Attachments:

1. Printout of Excel file worksheet 2014 Calc Dens.xls
2. Printout of Excel file worksheet 2014 Calc Dens Formulas.xls
3. CD including the Excel file and memorandum

2014 Calc Dens

A	B	C	D	E	F	G	H	I	J	K	L	M
Monitor Well	2014 Avg Calc Dens (g/cm ³)	2013 Avg Calc Dens (g/cm ³)	2014 - 2013 Diff (g/cm ³)	# of Dens Averaged	2014 Timeframe of Data	Pressure Gauge File Name (Gauge SN if INW)	Pressure Gauge Install Depth (ft BTOC/BTEC/BTOT)	Pressure Gauge Ideal Install Depth (ft BTOC/BTEC/BTOT) (ERMS 553781)	Length Off Ideal Depth (ft)	Date of Install	Installation Logbook Page	Comments/Explanations
AEC-7R	1.071	1.066	0.005	6	Feb - Apr	SN121344 013114 AEC-7R (C5) 2014-02-12 11.13.07.wsl, SN121344 021214 AEC-7R (C6) 2014-04-16 08.18.05.wsl	866.00	872.98	6.98	1/31/2014	LTM-21 pg. 15	
C-2737	1.022	1.021	0.001	6	Jul - Sept	SN121786 031814 C-2737 (C26) 2014-12-03 14.11.03.wsl	688.85	689.78	0.93	3/18/2014	LTM-21 pg. 36	
ERDA-9	1.070	1.069	0.001	5	Jul - Sept	ERDA-9 C19 071014 (21237073)	717.20	717.81	0.61	7/10/2014	LTM-21 pg. 105	
H-2b2	1.010	1.011	-0.001	6	Jul - Sept	H-2b2 C12 013014 (21225020)	635.50	635.50	0.00	1/30/2014	LTM-21 pg. 14	
H-3b2	1.025	1.03	-0.005	6	Jul - Sept	SN126697 031814 H-3b2 (C20) 2014-12-03 13.21.30.wsl	670.60	687.10	16.50	3/18/2014	LTM-21 pg. 35	
H-4bR	1.025	1.015	0.010	6	Jul - Sept	H-4bR C10 012814 (21237029)	507.90	507.54	-0.36	1/28/2014	LTM-21 pg. 5	
H-5b	1.087	1.09	-0.003	6	Jul - Sept	SN141106 032514 H-5b (C16) 2014-12-02 14.23.48.wsl	909.22	909.22	0.00	3/25/2014	LTM-21 pg. 40	
H-6bR	1.036	1.037	-0.001	6	Jul - Sept	H-6bR C08 013014 (21225019)	616.60	616.58	-0.02	1/30/2014	LTM-21 pg. 12	
H-7b1	1.007	1.005	0.002	6	Jul - Sept	H-7b1 C19 010814 (21237010)	269.90	269.13	-0.77	1/7/2014	LTM-20 pg. 106	
H-9bR	1.002	0.999	0.003	6	Jul - Sept	H-9bR C8 070314 (21237027)	660.54	660.54	0.00	7/3/2014	LTM-21 pg. 91	
H-10c	1.094	1.093	0.001	6	Jul - Sept	SN131837 031314 H-10c (C16) 2014-12-03 09.48.48.wsl	1372.10	1371.90	-0.20	3/13/2014	LTM-21 pg. 33	
H-11b4R	1.075	1.074	0.001	6	Jul - Sept	SN129856 042914 H-11b4R (C7) 2014-12-09 08-34-51-144.wsl	735.85	735.85	0.00	4/29/2014	LTM-21 pg. 59	
H-12R	1.040	1.106	-0.066	1	Aug	H-12R C01 081414 (21237071)	835.80	837.67	1.87	8/14/2014	LTM-21 pg. 123	2013 density is from H-12 prior to H-12R installation, H-12R is still being developed/purged so calculated density may not represent formation water
H-15R	1.116	1.116	0.000	6	Jul - Sept	H-15R C15 050814 (21237048)	872.50	872.57	0.07	5/8/2014	LTM-21 pg. 71	
H-16	1.033	1.034	-0.001	5	Jul - Oct	H-16 C08 072814 (21237076)	715.10	715.10	0.00	7/28/2014	LTM-21 pg. 109	
H-17	1.132	1.131	0.001	6	Jul - Sept	SN139810 031314 H-17 (C13) 2014-12-03 11.06.53.wsl	719.93	719.93	0.00	3/13/2014	LTM-21 pg. 34	
H-19b0	1.065	1.064	0.001	6	Jul - Sept	SN170831 040714 H-19b0 (C19) 2014-12-03 13.03.32.wsl	754.00	753.49	-0.51	4/7/2014	LTM-21 pg. 52	
IMC-461	0.994	0.997	-0.003	6	Jul - Sept	IMC-461 C27 05222014 (21237090)	376.50	376.10	-0.40	5/22/2014	LTM-21 pg. 76	
SNL-1	1.028	1.028	0.000	6	Jul - Sept	SN133569 031114 SNL-1 (C26) 2014-12-02 12.26.34.wsl	612.90	612.23	-0.67	3/11/2014	LTM-21 pg. 32	
SNL-2	1.008	1.007	0.001	6	Jul - Sept	SN143793 031114 SNL-2 (C31) 2014-12-02 09.54.08.wsl	470.70	470.69	-0.01	3/11/2014	LTM-21 pg. 31	
SNL-3	1.025	1.026	-0.001	6	Jul - Sept	SNL-3 C17 013014 (21237077)	766.50	766.19	-0.31	1/30/2014	LTM-21 pg. 11	
SNL-5	1.006	1.007	-0.001	5	Jul - Sept	SNL-5 C22 070814 (21237079)	649.00	648.84	-0.16	7/8/2014	LTM-21 pg. 96	
SNL-6	1.244	1.241	0.003	6	Jul - Sept	SN129649 012914 SNL-6 (C16) 2014-12-02 13.13.22.wsl	1338.20	1338.03	-0.17	1/29/2014	LTM-21 pg. 7	
SNL-8	1.093	1.093	0.000	6	Jul - Sept	SNL-8 C36 010814 (21237082)	969.70	969.70	0.00	1/7/2014	LTM-20 pg. 109	
SNL-9	1.016	1.016	0.000	6	Jul - Sept	SN149045 031114 SNL-9 (C26) 2014-12-04 09.52.04.wsl	567.20	567.20	0.00	3/11/2014	LTM-21 pg. 29	
SNL-10	1.008	1.008	0.000	4	Jul - Sept	SNL-10 C20 072214 (21237074)	613.50	613.46	-0.04	7/22/2014	LTM-21 pg. 108	
SNL-12	1.005	1.004	0.001	6	Jul - Sept	SN162603 022514 SNL-12 (C19) 2014-12-01 10.32.48.wsl	570.90	570.68	-0.22	2/25/2014	LTM-21 pg. 29	
SNL-13	1.02	1.015	0.005	5	Jul - Sept	SNL-13 C22 071014 (21237083)	401.00	400.62	-0.38	7/9/2014	LTM-21 pg. 102	
SNL-14	1.044	1.044	0.000	6	Jul - Sept	SN143789 031314 SNL-14 (C29) 2014-11-10 13.04.53.wsl	668.95	668.95	0.00	3/13/2014	LTM-21 pg. 34	
SNL-15	1.228	1.227	0.001	6	Jul - Sept	SN153537 052814 SNL-15 (C25) 2014-12-03 10.44.55.wsl	922.18	922.18	0.00	5/28/2014	LTM-21 pg. 77	
SNL-16	1.01	1.006	0.004	6	Jul - Sept	SNL-16 C18 010814 (21237006)	207.86	207.86	0.00	1/7/2014	LTM-20 pg. 105	
SNL-17A	1.005	1.003	0.002	6	Jul - Sept	SNL-17 C20 012914 (21237008)	349.60	349.93	0.33	1/29/2014	LTM-21 pg. 8	
SNL-18	1.007	1.007	0.000	5	Jul - Sept	SNL-18 C25 070814 (21237080)	549.30	549.30	0.00	7/8/2014	LTM-21 pg. 97	
SNL-19	1.004	1.005	-0.001	6	Jul - Sept	SN147216 031114 SNL-19 (C17) 2014-11-05 09.48.18.wsl	355.10	354.19	-0.91	3/11/2014	LTM-21 pg. 30	
WIPP-11	1.036	1.036	0.000	6	Jul - Sept	SN147947 031114 WIPP-11 (C26) 2014-12-02 11.30.20.wsl	857.80	857.41	-0.39	3/11/2014	LTM-21 pg. 31	
WIPP-13	1.035	1.038	-0.003	6	Jul - Sept	WIPP-13 C20 042914 (21237088)	715.30	714.88	-0.42	4/29/2014	LTM-21 pg. 61	
WIPP-19	1.051	1.05	0.001	6	Jul - Sept	SN121360 031814 WIPP-19 (C11) 2014-12-02 14.49.11.wsl	770.20	769.50	-0.70	3/18/2014	LTM-21 pg.37	

Notes:

All pressure gauges, except for the baro gauge, are In-Situ Level Troll or INW gauges and cables are all non-vented
 Barometric data are from INW gauge - gauge - 21237003, file - PAC-B BAR03 013014
 ft BTOC = feet below top of casing
 ft BTEC = feet below top of environmental casing
 ft BTOT = feet below top of tubing
 LTM = Long-Term Monitoring
 NA = Not available
 The "SNL-17A" and "SNL-17" names are used interchangeably for the same well

Information Only

2014 Calc Dens

A	B	C	D	E	F	G	H	I	J	K	L	M
Monitor Well	2014 Avg Calc Dens (g/cm ³)	2013 Avg Calc Dens (g/cm ³)	2014 - 2013 Diff (g/cm ³)	# of Dens Averaged	2014 Timeframe of Data	Pressure Gauge File Name (Gauge SN if INW)	Pressure Gauge Install Depth (ft BTOC/BTEC/BTOT)	Pressure Gauge Ideal Install Depth (ft BTOC/BTEC/BTOT) (ERMS 553781)	Length Off Ideal Depth (ft)	Date of Install	Installation Logbook Page	Comments/Explanations
AEC-7R	1.071	1.066	=B4-C4	6	Feb - Apr	SN121344 013114 AEC-7R (C5) 2014-02-12 11.13.07.wsl, SN121344 021214 AEC-7R (C6) 2014-04-16 08.18.05.wsl	866	872.98	=14-H4	41670	LTM-21 pg. 15	
C-2737	1.022	1.021	=B5-C5	6	Jul - Sept	SN121786 031814 C-2737 (C26) 2014-12-03 14.11.03.wsl	688.85	689.78	=15-H5	41716	LTM-21 pg. 36	
ERDA-9	1.07	1.069	=B6-C6	5	Jul - Sept	ERDA-9 C19 071014 (21237073)	717.2	717.81	=16-H6	41830	LTM-21 pg. 106	
H-2b2	1.01	1.011	=B7-C7	6	Jul - Sept	H-2b2 C12 013014 (21225020)	635.5	635.5	=17-H7	41669	LTM-21 pg. 14	
H-3b2	1.025	1.03	=B8-C8	6	Jul - Sept	SN126697 031814 H-3b2 (C20) 2014-12-03 13.21.30.wsl	670.6	687.1	=18-H8	41716	LTM-21 pg. 35	
H-4bR	1.025	1.015	=B9-C9	6	Jul - Sept	H-4bR C10 012814 (21237029)	507.9	507.54	=19-H9	41667	LTM-21 pg. 5	
H-5b	1.087	1.09	=B10-C10	6	Jul - Sept	SN141106 032514 H-5b (C16) 2014-12-02 14.23.48.wsl	909.22	909.22	=10-H10	41723	LTM-21 pg. 40	
H-6bR	1.036	1.037	=B11-C11	6	Jul - Sept	H-6bR C08 013014 (21225019)	616.6	616.58	=11-H11	41669	LTM-21 pg. 12	
H-7b1	1.007	1.005	=B12-C12	6	Jul - Sept	H-7b1 C19 010814 (21237010)	269.9	269.13	=12-H12	41646	LTM-20 pg. 105	
H-9bR	1.002	0.999	=B13-C13	6	Jul - Sept	H-9bR C8 070314 (21237027)	660.54	660.54	=13-H13	41823	LTM-21 pg. 91	
H-10c	1.094	1.093	=B14-C14	6	Jul - Sept	SN131837 031314 H-10c (C16) 2014-12-03 09.48.48.wsl	1372.1	1371.9	=14-H14	41711	LTM-21 pg. 33	
H-11b4R	1.075	1.074	=B15-C15	6	Jul - Sept	SN129856 042914 H-11b4R (C7) 2014-12-09_08-34-51-144.wsl	735.85	735.85	=15-H15	41758	LTM-21 pg. 59	
H-12R	1.04	1.106	=B16-C16	1	Aug	H-12R C01 081414 (21237071)	835.8	837.67	=16-H16	41855	LTM-21 pg. 123	2013 density is from H-12 prior to H-12R installation, H-12R is still being developed/purged so calculated density may not represent formation water
H-15R	1.116	1.116	=B17-C17	6	Jul - Sept	H-15R C15 050814 (21237048)	872.5	872.57	=17-H17	41767	LTM-21 pg. 71	
H-16	1.033	1.034	=B18-C18	5	Jul - Oct	H-16 C08 072814 (21237076)	715.1	715.1	=18-H18	41848	LTM-21 pg. 109	
H-17	1.132	1.131	=B19-C19	6	Jul - Sept	SN139810 031314 H-17 (C13) 2014-12-03 11.06.53.wsl	719.93	719.93	=19-H19	41711	LTM-21 pg. 34	
H-19b0	1.065	1.064	=B20-C20	6	Jul - Sept	SN170831 040714 H-19b0 (C19) 2014-12-03 13.03.32.wsl	754	753.49	=20-H20	41736	LTM-21 pg. 52	
IMC-461	0.994	0.997	=B21-C21	6	Jul - Sept	IMC-461 C27 05222014 (21237090)	376.5	376.1	=21-H21	41781	LTM-21 pg. 76	
SNL-1	1.028	1.028	=B22-C22	6	Jul - Sept	SN133569 031114 SNL-1 (C26) 2014-12-02 12.26.34.wsl	612.9	612.23	=22-H22	41709	LTM-21 pg. 32	
SNL-2	1.008	1.007	=B23-C23	6	Jul - Sept	SN143793 031114 SNL-2 (C31) 2014-12-02 09.54.08.wsl	470.7	470.69	=23-H23	41709	LTM-21 pg. 31	
SNL-3	1.025	1.026	=B24-C24	6	Jul - Sept	SNL-3 C17 013014 (21237077)	766.5	766.19	=24-H24	41669	LTM-21 pg. 11	
SNL-5	1.006	1.007	=B25-C25	5	Jul - Sept	SNL-5 C22 070814 (21237079)	649	648.84	=25-H25	41828	LTM-21 pg. 96	
SNL-6	1.244	1.241	=B26-C26	6	Jul - Sept	SN129649 012914 SNL-6 (C16) 2014-12-02 13.13.22.wsl	1338.2	1338.03	=26-H26	41668	LTM-21 pg. 7	
SNL-8	1.093	1.093	=B27-C27	6	Jul - Sept	SNL-8 C36 010814 (21237082)	969.7	969.7	=27-H27	41646	LTM-20 pg. 109	
SNL-9	1.016	1.016	=B28-C28	6	Jul - Sept	SN149045 031114 SNL-9 (C26) 2014-12-04 09.52.04.wsl	567.2	567.2	=28-H28	41709	LTM-21 pg. 29	
SNL-10	1.008	1.008	=B29-C29	4	Jul - Sept	SNL-10 C20 072214 (21237074)	613.5	613.46	=29-H29	41842	LTM-21 pg. 108	
SNL-12	1.005	1.004	=B30-C30	6	Jul - Sept	SN162603 022514 SNL-12 (C19) 2014-12-01 10.32.48.wsl	570.9	570.68	=30-H30	41695	LTM-21 pg. 29	
SNL-13	1.02	1.015	=B31-C31	5	Jul - Sept	SNL-13 C22 071014 (21237083)	401	400.62	=31-H31	41829	LTM-21 pg. 102	
SNL-14	1.044	1.044	=B32-C32	6	Jul - Sept	SN143789 031314 SNL-14 (C29) 2014-11-10 13.04.53.wsl	668.95	668.95	=32-H32	41711	LTM-21 pg. 34	
SNL-15	1.228	1.227	=B33-C33	6	Jul - Sept	SN153537 052814 SNL-15 (C25) 2014-12-03 10.44.55.wsl	922.18	922.18	=33-H33	41787	LTM-21 pg. 77	
SNL-16	1.01	1.006	=B34-C34	6	Jul - Sept	SNL-16 C18 010814 (21237006)	207.86	207.86	=34-H34	41646	LTM-20 pg. 105	
SNL-17A	1.005	1.003	=B35-C35	6	Jul - Sept	SNL-17 C20 012914 (21237008)	349.6	349.93	=35-H35	41668	LTM-21 pg. 8	
SNL-18	1.007	1.007	=B36-C36	5	Jul - Sept	SNL-18 C25 070814 (21237080)	549.3	549.3	=36-H36	41828	LTM-21 pg. 97	
SNL-19	1.004	1.005	=B37-C37	6	Jul - Sept	SN147216 031114 SNL-19 (C17) 2014-11-05 09.48.18.wsl	355.1	354.19	=37-H37	41709	LTM-21 pg. 30	
WIPP-11	1.036	1.036	=B38-C38	6	Jul - Sept	SN147947 031114 WIPP-11 (C26) 2014-12-02 11.30.20.wsl	857.8	857.41	=38-H38	41709	LTM-21 pg. 31	
WIPP-13	1.035	1.038	=B39-C39	6	Jul - Sept	WIPP-13 C20 042914 (21237088)	715.3	714.88	=39-H39	41758	LTM-21 pg. 61	
WIPP-19	1.051	1.05	=B40-C40	6	Jul - Sept	SN121360 031814 WIPP-19 (C11) 2014-12-02 14.49.11.wsl	770.2	769.5	=40-H40	41716	LTM-21 pg. 37	

Notes:
 All pressure gauges, except for the baro gauge, are In-Situ Level Troll or INW gauges and cables are all non-vented
 Barometric data are from INW gauge - gauge - 21237003, file - PAC-B BAR03 013014
 ft BTOC = feet below top of casing
 ft BTEC = feet below top of environmental casing
 ft BTOT = feet below top of tubing
 LTM = Long-Term Monitoring
 NA = Not available
 The "SNL-17A" and "SNL-17" names are used interchangeably for the same well

Information Only