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NOV 1 0 2016

Mr. John E. Kieling, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6303

Subject: Response to Technical Incompleteness Determination, Waste Isolation Pilot Plant Hazardous Waste Facility Permit Number: NM4890139088-TSDF

Reference: New Mexico Environment Department correspondence from John E. Kieling, Chief, Hazardous Waste Bureau to Dana C. Bryson, CBFO, and Philip J. Breidenbach, NWP, dated July 22, 2015, subject: Technical Incompleteness Determination, March 18, 2013 Class 3 Permit Modification Request, Waste Isolation Pilot Plant, EPA I.D. Number NM4890139088

Dear Mr. Kieling:

Enclosed is the Permittees' response to the subject Technical Incompleteness Determination, including a revised Permit Modification Request.

We certify under penalty of law that this document and all attachments were prepared under our direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on our inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of our knowledge and belief, true, accurate, and complete. We are aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

If you have any questions, please contact Mr. George T. Basabilvazo at 575-234-7488.

Sincerely,

Original Signatures on File

Todd Shrader, Manager
Carlsbad Field Office

Philip J. Breidenbach, Project Manager
Nuclear Waste Partnership LLC

Enclosure

cc: w/enclosure

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CBFO:OEP:GBT:AC:16-3304:UFC5486.00

Response to the Technical Incompleteness Determination

The New Mexico Environment Department (NMED) issued a draft Hazardous Waste Facility Permit (Permit) for public comment on February 14, 2014[1]. This draft Permit was based on a Class 3 Permit Modification Request (**PMR**) submitted in March 2013 by the U.S. Department of Energy (**DOE**), Carlsbad Field Office and Nuclear Waste Partnership LLC, collectively referred to as the Permittees. In light of the February 2014 underground vehicle fire and radiological events, the NMED withdrew the draft Permit on March 21, 2014. On July 22, 2015, the NMED issued a Technical Incompleteness Determination on the request in which NMED requested that "the Permittees update their request to reflect current conditions at the facility and resubmit the Request to NMED. NMED will determine, upon resubmittal, if the request is administratively and technically complete."[2]

This document has two items which respond to the Technical Incompleteness Determination:

1. Description of the current conditions at the facility, and
2. A revised PMR.

In response to item 1, the Permittees are providing a description of the physical conditions that have changed due to the impacts of the events of February 2014 and how these changes affect the topics covered in the March 2013 Class 3 PMR. This description includes the following:

- **Radiological Contamination**—Radiological contamination throughout the southern portions of the underground and in the active disposal panel (Panel 7) and its exhaust drift, impacting underground access, the ventilation system, and underground mining

- **Routine Underground Mine Maintenance**—Difficulty in performance of routine underground mine maintenance due to limited access

- **Operation of the Underground Ventilation System in Continuous Filtration Mode**—Operation of the underground ventilation system in reduced-flow filtration mode only, thereby limiting the number of activities that can be performed simultaneously

- **Isolation of Nitrate Salt Bearing Waste**—Initial closures in Panel 6 and a closure in Panel 7, Room 7 to isolate nitrate salt bearing waste have been installed pursuant to the *WIPP Nitrate Salt Bearing Waste Container Isolation Plan*[3] (**Isolation Plan**).

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[1] New Mexico Environment Department, February 14, 2014, Notice of Intent to Approve a Class 3 Modification to Change the Panel Closure Design, Allow Repository Reconfiguration of Panels 9 and 10 and Allow Revision of the Volatile Organic Compound (VOC) Target Analyte List and Other Changes to the VOC Monitoring Program at the Waste Isolation Pilot Plant (WIPP) Carlsbad, New Mexico, https://www.env.nm.gov/wipp/index.html.

[2] Letter from John E. Kieling to Jose Franco and Robert McQuinn, March 21, 2014 regarding Waste Isolation Pilot Plant, EPA I.D. Number NM4890139088: Notification of Draft Permit Withdrawal Regarding the Class 3 Permit Modification Request for 3 Items: Item 1, Modifications to the WIPP Panel Closure; Item 2, Repository Reconfiguration of Panels 9 and 10; Item 3, Revise Volatile Organic Compound (VOC) Target Analyte List and Other Changes to the VOC Monitoring Program, http://www.wipp.energy.gov/library/Information_Repository_A/Class_3_Permit_Modifications/NMED_Withdrawl_of_Draft_Permit_3-21-2014.pdf.

[3] WIPP Nitrate Salt Bearing Waste Container Isolation Plan, Revision 2 Waste Isolation Pilot Hazardous Waste Facility Permit Number: NM4890139088-TSDF Jose R. Franco/CBFO and Robert L. McQuinn/NWP dated May 29,

In response to item 2 above, the revised PMR (attached), which has been prepared to propose the replacement of the Panel Closure System with the WIPP Panel Closure (**WPC**), incorporates the changed conditions at the WIPP facility and includes:

1. Redesign of panel closures to include bulkheads for closing Panels 1 through 9 (referred to as WPC-A),

2. Panel closures for closing Panel 10 which include run-of-mine salt between bulkheads (referred to as WPC-B),

3. Withdrawal of the request for additional hazardous waste disposal units Panels 9A and 10A, and

4. Withdrawal of the volatile organic compound (**VOC**) monitoring program changes.

Description of the Current Conditions at the Waste Isolation Pilot Plant (WIPP) Facility

Operations at the WIPP facility were suspended by the Permittees on February 5, 2014, following a fire involving an underground vehicle. Nine days later, on February 14, 2014, a radiological event occurred underground, contaminating a portion of the mine primarily along the ventilation path from the location of the incident (Panel 7, Room 7), releasing a small amount of radioactive contamination into the environment. The Permittees are in the process of recovering from these events in order to resume normal operations. As a part of the recovery efforts, the Permittees have determined how conditions in the underground have changed due to limitations placed on the ventilation system and the presence of radioactive contamination. These changed conditions impact panel closure design and construction. The following is a discussion of these changed conditions and their impacts.

1. <u>Radiological Contamination</u>

As a result of the radiological event, portions of the WIPP underground and the existing surface mounted ventilation system have been radiologically contaminated. Comprehensive radiological surveys were conducted to determine the extent of the contamination. Figure 1 indicates contaminated areas in the underground. Based on the ventilation flow and radiological surveys, the Exhaust Shaft and its adjacent drift, Panel 7, the common drift area adjacent to Panels 1 through 7, the E-300 exhaust drift, and portions of the exhaust ducting on the surface remain contaminated.

Radiological Contamination Impacts to Underground Access

The presence of contamination in the underground areas shown in Figure 1 requires the Permittees to operate with uncontaminated and contaminated sections of the underground. When operating in contaminated areas, protective measures are required as follows:

<u>Controlled Areas (tan in Figure 1)</u>

- No restrictions

2015. http://www.wipp.energy.gov/library/Information_Repository_A/Responses_to_Administrative_Order/15-1489_Enclosure_WIPP_Nitrate_Salt_Bearing_Waste_Container_Isolation_Plan_Revision.pdf.

Radiological Buffer Areas (green in Figure 1)

- Radiological buffer areas are areas between contaminated areas and uncontaminated areas which DOE recommends be established to prevent and control the spread of radioactive contamination and to protect personnel from radiation exposure
- Rad Worker I training required
- No entry requirements other than reading and obeying all posted signage
- Hand and foot monitoring required prior to exit

Contamination Area (yellow and blue in Figure 1)

- Rad Worker II training required
- Radiological work permit required for entry
- Respiratory protection in airborne radioactivity areas
- Dosimeters shall be worn with protective clothing
- Whole body frisk prior to exit after doffing protective clothing

High Contamination Area (red in Figure 1)

- Rad Worker II training required
- Radiological work permit required for entry
- Respiratory protection in airborne radioactivity areas
- Dosimeters shall be worn with protective clothing
- Whole body frisk prior to exit after doffing protective clothing

Radiological Contamination Impacts to Panel Closure

There are two impacts to panel closure that resulted from the radiological contamination. One impact is to the ventilation system and the second impact is to performing routine operations such as mining, transporting salt which may be contaminated, and erecting and maintaining closure components such as bulkheads. These impacts are described as follows:

- Radiological Contamination Impacts to the Ventilation System

  The impact resulting from the radiological release event is twofold: the underground facility is operated in filtration mode and the amount of available ventilation air is limited. Since the radiological release, the underground ventilation system has operated in filtration mode, which means that underground ventilation air is exhausted to the ambient atmosphere through high efficiency particulate air (**HEPA**) filter banks with an air flow rate of up to approximately 106,000 standard cubic feet per minute (**scfm**) (114,000 actual cfm (acfm)) of filtered air (with the Interim Ventilation System). The implications of operating in filtration mode in order to reduce the probability of a radiological release are further discussed below. The reduced ventilation air flow rate also impacts the amount of operational activity and mining activity that can occur concurrently with panel closure activity because it is necessary to preserve air quality in areas where workers are present thereby protecting them from diesel emissions and radiological contamination.

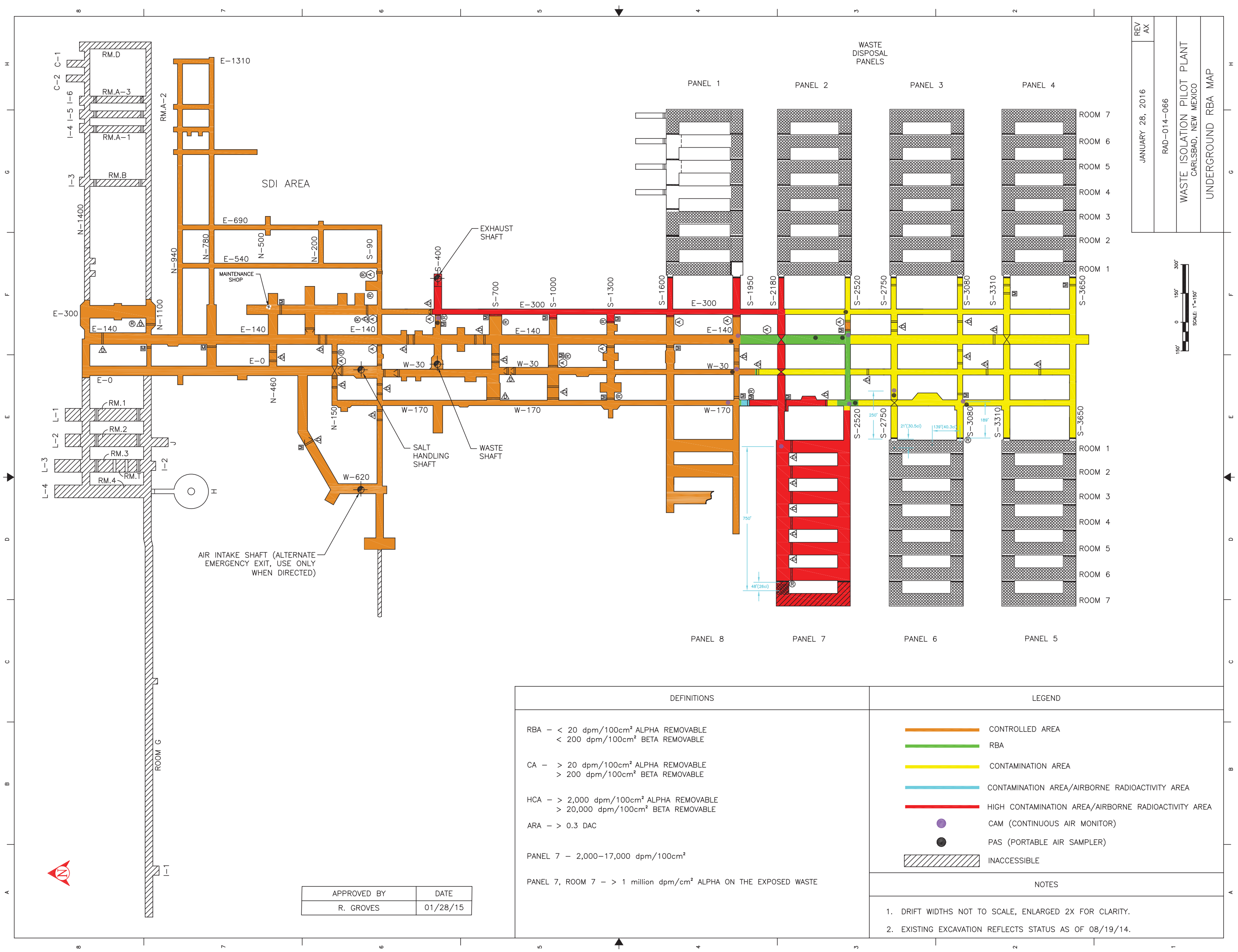

Figure 1. Contaminated Areas in the Underground

- Radiological Contamination Impacts to Routine Operations

  With the installation and operation of the Interim Ventilation System (**IVS**), which was installed to provide additional filtered ventilation air to the underground, the Permittees will have sufficient ventilation air to conduct waste emplacement operations, mine maintenance, and panel closure activities (as proposed herein). The Permittees must take care not to generate excessive dust which will clog the HEPA filtration system filters and require frequent filter media change-outs. Without incorporating additional dust control measures, significant amounts of mining under filtration are not practical due to dust generation and the need for numerous pieces of diesel equipment to support mining operations. Therefore, the proposed design for panel closures limits the amount of mining needed thereby accommodating continuous operation in filtration mode.

  In addition, transporting salt, equipment, and construction materials such as those required for the current closure design may be problematic since outbound (out of contamination areas) equipment and materials may be contaminated. These outbound materials and equipment will need to be stored underground or inbound materials will have to pass from clean areas into contaminated areas requiring a transfer process that may be dust intensive. Minimizing material haulage is a consideration for the WPC design.

  With regard to radiological contamination, the radiological conditions in the underground represent a changed condition that the Permittees anticipate will impact the placement and maintenance of panel closures. The Permittees are proposing a revised panel closure design to address this changed condition by:

  - Reducing the amount of time workers need to spend in radiologically contaminated areas completing panel closure,
  - Reducing the amount of mine-related dust generated by the panel closure process,
  - Reducing the amount of equipment and material needed to support panel closure, and
  - Reducing the ventilation requirements for panel closure installation.

  With these provisions, panel closures can be placed and maintained while keeping worker exposures to radioactivity as low as reasonably achievable. These activities will be conducted while keeping occupational exposures for workers to VOC emissions within national occupational standards and ensuring the releases of VOCs from the repository are not harmful to the public.

2. Routine Underground Mine Maintenance

Due to the February 2014 events, the Permittees were not able to resume normal underground maintenance until November 2014, at which time ground control, including roof-bolting, was reinitiated. Priority areas for bolting were areas around the shafts, shops, and Panels 6 and 7. Bolting was needed to recover areas in the underground, make them habitable, and to allow the initial closure of Panel 6 and the closure of Panel 7, Room 7. Currently, catch-up bolting in normally occupied uncontaminated areas is complete. Catch-up bolting continues in contaminated areas. This has been made more challenging since personnel now must wear additional PPE to protect against contamination and recover areas that could not be maintained by performing routine bolting.

The inability to perform routine bolting has led the Permittees to place access restrictions on some areas in the underground. These areas are not considered safe for normal access. Some of these restricted access areas are barricaded and access is prohibited due to ground conditions. These include entries to Panels 2, 3 and 4. Areas in the access drifts to Panels 3 and 4 have experienced roof falls, indicating the need for remedial action. Restricted or prohibited areas will have to be remediated before normal access is granted. The areas with restricted access are shown in Figure 2. The conditions in the restricted areas in the underground have an impact on panel closure since many of them are locations where the current closure design calls for extensive construction activity. An important consideration in proposing the WPC design is avoiding these areas where ground conditions require extensive remediation to make these areas safe for access prior to installation of the closure. The Permittees proposed changes include the ability to relocate the individual panel closures to location in the north-south mains, if such relocation is the best alternative for closing the panels and provides for greater worker protection by not requiring entry into areas that are now prohibited due to ground conditions.

3. <u>Operation of the Underground Ventilation System in Continuous Filtration Mode</u>

The design of the WIPP facility incorporates HEPA filtration as the primary method of protecting human health and the environment in the event of a radiological release in the underground. Ventilation air passes through and by waste disposal areas and is circulated through filtration units, ensuring that air follows the ventilation pathway and not into other portions of the mine or to the surface unfiltered. The filtration system has been operating continuously since February 14, 2014, thereby mitigating the public exposure hazards associated with a potential release of radioactive contaminants from waste containers and providing continued protection to human health and the environment. The filtration system consists of banks of filters that include roughing (Mod) filters, high-efficiency filters, and HEPA filters. Because of buildup of particulate on the filters, the Permittees perform a filter change-out based upon the condition (e.g., differential pressure) of each type of filter. The system is monitored continuously. Filter change-out is performed in a manner that minimizes the risk of an airborne release from the facility. Independent filter banks are normally available and can be changed out one at a time so that at least one bank continues to be in service to filter any possible releases. While filter change-out is underway, personnel access to the underground is prohibited. In the underground, the ongoing operating practice is to provide workers with personal protective equipment sufficient to mitigate potential exposures in those areas where exposure risk dictates protection. In radiologically contaminated areas, this personal protective equipment may include breathing protection, anti-contamination clothing, and administrative controls for the duration of underground activities.

Continuous Filtration Mode Impacts on Underground Operations

The original HEPA filtration system was designed for one exhaust fan to operate at a time. The two similar fans serve as redundant fans. The use of the fans is rotated between the three fans in order to accommodate operational needs such as periodic maintenance. Using a single fan provides 60,000 scfm of ventilation air to the underground.

Figure 2. Geotechnical Status of Underground

Recently, the Permittees have upgraded the filtration system by constructing the IVS as an augmentation to the originally installed filtration system. The IVS consists of two skid mounted fan and filter units that increase the filtration capacity. Similar to the original filtration system, the two primary functions of the augmented ventilation system will be to 1) remove the airborne radioactive particulate from the exhaust air through HEPA filtration before the air is released to the environment and 2) provide additional ventilation air flow in order to achieve up to 106,000 scfm (114,000 actual cubic feet per minute (**acfm**)) in filtration mode. In a letter dated August 5, 2014,[4] the NMED approved the continued use of filtration as a means of protecting human health and the environment as described above.

The current limited ventilation constrains the number of personnel and activities that can be conducted in the underground at any time. Operations impacted by the limited ventilation include activities that produce exhaust or fumes (e.g., diesel engines for roof bolters, forklifts, salt haul trucks, underground construction vehicles) and create underground dust (e.g., mining, roof bolting, vehicle movements, movement of salt). Closure planning is impacted in order to ensure the selection of equipment and activities that can be accommodated by the available air flow rate, particularly in the farthest portion of the underground regulated unit. This planning must also consider waste management activities.

The Permittees have contracted the services of a mine ventilation consultant to ensure there will be sufficient ventilation to support waste management activities and panel closure. The consultant's report is attached to the revised PMR (Appendix C). The report indicates that there is approximately 10,000 scfm of ventilation air available for the mine south of Panel 7. This may not be enough air to conduct panel closure activities simultaneously with waste handling. However, closure activities can proceed on a separate shift or at times when waste handling is not planned, thereby providing the necessary ventilation for panel closure.

As mentioned previously, the Permittees' proposal includes the ability to move the individual panel closures to the north-south mains. This action provides a closure system that is more protective to the workers who have to install the closure bulkheads. Placing closures in the mains instead of the individual panels effectively removes Panel 9 from further consideration for TRU waste disposal. Significant benefits include:

- Reducing the potential employee exposure to ground control hazards
- Reducing the potential employee exposure to VOCs in filled portions of the repository
- Reducing the footprint of the underground, which reduces costs to maintain
- Reducing the contamination footprint by approximately 60%
- Reducing the active area of the underground increases the available ventilation to Panel 7 and occupied areas of the mine
- Reducing the active area of the underground allows workforce to focus on the remaining areas for ground control
- Eliminating the requirement to further mine the South End or emplace run-of-mine salt reduces loading on the ventilation HEPA filters and reduces the costs and frequency of HEPA filter change.

Continuous Filtration Mode Impacts on VOC Emissions

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[4] WIPP Nitrate Salt Bearing Waste Container Isolation Plan Waste Isolation Pilot Plant EPA I.D. Number: NM4890139088-TSDF Ryan Flynn, Secretary of Environment date August 5, 2014.

Another impact of the changes in ventilation is associated with meeting the panel closure performance standards for VOC emissions. Operating in filtration mode impacts the dispersion of VOCs emitted from the underground. First, the emission point is the stack at Station B which is located north of the normal ventilation stacks. Second, the ventilation air flow is significantly reduced below what is available during normal ventilation. Combined, these factors change the impacts to environmental receptors such as the residents living outside the WIPP site boundary.

In order to evaluate the effects on residents living outside the WIPP site boundary (i.e., the nearby ranches), the Permittees performed additional air dispersion modeling in 2014[5] to evaluate the impacts of the enhanced ventilation system when compared to a previous air dispersion model run in 2010.[6] These results are summarized in Table 1. The Design Report[7] uses the WIPP Site Boundary as the point of compliance. The unit for comparison is micrograms per cubic meter per pounds per hour (μg/m^3 per lbs/hr) of VOCs emitted.

Table 1. Air Modeling Results

	Max Onsite Modeled Impact	**WIPP Site Boundary Impact**	**Smith Ranch Impact**	**Mills Ranch Impact**
Unit Impacts for the 2014 Analysis[1] (μg/m^3 per lbs/hr)	1.80	0.023	0.004	0.004
Air Dispersion Factor (**ADF**) from 2014 Analysis[1] (Dimensionless)	7.69E-04	9.82E-06	1.71E-06	1.71E-06
ADF from 2010 Analysis[2] (Dimensionless)	1.14E-02	8.78E-05	2.13E-05	1.63E-05

1 Extracted from Tables 3-1 and 3-2 of *Air Quality Analysis for the DOE Waste Isolation Pilot Plant (WIPP) Repository Vent Stack Modeling*, 2014, URS Corporation, Austin, TX 78729.

2 Extracted from Table 3c of *Human Health Protectiveness Evaluation VOC Releases to Atmosphere, Waste Isolation Pilot Plant, Carlsbad, NM, 2014,* URS Corporation, Overland Park, KS 66210.

This table indicates that, for the 2014 modeling, an emission of one pound per hour of a VOC (equivalent to 2,350 μg/m^3 at 114,000 acfm) results in a concentration at the property boundary that would be attenuated by air dispersion by five orders of magnitude (ADF = 9.82E-06). This equates to a factor of 10 higher attenuation than the analysis performed in 2010 when the facility was operating at full ventilation capacity.

The NMED established a total risk for offsite members of the public (residents) at one excess cancer death in one million (10^{-6}) and a hazard index[8] of less than 1.0 for non-carcinogens.[9] In

[5] URS Corporation, 2014, *Air Quality Analysis for the DOE Waste Isolation Pilot Plant (WIPP) Repository Vent Stack Modeling*, Austin, TX 78729.

[6] URS Corporation, 2010, *Human Health Protectiveness Evaluation VOC Releases to Atmosphere, Waste Isolation Pilot Plant, Carlsbad, NM,* Overland Park, KS 66210.

[7] Golder Associates Inc. (Golder). 2016. Design Report – WIPP Panel Closure report number 0632213 R1 Rev 1, Lakewood, Colorado, October 2016. (Included in Appendix E)

[8] Hazard Index a summation of the hazard quotients for all chemicals to which an individual is exposed. A hazard index value of 1.0 or less than 1.0 indicates that no adverse human health effects (noncancer) are expected to occur.

[9] New Mexico Environment Department, 1999, Direct Testimony, *Volatile Organic Compound Concentration Limits*, page 9 of 15 states: "NMED has set the acceptable risk levels as follows: (1) for a resident living at the WIPP site boundary, the total individual excess cancer risk from exposure to carcinogens and potential carcinogens shall be

order to equate these environmental performance levels to performance levels for panel closures, it is necessary to introduce risk-based levels also referred to as health based levels (**HBLs**) for WIPP facility-specific risk parameters.

Risk-based levels are chemical-specific concentrations that correspond to specified risk levels, such as a per chemical cancer risk of 10^{-6}. Risk-based levels can be obtained from the U.S. Environmental Protection Agency (**EPA**) Regional Screening Level (**RSL**) tables.[10] The EPA RSL tables use default exposure assumptions that are designed to be protective of a population that is exposed on a daily basis for many years. The RSL calculations can be modified to produce site-specific concentrations that account for site-specific exposure conditions as opposed to the generic conditions used by the EPA. For the WIPP facility, site-specific calculations have historically been referred to as HBLs.

For the ten VOCs of concern at the WIPP facility the EPA air RSLs using generic risk parameters and the WIPP facility-specific HBLs using WIPP facility-specific risk parameters are compared in Table 2. The EPA RSLs are based on target per chemical cancer risk for residents of 10^{-6} and a hazard index of 1.0. The exposure parameters that the EPA uses to generate these values are somewhat different than the assumptions used for the WIPP facility performance parameters. Table 2 also shows the WIPP facility-specific HBLs. The assessment parameters are shown in the lower portion of the table. Note that for VOCs that create both carcinogenic and non-carcinogenic effects, the RSL or HBL is the lesser of the two concentrations.

Monitoring VOC emissions from the underground is currently required by the Permit as part of the VOC Repository Monitoring Program. This monitoring is used to determine exposure of on-site non-waste surface workers to VOC emissions from disposed waste containers. Under the current Permit, compliance with the VOC Repository Monitoring Program limits and action levels indicates compliance with VOC limits for members of the public beyond the WIPP Site Boundary. This is because the difference in air dispersion between the on-site monitoring station and the boundary is several orders of magnitude which is sufficient to ensure the on-site measurements are bounding. No additional VOC monitoring is proposed for the WPC.

Table 2. EPA RSL and WIPP Facility HBL Values for Public Exposures

Volatile Organic Compounds	EPA RSL $\mu g/m^3$	WIPP Facility HBL $\mu g/m^3$
Carbon Tetrachloride	0.47	0.33
Toluene	5,210 (n)	5,000 (n)
Trichloroethylene	0.48	0.39
Chloroform	0.12	0.087
Methylene Chloride	101	101
1,1,1-Trichloroethane	5,210 (n)	5,000 (n)

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one in one million (10^{-6}); (2) for a WIPP non-waste surface worker, the total individual excess cancer risk from exposure to carcinogens and potential carcinogens shall be one in one hundred thousand (10^{-5}); and (3) for all persons, the acceptable risk level for exposure to non-carcinogens shall be a Hazard Index of less than 1.0."

[10] EPA Regional Screening Level Tables are available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-november-2015.

Volatile Organic Compounds	EPA RSL µg/m^3	WIPP Facility HBL µg/m^3
1,1,2,2-Tetrachloroethane	0.048	0.035
1,2-Dichloroethane	0.11	0.077
1,1-Dichloroethylene	209 (n)	200 (n)
Chlorobenzene	52 (n)	50.0 (n)
Assessment Parameters		
Target Risk: Carcinogenic	10^{-6}	10^{-6}
Target Risk: Non carcinogenic	Hazard Index <1.0	Hazard Index <1.0
Averaging time (days/year)	365	365
Exposure frequency (days/year)	350	350
Exposure duration (years)	26	35
Exposure time (hours/day)	24	24
Lifetime (years)	70	70

(n) indicates that the value is based on the non-carcinogenic risk

4. <u>Isolation of Nitrate Salt Bearing Waste</u>

The Isolation Plan was required by NMED Administrative Order 05-20001 (**Order**) issued to the Permittees on May 20, 2014.[11] The Order, at Paragraph 22, required the Permittees to submit an isolation plan for identified nitrate salt bearing waste disposed in the WIPP underground disposal facility. The Order required that the Isolation Plan include "a detailed proposal for the expedited closure of underground Hazardous Waste Disposal Unit (**HWDU**) Panel 6, so that a potential release from any nitrate salt bearing waste containers in Panel 6 does not pose a threat to human health or the environment." It also required "a detailed proposal for the expedited closure of underground HWDU Panel 7, Room 7, so that a potential release from any nitrate salt bearing waste containers in Panel 7, Room 7, does not pose a threat to human health or the environment." The Isolation Plan was submitted to the NMED by the Permittees on May 30, 2014.

On August 5, 2014, the NMED approved the Permittees proposal for the initial closure of Panel 6 and the Permittees proposal to continue to use the mine ventilation system in filtration mode to protect public health and the environment.[12] However, the NMED provided comments and

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[11] New Mexico Environment Department, 2014, Administrative Order under the New Mexico Hazardous Waste Act § 74-4-13, Waste Isolation Pilot Plant, Hazardous Waste Facility Permit Number: NM4890139088-TSDF Ryan Flynn, Secretary of Environment dated May 20, 2014. http://www.wipp.energy.gov/library/Information_Repository_A/Directives_from_the_Secretary/WIPP_Order_05-20001.pdf.

[12] New Mexico Environment Department, 2014, WIPP Nitrate Salt Bearing Waste Container Isolation Plan, Waste Isolation Pilot Plant EPA I.D. Number: NM4890139088-TSDF Ryan Flynn, Secretary of Environment date August 5, 2014. http://www.wipp.energy.gov/library/Information_Repository_A/Directives_from_the_Secretary/14-1561_Redacted.pdf.

questions requiring clarification and resubmittal of the Isolation Plan which was submitted to the NMED on September 30, 2014.[13]

On March 30, 2015, the NMED provided a second letter to the Permittees which:

- Approved Revision 1 of the Isolation Plan, including the closure plan for Panel 7, Room 7, except for Isolation Plan Sections 3.2.3 and 3.3.3

- Specified, with regard to Isolation Plan Sections 3.2.3 and 3.3.3 that the permanent closure for Panel 6 is to be approved through the permit modification process as specified in 20.4.1.901 New Mexico Administrative Code, incorporating Title 40, Code of Federal Regulations Part 270, §270.42;

- Requested an update to Revision 1 of the Isolation Plan[14]

Revision 2 of the Isolation Plan, which was submitted on May 29, 2015, addresses the NMED March 30, 2015 letter.[15]

Pursuant to the Isolation Plan the initial closures in Panel 6 and a closure in Panel 7, Room 7 to isolate nitrate salt bearing waste were installed. These closures are compatible with the proposed closure systems. In response to the NMEDs comments on the Isolation Plan, an analysis of the performance of standard bulkheads was performed. The analysis provided in the Isolation Plan, which is also provided with the revised PMR, includes a quantitative evaluation of bulkhead response should another event similar to the February 14, 2014 event occur.

Summary of the Current Conditions at the WIPP Facility

The Permittees have made significant progress in recovery efforts at the WIPP facility following the 2014 salt haul truck fire and radiological release events. Efforts have mitigated some of the changed repository conditions that affect panel closure. These are discussed below along with their ongoing implications with regard to the WPC design:

- In May of 2015, an initial panel closure, using chain link, brattice cloth, run-of-mine salt material, and steel bulkheads, was installed in Panel 6 and closures consisting of chain link, brattice cloth, and steel bulkheads were installed in Panel 7, Room 7, the location of the 2014 radiological release. These closures physically isolated the waste containers

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[13] U. S. Department of Energy, 2014, Information Regarding the Waste Isolation Pilot Plant Nitrate Salt Bearing Waste Container Isolation Plan Hazardous Waste Facility Permit Number: NM4890139088-TSDF Jose R. Franco/CBFO and Robert L. McQuinn/NWP dated September 30, 2014. http://www.wipp.energy.gov/library/Information_Repository_A/Responses_to_Administrative_Order/14-2614_WIPP_Nitrate_Salt_Bearing_Waste_Container_Isolation_Plan_2014%20_Redacted.pdf.

[14] New Mexico Environment Department, 2015, WIPP Nitrate Salt Bearing Waste Container Isolation Plan, Revision 1 Waste Isolation Pilot Plant EPA I.D. Number: NM4890139088-TSDF Ryan Flynn, Secretary of Environment dated March 30, 2015. http://www.wipp.energy.gov/library/Information_Repository_A/Directives_from_the_Secretary/Letter_Revision_1.pdf.

[15] WIPP Nitrate Salt Bearing Waste Container Isolation Plan, Revision 2 Waste Isolation Pilot Hazardous Waste Facility Permit Number: NM4890139088-TSDF Jose R. Franco/CBFO and Robert L. McQuinn/NWP dated May 29, 2015. http://www.wipp.energy.gov/library/Information_Repository_A/Responses_to_Administrative_Order/15-1489_Enclosure_WIPP_Nitrate_Salt_Bearing_Waste_Container_Isolation_Plan_Revision.pdf.

from the waste streams that caused the radiological release, providing additional protection for the underground workers and fulfilling one of the requirements in a NMED administrative order. Three analyses prepared to support these closures indicate that they are robust enough to withstand an event more severe than the radiological release event in 2014.[16, 17, 18] These closures were installed under adverse conditions which have subsequently been significantly mitigated. Bulkhead closures appear to be sufficient for closing underground HWDUs under the current conditions.

- DOE and Nuclear Waste Partnership LLC completed radiological risk reduction activities in select portions of the WIPP underground in the pathway leading to and in Panel 7. Mitigation activities included the application of a fine water mist to the roof, walls, and floor. As the mist evaporates, the salt recrystallizes, encapsulating the contamination that was on the surface. In addition, brattice cloth and a layer of previously-mined salt were laid along contaminated portions of the floor to trap any contamination and to provide a durable surface for vehicle traffic. These radiological risk mitigation techniques help prevent the resuspension of surface contamination and allow for a reduction in the level of radiological controls necessary to protect workers. However, activities that disturb the surface of the mine could resuspend radiological contamination and pose a threat to workers. Panel closure designs, such as the WPC, that minimize mine surface disturbance such as excavation, milling, roof support, and salt haulage are desirable.

- As a result of radiological risk mitigation efforts by WIPP Radiological Control teams, requirements for respiratory protection were lifted for a significant portion of the WIPP underground. The change in respiratory protection requirements applies to all areas south of S-2520 where VOC levels are not elevated. This change represents a significant milestone in radiological contamination mitigation efforts. In areas where VOC levels exceed 5 parts per million, respirators are required for access. In areas south of S-2520 where respirators are not required, the use of protective clothing, booties, and gloves remains necessary. Eliminating the need for air purifying respirators reduces physical stress on workers and makes performance of work activities easier and safer. Panel closure designs, such as the WPC, that minimize mine surface disturbance such as excavation, milling, roof support, and salt haulage are desirable.

- Maintenance (rock bolting) is normally performed on a daily basis. After an initial 9-month interruption during which no ground control could be performed, catch-up bolting became one of the highest priorities of the recovery process. Currently, catch-up bolting in normally occupied uncontaminated areas is complete. Catch-up bolting continues in contaminated areas. Under the current limited ventilation conditions, the amount of diesel equipment that can be operated in the WIPP underground at any given time is restricted. Panel closure designs, such as the WPC, that minimize the amount of mine maintenance and additional bolting are advantageous to workers.

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[16] Evaluation of Thermal Effects on Panel Closures from the “Heat Event” That Occurred in Room 7 of Panel 7 On February 14, 2014, September 29, 2014.

[17] Evaluation of Pressure Effects on Steel Bulkheads from a Future “Heat Event” in Room 1 of Panel 6 or Room 7 of Panel 7, September 29, 2014.

[18] Mitigation of Gas Buildup for Workers near Room 7 of Panel 7 or near Room 1 of Panel 6, May 11, 2015.

- To provide sufficient air flow necessary to allow workers to return to waste disposal operations, the IVS has been placed into service. The IVS unit consists of fans that will draw air out of the underground and pull it through HEPA filter units before it is released to the environment. The increase in air flow is necessary to meet permit requirements for resumption of waste emplacement operations and will increase the amount of work that can be performed simultaneously underground.

Acronyms and Abbreviations used in the Response to the Technical Incompleteness Determination

acfm	actual cubic feet per minute
ADF	air dispersion factor
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
HBL	health based level
HEPA	high efficiency particulate air
Isolation Plan	*WIPP Nitrate Salt Bearing Waste Container Isolation Plan*
IVS	Interim Ventilation System
NMED	New Mexico Environment Department
Order	NMED Administrative Order 05-20001
PCS	Panel Closure System
Permit	Hazardous Waste Facility Permit
PMR	Permit modification request
ROM	run-of-mine
RSL	Regional Screening Level
scfm	standard cubic feet per minute
VOC	volatile organic compound
WIPP	Waste Isolation Pilot Plant
WPC	WIPP Panel Closure

Revised Class 3 Permit Modification Request

Modifications to the WIPP Panel Closure Plan
Waste Isolation Pilot Plant
Carlsbad, New Mexico

WIPP Permit Number - NM4890139088-TSDF

November 2016

Table of Contents

Acronyms and Abbreviations

ATWIR	Annual Transuranic Waste Inventory Report
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DRZ	disturbed rock zone
EPA	U.S. Environmental Protection Agency
HWDU	Hazardous Waste Disposal Unit
MSHA	Mine Safety and Health Administration
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
PCS	Panel Closure System
Permit	Hazardous Waste Facility Permit
PMR	Permit Modification Request
RCRA	Resource Conservation and Recovery Act
ROM	run-of-mine
QA/QC	quality assurance/quality control
SMC	Salado Mass Concrete
TRU	transuranic
VOC	volatile organic compound
WIPP	Waste Isolation Pilot Plant
WPC	WIPP Panel Closure

Revision to the Permit Modification Request

This revised Permit Modification Request (**PMR**) is being submitted by the Permittees in accordance with the Permit Part 1, Section 1.3.1 (20.4.1.900 New Mexico Administrative Code (**NMAC**) (incorporating Title 40 Code of Federal Regulations (**CFR**) §270.42)) and in response to the Technical Incompleteness Determination issued by the New Mexico Environment Department (**NMED**) on July 22, 2015. This modification proposes a revision to the approved closure plan, as currently described in the Hazardous Waste Facility Permit (**Permit**), Attachments G and G1. These changes do not reduce the ability of the Permittees to provide continued protection of human health and the environment.

The previous submittal of this PMR to the NMED on March 18, 2013, contained three items proposed for modification through the Class 3 modification process. These were entitled as follows:

- Modification to the WIPP Panel Closure (**WPC**)
- Repository Reconfiguration
- Volatile Organic Compound Monitoring Program Changes

The Permittees are no longer considering the proposed repository reconfiguration and the volatile organic compound (**VOC**) monitoring program as part of this PMR. Therefore, this revised PMR focuses on modifications to the Waste Isolation Pilot Plant (**WIPP**) facility panel closures. The Permittees have organized this PMR to respond to the Technical Incompleteness Determination. The following information specifically addresses how compliance has been achieved with Permit Part 1, Section 1.3.1. Direct quotes are indicated by italicized text.

The proposed modifications to the text of the WIPP Permit have been identified using red text and a double underline for new text and a ~~strikeout~~ font for deleted information.

1. 20.4.1.900 NMAC (incorporating 40 CFR 270.42(c)(1)(i)) requires the applicant to describe the exact change to be made to the Permit conditions and supporting documents referenced by the Permit.

Revision to the WIPP Panel Closure System Design

This PMR proposes to amend the closure plan in Permit Attachment G by revising the existing Panel Closure System (**PCS**) design. In order to support the new WPC design, the following proposed changes are necessary:

- Revise the text of Attachment G to incorporate the WPC and the new schedule for closure.
- Delete the Detailed Design Report for an Operation Phase Panel Closure System in Attachment G1 and add a new Attachment G1 with reference to new Design Report[1].
- Add new Attachment G1, Appendix G1-A, with the technical specifications for the WPC design.
- Add new Attachment G1, Appendix G1-B, with the design drawings for the WPC design.

[1] Golder Associates Inc. (Golder). 2016. Design Report – WIPP Panel Closure report number 0632213 R1 Rev 1, Lakewood, Colorado, October 2016. (Included in Appendix E).

- Delete Attachment G1, Appendix G, which contains the technical specifications for the PCS design.
- Delete Attachment G1, Appendix H, which contains the design drawings for the PCS design.

The approved PCS design requires emplacing a 12-foot explosion-isolation wall and emplacing of a 26-foot monolith composed of Salado Mass Concrete (**SMC**) in the intake and exhaust drifts leading into each panel. The proposed WPC, which replaces the PCS, consists of up to two components, bulkheads, used by themselves to close Panels 1 through 9 (referred to as WPC-A) and bulkheads and run-of-mine (**ROM**) salt used to close Panel 10 (referred to WPC-B).[2] The bulkhead component is a standard WIPP facility bulkhead. Outbye bulkheads are placed in an area where they are accessible for maintenance to ensure the bulkhead meets its intended purpose of blocking ventilation to filled areas of the disposal unit. Bulkheads also prevent personnel access to closed areas.

Due to ground conditions in the entries to Panels 3 through 5 in the WIPP underground, panel-specific closures may be placed in the north-south mains outside these panels. In this case, the Permittees would forego placement of TRU mixed waste in the area designated as Panel 9. The closures would be the same design and construction of those proposed for individual panels. Their performance would be consistent with the designs modelled in the Design Report. Significant benefits include:

- Reducing the potential employee exposure to ground control hazards
- Reducing the potential employee exposure to VOCs in filled portions of the repository
- Reducing the footprint of the underground, which reduces costs to maintain
- Reducing the contamination footprint by approximately 60%
- Reducing the active area of the underground increases the available ventilation to Panel 7 and occupied areas of the mine
- Reducing the active area of the underground allows workforce to focus on the remaining areas for ground control
- Eliminating the requirement to further mine the South End or emplace run-of-mine salt reduces loading on the ventilation HEPA filters and reduces the costs and frequency of HEPA filter change.

Consideration of moving the panel closures to the mains is driven by recent roof falls in several panel entries in filled panels. These roof falls are likely to continue since the areas will not be maintained once the closures are in place. In light of this, the effect of a roof fall on VOC emissions is anticipated to be minimal since the event will be of short duration. Based on the assumptions and model used for establishing room-based VOC limits and an average concentration for carbon tetrachloride of 6,400 ppmv (based on measured headspace concentrations in the containers disposed in Panels 3 through 6), the ventilation required for waste emplacement (i.e., 35,000 scfm) will be sufficient to dilute emissions created by a roof fall to concentrations less than those that are harmful to workers.

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[2] The Permittees are required to demonstrate compliance with the long-term compliance standards found in 40 CFR 191 Subparts B and C. This is done by way of a performance assessment of repository performance for 10,000 years. This demonstration may require ROM salt to fill voids in entries.

The need for maintenance is determined based on routine inspections of accessible bulkheads. The inspection schedule in Permit Attachment E, Table E-1 is proposed for revision based on the longevity evaluation in the Design Report. An inspection frequency of semi-annually is expected to provide indications of bulkhead deterioration with sufficient time to implement repairs. Furthermore, unexplained increases in the concentrations of VOCs measured by the Repository VOC Monitoring Program may indicate bulkhead deterioration and will trigger bulkhead inspections. Bulkheads are expected to remain accessible until waste emplacement in the main drifts (Panels 9 and 10[3]) block access.

The major components of each system are summarized in the following table:

PCS	WPC
12-foot explosion isolation wall 26-foot SMC monolith	Barrier to block ventilation (i.e., standard bulkhead that is accessible and can be maintained) Run-of-mine salt between two barriers for Panel 10
Placed in the intake and exhaust drift of each filled panel	Bulkhead placed in the intake and exhaust drift of each filled panel or in the main entries to the panels, in combination with ROM salt in Panel 10

The WPC requires that a bulkhead be installed in the entry to each panel drift in an area accessible for maintenance or replacement until waste emplacement blocks the access or in the main entries to the panels. Typically, when closures are placed in panel drifts, this will be a few tens of feet inside the entry, depending on ground conditions and accessibility. Figure 1 shows closure locations. When WPC-A is installed in the main entries for Panel 9, bulkheads will be used. However, the WPC-B closure for Panel 10 will consist of ROM salt located between two bulkheads. The Permittees may close Panel 9 in lieu of placing individual closures in Panels 3 to 6 based on ground conditions in the individual panels.

[3] Panels 9 and 10 are not authorized for waste disposal at this time, however, the Closure Plan to covers these units should they be authorized for disposal in the future or should they be used for closure of panels in lieu of panel-specific closures.

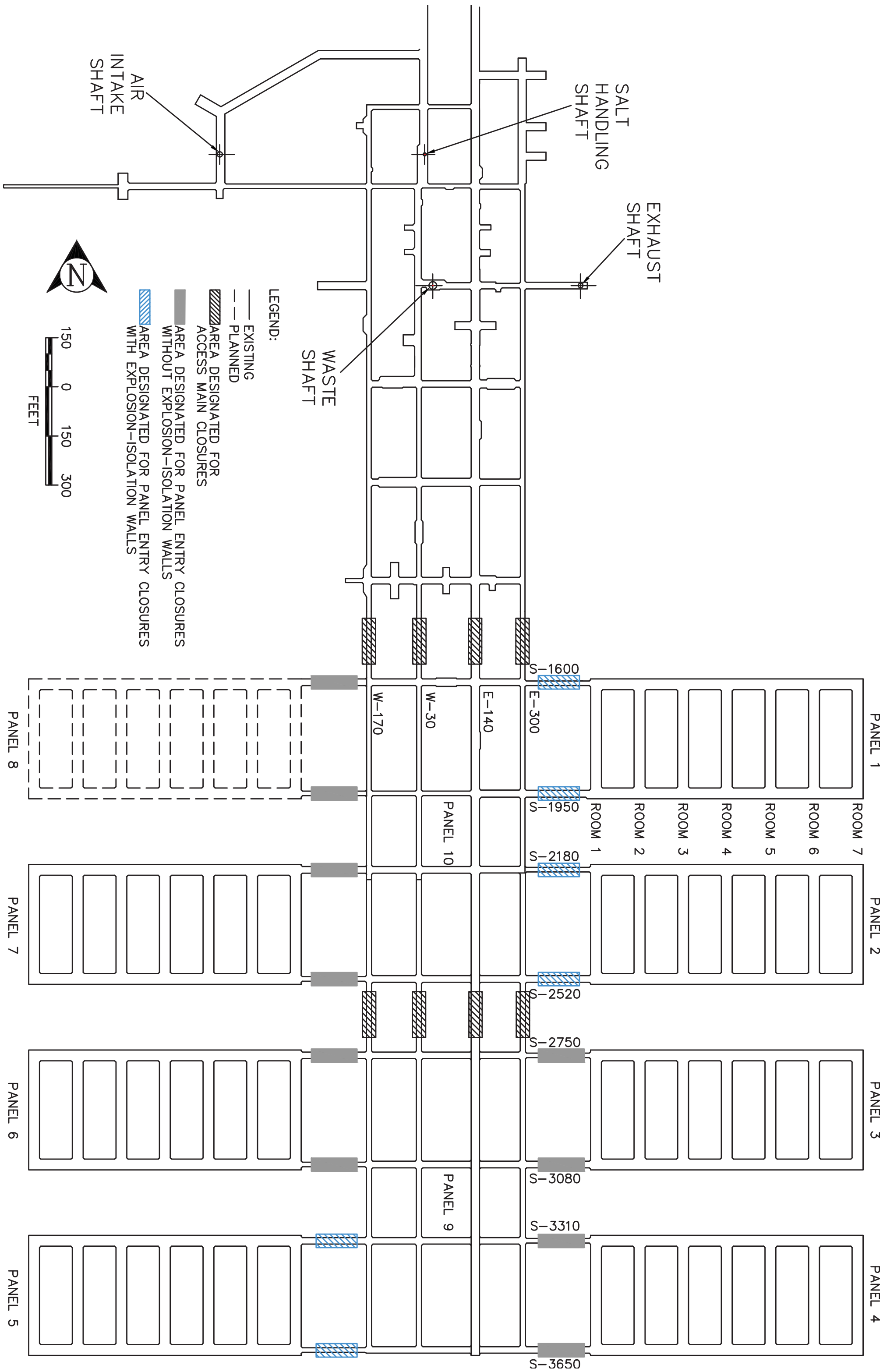

Figure 1. Proposed Panel Closure Locations

The Permittees are proposing that, in anticipation of final facility closure and shaft sealing, the placement of ROM salt in the Panel 10 permanently isolates the filled Hazardous Waste Disposal Units (**HWDUs**) south of S-1600 drifts. The WPC-B minimizes the need for further maintenance of the closure and the HWDUs pursuant to 40 CFR 264.111. It provides additional worker safety during construction of the shaft seals, after all panels have been filled with waste. In addition to meeting the required VOC containment, the WPC satisfies the requirements of the Mine Safety and Health Administration (**MSHA**) for the use of barriers with substantial construction to prevent personnel access into waste-filled areas of the mine during operations. The final facility closure schedule provided in Attachment G2 requires about 86 months to install final facility closures under the assumptions that were made when the Permit Application was submitted. However, that schedule did not anticipate the presence of radioactive contamination in the shafts and is based on four shafts. The Permittees now anticipate the schedule will be extended beyond the initial assumptions due to the radiological release and the anticipated construction of a fifth shaft as a component of the Permanent Ventilation System. Therefore, the presence of the WPC-B between shaft sealing work areas and the waste disposal areas will provide protection against VOC emissions without the need for prolonged maintenance of the Panel 10 bulkheads. As the closure of Panel 10 becomes imminent, the Permittees may evaluate alternate mine barrier technologies in lieu of the ROM salt. If an alternative material is selected, an amendment to the Closure Plan will be filed in accordance with 20.4.1.900 NMAC (incorporating 40 CFR 270.42).

The bulkhead component of the WPC design functions as an effective closure system, since it prevents the active ventilation of filled panels. Active ventilation removes VOCs from the panels and entrains them in the underground exhaust air. This exhaust air serves as the only pathway for VOCs associated with the hazardous waste to pose a threat to human health or the environment. The exhaust air is monitored to ensure environmental performance standards are met with regard to surface worker and public exposure to VOCs from the disposed waste.

The WPC presented in the attached Design Report allows the Permittees to control VOC releases to ensure compliance with VOC emission standards established for the WIPP facility. Analyses provided in the Design Report indicate that steel bulkheads provide an effective closure.

For the WPC-B, a minimum length of the ROM salt was selected based on an engineering evaluation in the Design Report to determine the minimum length needed to provide an adequate percentage of ROM salt to maintain its structural integrity under loads imparted by creep closure of the surrounding rock. The results of the engineering evaluation in the Design Report indicate that the minimum length of the ROM salt is a function of the access drift geometry. The minimum salt lengths are approximately 2.5 to 3 times the width of the underground opening.

The WPC design is of interest to the U.S. Environmental Protection Agency (**EPA**) because the PCS design was specified as a condition of the long-term performance of the WIPP disposal system when the U.S. Department of Energy (**DOE**) compliance to the disposal standards in 40 CFR Part 191 Subparts B and C was certified in 1998.[4] The DOE submitted a change notice to

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[4] Environmental Protection Agency, 40 CFR Part 194, Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the Disposal Regulations; Certification Decision, Final rule, Federal Register/Vol. 63, No. 95/Monday, May 18, 1998.

the EPA requesting approval for the ROM PCS.[5] The design of the ROM PCS was similar to the WPC except it included 100 feet of ROM salt in the two access drifts in each panel. The EPA approved this change in a rule issued October 8, 2014.[6] Unlike the EPA long-term performance standard, the Permit closure performance standard is related to the release of hazardous constituents (VOCs) from the waste and is not associated with radionuclides. These two distinct requirements will be managed separately by the Permittees and the respective agencies. This PMR focuses only on the Permit closure performance standards. According to the EPA ruling, changes that deviate from the design in the change notice will have to be evaluated and submitted to the EPA for consideration.[7] It is not unusual for the EPA certification to impose requirements that are different than those imposed by the Permit for the purposes of meeting long-term performance standards (e.g., requirements regarding magnesium oxide backfill and the random emplacement of waste are long-term performance requirements that are described in the Permit but do not impact compliance with Resource Conservation and Recovery Act (**RCRA**) standards). The installation of RCRA closures will not preclude the subsequent installation of long-term closures required by the EPA.

Modifying the Permit primarily entails replacing the PCS design specifications and drawings with the WPC specifications and drawings and adjusts the schedule for closure to accommodate the current conditions in the WIPP underground. The closure performance standards for closure involve the prevention of a chronic dose of VOCs to a resident who may live beyond the WIPP Land Withdrawal Boundary. This same standard was used to determine the adequacy of the WPC design. The Permittees have determined that the WPC design meets the protectiveness requirements of the Permit and can be installed within the timeframes mandated by the Permit. The evaluation of the WPC design and its level of protectiveness is provided in the Design Report.

Explosion-Isolation Walls

Explosion-isolation walls will no longer be part of the approved panel closure, therefore, the definition in Permit Part 1, Section 1.5.15 is being changed to only include the existing walls in Panels 1, 2, and 5. The inspection and certification requirements in Part 4, Section 4.6.12 and Permit Attachment E, Table E-1 are being eliminated since no more explosion-isolation walls will be constructed as part of panel closure and the existing walls are not needed to mitigate a postulated hydrogen/methane explosion. Also, the existing walls will no longer be accessible after the WPC is erected.

Closure Performance Standards

The Permit does not state the compliance requirements for closure with regard to the air pathway and VOC emissions. These are proposed to be placed in Part 6, Section 6.10.1.

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[5] Letter from Edward Ziemianski, CBFO to Jonathan Edwards, EPA, subject: Transmittal of Planned Change Request for Panel Closure Redesign, September 28, 2011.

[6] Environmental Protection Agency, 40 CFR Part 194, Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the Disposal Regulations; Panel Closure Redesign, Final rule, 60750 Federal Register / Vol. 79, No. 195 / Wednesday, October 8, 2014.

[7] Condition 1 in the 1998 certification rulemaking was modified to allow the ROMPCS and included the following: "DOE must inform EPA of any modification to the approved panel closure design pursuant to § 194.4(b)(3)(i), and provide any supporting information required by § 194.14, Content of compliance certification application."

Revision of Some Panel Closure Design Requirements

Certain panel closure design requirements specified in Permit Attachment G, Section G-1e(1) are proposed for deletion or revision. These changes are discussed in detail in Section 3 below.

Propose Alternate Locations for Panel Closures

The current conditions in the repository are such that careful selection of panel closure locations is important and may vary from panel to panel. For example, current ground conditions in Panel 3 would dictate that closures be placed close to E-300 in the panel entry to reduce personnel risk due to the need for extensive remediation of the roof in the panel intake and exhaust drifts. Locations in Panels 1 and 2 may be based on the extent of radiological contamination. In order to provide flexibility, the Permittees are not specifying a location for closures in each panel access drift, only that the process of selecting the best location be documented as part of the closure records. The selection of alternative locations includes the use of the north-south mains for closing individual panels.

Deletion of the Hydrogen and Methane Monitoring

The Hydrogen and Methane Monitoring Plan (Permit Attachment N1) is proposed for deletion, including any associated references and citations. These changes are discussed in detail in Section 3 below. Affected Permit sections are:

- Permit Part 4, Section 4.6.5 and
- Permit Attachment N1.

Remove Ongoing Disposal Room VOC Monitoring

Text is proposed for revision to remove requirements to perform ongoing disposal room VOC monitoring for filled panels since installing closures makes this monitoring unnecessary. Affected Permit sections are:

- Permit Part 4, Section 4.4.3 and
- Permit Attachment N, Section N-3a(3).

Replacement of Attachment G1

Attachment G1 describes the WPC design. Because of the extensive edits to this attachment, the Permittees are providing a new Attachment G1 and deleting the former version. Included are Attachment G1 appendices containing the technical specifications and drawings for the WPC.

Corrections to Permit Text Regarding Panel Closure

Changes are proposed, as necessary, to correct text and figures and clarify Permit text associated with the proposed revisions to the panel closure including changes to Parts 1,4, and 6 and Attachments A2, A3, B, D, E, and H. In addition, text related to the management of the radioactive portion of transuranic (**TRU**) mixed waste is proposed for deletion.

The Table of Changes (Appendix A) and the redline strikeout in this modification describe each change that is being proposed.

2. 20.4.1.900 NMAC (incorporating 40 CFR 270.42(c)(1)(ii)), requires the applicant to identify that the modification is a Class 3 modification.

The proposed modification is classified as a Class 3 Permit Modification in accordance with 20.4.1.900 NMAC (incorporating 40 CFR 270.42(d)(1)) which states:

> "(d) Other modifications, (1) *In the case of modifications not explicitly listed in Appendix I of this section, the Permittees may submit a Class 3 modification request to the Agency*…"

The Permittees are requesting that this modification be managed under the Class 3 process since the Permittees were unable to identify a similar item justifying a different classification in Appendix I.

3. 20.4.1.900 NMAC (incorporating 40 CFR 270.42(c)(1)(iii)) requires the applicant to identify why the modification is needed.

The current conditions in the WIPP underground have four critical areas that potentially affect panel closure. These areas are:

- Radiological contamination,
- Routine underground mine maintenance,
- Operation of the underground ventilation system in continuous filtration mode, and
- Isolation of nitrate salt bearing waste.

These conditions have necessitated a revised panel closure design that provides the needed protection to human health and the environment while minimizing activities that would resuspend radiological contamination, create excessive amounts of dust, or require workers to spend long periods of time in areas requiring extensive personal protective equipment. The conditions of concern are described in detail in the *Response to the Technical Incompleteness Determination*. The WPC design provides the requisite protection and regulatory compliance while minimizing impacts as described subsequently.

In early 2001, the Permittees began evaluating installation of the PCS design as specified in the WIPP Permit in anticipation of Panel 1 closure. Concerns were identified related to the erratic results obtained from several test pours of the SMC formulation specified in the WIPP Permit. The evaluation team concluded that there were significant opportunities for implementing an alternative design, which would:

- Have a higher certainty of successful installation,
- Meet the closure performance standard for protectiveness, and
- Be less impactive to facility operations.

In early 2002, the Permittees began the process of developing an alternative to the PCS design. The Permittees began preparing the engineering redesign, supporting documents, and assessments necessary to support a revised PCS design. In 2007, the Permittees initiated hydrogen and methane monitoring to gather data to establish whether generation of these gases actually occurs under repository conditions and if so, determine more realistic accumulation rates in filled panels. It was anticipated that more realistic accumulation rates may lead to panel closure designs that did not need to mitigate the hypothetical methane explosion and, therefore, are less complex than the PCS design.

Permit Attachment G, Section G-1e(1), specifically allows the Permittees to collect data on the behavior of the wastes and mined openings for the purpose of proposing a modification to the Closure Plan in the future and seek a permit modification for a panel closure design different from the PCS design.

The Permittees are proposing such a modification to the Closure Plan and seeking a panel closure design different from the PCS design with the submittal of this PMR for the reasons described below.

Higher Certainty of Success

The PCS design requires the use of unproven construction materials. For example, the SMC formulation specified by the Permit was developed specifically for use in a very different application (i.e., the WIPP shaft seals), and has never been successfully poured in a quantity larger than five cubic yards (yards). Each of the four cells associated with each PCS design monolith will be approximately 120 yards. Therefore, there is a much greater uncertainty in the successful use of SMC, as required for the PCS design in the current Closure Plan, than with the WPC design being proposed in this PMR.

Equivalent Level of Protectiveness

The closure performance standards for panel closure involve the prevention of a chronic dose of VOCs released from the repository to a resident who may live beyond the WIPP Site Boundary. This same standard was used to determine the adequacy of the WPC design. The Permittees have determined that the WPC meets the protectiveness requirements of the Permit and can be installed within the timeframes mandated by the Permit. The evaluation of the WPC design and its level of protectiveness is provided in the Design Report. The Permittees have determined that the WPC has a higher likelihood of success than the PCS design and will ensure protection of workers, human health, and the environment during the operational, closure, and post-closure phases of the WIPP facility.

Fewer Impacts to Facility Operations

A compelling reason to seek this permit modification is that installation of the WPC will be less impactive to facility operations (i.e., surface operations, waste disposal in the WIPP underground, and mining and excavation activities). The following table identifies how the WPC design is less impactive.

The WPC will significantly reduce the use of the waste hoist over both the extended construction time for a single PCS and the life of the facility. Once a pour begins for an individual cell of the PCS, dedicated use of the waste hoist is required until the pour is complete. This extended use of the hoist could cause operational delays and create conflicts with waste management activities.

Comparison of the PCS Design to the WPC Design

Item	PCS Design	WPC Design
Special materials	Quartz aggregate must be transported from outside the WIPP facility.	Steel bulkhead materials are readily available at the WIPP facility. Run-of-mine salt is available at the WIPP facility.
Staging	Salado Mass Concrete must be batched aboveground for installation. * Only concrete blocks for the explosion-isolation wall may be prestaged in the underground.	Construction materials may be prestaged in the underground.
Forms	Multiple sets of heavy steel forms must be constructed in the confined area of the panel access and exhaust drifts.	Standard bulkheads are readily constructed. No special forms are required.
Storage	Large quantities of aggregate, cement, fly ash, and other materials must be stored aboveground prior to use.	No aboveground storage beyond bulkhead materials that are kept on hand is anticipated
Handling/installation	Salado Mass Concrete must be batched aboveground and bulk, wet concrete transported underground for installation.	No concrete is required.
Salado Mass Concrete	Difficult to obtain correct mix to meet construction specifications in the WIPP Permit under constraints of underground installation.	Salado Mass Concrete not required.
Time to install	Installation estimated to be 14 months per panel, assuming no failed monolith cells.	Installation will be less than or equal to 180 days per panel.
Use of ventilation air	Once concrete placement begins dedicated and continuous ventilation will be required throughout the activity.	Ventilation can be controlled as needed to support other underground activities without impacting the closure installation.
Additional mining	Significant mining is associated with the preparation of the panel closure areas.	Minimal mining is necessary.
Creation of dust	Mining and transport will produce significant amounts of dust.	Dust generation is reduced by the limited amount of material needed to be transported, and ground preparation for the closure will likely require little mining.
Waste hoist use	Requires dedicated use of the waste hoist for extended periods of time	No unusual demands placed on the waste hoist and use can be scheduled to avoid conflicts with other hoisting needs.

* Although the WIPP Permit provides an option for underground batching, concerns related to water use and increased activity in the underground have all but eliminated this option.

Less Risk

It is commonly accepted that less time, transportation, handling, and reduction in complexity translates to lower risk to workers. Three factors are involved in qualitatively estimating the risk reduction associated with installation of a panel closure design. One factor is the time the workers spend transporting, handling, and installing. Another factor is the complexity of the construction project. As part of the redesign process, the Permittees prepared installation schedules for both the PCS and WPC designs. The underground construction activities for the

PCS design are estimated to require approximately 14 months. The comparable period for construction of the WPC is less than or equal to 180 days. The third factor is the risk due to the extensive mining and milling that is needed to emplace the PCS design. These activities present the possibility of radiological exposure and increased airborne dust.

The Permittees also reviewed the complexity of the construction project associated with the PCS design versus construction of the WPC design. The WPC design employs common materials and techniques, thereby reducing the number of workers required to be in the proximity of the project.

Less Expense

It is expected that the installation cost associated with the WPC design would be negligible and therefore, less expensive when compared to the PCS design, for the following reasons:

- Equipment and supplies used to construct bulkheads are maintained at the WIPP facility for routine application.

- Run-of-mine salt will be readily available at no extra cost due to planned mining activities in the underground.

- As opposed to the PCS design, construction of the WPC design may be achieved using existing mining personnel and equipment.

Any cost reduction associated with the WPC design, instead of the PCS design, is not a driver for the proposed change, but is identified as an additional positive benefit.

As part of the redesign process, comparable cost estimates were prepared by the Permittees for the PCS design (October 7, 2002 Permit Modification Request: Closure Plan Amendment). The cost for the PCS design was estimated to be approximately three times the cost for the explosion-isolation wall. The construction cost for the two explosion-isolation walls installed into Panel 5 in 2011 was $1.44 million.

Summary

The Permittees have identified the following advantages associated with installation of the WPC design which include:

- Less time to install;
- Less material transportation to the site;
- Less staging of materials at the surface;
- Less complex activity in the underground;
- No construction of special forms;
- No placement of bulk, wet SMC in the underground;
- Reduction of risks to workers;
- Higher certainty of success without reducing protectiveness;
- Less costs;
- Less possibility of resuspending radioactivity; and
- Less dust generation.

Explosion-Isolation Walls

The PCS includes an explosion-isolation wall as an integral part of the design. The purpose of the wall was to mitigate the effects of a postulated methane explosion in a filled and closed panel. The wall protected the concrete monolith portion of the closure. Both the wall and the monolith are being replaced by the WPC. Monitoring for hydrogen and methane accumulation in filled Panels 3 and 4 have demonstrated that the postulated explosion is unlikely to occur during the operational phase prior to final facility closure. Hydrogen and methane monitoring results are discussed subsequently. Explosion-isolation walls have been built in Panels 1, 2, and 5. Currently, the Permit requires that these walls be inspected by a registered professional engineer. These walls will be certified annually to ensure that they will serve their intended function. Since that function is being eliminated by the proposed WPC, the inspection and certification requirements are also proposed for removal from the Permit.

Closure Performance Standards

The closure performance standard for the WIPP repository is stated in Permit Attachment G, Section G-1a(2), Miscellaneous Unit, and is derived from 20.4.1.500 NMAC (incorporating 40 CFR 264.601). This standard mandates the prevention of any release that may have adverse effects on human health or the environment due to migration of waste constituents in groundwater, surface water, soil, or the air. Permit Attachment G, Section G-1e(1) Panel Closure, provides that the closure standard for air emissions is met by complying with the Repository VOC limits in Permit Part 4. This compliance is demonstrated by analysis in the Design Report referenced in Attachment G1. In order to facilitate the demonstration of compliance, the air emission closure performance standard for closure is proposed as VOC limits in a new Table 6.10.1 to be added to Permit Part 6, Section 6.10. These limits are expressed in terms of health-based limits.

Revision to Panel Closure Design Requirements

The panel closure design requirements specified in Permit Attachment G, Section G-1e(1) are proposed for revision as follows:

1. *the panel closure system shall contribute to meeting the closure performance standard in Permit Part 6, Section 6.10.1. by mitigating the migration of VOCs from closed panels*

   The Design Report demonstrates that the WPC can mitigate the migration of VOCs from closed panels and thus contribute to compliance with applicable closure performance standards. The requirement has been revised to clarify that the WPC will contribute to compliance, but, under some circumstances may not by itself ensure compliance. This is because during waste emplacement operations, the open disposal room in the open Panel will also contribute VOCs to the emissions. These cannot be controlled with closure bulkheads until the Panel is closed.

   The Permittees are proposing that, in anticipation of final facility closure and shaft sealing, the placement of WPC-B permanently isolates the filled HWDUs south of S-1600 drift. The WPC-B minimizes the need for further maintenance of the closure system and the HWDUs pursuant to 40 CFR 264.111. It provides additional worker safety during construction of the shaft seals after all panels have been filled with waste. In addition to meeting the required closure performance standard, the WPC satisfies the requirements of the MSHA for the use of barriers with substantial construction to prevent personnel access into waste-filled areas of the mine during operations. As the time for final facility closure approaches, maintenance of these bulkheads may become increasingly difficult as preparations such as removal of utilities and preparation of the shafts for sealing proceed. The final facility closure schedule provided in Permit Attachment G2 requires about 86 months to install final facility closures under the assumptions that were made when the Permit Application was submitted. However, that schedule did not anticipate the presence of radiological contamination in the shafts and is based on four shafts. The Permittees now anticipate the schedule will be extended beyond the initial assumptions due to the radiological release and the anticipated construction of a fifth shaft as a component of the Permanent Ventilation System. The presence of the ROM salt between shaft sealing work areas and the waste disposal areas will provide protection against VOC emissions without the need for prolonged maintenance of the Panel 10 bulkheads.

The requirement was also changed to reference the Closure Performance Requirements provided in Permit Part 6, Section 6.10.1 and the addition of Table 6.10.1.

2. *the panel closure system shall consider potential flow of VOCs through the disturbed rock zone (**DRZ**) in addition to flow through closure components*

   No changes are being proposed to this requirement.

3. *the panel closure system shall perform its intended functions under loads generated by creep closure of the tunnels*

   No changes are being proposed to this requirement. Accessible bulkheads will be maintained as needed to accommodate creep closure.

4. *the panel closure system shall perform its intended function under the conditions of a postulated thermal runaway involving nitrate salt bearing waste*

   This requirement has been changed because the hydrogen and methane monitoring data collected for Panels 3 and 4 indicate that the postulated methane explosion is not credible during the performance life of the WPC.

   The Permittees conducted hydrogen and methane sampling and analysis between April 24, 2008, and February 3, 2014. Hydrogen and Methane analytical results for the samples collected in both Panels 3 and 4 were reported and are evaluated in the report, *Statistical Analysis to Evaluate Methane and Hydrogen Concentrations in Filled Panels at the Waste Isolation Pilot Plant*, Revision 3, January 2016, included in Appendix D of this PMR. This report provides conclusions from the collected data. The data collected confirm a lack of significant flammable gas accumulation in the filled panels.

   With regard to the thermal runaway event that occurred in Panel 7 Room 7 in February 2014, the analysis provided in Revision 2 of the Isolation Plan includes the effectiveness of bulkheads to withstand the conditions created by a similar event three times larger than the one that occurred. The Isolation Plan contains three analyses:

- *Evaluation of Thermal Effects on Panel Closures from the "Heat Event" That Occurred in Room 7 of Panel 7 On February 14, 2014*, dated September 29, 2014

- *Evaluation of Pressure Effects on Steel Bulkheads from a Future "Heat Event" in Room 1 of Panel 6 or Room 7 of Panel 7*, dated September 29, 2014

- *Mitigation of Gas Buildup for Workers near Room 7 of Panel 7 or near Room 1 of Panel 6*, dated May 11, 2015

5. *the nominal operational life of the closure system is 35 years*

   No changes are being proposed to this requirement.

6. *the panel closure system may require minimal maintenance per 20.4.1.500 NMAC (incorporating 40 CFR 264.111)*

   This requirement has been changed because the WPC may require some minimal maintenance to the accessible bulkhead for as long as it is accessible. Minimal maintenance may include reinforcement and replacement of bulkhead components (such as flexible flashing) or it may consist of installation of a new bulkhead in front of the previous bulkhead.

   The need for maintenance is determined based on routine inspections of accessible bulkheads. The inspection schedule in Permit Attachment E, Table E-1 is proposed for revision based on the longevity evaluation in the Design Report. An inspection frequency of semi-annually is expected to provide indications of bulkhead deterioration with sufficient time to implement repairs. Unexplained increases in the concentrations of VOCs measured by the Repository VOC Monitoring Program may indicate bulkhead deterioration and will trigger bulkhead inspections. Bulkheads are expected to remain accessible until waste emplacement in the main drifts block access.

   The requirement has also been changed to reference the applicable regulatory citations: for example, 20.4.1.500 NMAC (incorporating 40 CFR 264.111). Changing this design requirement allows for maintenance to be performed on the accessible bulkheads of the WPC as necessary. 40 CFR 264.111 (a) states: "Minimizes the need for further maintenance." This change is consistent with 40 CFR 264.111 (a).

7. *the panel closure system shall address the expected ground conditions in the waste disposal area*

   The requirement has been changed to require the WPC to address the expected ground conditions instead of the most severe ground conditions expected since the WPC does not interact with the DRZ as does the PCS design, and the numerical modeling predicts that the DRZ will consolidate along with the ROM salt.

8. *the panel closure system shall be built of substantial construction and non-combustible material except for flexible flashing used to accommodate salt movement*

   This requirement has been changed because the design requirement "IIIb" currently identified in the Permit is obsolete.

9. *the design and construction shall follow conventional mining practices*

   No changes are being proposed to this requirement.

10. *structural analysis shall use data acquired from the WIPP underground*

    No changes are being proposed to this requirement.

11. *materials shall be compatible with their emplacement environment and function*

    No changes are being proposed to this requirement.

12. *treatment of surfaces in the closure areas shall be considered in the design*

    No changes are being proposed to this requirement.

13. *a QA/QC program shall verify material properties and construction*

    Some material properties and construction specifications may need to be verified prior to construction. The requirement has been revised to remove the restriction that a quality assurance/quality control (**QA/QC**) program need only verify material properties and construction specifications during construction.

14. *construction of the panel closure system shall consider shaft and underground access and services for materials handling*

    No changes are being proposed to this requirement.

The following requirement was deleted:

1. *thermal cracking of concrete shall be addressed*

   This requirement was deleted because concrete is not part of the WPC design.

Deletion of the Hydrogen and Methane Monitoring

Hydrogen and methane monitoring was initiated to establish the extent to which the generation of these gases actually occurs under repository conditions and to determine more realistic accumulation rates for filled panels. It was anticipated that more realistic accumulation rates may lead to panel closure designs that are less complex than the current design. The data obtained were used in development of the WPC. The hydrogen and methane monitoring program is no longer required for the following reasons.

There are three factors that indicate the amount of hydrogen and methane monitoring data collected in Panels 3 and 4 is sufficient. First, the accumulation rates are well below those predicted by Slezak and Lappin (1990).[8] Slezak and Lappin modeled a disposal panel that is filled with drums of waste over a 30-month period. Ventilation barriers are placed at the entries

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[8] Slezak, S. and A. Lappin, 1990, Memo to Darrell Mercer, Craig Fredrickson, DOE/SEIS Office, Potential for and Possible Impacts of Generation of Flammable and/or Detonable Gas Mixtures During the WIPP Transportation, Test, and Operational Phases, Sandia National Laboratories, Albuquerque, NM.

of each room after they are filled. They estimated that the first room filled would have a hydrogen concentration of 0.7 percent and a methane concentration of 3.4 percent using very conservative gas generation rates and the last room filled will have concentrations of 0.1 percent hydrogen and 0.6 percent methane. Data presented in Appendix D *Statistical Analysis to Evaluate Methane and Hydrogen Concentration in Filled Panels at the Waste Isolation Pilot Plant*, Rev. 2, agrees with the prediction that the first room (Room 7) will have the highest concentration. However, the measured levels are approximately a full order of magnitude smaller (see Table 2 in Appendix D) than those predicted by the analysis. These slow accumulation rates indicate that the time period for sufficient gas to reach a flammable mixture is long enough that continued monitoring is not necessary.

Second, Zerwekh (1979)[9] observed that gas generation decreases with time as source material is depleted. The general trend in the data taken at the WIPP facility similarly indicates that accumulation decreases with time (see Figures 16 and 20 in Appendix D), thereby supporting the conclusion that further monitoring is not necessary.

Third, researchers reporting on hydrogen generation rates in waste containers or in disposal rooms agree that in order to have an accumulation that is potentially explosive, the system needs to be sealed. For example, Zerwekh (1979), who undertook laboratory and field experiments at Los Alamos Scientific Laboratory to determine gas generation rates under conditions to simulate twenty years of storage in a waste container, concluded that without an air-tight seal, hydrogen would diffuse out and air would diffuse into drums. Eleven years later, Slezak and Lappin (1990) reviewed gas generation on various scales as it might apply to the WIPP underground repository. They concluded that there was no credible mechanism for the accumulation of flammable and possibly detonable mixtures of gas in a disposal room prior to the emplacement of the "composite panel seal." Their seal, which included a grout component, was assumed to be effective immediately in order to create conditions favorable to the accumulation of detonable quantities of flammable gases. They postulated that the 18-inch gap above the emplaced waste was nominally large enough to propagate an explosion. The proposed WPC does not create an impermeable seal. Calculations discussed in the Design Report show that for as long as there is a pressure differential across the entries, air flow of approximately several tens of cubic feet per minute is sufficient to prevent VOCs from building up. This phenomenon is applicable to hydrogen and methane as well. For those closures that include ROM salt, the closure of the air gap with time eliminates a suitably-sized duct to allow the propagation of an explosion should flammable mixtures accumulate.

Another factor to consider in terminating the hydrogen and methane monitoring program is whether or not the waste disposed in Panels 3 and 4 is representative of waste that will be disposed elsewhere in the facility with regard to the potential for hydrogen and methane gas generation. With regard to future waste streams, the Permittees examined the 2012 Annual Transuranic Waste Inventory Report (**ATWIR**) which was issued in October, 2012.[10] In this version of the ATWIR there are approximately 68,000 cubic meters of WIPP-bound waste streams (ATWIR Table 3-1). This volume excludes emplaced or potential waste streams. The characterization information for most of these inbound waste streams is well known and they are represented by waste in Panels 3 and 4. Based on information in Table 4-1 and

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[9] Zerwekh, A, 1979, Gas Generation from Radiolytic Attack of TRU-Contaminated Hydrogenous Waste, LA-7674-MS, Los Alamos Scientific Laboratory, Los Alamos, NM.

[10] ATWIR Annual Transuranic Waste Inventory Report - 2012 DOE/TRU-12-3425, Effective date 10/12.

Appendices A, B, and C of the ATWIR, there are about 60 waste streams which represents about 9,800 cubic meters of TRU waste, where the characterization information is not well known. The descriptions of these waste streams indicate they are generated by processes that generated waste already shipped to the WIPP facility. Therefore, the Permittees have no reason to anticipate that gas generation rates associated with future waste will be significantly different than those monitored in Panels 3 and 4. The conclusions drawn from the hydrogen and methane monitoring in Panels 3 and 4 are expected to hold for future waste streams.

The Permittees are proposing that the hydrogen and methane monitoring program is no longer required for the following reasons:

- Sufficient data have been obtained to develop the design of the WPC.

- Sufficient data have been obtained to demonstrate that explosive levels of hydrogen and methane will not accumulate in either Panel 3 or 4 fast enough to pose a threat (see Appendix D to this PMR). In addition, review of available data on waste inventory indicates that the gas generation rates will not be significantly different in the future (i.e., the waste expected to be received is similar to waste currently disposed at the WIPP facility).

- Continued monitoring is not feasible in panels after installation of the WPC.

Revision to Remove Ongoing Disposal Room VOC Monitoring

Ongoing disposal room VOC monitoring is required by the Permit to protect underground workers from an acute exposure to VOCs for HWDUs that do not contain an explosion-isolation wall and are scheduled to remain unclosed for an extended period of time awaiting approval of a final closure design. Panel closure requires the termination of monitoring lines and the cessation of monitoring. Therefore, ongoing disposal room VOC monitoring is proposed for deletion since it will no longer be needed as panel closures are installed and closure performance standards are applied.

Corrections to Permit Text Regarding Panel Closure

Corrections are necessary to ensure consistency between the Permit text and the proposed panel closure design in Permit Attachments G and G1. These apply to figures of the underground that identify closures and to radiation-related requirements that are not governed under RCRA. Radiological contamination is addressed by references to free release limits and radiological clean-up criteria, references to radiological decontamination and decommissioning, and references to the "Start Clean, Stay Clean" operating philosophy. "Fixing" radiological contamination is added as an option to decontamination in some contaminated areas where it is determined to be the best alternative for protecting workers from radiological contamination. In addition, reference to the obsolete Final Safety Analysis Report is proposed for deletion. The Permittees are also removing reference to the Material Act of 1947 and the disposition of stockpiled mined salt since these are not RCRA closure concerns. These and other editorial changes are explained in the attached Table of Changes (Appendix A) for each respective change.

4. 20.4.1.900 NMAC (incorporating 40 CFR §270.42(c)(1)(iv)), requires the applicant to provide the applicable information required by 40 CFR §§270.13 through 270.22, 270.62, 270.63, and 270.66.

The regulatory crosswalk describes those portions of the WIPP Permit that are affected by this PMR. Where applicable, regulatory citations in this modification reference Title 20, Chapter 4, Part 1, NMAC, revised March, 2009, incorporating the CFR, Title 40 (40 CFR Parts 264 and 270). 40 CFR §§270.16 through 270.22, 270.62, 270.63 and 270.66 are not applicable at WIPP and they are not listed in the regulatory crosswalk table. 40 CFR §270.23 is applicable to the WIPP HWDUs.

5. 20.4.1.900 NMAC (incorporating 40 CFR §270.11(d)(1) and 40 CFR §270.30(k)), requires any person signing under paragraph a and b must certify the document in accordance with 20.4.1.900 NMAC.

The transmittal letter for this PMR contains the signed certification statement in accordance with Permit Condition 1.9 of the WIPP Permit.

Regulatory Crosswalk

Regulatory Citation(s) 20.4.1.900 NMAC (incorporating 40 CFR Part 270)	Regulatory Citation(s) 20.4.1.500 NMAC (incorporating 40 CFR Part 264)	Description of Requirement	Added or Clarified Information		
			Section of the WIPP Permit Application	Yes	No
§270.13		Contents of Part A permit application	Attachment B Part A	✓	
§270.14(b)(1)		General facility description	Attachment A		✓
§270.14(b)(2)	§264.13(a)	Chemical and physical analyses	Part 2.3.1 Attachment C		✓
§270.14(b)(3)	§264.13(b)	Development and implementation of waste analysis plan	Part 2.3.1.1 Attachment C		✓
	§264.13(c)	Off-site waste analysis requirements	Part 2.2.1 Attachment C		✓
§270.14(b)(5)	§264.15(a-d)	General inspection requirements	Part 2.7 Attachment E-1a	✓	
	§264.174	Container inspections	Attachment E-1b(1)		✓
§270.23(a)(2)	§264.602	Miscellaneous units inspections	Attachment E-1b Attachment E-1b(1)	✓	
§270.14(b)(6)		Request for waiver from preparedness and prevention requirements of Part 264 Subpart C	NA		✓
§270.14(b)(7)	264 Subpart D	Contingency plan requirements	Part 2.12 Attachment D		✓
	§264.51	Contingency plan design and implementation	Part 2.12.1 Attachment D		✓
	§264.52 (a) & (c-f)	Contingency plan content	Attachment D		✓
	§264.53	Contingency plan copies	Part 2.12.2 Attachment D		✓
	§264.54	Contingency plan amendment	Part 2.12.3 Attachment D		✓
	§264.55	Emergency coordinator	Part 2.12.4 Attachment D-4a(1)		✓
	§264.56	Emergency procedures	Attachment D-4		✓
§270.14(b)(8)		Description of procedures, structures or equipment for:	Attachment A Part 2.11		✓
§270.14(b)(8)(i)		Prevention of hazards in unloading operations (e.g., ramps and special forklifts)	Part 2.11		✓
§270.14(b)(8)(ii)		Runoff or flood prevention (e.g., berms, trenches, and dikes)	Attachment A1-1c(1) Part 2.11		✓
§270.14(b)(8)(iii)		Prevention of contamination of water supplies	Part 2.11		✓
§270.14(b)(8)(iv)		Mitigation of effects of equipment failure and power outages	Part 2.11		✓
§270.14(b)(8)(v)		Prevention of undue exposure of personnel (e.g., personal protective equipment)	Part 2.11		✓
§270.14(b)(8)(vi) §270.23(a)(2)	§264.601	Prevention of releases to the atmosphere	Part 2.11 Part 4.4 Attachment D-4e Attachment G-1a		✓
	264 Subpart C	Preparedness and Prevention	Part 2.10		✓
	§264.31	Design and operation of facility	Part 2.1		✓

Regulatory Citation(s) 20.4.1.900 NMAC (incorporating 40 CFR Part 270)	Regulatory Citation(s) 20.4.1.500 NMAC (incorporating 40 CFR Part 264)	Description of Requirement	Added or Clarified Information		
			Section of the WIPP Permit Application	Yes	No
	§264.32	Required equipment	Part 2.10.1 Attachment D		✓
	§264.33	Testing and maintenance of equipment	Part 2.10.2 Attachment E-1a		✓
	§264.34	Access to communication/alarm system	Attachment E-1a Part 2.10.3		✓
	§264.35	Required aisle space	Part 2.10.4		✓
	§264.37	Arrangements with local authorities	Attachment D-4a(3)		✓
§270.14(b)(9)	§264.17(a-c)	Prevention of accidental ignition or reaction of ignitable, reactive, or incompatible wastes	Part 2.9		✓
§270.14(b)(10)		Traffic pattern, volume, and controls, for example: Identification of turn lanes Identification of traffic/stacking lanes, if appropriate Description of access road surface Description of access road load-bearing capacity Identification of traffic controls	Attachment A4		✓
§270.14(b) (11)(i) and (ii)	§264.18(a)	Seismic standard applicability and requirements	Attachment G2-2.2 Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.14(b)(11)(iii-v)	§264.18(b)	100-year floodplain standard	Attachment A1-1c(1) Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.14(b)(12)	§264.16(a-e)	Personnel training program	Part 2.8 Attachment F		✓
§270.14(b)(13)	264 Subpart G	Closure and post-closure plans	Part 6 & 7 Attachment G & H	✓	
§270.14(b)(13)	§264.111	Closure performance standard	Attachment G-1a	✓	
§270.14(b)(13)	§264.112(a), (b)	Written content of closure plan	Attachment G-1	✓	
§270.14(b)(13)	§264.112(c)	Amendment of closure plan	Part 6.3 Attachment G-1d(4)		✓
§270.14(b)(13)	§264.112(d)	Notification of partial and final closure	Attachment G-2a		✓
§270.14(b)(13)	§264.112(e)	Removal of wastes and decontamination/dismantling of equipment	Attachment G-1e(2)	✓	
§270.14(b)(13)	§264.113	Time allowed for closure	Part 6.5 Attachment G-1d		✓
§270.14(b)(13)	§264.114	Disposal/decontamination	Part 6.6 Attachment G-1e(2)	✓	
§270.14(b)(13)	§264.115	Certification of closure	Part 6.7 Attachment G-2a		✓
§270.14(b)(13)	§264.116	Survey plat	Part 6.8 Attachment G-2b		✓

Regulatory Citation(s) 20.4.1.900 NMAC (incorporating 40 CFR Part 270)	Regulatory Citation(s) 20.4.1.500 NMAC (incorporating 40 CFR Part 264)	Description of Requirement	Added or Clarified Information		
			Section of the WIPP Permit Application	Yes	No
§270.14(b)(13)	§264.117	Post-closure care and use of property	Part 7.3 Attachment H-1a		✓
§270.14(b)(13)	§264.118	Post-closure plan; amendment of plan	Part 7.5 Attachment H-1a (1)		✓
§270.14(b)(13)	§264.178	Closure/containers	Part 6.9 Attachment A1-1h Attachment G-1		✓
§270.14(b)(13)	§264.601	Environmental performance standards-miscellaneous units	Part 6, Section 6.10.1 Attachment A-4 Attachment D-1 Attachment G-1a	✓	
§270.14(b)(13)	§264.603	Post-closure care	Part 7.3 Attachment G-1a(3)		✓
§270.14(b)(14)	§264.119	Post-closure notices	Part 7.4 Attachment H-2		✓
§270.14(b)(15)	§264.142	Closure cost estimate	NA		✓
	§264.143	Financial assurance	NA		✓
§270.14(b)(16)	§264.144	Post-closure cost estimate	NA		✓
	§264.145	Post-closure care financial assurance	NA		✓
§270.14(b)(17)	§264.147	Liability insurance	NA		✓
§270.14(b)(18)	§264.149-150	Proof of financial coverage	NA		✓
§270.14(b)(19)(i), (vi), (vii), and (x)		Topographic map requirements Map scale and date Map orientation Legal boundaries Buildings Treatment, storage, and disposal operations Run-on/run-off control systems Fire control facilities	Attachment B2 Part A Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.14(b)(19)(ii)	§264.18(b)	100-year floodplain	Attachment B2 Part A Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.14(b)(19)(iii)		Surface waters	Attachment B2 Part A Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.14(b)(19)(iv)		Surrounding land use	Attachment B2 Part A Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓

Regulatory Citation(s) 20.4.1.900 NMAC (incorporating 40 CFR Part 270)	Regulatory Citation(s) 20.4.1.500 NMAC (incorporating 40 CFR Part 264)	Description of Requirement	Added or Clarified Information		
			Section of the WIPP Permit Application	Yes	No
§270.14(b)(19)(v)		Wind rose	Attachment B2 Part A Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.14(b)(19)(viii)	§264.14(b)	Access controls	Attachment B2 Part A Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.14(b)(19)(ix)		Injection and withdrawal wells	Attachment B2 Part A Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.14(b)(19)(xi)		Drainage on flood control barriers	Attachment B2 Part A Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.14(b)(19)(xii)		Location of operational units	Attachment B2 Part A Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.14(b)(20)		Other federal laws Wild and Scenic Rivers Act National Historic Preservation Act Endangered Species Act Coastal Zone Management Act Fish and Wildlife Coordination Act Executive Orders	Attachment B Renewal App. Sep. 2009, 270.14 Contents of Part B: General Requirements		✓
§270.15	§264 Subpart I	Containers	Part 3 Part 4.3 Attachment A1		✓
	§264.171	Condition of containers	Part 3.3 Attachment A1		✓
	§264.172	Compatibility of waste with containers	Part 3.4 Attachment A1		✓
	§264.173	Management of containers	Part 3.5 Attachment A1		✓
	§264.174	Inspections	Part 3.7 Attachment E-1 Attachment A1-1e		✓

Regulatory Citation(s) 20.4.1.900 NMAC (incorporating 40 CFR Part 270)	Regulatory Citation(s) 20.4.1.500 NMAC (incorporating 40 CFR Part 264)	Description of Requirement	Added or Clarified Information		
			Section of the WIPP Permit Application	Yes	No
§270.15(a)	§264.175	Containment systems	Part 3.6 Attachment A1		✓
§270.15(c)	§264.176	Special requirements for ignitable or reactive waste	Attachment A1-1g Permit Part 2.1		✓
§270.15(d)	§264.177	Special requirements for incompatible wastes	Attachment A1-1g Permit Part 2.3.3.4		✓
	§264.178	Closure	Part 6 Attachment G	✓	
§270.15(e)	§264.179	Air emission standards	Part 4.4.2 Attachment N		✓
§270.23	264 Subpart X	Miscellaneous units	Part 1.3.1 Attachment A2-1 Attachment G1.3.1	✓	
§270.23(a)	§264.601	Detailed unit description	Part 4 Part 5 Attachment A2 Attachment L	✓	
§270.23(b)	§264.601	Hydrologic, geologic, and meteorologic assessments	Part 4 Part 5 Attachment A2 Attachment L		✓
§270.23(c)	§264.601	Potential exposure pathways	Part 4 Part 5 Attachment A2 Attachment N Attachment L		✓
§270.23(d)		Demonstration of treatment effectiveness	Part 4 Attachment A2 Attachment N		✓
	§264.602	Monitoring, analysis, inspection, response, reporting, and corrective action	Part 4 Part 5 Attachment A2 Attachment E-1 Attachment N Attachment L	✓	
	§264.603	Post-closure care	Attachment H Attachment H1	✓	
	264 Subpart E	Manifest system, record keeping, and reporting	Permit Part 1 Permit Part 2.13 & 2.14 Permit Part 4 Attachment C		✓
§270.30(j)(2)	§264.73(b)	Ground-water records	Part 1		✓
	264 Subpart F	Releases from solid waste management units	Part 5 & 7 Attachment G2 & L		✓
	§264.90	Applicability	Part 5 Attachment L		✓
	§264.91	Required programs	Attachment L		✓
	§264.92	Ground-water protection standard	Attachment L		✓
	§264.93	Hazardous constituents	Attachment L		✓

Regulatory Citation(s) 20.4.1.900 NMAC (incorporating 40 CFR Part 270)	Regulatory Citation(s) 20.4.1.500 NMAC (incorporating 40 CFR Part 264)	Description of Requirement	Added or Clarified Information		
			Section of the WIPP Permit Application	Yes	No
	§264.94	Concentration limits	Part 5 Attachment L		✓
	§264.95	Point of compliance	Part 5 Attachment L		✓
	§264.96	Compliance period	Attachment L		✓
	§264.97	General ground-water monitoring requirements	Part 5 Attachment L		✓
	§264.98	Detection monitoring program	Part 5 Attachment L		✓
	§264.99	Compliance monitoring program	Part 5 Attachment L		✓
	§264.100	Corrective action program	Part 5 Attachment L		✓
	§264.101	Corrective action for solid waste management units	Part 8 Attachment L		✓
	264 Appendix IX	Ground-water Monitoring List	Part 5 Attachment L		✓

Appendix A
Table of Changes

Table of Changes

Affected Permit Section	Explanation of Change
Part 1, Section 1.5.15	Revise the definition of Explosion-isolation Wall (Section 1.5.15) to apply to existing walls only.
Part 1, Permit Attachments	Editorial change in reference to Permit Attachment G1 to add title "WIPP Panel Closure Design Description and Specifications" and to delete the associated parenthetical information that no longer applies.
Part 4, Section 4.4.3	Deleted section in its entirety to remove ongoing disposal room VOC monitoring.
Part 4, Section 4.5.1	Update title of Attachment A3.
Part 4, Section 4.6.1.2	Change to delete text associated with certification of the stability of any explosion-isolation walls because explosion-isolation walls will no longer be accessible for inspection.
Part 4, Section 4.6.5	Deleted section in its entirety as it pertains solely to hydrogen and methane monitoring which is being deleted as part of this PMR.
Part 4, Permit Attachments	Editorial change in reference to Permit Attachment G1 to add title "WIPP Panel Closure Design Description and Specifications" and to delete the associated parenthetical information that no longer applies. Deleted reference to Permit Attachment N1 that is being deleted in its entirety as part of this PMR.
Part 6, Section 6.10.1	Added the closure performance standard as WIPP *Site Panel Closure Volatile Organic Compound Closure Standard for Public Exposure* as Table 6.10.1.
Part 6, Permit Attachments	Editorial changes in references to Permit Attachment G to add title "Closure Plan" and Permit Attachment G1 to add title "WIPP Panel Closure Design Description and Specifications" and to delete the associated parenthetical information that no longer applies to both attachments.
Attachment A2, Figures	Replaced Figure A1-1 with new figure for the Repository Horizon.
Attachment A3, Drawing Number 51-W-214-W	Updated attachment title. Replaced Drawing Number 51-W-214-W with new figure and updated figure caption.
Attachment B, Appendix B3	Replaced Figure B3-2 with new figure for the Repository Horizon.
Attachment D, Figures	Replaced Figure D-3 with new figure of the WIPP Underground Facilities. Replaced Figure D-7 with new figure of the Designated Underground Assembly Areas.
Attachment E, Table E-1	Remove the requirement to inspect explosion-isolation walls since these are no longer part of the closure and will be inaccessible after the WPC-A is constructed in Panels 1, 2, and 5. Change the bulkhead title to Closure Bulkheads and set the frequency to semi-annually based on the longevity evaluation in the Design Report.
Attachment G, Introduction	Deleted text to mitigate the impacts of methane buildup and deflagration that may be postulated for some closed panels since a postulated methane explosion is being deleted as part of this PMR. Added text to include Panels 9 and 10. Removed reference to submittal of plan to the U.S. Environmental Protection Agency (EPA) because the statement is not required.
Attachment G, Section G-1	Changes are proposed to remove unnecessary detail regarding future activities associated with final facility closure, to assure consistency with panel closure changes, and make editorial correction.

Affected Permit Section	Explanation of Change
Attachment G, Section G-1a(1)	Replaced "free release limits[2]" with "DOE-established radiological protection limits" in first paragraph and deleted last sentence of first paragraph. Deleted footnote "2"
Attachment G, Section G-1a(2)	Deleted text "and to withstand any flammable gas deflagration that may occur prior to final facility closure" since a flammable gas deflagration is being deleted as part of this PMR. Deleted (i.e., decontaminated and decommissioned)" in fourth paragraph.
Attachment G, Section G-1c	Change clarifies the status of Panels 9 and 10 with regard to authorization for waste disposal.
Attachment G, Section G-1d(1)	Change to delete redundant text with respect to initially blocking ventilation and panel specific closure schedule that is specified previously in Section G-1d(1) and in Table G-1. Change to add text to clarify that the Permittees initially block ventilation through the panel in compliance with Section A2-2a(3) of Permit Attachment A2. Change to delete text associated with installation of explosion-isolation walls since explosion-isolation walls are not required to be constructed as a component of the panel closure design.
Attachment G, Section G-1d(2)	Change to delete reference to obsolete document and to clarify text.
Attachment G, Section G-1d(3)	Changes are editorial to clarify text.
Attachment G, Section G-1e	Editorial change to add the word "respectively" to clarify that Permit Attachment G1 pertains to the WPC and Permit Attachment G2 pertains to the shaft seal designs.
Attachment G, Section G-1e(1)	Modified some WPC design requirements for clarity and applicability. Editorial change to delete the reference to Permit Attachment A2 because Permit Attachment A2 does not pertain to the closure performance standard for air emissions from the WIPP facility. Change to add the ability to simultaneously close panels by placing the closures in the mains. Deleted text pertaining to explosion-isolation wall and design Option D since design Option D is no longer part of the panel closure design and explosion-isolation walls are not required to be constructed as a component of the panel closure design. Change to identify date of source term that was used as the design basis for the WPC. Change to revise text pertaining to release of VOCs by diffusion through container vents. Change to delete text pertaining to discussion on proposed panel closure design options and reference to design Option D since this discussion is no longer applicable for the final panel closure design.
Attachment G, Section G-1e(2)	Added new section to address prerequisite activities for Panel 6 Final Closure
Attachment G, Section G-1e(2)	Renumbered section to G-1e(3). Change to reword text for Item 6 to clarify that the item refers to emplacement in the last HWDU to be filled and not the final panel closure design itself. Also made changes to clarify references to radiological-specific practices and to make editorial corrections or clarifications.
Attachment G, Section G-1e(2)(a)	Renumbered section to G-1e(3)(a). Changes clarify references to radiological-specific practices and to make editorial corrections or clarifications.
Attachment G, Section G-1e(2)(b)	Renumbered section to G-1e(3)(b). Changes clarify references to radiological-specific practices and to make editorial corrections or clarifications.

Affected Permit Section	Explanation of Change
Attachment G, Section G-1e(2)(c)	Renumbered section to G-1e(3)(c). Changes clarify references to radiological-specific practices and to make editorial corrections or clarifications.
Attachment G, Section G-1e(2)(d)	Renumbered section to G-1e(3)(d).
Attachment G, Section G-1e(2)(e)	Renumbered section to G-1e(3)(e). Changes are to make editorial corrections or clarifications.
Attachment G, Section G-1e(2)(f)	Renumbered section to G-1e(3)(f).
Attachment G, Section G-1e(2)(g)	Renumbered section to G-1e(3)(g). Changes are to make editorial corrections or clarifications.
Attachment G, Section G-1e(3)	Renumbered section to G-1e(4). Changes are to make editorial corrections or clarifications.
Attachment G, References	Updated references. Deleted reference for DOE 1997 and added reference for DOE 2015.
Attachment G, Table G-1	Table G-1 was updated to reflect current actual and anticipated dates. Clarified text for NOTE 1.
Attachment G, Figures	Replaced Figure G-1 with a new figure for the location of underground HWDUs and anticipated WPC Locations. Replaced Figure G-2 with a new figure for the WIPP panel closure schedule. Replaced Figure G-3 with a new figure for the WIPP facility final closure 84-month schedule. Replaced Figure G-4 with a new figure for the design of a panel closure system. Replaced Figure G-5 with a new figure for the typical design panel. Replaced Figure G-6 with a new figure for the approximate locations of boreholes in relation to the WIPP underground.
Attachment G1	Replaced the contents of this attachment with the text (without appendices) of the new WPC Design Report.
Attachment G1, Appendix G1-A	Create a new Attachment G1, Appendix G1-A, with the technical specifications for the WPC as presented in Attachment G1.
Attachment G1, Appendix G1-B	Create a new Attachment G1, Appendix G1-B, with the design drawings for the WPC as presented Attachment G1.
Attachment G1, Appendix G	Deleted the appendix in its entirety. New panel closure technical specifications were incorporated into the new Attachment G1, Appendix G1-A, that is being proposed for addition as part of this PMR.
Attachment G1, Appendix H	Deleted the appendix in its entirety. New panel closure design drawings were incorporated into the new Attachment G1, Appendix G1-B, that is being proposed for addition as part of this PMR.
Attachment H, Section H-1	Change to add text to clarify that panel closures are designed to require no post-closure maintenance of the disposal unit rather than the closure system. Editorial change to add the word “Repository” to the reference to the VOC Monitoring Program to clearly identify that it is the Repository VOC Monitoring Program, and not the Disposal Room VOC Monitoring Program, that is an aspect of the post-closure care program for closed panels.
Attachment N, Table of Contents	Change made to the Table of Contents to delete entry for Section N-3a(3).
Attachment N, Section N-3a(3)	Deleted section in its entirety to remove ongoing disposal room VOC monitoring.

Affected Permit Section	Explanation of Change
Attachment N1	Deleted this attachment in its entirety as it pertains solely to hydrogen and methane monitoring which is being deleted as part of this PMR.

Appendix B
Proposed Revised Permit Text

Proposed Revised Permit Text:

PART 1 - GENERAL PERMIT CONDITIONS

1.5.15 Explosion-Isolation Wall

"Explosion-isolation wall" means the 12-foot wall intended as an explosion isolation device that has been constructed to initially close Panels 1, 2, and 5 subsequent to the completion of waste emplacement ~~is part of the approved panel-closure system specified in Permit Attachment G1 (Detailed Design Report for an Operation Phase Panel Closure System)~~.

PERMIT ATTACHMENTS

Permit Attachment G1, "WIPP Panel Closure Design Description and Specifications." ~~(as modified from WIPP Hazardous Waste Facility Permit Amended Renewal Application, "Detailed Design Report for an Operation Phase Panel Closure System" – Appendix I1)~~

PART 4 - GEOLOGIC REPOSITORY DISPOSAL

4.4.3 Ongoing Disposal Room VOC Monitoring in Panels 3 Through 8

The Permittees shall continue disposal room VOC monitoring in Room 1 of Panels 3 through 8 after completion of waste emplacement until final panel closure unless the explosion-isolation wall specified in Permit Attachment G1 (Detailed Design Report for an Operation Phase Panel Closure System) is installed in the panel.

4.5.1. Repository Design

The Permittees shall construct each Underground HWDU in conformance with the requirements specified in Permit Attachment A2 and Permit Attachment A3 (Drawing Number 51-W-214-W, "Underground Facilities Typical Disposal Panel").

4.6.1.2 Reporting Requirements

The Permittees shall submit to the Secretary an annual report in October evaluating the geomechanical monitoring program and shall include geomechanical data collected from each Underground HWDU during the previous year, as specified in Permit Attachment A2, Section A2-5b(2), "Geomechanical Monitoring", and shall also include a map showing the current status of HWDU mining. The Permittees shall also submit at that time an annual certification by a registered professional engineer certifying the stability of any explosion-isolation walls. The Permittees shall post a link to the geomechanical monitoring report transmittal letter on the WIPP Home Page and inform those on the e-mail notification list as specified in Permit Section 1.11.

4.6.5 Hydrogen and Methane Monitoring

4.6.5.1. Implementation of Hydrogen and Methane Monitoring

The Permittees shall implement the Hydrogen and Methane Monitoring Plan specified in Permit Attachment N1 (Hydrogen and Methane Monitoring Plan).

4.6.5.2. Reporting Requirements

The Permittees shall report to the Secretary semi-annually in April and October the data and analysis of the Hydrogen and Methane Monitoring Plan.

4.6.5.3. Notification Requirements

The Permittees shall notify the Secretary in writing, within seven calendar days of obtaining validated analytical results, whenever the concentration of hydrogen or methane in a filled panel exceeds the action levels specified in Table 4.6.5.3 below.

The Permittees shall post a link to the notification letter on the WIPP Home Page and inform those on the e-mail notification list as specified in Permit Section 1.11.

Table 4.6.5.3 - Action Levels for Hydrogen and Methane Monitoring		
Compound	**Action Level 1**	**Action Level 2**
Hydrogen	4,000 ppm	8,000 ppm
Methane	5,000 ppm	10,000 ppm

4.6.5.4. Remedial Action

Upon receiving validated analytical results that indicate at least one compound exceeded "Action Level 1" in Table 4.6.5.3, the sampling frequency in that filled panel will increase to once per week. Upon receiving validated analytical results that indicate at least one compound exceeded "Action Level 2" in Table 4.6.5.3 in two consecutive weekly samples, the Permittees shall install in that panel the explosion-isolation wall specified in Permit Attachment G1.

4.6.5.5. Sampling Line Loss

The Permittees shall notify the Secretary in writing within seven calendar days of the discovery of loss of sampling line(s). The Permittees shall evaluate any loss of sampling lines as described in Permit Attachment N1, Section N1-5b, "Sample Tubing", and shall notify the Secretary in writing within seven calendar days the results of such evaluation. The Permittees shall also post a link to such notification letters on the WIPP Home Page and inform those on the e-mail notification list as specified in Permit Section 1.11

PERMIT ATTACHMENTS

Permit Attachment G1, "WIPP Panel Closure Design Description and Specifications." (as modified from WIPP Hazardous Waste Facility Permit Amended Renewal Application, "Detailed Design Report for an Operation Phase Panel Closure System" – Appendix I1).

Permit Attachment N1 (as modified from WIPP Hazardous Waste Facility Permit Amended Renewal Application, "Hydrogen and Methane Monitoring Plan" - Appendix N1)

PART 6 – CLOSURE REQUIREMENTS

6.10.1 Panel Closure

The Permittees shall close each Underground HWDU in a manner that meets the closure standard for volatile organic compounds in Table 6.10.1, which represent health based levels (**HBLs**) at the location of the nearest permanent downwind resident. Upon completion of disposal in an Underground HWDU, the Permittees shall provide written notification to the Secretary stating the final volume of TRU mixed waste emplaced in the Underground HWDU. The Permittees shall also close the Underground HWDU as specified in Permit Attachment G and Permit Attachment G1 (*WIPP Panel Closure Design Description and Specifications*~~Detailed Design Report for an Operation Phase Panel Closure System~~). The Permittees shall post a link to the final panel volume notice transmittal letter on the WIPP Home Page and inform those on the e-mail notification list as specified in Permit Section 1.11.

Table 6.10.1. WIPP Panel Closure Volatile Organic Compound Closure Standard for Public Exposures

Volatile Organic Compound	**WIPP HBL µg/m^3**
Carbon Tetrachloride	0.33
Toluene	5,000
Trichloroethylene	0.39
Chloroform	0.087
Methylene Chloride	101
1,1,1-Trichloroethane	5,000
1,1,2,2-Tetrachloroethane	0.035
1,2-Dichloroethane	0.077
1,1-Dichloroethylene	200
Chlorobenzene	50.0

PERMIT ATTACHMENTS

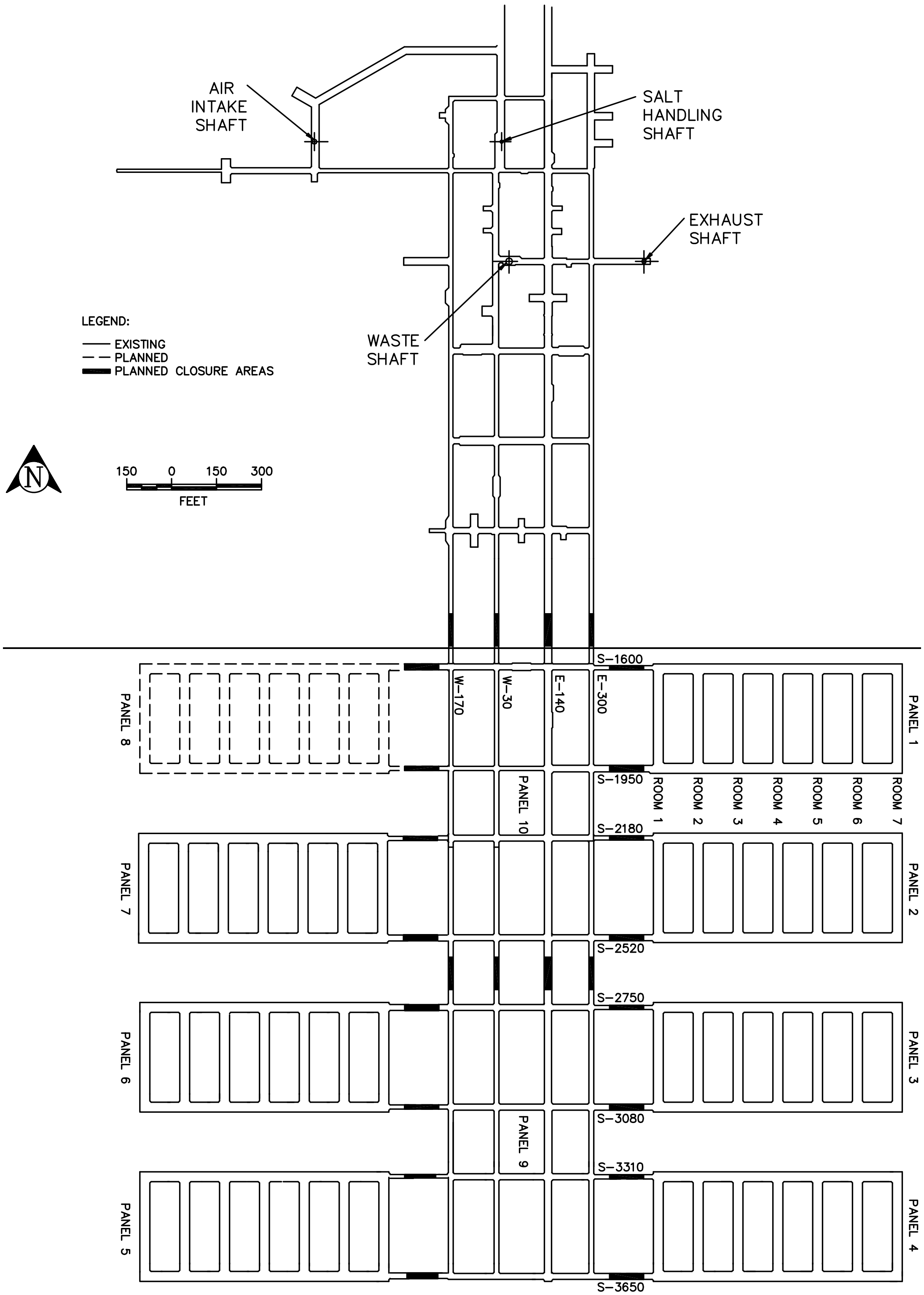
Permit Attachment G, "Closure Plan." ~~(as modified from WIPP RCRA Part B Permit Application, "Closure Plans, Post-Closure Plans, and Financial Requirements" - Chapter I)~~.

Permit Attachment G1, "WIPP Panel Closure Design Description and Specifications.~~Detailed Design Report for an Operational Phase Panel Closure System~~" ~~(as modified from WIPP RCRA Part B Permit Application, "Detailed Design Report for an Operation Phase Panel Closure System" - Appendix I1).~~

ATTACHMENT A2

GEOLOGIC REPOSITORY

FIGURES


AIR
INTAKE
SHAFT
SALT
HANDLING
SHAFT
EXHAUST
SHAFT
WASTE
SHAFT
LEGEND:
EXISTING
PLANNED
PLANNED CLOSURE AREAS
150 0 150 300
FEET
N
S-1600
S-1950
S-2180
S-2520
S-2750
S-3080
S-3310
S-3650
W-170
W-30
E-140
E-300
PANEL 1
PANEL 2
PANEL 3
PANEL 4
PANEL 5
PANEL 6
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PANEL 9
PANEL 10
ROOM 1
ROOM 2
ROOM 3
ROOM 4
ROOM 5
ROOM 6
ROOM 7

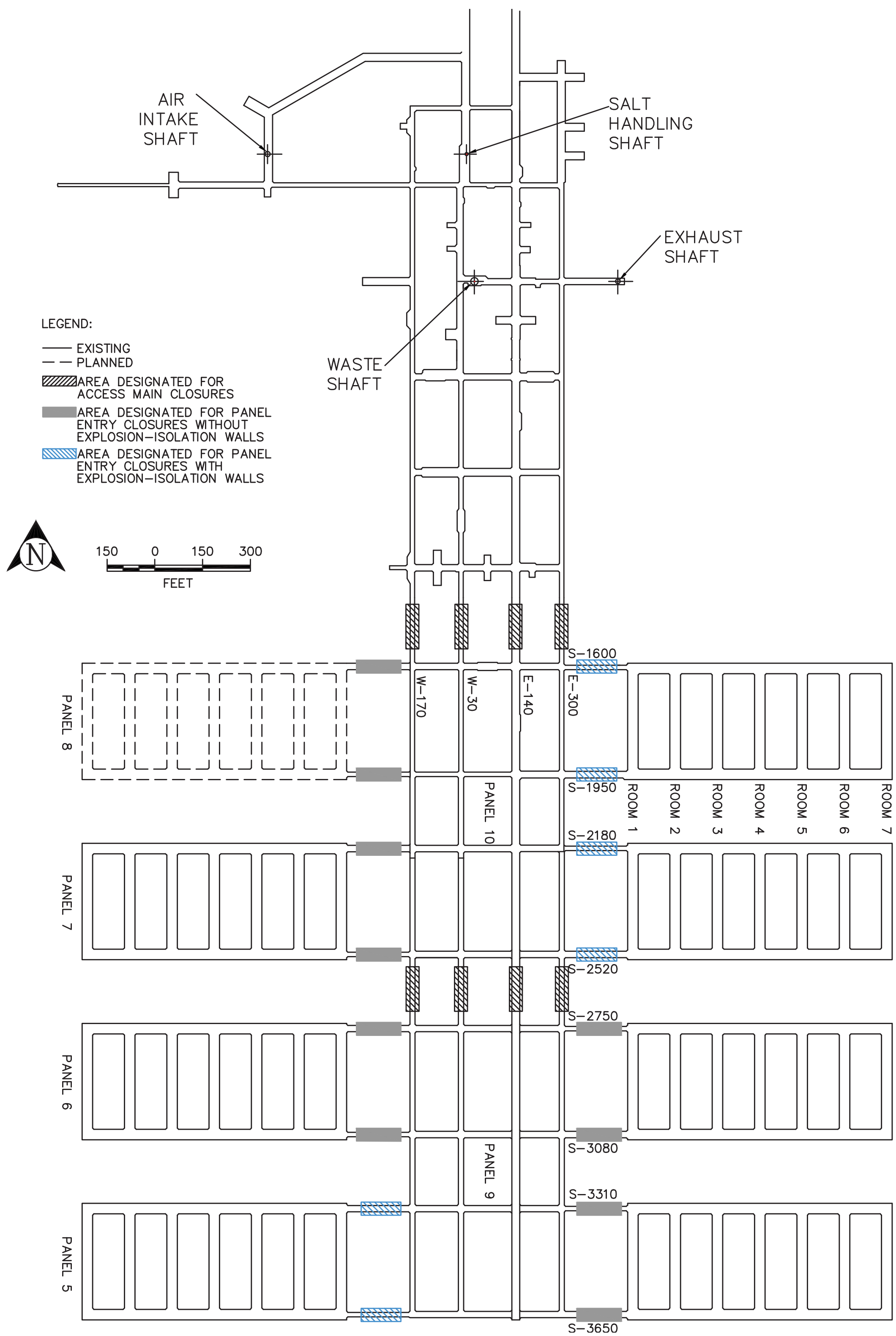
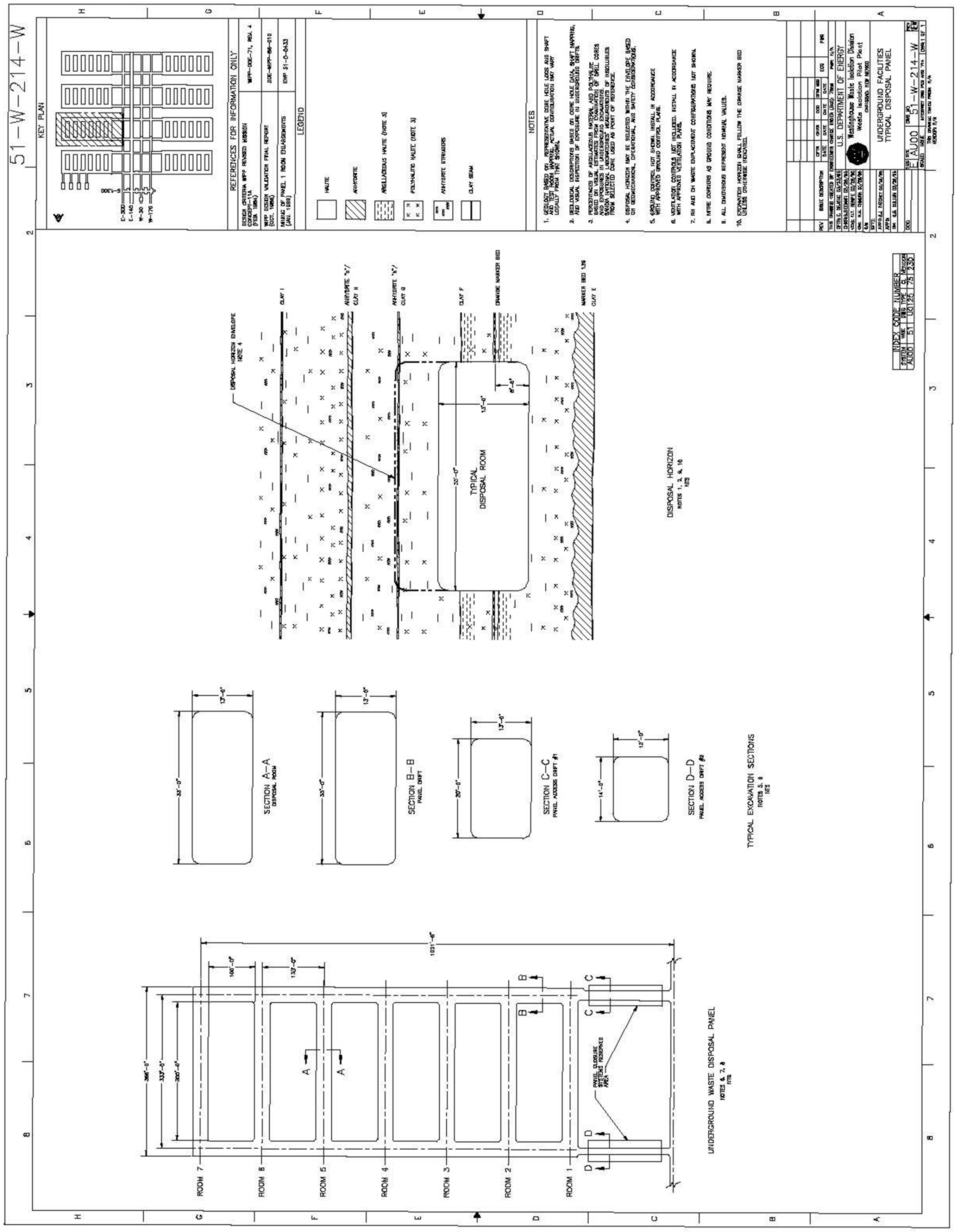
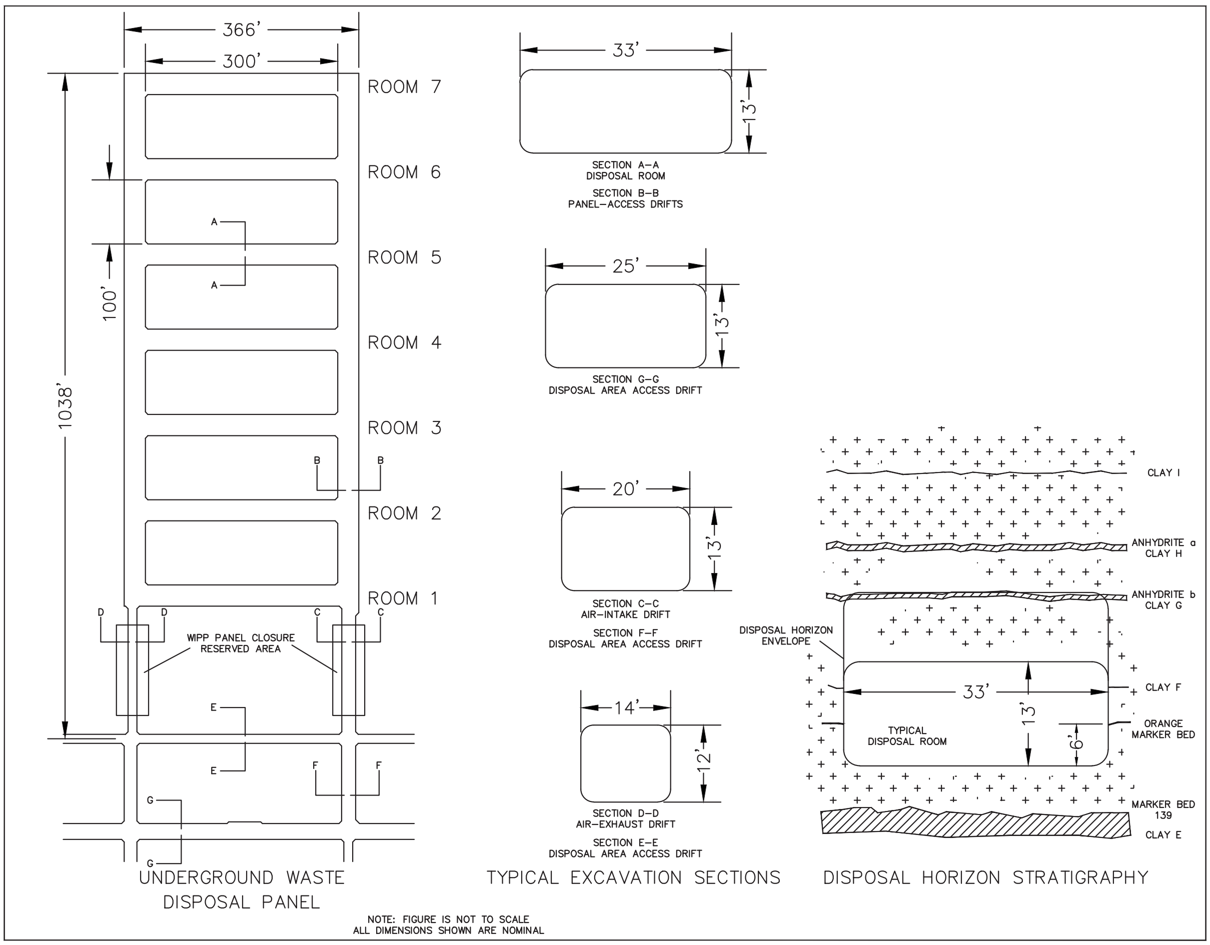


Figure A2-1
Repository Horizon

ATTACHMENT A3

~~DRAWING NUMBER 51-W-214-W~~
~~UNDERGROUND FACILITIES~~ TYPICAL DISPOSAL PANEL


51-W-214-W
KEY PLAN
REFERENCES FOR INFORMATION ONLY
LEGEND
NOTES
TYPICAL DISPOSAL ROOM
DISPOSAL HORIZON
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
TYPICAL EXCAVATION SECTIONS
UNDERGROUND WASTE DISPOSAL PANEL
ROOM 7
ROOM 6
ROOM 5
ROOM 4
ROOM 3
ROOM 2
ROOM 1
U.S. DEPARTMENT OF ENERGY
UNDERGROUND FACILITIES
TYPICAL DISPOSAL PANEL

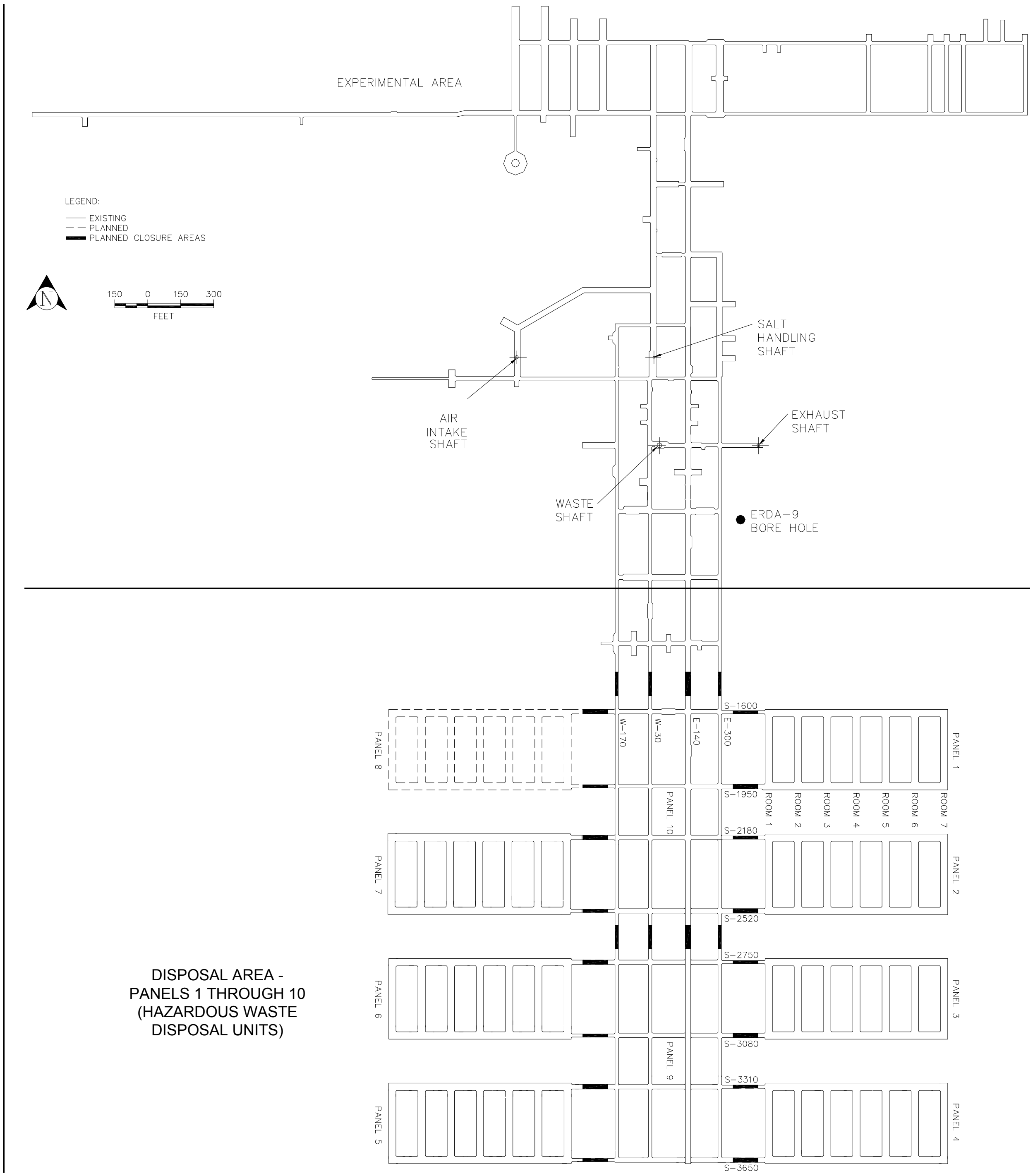


~~Drawing 51-W-214-W Underground Facilities~~ Typical Disposal Panel

ATTACHMENT B

HAZARDOUS WASTE PERMIT APPLICATION PART A

APPENDIX B3
FACILITIES



EXPERIMENTAL AREA
LEGEND:
EXISTING
PLANNED
PLANNED CLOSURE AREAS
N
150 0 150 300
FEET
SALT HANDLING SHAFT
AIR INTAKE SHAFT
EXHAUST SHAFT
WASTE SHAFT
ERDA-9 BORE HOLE
S-1600
W-170
W-30
E-140
E-300
PANEL 8
PANEL 1
S-1950
ROOM 1
ROOM 2
ROOM 3
ROOM 4
ROOM 5
ROOM 6
ROOM 7
PANEL 10
S-2180
PANEL 7
PANEL 2
S-2520
S-2750
DISPOSAL AREA - PANELS 1 THROUGH 10 (HAZARDOUS WASTE DISPOSAL UNITS)
PANEL 6
PANEL 3
S-3080
PANEL 9
S-3310
PANEL 5
PANEL 4
S-3650

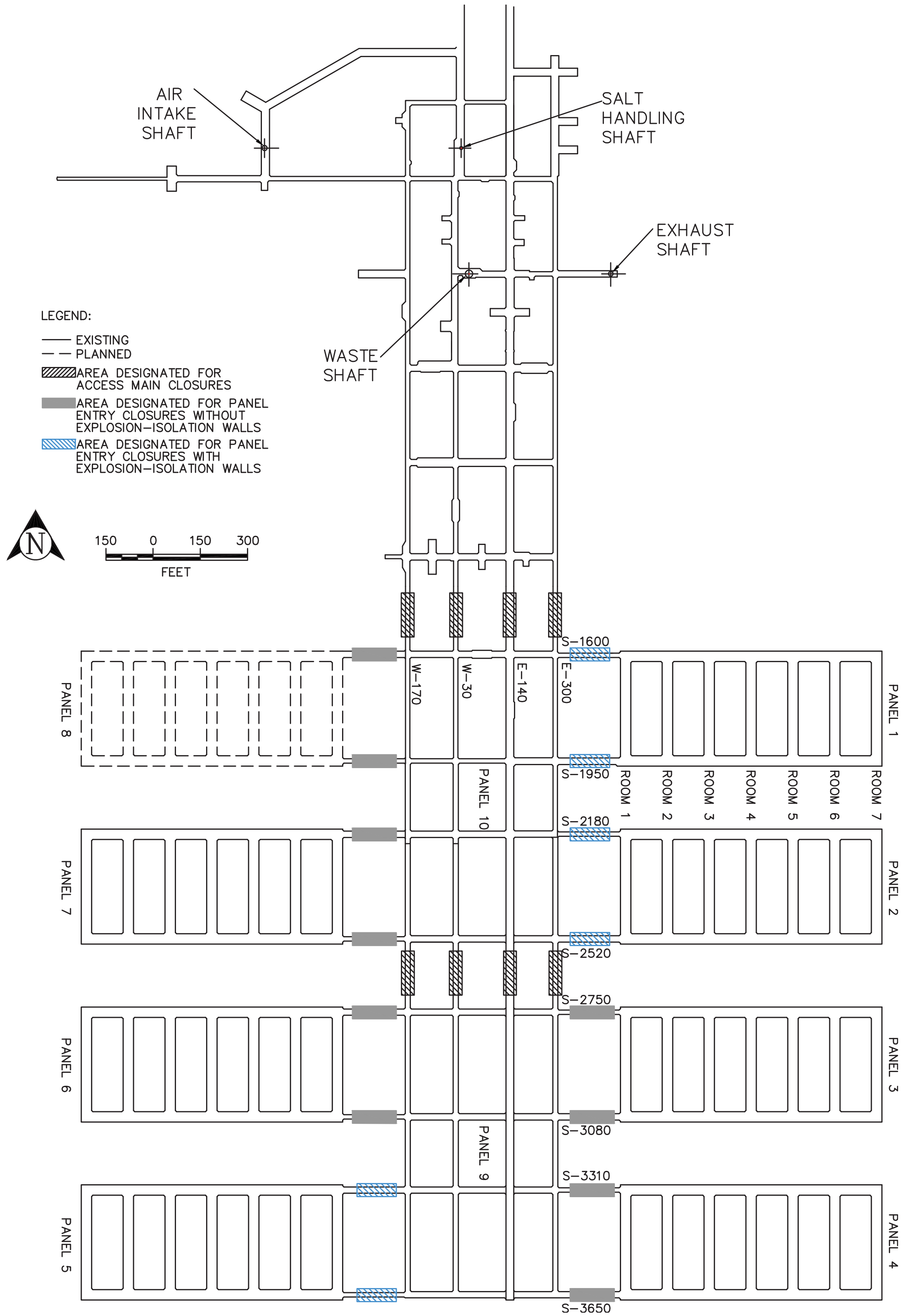
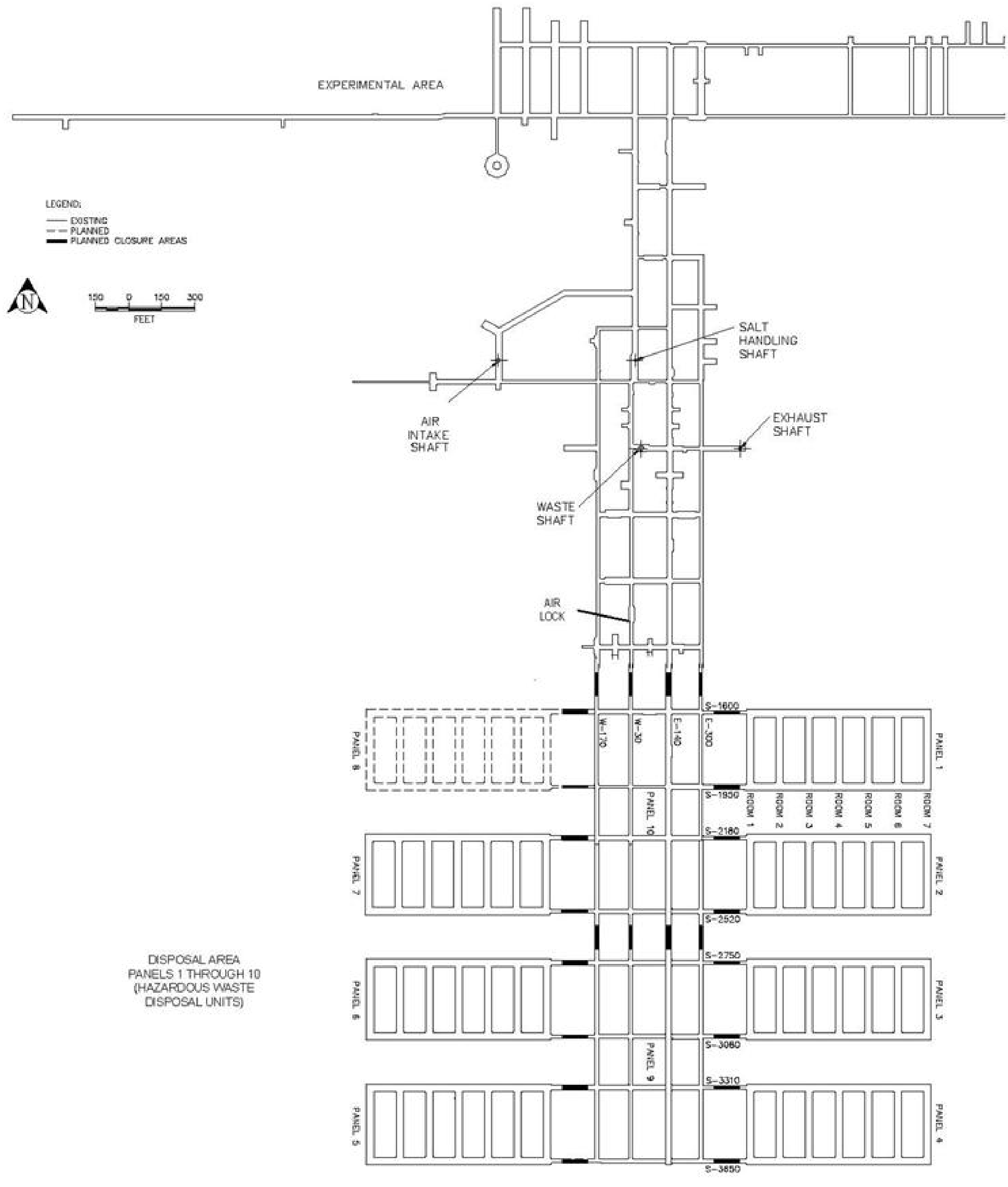


Figure B3-2
Repository Horizon

ATTACHMENT D

RCRA CONTINGENCY PLAN

FIGURES


EXPERIMENTAL AREA
LEGEND:
EXISTING
PLANNED
PLANNED CLOSURE AREAS
150 0 150 300
FEET
SALT HANDLING SHAFT
AIR INTAKE SHAFT
EXHAUST SHAFT
WASTE SHAFT
AIR LOCK
S-1600
W-170
W-30
E-140
E-300
S-1950
S-2180
S-2520
S-2750
S-3080
S-3310
S-3850
PANEL 1
PANEL 2
PANEL 3
PANEL 4
PANEL 5
PANEL 6
PANEL 7
PANEL 8
PANEL 9
PANEL 10
ROOM 1
ROOM 2
ROOM 3
ROOM 4
ROOM 5
ROOM 6
ROOM 7
DISPOSAL AREA
PANELS 1 THROUGH 10
(HAZARDOUS WASTE
DISPOSAL UNITS)

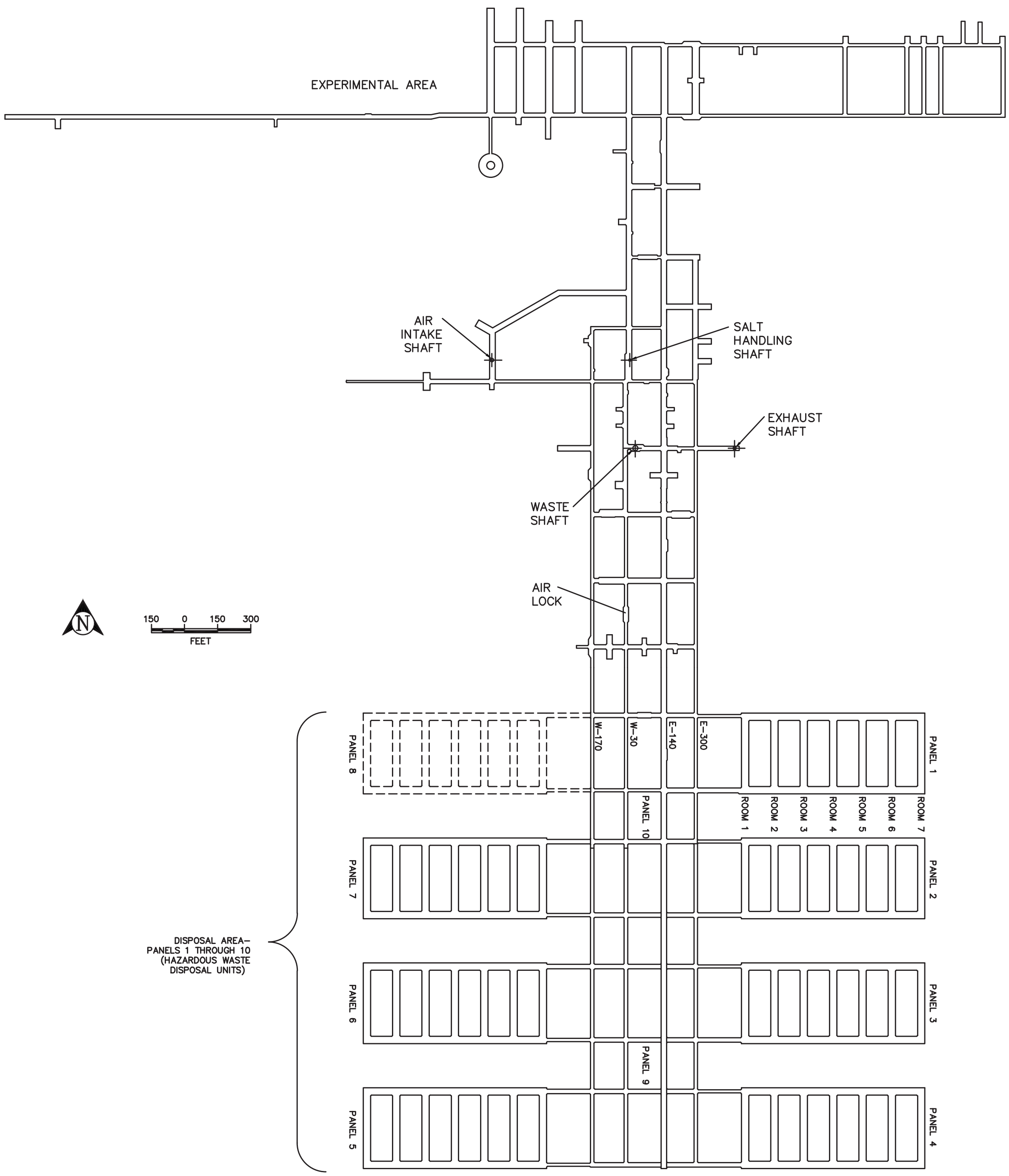
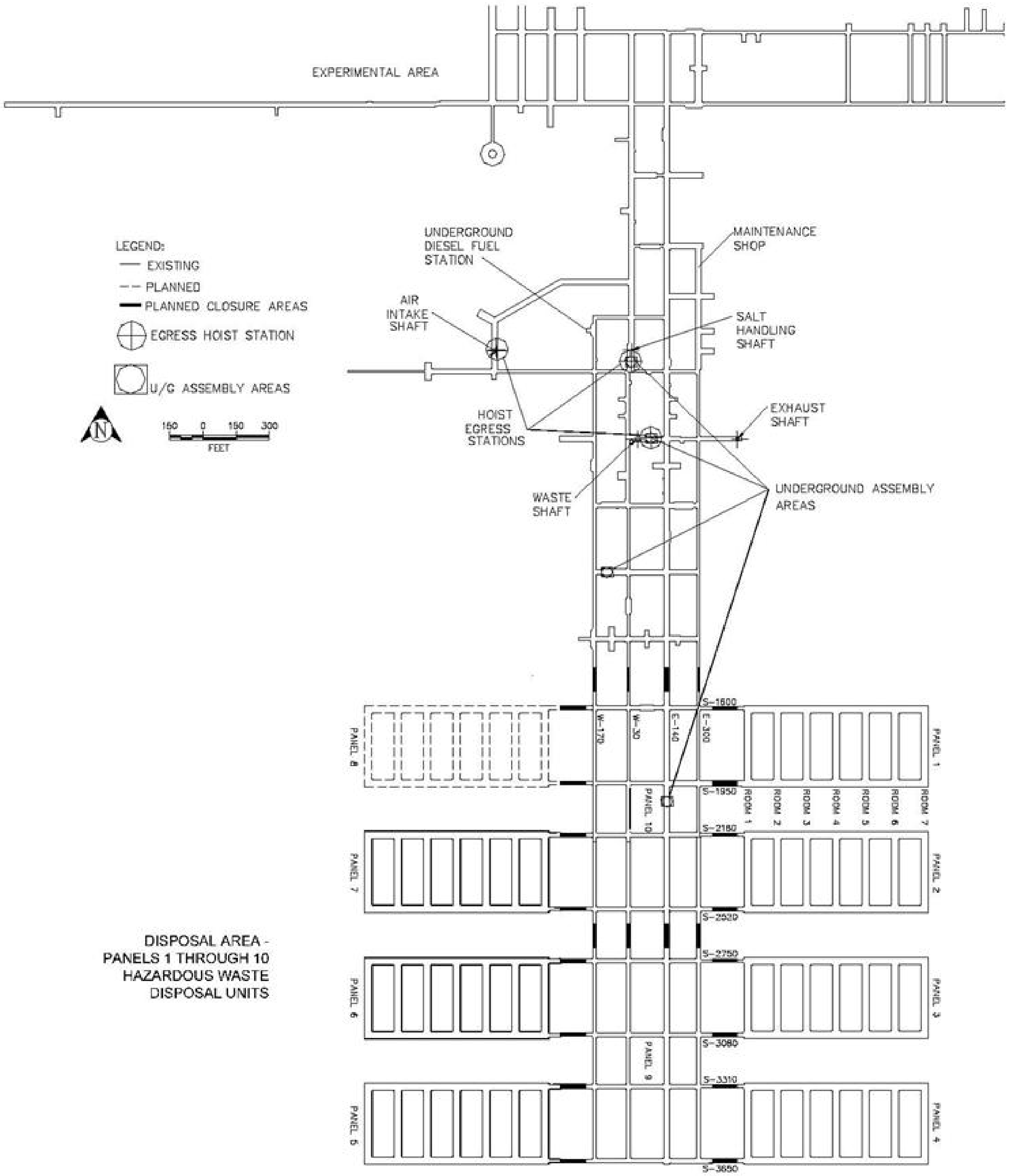


Figure D-3
WIPP Underground Facilities


EXPERIMENTAL AREA
LEGEND:
EXISTING
PLANNED
PLANNED CLOSURE AREAS
EGRESS HOIST STATION
U/G ASSEMBLY AREAS
150 0 150 300
FEET
UNDERGROUND DIESEL FUEL STATION
MAINTENANCE SHOP
AIR INTAKE SHAFT
SALT HANDLING SHAFT
HOIST EGRESS STATIONS
EXHAUST SHAFT
WASTE SHAFT
UNDERGROUND ASSEMBLY AREAS
S-1600
PANEL 8
W-170
W-30
E-140
E-300
PANEL 1
S-1950
PANEL 10
ROOM 1
ROOM 2
ROOM 3
ROOM 4
ROOM 5
ROOM 6
ROOM 7
S-2180
PANEL 7
PANEL 2
S-2520
S-2750
DISPOSAL AREA - PANELS 1 THROUGH 10 HAZARDOUS WASTE DISPOSAL UNITS
PANEL 6
PANEL 3
S-3080
PANEL 9
S-3310
PANEL 5
PANEL 4
S-3650

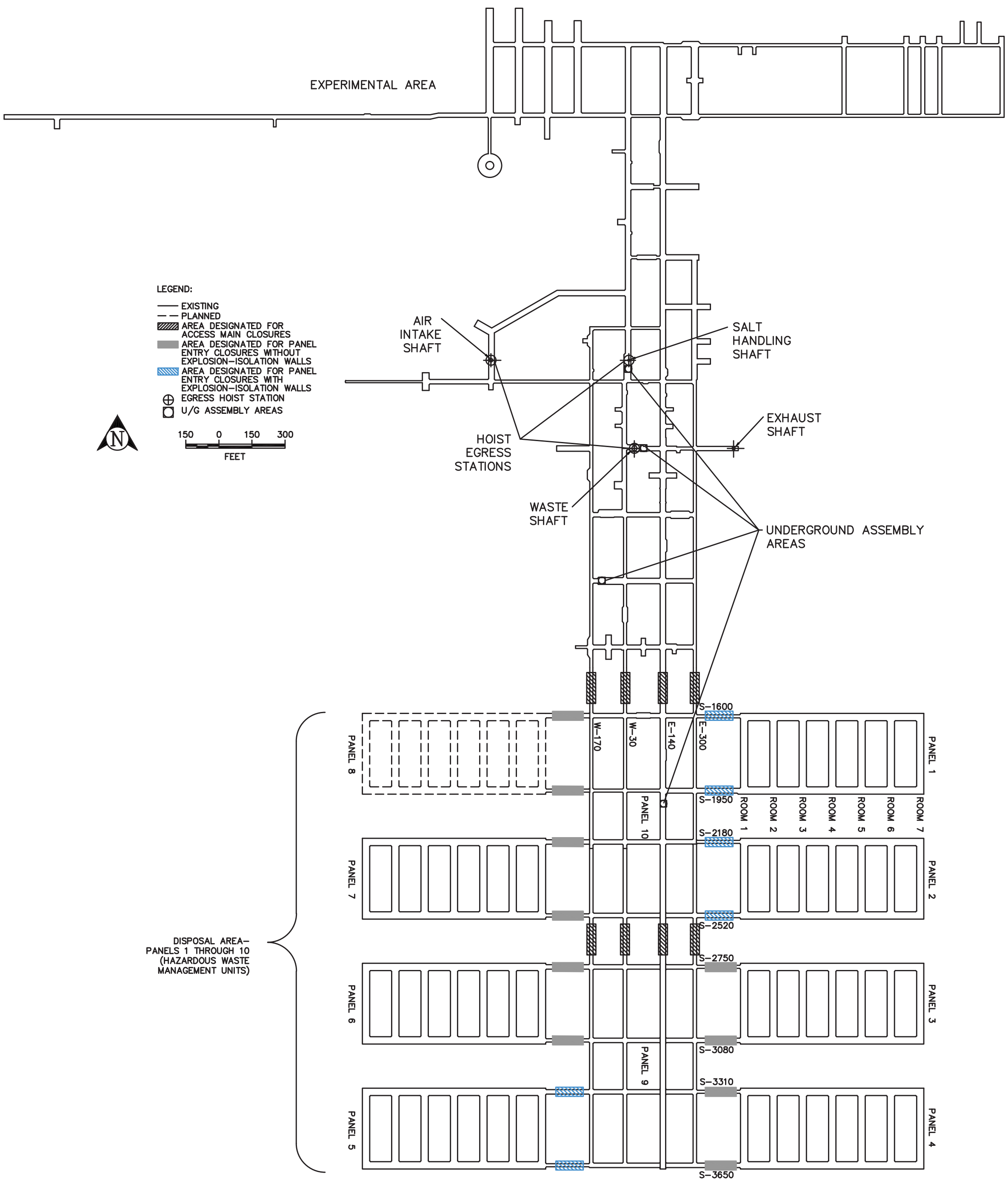


Figure D-7
Designated Underground Assembly Areas

ATTACHMENT E

INSPECTION SCHEDULE, PROCESS, AND FORMS

Table E-1
Inspection Schedule/Procedures

System/Equipment Name	Responsible Organization	Inspection[a] Frequency and Job Title of Personnel Normally Making Inspection	Procedure Number and Inspection Criteria[h]
Air Intake Shaft Hoist	Underground Operations	Preoperational [c] See Lists 1b and c	WP 04-HO1004 Inspecting for Deterioration[b], Safety Equipment, Communication Systems, and Mechanical Operability[m] in accordance with Mine Safety and Health Administration (MSHA) requirements
Ambulance (Surface) and Medical Cart (Underground)	Fire Department	Weekly See List 11	12-FP0030 Inspecting for Mechanical Operability[m], Deterioration[b], and Required Equipment[n]
Adjustable Center of Gravity Lift Fixture	Waste Handling	Preoperational See List 8	WP 05-WH1410 Inspecting for Mechanical Operability[m] and Deterioration[b]
Backup Power Supply Diesel Generators	Facility Operations	Monthly See List 3	WP 04-ED1301 Inspecting for Mechanical Operability[m] and Leaks/Spills by starting and operating both generators. Results of this inspection are logged in accordance with WP 04-AD3008.
Facility Inspections (Water Diversion Berms)	Facility Engineering	Annually See List 4	WP 10-WC3008 Inspecting for Damage, Impediments to water flow, and Deterioration[b]
Central Monitoring Systems (CMS)	Facility Operations	Continuous See List 3	Automatic Self-Checking
Contact-Handled (CH) TRU Underground Transporter	Waste Handling	Preoperational See List 8	WP 05-WH1603 Inspecting for Leaks/Spills, Mechanical Operability[m], Deterioration[b], and area around transporter clear of obstacles
Conveyance Loading Car	Waste Handling	Preoperational See List 8	WP 05-WH1406 Inspecting for Mechanical Operability[m], Deterioration[b], path clear of obstacles, and guards in the proper place
Facility Transfer Vehicle	Waste Handling	Preoperational See List 8	WP 05-WH1204 Inspecting for Mechanical Operability[m], Deterioration[b], path clear of obstacles, and guards in the proper place

System/Equipment Name	Responsible Organization	Inspection[a] Frequency and Job Title of Personnel Normally Making Inspection	Procedure Number and Inspection Criteria[h]
Exhaust Shaft	Underground Operations	Quarterly See List 1a	PM041099 Inspecting for Deterioration[b] and Leaks/Spills
Eye Wash and Shower Equipment	Equipment Custodian	Weekly See List 5	WP 12-IS1832 Inspecting for Deterioration[b]
		Semi-annually See List 2a	WP 12-IS1832 Inspecting for Deterioration[b] and Fluid Levels–Replace as Required
Fire Detection and Alarm System	Fire Protection Engineering	Monthly/quarterly/semi-annually/annually See List 12	12-FP0027 Inspecting for Deterioration[b] and Operability of underground fuel station fire suppression system in accordance with NFPA 17; 12-FP0028 Inspecting for Deterioration[b], and Operability of the alarm panel and transmitter, audible/visual alarm devices, detectors, and pull stations in accordance with NFPA 72, 101, and 801
Fire Extinguishers[j]	Fire Department	Monthly See List 11	12-FP0036 Inspecting for Deterioration[b], Leaks/Spills, Expiration, seals, fullness, and pressure
Fire Hoses	Fire Department	Annually (minimum) See List 11	12-FP0031 Inspecting for Deterioration[b] and Leaks/Spills
Fire Hydrants	Fire Protection Engineering	Semi-annual/annually See List 12	12-FP0034 Inspecting for Deterioration[b] and Leaks/Spills
Fire Pumps	Fire Protection Engineering	Weekly/annually See List 12	WP 12-FP0026 Inspecting for Deterioration[b], Leaks/Spills, valves, and panel lights
Fire Sprinkler Systems	Fire Protection Engineering	Monthly/ quarterly/ annually See List 12	WP 12-FP0025 Inspecting for Deterioration[b], Leaks/Spills, water pressures, and main drain test
Fire and Emergency Response Vehicles (Fire Trucks, Fire Suppression Cart, and Rescue Carts/Trucks)	Fire Department	Weekly See List 11	12-FP0033 Inspecting for Mechanical Operability[m], Deterioration[b], Leaks/Spills, and Required Equipment[n]

System/Equipment Name	Responsible Organization	Inspection[a] Frequency and Job Title of Personnel Normally Making Inspection	Procedure Number and Inspection Criteria[h]
Forklifts Used for Waste Handling (Electric and Diesel forklifts, Push-Pull Attachment)	Waste Handling	Preoperational See List 8	WP 05-WH1201, WP 05-WH1207, WP 05-WH1401, WP 05-WH1402, WP 05-WH1403, and WP 05-WH1412 Inspecting for Leaks/Spills, Mechanical Operability[m], Deterioration[b], and On board fire suppression system
Automatic on-board fire suppression systems	Fire Protection Engineering	Semi-annually See List 12	WP 12-FP0060 Inspecting for Mechanical Operability[m] and Deterioration[b]
Hazardous Material Response Equipment	Fire Department	Quarterly See List 11	12-FP0033 Inspecting for Deterioration[b], and Required Equipment[n]
Head Lamps	Facility Personnel	Daily[i]	Head lamps are operated daily and are repaired or replaced upon failure
Miners First Aid Station	Fire Department	Quarterly See List 11	12-FP0035 Inspecting for Required Equipment[n]
Mobile Phones	Facility Personnel	Daily[i]	Mobile Phones are operated daily and are repaired or replaced upon failure
Mine Pager Phones (between surface and underground)	Facility Operations	Monthly[o] See List 3	WP 04-PC3017 Testing of Mine Pager Phones at essential locations
MSHA Air Quality Monitor	Maintenance/ Underground Operations	Daily[l] See Lists 1 and 10	WP 12-IH1828 Inspecting for Air Quality Monitoring Equipment Functional Check
Perimeter Fence, Gates, Signs	Security	Daily See List 6	PFO-008 Inspecting for Deterioration[b] and Posted Warnings
Mine Rescue Self-Contained Breathing Apparatus (**SCBA**)	Mine Rescue Team	30 days See List 5	Inspection for Deterioration[b] and Pressure[g]
Fire Department SCBA	Fire Department	Weekly/monthly See List 11	12-FP0029 Inspecting for Deterioration[b] and Pressure
Site Notification System; Underground Evacuation Alarm System	Facility Operations	Monthly See List 3	WP 04-PC3017 Testing of PA and Underground Alarms
Radio Equipment	Facility Personnel	Daily[i]	Radios are operated daily and are repaired or replaced upon failure

System/Equipment Name	Responsible Organization	Inspection[a] Frequency and Job Title of Personnel Normally Making Inspection	Procedure Number and Inspection Criteria[h]
Salt Handling Shaft Hoist	Underground Operations	Preoperational See List 1b and c	WP 04-HO1002 Inspecting for Deterioration[b], Safety Equipment, Communication Systems, and Mechanical Operability[m] in accordance with MSHA requirements
Self-Rescuers	Underground Operations	Quarterly See List 1c	WP 04-AU1026 Inspecting for Deterioration[b] and Functionality in accordance with MSHA requirements
Surface TRU Mixed Waste Handling Area [k]	Waste Handling	Preoperational or Weekly [e] See List 8	WP 05-WH1101 Inspecting for Deterioration[b], Leaks/Spills, Required Aisle Space, Posted Warnings, Communication Systems, Container Condition, and Floor coating integrity
TRU Mixed Waste Decontamination Equipment	Waste Handling	Annually See List 8	WP 05-WH1101 Inspecting for Required Equipment[n]
Underground Openings—Roof Bolts and Travelways	Underground Operations	Weekly See List 1a	WP 04-AU1007 Inspecting for Deterioration[b]
Underground— Geomechanical Instrumentation System (GIS)	Geotechnical Engineering	Monthly See List 9	WP 07-EU1301 Inspecting for Deterioration[b]
Underground TRU Mixed Waste Disposal Area	Waste Handling	Preoperational See List 8	WP 05-WH1810 Inspecting for Deterioration[b], Leaks/Spills, mine pager phones, equipment, unobstructed access, signs, debris, and ventilation
Uninterruptible Power Supply (Central UPS)	Facility Operations	Daily See List 3	WP 04-ED1542 Inspecting for Mechanical Operability[m] and Deterioration[b] with no malfunction alarms. Results of this inspection are logged in accordance with WP 04-AD3008.
TDOP Upender	Waste Handling	Preoperational See List 8	WP 05-WH1010 Inspecting for Mechanical Operability[m] and Deterioration[b]
Ventilation Exhaust	Maintenance Operations	Quarterly See List 10	IC041098 Check for Deterioration[b] and Calibration of Mine Ventilation Rate Monitoring Equipment

System/Equipment Name	Responsible Organization	Inspection[a] Frequency and Job Title of Personnel Normally Making Inspection	Procedure Number and Inspection Criteria[h]
Waste Handling Cranes	Waste Handling	Preoperational See List 8	WP 05-WH1407 Inspecting for Mechanical Operability[m], Deterioration[b], and Leaks/Spills
Waste Hoist	Underground Operations	Preoperational See List 1b and c	WP 04-HO1003 Inspecting for Deterioration[b], Safety Equipment, Communication Systems, and Mechanical Operability[m], Leaks/Spills, in accordance with MSHA requirements
Water Tanks	Facility Operations	Daily See List 3	SDD-WD00 Inspecting for Deterioration[b], and water levels. Results of this inspection are logged in accordance with WP 04-AD3008.
Push-Pull Attachment	Waste Handling	Preoperational See List 8	WP 05-WH1401 Inspecting for Damage and Deterioration[b]
Trailer Jockey	Waste Handling	Preoperational See List 8	WP 05-WH1405 Inspecting for Leaks/Spills, Mechanical Operability[m] and Deterioration[b]
~~Explosion-Isolation Walls~~	~~Underground Operations~~	~~Quarterly~~ ~~See List 1~~	~~PM000032~~ ~~Integrity and Deterioration[b] of Accessible Areas~~
Closure Bulkheads~~ in Filled Panels~~	Underground Operations	Semi-annually~~Monthly~~ See List 1	PM000011 Integrity and Deterioration[b] of Accessible Areas
Bolting Robot	Waste Handling	Preoperational See List 8	WP 05-WH1203 Mechanical Operability[m]
Yard Transfer Vehicle	Waste Handling	Preoperational See List 8	WP 05-WH1205 Mechanical Operability[m], Deterioration[b], Path clear of obstacles and Guards in proper place
Payload Transfer Station	Waste Handling	Preoperational See List 8	WP 05-WH1208 Mechanical Operability[m], Deterioration[b], and Guards in proper place
Monorail Hoist	Waste Handling	Preoperational See List 8	WP 05-WH1202 Mechanical Operability[m], Deterioration[b], and Leaks/Spills

System/Equipment Name	Responsible Organization	Inspection[a] Frequency and Job Title of Personnel Normally Making Inspection	Procedure Number and Inspection Criteria[h]
Bolting Station	Waste Handling	Preoperational See List 8	WP 05-WH1203 Mechanical Operability[m], Deterioration[b], and Guards in proper place

ATTACHMENT G

CLOSURE PLAN

Introduction

This Permit Attachment contains the Closure Plan that describes the activities necessary to close the Waste Isolation Pilot Plant (**WIPP**) individual units and facility. Since the current plans for operations extend over several decades, the Permittees will periodically reapply for an operating permit in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.10(h)). Consequently, this Closure Plan describes several types of closures. The first type is panel closure, which involves constructing closures in each of the underground hazardous waste disposal units (**HWDUs**) after they are filled. The second type is partial closure, which can be less than the entire facility and therefore less than an entire unit as described herein for the Waste Handling Building (**WHB**) Unit and the Parking Area Unit (**PAU**). The third type of closure is final facility closure at the end of the Disposal Phase, which will entail "clean" closure of all remaining surface storage units and construction of the four shaft seal systems. Finally, in the event a new permit is not issued prior to expiration of an existing permit, a modification to this Closure Plan will be sought to perform contingency closure. Contingency closure defers the final closure of waste management facilities such as the Waste Handling Building Container Storage Unit (**WHB Unit**), the conveyances, the shafts, and the haulage ways because these will be needed to continue operations with non-mixed Transuranic (**TRU**) waste.

The hazardous waste management units (**HWMUs**) addressed in this Closure Plan include the aboveground HWMU in the WHB, the parking area HWMU, and Panels 1 through 8, each consisting of seven rooms. In addition, this Closure Plan includes Panels 9 and 10 which are the main north-south entries in the underground, a portion of which may be used for waste disposal.

This plan was submitted to the New Mexico Environment Department (**NMED**) ~~and the U.S. Environmental Protection Agency (**EPA**)~~ in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.14(b)(13)). Closure at the panel level will include the construction of barriers ~~to limit~~that will contribute to limiting the emission of hazardous waste constituents from the panel into the mine ventilation air stream below levels that meet environmental performance standards[1] ~~and to mitigate the impacts of methane buildup and deflagration that may be postulated for some closed panels~~. The Post-Closure Plan (Permit Attachment H) includes the implementation of institutional controls to limit access and groundwater monitoring to assess disposal system performance. Until final closure is complete and has been certified in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.115), a copy of the approved

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~~[1] The mechanism for air emissions prior to closure is different than the mechanism after closure. Prior to closure, volatile organic compounds (VOC) will diffuse through drum filters based on the concentration gradient between the disposal room and the drum headspace. These VOCs are swept away by the ventilation system, thereby maintaining a concentration gradient that is assumed to be constant. Hence, the VOCs in the ventilation stream are a function of the number of containers only. After closure, the panel air will reach an equilibrium concentration with the drum headspace and no more diffusion will occur. The only mechanism for release into the mine ventilation system is due to pressure that builds up in the closed panel. This pressure arises from the creep closure mechanism that is reducing the volume of the rooms and from the postulated generation of gas as the result of microbial degradation of organic matter in the waste. Consequently, the emissions after panel closure are a direct function of pressurization processes and rates within the panel.~~

Closure Plan and all approved revisions will be on file at the WIPP facility and will be available to the Secretary of the NMED or the EPA Region VI Administrator upon request.

G-1 Closure Plan

This Closure Plan is prepared in accordance with the requirements of 20.4.1.500 NMAC (incorporating 40 CFR §264 Subparts G, I, and X), Closure and Post-Closure, Use and Management of Containers, and Miscellaneous Units. The WIPP underground HWDUs~~,~~ ~~including Panels 1 through 8~~ shown on Figure G-1, will be closed under this ~~permit~~ Closure Plan to meet the performance standards in 20.4.1.500 NMAC (incorporating 40 CFR §264.601). The WIPP surface facilities, including Waste Handling Building Container Storage Unit and the Parking Area Container Storage Unit, will be closed in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.178). The Permittees may perform partial closure of the WHB and PAU HWMUs prior to final facility closure and certification. For final facility closure, this plan also includes closure ~~of future waste disposal areas including Panels 9 and 10 and closure~~ and sealing of the facility shafts in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.601).

Following completion of waste emplacement in each underground HWDU, the HWDU will be closed. The Permittees will notify the NMED of the closure of each underground HWDU as specified in the schedule in Figure G-2. For the purpose of this Closure Plan, panel closure is defined as the process of rendering underground HWDUs in the repository inactive and closed according to the facility Closure Plan. The Post-Closure Plan (Permit Attachment H) addresses requirements for future monitoring that are deemed necessary for the post-closure period, ~~including monitoring closed panels~~ prior to final facility closure.

For the purposes of this Closure Plan, final facility closure is defined as closure that will occur when all waste disposal areas are filled or when the WIPP achieves its capacity of 6.2 million cubic feet (ft^3) (175,564 cubic meters (m^3)) of TRU waste. At final facility closure, the surface container storage areas will be closed, and equipment that can be decontaminated and used at other facilities will be cleaned and sent off site. Equipment that cannot be decontaminated plus any derived waste resulting from decontamination will be placed in the last open underground HWDU. ~~Stockpiled salt may be placed in the underground; it may be used as the core material for the berm component of the permanent marker system; or it must be otherwise disposed of in accordance with Sections 2 and 3 of the Minerals Act of 1947 (30 U.S.C. §§602 and 603).~~ In addition, shafts and boreholes which lie within the WIPP Site Boundary and penetrate the Salado Formation (**Salado**) will be plugged and sealed, and surface and subsurface facilities and equipment will be decontaminated and removed. Final facility closure will be completed to demonstrate compliance with the Closure Performance Standards contained in 20.4.1.500 NMAC (incorporating 40 CFR §264.111, 178, and 601).

In the event the Permittees fail to obtain an extension of the hazardous waste permit in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.51) or fail to obtain a new permit in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.10(h)), the Permittees will seek a modification to this Closure Plan in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.42) to accommodate a contingency closure. Under contingency closure, storage units will undergo clean closure in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.178); waste handling equipment, shafts, and haulage ways will be inspected for hazardous waste residues (using, among other techniques, radiological surveys to indicate potential hazardous waste releases as described in Permit Attachment G3) and decontaminated as necessary; and underground HWDUs that contain radioactive mixed waste will be closed in accordance with the panel closure design described in this Closure Plan. Final facility closure, however, will be redefined and ~~a request for~~ a time extension for final closure will be requested. A copy of this Closure Plan will be maintained by the Permittees at the WIPP facility and at the U.S. Department of Energy (DOE) Carlsbad Field Office. The primary contact person at the WIPP facility is:

Manager, Carlsbad Field Office
U.S. Department of Energy
Waste Isolation Pilot Plant
P. O. Box 3090
Carlsbad, New Mexico 88221-3090
(575) 234-7300

G-1a Closure Performance Standard

The closure performance standard specified in 20.4.1.500 NMAC (incorporating 40 CFR §264.111), states that the closure shall be performed in a manner that minimizes the need for further maintenance; that minimizes, controls, or eliminates the escape of hazardous waste; and that conforms to the closure requirements of §264.178 and §264.601. These standards are discussed in the following paragraphs.

G-1a(1) Container Storage Units

Final or partial closure of the permitted container storage units (the Waste Handling Building Unit and Parking Area Unit) will be accomplished by removing all waste and waste residues. Indication of waste contamination will be based, among other techniques, on the use of radiological surveys as described in Permit Attachment G3. Radiological surveys use very sensitive radiation detection equipment to indicate if there has been a potential release of TRU mixed waste, including hazardous waste components, from a container. This allows the Permittees to indicate potential releases that are not detectable from visible evidence such as stains or discoloration. Visual inspection and operating records will also be used to identify areas where decontamination is necessary. Contaminated surfaces will be decontaminated until radioactivity is below ~~free release limits~~[2]DOE-established radiological protection limits. Once surfaces are determined to be free of radioactive waste constituents, they will be tested for hazardous waste contamination. These surface decontamination activities will ensure the removal of waste residues to levels protective of human health and the environment. The facility is expected to require no decontamination at closure because any waste spilled or released during operations will be contained and removed immediately. Solid waste management units listed in Attachment K, Table K-4 will be subject to closure. ~~In the event portions of these units which require decontamination cannot be decontaminated, these portions will be removed and the resultant wastes will be managed as appropriately.~~

Once the container storage units are decontaminated and certified by the Permittees to be clean, no further maintenance is required. The facilities and equipment in these units will be reused for other purposes as needed.

~~[2] The free release criteria for items, equipment, and areas is < 20 dpm/100 cm^2 for alpha radioactivity and < 200 dpm/100 cm^2 for beta-gamma radioactivity.~~

G-1a(2) Miscellaneous Unit

Post-closure migration of hazardous waste or hazardous waste constituents to ground or surface waters or to the atmosphere, above levels that will harm human health or the environment, will not occur due to facility engineering and the geological isolation of the unit. The engineering aspects of closure are centered on the use of panel closures on each of the underground HWDUs and final facility seals placed in the shafts. The design of the panel closure system is based on the criteria that the closure system for closed underground HWDUs will prevent migration of hazardous waste constituents in the air pathway in concentrations above health-based levels beyond the WIPP land withdrawal boundary during the 35 year operational and facility closure period ~~and to withstand any flammable gas deflagration that may occur prior to final facility closure~~.

Consistent with the definitions in 20.4.1.101 NMAC (incorporating 40 CFR §260.10), the process of panel closure is considered partial closure because it is a process of rendering a part of the repository inactive and closed according to the approved underground HWDU partial closure plan. Panel closure will be complete when the panel closure system is emplaced and operational, when that underground HWDU and related equipment and structures have been decontaminated (if necessary), and when the NMED has been notified of the closure.

Shaft seals are designed to provide effective barriers to the inward migration of ground water and the outward migration of gas and contaminated brine over two discrete time periods. Several components become effective immediately and are expected to function for 100 years. Other components become effective more slowly, but provide permanent isolation of the waste. The final shaft seal design is specified in Permit Attachment G2.

The facility will be finally closed ~~(i.e., decontaminated and decommissioned)~~ to minimize the need for continued maintenance. Protection of human health and the environment includes, but is not limited to:

- Prevention of any releases that may have adverse effects on human health or the environment due to the migration of waste constituents in the groundwater or in the subsurface environment [20.4.1.500 NMAC, incorporating 40 CFR §264.601(a)].

- Prevention of any releases that may have adverse effects on human health or the environment due to migration of waste constituents in surface water, in wetlands, or on the soil surface [20.4.1.500 NMAC, incorporating 40 CFR §264.601(b)].

- Prevention of any release that may have adverse effects on human health or the environment due to migration of waste constituents in the air [20.4.1.500 NMAC, incorporating 40 CFR §264.601(c)].

As part of final facility closure, surface recontouring and reclamation will establish a stable vegetative cover, and further surface maintenance will not be necessary to protect human health and the environment. Prior to cessation of active controls, monuments will be emplaced to serve as long-term site markers to discourage activities that would penetrate the facility or impair the ability of the salt formation to isolate the waste from the surface environment for at least 10,000 years. The Federal government will maintain administrative responsibility for the repository site in perpetuity and will limit future use of the area.

If, during panel or final facility closure activities, unexpected events require modification of this Closure Plan to demonstrate compliance with closure performance standards, a Closure Plan amendment will be submitted in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.42).

G-1a(3) Post-Closure Care

The post-closure care period will begin after completion of the first panel closure and will continue for 30 years after final facility closure. The post-closure care period may be shortened or lengthened at the discretion of the regulatory agency based on evidence that human health and the environment are being protected or that they are at risk. During the post-closure period, the WIPP shall be maintained in a manner that complies with the environmental performance standards in 20.4.1.500 NMAC (incorporating 40 CFR §264.601). Post-closure activities are described in Permit Attachment H.

G-1b Requirements

The Permit specifies a sequential process for the closure of individual HWMUs at the WIPP. Each underground HWDU will undergo panel closure when waste emplacement in that panel is complete. Following waste emplacement in each underground HWDU, construction-side ventilation will be terminated and waste-disposal-side ventilation will be established in the next underground HWDU to be used, and the underground HWDU containing the waste will be closed. The Permittees will notify the NMED of the closure of each of the underground HWDUs as they are sequentially filled on a HWDU-by-HWDU basis. The HWMUs in the WHB and in the parking area will be closed as part of final facility closure of the WIPP facility.

The Permittees will notify the Secretary of the NMED in writing at least 60 days prior to the date on which closure activities are scheduled to begin.

G-1c Maximum Waste Inventory

The WIPP will receive no more than 6.2 million ft^3 (175,564 m^3) of TRU mixed waste, which may include up to 250,000 ft^3 (7,079 m^3) of remote-handled (**RH**) TRU mixed waste. Excavations are mined as permitted when needed during operations to maintain a reserve of disposal areas. The amount of waste placed in each room is limited by structural and physical considerations of equipment and design. Waste volumes include waste received from off-site generator locations as well as derived waste from disposal and decontamination operations. The maximum volume of TRU mixed waste in a disposal panel is established in Permit Part 4, Table 4.1.1. For closure planning purposes, a maximum achievable volume of 685,100 ft^3 (19,400 m^3) of TRU mixed waste per panel is used. This equates to 662,150 ft^3 (18,750 m^3) of contact-handled (**CH**) TRU mixed waste and 22,950 ft^3 (650 m^3) of RH TRU mixed waste per panel.

The maximum extent of operations during the term of this permit is expected to be Panels 1 through ~~8~~ 10 as shown on Figure G-1, the WHB Container Storage Unit, and the Parking Area Container Storage Unit. Note that panels 9 and 10 are ~~scheduled for excavation only~~not authorized for waste emplacement under this permit. If other waste management units are permitted during the Disposal Phase, this Closure Plan will be revised to include the additional waste management units. At any given time during disposal operations, it is possible that multiple rooms may be receiving TRU mixed waste for disposal at the same time. Underground HWDUs in which disposal has been completed (i.e., in which CH and RH TRU mixed waste emplacement activities have ceased) will undergo panel closure.

G-1d Schedule for Closure

For the purpose of establishing a schedule for closure, an operating and closure period of no more than 35 years (25 years for disposal operations and 10 years for closure) is assumed. This operating period may be extended or shortened depending on a number of factors, including the rate of waste approved for shipment to the WIPP facility and the schedules of TRU mixed waste generator sites, and future decommissioning activities.

G-1d(1) Schedule for Panel Closure

The anticipated schedule for the closure of the underground HWDUs ~~known as Panels 3 through 8~~ is shown in Figure G-2. ~~This schedule assumes there will be little contamination within the exhaust drift of the panel.~~ Underground HWDUs should be ready for closure according to the schedule in Table G-1. ~~These~~ Future dates are estimates for planning and permitting purposes. Actual dates may vary depending on the availability of waste from the generator sites.

In the schedule in Figure G-2, notification of intent to close occurs 30 days before placing the final waste in a panel. Once a panel is full, the Permittees will initially block ventilation through the panel as described in Permit Attachment A2, Section A2-2a(3) "Subsurface Structures," and then will assess the closure area for ground conditions and contamination so that a definitive schedule and closure ~~design~~ location can be determined. If as the result of this assessment the Permittees determine that a panel closure cannot be emplaced in accordance with the schedule in this Closure Plan, a modification will be submitted requesting an extension to the time for closure.

~~The Permittees will initially block ventilation through Panel 5 as described in Permit Attachment A2, Section A2-2a(3), "Subsurface Structures," once Panel 5 is full. The Permittees will then install the explosion-isolation wall portion of the panel closure system that is described in Permit Attachment G1, Section 3.3.2, "Explosion- and Construction-Isolation Walls." Construction of the explosion-isolation wall shall be completed within 180 days after the last receipt of waste in Panel 5. Final closure of Panels 1 through 6 will be completed as specified in this Permit no later than June 30, 2018.~~

~~To ensure continued protection of human health and the environment, the Permittees will initially block ventilation through Panels 3 through 7 as described in Permit Attachment A2, Section A2-2a(3), after waste disposal in each panel has been completed. The Permittees shall continue VOC monitoring in such panels until final panel closure. If the measured concentration, as confirmed by a second sample, of any VOC in a panel exceeds the 95% action level given in Permit Part 4, Table 4.6.3.2, the Permittees will initiate remedial actions as required by Permit Part 4, Section 4.6.3.3. Regardless of the outcome of disposal room VOC monitoring, final closure of Panels 3 and 4 will be completed as specified in this Permit no later than June 30, 2018.~~

G-1d(2) Schedule for Final Facility Closure

The Disposal Phase for the WIPP facility is expected to require a period of 25 years beginning with the first receipt of TRU waste at the WIPP facility and followed by a period ranging from 7 to 10 years for decontamination, decommissioning, and final closure. The Disposal Phase may therefore extend until 2024, and the latest expected year of final closure of the WIPP facility (i.e., date of final closure certification) would be 2034. If, as is currently projected, the WIPP facility is dismantled at closure, all surface and subsurface facilities (except the hot cell portion of the WHB, which will remain as an artifact of the Permanent Marker System [**PMS**]) will be disassembled and either salvaged or disposed in accordance with applicable standards. In addition, asphalt and crushed caliche that was used for paving will be removed, and the area will be recontoured and revegetated in accordance with a land management plan. A detailed closure schedule will be submitted in writing to the Secretary of the NMED, along with the notification of closure. Throughout the closure period, all necessary steps will be taken to prevent threats to human health and the environment in compliance with all applicable Resource Conservation and Recovery Act (**RCRA**) permit requirements. Figure G-3 presents an estimate of a final facility closure schedule based on 84 months to implement final closure.

The schedule for final facility closure is considered to be a best estimate because closure of the facility is driven by policies and practices established for the decontamination, if necessary, and decommissioning of radioactively contaminated facilities. These required activities include extensive radiological contamination surveys and hazardous constituent surveys using, among other techniques, radiological surveys to indicate potential hazardous waste releases. Both types of surveys will be performed at all areas of the WIPP site where hazardous waste were managed. These surveys, along with historical radiological survey records, will provide the basis for release of structures, equipment, and components for disposal or decontamination for release off site. Specifications will be developed for each structure to be removed. A cost benefit analysis will be needed to evaluate decontamination options if extensive decontamination is necessary. Individual equipment surveys, structure surveys, and debris surveys will be required prior to disposition. Size-reduction techniques may be required to dispose of mixed or radioactive waste at the WIPP site. Current DOE policy~~, as reflected in the WIPP facility Safety Analysis Report (**SAR**) (DOE 1997)~~, requires the preparation of a final decommissioning and decontamination (**D&D**) plan immediately prior to final facility closure. In this way, the specific conditions of the facility at the time D&D is initiated will be addressed. Section G-1e(~~2~~3) provides a more detailed discussion of final facility closure activities.

Figure G-3 shows the schedule for the final facility closure consisting of decontamination, as needed, of the TRU waste-handling equipment, and of the aboveground equipment and facilities, including closure of surface HWMUs; decontamination of the shaft and haulage ways; disposal of decontamination derived wastes in the last open underground HWDU; and subsequent closure of this underground HWDU. Subsequent activities will include installation of repository shaft seals.

An overall schedule for final facility closure, showing currently scheduled dates for the start and end of final facility closure activities is shown in Table G-2. The dates assume a ~~start up~~startup date of March 1999 and continued permitting of the WIPP facility until it is filled. ~~Details~~ Schedule details for panel closures are shown on Table G-1.

G-1d(3) Extension for Closure Time

As indicated by the closure schedule presented in Figure G-3, the activities necessary to perform facility closure of the WIPP facility ~~will~~ may require more than 180 days to complete because of additional stringent requirements for managing radioactive materials. Therefore, the Permit provides an extension of the 180-day final closure requirement in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.113). During the extended closure period, the Permittees will continue to demonstrate compliance with applicable permit requirements and will take ~~all~~ steps necessary to prevent threats to human health and the environment as a result of TRU mixed waste management at the WIPP facility including ~~all of~~ the applicable measures in Permit Part 2.10 (~~Preparedness and Prevention~~*Preparedness and Prevention*).

In addition, according to the schedules in Figure G-3, the final derived wastes that are generated as the result of decontamination activities will not be disposed of for 16 months after the initiation of final facility closure. In accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.113(a)), the Permit provides an extension of the 90-day limit to dispose of final derived waste resulting from the closure process. This provision is necessitated by the fact that the radioactive nature of the derived waste makes placement in the WIPP repository the best disposition, and the removal of these wastes will, by necessity, take longer than 90 days in accordance with the closure schedules. During this extended period of time, the Permittees will take ~~all~~ steps necessary to prevent threats to human health and the environment, including compliance with ~~all~~ applicable permit requirements. These steps include ~~all of~~ the applicable preparedness and prevention measures in Permit Part 2.10 (*Preparedness and Prevention*)~~Permit Attachment A~~.

Finally, in the event the hazardous waste permit is not renewed as assumed in the schedule, the Permittees will submit a modification to the Closure Plan to implement a contingency closure that will allow the Permittees to continue to operate for the disposal of non-mixed TRU waste. This modification will include a request for an extension of the time for final facility closure. This modified Closure Plan will be submitted to the NMED for approval.

G-1d(4) Amendment of the Closure Plan

If it becomes necessary to amend the Closure Plan for the WIPP facility, the Permittees will submit, in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §270.42), a written notification of or request for a permit modification describing any change in operation or facility design that affects the Closure Plan. The written notification or request will include a copy of the amended Closure Plan for approval by the NMED. The Permittees will submit a written notification of or request for a permit modification to authorize a change in the approved plan, if:

- There are changes in operating plans or in the waste management unit facility design that affect the Closure Plan
- There is a change in the expected year of closure
- Unexpected events occur during panel or final facility closure that require modification of the approved Closure Plan
- Changes in State or Federal laws affect the Closure Plan
- Permittees fail to obtain permits for continued operations as discussed above

The Permittees will submit a written request for a permit modification with a copy of the amended Closure Plan at least 60 days prior to the proposed change in facility design or operation or within 60 days of the occurrence of an unexpected event that affects the Closure Plan. If the unexpected event occurs during final closure, the permit modification will be requested within 30 days of the occurrence. If the Secretary of the NMED requests a modification of the Closure Plan, a plan modified in accordance with the request will be submitted within 60 days of notification or within 30 days, if the change in facility condition occurs during final closure.

G-1e Closure Activities

Closure activities include those instituted for panel closure (i.e., closure of filled underground HWDUs), contingency closure (i.e., closure of surface HWMUs and decontamination of other waste handling areas), and final facility closure (i.e., closure of surface HWMUs, D&D of surface facilities and the areas surrounding the WHB, and placement of repository shaft seals). Panel closure systems will be emplaced to separate areas of the facility and to isolate panels. Permit Attachments G1 and G2 provide panel closure system and shaft seal designs, respectively. All closure activities will meet the applicable quality assurance (**QA**)/quality control (**QC**) program standards in place at the WIPP facility. Facility monitoring procedures in place during operations will remain in place through final closure, as applicable.

G-1e(1) Panel Closure

Following completion of waste emplacement in each underground HWDU, disposal-side ventilation will be established in the next panel to be used, and the panel HWDU containing the waste will be closed. A panel closure systemWIPP Panel Closure (**WPC**) will be emplaced in the panel access drifts, in accordance with the design in Permit Attachment G1 and the schedule in Figure G-2 and Table G-1. Alternatively, panels may be closed simultaneously by placing panel closures in the north-south mains. The panel closure system is designed to meet the following requirements that were established by the DOE for the design to comply with 20.4.1.500 NMAC (incorporating 40 CFR §264.601(a)):

- the panel closure system shall contribute to meeting the closure performance standards in Permit Part 6, Section 6.10.1 by mitigating the migration of VOCs from closed panels limit the migration of VOCs to the compliance point so that compliance is achieved by at least one order of magnitude

- the panel closure system shall consider potential flow of VOCs through the disturbed rock zone (**DRZ**) in addition to flow through closure components

- the panel closure system shall perform its intended functions under loads generated by creep closure of the tunnels

- the panel closure system shall perform its intended function under the conditions of a postulated thermal runaway involving nitrate salt bearing wastemethane explosion

- the nominal operational life of the closure system is 35 years

- the panel closure system may require minimal maintenance per 20.4.1.500 NMAC (incorporating 40 CFR 264.111) for each individual panel shall not require routine maintenance during its operational life

- the panel closure system shall address the most severeexpected ground conditions expected in the waste disposal area

- the design class of the panel closure system shall be built of substantial construction and non-combustible material except for flexible flashing used to accommodate salt movement IIIb (which means that it is to be built to generally accepted national design and construction standards)

- the design and construction shall follow conventional mining practices
- structural analysis shall use data acquired from the WIPP underground
- materials shall be compatible with their emplacement environment and function
- treatment of surfaces in the closure areas shall be considered in the design
- ~~thermal cracking of concrete shall be addressed~~
- ~~during construction,~~ a QA/QC program shall ~~be established to~~ verify material properties and construction ~~practices~~
- construction of the panel closure system shall consider shaft and underground access and services for materials handling

The closure performance standard for air emissions from the WIPP facility is one excess cancer death in one million and a hazard index (**HI**) of 1 for a member of the public living outside the WIPP Site Boundary as specified in Part 6, Section 6.10.1. ~~established in Permit Part 4 and Permit Attachment A2~~. Releases shall be below these limits for the facility to remain in compliance with standards to protect human health and the environment. The ~~following~~ panel closure design has been shown, through analysis, to meet these standards, if emplaced in accordance with the specifications in Permit Attachment G1. Compliance will be demonstrated by the Repository VOC Monitoring Program (**RVMP**) in Permit Attachment N. Compliance with the standards established for the RVMP constitutes compliance with the closure standards in Permit Part 6, Table 6.10.1

~~The approved design for the panel closure system calls for a composite panel barrier system consisting of a rigid concrete plug with removal of the DRZ, and an explosion-isolation wall.~~ The design basis for this closure is such that the migration of hazardous waste constituents from closed panels during the operational and closure period would result in concentrations ~~well~~ below health-based standards. The source term used as the design basis included the average concentrations of VOCs from CH waste containers as measured in headspace gases through ~~January 1995~~November 2010. The VOCs are assumed to have been released by diffusion through the container vents and are ~~assumed to be in equilibrium with the air in the panel. Emissions from the closed panel occur at a rate determined by gas generation within the waste and creep closure of the panel.~~removed from the closed room by air leakage that occurs due to ventilation-related pressure differentials.

Figures G-4 and G-5 show a diagram of the panel closure design and installation envelopes. Permit Attachment G1 provides the detailed design and the design analysis for the panel closure system. ~~Although the permit application proposed several panel closure design options, depending on the gas generated by wastes and the age of the mined openings, the NMED and EPA determined that only the most robust design option (D) would be approved. This decision does not prevent the Permittees from continuing to collect data on the behavior of the wastes and mined openings, or proposing a modification to the Closure Plan in the future, using the available data to support a request for reconsideration of one or more of the original design options. If a design different from Option D as defined in Permit Attachment G1 is proposed, the appropriate permit modification will be sought.~~

The Permittees shall use bulkheads as specified in Attachment G1 for the closure of filled panels. A run-of-mine (**ROM**) salt component will be included in the closure for Panel 10.

G-1e(2) Prerequisite Activities for Panel 6 Final Closure

The NMED-approved WIPP Nitrate Salt Bearing Waste Container Isolation Plan (DOE, 2015) provides for performing prerequisite activities associated with ground control, equipment readiness, work control authorization, and ventilation prior to construction of the final closure in Panel 6. These activities are considered closure activities and will be completed in accordance with the WIPP Nitrate Salt Bearing Waste Container Isolation Plan (DOE, 2015).

G-1e(~~2~~3) Decontamination and Decommissioning

Decontamination is defined as those activities which are performed to remove contamination from surfaces and equipment that are not intended to be disposed of at the WIPP facility. The policy at the WIPP facility will be to decontaminate as many areas as possible or to fix the contaminants to the surface so they are not easily removable, consistent with ~~radiation~~ radiological protection policy. Decontamination or fixing are ~~is~~ part of ~~all~~ closure activities and ~~is~~ are a necessary activity in the clean closure of the surface container management units. Decontamination or fixing determinations are based upon radiological ~~and hazardous constituent~~ surveys.

Decommissioning is the process of removing equipment, facilities, or surface areas from further use and closing the facility. Decommissioning is part of final facility closure only and will involve the removal of equipment, buildings, closure of the shafts, and establishing active and passive institutional controls for the facility. Passive institutional controls are not included in the Permit.

The objective of D&D activities at the WIPP facility is to return the surface to as close to the preconstruction condition as reasonably possible, while protecting the health and safety of the public and the environment. Major activities required to accomplish this objective include, but are not limited to the following:

1. Review of operational records for historical information on releases
2. Visual examination of surface structures for evidence of spills or releases
3. Performance of site contamination surveys
4. Decontamination, if necessary, of usable equipment, materials, and structures including surface facilities and areas surrounding the WHB.
5. Disposal of equipment/materials that cannot be decontaminated but that meet the treatment, storage, and disposal facility waste acceptance criteria (**TSDF-WAC**) in an underground HWDU
6. Emplacement of ~~final~~ panel closure system in the last HWDU

7. Emplacement of shaft seals[3]

8. Regrading the surface to approximately original contours

9. Initiation of active controls

This Closure Plan will be amended prior to the initiation of final closure activities to specify the methods to be used.

Health and Safety

Before final closure activities begin, ~~health physics~~radiation protection personnel will conduct a hazards survey of the unit(s) being closed. A release of radionuclides could also indicate a release of hazardous constituents. If radionuclides are not detected, sampling for hazardous constituents will still be performed if there is documentation or visible evidence that a spill or release has occurred. The purpose of the hazards survey will be to identify potential contamination concerns that may present hazards to workers during the closure activities and to specify any control measures necessary to reduce worker risk. This survey will provide the information necessary for the health physics personnel to identify worker qualifications, personal protective equipment (**PPE**), safety awareness, work permits, exposure control programs, and emergency coordination that will be required to perform closure related activities.

G-1e(~~2~~)3(a) Determine the Extent of Contamination

The first activities performed as part of decontamination include those needed to determine the extent of any contamination that needs to be removed or fixed prior to decommissioning a facility. This includes activities 1 to 3 above and, as can be seen by the schedules in Figures G-3 and G-4 (Items B and C), these surveys are anticipated to take 10 months to perform, including obtaining the results of any sample analyses. The process of identifying areas that require decontamination or fixing include three sources of information. First, operating records will be reviewed to determine where contamination has previously been found as the result of historical releases and spills. Even though releases and spills in the above ground storage units will have been cleaned up at the time of occurrence, newer equipment and technology may allow further cleaning. Second, surfaces of facilities and structures will be examined visually for evidence of spills or releases. Finally, extensive detailed contamination surveys will be performed to document the level of cleanliness for ~~all~~ surface structures and equipment that are subject to decontamination. If equipment or areas are identified as contaminated, the Permittees will notify NMED as specified in Permit Part 1, and a plan and procedure(s) will be developed and implemented to address decontamination-related questions, including:

- Should the component be decontaminated or disposed of as waste?
- What is the most cost-effective method of decontaminating the component?
- Will the decontamination procedures adequately contain the contamination?

Radiological and hazardous constituent surveys will be used in determining the presence of hazardous waste and hazardous waste residues in areas where spills or releases have occurred. Radiological surveys are described in Permit Attachment G3. For contamination that

[3] For the purposes of planning, the conclusion of shaft sealing is used by the DOE as the end of closure activities and the beginning of the Post-Closure Care Period.

~~Once~~ is cleaned up, once cleanup of the radioactivity has been completed, the surface will be sampled for hazardous constituents specified in Permit Attachment B to determine that they, too, have been cleaned up. Sampling and analysis protocols will be consistent with EPA's document SW-846 (EPA, 1996).

G-1e(~~2~~3)(b) Decontamination Activities

Once the extent of contamination is known, decontamination or fixing activities will be planned and performed. Radiological control and the control of hazardous waste residues are the primary criteria used in the design of decontamination activities. ~~Radiation~~ Radiological control procedures require that careful planning and execution be used in decontamination activities to prevent the exposure of workers beyond applicable standards and to prevent the further spread of contamination. Careful control of entry, cleanup, and ventilation are vital components of ~~radiation~~ radiological decontamination. The level of care mandated by DOE orders and occupational protection requirements results in closure activities that will exceed the 180 days allowed in 20.4.1.500 NMAC (incorporating 40 CFR §264.113(b)). Decontamination activities are included as item 4 above and are shown on the schedules for contingency closure and final facility closure (Figures G-3 and G-4) as activities D, E, and F. These activities are anticipated to have a duration of 20 months for both contingency closure and for final facility closure. The result of these activities is the clean closure of the surface container management units. Under contingency closure, the other areas that have been decontaminated will not be closed. Instead they will remain in use for continued waste management activities involving non-mixed waste. Under final facility closure, other areas that are decontaminated are eligible for closure.

~~The "Start Clean—Stay Clean" operating philosophy of the WIPP Project will provide for minimum need for decontamination. However, the need for decontamination techniques may arise.~~

Decontamination activities will be coordinated with closure activities so that areas that have been decontaminated will not be recontaminated. All waste resulting from decontamination activities will be surveyed and analyzed for the presence of radioactive contamination and a determination of hazardous constituents specified in Permit Attachment B. The waste will be characterized as hazardous, mixed, or radioactive and will be packaged and handled appropriately. Mixed and radioactive waste ~~will~~ may be classified as TRU mixed waste managed in accordance with the applicable Permit requirements. Derived mixed waste collected during decontamination activities that are generated before repository shafts have been sealed will be emplaced in the facility, if appropriate, or will be managed together with decontamination derived waste collected after the underground is closed. This waste will be classified and shipped off site to an appropriate, permitted facility for treatment, if necessary, and for disposal.

Removal of Hazardous Waste Residues

Because of the type of waste management activities that will occur at the WIPP facility, waste residues that may be encountered during the operation of the facility and at closure may include derived waste. Derived wastes result from the management of the waste containers or may be collected as part of the closure activities (such as those during which wipes were used to sample the containers and equipment for potential radioactive contamination or those involving solidified decontamination solutions, the handling of equipment designated for disposal, and the handling of residues collected as a result of spill cleanup). Derived wastes collected during the operation and closure of the WIPP facility will be identified and managed as TRU mixed wastes. These wastes will be disposed in the active underground HWDU. ~~D&D~~Decontamination and decommissioning derived wastes and equipment designated for disposal will be placed in the last underground HWDU panel before closure of that unit.

Surface Container Storage Units

The procedures employed for waste receipt at the WIPP facility minimize the likelihood for any waste spillage to occur on the surface outside the WHB. TRU mixed waste is shipped to the WIPP facility in approved shipping containers (i.e., Contact-Handled or Remote-Handled Packages) that are not opened until they are inside the WHB. Therefore, it is unlikely that soil in the Parking Area Unit or elsewhere in the vicinity of the WHB will become contaminated with TRU mixed waste constituents as a result of TRU mixed waste management activities. An evaluation of the soils in the vicinity of the WHB will only be necessary if an documented event resulting in a release of hazardous waste has occurred outside the WHB.

The “Start Clean—Stay Clean” operating philosophy of the WIPP Project will minimize the need for decontamination of the WHB during decommissioning and closure. Procedures for opening shipping containers in the WHB limit the opportunity for waste spillage.

Should the need for decontamination of the WHB arise, the following methods may be employed, as appropriate, for the hazardous constituent/contaminant type and extent:

- Chemical cleaning (e.g., water, mild detergent cleanser, and polyvinyl alcohol)
- Nonchemical cleaning (e.g., sandblasting, grinding, high-pressure water spray, scabbler pistons and needle scalers, ice-blast technology, dry-ice blasting)
- Removal of contaminated components such as pipe and ductwork

Waste generated as a result of WHB decontamination activities will be managed as derived waste in accordance with applicable permit Permit requirements and will be emplaced in the last open underground HWDU for disposal.

Waste Handling Equipment and

The waste shaft conveyance and associated waste handling equipment will be decontaminated to background or be disposed as derived waste as part of both contingency and final facility closure. Procedures for detection and sampling will be as described above. Equipment cleanup will be as above using chemical or nonchemical techniques.

Personnel Decontamination

PPE Personal protective equipment (PPE) worn by personnel performing closure activities in areas determined to be contaminated will be disposed of appropriately. Disposable PPE used in such areas will be placed into containers and managed as TRU mixed waste. Non-disposable PPE will be decontaminated, if possible. Non-disposable PPE that cannot be decontaminated will be managed as TRU mixed waste.

In accordance with DOE policy, TRU mixed waste PPE will be considered to be contaminated with all of the hazardous waste constituents contained in the containers that have been managed within the unit being closed. Wastes collected as a result of closure activities and that may be contaminated with radioactive and hazardous constituents will be considered TRU mixed wastes. These wastes will be managed as derived wastes, as described in Permit Attachment A2. Such waste, collected as the result of closure of the WIPP facility, will be disposed of in the final open underground HWDU.

Cleanup Criteria

~~Radiation~~ Radiological decontamination will be less than or equal to ~~the following levels, or to~~ whatever ~~lesser~~ levels that may be established by DOE Order at the time of cleanup~~:~~.

~~Contamination Type~~	~~Loose~~[4]	~~Fixed plus removable~~
~~alpha contamination (α)~~	~~20 dpm/100 cm^2~~	~~500 dpm/100 cm^2~~
~~beta-gamma contamination (β-γ)~~	~~200 dpm/100 cm^2~~	~~1000 dpm/100 cm^2~~

Hazardous waste decontamination will be conducted in accordance with standards in 20.4.1.500 NMAC (incorporating 40 CFR §264) or as incorporated into the Permit.

Final Contamination Sampling and Quality Assurance

Verification samples will be analyzed by an approved laboratory that has been qualified by the DOE according to a written program with strict criteria. The QA requirements of EPA/SW-846, "Test Methods for Evaluating Solid Waste" (EPA, ~~1986~~1996), will be met for hazardous constituent sampling and analyses.

Quality Assurance/Quality Control

Because decisions about closure activities may be based, in part, on analyses of samples of potentially contaminated surfaces and media, a program to ensure reliability of analytical data is essential. Data reliability will be ensured by following a QA/QC program that mandates adequate precision and accuracy of laboratory analyses. Field documentation will be used to document the conditions under which each sample is collected. The documented QA/QC program in place at the WIPP facility will meet applicable RCRA QA requirements.

Field blanks and duplicate samples will be collected in the field to determine potential errors introduced in the data from sample collection and handling activities. To determine the potential for cross-contamination, rinsate blanks (consisting of rinsate from decontaminated sampling equipment) will be collected and analyzed. At least one rinsate blank will be collected for every 20 field samples. Duplicate samples will be collected at a frequency of one duplicate sample for every ten field samples. In no case will less than one rinsate blank or duplicate sample be collected for a field-sampling effort. These blank and duplicate samples will be identified and treated as separate samples. Acceptance criteria for QA/QC hazardous constituent sample analyses will adhere to the most recent version of EPA SW-846 or other applicable EPA guidance.

[4] ~~The unit "dpm" stands for "disintegration per minute" and is the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.~~

G-1e(~~2~~3)(c) Dismantling

Final facility closure will include dismantling of structures on the surface and in the underground. These are items 6 and 7 above and are represented as Activity G in the final facility closure schedule in Figure G-~~4.~~3 During dismantling, priority will be given to contaminated structures and equipment that cannot be decontaminated to assure these are properly disposed of in the remaining open underground HWDU in a timely manner. All such facilities and equipment are expected to be removed and disposed of 16 months after the initiation of closure. Dismantling of the balance of the facility, including those structures and equipment that are not included in the application and are not used for TRU mixed waste management, is anticipated to take an additional 66 months. It should be noted that the placement of D&D waste into the final underground HWDU may, by necessity, involve the placement of uncontainerized bulk materials such as concrete components, building framing, structural members, disassembled or partially disassembled equipment, or containerized materials in non-standard waste boxes. Such placement will only occur if it can be shown that it is protective of human health and the environment and all items are described in an amendment to the Closure Plan. Identification of bulk items is not possible at this time since their size and quantity will depend on the extent of non-removable contamination.

G-1e(~~2~~3)(d) Closure of Open Underground HWDU

The closure of the final underground HWDU is shown by Activity H in Figure G-3. This closure will be consistent with the description in Section G-1e(1) and the design in Permit Attachment G1. Detailed closure schedules for underground HWDUs are given in Figure G-2 and Table G-1.

G-1e(~~2~~3)(e) Final Facility Closure

Final facility closure includes several activities designed to assure both the short-term isolation of the waste and the long-term integrity of the disposal system. These include the placement of plugs in boreholes that penetrate the salt and the placement of the repository sealing system. In addition, the surface will be returned to as near its original condition as practicable, and will be readied for the construction of markers and monuments that will provide permanent marking of the repository location and contents.

Figure G-6 identifies where three existing boreholes overlie the proximate area of the repository footprint. Of these identified boreholes in Figure G-6, all but ERDA-9 are terminated hundreds of feet above the repository horizon. Only ERDA-9, which is accounted for in long-term performance modeling, is drilled through the repository horizon, near the WIPP excavations.

To mitigate the potential for migration beyond the repository horizon, the DOE has specified that borehole seals be designed to limit the volume of water that could be introduced to the repository from the overlying water-bearing zones and to limit the volume of contaminated brine released from the repository to the surface or water-bearing zones.

Borehole plugging activities have been underway since the 1970s, from the early days of the development of the WIPP facility. Early in the exploratory phase of the project, a number of boreholes were sunk in Lea and Eddy counties. After the WIPP site was situated in its current location, an evaluation of all vertical penetrations was made by Christensen and Peterson (1981).

As an initial criterion, any borehole that connects a fluid-producing zone with the repository horizon becomes a plugging candidate.

Grout plugging procedures are routinely performed in standard oil-field operations; however, quantitative measurements of plug performance are rarely obtained. The Bell Canyon Test reported by Christensen and Peterson (1981) was a field test demonstration of the use of cementitious plugging materials and modification of existing industrial emplacement techniques to suit repository plugging requirements. Cement emplacement technology was found to be “generally adequate to satisfy repository plugging requirements.” Christensen and Peterson (1981) also report “that grouts can be effective in sealing boreholes, if proper care is exercised in matching physical properties of the local rock with grout mixtures. Further, the reduction in fluid flow provided by even limited length plugs is far in excess of that required by bounding safety assessments for the WIPP.” The governing regulations for plugging and/or abandonment of boreholes are summarized in Table G-3.

The proposed repository sealing system design will prevent water from entering the repository and will prevent gases or brines from migrating out of the repository. The proposed design includes the following subsystems and associated principal functions:

- Near-surface: to prevent subsidence at and around the shafts
- Rustler Formation: to prevent subsidence at and around the shafts and to ensure compliance with ~~Federal~~ federal and ~~State of~~ New Mexico groundwater protection requirements
- Salado ~~Formation~~: to prevent transporting hazardous waste constituents beyond the point of compliance specified in Permit Part 5

The repository sealing system will consist of natural and engineered barriers within the WIPP repository that will withstand forces expected to be present because of rock creep, hydraulic pressure, and probable collapses in the repository and will meet the closure requirements of 20.4.1.500 NMAC (incorporating 40 CFR §264.601 and §264.111). Permit Attachment G2 presents the final repository sealing system design.

Once shaft sealing is completed, the Permittees will consider closure complete and will provide the NMED with a certification of such within 60 days.

G-1e(~~2~~3)(f) Final Contouring and Revegetation

In the preparation of its Final Environmental Impact Statement (DOE, 1980), the DOE committed to restore the site to as near to its original condition as is practicable. This involves removal of access roads, unneeded utilities, fences, and any other structures built by the DOE to support WIPP operations. Provisions would be left for active post-closure controls of the site and for the installation of long-term markers and monuments for the purpose of permanently marking the location of the repository and waste. Permit Attachment H-1a(1) discusses the active and long-term controls proposed for the WIPP. Installation of borehole seals are anticipated to take 12 months, shaft seals 52 months, and final surface contouring 8 months.

G-1e(~~2~~3)(g) Closure, Monuments, and Records

A record of the WIPP Project shall be listed in the public domain in accordance with the requirements of 20.4.1.500 NMAC (incorporating 40 CFR §264.116). Active access controls will be employed for at least the first 100 years after final facility closure. In addition, a passive control system consisting of monuments or markers will be erected at the site to inform future generations of the location of the WIPP repository (see "Permanent Marker Conceptual Design Report" [DOE, 1995~~b~~]).

This Permit requires only a ~~30 year~~30-year post-closure period. This is the maximum post-closure time frame allowed in an initial Permit for any facility, as specified in 20.4.1.500 NMAC (incorporating 40 CFR §264.117(a)). The Secretary of the NMED may shorten or extend the post-closure care period at any time in the future prior to completion of the original post-closure period (30 years after the completion of construction of the shaft seals). The Permanent Marker Conceptual Design Report and other provisions during the first 100 years after closure are addressed under another ~~Federal~~ federal regulatory program.

Closure of the WIPP facility will contribute to the following:

- Prevention of the intrusion of fluids into the repository by sealing the shafts
- Prevention of human intrusion after closure
- Minimization of future physical and environmental surveillance

Detailed records shall be filed with local, ~~State~~state, and ~~Federal~~ federal government agencies to ensure that the location of the WIPP facility is easily determined and that appropriate notifications and restrictions are given to anyone who applies to drill in the area. This information, together with land survey data, will be on record with the U.S. Geological Survey and other agencies. The ~~Federal~~ federal government will maintain permanent administrative authority over those aspects of land management assigned by law. Details of post-closure activities are in Permit Attachment H.

G-1e(~~3~~4) Performance of the Closed Facility

20.4.1.500 NMAC (incorporating 40 CFR §264.601) requires that a miscellaneous unit be closed in a manner that protects human health and the environment. The RCRA Part B permit application addressed the expected performance of the closed facility during the ~~30 year~~30-year post closure period. Groundwater monitoring will provide information on the performance of the closed facility during the post-closure care period, as specified in Section H-1a(2) (Monitoring) of Permit Attachment H.

The principal barriers to the movement of hazardous constituents from the facility or the movement of waters into the facility are the halite of the Salado ~~Formation~~ (natural barrier) and the repository seals (engineered barrier). Data and calculations that support this discussion were presented in the permit application. The majority of the calculations performed for the repository are focused on long-term performance and making predictions of performance over 10,000 years. In the short term, the repository is reaching a steady state configuration where the hypothetical brine inflow rate is affected by the increasing pressure in the repository due to gas generation and creep closure. These three phenomena are related in the numerical modeling performed to support the permit application. The modeling parameters, assumptions and methodology were described in detail in the permit application.

G-2 Notices Required for Disposal Facilities

G-2a Certification of Closure

Within 60 days after completion of closure activities for a HWMU (i.e., for each storage unit and each disposal unit), the Permittees will submit to the Secretary of the NMED a certification that the unit (and, after completion of final closure, the facility) has been closed in accordance with the specifications of this Closure Plan. The certification will be signed by the Permittees and by an independent New Mexico registered professional engineer. Documentation supporting the independent registered engineer's certification will be furnished to the Secretary of the NMED with the certification.

G-2b Survey Plat

Within 60 days of completion of closure activities for each underground HWDU, and no later than the submission of the certification of closure of each underground HWDU, the Permittees will submit to the Secretary of the NMED a survey plat indicating the location and dimensions of hazardous waste disposal units with respect to permanently surveyed benchmarks. The plat will be prepared and certified by a professional land surveyor and will contain a prominently displayed note that states the Permittees' obligation to restrict disturbance of the hazardous waste disposal unit. In addition, the land records in the Eddy County Courthouse, Carlsbad, New Mexico, will be updated through filing of the final survey plats.

<u>References</u>

Christensen, C. L., and Peterson, E. W. 1981. "Field-Test Programs of Borehole Plugs in Southeastern New Mexico." In ~~The~~ *The* *Technology of High-Level Nuclear Waste Disposal Advances in the Science and Engineering of the Management of High-Level Nuclear Wastes*, P. L. Hofman and J. J. Breslin, eds., SAND79-1634C, DOE/TIC-4621, Vol. 1, pp. 354–369. Technical Information Center of the U.S. Department of Energy, Oak Ridge, TN.

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~~U.S. Department of Energy, 1997, "WIPP Safety Analysis Report," DOE/WIPP-95-2065, Revision 1, U.S. Department of Energy, Carlsbad, NM.~~

<u>U.S. Department of Energy, 2015, "WIPP Nitrate Salt Bearing Waste Container Isolation Plan, Revision 2, Waste Isolation Pilot Plant Hazardous Waste Facility Permit Number: NM4890139088-TSDF," May 29, 2015, U.S. Department of Energy, Carlsbad, NM.</u>

U.S. Environmental Protection Agency, 1996, "Test Methods for Evaluating Solid Waste," SW-846, U.S. Environmental Protection Agency, Washington, D.C.

TABLES

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Table G-1
Anticipated Earliest Closure Dates for the Underground HWDUs

HWDU	OPERATIONS START	OPERATIONS END	CLOSURE START	CLOSURE END
PANEL 1	3/99*	3/03*	3/03*	7/03* SEE NOTE 5
PANEL 2	3/03*	10/05*	10/05*	3/06* SEE NOTE 5
PANEL 3	4/05*	2/07*	2/07*	2/07* SEE NOTE 5
PANEL 4	1/07*	5/09*	5/09*	8/09* SEE NOTE 5
PANEL 5	3/09*	7/11*	7/11*	11/11* SEE NOTE 5
PANEL 6	3/11*	1/14*	1/14*	6/18* SEE NOTE 5
PANEL 7	9/13*	6/18	7/18	3/19
PANEL 8	6/18	6/20	7/20	3/21
PANEL 9	6/20	1/28	2/28	SEE NOTE 4
PANEL 10	1/28	9/30	10/30	SEE NOTE 4

* Actual month and year

NOTE 1: Only Panels 1 to 4 will be closed under the initial term of this permit. Closure schedules for Panels 5 through 10 are projected assuming ~~new permits~~the Permit will be ~~issued~~renewed~~ in 2009 and 2019~~.

NOTE 2: The point of closure start is defined as 60 days following notification to the NMED of closure.

NOTE 3: The point of closure end is defined as 180 days following placement of final waste in the panel.

NOTE 4: The time to close these areas may be extended depending on the nature and extent of the disturbed rock zone. The excavations that constitute these panels will have been opened for as many as 40 years so that the preparation for closure may take longer than the time allotted in Figure G-2. If this extension is needed, it will be requested as an amendment to the Closure Plan.

NOTE 5: Installation of the 12-foot explosion-isolation wall for Panels 1, 2, and 5 has been completed. Final closure of Panels 1 through 6 will be completed as specified in this Permit no later than June 30, 2018.

Table G-2
Anticipated Overall Schedule for Closure Activities

ACTIVITY	FINAL FACILITY CLOSURE	
	START	STOP
Notify NMED of Intent to Close WIPP (or to Implement Contingency Closure)	October 2030	N/A
Perform Contamination Surveys in both Surface Storage Areas	October 2030	April 2031
Sample Analysis	December 2030	July 2031
Decontamination as Necessary of both Surface Storage Areas	June 2031	January 2032
Final Contamination Surveys of both Surface Storage Areas	February 2032	September 2032
Sample Analysis	June 2032	January 2033
Prepare and Submit Container Management Unit Closure Certification	February 2033	May 2033
Dispose of Closure-Derived Waste	November 2030	January 2032
Closure of Open Underground HWDU panel	February 2032*	September 2032
Install Borehole Seals	October 2032	September 2033
Install Repository Seals	June 2033	September 2037
Recontour and Revegetate	October 2037	May 2038
Prepare and Submit Final (Contingency) Closure Certification	October 2037	May 2038
Post-closure Monitoring	July 2038	N/A

N/A--Not Applicable

Refer to Figures G-3 and G-4 for precise activity titles.

*This assumes the final waste is placed in this unit in January 2032 and notification of closure for this HWDU is submitted to the NMED in December 2031.

Table G-3
Governing Regulations for Borehole Abandonment

Federal or State Land	Type of Well or Borehole	Governing Regulation	Summary of Requirements
Both	Groundwater Surveillance	State and Federal regulation in effect at time of abandonment	Monitor wells no longer in use shall be plugged in such a manner as to preclude migration of surface runoff or groundwater along the length of the well. Where possible, this shall be accomplished by removing the well casing and pumping expanding cement from the bottom to the top of the well. If the casing cannot be removed, the casing shall be ripped or perforated along its entire length if possible, and grouted. Filling with bentonite pellets from the bottom to the top is an acceptable alternative to pressure grouting.
Federal	Oil and Gas Wells	43 CFR Part 3160, §§ 3162.3-4	The operator shall promptly plug and abandon, in accordance with a plan first approved in writing or prescribed by the authorized officer.
Federal	Potash	43 CFR Part 3590, § 3593.1	(b) Surface boreholes for development or holes for prospecting shall be abandoned to the satisfaction of the authorizing officer by cementing and/or casing or by other methods approved in advance by the authorized officer. The holes shall also be abandoned in a manner to protect the surface and not endanger any present or future underground operation, any deposit of oil, gas, or other mineral substances, or any aquifer.
State	Oil and Gas Well Outside the Oil-Potash Area	State of New Mexico, Oil Conservation Division, Rule 202 (eff. 3-1-91)	B. Plugging (1) Prior to abandonment, the well shall be plugged in a manner to permanently confine all oil, gas, and water in the separate strata where they were originally found. This can be accomplished by using mud-laden fluid, cement, and plugs singly or in combination as approved by the Division on the notice of intention to plug. (2) The exact location of plugged and abandoned wells shall be marked by the operator with a steel marker not less than four inches (4") in diameter, set in cement, and extending at least four feet (4') above mean ground level. The metal of the marker shall be permanently engraved, welded, or stamped with the operator name, lease name, and well number and location, including unit letter, section, township, and range.
State	Oil and Gas Wells Inside the Oil-Potash Area	State of New Mexico, Oil Conservation Division, Order No. R-111-P (eff. 4-21-88)	F. Plugging and Abandonment of Wells (1) All existing and future wells that are drilled within the potash area, shall be plugged in accordance with the general rules established by the Division. A solid cement plug shall be provided through the salt section and any water-bearing horizon to prevent liquids or gases from entering the hole above or below the salt selection. It shall have suitable proportions—but no greater than three (3) percent of calcium chloride by weight—of cement considered to be the desired mixture when possible.

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FIGURES

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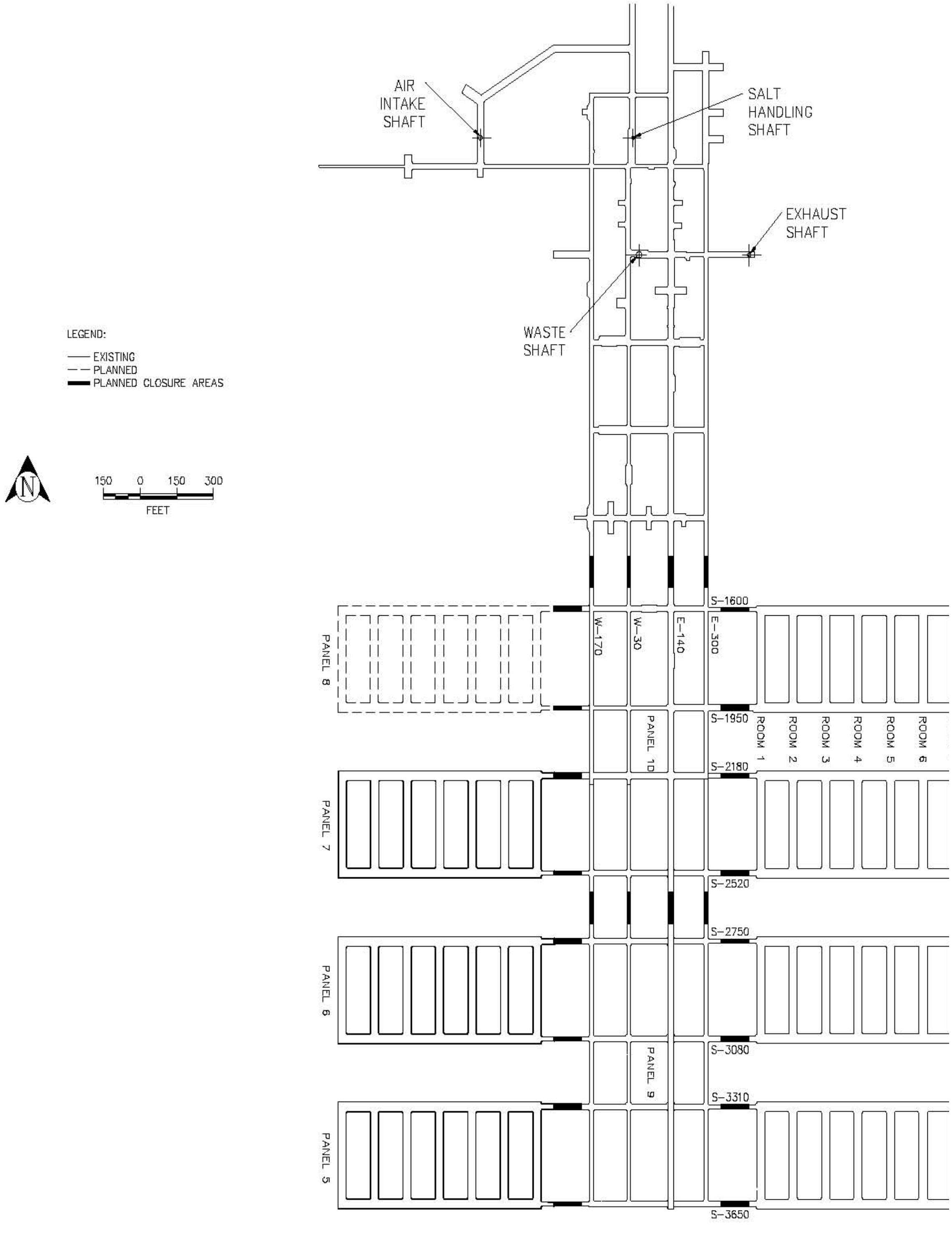
AIR
INTAKE
SHAFT
SALT
HANDLING
SHAFT
EXHAUST
SHAFT
WASTE
SHAFT
LEGEND:
EXISTING
PLANNED
PLANNED CLOSURE AREAS
150 0 150 300
FEET
S-1600
W-170
W-30
E-140
E-300
PANEL 8
S-1950
PANEL 10
ROOM 1
ROOM 2
ROOM 3
ROOM 4
ROOM 5
ROOM 6
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PANEL 9
S-3310
PANEL 5
S-3650

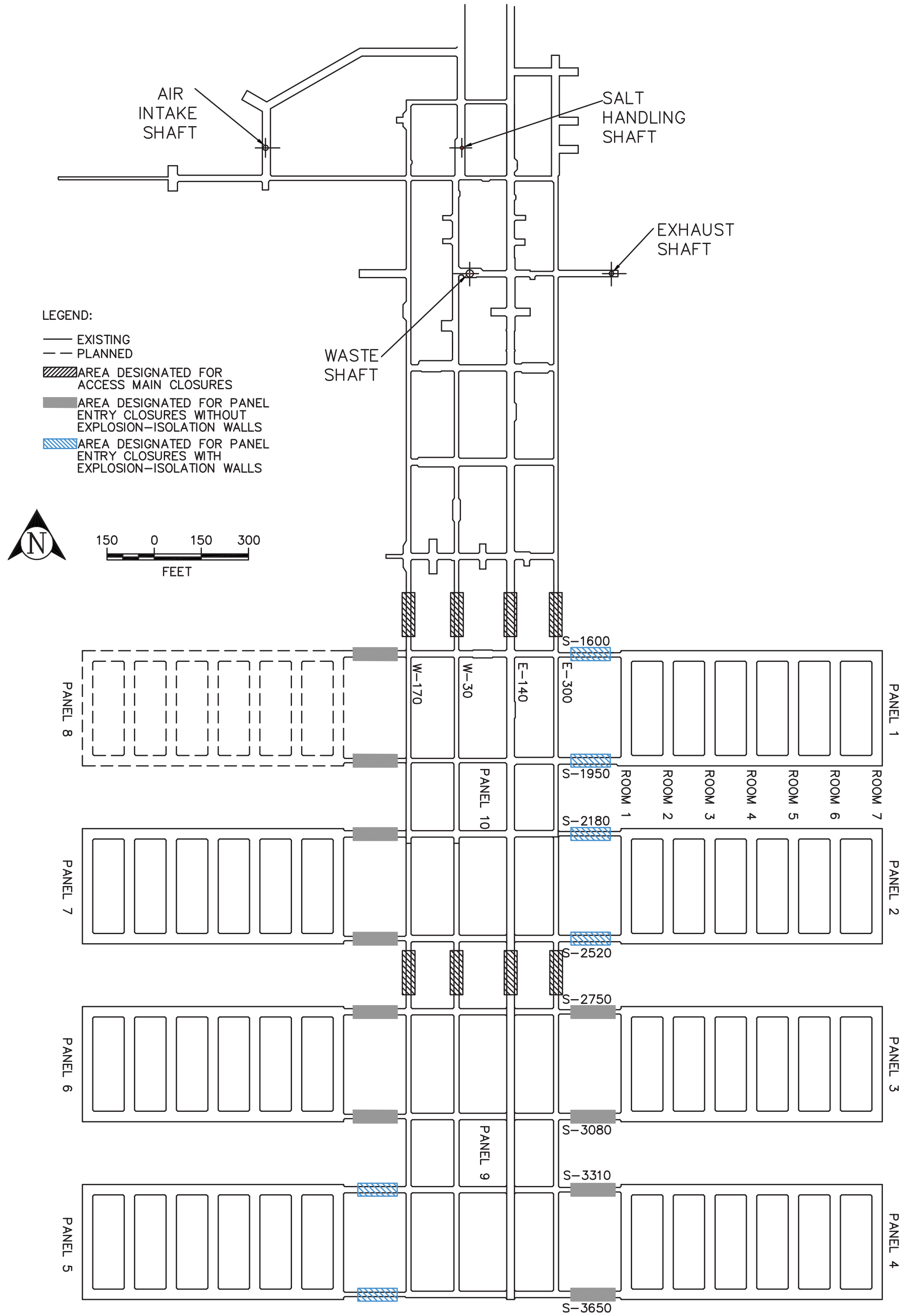


Figure G-1
Location of Underground HWDUs and Anticipated ~~Closure~~WPC Locations

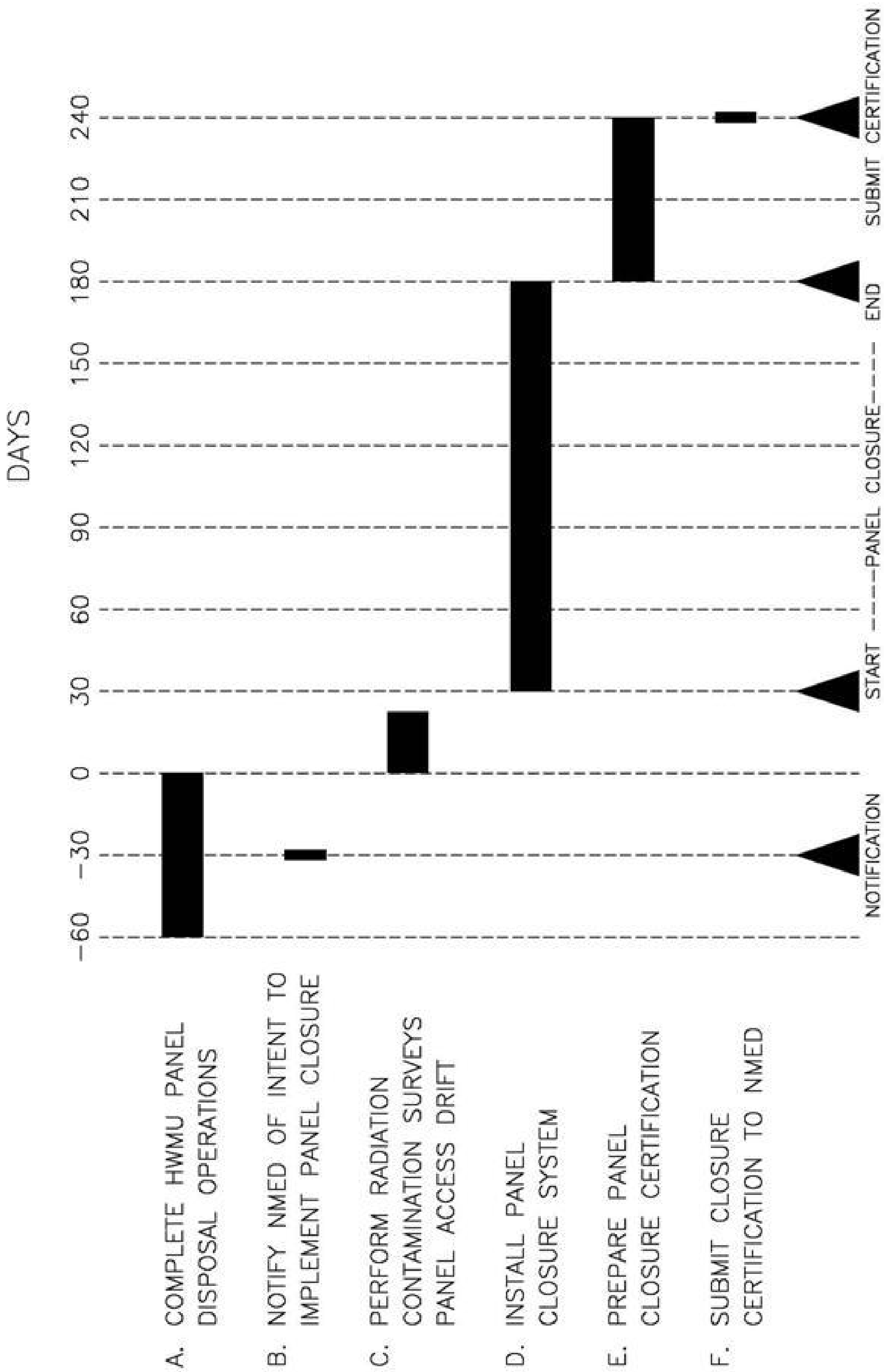


Figure G-2
WIPP Panel Closure Schedule

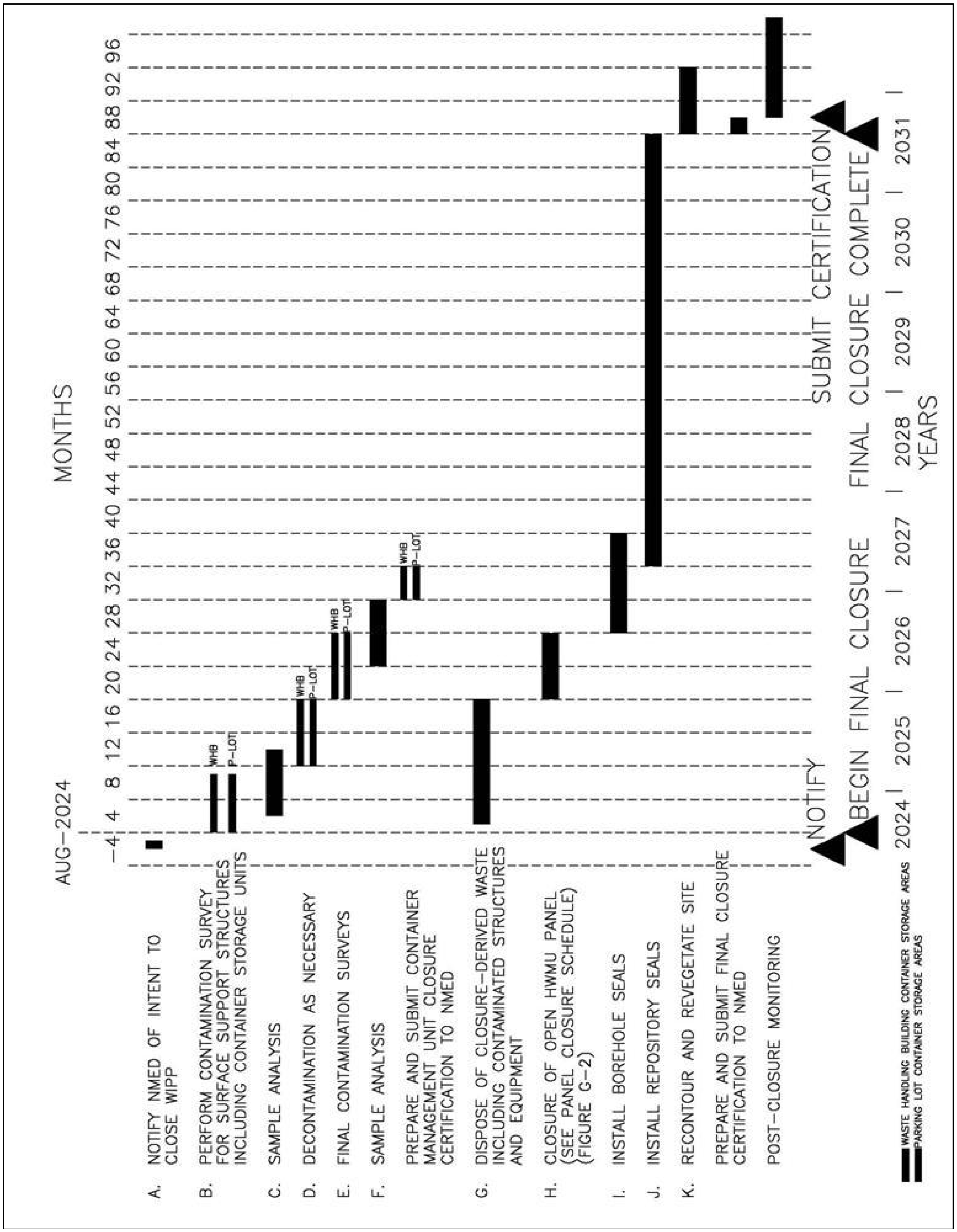
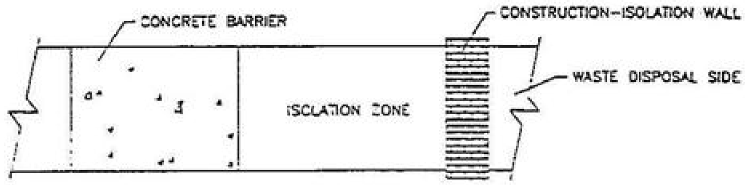
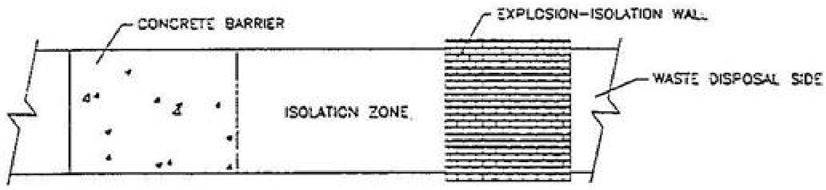


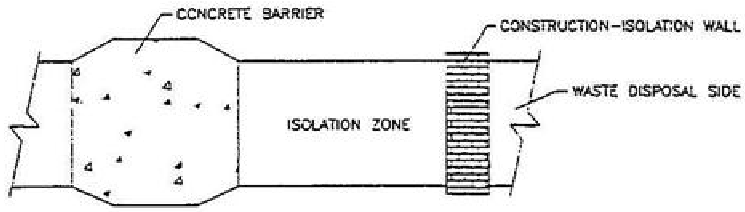
Figure G-3
WIPP Facility Final Closure 84-Month Schedule



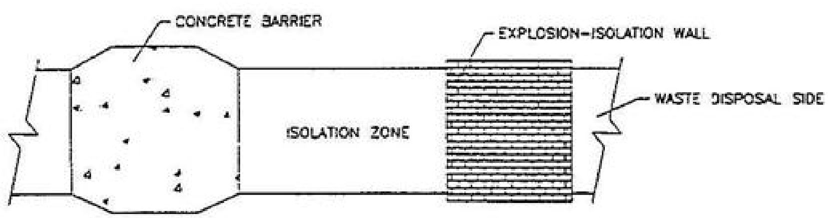
OPTION A. CONSTRUCTION ISOLATION WALL AND CONCRETE BARRIER WITHOUT DRZ REMOVED



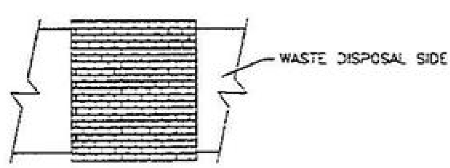
OPTION B. EXPLOSION ISOLATION WALL AND CONCRETE BARRIER WITHOUT DRZ REMOVED



OPTION C. CONSTRUCTION ISOLATION WALL AND CONCRETE BARRIER WITH DRZ REMOVED



OPTION D. EXPLOSION ISOLATION WALL AND CONCRETE BARRIER WITH DRZ REMOVED



OPTION E. CINDERBLOCK BARRIER/EXPLOSION-ISOLATION WALL

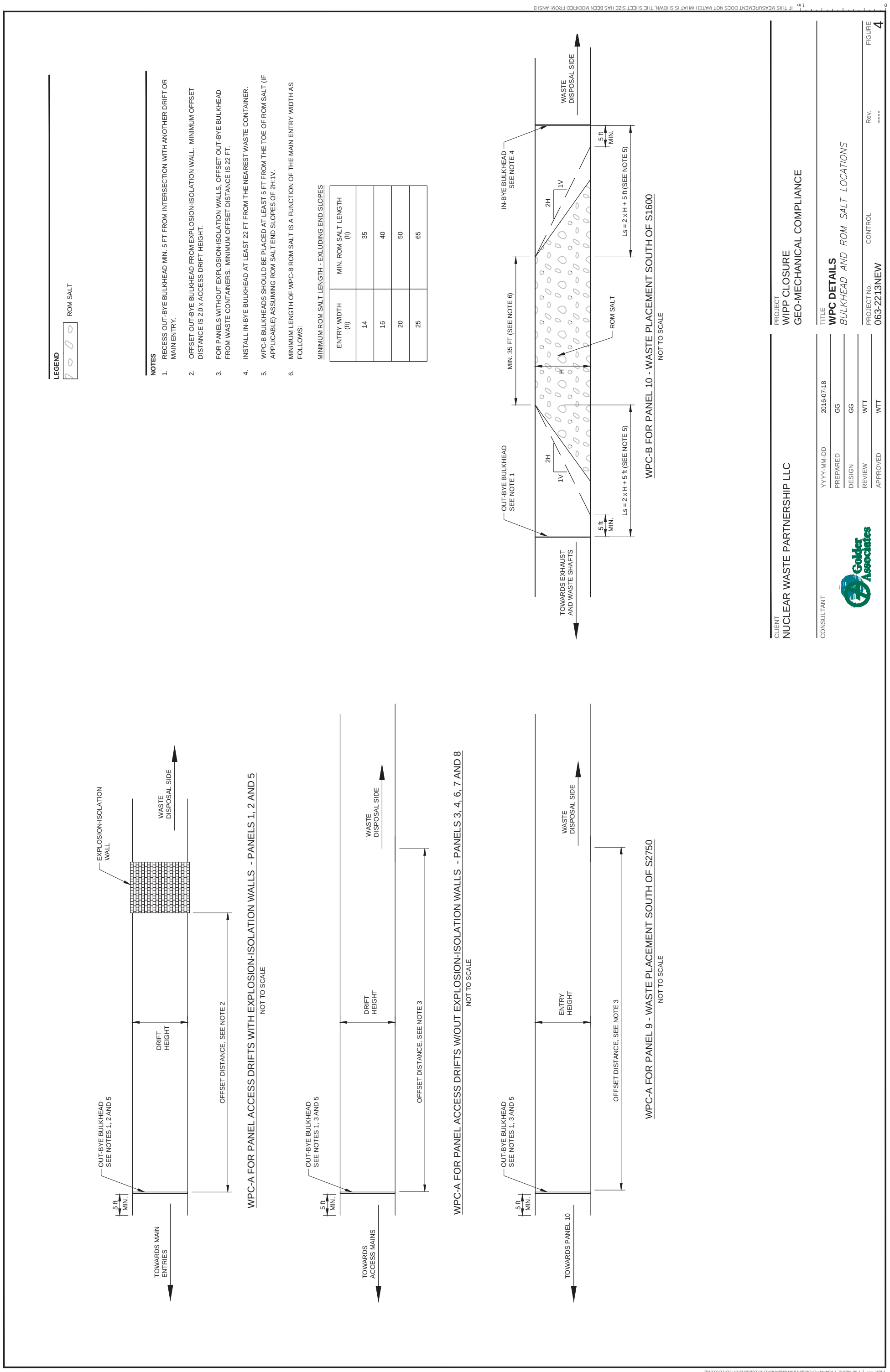
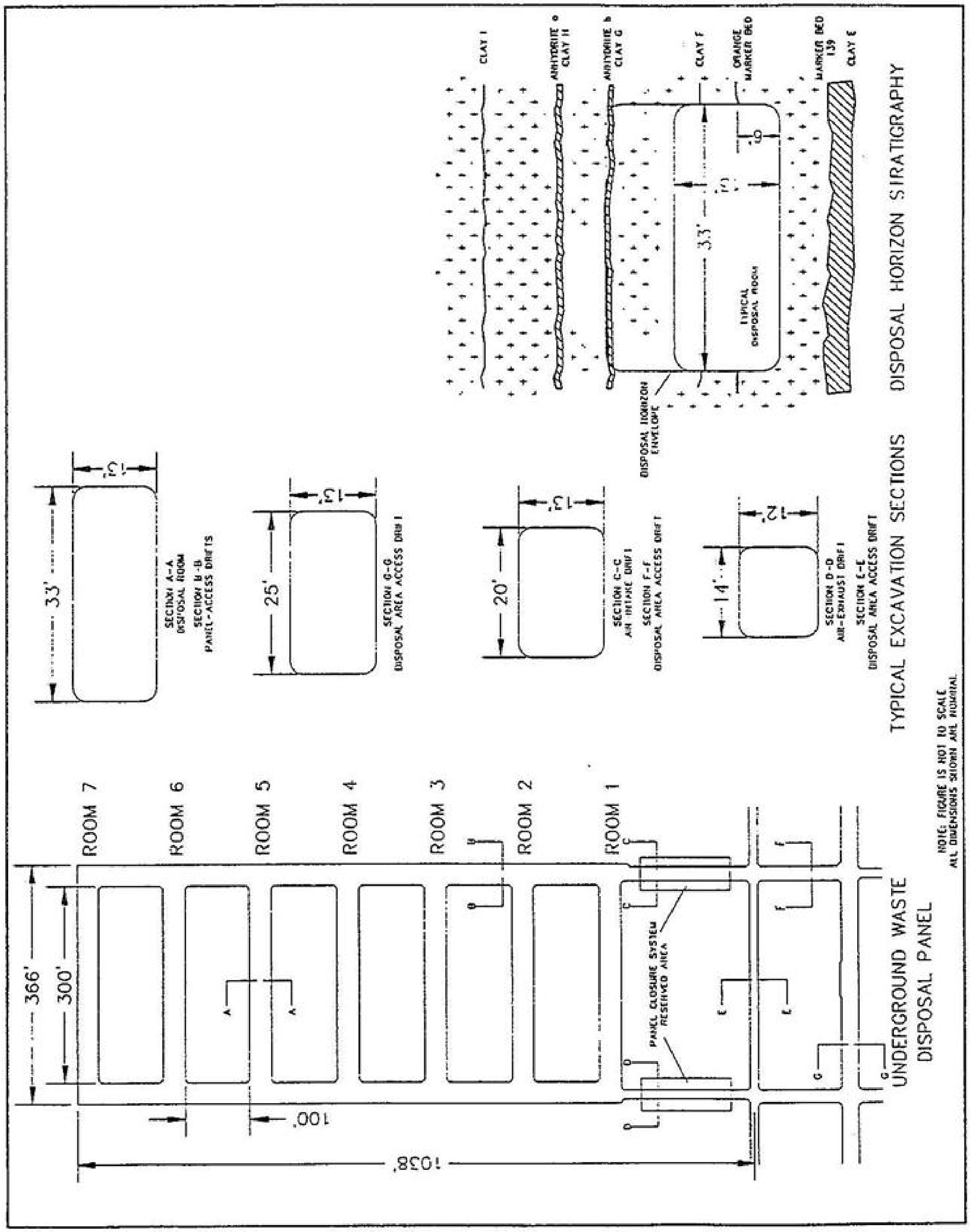


Figure G-4

~~Design of a Panel Closure System~~Bulkhead and ROM Salt Locations


UNDERGROUND WASTE DISPOSAL PANEL
ROOM 1
ROOM 2
ROOM 3
ROOM 4
ROOM 5
ROOM 6
ROOM 7
366'
300'
100'
1038'
PANEL CLOSURE SYSTEM RESERVED AREA
TYPICAL EXCAVATION SECTIONS
33'
13'
SECTION A-A DISPOSAL ROOM
SECTION B-B PANEL-ACCESS DRIFTS
25'
13'
SECTION G-G DISPOSAL AREA ACCESS DRIFT
20'
13'
SECTION C-C AIR INTAKE DRIFT
SECTION F-F DISPOSAL AREA ACCESS DRIFT
14'
12'
SECTION D-D AIR-EXHAUST DRIFT
SECTION E-E DISPOSAL AREA ACCESS DRIFT
DISPOSAL HORIZON STRATIGRAPHY
CLAY I
ANHYDRITE a
CLAY H
ANHYDRITE b
CLAY G
CLAY F
ORANGE MARKER BED
MARKER BED 139
CLAY E
TYPICAL DISPOSAL ROOM
DISPOSAL HORIZON ENVELOPE
33'
6'
NOTE: FIGURE IS NOT TO SCALE
ALL DIMENSIONS SHOWN ARE NOMINAL

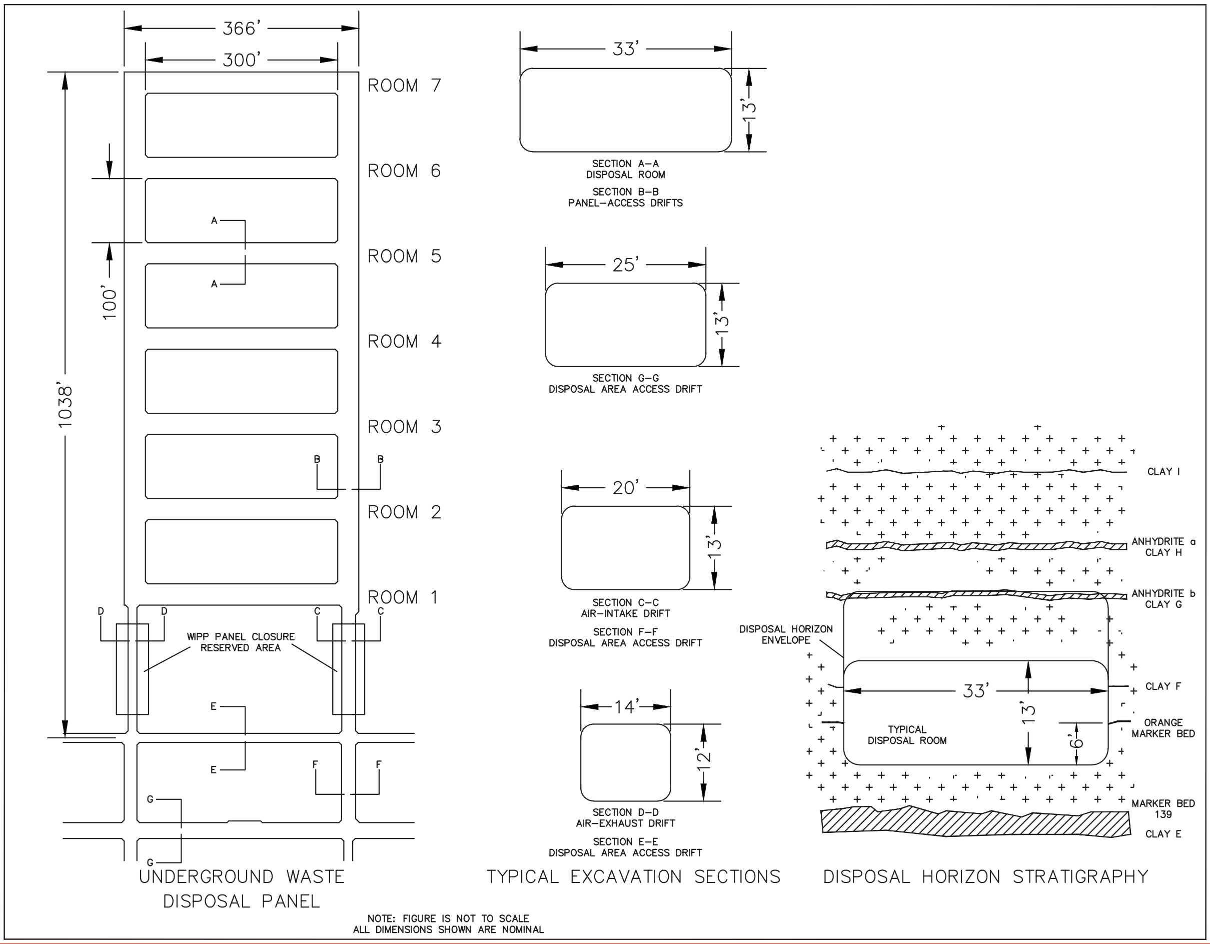
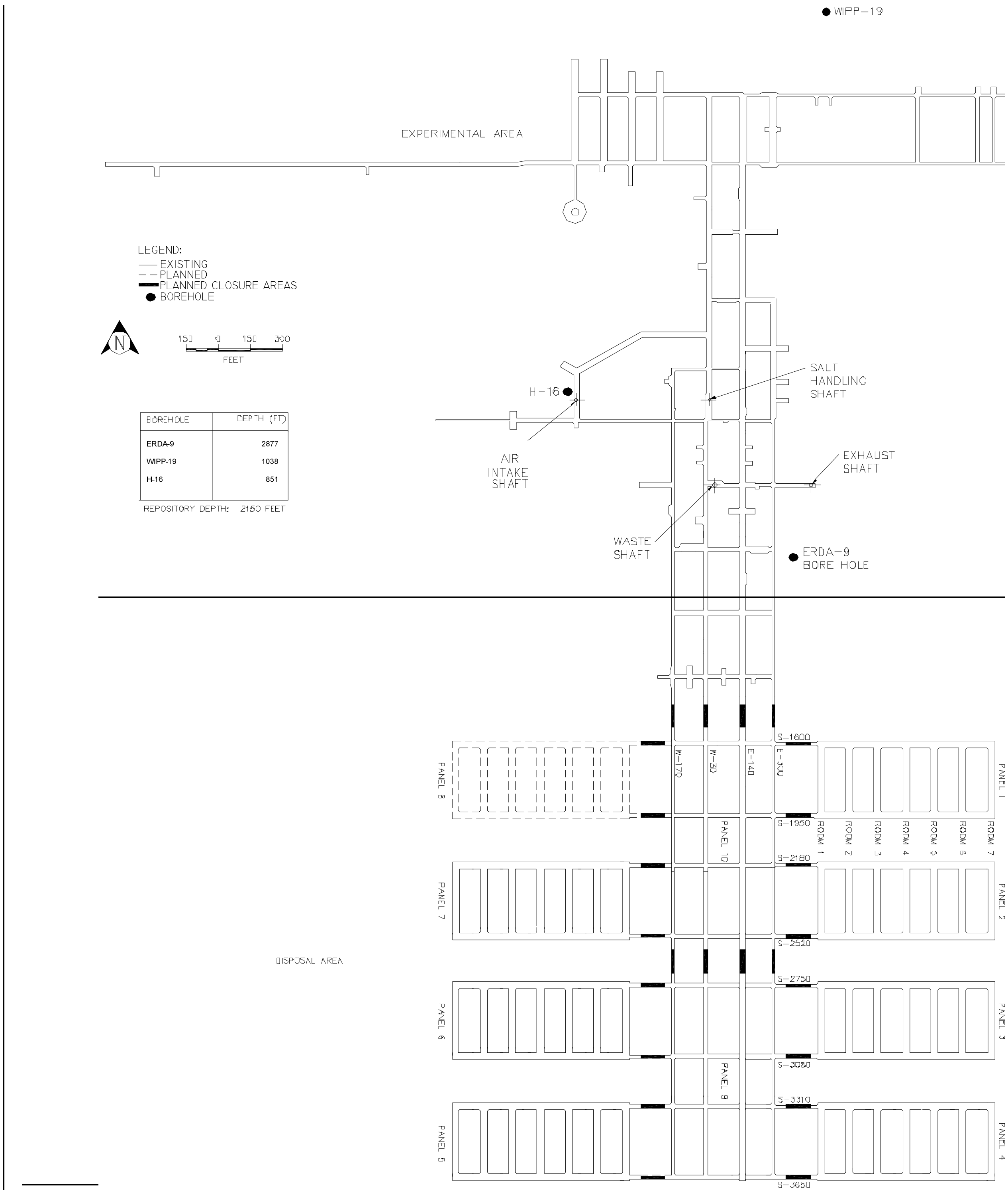


Figure G-5
Typical Disposal Panel


WIPP-19
EXPERIMENTAL AREA
LEGEND:
EXISTING
PLANNED
PLANNED CLOSURE AREAS
BOREHOLE
150 0 150 300
FEET
H-16
SALT
HANDLING
SHAFT
AIR
INTAKE
SHAFT
EXHAUST
SHAFT
BOREHOLE DEPTH (FT)
ERDA-9 2877
WIPP-19 1038
H-16 851
REPOSITORY DEPTH: 2150 FEET
WASTE
SHAFT
ERDA-9
BORE HOLE
S-1600
W-170
W-30
E-140
E-300
PANEL 8
PANEL 1
S-1950
ROOM 1
ROOM 2
ROOM 3
ROOM 4
ROOM 5
ROOM 6
ROOM 7
PANEL 10
S-2180
PANEL 7
PANEL 2
S-2520
DISPOSAL AREA
S-2750
PANEL 6
PANEL 3
S-3080
PANEL 9
S-3310
PANEL 5
PANEL 4
S-3650

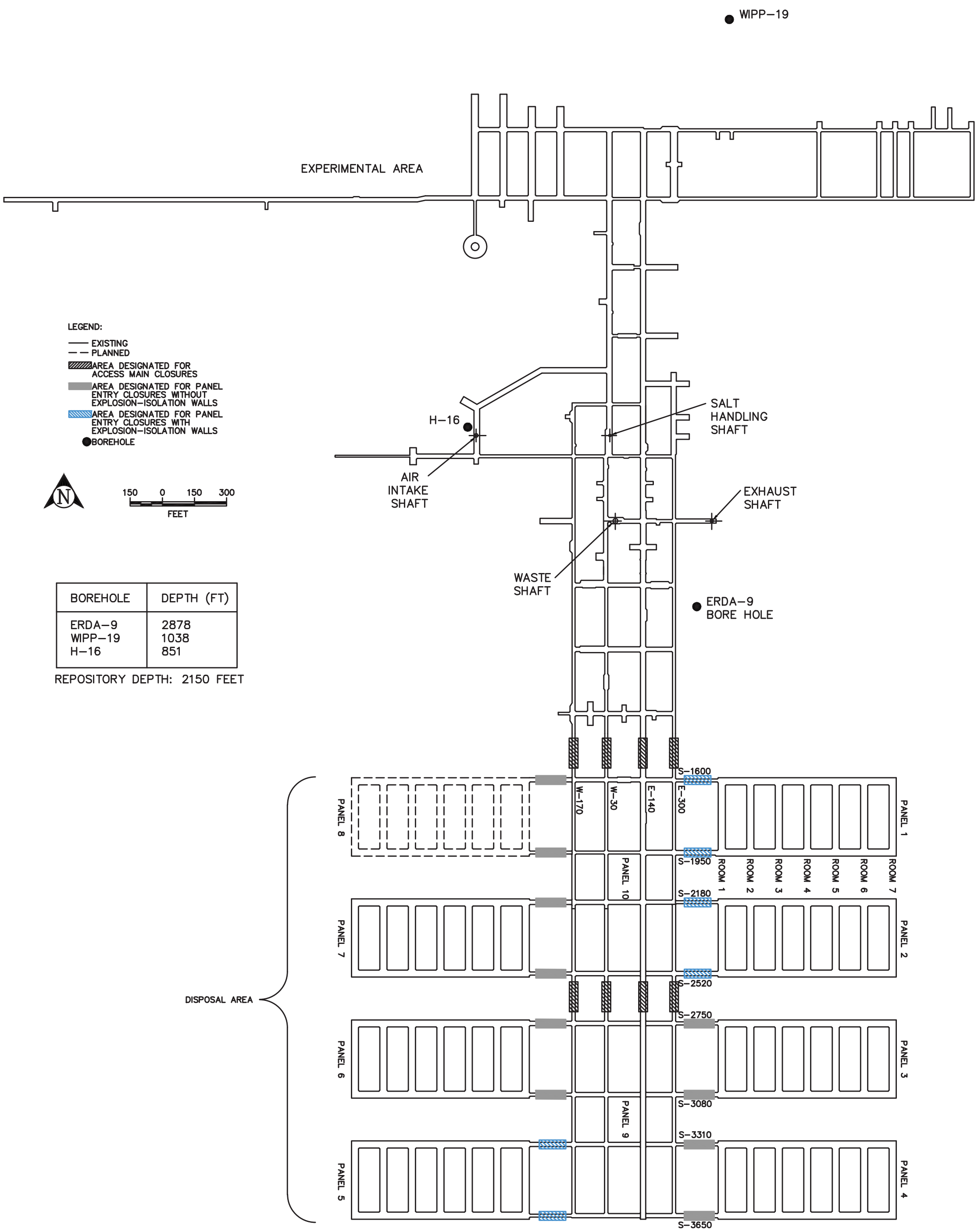


Figure G-6
Approximate Locations of Boreholes in Relation to the WIPP Underground

ATTACHMENT G1

DETAILED DESIGN REPORT FOR AN OPERATION PHASE PANEL CLOSURE SYSTEM

Adapted from DOE/WIPP 96-2150

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~~ATTACHMENT G1~~

~~DETAILED DESIGN REPORT FOR AN OPERATION PHASE PANEL CLOSURE SYSTEM~~

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~~*Appendix B—Calculations in Support of Panel Gas Pressurization Due to Creep Closure~~
~~*Appendix C—FLAC Modeling of the Panel Closure System~~
~~*Appendix D—Brine/Cement Interactions~~
~~*Appendix E—Previous Studies of Panel-Closure System Materials~~
~~*Appendix F—Heat Transfer Model, Derivation Methane Explosion~~
~~Appendix G1-G—Technical Specifications~~
~~Appendix G1-H—Design Drawings~~

~~*Appendices A through F are not included in the Permit.~~

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LIST OF ABBREVIATIONS/ACRONYMS

ACI	American Concrete Institute
AISC	American Institute for Steel Construction
*CFR	Code of Federal Regulations
cm	centimeter
°C	degrees celsius
°F	degrees Fahrenheit
DOE	U.S. Department of Energy
DRZ	disturbed rock zone
EEP	Excavation Effects Program
ESC	expansive salt-saturated concrete
FLAC	Fast Lagrangian Analysis of Continua
ft	foot (feet)
GPR	ground-penetrating radar
Kips	1,000 pounds
m	meter(s)
MB 139	Marker Bed 139
MOC	Management and Operating Contractor (Permit Section 1.5.3)
MPa	megapascal(s)
MSHA	Mine Safety and Health Administration
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NaCl	sodium chloride
NMVP	no-migration variance petition
psi	pound(s) per square inch
RCRA	Resource Conservation and Recovery Act
SMC	Salado Mass Concrete
TRU	transuranic
VOC	volatile organic compound(s)
WIPP	Waste Isolation Pilot Plant

~~ATTACHMENT G1~~

~~DETAILED DESIGN REPORT FOR AN OPERATION PHASE PANEL CLOSURE SYSTEM~~

~~Executive Summary~~

~~**Scope.** Under contract to the Management and Operating Contractor (**MOC**), IT Corporation has prepared a detailed design of a panel-closure system for the Waste Isolation Pilot Plant (**WIPP**). Preparation of this detailed design of an operational-phase closure system is required to support a Resource Conservation and Recovery Act (**RCRA**) Part B permit application. This report describes the detailed design for a panel-closure system specific to the WIPP site. The recommended panel-closure system will adequately isolate the waste-emplacement panels for at least 35 years.~~

~~The report was modified to make it a part of the RCRA Permit issued by the New Mexico Environment Department. The primary change required in the original report was to specify that Panel Closure Design Options A, B, C and E are not approved as part of the facility Permit. Option D is the most robust of the original group of options, and it was specified in the Permit as the design to be constructed for all panel closures. The concrete to be used for panel closures is salt-saturated Salado Mass Concrete as specified in Permit Attachment G1, Appendix G, instead of the proposed plain concrete. The Permittees may submit proposals to modify the Permit (Part 2), the Closure Plan (Permit Attachment G) and this Appendix (identified as Permit Attachment G1) in the future, as specified in 20.4.1.900 NMAC (incorporating 40 CFR §270.42).~~

~~Other changes included in this version of the report revised for the permit are minor edits to regulatory citations, deletion of references to the No Migration Variance Petition (no longer required under 40 CFR §268.6), and movement of all figures to the end of the document. Appendices A through F in the original document are not included in this Permit Attachment. Although those Appendices were important in demonstrating that the panel closures will meet the performance standards in the hazardous waste regulations, they do not provide design details or plans to be implemented as Permit requirements. References to these original Appendices were modified to indicate that they were part of the permit application, but are not included in the Permit. In contrast, Appendix G (Technical Specifications) and Appendix H (Design Drawings) are necessary components of future activities and are retained as parts of this Permit Attachment.~~

~~**Purpose.** This report provides detailed design and material engineering specifications for the construction, emplacement, and interface-grouting associated with a panel-closure system at the WIPP repository, which would ensure that an effective panel-closure system is in place for at least 35 years. The panel-closure system provides assurance that the limit for the migration of volatile organic compounds (**VOC**) will be met at the point of compliance, the WIPP site boundary. This assurance is obtained through the inherent flexibility of the panel-closure system. The panel-closure system will be located in the air-intake and air-exhaust drifts (Figure G1-1). The system components have been designed to maintain their intended functional requirements under loads generated from salt creep, internal pressure, and a postulated methane explosion. The design complies with regulatory requirements for a panel-closure system promulgated by RCRA and the Mine Health and Safety Administration (**MSHA**). The design uses common construction practices according to existing standards.~~

Background. The engineering design considers a range of expected subsurface conditions at the location of a panel-closure system. The geology is predominantly halite with interbedded anhydrite at the repository horizon. During the operational period, the panel-closure system would be subject to creep from the surrounding host rock that contains trace amounts of brine.

During the conceptual design stage, two air-flow models were evaluated: (1) unrestricted flow and (2) restricted flow through the panel-closure system. The "unrestricted" air flow model is defined as a model in which the gas pressure that develops is at or very near atmospheric pressure such that there exists no back pressure in the disposal areas. Flow is unrestricted in this model. The "restricted" air flow model is defined as a model in which the back pressure in the waste emplacement panels develops due to the restriction of flow through the barrier, and the surrounding disturbed rock zone. The analysis was based on an assumed gas generation rate of 8,200 moles per panel per year (0.1 moles per drum per year) due to microbial degradation, an expected volumetric closure rate of 28,000 cubic feet (800 cubic meters) per year due to salt creep, the expected headspace concentration for a series of nine VOCs, and the expected air dispersion from the exhaust shaft to the WIPP site boundary. The analysis indicated that the panel-closure system would limit the concentration of each VOC at the WIPP site boundary to a small fraction of the health-based exposure limits during the operational period.

Alternate Designs. Various options were evaluated considering active systems, passive systems, and composite systems. Consideration of the aforementioned factors led to the selection of a passive panel-closure system consisting of an enlarged tapered concrete barrier which will be grouted at the interface and an explosion-isolation wall. This system provides flexibility for a range of ground conditions likely to be encountered in the underground repository. No other special requirements for engineered components beyond the normal requirements for fire suppression and methane explosion or deflagration containment exist for the panel-closure system during the operational period.

The panel-closure system design incorporates mitigative measures to address the treatment of fractures and therefore minimizes the potential migration of contaminants. The design includes excavating the disturbed rock zone (**DRZ**) and emplacing an enlarged concrete barrier.

To be effective, the excavation and installation of the panel-closure system must be completed within a short time frame to minimize disturbance to the surrounding salt. A rigid concrete barrier will promote interface stress buildup, as fractures are expected to heal with time. For this purpose, the main concrete barrier would be tapered to reduce shear stress and to increase compressive stress along the interface zone.

Design Classification. Procedure WP 09-CN3023 (Westinghouse, 1995a) was used to establish a design classification for the panel-closure system. It uses a decision-flow-logic process to designate the panel-closure system as a Class IIIB structure. This is because during the methane explosion the concrete barrier would not fail.

Design Evaluations. To investigate several key design issues, design evaluations were performed. These design evaluations can be divided into those that satisfy (1) the operational requirements of the system and (2) the structural and material requirements of the system.

The conclusions reached from the evaluations addressing the operational requirements are as follows:

- Based on an air-flow model used to predict the mass flow rate of carbon tetrachloride through the panel-closure system for the alternatives, the air-flow analysis suggests that the fully enlarged barrier provides the highest protection for restricting VOCs during the operational period of 35 years.

- Results of the Fast Lagrangian Analysis of Continua (**FLAC**) analyses show that the recommended enlarged configuration is a circular rib-segment excavated to Clay G and under MB 139. Interface grouting would be performed at the upper boundary of the concrete barrier.

- The results of the transverse plane-strain models show that higher stresses would form in MB 139 following excavation, but that after installation of the panel-closure system, the barrier confinement will result in an increase in barrier-confining stress and a reduction in shear stress. The main concrete barrier would provide substantial uniform confining stresses as the barrier is subjected to secondary salt creep.

- The removal of the fractured salt prior to installation of the main concrete barrier would reduce the potential for flexure. The fracturing of MB 139 and the attendant fracturing of the floor could reduce structural load resistance (structural stiffness), which could initially result in barrier flexure and shear. With the removal of MB 139, the fractured salt stiffens the surrounding rock and results in the development of more uniform compression.

- The trade-off study also showed that a panel-closure system with an enlarged concrete barrier with the removal of the fractured salt roof and anhydrite in the floor was found to be the most protective.

The conclusions reached from the design evaluations addressing the structural and material requirements of the panel-closure system are as follows:

- Existing information on the heat of hydration of the concrete supports placing concrete with a low cement content to reduce the temperature rise associated with hydration. Plasticizers might be used to achieve the required slump at the required strength. A thermal analysis, coupled with a salt creep analysis, suggests installation of the enlarged barrier at or below ambient temperatures to adequately control hydration temperatures.

- In addition to installation at or below ambient temperatures, the concrete used in the main barrier would exhibit the following:

    - An 8 inch (0.2 meter) slump after 3 hours of intermittent mixing

    - A less-than-25-degree Fahrenheit heat rise prior to installation

    - An unconfined compressive strength of 4,000 pounds per square inch (psi) (28 megapascals [MPa]) after 28 days

- Volume stability

- Minimal entrained air.

- The trace amounts of brine from the salt at the repository horizon will not degrade the main concrete barrier for at least 35 years.

- In 20 years, the open passage above the waste stack would be reduced in size. Further, rooms with bulkheads at each end would be isolated in the panel. It is unlikely that a long passage with an open geometry would exist; therefore, the dynamic analysis considered a deflagration with a peak explosive pressure of 240 psi (1.7 MPa).

- The heat-transfer analysis shows that elevated temperatures would occur within the salt and the explosion-isolation wall; however, the elevated temperatures will be isolated by the panel-closure system. Temperature gradients will not significantly affect the stability of the wall.

- The fractures in the roof and floor could be affected by expanding gas products reaching pressures on the order of 240 psi (1.7 MPa). Because the peak internal pressure from the deflagration is only one fifth of the pressure, fractures could not propagate beyond the barrier.

A composite system is selected for the design with various components to provide flexibility. These design options are described below.

Design Options. Figure G1-2 illustrates the options developed to satisfy the requirements for the panel-closure system. The basis for selecting an option depends on conditions at the panel-closure system locations as would be documented by future subsurface investigations. As noted earlier, Option D is the only option approved for construction as part of the facility permit issued by the NMED.

While no specific requirements exist for barricading inactive waste areas under the MSHA, their intent is to safely isolate these abandoned areas from active workings using barricades of “substantial construction.” A previous analysis (DOE, 1995) examined the issue of methane gas generation from transuranic waste and the potential consequence in closed areas. The principal concern is whether an explosive mixture of methane with an ignition source would result in deflagration. A concrete block wall of sufficient thickness will be used to resist dynamic and salt creep loads.

It was shown (DOE, 1995) that an explosive atmosphere may exist after approximately 20 years.

Design Components. The enlarged concrete barrier location within the air-intake and air-exhaust drifts will be determined following observation of subsurface conditions. The enlarged concrete barrier will be composed of salt-saturated Salado Mass Concrete with sufficient unconfined compressive strength. The barrier will consist of a circular rib segment excavated into the surrounding salt where the central portion of the barrier will extend just beyond Clay G and MB 139. FLAC analyses showed that plain concrete will develop adequate confined compressive strength.

The enlarged concrete barrier will be placed in four cells, with construction joints formed perpendicular to the direction of potential air flow. The concrete will be placed through 6-inch (15.2 centimeter) diameter steel pipes and will be vibrated from outside the formwork. The formwork is designed to withstand the hydrostatic loads that would occur during installation with minimal bracing onto exposed salt surfaces. This will be accomplished by a series of steel plates that are stiffened by angle iron, with load reactions carried by spacer rods. Some exterior bracing will be required when the concrete is poured into the first cell at the location for the enlarged concrete barrier. All structural steel will be American Society of Testing and Materials [grade] A36 in conformance with the latest standards specified by the American Institute for Steel Construction. After concrete placement, the formwork will be left in place and will stiffen the enlarged concrete barrier if nonuniform reactive loadings should occur after panel closure.

After completion of the enlarged concrete barrier installation, it will be grouted through a series of grout supply and air return lines that terminate in grout boxes. The boxes will be mounted near the top of the barrier. The grout will be injected through one set of lines and returned through a second set of air lines.

An explosion-isolation wall, constructed with concrete-blocks, will mitigate the effects of a methane explosion. The explosion-isolation wall would consist of 3,500 psi (24 MPa) concrete blocks mortared together with a bonding agent. The concrete-block wall design complies with MSHA requirements, because it consists of noncombustible materials of “substantial construction.” The concrete-block walls will be keyed into the salt. For the WIPP, an explosion-isolation wall is designed to resist loading from salt creep.

The compliance of the detailed design was evaluated against the design requirements established for the panel-closure system. The design complies with all aspects of the design basis established for the panel-closure system.

1.0 Introduction

The Waste Isolation Pilot Plant (**WIPP**) repository, a U.S. Department of Energy (**DOE**) research facility located near Carlsbad, New Mexico, is approximately 2,150 feet (ft) (655 meters [m]) below the surface, in the Salado Formation. The WIPP facility consists of a northern experimental area, a shaft-pillar area, and a waste-emplacement area. The WIPP facility will be used to dispose transuranic (**TRU**) mixed waste.

One important aspect of future repository operations at the WIPP is the activities associated with closure of waste-emplacement panels. Each panel consists of air-intake and air-exhaust drifts, panel-access drifts, and seven rooms (Figure G1-1). After completion of waste-emplacement activities, each panel will be closed, while waste emplacement may be occurring in the other panel(s). The closure of individual panels during the operational period will be conducted in compliance with project-specific health, safety, and environmental performance criteria.

1.1 Scope

This report provides information on the detailed design and material engineering specifications for the construction, installation, and interface grouting associated with a panel-closure system for a minimum operational period of 35 years. The panel-closure system design provides assurance that the limit for the migration of volatile organic compounds (**VOC**) will be met at the point of compliance, the WIPP site boundary. This assurance is obtained through the inherent flexibility of the panel closure system. The panel-closure system will be located in the air-intake and air-exhaust drifts to each panel (Figure G1-1). The panel-closure system design maintains its intended functional requirements under loads generated from salt creep, internal panel pressure, and a postulated methane explosion. The design complies with regulatory requirements for a panel-closure system promulgated by the Resource Conservation and Recovery Act (**RCRA**) and Mine Safety and Health Administration (**MSHA**) (see citations in Section 1.3 below).

Figure G1-3 illustrates the design process used for preparing the detailed design. The design process commenced with the evaluation of the performance requirements of the panel-closure system through review of the work performed in developing the conceptual design and the "Underground Hazardous Waste Management Unit Closure Criteria for the Waste Isolation Pilot Plant Operation Phase" (Westinghouse, 1995b). The various design evaluations were performed to address specific design-implementation issues identified by the project. The results of these design evaluations are presented in this report.

1.2 Design Classification

Procedure WP 09-CN3023 (Westinghouse, 1995a) was used to establish a design classification for the panel-closure system. The design classification for the panel-closure system evolved from addressing the short-term operational issues regarding the reduction of VOC migration. Figure G1-4 shows the decision flow logic process used to designate the panel-closure system as a Class IIIB structure.

1.3 Regulatory Requirements

The following subsections discuss the regulatory requirements specified in RCRA and MSHA for the panel-closure system.

1.3.1 Resource Conservation and Recovery Act (40 CFR §264 and §270)

In accordance with 20.4.1.500 NMAC, incorporating Title 40, Code of Federal Regulations (**CFR**), Part 264, Subpart X (40 CFR §264, Subpart X), "Miscellaneous Units," and 20.4.1.900 NMAC, incorporating 40 CFR §270.23, "Specific Part B Information Requirements for Miscellaneous Units," a RCRA Part B permit application has been submitted for the WIPP facility.

1.3.2 Protection of the Environment and Human Health

The WIPP RCRA Part B permit application indicates that VOCs must not exceed health-based standards beyond the WIPP site boundary. Worker exposure to VOCs, and VOC emissions to non-waste workers or to the nearest resident will not pose greater than a 10^{-6} excess cancer risk in order to meet health-based standards. The panel-closure system design incorporates measures to mitigate VOC migration for compliance with these standards.

1.3.3 Closure Requirements 20.4.1.500 NMAC

The Permittees will notify the Secretary of the New Mexico Environment Department in writing at least 60 days prior to the date on which partial and final closure activities are scheduled to begin.

1.3.4 Mining Safety and Health Administration

The significance of small natural-gas occurrences within the WIPP repository is within the classification of Category IV for natural gas under the MSHA (30 CFR 57, Subpart T) (MSHA, 1987). These regulations include the hazards of methane gas and volatile dust. Category IV "applies to mines in which non-combustible ore is extracted and which liberate a concentration of methane that is not explosive nor capable of forming explosive mixtures with air based on the history of the mine or the geological area in which the mine is located." For "barriers and stoppings," the regulations provide for noncombustible materials (where appropriate) for the specific mine category and require that "barriers and stoppings" be of "substantial construction." Substantial construction implies construction of such strength, material, and workmanship that the barrier could withstand air blasts, methane detonation or deflagration, blasting shock, and ground movement expected in the mining environment.

1.4 Report Organization

This report presents the engineering package for the detailed design of the panel-closure system. Chapter 2.0 presents the design evaluations. Chapter 3.0 describes the design and Chapter 4.0 presents the Constructability Design Calculations Index. Chapter 5.0 shows the technical specifications. Chapter 6.0 presents the design drawings. The conclusions are presented in Chapter 7.0 and the references presented in Chapter 8.0. Appendices to this report provide detailed information to support the information contained in Chapters 2.0 through 7.0 of this report.

~~2.0 Design Evaluations~~

~~This chapter in the Part B permit application presented the results of the various design evaluations that support the panel-closure system: (1) analyses addressing the operational requirements, and (2) analyses addressing the structural and material requirements. These evaluations were important in demonstrating that the panel closures will adequately restrict releases of VOCs and will be structurally stable during the operations phase of the WIPP. However, these evaluations are not necessary as part of the facility permit and have been deleted from this edited document.~~

3.0 Design Description

This chapter presents the final design selected from the evaluations performed in the previous chapter. It presents design modifications to cover a range of conditions that may be encountered in the underground and describes the design components for the panel-closure system. Finally, information is presented on the proposed construction for the panel-closure system.

3.1 Design Concept

The composite panel-closure system proposed in the permit application included (1) a standard concrete barrier, rectangular in shape, or (2) an enlarged tapered concrete barrier. Options (1) and (2) were both proposed to be grouted along the interface and may contain explosion- or construction-isolation walls. Figure G1-2 illustrates these design components. The construction methods and materials to be used to implement the design have been proven in previous mining and construction projects. The standard concrete barrier without DRZ removal was intended to apply to future panel air-intake and air-exhaust drifts where the time duration between excavation and barrier emplacement is short. The enlarged concrete barrier with DRZ removal and explosion-isolation wall is the only option approved in the RCRA facility Permit. The design concept for the enlarged concrete barrier incorporates:

- A concrete barrier that is tapered to promote the rapid stress buildup on the host rock. The stiffness was selected to provide rapid buildup of compressive stress and reduction in shear stress in the host rock.

- The enlarged barrier requires DRZ removal just beyond Clay G and MB 139, and to a corresponding distance in the ribs to keep the tapered shape approximately spherical. The design includes DRZ removal and thereby limits VOC flow through the panel-closure system.

- The design of the approved panel-closure system includes an explosion-isolation wall designed to provide strength and deformational serviceability during the operational period. The length was selected to assure that uniform compression develops over a substantial portion of the structure and that end-shear loading that might result in fracturing of salt into the back is reduced.

3.2 Design Options

The design options consist of the following:

- An enlarged concrete barrier with the DRZ removed and a construction-isolation wall

- An enlarged concrete barrier with the DRZ removed and an explosion-isolation wall (This is the only option approved in the RCRA facility Permit.)

- A rectangular concrete barrier without the DRZ removed and a construction-isolation wall

- A rectangular concrete barrier without the DRZ removed and an explosion-isolation wall.

In each case, interface grouting will be used for the upper barrier/salt interface to compensate for any void space between the top of the barrier and the salt. The process for selecting these options was proposed to depend on the subsurface conditions at the panel-closure system locations described in the following subsections.

Observation boreholes will be drilled into the roof or floor of the new air-intake and air-exhaust drifts and will be used for observation of fractures and bed separation. Observations can be made in the boreholes using a small video camera, or a scratch rod. A scratch rod survey will be performed in accordance with the current Excavation Effects Program (**EEP**) procedure.

The EEP was initiated in 1986 with the occurrence of fractures in Site and Preliminary Design Validation Room 3. The purpose of the EEP is to study fractures that develop as a result of underground excavation at the WIPP and to monitor those fractures. Borehole inspections have been successful for determining the fracturing and bed separation in the host rock. These inspections have been performed since 1983 (Francke and Terrill, 1993). This technique in addition to the above will be used to determine the optimum location for the panel-closure system.

Since the enlarged barrier is required to be constructed for all panel closures, the proposed DRZ investigations are not required as part of the RCRA facility Permit.

3.3 Design Components

The following subsections present system and components design features.

3.3.1 Concrete Barrier

The enlarged concrete barrier consists of Salado Mass Concrete, with sufficient unconfined compressive strength and with an approximately circular cross-section excavated into the salt over the central portion of the barrier (Figure G1-5). The enlarged concrete barrier will be located at the optimum locations in the air-intake and air-exhaust drifts with the central portion extending just beyond Clay G and MB 139.

The enlarged concrete barrier will be placed in four cells, with construction joints perpendicular to the direction of potential air flow. The concrete strength will be selected according to the standards specified by the latest edition of the ACI code for plain concrete. The concrete will be placed through 6-inch- (15-cm)-diameter steel pipes and vibrated from outside the formwork. The formwork is designed to withstand the hydrostatic loads during construction, with minimal bracing onto exposed salt surfaces. This will be accomplished by placing a series of steel plates that are stiffened by angle iron, with load reactions carried by spacer rods. The spacer rods will be staggered to reduce potential flow along the rod surfaces through the barrier. Some exterior bracing will be required when the first cell is poured. All structural steel will be ASTM A36, with detailing, fabrication, and erection of structural steel in conformance with the latest edition of the AISC steel manual (AISC, 1989). After concrete placement, the formwork will be left in place.

The above design is for the most severe conditions expected to be encountered at the WIPP.

3.3.2 Explosion- and Construction-Isolation Walls

An explosion-isolation wall, consisting of concrete-blocks, will mitigate the effects of a postulated methane explosion. The explosion-isolation wall consists of 3,500-psi (24-MPa) concrete blocks mortared together with cement (Figure G1-6).

The concrete block wall design complies with MSHA requirements (MSHA, 1987) because it uses incombustible materials of substantial construction. The explosion-isolation wall will be placed into the salt for support. The explosion-isolation walls are designed to resist creep loading from salt deformation. In the absence of the postulated methane explosion, the design was proposed to be simplified to a construction-isolation wall. The construction-isolation wall design provides temporary isolation during the time the main concrete barrier is being constructed. The construction-isolation wall was not approved as part of the RCRA facility Permit.

3.3.3 Interface Grouting

After construction of the main concrete barrier, the interface between the main concrete barrier and the salt will be grouted through a series of grout-supply and air-return lines that will terminate in grout distribution collection boxes. The openings in these boxes will be protected during concrete placement (Figure G1-7). The grout boxes will be mounted near the top of the barrier. The grout will be injected through one distribution system, with air and return grout flowing through a second distribution system.

3.4 Panel-Closure System Construction

The construction methods and materials to be used to implement the design have been proven in previous mining and construction projects. The design uses common construction practices according to existing standards. The proposed construction sequence follows completion of the waste-emplacement activities in each panel: (1) Perform subsurface exploration to determine the optimum location for the panel closure system, (2) select the appropriate design option for the location, (3) prepare surfaces for the construction- or explosion-isolation walls, (4) install these walls, (5) excavate for the enlarged concrete barrier (if required), (6) install concrete formwork, (7) emplace concrete for the first cell, (8) grout the completed cell, and (9) install subsequent formwork, concrete and grout until completion of the enlarged concrete barrier. (Step 2 above is not required as part of the RCRA facility Permit, because there are no design options to choose between.)

The explosion-isolation wall will be located approximately 30 feet from the main concrete barrier. The host rock will be excavated 6 inches (15 cms) around the entire perimeter prior to installing the explosion-isolation wall. The surface preparation will produce a level surface for placing the first layer of concrete blocks. Excavation may be performed by either mechanical or manual means.

Excavation for the enlarged concrete barrier will be performed using mechanical means, such as a cutting head on a suitable boom. The existing roadheader at the main barrier location in each drift is capable of excavating the back and the portions of the ribs above the floor level. Some manual excavation may be required in this situation as well. If mechanical means are not available, drilling boreholes and an expansive agent can be used to fragment the rock (Fernandez et al., 1989). Excavation will follow the lines and grades established for the design. The roof will be excavated to just above Clay G and then the floor to just below MB 139 to

~~remove the DRZ. The tolerances for the enlarged concrete-barrier excavation are +6 to 0 inches (+15 to 0 cm). In addition, loose or spalling rock from the excavation surface will be removed to provide an appropriate surface abutting the enlarged concrete barrier. The excavations will be performed according to approved ground control plans.~~

~~Following completion of the roof excavation for the enlarged barrier, the floor will be excavated. If mechanical means are not available, drilling boreholes and using an expansive agent to fragment the rock (Fernandez et al., 1989) is a method that can be used. Expansive agents would load the rock salt and anhydrite, producing localized tensile fracturing in a controlled manner, to produce a sound surface.~~

~~A batch plant at the surface or underground will be prepared for batching, mixing, and delivering the concrete to the underground in sufficient quantity to complete placement of the concrete within one form cell. The placement of concrete will be continuous until completion, with a time for completing one section not to exceed 10 hours, allowing an additional 2 hours for cleanup of equipment.~~

~~Pumping equipment suitable for placing the concrete into the forms will be provided at the main concrete barrier location. After transporting, and prior to pumping, the concrete will be remixed to compensate for segregation of aggregate during transport. Batch concrete will be checked at the surface at the time of mixing and again at the point of transfer to the pump for slump and temperature. Admixtures may be added at the remix stage in accordance with the batch design.~~

4.0 Design Calculations

Table G1-1 summarizes calculations to support the construction details for an explosion-isolation wall, construction-isolation wall, and structural steel formwork for concrete barriers up to 29-ft high. The codes for the explosion-isolation and construction-isolation wall are specified by the Uniform Building Code (International Conference of Building Officials, 1994), with related seismic design requirements. The external loads for the solid block wall are as developed in the methane-explosion and fracture propagation design evaluations.

Table G1-1
Constructability Design Calculations Index

Section	Design Area	Category
1.0	Explosion-isolation wall	W
2.0	Explosion-isolation wall seismic check	S
3.0	Formwork design	F

The structural formwork for all cells is designed in accordance with the AISC guidelines on allowable stress (AISC, 1989). Lateral pressures are developed using ACI 347R-88, using a standard concrete weighing 150 pounds per cubic foot (2,410 kg/m^3) with a slump of 8 inches (20 cm) or less. Design loadings reflect full hydrostatic head of concrete, with lifts spaced at 4 ft (1.2 m) intervals from bottom to top through portals, with no external vibration. All forms will remain in place.

5.0 Technical Specifications

The specifications are in the engineering file room at the WIPP and are the property of the MOC. These specifications are included as an attachment in Appendix G and summarized in Table G1-2.

Table G1-2
Technical Specifications for the WIPP Panel-Closure System

Division 1 - General Requirements	
Section 01010	Summary of Work
Section 01090	Reference Standards
Section 01400	Contractor Quality Control
Section 01600	Material and Equipment
Division 2 - Site Work	
Section 02010	Mobilization and Demobilization
Section 02222	Excavation
Section 02722	Grouting
Division 3 - Concrete	
Section 03100	Concrete Formwork
Section 03300	Cast-in-Place Concrete
Division 4 - Masonry	
Section 04100	Mortar
Section 04300	Unit Masonry System

6.0 Drawings

The drawings (Appendix H) are in the engineering file room at the WIPP and are the property of the MOC and summarized in Table G1-3.

Table G1-3
Panel-Closure System Drawings

Drawing Number	Title
762447-E1	Title Sheet
762447-E2	Underground Waste Disposal Plan
762447-E3	Air Intake Drift Construction Details
762447-E4	Air Exhaust Drift Construction Details
762447-E5	Construction and Explosion Barrier Construction Details
762447-E6	Grouting and Miscellaneous Details

~~7.0 Conclusions~~

~~This chapter presents the conclusions for the detailed design activities of the panel-closure system. A design basis, including the operational requirements, the structural and material requirements, and the construction requirements, was developed that addresses the governing regulations for the panel-closure system. Table G1-4 summarizes the design basis for the panel-closure system and the compliance with the design basis. The panel-closure system design incorporates mitigative measures to address the treatment of fractures and therefore counter the potential migration of VOCs. Several alternatives were evaluated for the treatment of fractures. These included excavation and emplacement of a fully enlarged barrier with removal of the DRZ, excavation of the roof and emplacement of a partially enlarged barrier, and emplacement of a standard barrier with formation grouting.~~

~~To investigate several key design issues and to implement the design, design evaluations were performed. These design evaluations can be divided into evaluations satisfying the operational requirements of the system and evaluations satisfying the structural and materials requirements of the system. The conclusions reached from the evaluations addressing the operational requirements are as follows:~~

- ~~Based on an air-flow model used to predict the mass flow rate of carbon tetrachloride through the panel-closure system for the alternatives, the air-flow analysis suggests that the fully enlarged barrier is the most protective for restricting VOCs during the operational period of 35 years.~~

- ~~Results of the FLAC analyses show that the recommended enlarged configuration is a circular rib-segment excavated to Clay G and under MB 139. Interface grouting would be performed at the upper boundary of the concrete barrier.~~

- ~~The results of the transverse plane-strain models show that high stresses would form in MB 139 following excavation, but that after installation of the panel-closure system, an increase in barrier-confining stress and a reduction in shear stress would result. The concrete barrier would provide substantial uniform confining stresses as the barrier is subjected to secondary salt creep.~~

- ~~The removal of the fractured salt prior to installation of the main concrete barrier would reduce the potential for flexure. With the removal of MB 139, the fractured salt stiffens the surrounding rock and results in the development of more uniform compression.~~

- ~~The trade-off study also showed that a panel-closure system with an enlarged concrete barrier with the removal of the fractured salt roof and anhydrite in the floor was found to be the most protective.~~

Table G1-4
Compliance of the Design with the Design Requirements

Type of Requirement	Requirement	Section	Compliance with Requirement	Notes on Compliance
Operational	Individual panels shall be closed in accordance with the schedule of actual waste emplacement.	2.1.1	Complies	Gas-flow models used for design are based on the waste-emplacement operational schedule.
	The panel-closure system shall provide assurance that the limit for the migration of volatile organic compounds (**VOC**) of concern will be met at the point of compliance. To achieve this assurance, the design shall consider the potential flow of VOCs through the several components of the disturbed rock zone and the panel-closure system.	2.1.1, 2.1.2	Complies	Gas-flow modeling shows that the VOC flow is less than the design migration limit.
	The panel-closure system shall comply with its intended functional requirements under loads generated from creep closure and any internal pressure that might develop in the disposal panel under reasonably anticipated conditions.	2.1.2, 4.0	Complies	Stress analyses and design calculations show that the panel-closure system performs as intended.
	The panel-closure system shall comply with its intended functional requirements under a postulated methane explosion.	2.2.3, 2.2.4, 4.0	Complies	The methane explosion studies, fracture propagation studies, and supporting design calculations show that the panel-closure system performs as intended.
	The operational life of the panel-closure system shall be at least 35 years.	2.1.1	Complies	Gas-flow modeling and analyses shows satisfactory performance for at least 35 years.
	The panel-closure system for each individual panel shall not require routine maintenance during its operational life.	3.2	Complies	Passive design components require no routine maintenance.
	The panel-closure system shall address the most severe ground conditions expected in the panel entries. If actual conditions are found to be more favorable, this design can be simplified and still satisfy the operational requirements of the system.	2.1.1 2.1.3 3.2	Complies	Design is based upon flow and structural analyses for the most severe expected ground conditions. If conditions are less severe, simpler design options are used. The various design options accommodate all expected conditions.

Type of Requirement	Requirement	Section	Compliance with Requirement	Notes on Compliance
Design configuration and essential features	The panel-closure system shall be emplaced in the air-intake and air-exhaust drifts identified by Westinghouse (1995c)	3.2	Complies	The design shows placement in the designated areas for panel closure.
	The panel-closure system shall consist of a concrete barrier and construction-isolation and explosion-isolation walls with dimensions to satisfy the operational requirements of the system.	3.2, 3.3	Complies	The panel-closure system design uses the identified components with dimensions to satisfy the operational requirements of the system.
Safety	The design class for the panel-closure system shall be IIIb. Design and construction shall follow conventional mining and construction practices.	3.4	Complies	Components are designed according to Class IIIb. The construction sequence for the design followed conventional mining practices.
	The structural analysis for the underground shall use the empirical data acquired from the WIPP Excavation Effects Program.	2.1.2	Complies	The structural analysis uses properties that model creep closure for stress analyses from data acquired in the WIPP Excavation Effects Program.
Structural and material	The panel-closure system materials shall be compatible with their emplacement environment and function. Surface treatment between the host rock and the panel-closure system shall be considered in the design.	2.2.1	Complies	The material compatibility studies showed no degradation of materials and no need for surface treatment.
	The selection and placement of concrete in the concrete barrier shall address potential thermal cracking due to the heat of hydration.	2.2.2	Complies	The heat generation studies show that hydration temperatures are controlled by appropriate selection of cement type and placement temperature.
	The panel-closure system shall sustain the dynamic pressure and subsequent temperature generated by a postulated methane explosion.	2.2.3, 2.2.4, 4.0	Complies	The methane explosion study shows that the explosion-isolation wall protects the concrete barrier from pressure loading and thermal loading. The fracture propagation study shows that the system performs as intended.

Type of Requirement	Requirement	Section	Compliance with Requirement	Notes on Compliance
Construction	The panel-closure system shall use to the extent possible normal construction practices according to existing standards.	3.4	Complies	The specifications include normal construction practices used in the underground at WIPP and according to the most current steel and concrete specifications.
	During construction of the panel-closure system, a quality assurance/quality control program shall be established to verify material properties and construction practices.	3.4	Complies	The specifications include materials testing to verify material properties and construction practices.
	The construction specification shall take into account the shaft and underground access capacities and services for materials handling.	3.4	Complies	The specifications allow construction within the capacities of underground access.

The conclusions reached from the design evaluations addressing the structural and material requirements of the panel-closure system are as follows:

- Existing information on the heat of hydration of the concrete supports placing concrete with a low cement content to reduce the temperature rise associated with hydration. The slump at the required strength would be achieved through the use of plasticizers. A thermal analysis coupled with a salt creep analysis suggest installation of the enlarged barrier at or below ambient temperatures to adequately control hydration temperatures.

- In addition to installation at or below ambient temperatures, the concrete used in the main concrete barrier would exhibit the following:

  - An 8 inch (0.2 meter) slump after 3 hours of intermittent mixing
  - A less-than-25-degree Fahrenheit heat rise prior to installation
  - An unconfined compressive strength of 4,000 psi (28 MPa) after 28 days
  - Volume stability
  - Minimal entrained air.

- The trace amounts of brine from the salt at the repository horizon should not degrade the main concrete barrier for at least 35 years.

- In 20 years, the open passage above the waste stack would be reduced in size. Further, rooms with bulkheads at each end would be isolated in the panel. It is unlikely that a long passage with an open geometry would exist; therefore, the dynamic analysis considered a deflagration with a peak explosive pressure of 240 psi (1.7 MPa).

- The heat-transfer analysis shows that elevated temperatures would occur within the salt and the explosion-isolation wall; however, the elevated temperatures will be isolated by the panel-closure system. Temperature gradients will not significantly affect the stability of the wall.

- The fractures in the roof and floor could be affected by expanding gas products reaching pressures of the order of 240 psi (1.7 MPa). Because the peak internal pressure from the deflagration is only one fifth of the pressure, fractures could not propagate beyond the wall.

The design options proposed to satisfy the design requirements for the panel-closure system include (1) a standard barrier, rectangular in shape, or (2) an enlarged concrete barrier, approximately spherical in shape. Options (1) and (2) will be grouted at the interface and may contain explosion- or construction-isolation walls. Only the enlarged barrier with an explosion-isolation wall is approved as part of the RCRA facility Permit.

The design provides flexibility to satisfy the design migration limit for the flow of VOCs out of the panels. An enlarged concrete barrier would be selected where the air-intake and air-exhaust drifts have aged and where there is fracturing resulting in significant flow of VOCs. These conditions apply to the most severe ground conditions in the air-intake and air-exhaust drifts of Panel 1. If ground conditions are more favorable, such as might be the case for future panel entries, the design was proposed to be simplified to a standard concrete barrier rectangular in shape, with a construction isolation wall. GPR and observation boreholes are available for detecting the location and extent of fractures in the DRZ. These methods may be used to select

~~the optimum location within each entry and exhaust drift for the enlarged barrier panel-closure system.~~

~~The design is presented in this report as a series of calculations, engineering drawings, and technical performance specifications. The drawings illustrate the construction details for the system. The technical performance specifications cover the general requirements of the system, site work, concrete, and masonry. Information on the proposed construction method is also presented.~~

~~The design complies with all aspects of the design basis established for the WIPP panel-closure system. The design can be constructed in the underground environment with no special requirements at the WIPP.~~

8.0 References

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FIGURES

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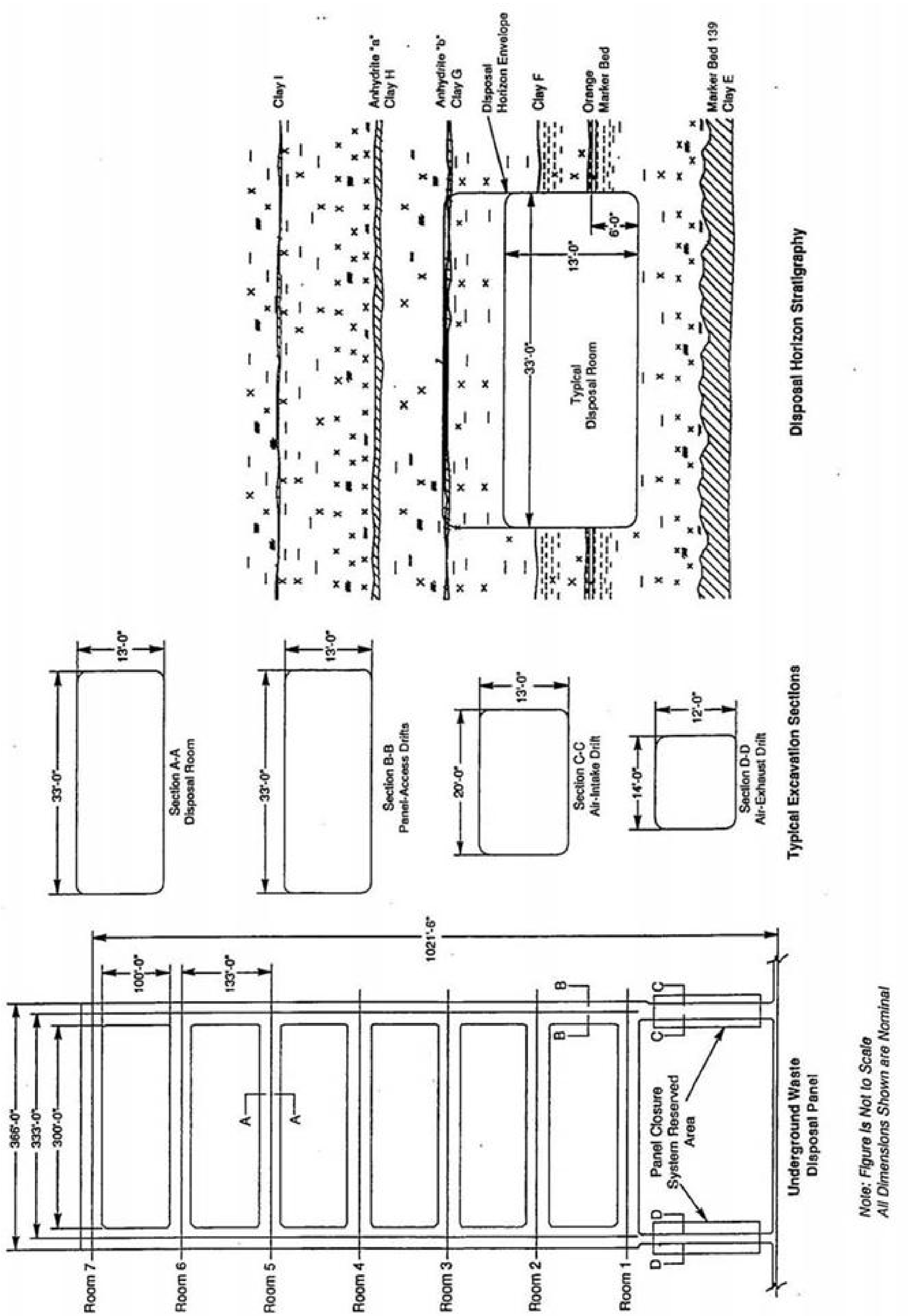
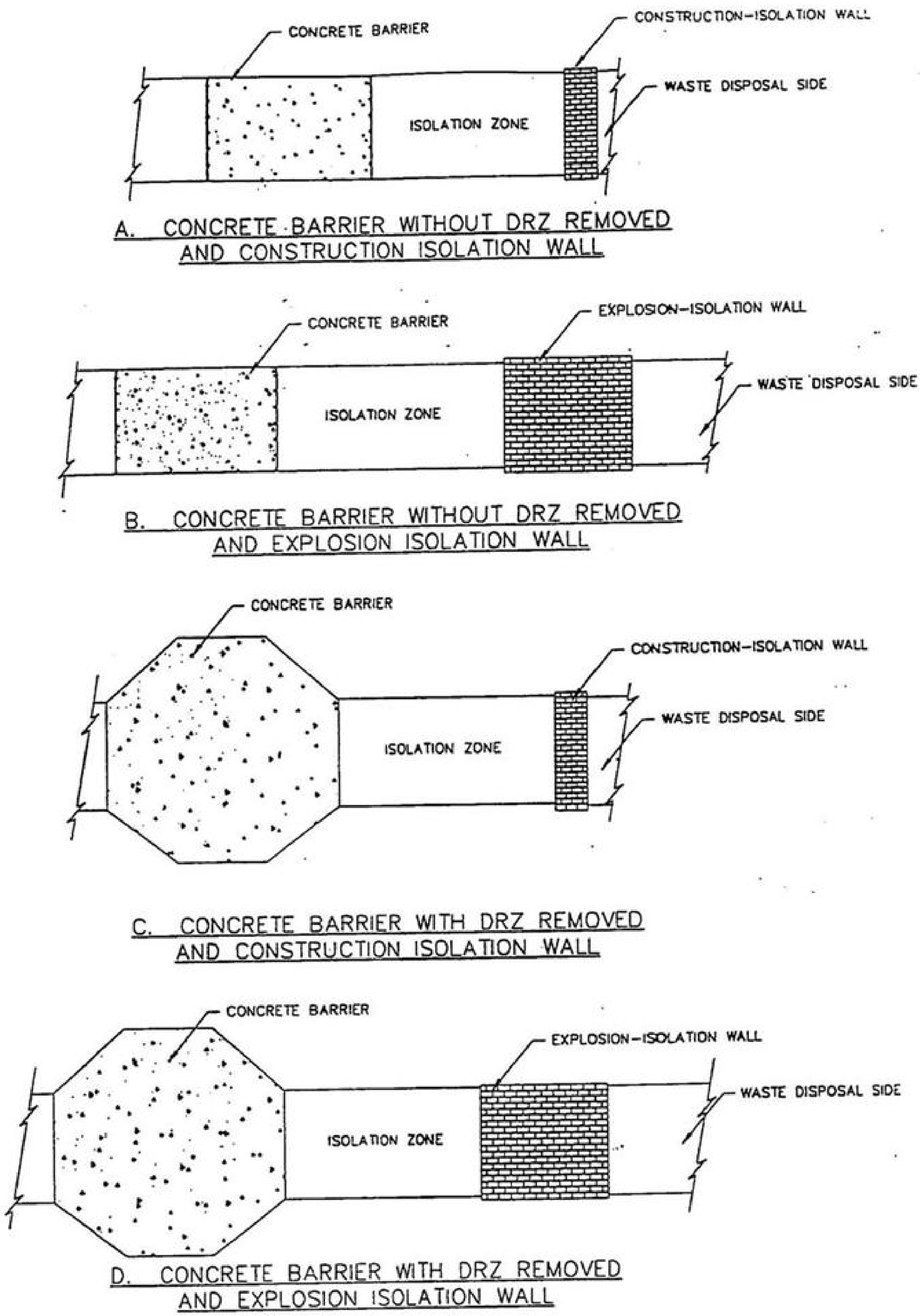


~~Figure G1-1~~
~~Typical Facilities—Typical Disposal Panel~~



~~Figure G1-2~~
~~Main Barrier with Wall Combinations~~

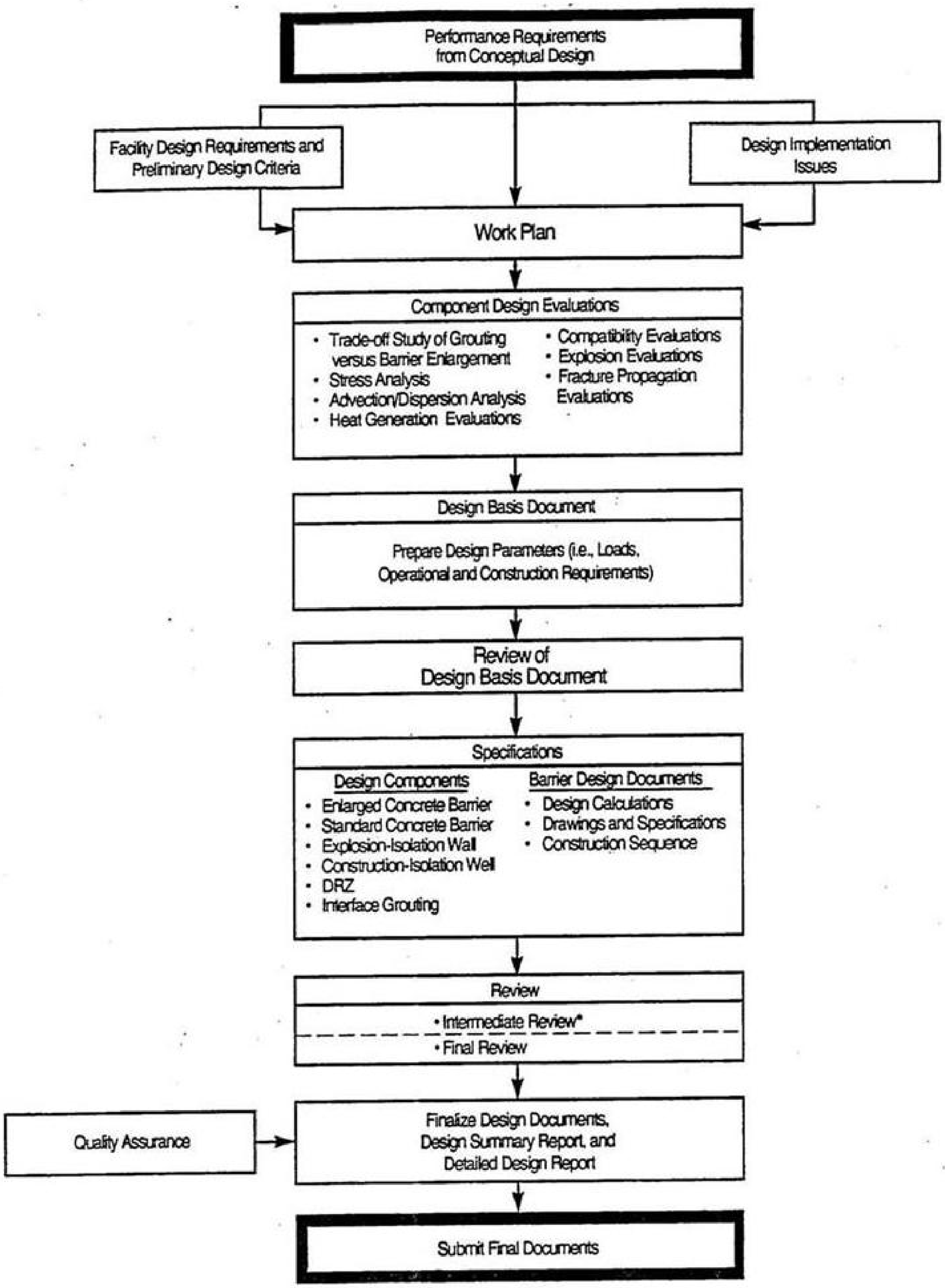


Figure G1-3
Design Process for the Panel-Closure System

A. Select a system structure or component for classification. (Start with a mitigating item)

B. Is the system, structure, or component required to mitigate the consequences of an accident?

C. Would the system, structure, or component failure result in loss of safety functions of a Design Class I components?

D. Does the system, structure, or component provide any function related to nuclear materials?

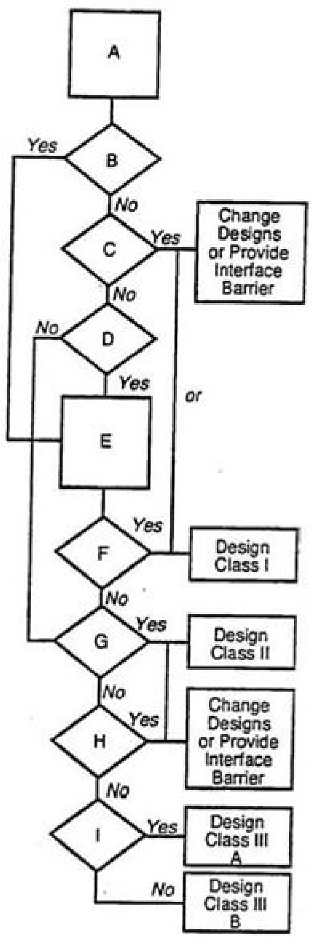
E. Select a conservative accident scenario and perform safety analysis.

F. Does the cumulative radiological consequences following the accident exceed 25 Rem whole body or 75 Rem organ dose commitment to an individual at the Zone I boundary

G. Does the structure, system, operation or component conform to the Class II criteria as defined in Attachment 2?

H. Would the structure, system, operation or component failure result in loss of the required function of a Class II component?

I. Are special design requirements necessary to ensure that failure of the system, structure, or component will NOT result in a significant shutdown of the facility or inhibit accessibility or maintainability of required equipment or have special significance to health and safety of operations personnel?



B. ______YES __X__ NO
Descibe requirement

C. ______YES __X__ NO
Failure mode and affected class I component

D. ______YES __X__ NO
Describe function

E. ______YES __N/A__ NO
Attach safety analysis

F. ______YES ______NO
Calculate dose rates
N/A

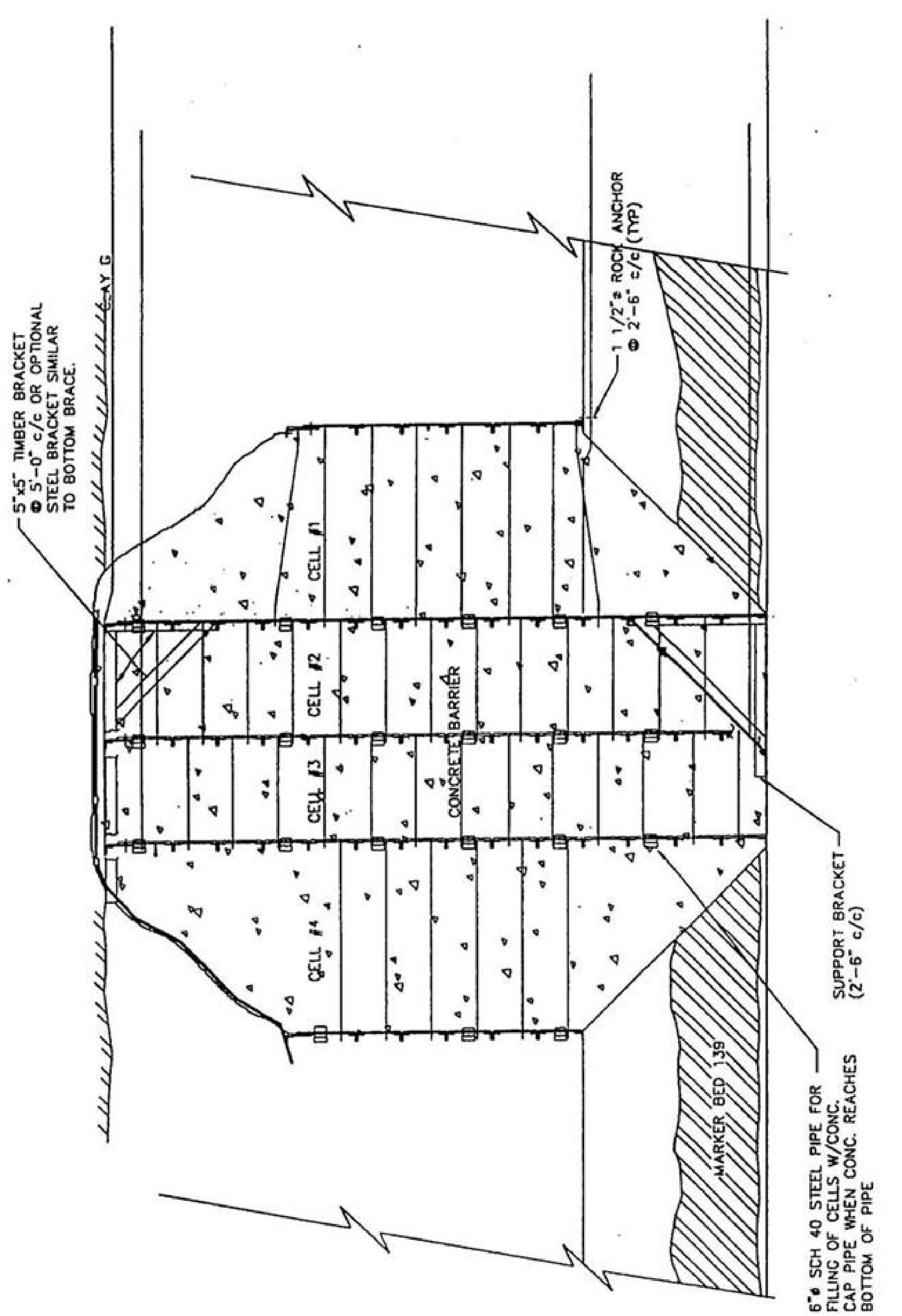
(Attach calculations to this form)

G. ______YES __X__ NO
Criteria
N/A

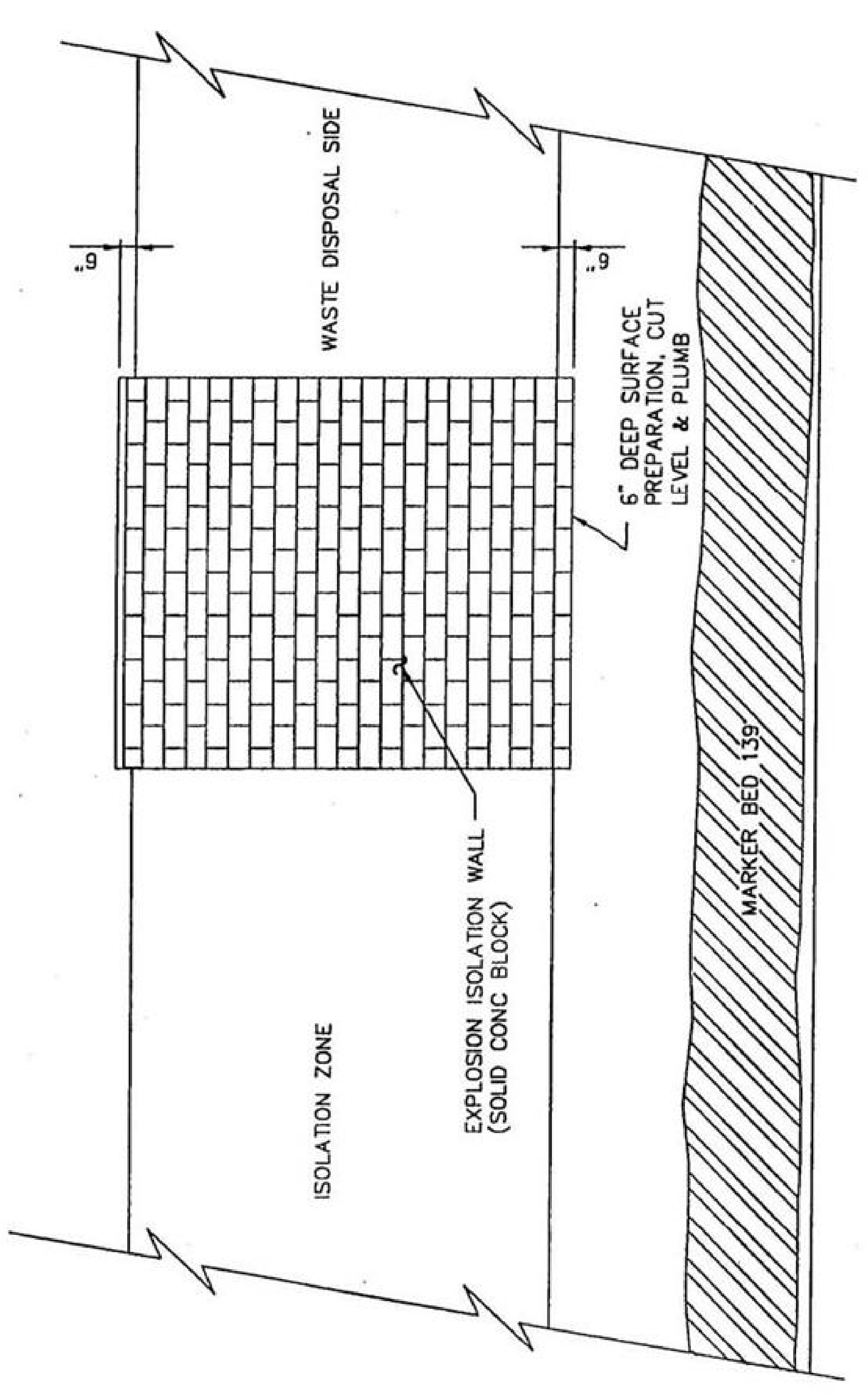
H. ______YES __X__ NO
Failure mode and affected Class II component

I. ______YES __X__ NO
Requirements

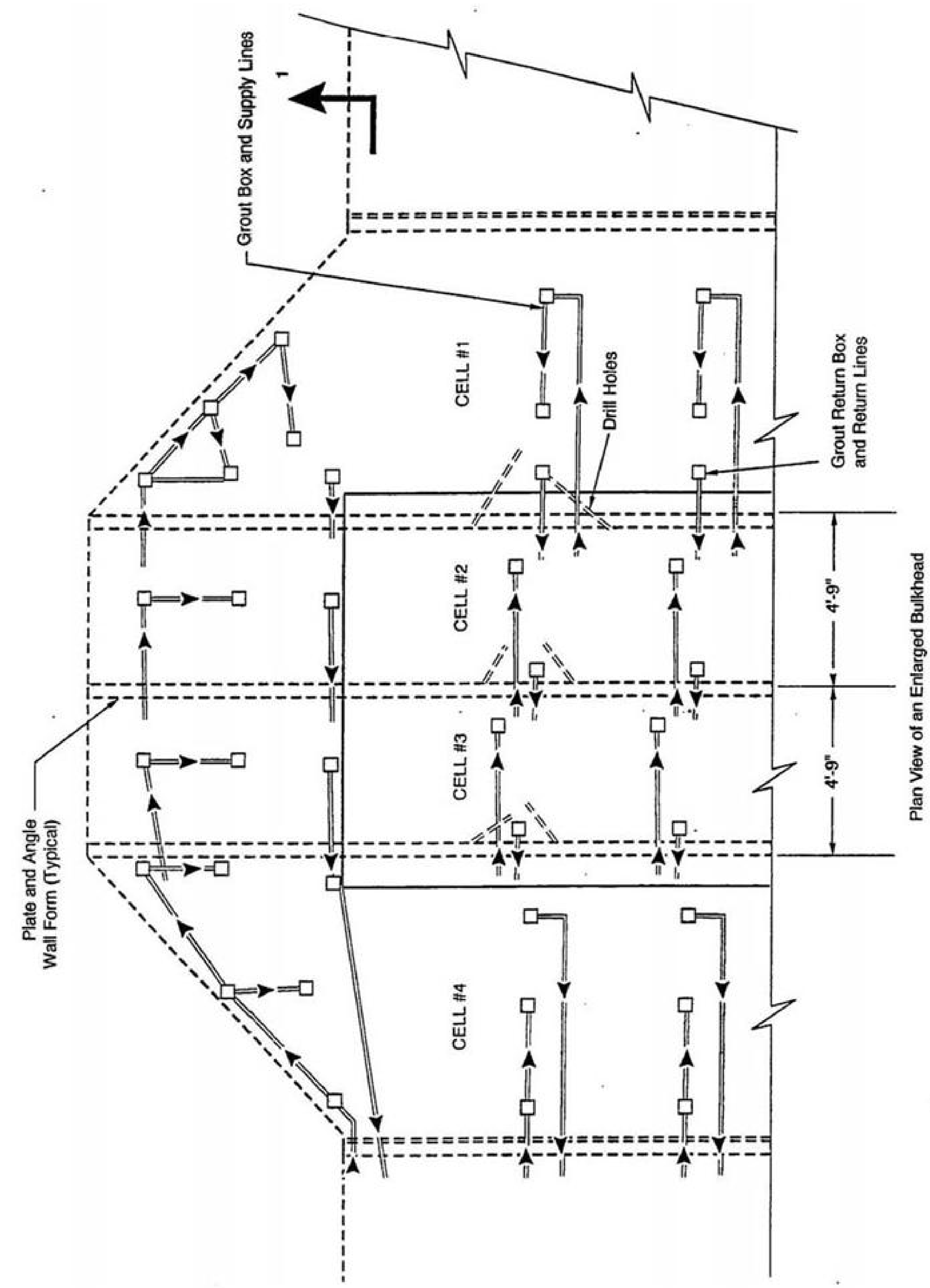
~~**Figure G1-4**~~
~~**Design Classification of the Panel-Closure System**~~



~~Figure G1-5~~
~~Concrete Barrier with DRZ Removal~~



~~Figure G1-6~~
~~Explosion-Isolation Wall~~



~~**Figure G1-7**~~
~~**Grouting Details**~~

~~ATTACHMENT G1~~
~~APPENDIX G~~

~~TECHNICAL SPECIFICATIONS~~

~~PANEL CLOSURE SYSTEM~~
~~WASTE ISOLATION PILOT PLANT~~
~~CARLSBAD, NEW MEXICO~~

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~~ATTACHMENT G1~~
~~APPENDIX G~~

~~TECHNICAL SPECIFICATIONS~~

~~PANEL CLOSURE SYSTEM~~
~~WASTE ISOLATION PILOT PLANT~~
~~CARLSBAD, NEW MEXICO~~

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LIST OF FIGURES

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~~DIVISION 1 - GENERAL REQUIREMENTS~~

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Section 01010 - Summary of Work

Part 1 - General

1.1 Scope

This section includes:

- Scope of Work
- Definitions and Abbreviations
- Drawings
- Work by Others
- Contractors Use of Site
- Contractors Use of Facilities
- Work Sequence
- Work Plan
- Submittals

1.2 Scope of Work

The Contractor shall furnish all labor, materials, equipment and tools to perform operations in connection with the construction of two (2) panel closure systems for each panel, one of each to be installed in the air intake drift and the air exhaust drift of a waste-emplacement panel, as shown on the drawings and called for in these specifications.

Four (4) possible arrangements of the concrete barrier and isolation walls are shown on the attached Figure G1-1 “Plan Variations.”

- Concrete barrier without disturbed rock zone (**DRZ**) removal in combination with construction isolation wall (Sketch A).

- Concrete barrier without DRZ removal in combination with an explosion isolation wall (Sketch B).

- Concrete barrier with DRZ removal up through clay seam G and down through marker bed 139 (**MB 139**) in combination with a construction isolation wall (Sketch C).

- Concrete barrier with DRZ removal in combination with an explosion isolation wall (Sketch D) (This is the only approved configuration in this Permit).

The scope of work shall include but not be limited to the following units of work:

- Develop work plan, health and safety plan (**HASP**) and contractors quality control plan (**CQCP**)

- Prepare and submit all plans requiring approval

- Mobilize to site

- Coordinate construction with operations

- Perform the following for the air intake entry and the air exhaust entry.

  - Excavate the surface preparation for the explosion isolation wall
  - Construct the explosion isolation wall
  - Excavate the DRZ
  - Install the form work for the concrete barrier
  - Place concrete for the concrete barrier
  - Grout the interface of concrete barrier/back wall
  - Provide contact grouting along the contact surface (if required by the engineer)

- Clean up construction areas in underground and above ground

- Submit all required record documents

- Demobilize from site

1.3 Definitions and Abbreviations

Definitions

Contact-handled waste—Contact-handled defense transuranic (**TRU**) waste with a surface dose rate not to exceed 200 millirem per hour.

Concrete barrier—A barrier placed in the access drifts of a panel to restrict the mass flow rate of volatile organic compounds (**VOC**).

Concrete block—Concrete used for construction of either an explosion-isolation wall or a construction-isolation wall.

Construction-isolation wall—A wall immediately adjacent to the panel waste-emplacement area that is made of concrete block, with mortar or steel frame to isolate construction personnel from coming into contact with the waste.

Creep—Plastic deformation of salt under deviatoric stress.

Design migration limit—A mass flow rate that is at least 1 order of magnitude below the health-based levels for VOCs during the Waste Isolation Pilot Plant (**WIPP**) operational period.

Disturbed rock zone (**DRZ**)—A zone surrounding underground excavations where stress redistribution occurs with attendant dilation and fracturing.

Explosion-isolation wall—A concrete-block wall adjacent to the panel waste-emplacement area with mortar that can sustain the pressure and temperature transients of a methane explosion.

Health-based concentration level—The concentration level for a VOC in air that must not be exceeded at the point of compliance during the WIPP operational period.

Health-based migration limit—The mass flow rate of a VOC from all closed panels that results in the health-based concentration level at the point of compliance.

Hydration temperature—The temperature developed by a cementitious material due to the hydration of the cement.

Interface grouting—Grouting performed through grout boxes and pipe lines to fill the void at the concrete barrier/back-wall interface.

Methane explosion—A postulated deflagration caused by the buildup of methane gas to explosive levels.

Partial closure—The process of rendering a part of the underground repository inactive and closed according to approved facility closure plans. The partial-closure process is considered complete after partial-closure activities are performed in accordance with approved Resource Conservation and Recovery Act (**RCRA**) partial closure plans.

Point of compliance—The operating point of compliance for VOC levels at the WIPP, which is the 16-section land withdrawal boundary.

Remote-handled waste—Any of the various forms of high beta-gamma defense TRU waste requiring remote-handling and with a surface dose rate exceeding 200 millirem per hour.

Standard barrier—A concrete barrier emplaced into the panel-access drifts without major excavation of the surrounding rock.

Volatile Organic Compound (**VOC**)—Any VOC comprising the land-disposal-restricted indicator VOC constituents in the WIPP waste inventory.

Abbreviations/Acronyms

ACI	American Concrete Institute
AISC	American Institute for Steel Construction
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DRZ	Disturbed rock zone
EPA	U.S. Environmental Protection Agency
MB 139	Marker Bed 139
MSHA	U.S. Mine Safety and Health Administration
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
MOC	Management and Operating Contractor (Permit Section 1.5.3)
RCRA	Resource Conservation and Recovery Act
SMC	Salado Mass Concrete
USACE	U.S. Army Corps of Engineers
WIPP	Waste Isolation Pilot Plant

1.4 List of Drawings

The following drawings are made apart of this specification:

762447-E1 Panel closure system, air intake and exhaust drifts, title sheet

762447-E2 Panel closure system, underground waste-emplacement panel plan

762447-E3 Panel closure system, air intake drift, construction details

762447-E4 Panel closure system, air exhaust drift, construction details

762447-E5 Panel closure system, construction and explosion walls, construction details

762447-E6 Panel closure system, air intake and exhaust drifts, grouting and miscellaneous details

1.5 Work by Others

Survey

All survey work to locate the barriers and walls, control and confirm excavation, and complete the work will be supplied by the Permittees. All survey measurements for record purposes will also be performed/supplied by the Permittees. The Contractor shall be responsible for verifying the excavation dimensions to develop the form work to fit the excavation.

Excavation

The Permittees may elect to perform certain portions of the work, notably the excavation. The work performed by the Permittees will be defined prior to the contract.

1.6 Contractor's Use of Site

Site Conditions

The site is located near Carlsbad, New Mexico, as shown on the site location maps and the title sheet drawing. The underground arrangements and location of the WIPP waste-emplacement panels are shown on the plan view drawing. The work described above is to construct the concrete barriers in the air intake and exhaust drifts of one of the panels upon completion of the disposal phase of that panel. The waste-emplacement panels are located approximately 2,150 feet below the ground surface. The Contractor shall visit the site and become familiar with the site and site conditions prior to preparing his bid proposal.

Contractor's Use of Site

Areas at the ground surface will be designated for the Contractor's use in assembling and storing his equipment and materials. The Contractor shall utilize only those areas designated.

Limited space within the underground area will be designated for the Contractor's use for storage of material and setup of equipment.

Coordination of Contractor's Work

The Contractor is advised that on-going waste emplacement and excavation operations are being conducted throughout the period of construction of the panel barrier system. The

~~Contractor shall coordinate his construction operations with that of the waste emplacement and mining operations. All coordination shall be through the Engineer.~~

~~1.7 Contractor's Use of Facilities~~

~~Existing facilities at the site which are available for use by the Contractor are:~~

- ~~WIPP roadheader~~
- ~~Waste shaft conveyance~~
- ~~Salt skip hoist~~
- ~~(1) 20 ton forklift~~
- ~~(1) 40 ton forklift~~
- ~~460 volt AC, 3 phase power~~
- ~~Water (underground, at waste shaft only) (above ground, at location designated by Engineer)~~

~~Additional information on these facilities is presented in Section 02010.~~

~~1.8 Work Sequence~~

~~Work Sequence shall be as shown on the drawings and directed by the Engineer.~~

~~1.9 Work Plan~~

~~The Contractor shall prepare and submit for approval by the Engineer a Work Plan fully describing his proposed construction operation. The work plan shall define all proposed equipment. The work plan shall also include the method of excavation, grouting, and pumping concrete. The work plan shall also contain such items as control of surface dust emissions. No work shall be performed prior to approval of the Work Plan.~~

~~1.10 Submittals~~

~~Submittals to the Permittees shall be in accordance with the Permittees' Submittal Procedures and as required by the individual specifications. Approval by the Permittees shall not constitute approval by NMED. Any submittals that propose a change to the panel closure requirements of this Permit (e.g., changes in grout composition, detailed design, etc.) shall be submitted to NMED as required by 20.4.1.900 NMAC (incorporating 40 CFR §270.42).~~

~~Part 2 - Products~~

~~Not used.~~

~~Part 3 - Execution~~

~~Not Used.~~

End of Section

Section 01090 - Reference Standards

Part 1 - General

1.1 Scope

This section includes:

- Provision of Reference Standards at Site.
- Acronyms used in Contract Documents for Reference Standards. Source of Reference Standards.

1.2 Quality Assurance

For products or workmanship specified by association, trade, or Federal Standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

Conform to reference by date of issue current on the date of the agreement between the Permittees and the contractor.

The Contractor shall obtain copy of the standards referenced in the individual specification sections. Maintain a copy at jobsite during submittals, planning, and progress of the specific work, until completion of work.

Should specified reference standards conflict with the contract documents, request clarification from the Engineer before proceeding.

1.3 Schedule of References

Various publications are referenced in other sections of the specifications to establish requirements for the work. These referenced are identified by documents number and title. The addresses of the organizations whose publications are referenced are listed below.

ACI	ACI International P.O. Box 19150 Detroit, MI 48219-0150 Ph: 313-532-2600 Fax: 313-533-4747
AITC	American Institute of Timber Construction 7012 So. Revere Parkway, Suite 140 Englewood, CO 80112 Ph: 303-792-9559 Fax: 303-792-0669

~~AISC~~	~~American Institute of Steel Construction~~ ~~One E. Wacker Dr., Suite 3100~~ ~~Chicago, IL 60601-2001~~ ~~Ph: 312-670-2400~~ ~~Fax: 312-670-5403~~
~~ANSI~~	~~American National Standards Institute~~ ~~11 West 42nd St.~~ ~~New York NY 10036~~ ~~Ph: 212-642-4900~~ ~~Fax: 212-302-1286~~
~~API~~	~~American Petroleum Institute~~ ~~1220 L. St., NW~~ ~~Washington, DC 20005~~ ~~Ph: 202-682-8375~~ ~~Fax: 202-962-4776~~
~~ASTM~~	~~American Society for Testing and Materials~~ ~~1916 Race St.~~ ~~Philadelphia, PA 19103~~ ~~Ph: 215-299-5585~~ ~~Fax: 215-977-9679~~
~~AWS~~	~~American Welding Society~~ ~~550 LeJeune Road~~ ~~Miami, FL 33135~~ ~~Ph: 800-443-9353~~ ~~Fax: 305-443-7559~~
~~CFR~~	~~Code of Federal Regulations~~ ~~Government Printing Office~~ ~~Washington, DC 20402~~ ~~Ph: 202-783-3238~~ ~~Fax: 202-223-7703~~
~~EPA~~	~~Environmental Protection Agency~~ ~~Public Information Center~~ ~~Ariel Rios Building~~ ~~1200 Pennsylvania Avenue, NW~~ ~~Washington, DC 20460~~ ~~Ph: 202-272-0167~~
~~FTM-STO~~	~~Federal Test Method Standards~~ ~~Standardization Documents Order Desk~~ ~~Bldg. 4D~~ ~~700 Robbins Ave.~~ ~~Philadelphia, PA 19111-5094~~ ~~Ph: 215-697-2179~~ ~~Fax: 215-697-2978~~

NRMCA	National Ready-Mixed Concrete Association 900 Spring St. Silver Spring, MD 20910 Ph: 301-587-1400 Fax: 301-585-4219
NTIS	National Technical Information Service U.S. Department of Commerce Springfield, VA 22161 (703) 487-4650
PCA	Portland Cement Association 5420 Old Orchard Road Skokie, IL 60077
USACE	U.S. Army Corps of Engineers U.S. Army Engineer Waterway Experiment Station ATTN: Technical Report Distribution Section, Services Branch, TIC 3909 Halls Ferry Rd. Vicksburg, MS 39180-6199 Ph: 601-634-2355 Fax: 601-634-2506
MOC	Nuclear Waste Partnership LLC PO Box 2078 Carlsbad, New Mexico 88221

End of Section

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Section 01400 - Contractor Quality Control

Part 1 - General

1.1 Scope

This section includes:

- Contractor Quality Control Plan (**CQCP**)
- Reference Standards
- Quality Assurance
- Tolerances
- Testing Services
- Inspection Services
- Submittals

1.2 Related Sections

- 01090 - Reference Standards
- 01600 - Material and Equipment
- 02222 - Excavation
- 02722 - Grouting
- 03100 - Concrete Formwork
- 03300 - Cast-in-Place Concrete
- 04100 - Mortar
- 04300 - Unit Masonry System

1.3 Contractor Quality Control Plan

The Contractor shall prepare and submit for approval by the Engineer, a Quality Control Plan, as described in Section 3.2. No work shall be performed prior to approval of the Contractor's Quality Control Plan.

1.4 References and Standards

Refer to individual specification sections for standards referenced therein, and to Section 01090 - Reference Standards for general listing.

Standards referenced in this section are as follows:

ASTM C1077	Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C1093	Practice for Accreditation of Testing Agencies for Unit Masonry
ASTM E329	Practice for Use in the Evaluation of Inspection and Testing Agencies as Used in Construction
ASTM E543	Practice for Determining the Qualification of Nondestructive Testing Agencies

ASTM E548 — Practice for Preparation of Criteria for Use in the Evaluation of Testing Laboratories and Inspection Bodies

1.5 Quality Assurance

- Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce work of specified quality

- Comply with specified standards as minimum quality for the work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship

- Perform work by persons qualified to produce required and specified quality

- Verify that field measurements are as indicated on shop drawings

- Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

1.6 Tolerances

Monitor excavation fabrication and installation tolerance control of work and products to produce acceptable work. Do not permit tolerances to accumulate.

Adjust products to appropriate dimensions; position before securing products in place.

1.7 Testing Services

Unless otherwise indicated by the Engineer, the Contractor shall employ an independent firm to perform the testing services and other services specified in the individual specification sections, and as required by the Engineer. Testing and source quality control may occur on or off the project site.

The testing laboratory shall comply with applicable sections of the reference standards and shall be authorized to operate in the state in which the project is located.

Testing equipment shall be calibrated at reasonable intervals with devices of an accuracy traceable to either the National Bureau of Standards or accepted values of natural physical constants.

1.8 Inspection Services

The Contractor shall employ an independent firm to perform inspection services as a supplement to the Contractor's quality control as specified in the individual specification sections, and as required by the Engineer. Inspection may occur on or off the project site.

The inspection firm shall comply with applicable sections of the reference standards.

1.9 Submittals

The Contractor shall submit a Contractors' Quality Control Plan as described herein.

Prior to start of work, the Contractor shall submit for approval, the testing laboratory name, address, telephone number and name of responsible officer of the firm. He shall also submit a copy of the testing laboratory compliance with the reference ASTM standards, and a copy of report of laboratory facilities inspection made by Materials Reference Laboratory of National Bureau of Standards with memorandum of remedies of any deficiencies reported by the inspection.

Prior to start of work, the Contractor shall submit for approval the inspection firm name, address, telephone number and name of responsible officer of the firm. He shall also submit the personnel proposed to perform the required inspection, along with their individual qualifications and certifications (Example: Certified AWS Welding Inspector.)

Part 2 - Products

Not used.

Part 3 - Execution

3.1 General

The Contractor is responsible for quality control and shall establish and maintain an effective quality control system. The quality control system shall consist of plans, procedures, and organization necessary to produce an end product which complies with the contract requirements. The system shall cover all construction operations, both on site and off site, and shall be keyed to the proposed construction sequence. The project superintendent will be held responsible for the quality of work on the job. The project superintendent in this context shall mean the individual with the responsibility for the overall management of the project including quality and production.

3.2 Quality Control Plan

3.2.1 General

The Contractor shall furnish for review and approval by the Engineer, not later than 30 days after receipt of notice to proceed, the Contractor Quality Control (**CQC**) Plan proposed to implement the requirements of the Contract. The plan shall identify personnel, procedures, control, instructions, test, records, and forms to be used. Construction will be permitted to begin only after acceptance of the CQC Plan.

3.2.2 Content of the CQC Plan

The CQC Plan shall include, as a minimum, the following to cover all construction operations, both on site and off site, including work by subcontractors, fabricators, suppliers, and purchasing agents:

- A description of the quality control organization, including a chart showing lines of authority and acknowledgment that the CQC staff shall implement the control system for all aspects of the work specified. The staff shall include a CQC System Manager who shall report to the project superintendent.

- ~~The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a CQC function.~~

- ~~Description of the CQC System Manager's responsibilities and delegation of authority to adequately perform the functions of the CQC System Manager, including authority to stop work which is not in compliance with the contract. The CQC System Manager shall issue letters of direction to all other various quality control representatives outlining duties, authorities, and responsibilities.~~

- ~~Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, off site fabricators, suppliers, and purchasing agents. These procedures shall be in accordance with the Permittees' Submittal Procedures.~~

- ~~Control, verification, and acceptance testing procedures for each specific test to include the test name, specification paragraph requiring test, feature of work to be tested, test frequency, and person responsible for each test. (Laboratory facilities will be subject to approval by the Engineer.)~~

- ~~Procedures for tracking construction deficiencies from identification through acceptable corrective action. These procedures will establish verification that identified deficiencies have been corrected.~~

- ~~Reporting procedures, including proposed reporting formats.~~

- ~~A list of the definable features of work. A definable feature of work is a task which is separate and distinct from other tasks and has separate control requirements. It could be identified by different trades or disciplines, or it could be work by the same trade in a different environment. Although each section of the specifications may generally be considered as a definable feature of work, there are frequently more than one definable feature under a particular section. This list will be agreed upon by the Engineer.~~

~~3.2.3 Acceptance of Plan~~

~~Acceptance of the Contractor's plan is required prior to the start of construction. Acceptance is conditional and will be predicated on satisfactory performance during the construction. The Permittees reserve the right to require the Contractor to make changes in his CQC Plan and operations including removal of personnel, as necessary, to obtain the quality specified.~~

~~3.2.4 Notification of Changes~~

~~After acceptance of the CQC Plan, the Contractor shall notify the Engineer in writing of any proposed change. Proposed changes are subject to acceptance by the Engineer.~~

~~3.3 Quality Control Organization~~

~~3.3.1 General~~

~~The requirements for the CQC organization are a CQC System Manager and sufficient number of additional qualified personnel supplemented by independent testing and inspection firms as required by the specifications, to ensure contract compliance. The Contractor shall provide a CQC organization which shall be at the site at all times during progress of the work and with~~

~~complete authority to take any action necessary to ensure compliance with the contract. All CQC staff members shall be subject to acceptance by the Engineer.~~

~~3.3.2 CQC System Manager~~

~~The Contractor shall identify as CQC System Manager an individual within his organization at the site of the work who shall be responsible for overall management of CQC and have the authority to act in all CQC matters for the Contractor. The CQC System Manager shall be a graduate engineer, with a minimum of five years construction experience on construction similar to this contract. This CQC System Manager shall be on the site at all times during construction and will be employed by the prime Contractor. The CQC System Manager shall be assigned no other duties. An alternate for the CQC System Manager will be identified in the plan to serve in the event of the System Manager's absence. The requirements for the alternate will be the same as for the designated CQC System Manager.~~

~~3.3.3 CQC Personnel~~

~~In addition to CQC personnel specified elsewhere in the contract, the Contractor shall provide as part of the CQC organization specialized personnel or third party inspectors to assist the CQC System Manager. These individuals shall be employed by the prime Contractor; be responsible to the CQC System Manager; be physically present at the construction site during work on their areas of responsibility; have the necessary education and/or experience. These individuals shall have no other duties other than quality control.~~

~~3.3.4 Organizational Changes~~

~~The Contractor shall maintain his CQC staff at full strength at all times. When it is necessary to make changes to the CQC staff the Contractor shall revise the CQC Plan to reflect the changes and submit the changes to the Engineer for acceptance at the Contractors' expense.~~

~~3.4 Tests~~

~~3.4.1 Testing Procedure~~

~~The Contractor shall perform specified or required tests to verify that control measures are adequate to provide a product which conforms to contract requirements. Upon request, the Contractor shall furnish to the Engineer duplicate samples of test specimens for possible testing by the Engineer. Testing includes operation and/or acceptance tests when specified. The Contractor shall procure the services of an approved testing laboratory. The Contractor shall perform the following activities and record and provide the following data:~~

- ~~Verify that testing procedures comply with contract requirements.~~
- ~~Verify that facilities and testing equipment are available and comply with testing standards.~~
- ~~Check test instrument calibration data against certified standards.~~
- ~~Verify that recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.~~

- Results of all tests taken, both passing and failing tests, will be recorded on the CQC report for the date taken. Specification paragraph reference, location where tests were taken, and the sequential control number identifying the test will be given. If approved by the Engineer, actual test reports may be submitted later with a reference to the test number and date taken. An information copy of tests performed by an off site or commercial test facility will be provided directly to the Engineer. Failure to submit timely test reports as stated may result in nonpayment for related work performed and disapproval of the test facility for this contract.

3.5 Testing Laboratory

The testing laboratory shall provide qualified personnel to perform specified sampling and testing of products in accordance with specified standards, and ascertain compliance of materials and mixes with requirements of Contract Documents. The testing laboratory shall promptly notify the Engineer and Contractor of any observed irregularities or non-conformance of Work or Products.

Reports indicating results of tests, and compliance (or noncompliance) with the contract documents will be submitted in accordance with the Permittees' submittal procedures.

The Contractor shall cooperate with the independent testing firm, furnish samples, storage, safe access, and assistance by incidental labor as required. Testing by the independent firm does not relieve the contractor of the responsibility to perform the work to the contract requirements.

The laboratory may not:

- Release, revoke, alter, or enlarge on requirements of the contract
- Approve or accept any portion of the work
- Assume any duties of the Contractor.

The laboratory has no authority to stop the work.

3.6 Inspection Services

The inspection firm shall provide qualified personnel at site to supplement the Contractor's Quality Control Program to perform specified inspection of Products in accordance with specified standards. He shall ascertain compliance of materials and mixes with requirements of Contract Documents, and promptly notify the CQC System Manager, the Engineer and the Contractor of observed irregularities or non-conformance of Work or Products. The inspector does not have the authority to stop the work. The inspector shall refer such cases to the CQC System Manager who has the authority to stop work (see Section 3.2.2).

Reports indicating results of the inspection and compliance (or noncompliance) with the contract documents will be submitted in accordance with the Permittees' submittal procedures.

The Contractor shall cooperate with the independent inspection firm, furnish samples, storage, safe access and assistance by incidental labor, as requested.

Inspection by the independent firm does not relieve the Contractor of the responsibility to perform the work to the contract requirements.

3.7 Completion Inspection

3.7.1 Pre-Final Inspection

At the completion of all work the CQC System Manager shall conduct an inspection of the work and develop a “punch list” of items which do not conform to the approved drawings and specifications. Once this is accomplished the Contractor shall notify the Engineer that the facility is complete and is ready for the “Prefinal” inspection. The Engineer will perform this inspection to verify that the facility is complete. A “Final Punch List” will be developed as a result of this inspection. The Contractor’s CQC System Manager shall ensure that all items on this list have been corrected and notify the Engineer so that a “Final” inspection can be scheduled. Any items noted on the “Final” inspection shall be corrected in a timely manner. These inspections and any deficiency corrections required by this paragraph will be accomplished within the time slated for completion of the entire work.

3.7.2 Final Acceptance Inspection

The final acceptance inspection will be formally scheduled by the Engineer based upon notice from the Contractor. This notice will be given to the Engineer at least 14 days prior to the final acceptance inspection and must include the Contractor’s assurance that all specific items previously identified to the Contractor as being unacceptable, along with all remaining work performed under the contract, will be complete and acceptable by the date scheduled for the final acceptance inspection.

3.8 Documentation

The Contractor shall maintain current records providing factual evidence that required quality control activities and/or tests have been performed. These records shall include the work of subcontractors and suppliers and shall be on an acceptable form that includes, as a minimum, the following information:

- Contractor/subcontractor and their area of responsibility.
- Operating plant/equipment with hours worked, idle, or down for repair.
- Work performed each day, giving location, description, and by whom.
- Test and/or quality control activities performed with results and references to specifications/drawings requirements. List deficiencies noted along with corrective action.
- Quantity of materials received at the site with statement as to acceptability, storage, and reference to specifications/drawings requirements.
- Submittals reviewed, with contract reference, by whom, and action taken.
- Off-site surveillance activities, including actions taken.
- Instructions given/received and conflicts in plans and/or specifications.
- Contractor’s verification statement.

These records shall indicate a description of trades working on the project; the number of personnel working; weather conditions encountered; and any delays encountered. These records shall cover both conforming and deficient features and shall include a statement that equipment and materials incorporated in the work and workmanship comply with the contract. The original and one copy of these records in report form shall be furnished to the Engineer daily. Reports shall be signed and dated by the CQC System Manager. The report from the CQC System Manager shall include copies of test reports and copies of reports prepared by all subordinate quality control personnel.

3.9 Notification of Noncompliance

The Engineer will notify the Contractor of any detected noncompliance with the foregoing requirements. The Contractor shall take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the worksite, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the Engineer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

End of section.

Section 01600 - Material and Equipment

Part 1 - General

1.1 Scope

This section includes:

- Equipment
- Products
- Transportation and handling
- Storage and protection
- Substitutions

1.2 Related Sections

- 01010 - Summary of Work
- 01400 - Contractor Quality Control
- 02010 - Mobilization and Demobilization
- 02222 - Excavation
- 02722 - Grouting
- 03100 - Concrete Formwork
- 03300 - Cast-in-Place Concrete
- 04100 - Mortar
- 04300 - Unit Masonry System

1.3 Equipment

The Contractor shall specify his proposed equipment in the Work Plan. Power equipment for use underground shall be either electrical or diesel engine driven. All diesel engine equipment shall be certified for use underground.

1.4 Products

The Contractor shall specify in the Work Plan, or in subsequently required submittals the proposed products including, but not limited to the grout mix and its components, concrete mix and its components, mortar mix and its components, formwork, and masonry. The proposed products shall be supported by laboratory test results as required by the specifications. All products shall be subject to approval by the Engineer.

1.5 Transportation and Handling

- Transport and handle products in accordance with manufacturer's instructions.

- Promptly inspect shipments to ensure that products comply with requirements, quantities are correct, and products are undamaged.

- Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.6 Storage and Protection

- Store and protect products in accordance with manufacturers' instructions.
- Store with seals and labels intact and legible.
- Store sensitive products in weather tight, climate controlled, enclosures in an environment favorable to product.
- For exterior storage of fabricated products, place on sloped supports above ground.
- Cover products subject to deterioration with impervious sheet covering. Provide ventilation to prevent condensation and degradation of products.
- Store loose granular materials on solid flat surfaces in a well-drained area. Prevent mixing with foreign matter.
- Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.
- Arrange storage of products to permit access for inspection. Periodically inspect to verify products are undamaged and are maintained in acceptable condition.

1.7 Substitutions

1.7.1 Equipment Substitutions

The Contractor may substitute equipment for that proposed in the Work Plan subject to the Engineer's approval. The Contractor shall demonstrate the need for the substitution, and the applicability of the proposed substitute equipment.

1.7.2 Product Substitutions

The Contractor may not substitute products after the proposed products have been approved by the Engineer unless he can demonstrate that the supplier/source of that product no longer exists in which case he shall submit alternate products with lab test results to the Engineer for approval. In the case that product is a component in a mix, the Contractor shall perform mix testing using that component and submit laboratory test results.

Part 2 - Products

Not used.

Part 3 - Execution

Not used.

End of section.

~~DIVISION 2 - SITE WORK~~

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Section 02010 - Mobilization and Demobilization

Part 1 - General

1.1 Scope

This section includes:

Mobilization of equipment and facilities to site

- Contractor use of site
- Use of existing facilities
- Demobilization of equipment and facilities
- Site cleanup

1.2 Related Sections

- 01010 - Summary of Work
- 01600 - Material and Equipment

Part 2 - Products

Not used.

Part 3 - Execution

3.1 Mobilization of Equipment and Facilities to Site

Upon authorization to proceed, the Contractor shall mobilize his equipment and facilities to the jobsite. Equipment and facilities shall be as specified, and as defined in the Contractor's Work Plan. The Contractor shall erect the batch plant and assemble his equipment and materials in the areas designated by the Engineer. Facilities shall be located as near as practical to the existing utilities.

The Permittees will provide utilities (460 volt AC, 3 phase, and water) at designated locations. The Contractor shall be responsible for all hookups and tie-ins required for his operations.

The Contractor shall be responsible for providing his own office, storage, and sanitary facilities.

Areas will be designated for the Contractor's use in the underground area in the vicinity of the panel closure system installation. These areas are limited.

3.2 Use of Site

The Contractor shall use only those areas specifically designated for his use by the Engineer. The Contractor shall limit his on-site travel to the specific routes required for performance of his work, and designated by the Engineer.

3.3 Use of Existing Facilities

Existing facilities at the site which are available for use by the Contractor are:

- WIPP roadheader
- Waste shaft conveyance
- Salt skip hoist
- (1) 20 ton forklift
- (1) 40-ton forklift
- 460 Volt AC, 3 phase power
- Water (in mine, at waste shaft only-above ground at location designated by the Engineer).

The Contractor shall arrange for use of the facilities with the Engineer and coordinate his actions/requirements with that of the ongoing operations.

Use of water in the underground will be restricted. No washout or cleanup will be permitted in the underground. Above ground washout/cleanup or equipment will be allowed in the areas designated by the Engineer.

The Contractor is cautioned to be aware of the physical dimensions of the waste conveyance and the air lock (see Figures G1-2 and G1-3, attached).

The Contractor shall be responsible for any damage incurred by the existing site facilities as a result of his operations. Any damage shall be reported immediately to the Engineer and repaired at the Contractor's cost.

3.4 Demobilization of Equipment and Facilities

At completion of this work, the Contractor shall demobilize his equipment and facilities from the job site. The batch plant shall be disassembled and removed along with any unused material. All Contractor's equipment and materials shall be removed from the mine and all disturbed areas restored. Utilities shall be removed to their connection points unless otherwise directed by the Engineer.

3.5 Site Cleanup

At conclusion of the work, the Contractor shall remove all trash, waste, debris, excess construction materials, and restore the affected areas to its prior condition, to the satisfaction of the Engineer. A final inspection of the areas will be conducted by the Engineer and the Contractor before final payment is approved.

End of section.

Section 02222 - Excavation

Part 1 - General

1.1 Scope

This section includes:

Excavation for main concrete barrier

- Excavation for surface preparation and leveling of base areas for isolation walls
- Disposition of excavated materials.

1.2 Related Sections

- 01010 - Summary of Work
- 01600 - Material and Equipment
- 03100 - Concrete Form Work
- 04300 - Unit Masonry System.

1.3 Reference Documents

"Reference Stratigraphy and Rock Properties for the Waste Isolation Pilot Plant (WIPP) Project" by R.D. Krieg-Sandia National Laboratory Document Sand 83-1908. [Available through National Technical Information Service (**NTIS**).]

1.4 Field Measurements and Survey

All surveys required for performance of the work will be provided by the Permittees. To develop the concrete formwork to fit the excavation, the Contractor shall be responsible for verifying the excavation dimensions.

Part 2 - Products

Not used.

Part 3 - Execution

3.1 Excavating for Concrete Barrier

Excavation for the main concrete barrier shall be performed to the lines and grades shown on the drawings. Excavate the back a minimum of 1 inch to 3 inches beyond clay seam G, and the floor a minimum of 1 inch to 3 inches below the anhydride marker bed 139 (**MB-139**) to assure removal of the disturbed rock zone (**DRZ**). Excavation shall be performed utilizing mechanical means such as a cutting head on a suitable boom, by drilling boreholes and using an expansive agent to fragment the rock or other competent equipment or methods submitted to the Engineer for review and approval. The use of explosives is prohibited. The existing WIPP roadheader mining machine may also be available for use. The Contractor is to determine availability and coordinate proposed use of the roadheader with the Engineer. The existing roadheader is capable of excavating the back and the portions of the ribs above the floor level. However, it is not capable of excavating the portion below floor level.

The tolerances for the concrete barrier excavation shall be +6 inches, to 0 inch. In addition, the Contractor is to remove all loose or spalling rock from the excavation surface to provide a sound surface abutting the concrete barrier. The Contractor shall provide and install roof bolts for support as required for personnel protection and approved ground control plans.

3.2 Excavating for Surface Preparation and leveling of Base Areas for Isolation Walls

The Contractor shall excavate a 6-inch surface preparation around the entire perimeter of the isolation walls. The surface preparation in the floor shall be made level to produce a surface for placing the first course of block in the isolation walls. Tolerances for the leveled portion of the surface preparation are ±1 inch. Excavation may be performed by either mechanical or manual means. Use of explosives is prohibited.

3.3 Disposition of Excavated Materials

The Contractor shall remove all excavated materials from the panel-access drift where they are excavated. Excavated materials shall be removed from the mine via the salt skip to the surface, where they will be disposed on site at a location as directed by the Engineer.

3.4 Field Measurements and Survey

All survey required for performance of the work will be provided by the Permittees. The Contractor shall protect all survey control points, bench marks, etc., from damage by his operations. MOC will verify by survey that the Contractor has excavated to the required lines and grades. The Contractor shall be responsible for verifying the excavation dimensions to develop concrete formwork to fit the excavation. No form work or block work is to be erected until this survey is completed. The Contractor is to coordinate the survey work with his operations to assure against lost time. The Contractor shall notify the Engineer at least 24 hours prior to the time surveying is required

End of section.

Section 02722 - Grouting

Part 1 - General

1.1 Scope

This section includes:

- Grouting of concrete barrier.

1.2 Related Sections

- 01010 - Summary of Work
- 01400 - Contractor Quality Control
- 01600 - Material and Equipment
- 03100 - Concrete Form Work
- 03300 - Cast-in-Place Concrete

1.3 References

ASTM C1107 Standard Specification for Nonshrink Grout

ASTM C109 Test Method for Compressive Strength of Hydraulic Cement Mortars

1.4 Submittals for Review and Approval

Thirty days prior to the initiation of grouting, the Contractor shall submit to the Engineer for review and approval, the following:

- Type of grout proposed

- Product data:

Manufacturer's specification and certified laboratory tests for the manufactured grout, if proposed

Certified laboratory tests for the salt-saturated grout, if proposed, using project-specific materials

Proposed grouting method, including equipment and materials and construction sequence in Work Plan.

1.5 Submittals for Construction

Daily grouting report indicating the day, date, time of mixing and delivery, quantity of grout placed, water used, pressure required, problems encountered, action taken, quality control data, testing results, etc., no later than 24 hours following construction.

Part 2 - Products

2.1 Grout Materials

Grout used for grouting in connection with fresh water/plain cement concrete shall be nonshrink, cement-based grout, Five Star 110 as manufactured by Five Star Products Inc., 425 Stillson Road, Fairfield, Connecticut 06430 or approved equal. Mixing and installation shall be in accordance with the manufacturer's recommendations.

As an alternate to the above grout, in connection with the Salado Mass concrete mix, the Contractor shall use, subject to the approval of the Engineer, a salt saturated grout. The following formulation is suggested to the Contractor as an initiation point for selection of the grout mix. Salt saturated grout strength shall be 4500 psi at 28 days.

Salt-Saturated Grout (BCT-1F)

Component	Percent of total Mass (wt.)
Class H Cement	48.3
Class C Fly Ash	16.2
Cal Seal (Plaster - from Halliburton)	5.7
Sodium chloride	7.9
Dispersant	0.78
Defoamer	0.02
Water	21.1

Water for mixing shall be of potable quality, free from injurious amounts of oil, acid, alkali, salt, or organic matter, sediments, or other deleterious substances, as specified for concrete, Section 03300-2.3.

2.2 Product Data

If the Contractor proposes to utilize a manufactured nonshrink cement-based grout, he shall submit complete manufacturer's specifications for the product, along with certified laboratory test results of the material.

If the Contractor proposes to utilize the salt-saturated grout in connection with the Salado Mass concrete mix, he shall submit manufacturer's/supplier's specifications for the component materials, and certified laboratory test results for the resultant mix.

Part 3 - Execution

3.1 General

The Contractor shall furnish all labor material, equipment, and tools to perform all operations in connection with the grouting.

Grout delivery and return lines for interface grouting shall be installed in the form work or in the area to be grouted to provide uniform distribution of the grout as shown on the drawings. The exact location of the boxes and lines shall be determined in the field. Additional grout delivery and return lines and boxes may be required by the Engineer.

Pumps shall be positive displacement piston type pump designed for grouting service capable of operating at a discharge pressure of 100 psi. The Contractor shall supply a standby pump to be utilized in the event of a breakdown of the primary unit.

Mixers shall be high velocity "colloidal" type with a rotary speed of 1,200 to 1,500 rpm. Grout shall be mixed to a pumpable mix as per the manufacturer's recommendations.

Mixing water shall be accurately metered to control the consistency of the grout.

The Contractor shall provide all necessary valves, gages, and pressure hoses.

Water for mixing is available at the waste shaft. The Contractor is cautioned that no free water discharges or spills are permitted in the mine. All cleanup and washout operations shall be performed at the ground surface.

Potential spill areas in the underground shall be identified by the Contractor in the work plan. The Contractor shall provide adequate containment for potential spills. Isolation measures shall include, but are not limited to, lining with a membrane material (PVC, hypalon, HDPE), draped curtains (polyethylene, PVC, etc.), corrugated sheet metal protective walls or a combination of these and other measures.

If salt-saturated grout is selected for use, the Contractor shall make provisions to accurately proportion the components. Proportioning shall be by weighing. Sufficient quantities of dry components shall be developed prior to initiation of the grouting to perform the work so as not to incur delays during the mixing/placing sequence.

3.2 Interface Grouting of Concrete Barrier

After each cell of the concrete barrier has been allowed to cure for a period of seven days, or as directed by the Engineer, the Contractor shall interface grout the remaining space between the back wall and the top surface of the concrete barrier.

Each cell of the concrete barrier shall be grouted before the next adjacent cell is formed and concrete placed. Grout delivery and return lines shall be installed with the form work as shown and called for on the drawings, or as directed by the Engineer.

The placing of grout, unless otherwise directed by the Engineer shall be continuous until completed. Grouting shall progress from lower to higher grout pipes. Grouting shall proceed through a single delivery line until grout escapes from the adjacent return line. The Contractor shall then secure these lines and move to the next adjacent set of delivery and return lines. Pressure shall be adjusted to adequately deliver the grout to the forms, as witnessed by grout in the return line.

The grouting operation shall be conducted in a manner such that it does not affect the stability of the concrete barrier structure.

3.3 Contact Grouting

After completion of interface grouting if directed by the Engineer, the Contractor shall contact grout to fill any remaining voids at the concrete barrier/back wall interface. Contact grouting includes all operations to drill, clean, and grout holes installed in the concrete barrier.

The Contractor shall drill and grout the interface zone to the main concrete barrier as directed by the Engineer.

The location, direction, and depth of each grout hole shall be as directed by the Engineer. The order in which the holes are drilled and the manner in which each hole is drilled and grouted, the proportions of the water used in the grout, the time of grouting, the pressures used in grouting, and all other details of the grouting operations shall be as directed by the Engineer.

Wherever required, contact grouting will entail drilling the hole to a limited depth, installing a packer, and performing grouting.

3.3.1 Drilling

The holes shall be drilled with rotary-type drills. Drilling grout holes with percussion-type drills will not be permitted except as approved by the Engineer.

The requirements as to location, depth, spacing, and direction of the holes shall be as directed by the Engineer.

The minimum diameter shall be approximately 11/2 inches.

When the drilling of each hole or stage of has been completed, compressed air will be used to flush out drill cuttings. The hole shall then be temporarily capped or otherwise suitably protected to prevent the hole from becoming clogged or obstructed until it is grouted.

~~3.3.2 Materials for Contact Grouting~~

~~Standard weight black steel pipe conforming to ASTM A-53 shall be set in the concrete in the locations as directed by the Engineer. All pipe and fittings shall be furnished by the Contractor.~~

~~The size of the grout pipe for each hole and the depth of the holes for setting pipe for grouting shall be as directed by the Engineer. Care shall be taken to avoid clogging or obstructing the pipes before being grouted, and any pipe that becomes clogged or obstructed from any cause shall be cleaned satisfactorily or replaced.~~

~~The packers shall be furnished by the Contractor and shall consist of expansible tubes or rings of rubber, leather, or other suitable material attached to the end of the grout supply pipe. The packers shall be designed so that they can be expanded to seal the drill hole at the specified locations and when expanded shall be capable of withstanding without leakage, for a period of 5 minutes, air pressure equal to the maximum grout pressures to be used.~~

~~3.3.3 Grouting Procedures~~

~~Different grouting pressures will be required for grouting different sections of the grout holes. Pressures as high as necessary to deliver the grout but which, as determined by trial, are safe against concrete displacement shall be used in the grouting.~~

~~If, during the grouting of any hole, grout is found to flow from adjacent grout holes or connections in sufficient quantity to interfere seriously with the grouting operation or to cause appreciable loss of grout, such grout holes and connections shall be capped temporarily. Where such capping is not essential, inaugurated holes shall be left open to facilitate the escape of air as the grout is forced into other holes. Before the grout has set, the grout pump shall be connected to adjacent capped holes and to other holes from which grout flow was observed, and grouting of all holes shall be completed. If during the grouting of any hole, grout is found to flow from points in the barrier, any parts of the concrete structure, or other locations, such flows or leaks shall be plugged or caulked by the Contractor as directed by the Engineer.~~

~~As a safeguard against concrete displacement, excessive grout travel, or while grout leaks are being caulked, the Engineer may require the reduction of the pumping pressure, intermittent pumping, or the discontinuance of pumping.~~

~~The consistency of the grout mix shall be varied, as directed by the Engineer, depending on the conditions encountered. Where the grout hole or connection continues to take a large amount of grout after the mix has been thickened, the Engineer may require that pumping be done intermittently, waiting up to 8 hours between pumping periods to allow grout in the barrier to set. After the grouting is complete, the pressure shall be maintained by means of stopcocks, or other suitable valve that it will be retained in the holes or connections being grouted.~~

~~3.4 Cleanup~~

~~No clean-up or washing of equipment with water is allowed in the underground. No free water spills are permitted. All clean out or wash out requiring water will be performed above ground at the location approved by the Engineer. See note above regarding potential spill areas in Section 3.1 - General.~~

3.5 Quality Control

The Contractor shall provide a third-party quality control inspector at the site throughout the grout placement operations. The inspector shall determine that the grout mix is properly proportioned and properly mixed to the approved consistency. The inspector shall sample and make one set of grout cubes for compression testing for every 50 cubic feet of grout placed, or fraction thereof, for each day of grout placement.

End of section.

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DIVISION 3 - CONCRETE

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Section 03100 - Concrete Formwork

Part 1 - General

1.1 Scope

This section includes:

Formwork for cast-in-place concrete with shoring, bracing, and anchorage

- Accessory items, grout pipes, concrete delivery pipes.

1.2 Related Sections

- 01010 - Summary of Work
- 01400 - Contractor Quality Control
- 01600 - Material and Equipment
- 02722 - Grouting
- 03300 - Cast-in-Place Concrete
- 04300 - Unit Masonry System

1.3 References

ACI 301 Specifications for Structural Concrete for Buildings

ACI 318 Building Code Requirements for Reinforced Concrete

ACI 347 Recommended Practice for Concrete Formwork

ASTM A-36 Standard Specification for Structural Steel

ASTM A-53 Standard Specification for Pipe, Steel, Black, and Hot-Dipped Zinc Coated

ASTM A-325 High Strength, Structural Bolts

ASTM A-615 Standard Specifications for Deformed and Plain Billet-Steel Bars for Concrete Reinforcements

AWS A3.0 Welding Terms and Definitions

AWS A5.1 Specification for Mild Steel Covered Arc Welding Electrodes

AWS D1.1 Structural Welding Code-Steel

AISC Manual of Steel Construction Latest Edition

1.4 Submittals

The Contractor shall submit the following 30 days prior to initiation of work at site.

Shop detail drawings with appropriate calculations to support the adequacy or the formwork.

Mill test certification of materials utilized in construction of the forms.

Details of installation contained in the Contractor's Work Plan.

1.5 Quality Assurance

Design and detail the formwork under direct supervision of a professional structural Engineer experienced in design of this work and licensed in the state of New Mexico.

Perform work in accordance with ACI 301, 318, and 347, AISC and AWS standards. Maintain one copy of all standards at site.

Perform all fabrication in accordance with AISC manual of steel construction.

Perform all welding in accordance with AWS D1.1 structural welding code.

Perform all bolting in accordance with AISC specification for structural joints using ASTM A325 or A490 bolts.

Part 2 - Products

2.1 Form Materials

Forms for the concrete barrier shall be constructed of ASTM A-36 steel.

Pipe inserts shall be ASTM A-53 black standard weight pipe.

Form spacers shall be ASTM A-36 round stock.

Bolts shall be ASTM A325 high strength structural bolts.

Grout pipes shall be ASTM A-53 standard weight pipe or flex conduit as shown on the drawings.

Rock anchors shall develop strength equal to or greater than ASTM A-36 round stock.

Welding electrodes shall conform to AWS A5.1.

Part 3 - Execution

3.1 General

The Contractor shall furnish all labor material equipment and tools to perform all operations in connection with the design, detail, fabrication and erection of the formwork and the fabrication and installation of grout pipes for the main concrete barrier.

The Contractor may, at his option submit an alternate design or modify the design shown on the drawings, subject to the approval of the Engineer. All designs must be supported by design calculations stamped and sealed by a registered professional engineer.

The Contractor shall furnish, fabricate and install all grout pipes and grout boxes for both the concrete barrier and the isolation walls.

3.2 Shop Drawings

The Contractor shall design and detail all formwork for the concrete barrier, complete with any required bracing and shoring for the concrete barrier as shown on the drawings, in accordance with ACI 318 and 347 and the AISC manual of steel construction.

The details shall incorporate provision for adjusting and modifying the formwork to suit the excavation. Excavation tolerances are given in Section 02222 Excavation.

The Contractor shall be responsible for verifying the excavation dimensions to develop the concrete formwork to fit the excavation.

Prior to fabrication, the Contractor shall submit shop drawings complete with supporting calculations for review/approval by the Engineer 30 days prior to initiating work. The contractor shall incorporate all Engineer's comments, revisions, resolve all questions and resubmit drawings for final approval prior to proceeding with fabrication.

3.3 Fabrication

The Contractor shall fabricate all formwork and ancillary items in accordance with the latest edition of the AISC Manual of Steel Construction and the approved detail drawings.

Formwork shall contain all inserts for grouting and pumping concrete. Sufficient valving shall be provided on inserts to allow shut off of concrete and grout to prevent back flow through the form work.

All welding shall be in accordance with AWS D1.1 structural welding code including operator and procedure certifications. Elements shall be welded using E-7018 low hydrogen electrodes. Panels shall be piece marked to correspond to the erection drawing(s) and sequence at fabrication.

3.4 Installation

3.4.1 Grout Pipes

The Contractor shall furnish, fabricate, and install all grout pipes and boxes as approved by the Engineer. Grout pipes and boxes shall be attached to the back surface using masonry anchors as shown on the drawings or other approved methods. Grout pipes shall be connected to the inserts installed in the permanent forms and securely fastened to the formwork. All grout pipes will be blown out with compressed air after installation and prior to closure of the formwork to assure they are clean and free from debris or obstructions. Grout pipes shall then be temporarily capped to prevent entry of foreign matter until ready for grouting. The Contractor shall apply masking tape to the grout box openings to prevent concrete infiltration during concrete placement.

3.4.2 Formwork

The steel formwork for the concrete barrier is to remain in place at completion of each segment of the barrier, therefore all formwork shall be free from oil, grease, rust, dirt, mud or other material that would prevent bonding by the concrete. Forms will not be oiled or receive application of release agent.

The Contractor shall install formwork at the locations shown on the drawings to the lines and grades shown. Forms are to be mortar tight. The Contractor shall adjust the formwork to suit the contour of the excavation. Rock may be trimmed or chipped to suit where interferences are encountered. Where overexcavation has occurred in excess of the designed-in adjustability of the formwork, modifications shall be proposed to the Engineer for his approval prior to installation. Installation of the formwork shall be reviewed and approved by the Engineer prior to proceeding with concrete installation.

The Contractor shall provide a sealant or gasket material on mating surfaces to provide mortar-tite joints.

3.5 Quality Control

The Contractor shall arrange for and contract with an approved third party inspector to provide inspection/testing services for the fabrication and installation of the formwork and ancillary items, as required by the QA/QC plan.

The Contractor shall furnish certified mill test reports for all materials utilized in the fabrication.

All welding shall be in accordance with AWS D1.1 structural welding code. The Contractor shall furnish welding operator and procedure certifications for all operators and procedures utilized.

Fabricated components shall be inspected for dimension and overall quality. Welds shall be inspected by an AWS certified welding inspector.

The inspector shall visually inspect the installation for fit-up and dimensionally for location.

3.6 Handling, Shipping, Storage

The Contractor shall handle, ship, and store fabricated components with care to avoid damage. Stored components shall be placed on timbers or pallets off the ground to keep the units clean. Components shall be tarped while in outdoor storage. Components that become spattered or contaminated with mud will be thoroughly cleaned before delivering to the mine for installation. Damaged components will be rejected by the inspector and replaced by the contractor at his cost.

End of section.

Section 03300 - Cast-in-Place Concrete

Part 1 - General

1.1 Scope

This section includes:

Cast-in-place concrete for concrete barrier

Concrete mix design.

1.2 Related Sections

- 01010 - Summary of Work
- 01400 - Contractor Quality Control
- 01600 - Material and Equipment
- 02222 - Excavation
- 02722 - Grouting
- 03100 - Concrete Formwork

1.3 References

ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavy Weight, and Mass Concrete
ACI 318.1	Building Code Requirements for Structural Plain Concrete
ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 143	Standard Specification for Slump of Portland Cement Concrete
ASTM C 150	Standard Specification for Portland Cement
ASTM C 186	Standard Test Method for Heath of Hydration of Hydraulic Cement
ASTM C 403	Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance
ASTM C 618	Fly ash and Raw or Calcined Natural Pozzolan for Use as an Admixture in Portland Cement Concrete

ASTM D 2216	Standard Test Method for Laboratory Determination of Water (moisture) Content of Soil and Rock
USACE CRD-C 36	Method of Test for Thermal Diffusivity of Concrete
USACE CRD-C 48	Standard Test Method for Water Permeability of Concrete
API 10	Cements
NRMCA	Check List for Certification of Ready Mixed Concrete Production Facilities
NRMCA	Concrete Plant Standards

MOC Standards

WIPP-DOE-71	Design Criteria Waste Isolation Pilot Plant, Revised Mission Concept -- IIA (DOE, 1984)
WP 03-1	WIPP Startup and Acceptance Test Program (Westinghouse, 1993b)
WP 09-010	Design Development Testing (Westinghouse, 1991)
WP 09-CN3021	Component Numbering (Westinghouse, 1994a)
WP 09-024	Configuration Management Board/Engineering Change Proposal (**ECP**) (Westinghouse, 1994b)

1.4 Submittals for Review/Approval

The Contractor shall submit the following for approval 30 days prior to initiating any work at the site.

Specific sources of supply and detailed product information for each component of the concrete mix is specified in Section 2.6 below.

Product Data - Laboratory test data and trial mix data for the proposed concrete to be utilized for the concrete barrier.

Proposed method of installation, including equipment and materials in work plan.

1.5 Submittals at Completion

Laboratory test data developed during the installation of the concrete barrier.

1.6 Quality Assurance

Perform work in accordance with the Contractor's Quality Control Plan and referenced ACI and ASTM standards.

Acquire cement, aggregate and component materials from the same source throughout the work.

Part 2 - Products

2.1 Cement

Portland cement shall conform to API 10 Class H oil well cements. The source of the cement to be used shall be indicated and manufacturer's certification that the cement complies to the applicable standard shall be provided with each shipment.

2.2 Aggregates

Aggregates shall be quartz aggregates conforming to the requirements of ASTM C33.

Fine aggregate shall meet the requirements of ASTM C33 having a fineness modules in the range of 2.80 to 3.00.

Coarse aggregate maximum size shall be 1 ½ inches and shall be clean, cubical, angular, 100 percent crushed aggregate without flat or elongated particles.

The source of the aggregate is to be indicated and test reports certifying that the aggregate complies with the applicable standard are to be submitted for approval with the trial mix data.

2.3 Water

Water used in mixing concrete shall be of potable quality, free of injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances.

Water shall conform to the provisions in ASTM C94, and in addition, shall conform to the following:

- pH not less 6.0 or greater than 8.0
- Carbonates and/or bicarbonates of sodium and potassium: 1000 ppm maximum
- Chloride ions (C1): 250 ppm maximum
- Sulfate ions (SO_4): 1000 ppm maximum
- Iron content: 0.3 ppm maximum
- Total solids: 2000 ppm maximum

When ice is used in concrete mix, the water used for making ice shall meet all of the above requirements.

The source of water is to be indicated and certified copies of test data from an approved laboratory confirming that the water to be used meets the above requirements shall be submitted for approval with the trial mix data.

2.4 Admixtures

Pozzolan shall conform to ASTM C618. Sampling and testing of pozzolans shall conform to ASTM C311. Approximately 5 percent by weight of pozzolan may be used to replace cement in the mixes when approved.

The source of any admixtures proposed are to be indicated and certified copies of test data from an approved laboratory shall be submitted for approval with the trial mix.

2.5 Concrete Mix Properties

The Contractor shall develop and proportion a Salado Mass Concrete mix for use in constructing the concrete barrier. Cement utilized in the mix shall be Class H. The Contractor shall demonstrate by trial mix that the proposed concrete meets the following properties:

Target properties for Barrier Concrete

Property	Comment
4-hr working time	Indicated by 8-inch slump (ASTM C 142) after 3-hr intermittent mixing. Max 10-inch slump at mixing.
Nonsegregating	Aggregates do not readily separated from cement paste during handling
Less than 25°F heat rise prior to placement	Difference between initial condition and temperature after 4 hr.
4,500 psi compressive strength (f'_c)	At 28 days after casting (ASTM C39)
Volume stability	Length change between +0.05 percent and -0.02 percent (ASTM C 490)
Minimal entrained air	2 percent to 3 percent air

The Contractor shall provide certified copies of test data from an approved laboratory demonstrating compliance with the above target properties.

In addition to the target properties the Contractor shall provide certified test data for the trial mix for the following properties:

- Heat of hydration ASTM C-186
- Concrete Set ASTM C-403
- Thermal Diffusivity USACE CRD-C36
- Water Permeability USACE CRD-C43

2.6 Salado Mass Concrete

The Contractor shall utilize the Salado Mass concrete. The Contractor shall demonstrate that the Salado Mass concrete meets the target properties shown above. Recommended initial proportioning of the Salado Mass concrete is as follows:

Component	Percent of Total Mass
Class H Cement	4.93
Chem Comp III	2.85
Class F fly ash	6.82
Fine aggregate	33.58
Coarse aggregate	43.02
Sodium chloride	2.18
Defoaming agent	0.15
Sodium citrate	0.09
Water	6.38

The Contractor shall prepare a trial mix and provide certified test data from an approved testing laboratory for slump, compressive strength, heat rise, heat of hydration, concrete set time, thermal diffusivity, and water permeability as indicated above for the plain concrete mix.

Part 3 - Execution

3.1 General

The Contractor shall provide all labor material, equipment and tools necessary to develop, supply, mix, transport and place mass concrete in the forms as shown on the drawings and called for in these specifications

The Contractor will be required to provide and erect on the site a batch plant, suitable to store, handle, weight and deliver the proposed concrete mix. The batch plant shall be certified to NRMCA standards. The batch plant shall be erected on site in the location as directed by the Engineer.

The Contractor shall batch, mix, and deliver to the underground, sufficient quantity of concrete to complete placement of concrete within one form section, as shown on the drawings. Once begun, placement of concrete in a section shall be continuous until completed. The time for concreting one section will not exceed ten hours.

It is expected that addition of water to the dry materials and mixing of the concrete will occur at the ground surface with transport of wet concrete to a pump at the underground level where it will be pumped into the forms.

The Contractor is to provide all transport vehicles or means to transfer the wet concrete from the mixer truck to the pump. It is expected that the Contractor will use the waste conveyance hoist to transfer from the ground surface to the mine level. The Contractor is to familiarize himself with the dimensions of the waste conveyance and the airlock in order to provide suitable transport vehicles. The Contractor is also to familiarize himself with the capacity and speed of the conveyance to allow transfer of sufficient concrete to sustain the continuing placement of concrete. (See Figures G1-2 and G1-3, attached).

The Contractor shall determine the horizontal distance to the entry where placement of the concrete barrier is to occur, and develop a route, with the approval of the Engineer for traffic flow within the underground.

Details of the logistics for handling the concrete shall be included in the Contractors' Work Plan, and submitted to the Engineer for approval prior to start of work at the site.

Potential spill areas in the underground shall be identified by the Contractor in the Work Plan. The Contractor shall provide measures to contain and isolate any water from contact with the halite in these areas. Suitable containment isolation measures shall include but are not limited to, lining with a membrane material (PVC, hypalon, HDPE), draped curtains (polyethylene, PVC, etc.), corrugated sheet metal protective walls or a combination of these and other measures.

~~3.2 Pumping Concrete~~

~~The Contractor shall provide pumping equipment suitable for placing the concrete into the forms. The Contractor at a minimum, shall provide an operating and a spare pump, to be used in the event of breakdown of the primary unit. After transporting and prior to pumping the concrete shall be remixed to compensate for segregation of aggregate during transport. The Contractor shall indicate the equipment proposed for pumping (manufacturer, model, type, capacity, pressure and remixing at the point of delivery in the Work Plan).~~

~~Each batch of concrete shall be checked at the surface at the time of mixing and again at the point of transfer to the pump for slump and temperature, and shall conform to the following:~~

- ~~Maximum slump at mixing - 10 inches~~
- ~~Maximum slump at delivery to pump - 8 inches~~
- ~~Maximum mix temperature at placement = 70°F~~

~~Note: No water is to be added to the mix after the initial mixing and slump are determined.~~

~~The Contractor shall connect to the pipe ports fabricated into the forms for delivery of the concrete, beginning with the lowest ports first. Pumping shall continue until concrete is seen in the adjacent port at which time the delivery hose will be transferred to that port and the first port capped.~~

~~Pumping shall continue moving laterally then upward until the entire form is filled and the pour is completed.~~

~~3.3 Coordination of Work~~

~~The Contractor is to coordinate his work mixing, transporting, and placing the mass concrete with the on-going operations in the underground. Coordination of use of the facilities and existing equipment shall be through the Engineer.~~

~~3.4 Clean-Up~~

~~No clean up or washing of equipment with water will be allowed in the underground. No free water spills are permitted in the underground. All clean-out or wash-out requiring water will be performed above ground at the location approved by the Engineer.~~

~~3.5 Quality Control~~

~~The Contractor shall provide a third-party quality control inspector at the site throughout the concrete placement. The inspector shall be responsible for determining that the batch plant is proportioning the mix according to the approved proportions. The batch plant shall provide a print out of batch quantities for each truck delivered to the mine. The inspector shall also determine the slump for each batch as it is mixed and allow additional water to be added until the initial slump is achieved. No additional water is to be added after this time. Temperature will also be recorded at this time.~~

~~The inspector shall also determine the slump and temperature following the remixing when concrete is transferred to the pump. Concrete not meeting or exceeding the specification is to be rejected and removed from the underground.~~

~~Concrete test cylinders to determine unconfined compression strength shall be taken by the inspection at the delivery from remixer to the pump in the underground. Four (4) cylinders shall be made for each 50 cubic yards of concrete placed. Cylinders shall be sealed with polyethylene and taped and field cured at ambient temperatures in the mine adjacent to the concrete barrier area. Two (2) samples shall be tested at 7 days and the remaining two (2) at 28 days.~~

~~End of section.~~

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DIVISION 4 - MASONRY

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Section 04100 - Mortar

Part 1 - General

1.1 Scope

This section includes:

- Mortar for Isolation Wall Construction.

1.2 Related Sections

- 01010 - Summary of Work
- 01400 - Contractor Quality Control
- 01600 - Material and Equipment
- 04300 - Unit Masonry System

1.3 References

ASTM C91 Standard Specification for Masonry Cement

ASTM C144 Standard Specification for Aggregate for Masonry Mortar

ASTM C150 Standard Specification for Portland Cement

ASTM C207 Standard Specification for Hydrated Lime for Masonry Purposes

ASTM C270 Standard Specification for Mortar for Unit Masonry

ASTM C7805 Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry

ASTM C1142 Ready-Mixed Mortar for Unit Masonry

ASTM E447 Test Methods for Compressive Strength of Masonry Prisms

1.4 Submittals for Review and Approval

The Contractor shall submit for approval the following 30 days prior to the initiation of work at the site:

Design mix.

Certified laboratory tests for the proposed design mix, indicating conformance of mortar to property requirements of ASTM C270, and test and evaluation reports to ASTM C780.

1.5 Submittals at Completion

Certified laboratory test results for the construction testing of mortar mix.

1.6 Quality Assurance

Perform work in accordance with the Contractor's Quality Control Plan and referenced ASTM standards. Acquire cement, aggregate, and component materials from the same source throughout the work.

1.7 Delivery Storage Handling

Maintain packaged materials clean, dry and protected against dampness, freezing and foreign matter.

Part 2 - Products

2.1 Mortar Mix

The Contractor shall provide mortar for Isolation Walls, which shall be in conformance with ASTM C270 type M, using the property specification (3,000 psi at 28 days).

Sand for mortar shall conform to ASTM C144.

Water used for mixing mortar shall be of potable quality, free of injurious amounts of oil, acid alkali, organic matter, sediments, or other deleterious substances, as specified for Concrete, Section 03300 2.3.

The supply of materials as defined in the design mix shall remain the same throughout the job.

Part 3 - Execution

3.1 General

The Contractor shall furnish all labor material equipment and tools to perform all operations in connection with supplying and mixing mortar for constructing the isolation walls.

The Contractor shall fully describe his proposed mortar mixing operation, including proposed equipment and materials in the Work Plan.

3.2 Mortar Mixing

Mortar shall be machine-mixed with sufficient water to achieve satisfactory workability. Maintain sand uniformly damp immediately before the mixing process. If water is lost by evaporation, retemper only within one and one half hours of mixing. Use mortar within two hours of mixing at ambient temperature of 85° in the mine.

3.3 Installation

The Contractor shall install mortar to the requirements of Section 04300 Unit Masonry System.

3.4 Field Quality Control

The Contractor shall provide a third party Quality Control Inspector to perform all sampling and testing to confirm that the mortar mix conforms to the proposed mix properties developed in the design mix.

Construction testing of mortar mix shall be in accordance with ASTM C780 for compression strength. Four (4) prism specimens shall be taken for each 50 cu. ft. of mortar or fraction thereof placed each day.

End of Section.

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Section 04300 - Unit Masonry System

Part 1 - General

1.1 Scope

This section includes:

- Concrete Masonry Units

1.2 Related Sections

- 01010 Summary of Work
- 01400 Contractor Quality Control
- 01600 Material and Equipment
- 02722 Grouting
- 03100 Concrete Formwork
- 04100 Mortar

1.3 References

ASTM C55 Standard Specification for Concrete Building Brick

ASTM C140 Standard Method of Sampling and Testing Concrete Masonry Units

1.4 Submittals for Revision and Approval

The Contractor shall submit for approval the following 30 days prior to initiation of the work at the site.

Certified laboratory test results for the proposed solid masonry units.

1.5 Quality Assurance

Perform the work in accordance with the Contractor's Quality Control Plan.

Part 2 - Products

2.1 Concrete Masonry Units

Concrete masonry units shall be solid (no cavities or cores), load bearing high-strength units having a minimum compressive strength of 3500 psi. Concrete masonry units shall be tested in accordance with ASTM C140. All other aspects of the concrete masonry units shall comply with ASTM C55, Type I Moisture Controlled.

Nominal modular size shall be 8 x 8 x 16 inches, or as otherwise approved by the Engineer.

Concrete brick shall comply with ASTM C55, Grade N, Type I (moisture controlled) having a minimum compressive strength of 3500 psi (Avg. 3 units) or 3000 psi for individual unit.

2.2 Mortar

Mortar shall be as specified in Section 04100 Mortar.

Part 3 - Execution

3.1 General

The Contractor shall furnish all labor, material, equipment and tools to perform all operations of installing Unit Masonry Isolation Walls to the lines and grades shown on the drawings.

The Contractor shall examine the excavation of the entry to affirm that the keys have been properly leveled and cut to the appropriate depths, at the proper locations prior to any to any work.

3.2 Installation

The Contractor shall install the isolation walls using concrete masonry units as specified above. Masonry units shall be installed with 3/8-inch mortar joints with full mortar bedding and full head joints. Masonry units shall be installed in running bond with headers every third course. Masonry units shall be mortared tight to the ribs and the back wall to provide a seal all around the isolation wall.

Concrete brick may be used as required for fit-up around grout pipes, or minimizing the dimensional fit-up at the top or sides of the isolation walls as approved by the Engineer. The interface between the top of the isolation wall and the back wall shall be completely mortared to provide full contact between the back and the block wall.

3.3 Field Quality Control

The Contractor shall provide a third-party Quality Control Inspector to inspect the installation of the Concrete Masonry Unit Isolation Walls. Inspection and testing of the mortar shall be in accordance with Section 04100 Mortar.

End of Section

~~**FIGURES**~~

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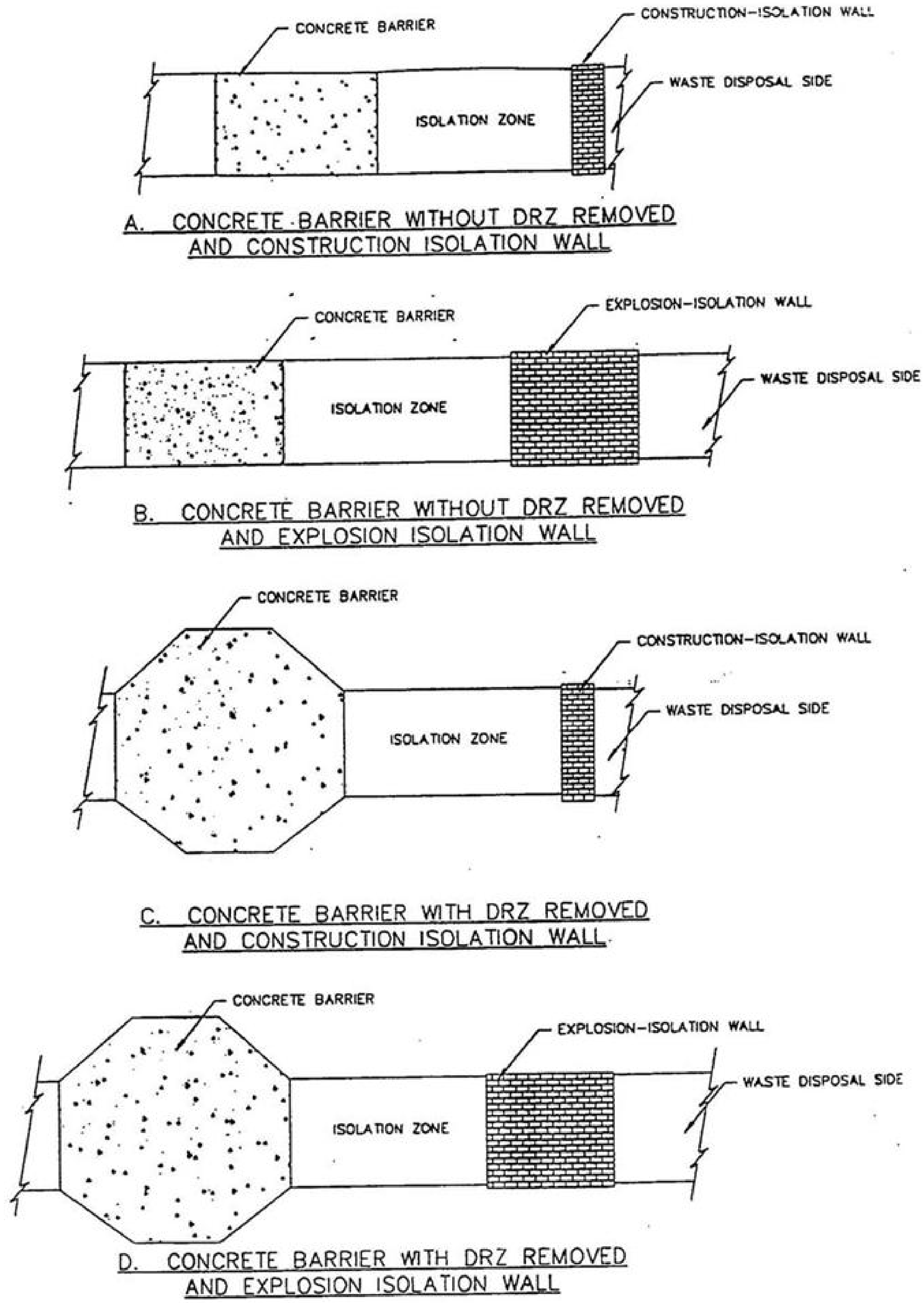


~~Figure G1G-1~~
~~Plan Variations~~

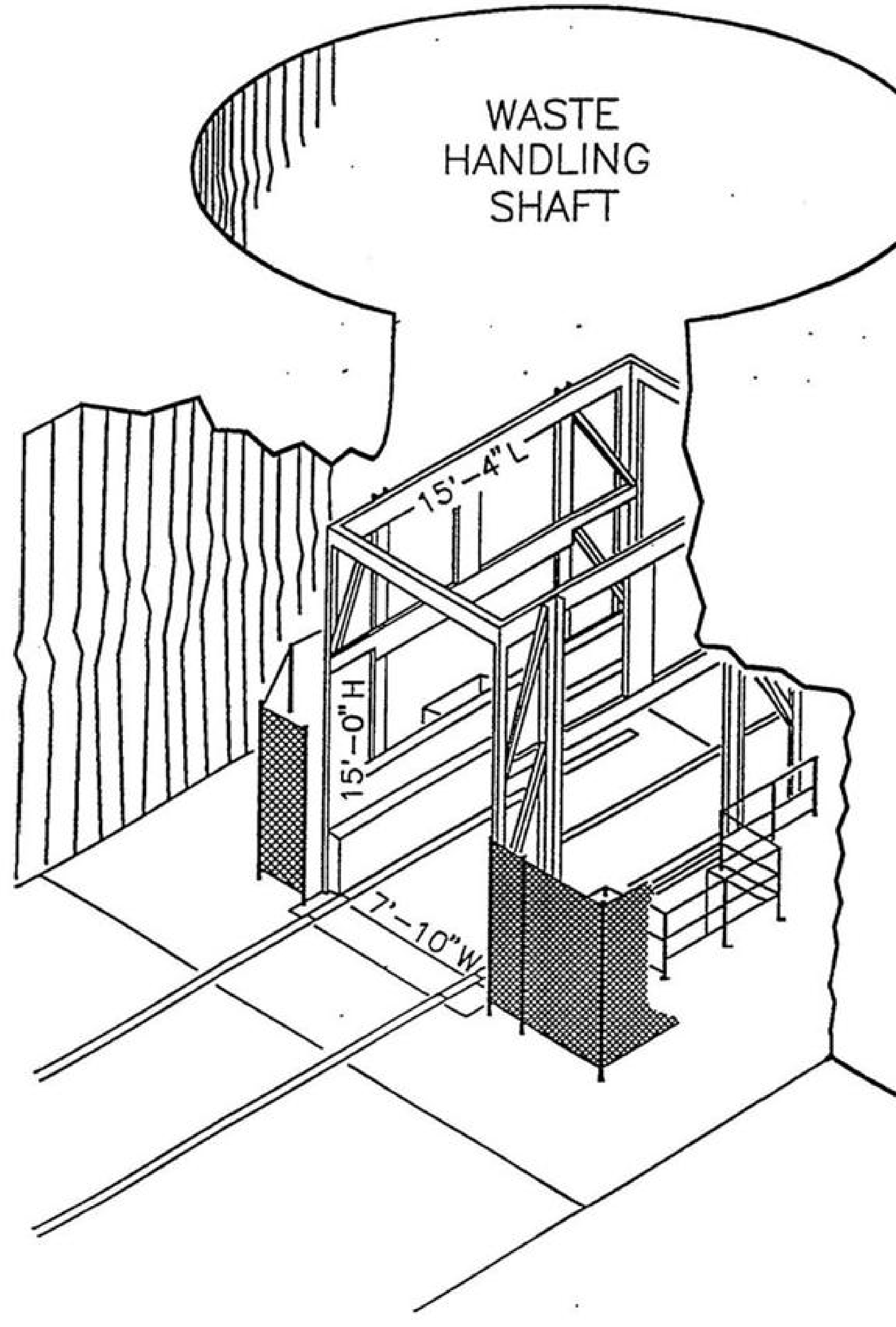
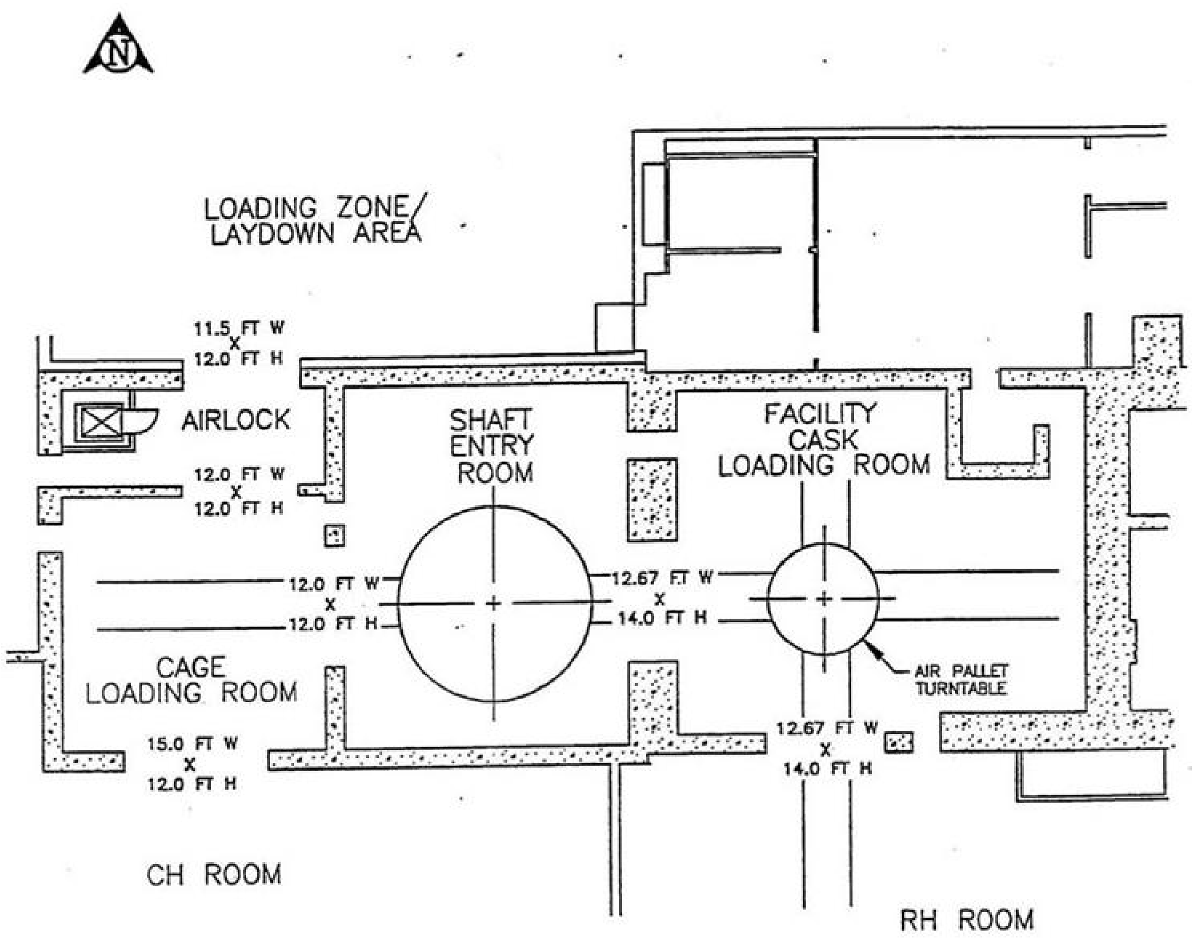


Figure G1G-2
Waste Handling Shaft Cage Dimensions



~~Figure G1G-3~~
~~Waste Shaft Collar and Airlock Arrangement~~

ATTACHMENT G1
APPENDIX H

DESIGN DRAWINGS

PANEL CLOSURE SYSTEM
WASTE ISOLATION PILOT PLANT
CARLSBAD, NEW MEXICO

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~~ATTACHMENT G1~~
~~APPENDIX H~~

~~DESIGN DRAWINGS~~

~~PANEL CLOSURE SYSTEM~~
~~WASTE ISOLATION PILOT PLANT~~
~~CARLSBAD, NEW MEXICO~~

~~**Drawing**~~	~~**Title**~~
~~762447-E1~~	~~Panel closure system, air intake and exhaust drifts, title sheet~~
~~762447-E2~~	~~Panel closure system, underground waste-emplacement panel plan~~
~~762447-E3~~	~~Panel closure system, air intake drift, construction details~~
~~762447-E4~~	~~Panel closure system, air exhaust drift, construction details~~
~~762447-E5~~	~~Panel closure system, construction and explosion walls, construction details~~
~~762447-E6~~	~~Panel closure system, air intake and exhaust drifts, grouting and miscellaneous details~~

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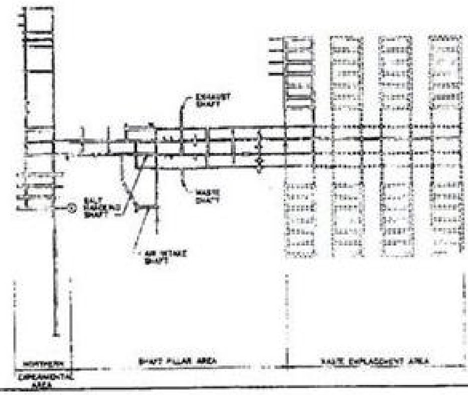
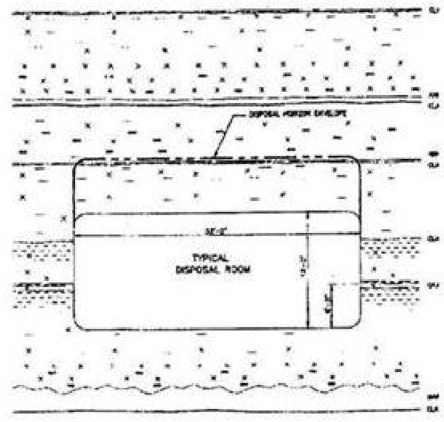
762447-E1	TITLE SHEET
762447-E2	UNDERGROUND WASTE DISPOSAL PANEL-PLAN
762447-E3	PANEL CLOSURE SYSTEM-AIR INTAKE DRIFT-CONSTRUCTION DETAILS
762447-E4	PANEL CLOSURE SYSTEM-AIR EXHAUST DRIFT-CONSTRUCTION DETAILS
762447-E5	PANEL CLOSURE SYSTEM-CONSTRUCTION AND EXPLOSION WALLS-CONSTRUCTION DETAILS
762447-E6	PANEL CLOSURE SYSTEM-AIR ENTRANCE AND EXHAUST DRIFT GROUTING AND MISCELLANEOUS DETAILS



UNDERGROUND REPOSITORY LAYOUT PLAN
NTS

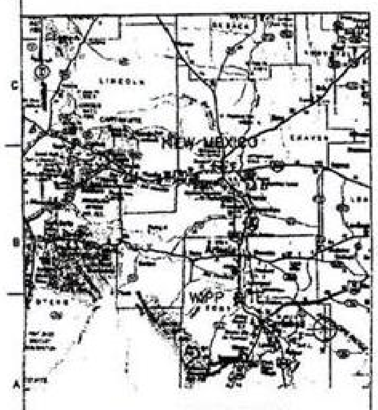


DETAILED STRATIGRAPHY AT THE REPOSITORY HORIZO
NTS

WASTE ISOLATION PILOT PLANT
PANEL CLOSURE SYSTEM
CARLSBAD, NEW MEXICO

prepared by

IT CORPORATION
ALBUQUERQUE, NEW MEXICO

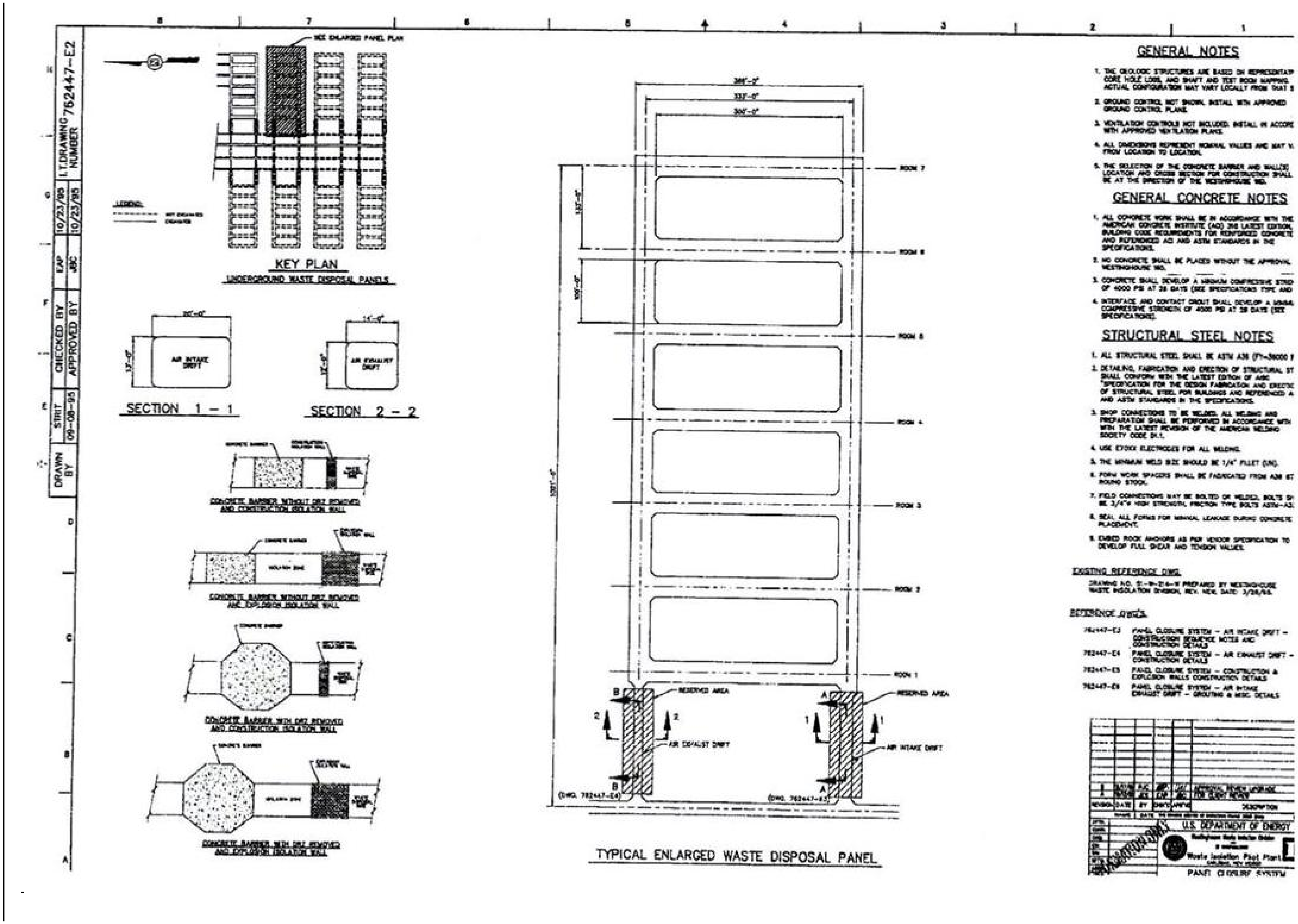


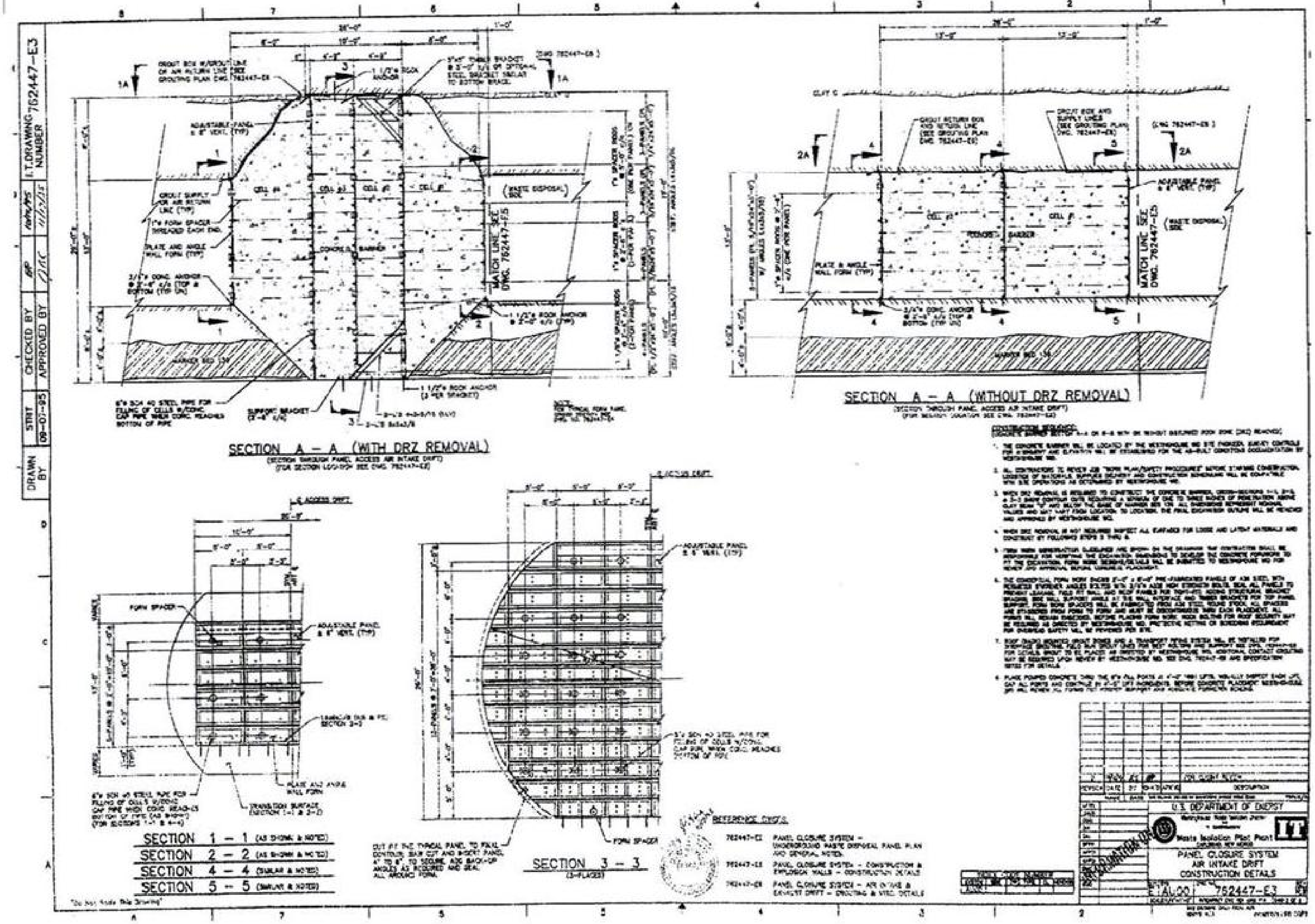
GENERAL LOCATION MAP
NTS

I.T. DRAWING NUMBER 7624

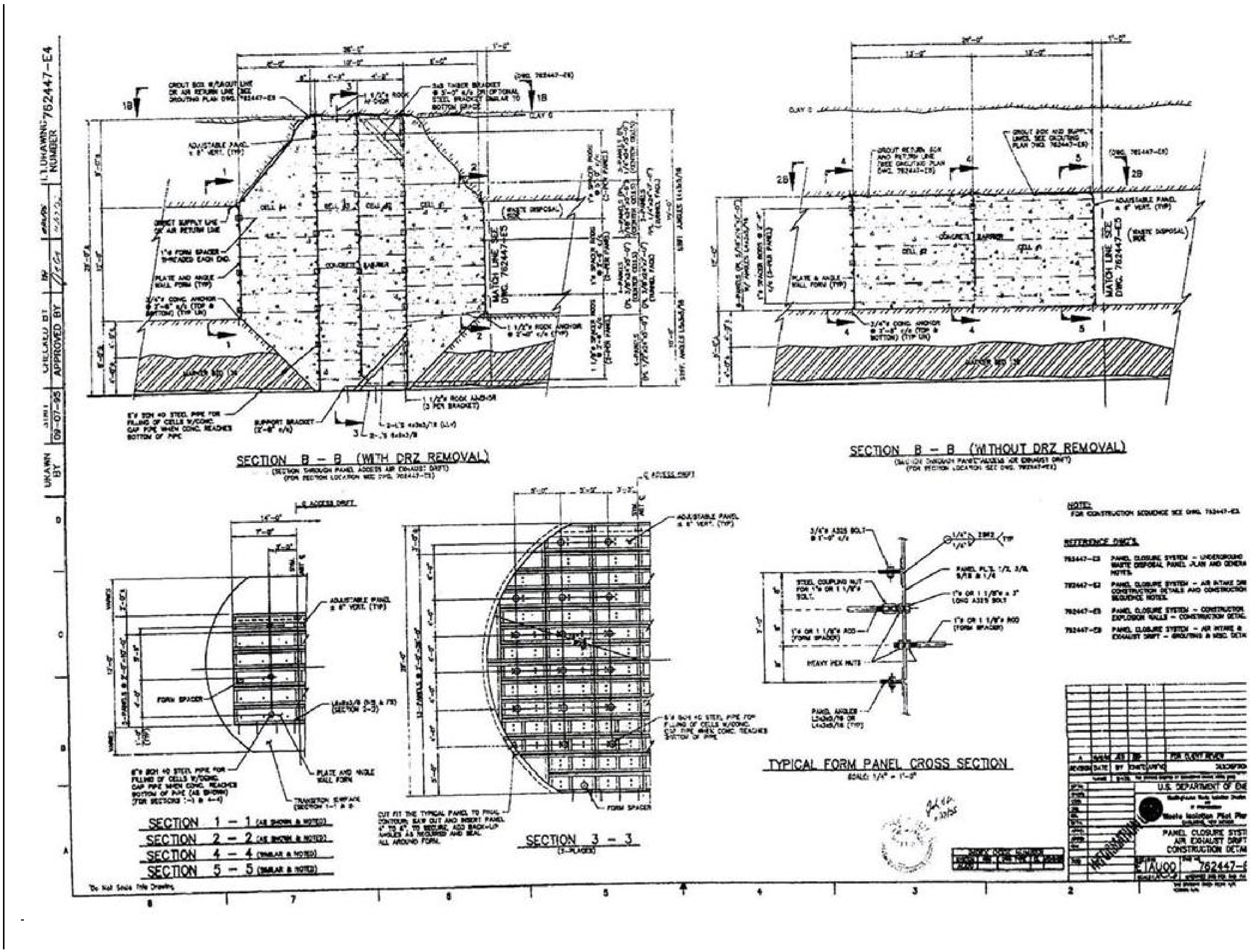
CHECKED BY | APPROVED BY | DRAWN BY | 09-08-95

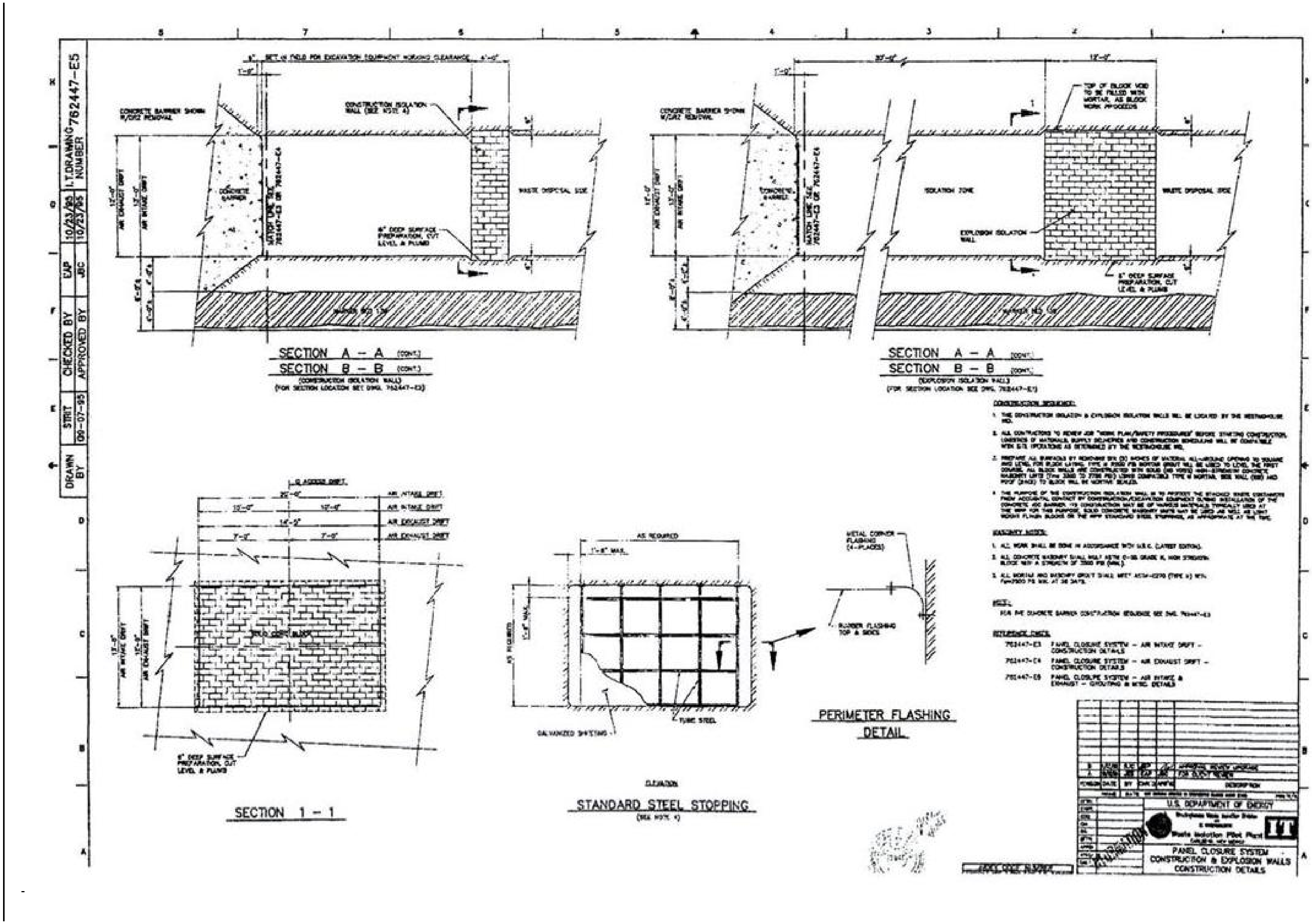
U.S. DEPARTMENT
Waste Isolation
PANEL CLOSUR
AIR INTAKE AND E
TITLE SH
E AU00 762

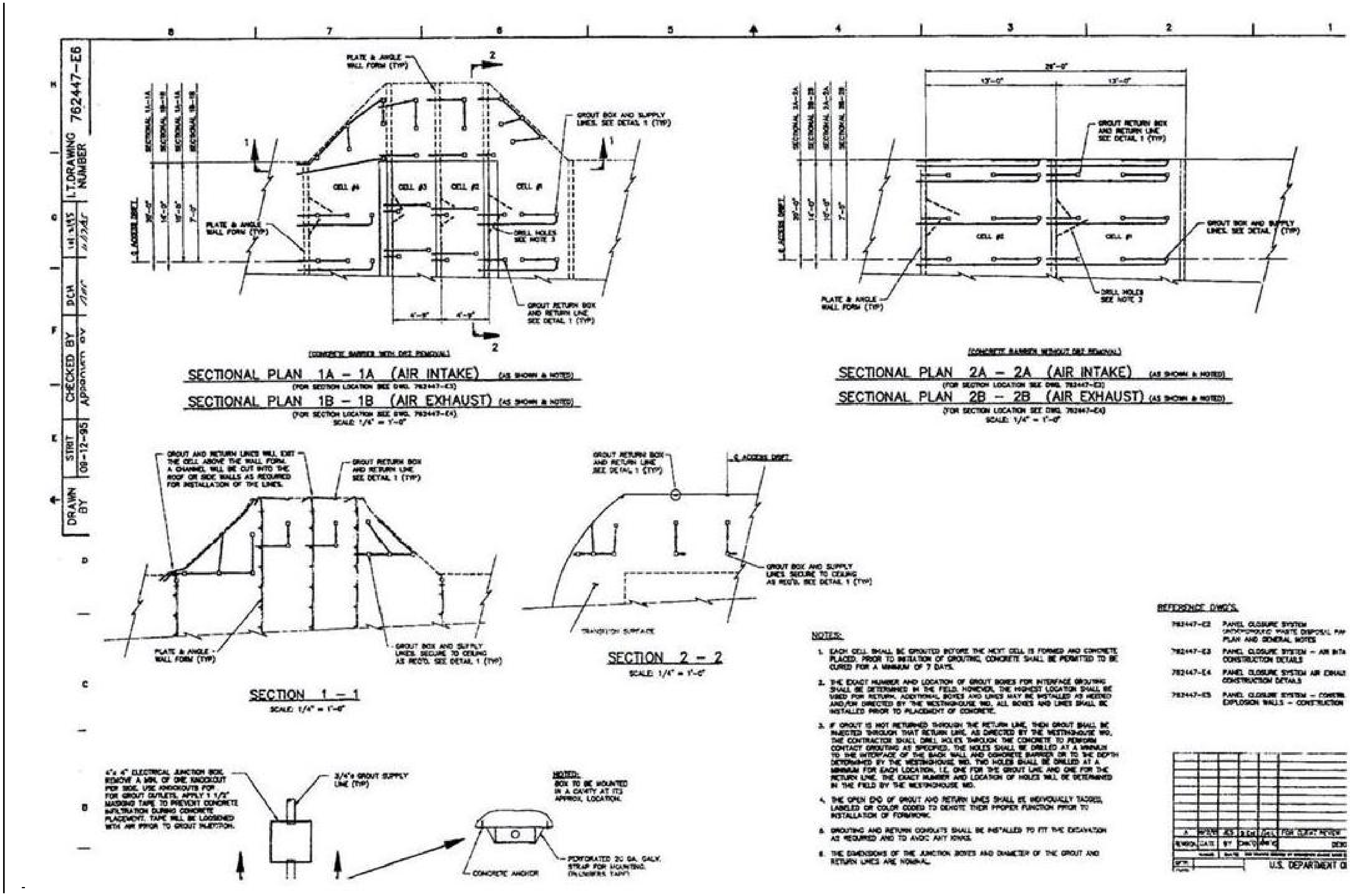

I.T. DRAWING NUMBER 762447-E2
DRAWN BY
STRIT 09-08-95
CHECKED BY EAP 10/23/95
APPROVED BY JBC 10/23/95
KEY PLAN
UNDERGROUND WASTE DISPOSAL PANELS
SECTION 1 - 1
AIR INTAKE DRIFT
SECTION 2 - 2
AIR EXHAUST DRIFT
TYPICAL ENLARGED WASTE DISPOSAL PANEL
ROOM 7
ROOM 6
ROOM 5
ROOM 4
ROOM 3
ROOM 2
ROOM 1
RESERVED AREA
AIR EXHAUST DRIFT
AIR INTAKE DRIFT
GENERAL NOTES
GENERAL CONCRETE NOTES
STRUCTURAL STEEL NOTES
U.S. DEPARTMENT OF ENERGY
Waste Isolation Pilot Plant
PANEL CLOSURE SYSTEM



I.T. DRAWING NUMBER 762447-E3
DRAWN BY
CHECKED BY
APPROVED BY
SECTION A – A (WITH DRZ REMOVAL)
SECTION A – A (WITHOUT DRZ REMOVAL)
CELL #4
CELL #3
CELL #2
CELL #1
CONCRETE BARRIER
MARKER BED 139
MATCH LINE SEE DWG. 762447-E5
SECTION 1 – 1
SECTION 2 – 2
SECTION 4 – 4
SECTION 5 – 5
SECTION 3 – 3
FORM SPACER
ADJUSTABLE PANEL
PLATE AND ANGLE WALL FORM
REFERENCE DWGS.
CONSTRUCTION SEQUENCE
U.S. DEPARTMENT OF ENERGY
Waste Isolation Pilot Plant
IT
PANEL CLOSURE SYSTEM
AIR INTAKE DRIFT
CONSTRUCTION DETAILS
ETAL00
762447-E3


762447-E4
DRAWN BY
CHECKED BY
APPROVED BY
09-07-95
SECTION B – B (WITH DRZ REMOVAL)
SECTION B – B (WITHOUT DRZ REMOVAL)
MATCH LINE SEE DWG. 762447-E5
CONCRETE BARRIER
SECTION 1 – 1
SECTION 2 – 2
SECTION 4 – 4
SECTION 5 – 5
SECTION 3 – 3
TYPICAL FORM PANEL CROSS SECTION
NOTE:
REFERENCE DWG'S
PANEL CLOSURE SYSTEM
AIR EXHAUST DRIFT
CONSTRUCTION DETAIL


I.T. DRAWING NUMBER 762447-E5
DRAWN BY
STRIT
09-07-95
CHECKED BY
EAP
10/23/95
APPROVED BY
JBC
10/23/95
CONCRETE BARRIER SHOWN W/DRZ REMOVAL
CONSTRUCTION ISOLATION WALL (SEE NOTE 4)
CONCRETE BARRIER
WASTE DISPOSAL SIDE
ISOLATION ZONE
EXPLOSION ISOLATION WALL
TOP OF BLOCK VOID TO BE FILLED WITH MORTAR, AS BLOCK WORK PROCEEDS
6" DEEP SURFACE PREPARATION, CUT LEVEL & PLUMB
SECTION A – A (CONT.)
SECTION B – B (CONT.)
(CONSTRUCTION ISOLATION WALL)
(EXPLOSION ISOLATION WALL)
AIR INTAKE DRIFT
AIR EXHAUST DRIFT
SECTION 1 – 1
AS REQUIRED
GALVANIZED SHEETING
TUBE STEEL
ELEVATION
STANDARD STEEL STOPPING
METAL CORNER FLASHING (4-PLACES)
RUBBER FLASHING TOP & SIDES
PERIMETER FLASHING DETAIL
CONSTRUCTION SEQUENCE:
MASONRY NOTES:
NOTE:
REFERENCE DWGS.
762447-E3 PANEL CLOSURE SYSTEM – AIR INTAKE DRIFT – CONSTRUCTION DETAILS
762447-E4 PANEL CLOSURE SYSTEM – AIR EXHAUST DRIFT – CONSTRUCTION DETAILS
762447-E5 PANEL CLOSURE SYSTEM – AIR INTAKE & EXHAUST – GROUTING & MISC. DETAILS
U.S. DEPARTMENT OF ENERGY
Waste Isolation Pilot Plant
PANEL CLOSURE SYSTEM CONSTRUCTION & EXPLOSION WALLS CONSTRUCTION DETAILS
IT


I.T. DRAWING NUMBER 762447-E6
DRAWN BY
STRIT
08-12-95
CHECKED BY
DCM
APPROVED BY
SECTIONAL PLAN 1A – 1A (AIR INTAKE) (AS SHOWN & NOTED)
SECTIONAL PLAN 1B – 1B (AIR EXHAUST) (AS SHOWN & NOTED)
SCALE: 1/4" = 1'-0"
SECTIONAL PLAN 2A – 2A (AIR INTAKE) (AS SHOWN & NOTED)
SECTIONAL PLAN 2B – 2B (AIR EXHAUST) (AS SHOWN & NOTED)
SCALE: 1/4" = 1'-0"
CELL #4
CELL #3
CELL #2
CELL #1
PLATE & ANGLE WALL FORM (TYP)
GROUT BOX AND SUPPLY LINES. SEE DETAIL 1 (TYP)
GROUT RETURN BOX AND RETURN LINE SEE DETAIL 1 (TYP)
DRILL HOLES SEE NOTE 3
SECTION 1 – 1
SCALE: 1/4" = 1'-0"
SECTION 2 – 2
SCALE: 1/4" = 1'-0"
GROUT AND RETURN LINES WILL EXIT THE CELL ABOVE THE WALL FORM. A CHANNEL WILL BE CUT INTO THE ROOF OR SIDE WALLS AS REQUIRED FOR INSTALLATION OF THE LINES.
GROUT BOX AND SUPPLY LINES. SECURE TO CEILING AS REQ'D. SEE DETAIL 1 (TYP)
TRANSITION SURFACE
3/4"ø GROUT SUPPLY LINE (TYP)
CONCRETE ANCHOR
NOTES:
1. EACH CELL SHALL BE GROUTED BEFORE THE NEXT CELL IS FORMED AND CONCRETE PLACED. PRIOR TO INITIATION OF GROUTING, CONCRETE SHALL BE PERMITTED TO BE CURED FOR A MINIMUM OF 7 DAYS.
2. THE EXACT NUMBER AND LOCATION OF GROUT BOXES FOR INTERFACE GROUTING SHALL BE DETERMINED IN THE FIELD. HOWEVER, THE HIGHEST LOCATION SHALL BE USED FOR RETURN. ADDITIONAL BOXES AND LINES MAY BE INSTALLED AS NEEDED AND/OR DIRECTED BY THE WESTINGHOUSE WID. ALL BOXES AND LINES SHALL BE INSTALLED PRIOR TO PLACEMENT OF CONCRETE.
3. IF GROUT IS NOT RETURNED THROUGH THE RETURN LINE, THEN GROUT SHALL BE INJECTED THROUGH THAT RETURN LINE, AS DIRECTED BY THE WESTINGHOUSE WID. THE CONTRACTOR SHALL DRILL HOLES THROUGH THE CONCRETE TO PERFORM CONTACT GROUTING AS SPECIFIED. THE HOLES SHALL BE DRILLED AT A MINIMUM TO THE INTERFACE OF THE BACK WALL AND CONCRETE BARRIER OR TO THE DEPTH DETERMINED BY THE WESTINGHOUSE WID. TWO HOLES SHALL BE DRILLED AT A MINIMUM FOR EACH LOCATION, I.E. ONE FOR THE GROUT LINE AND ONE FOR THE RETURN LINE. THE EXACT NUMBER AND LOCATION OF HOLES WILL BE DETERMINED IN THE FIELD BY THE WESTINGHOUSE WID.
4. THE OPEN END OF GROUT AND RETURN LINES SHALL BE INDIVIDUALLY TAGGED, LABELED OR COLOR CODED TO DENOTE THEIR PROPER FUNCTION PRIOR TO INSTALLATION OF FORMWORK.
5. GROUTING AND RETURN CONDUITS SHALL BE INSTALLED TO FIT THE EXCAVATION AS REQUIRED AND TO AVOID ANY KINKS.
6. THE DIMENSIONS OF THE JUNCTION BOXES AND DIAMETER OF THE GROUT AND RETURN LINES ARE NOMINAL.
REFERENCE DWG'S.
762447-E2 PANEL CLOSURE SYSTEM PLAN AND GENERAL NOTES
762447-E3 PANEL CLOSURE SYSTEM – AIR INTA CONSTRUCTION DETAILS
762447-E4 PANEL CLOSURE SYSTEM AIR EXHAU CONSTRUCTION DETAILS
762447-E5 PANEL CLOSURE SYSTEM – CONSTR EXPLOSION WALLS – CONSTRUCTION
U.S. DEPARTMENT O

ATTACHMENT G1

WIPP PANEL CLOSURE DESIGN DESCRIPTION AND SPECIFICATIONS

Adapted from the October 2016 Design Report – WIPP Panel Closure

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ATTACHMENT G1

WIPP PANEL CLOSURE DESIGN DESCRIPTION AND SPECIFICATIONS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS/ACRONYMS/UNITS

ADF	air dispersion factor
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CCl_4	carbon tetrachloride
cm	centimeter
DOE	Department of Energy
DRZ	disturbed rock zone
EPA	US Environmental Protection Agency
E-W	cross entries
ft	foot (feet)
FLAC	Fast Lagrangian Analysis of Continua
FLAC3D	Fast Lagrangian Analysis of Continua in Three Dimensions
HBL	Health Based Levels
HWDU	Hazardous Waste Disposal Unit
in./yr.	inches per year
IVS	Interim Ventilation System
Isolation Plan	Nitrate Salt Bearing Waste Isolation Plan
kg	kilogram
m	meter
MSHA	Mine Safety and Health Administration
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
N-S	main entries
Permit	WIPP Hazardous Waste Facility Permit
PMR	Permit Modification Request
ppbv	parts per billion by volume
PPE	personal protective equipment
P.U.	Practical Units
QA/QC	quality assurance/quality control
RAA	running annual average
RCRA	Resource Conservation and Recovery Act
ROM	run-of-mine
scfm	standard cubic feet per minute
TRU	transuranic
VOC	volatile organic compound
w.g.	water gage
WIPP	Waste Isolation Pilot Plant
WPC	WIPP Panel Closure

ATTACHMENT G1

WIPP PANEL CLOSURE DESIGN DESCRIPTION AND SPECIFICATIONS

G1-1 Introduction

An important aspect of repository operations at the Waste Isolation Pilot Plant (WIPP) facility is the closure of waste disposal panels, also referred to as Hazardous Waste Disposal Units (**HWDUs**), under the Resource Conservation and Recovery Act (**RCRA**). Each of Panels 1 through 8 consists of a panel air-intake drift, a panel air-exhaust drift, and seven rooms. Panels 9 and 10 consist of the main entries (North to South) and cross entries (East to West). The closure of individual panels shall meet the closure requirements described in Attachment G and shall be built in accordance with the specifications in this attachment. This attachment describes the panel closure design and presents the applicable specifications and requirements for fabrication, installation and maintenance of the WIPP Panel Closure (WPC).

The design discussed in this attachment is based on the Design Report, prepared by Golder Associates (Golder, 2016). Calculations demonstrating compliance with the VOC emission standards are included with the Design Report. Calculations addressing the performance of the WIPP Panel Closure (**WPC**) under the geometries in the access drifts and main entries, including an assessment of the required length of the run-of-mine (**ROM**) salt component, are also included in the Design Report. The specifications for standard steel bulkheads and ROM salt are included as Attachment G1 Appendix G1-A *Technical Specifications* and Attachment G1 Appendix G1-B *Drawings*.

G1-2 WPC Description

The WPC consists of WPC-A and WPC-B. The WPC-A is the design for Panels 1 through 8. They shall be closed using out-bye bulkheads in the panel intake and exhaust drifts. The WPC-A is also installed in Panel 9 in the main entries between S-2750 and S-2520. The WPC-B is the closure design for Panel 10. It consists of a combination of in-bye and out-bye bulkheads and a length of ROM salt placed in the main entries north of S-1600. The WPC locations are depicted in Figure G1-1.

G1-2a Permit Design Requirements

The applicable design requirements are provided in Permit Attachment G, Section G-1e(1). The WPC meets these design requirements as documented in the Design Report.

G1-2b Design Component Descriptions

The following subsections present a description of the WPC components. Individual specifications address shaft and underground access and materials handling, construction quality control, treatment of surfaces in the closure areas, and applicable design and construction standards.

The WPC-A consists of a standard steel bulkhead in the panel access drifts for Panels 1 through 8, near the intersection with the main entries or relocated to the main north-south drifts as determined by the geotechnical engineer. This bulkhead is referred to as the closure/out-bye bulkhead and it will be maintained for as long as it is accessible. Additional ventilation barriers may remain in the panels as part of the operational controls prior to WPC installation. These ventilation barriers include steel bulkheads, brattice cloth and chain link, as well as concrete block walls in Panels 1, 2 and 5. These ventilation barriers are not part of the WPC design and will not impact the WPC-A bulkheads nor will they impede construction and maintenance of closure bulkheads. WPC-A will also be emplaced in the main entries between Panels 9 and 10 (between S-2520 and S-2750).

The WPC-B design for the closure installed in the main entries north of Panel 10 (north of S-1600) consists of ROM salt between in-bye and out-bye bulkheads as shown in Figure G1-2.

G1-2b(1) Steel Bulkhead

A bulkhead (Figure G1-3) serves to close panels by blocking ventilation to the intake and exhaust access drifts of the panel and preventing personnel access. This use of a bulkhead is a standard practice and the closure bulkhead shall be constructed as a typical WIPP facility bulkhead. The bulkhead will consist of a steel member frame covered with sheet metal. Telescoping tubular steel or functionally equivalent material shall be used to bolt the bulkhead to the floor and roof. Flexible flashing material such as a rubber conveyor belt (or other appropriate material) will be attached to the steel frame and the salt as a gasket, thereby providing an effective yet flexible blockage to ventilation air. The steel bulkheads will be maintained for as long as they are accessible to workers. In this regard, accessible bulkheads will be repaired, renovated, or replaced as required. Permit Attachment E, Table E-1 provides the schedule for inspecting panel closure bulkheads.

G1-2b(2) ROM Salt

Run-of-mine salt material from mining operations will be used in the main entries north of Panel 10. The salt will be emplaced to a specified design length based on geomechanical calculations described in detail in the Design Report.

G1-3 Constructability

The WPC-A and WPC-B can be constructed using available technologies for the construction of bulkheads. The use of bulkheads is a standard practice at the WIPP facility and the closure bulkheads will be constructed as typical WIPP facility bulkheads. Run-of-mine salt is available from mining operations in sufficient quantities. The construction methods and materials required for the ROM salt placement north of Panel 10 will use available technologies as discussed in the Design Report.

Conventional WIPP facility mining practices will be used for the WPC construction. Work packages will be prepared for the fabrication and installation of steel bulkheads and will list the materials used, the equipment used, special precautions, and limitations. Each work package will address location-specific prerequisites for installing the closure components, will contain the bulkhead specifications, as appropriate, and the location where the closure components are to be installed. Details on the conventional mining practices and work package preparation are discussed in the Design Report and, further construction details are given in the Technical Specifications included in Attachment G1, Appendix G1-A.

G1-4 Technical Specifications

The technical specifications are included in Attachment G1 and Appendix G1-A and are listed in Table G1-1.

G1-5 Drawings

The drawings are included in Attachment G1, Appendix G1-B and are listed in Table G1-2.

G1-6 References

Golder Associates Inc. (Golder). 2016. Design Report – WIPP Panel Closure report number 0632213 R1 Rev 1, Lakewood, Colorado, October 2016.

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TABLES

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Table G1-1 WIPP Panel Closure Technical Specifications

Division 1 – General Requirements	
Section 01010	Summary of Work
Section 01090	Reference Standards
Section 01400	Contractor Quality Control
Section 01600	Material and Equipment
Division 2 – Site Work	
Section 02010	Mobilization and Demobilization
Section 02222	Excavation
Division 3 – WPC Components	
Section 03100	Run-of-Mine Salt
Section 03200	Steel Bulkheads

Table G1-2 WIPP Panel Closure Drawings

Drawing Number	Title
262-001	WIPP Panel Closure (WPC) Title Sheet
262-002	WPC Locations
262-003	Typical Panel Layout and Mined Entry Cross-Sections
262-004	WPC Details – Bulkhead and ROM Salt Locations
262-005	WPC Details – Bulkhead Front-View and Attachment Detail

FIGURES

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Figure G1-1
WPC Locations

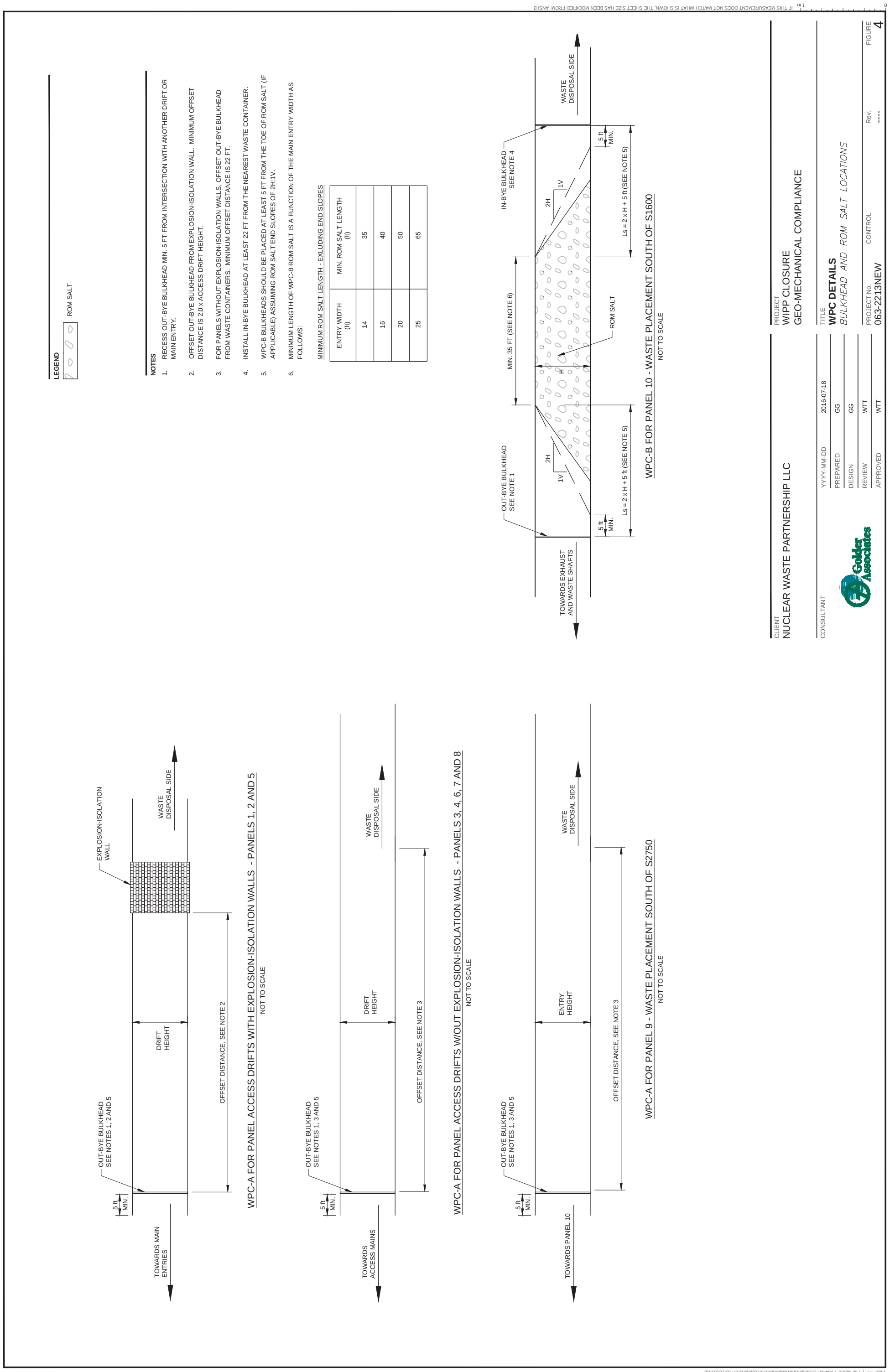
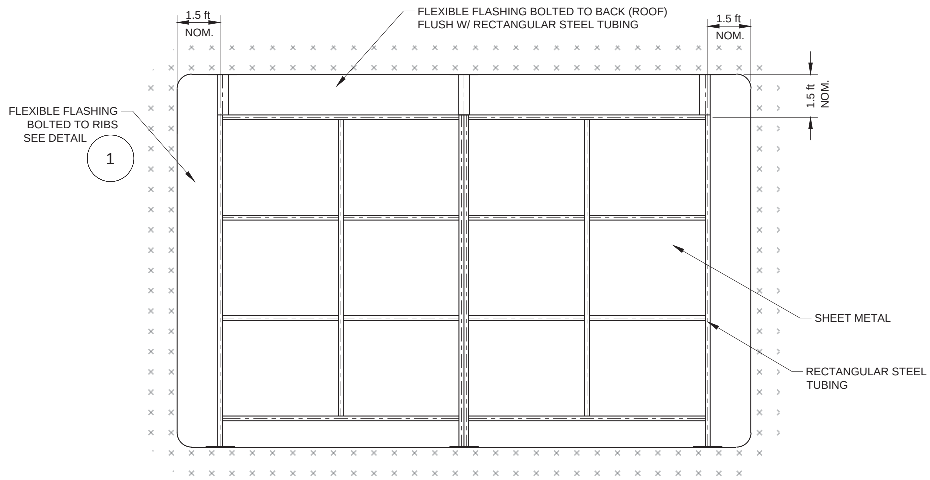
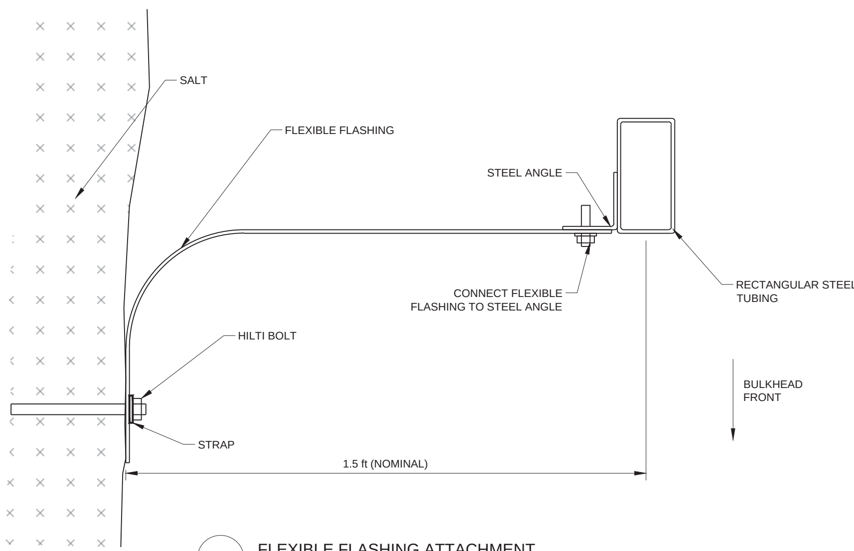


Figure G1-2
WPC Details – Bulkhead and Run-of-Mine Salt Locations



TYPICAL STEEL BULKHEAD FRONT-VIEW

SCALE: NOT TO SCALE (NTS)



1 FLEXIBLE FLASHING ATTACHMENT

SCALE: NTS

CLIENT NUCLEAR WASTE PARTNERSHIP LLC	PROJECT WIPP CLOSURE GEO-MECHANICAL COMPLIANCE

CONSULTANT		
Golder Associates	YYYY-MM-DD	2016-07-18
	PREPARED	GG
	DESIGN	GG
	REVIEW	WTT
	APPROVED	WTT

TITLE
WPC DETAILS
BULKHEAD FRONT–VIEW AND ATTACHMENT DETAIL

PROJECT No.	CONTROL	Rev.	FIGURE
063-2213NEW		----	5

Path: ---- | File Name: FIG5-WPC-BulkheadDetails-07-18-2016.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

Figure G1-3
WPC Details – Bulkhead Front-View and Attachment Detail

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ATTACHMENT G1
APPENDIX G1-A

TECHNICAL SPECIFICATIONS

WIPP PANEL CLOSURE
WASTE ISOLATION PILOT PLANT
CARLSBAD, NEW MEXICO

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TABLE OF CONTENTS

LIST OF TABLES

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DIVISION 1 – GENERAL REQUIREMENTS

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SECTION 01010
SUMMARY OF WORK

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Scope of Work

B. Definitions and Abbreviations

C. List of Drawings

D. Work by Others

E. Contractors Use of Site

F. Contractors Use of Facilities

G. Work Sequence

H. Work Plan

I. Health and Safety Plan (**HASP**)

J. Contractor Quality Control Plan (**CQCP**)

K. Submittals

1.2 Scope of Work

The Contractor shall furnish all labor, materials, equipment, and tools to construct WIPP panel closure (WPC), including the WPC-A for Panels 1 through 9, and the WPC-B to the north of Panel 10. Each WPC-A in each of Panels 1-9 consists of a single steel bulkhead while the WPC-B north of Panel 10 will include dual bulkheads with ROM salt installed between. NWP may elect to perform any portion or all of the work herein. Details are as follows:

A. Install WPC-A in the air-intake and the air-exhaust drifts of Panel 1, 2 and 5 with the explosion-isolation walls (block walls), as shown on the Drawings and described in these Specifications. The WPC-A consists of an out-bye steel bulkhead. Alternatively, install WPC-A in the main entries and cross-drifts in order to close multiple panels simultaneously based on the direction of the geotechnical engineer.

B. Install WPC-A in the air-intake and the air-exhaust drifts of Panel 3, 4, 6, 7, and 8 without the explosion-isolation walls (block walls), as shown on the Drawings and described in these Specifications. The WPC-A consists of an out-bye steel bulkhead. Alternatively, install WPC A in access mains and cross-drifts in order to close multiple panels simultaneously based on the direction of the geotechnical engineer.

C. Install WPC-A in the main entries between Panels 9 and 10, as shown on the Drawings and described in these Specifications. The WPC-A consists of an out-bye steel bulkhead.

D. Install WPC-B in the main entries north of Panel 10, as shown on the Drawings and described in these Specifications. The WPC-B consists of an in-bye and an out-bye steel bulkhead with ROM salt installed between.

Unless otherwise agreed by Nuclear Waste Partnership LLC (**NWP**), the Contractor shall use NWP supplied equipment underground. Such use shall be coordinated with NWP and may include the use of NWP qualified operators.

The scope of work shall include but not necessarily be limited to the following units of work:

A. Develop work plan, health and safety plan (HASP) and contractors quality control plan (CQCP) and submit for approval

B. Prepare and submit any other plans requiring approval

C. Mobilize to site

D. Coordinate construction with WIPP operations

E. Perform the following operations for the air-intake drift and the air-exhaust drift that do not contain block walls (Panels 3, 4, 6, 7 and 8):

1. Prepare the surfaces for the out-bye steel bulkhead placement
2. Construct the out-bye steel bulkhead
3. Clean up construction areas in underground and above ground
4. Submit required record documents
5. Demobilize from site

F. Perform the following operations for the air-intake drift and the air-exhaust drift with block walls (Panels 1, 2 and 5):

1. Prepare the surfaces for the out-bye steel bulkhead placement
2. Construct the out-bye steel bulkhead
3. Clean up construction areas in underground and above ground
4. Submit required record documents
5. Demobilize from site

G. Perform the following operations for the main entries between Panels 9 and 10:

1. Prepare the surfaces for the out-bye steel bulkhead placement
2. Construct the out-bye steel bulkhead
3. Clean up construction areas in underground and above ground
4. Submit required record documents
5. Demobilize from site

H. Perform the following operations for the main entries north of Panel 10:

1. Prepare the surfaces for the in-bye steel bulkhead placement
2. Construct the in-bye steel bulkhead
3. Prepare the surfaces for the ROM salt placement
4. Place ROM salt material in multiple layers
5. Prepare surfaces for the out-bye steel bulkhead placement
6. Construct the out-bye steel bulkhead
7. Clean up construction areas in underground and above ground
8. Submit required record documents
9. Demobilize from site

1.3 Definitions and Abbreviations

A. Definitions

1. Block wall – Existing mortared concrete block wall adjacent to the panel waste disposal area as shown in the Drawings; also known as explosion-isolation wall
2. Creep – Viscoplastic deformation of salt under deviatoric stress
3. Partial closure – The process of rendering a part of the hazardous waste management unit in the underground repository inactive and closed according to approved facility closure plans
4. Run-of-mine salt (ROM) – A salt backfill obtained from mining operations and emplaced in an uncompacted state
5. Volatile organic compound (**VOC**) – Any VOC with Hazardous Waste Facility Permit emission limits
6. Nuclear Waste Partnership LLC (NWP) – the construction management authority

B. Abbreviations/Acronyms

1. ACI American Concrete Institute
2. ANSI American National Standards Institute
3. ASTM American Society for Testing and Materials
4. CFR Code of Federal Regulations
5. CQCP Contractor Quality Control Plan
6. DOE U.S. Department of Energy
7. DWG drawing
8. EPA U.S. Environmental Protection Agency
9. HASP Health and Safety Plan
10. JHA Job Hazard Analysis

11. LHD load haul dump
12. LLC Limited Liability Corporation
13. MSHA U.S. Mine Safety and Health Administration
14. NWP Nuclear Waste Partnership LLC
15. USACE U.S. Army Corps of Engineers
16. VOC volatile organic compound
17. WIPP Waste Isolation Pilot Plant
18. WPC WIPP Panel Closure

1.4 List of Drawings

The following drawings were prepared as a part of the WPC design report (Drawings):

A. DWG 262-001 WIPP Panel Closure (WPC) Title Sheet

B. DWG 262-002 WPC Locations

C. DWG 262-003 Typical Panel Layout and Mined Entry Cross-Sections

D. DWG 262-004 WPC Details – Bulkhead and ROM Salt Locations

E. DWG 262-005 WPC Details – Bulkhead Front-View and Attachment Detail

1.5 Work by Others

A. Survey

All survey work to locate, control, confirm, and complete the work will be performed by NWP. All survey work for record purposes will be performed by NWP. NWP may elect to perform certain portions or all of the work. The work performed by the NWP will be defined prior to the contract. Unless otherwise agreed by NWP, the Contractor shall use underground equipment furnished by NWP for construction of the steel bulkheads and placement of ROM salt. Underground mining personnel who are qualified for the operation of such underground construction equipment may be made available to the Contractor. The use of NWP equipment shall be coordinated with NWP.

1.6 Contractor's Use of Site

A. Site Conditions

The WIPP site is located near Carlsbad in southeastern New Mexico, as shown on the Drawings. The underground arrangements and location of the WIPP waste disposal panels are shown on the Drawings. The work is to construct steel bulkheads in the air-intake drifts, air-exhaust drifts, and main access drifts between Panels 9 and 10 after cessation of the disposal phase in the specific panel. The work may include installation of steel bulkheads at alternative locations. Alternative locations will be specified by the NWP geotechnical engineer prior to installation activities. Dual bulkheads will be emplaced in the main entries north of Panel 10 after cessation of all disposal activities, and ROM salt placed between these bulkheads at a length to be specified by NWP. The waste disposal panels are located approximately 2,150 feet (655 meters) below the ground surface. The Contractor shall visit the site, and become familiar with the site and site conditions, prior to preparing a bid proposal.

B. Contractor's Use of Site

Areas at the ground surface will be designated for the Contractor's use in assembling and storing his equipment and materials. The Contractor shall utilize only those areas so designated.

Limited space within the underground area will be designated for the Contractor's use for storage of material and setup of equipment.

1.7 Contractor's Use of Facilities

Existing facilities at the site available for use by the Contractor are:

A. Waste shaft conveyance

B. Salt skip hoist

C. 460 volt AC, 3 phase power

D. Water (underground, at waste shaft only) (above ground, at a location designated by NWP)

Additional information on mobilization and demobilization to these facilities is presented in Section 02010.

1.8 Work Sequence

Work Sequence shall be as shown on the Drawings and as directed by NWP. NWP will designate the order in which panels are to be closed.

1.9 Work Plans

The Contractor shall prepare Work Plans fully describing the proposed fabrication, installation, and construction for each WIPP Panel Closure. The work plan shall define proposed materials, equipment and construction methods. The Work Plan shall state supporting processes, procedures, materials safety data sheets, and regulations by reference. The work plans shall address precautions related to the Job Hazards Check List. The Work Plan shall address limitations such as hold and witness points. The Work Plans shall address prerequisites for work. NWP shall approve the Work Plan and no work shall be performed prior to approval of the Work Plan.

1.10 Health and Safety Plan (HASP)

The Contractor shall obtain, review, and agree to applicable portions of the existing WIPP Safety Manual, WP 12-1. The Contractor shall prepare a project-specific HASP taking into account applicable sections of the WIPP Safety Manual. Personnel performing work shall be qualified to work underground. Personnel operating heavy construction equipment shall be qualified to operate such equipment. The Contractor shall also perform a Job Hazard Analysis (JHA) in accordance with WP 12-111. NWP shall approve the HASP and JHA and no work shall be performed prior to approval of the HASP and JHA.

1.11 Contractor Quality Control Plan (CQCP)

The Contractor shall prepare a CQCP identifying all personnel and procedures necessary to produce an end product that complies with the contract requirements. The CQCP shall comply with applicable NWP requirements, including operator training and qualification; and Section 01400, Contractor Quality Control, of this Specification. NWP shall approve the CQCP and no work shall be performed prior to approval of the CQCP.

1.12 Submittals

Submittals shall be in accordance with NWP Submittal Procedures and as required by the individual Specifications.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

Not used.

END OF SECTION

SECTION 01090
REFERENCE STANDARDS

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Provision of Reference Standards at Site

B. Acronyms used in Contract Documents for Reference Standards

1.2 Quality Assurance

For products or workmanship specified by association, trade, or Federal Standards, the Contractor shall comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

Conform to reference by date of issue current on the date of the owner-contractor agreement.

The Contractor shall obtain, at his own expense, a copy of the standards referenced in the individual Specification sections and shall maintain that copy at the job site until completion and acceptance of the work.

Should specified Reference Standards conflict with the contract documents, the Contractor shall request clarification from NWP before proceeding.

1.3 Schedule of References

Various publications referenced in other sections of the Specifications establish requirements for the work. These references are identified by document number and title. The addresses of the organizations responsible for these publications are listed below.

A. **ANSI** – American National Standards Institute
25 West 43rd Street
New York, New York 10036
Ph: 212-642-4900
Fax: 212-398-0023

B. **ASTM** – ASTM International
100 Barr Harbor Drive
P.O. Box C700
West Conshohocken, Pennsylvania 19428-2959
Ph: 610-832-9585
Fax: 610-832-9555

C. **CFR** – Code of Federal Regulations
Government Printing Office
732 North Capital Street, NW
Washington, District of Columbia 20401-0001

Ph: 202-512-1800
Fax: 202 512-2104

D. **EPA** – Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733
Ph: 214-665-2200

E. **FTM-STD** – Federal Test Method Standards
Standardization Documents Order Desk, Building 4D
700 Robbins Avenue
Philadelphia, Pennsylvania 19111-5094
Ph: 215-697-2179
Fax: 215-697-2978

F. **NIST** – National Institute of Standards and Technology
100 Bureau Drive, Stop 1000
Gaithersburg, Maryland 20899-1000
Ph: 301-975-6478
Fax: 301-975-8295

G. **NTIS** – National Technical Information Service
U.S. Department of Commerce
5301 Shawnee Road
Alexandria, Virginia 22312
Ph: 703-605-6000
Fax: 703-605-6900

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

Not used.

END OF SECTION

SECTION 01400
CONTRACTOR QUALITY CONTROL

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Contractor Quality Control Plan (**CQCP**)

B. Reference Standards

C. Quality Assurance

D. Tolerances

E. Testing Services

F. Inspection Services

G. Submittals

1.2 Related Sections

A. 01090 – Reference Standards

B. 01600 – Material and Equipment

C. 02222 – Excavation

D. 04100 – Run-of-Mine Salt

1.3 Contractor Quality Control Plan (CQCP)

The Contractor shall prepare a Contractor Quality Control Plan (CQCP) describing the methods to be used to verify the performance of the engineered components of the WPC. The quality control plan for the run-of-mine (ROM) salt shall detail the methods the Contractor proposes to meet the minimum requirements, and the standard quality control test methods to be used to verify compliance with minimum requirements. Equipment methods employed shall be traceable to standard quality control tests as approved in the CQCP. No work shall be performed prior to NWP approval of the CQCP.

1.4 References and Standards

Refer to individual specification sections for standards referenced therein, and to Section 01090, Reference Standards, for general listing. Additional standards will be identified in the CQCP.

Standards referenced in this section are as follows:

A. ASTM E 329-01b – Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

B. ASTM E 543-02 – Standard Practice for Agencies Performing Nondestructive Testing

1.5 Quality Assurance

The Contractor shall:

A. Monitor suppliers, manufacturers, products, services, site conditions, and workmanship to produce work of specified quality

B. Comply with specified standards as minimum quality for the work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship

C. Perform work with qualified persons to produce required and specified quality

1.6 Tolerances

The Contractor shall:

A. Monitor excavation, fabrication, and tolerances to produce acceptable work. The Contractor shall not permit tolerances to accumulate.

1.7 Testing Services

Unless otherwise agreed by NWP, the Contractor shall employ an independent firm qualified to perform the testing services and other services specified in the individual Specification sections, and as may otherwise be required by NWP. Testing and source quality control may occur on or off the project site.

The testing laboratory, if used, shall comply with applicable sections of the Reference Standards and shall be authorized to operate in the State of New Mexico.

Testing equipment shall be calibrated at reasonable intervals traceable either to the standards from the National Institute of Standards and Technology or to accepted values of natural physical constants.

1.8 Inspection Services

The Contractor may employ an independent firm to perform inspection services as a supplement to the Contractor's quality control as specified in the individual Specification sections, and as may be required by NWP. Inspection may occur on or off the project site.

The inspection firm shall comply with applicable sections of the Reference Standards.

Submittals

The Contractor shall submit a CQCP as described herein.

Prior to start of work, if a testing laboratory is used, the Contractor shall submit for approval the testing laboratory name, address, telephone number, and name of responsible officer of the firm, as well as a copy of the testing laboratory compliance with the referenced ASTM standards, and a copy of the report of laboratory facilities inspection made by Materials Reference Laboratory of National Institute of Standards and Technology with memorandum of remedies of any deficiencies reported by the inspection.

The Contractor shall submit the names and qualifications of personnel proposed to perform the required inspections, along with their individual qualifications and certifications. Once approved by NWP, these personnel shall be available as may be required to promptly and efficiently complete the work.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

3.1 General

The Contractor is responsible for quality control and shall establish and maintain an effective quality control system. The quality control system shall consist of plans, procedures, and organization necessary to produce an end product that complies with the contract requirements. The quality control system shall cover construction operations, both on site and off site, and shall be keyed to the proposed construction sequence. The project superintendent will be held responsible for the quality of work on the job. The project superintendent in this context is the individual with the responsibility for the overall management of the project, including quality and production.

3.2 Contractor Quality Control Plan

A. General

The Contractor shall supply, not later than 30 days after receipt of notice to proceed, the Contractor Quality Control Plan (CQCP), which implements the requirements of the Contract. The CQCP shall identify personnel, procedures, control, instructions, tests, records, and forms to be used. Construction shall not begin until the CQCP is approved by NWP.

B. Content of the Contractor Quality Control Plan (CQCP)

The CQCP shall cover construction operations, both on site and off site, including work by subcontractors, fabricators, suppliers, and purchasing agents and shall include, as a minimum, the following items:

1. A description of the quality control organization, including a chart showing lines of authority and acknowledgment that the Contractor Quality Control (CQC) staff shall implement the control system for all aspects of the work specified.
2. The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a CQC function.
3. A description of CQCP responsibilities and a delegation of authority to adequately perform the functions described in the CQCP, including authority to stop work.
4. Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, off-site fabricators, suppliers, and purchasing agents. These procedures shall be in accordance with NWP Submittal Procedures.

5. Control, verification, and acceptance testing procedures as may be necessary to ensure that the work is completed to the requirements of the Drawings and Specifications.

6. Procedures for tracking deficiencies from identification, through acceptable corrective action, to verification that identified deficiencies have been corrected.

7. Reporting procedures, including proposed reporting formulas.

C. Acceptance of Plan

Acceptance of the Contractor's plan is conditional. NWP reserves the right to require the Contractor to make changes in the CQCP and operations, including removal of personnel, if necessary, to obtain the quality specified.

D. Notification of Changes

After acceptance of the CQCP, the Contractor shall notify NWP in writing of any proposed change. Proposed changes are subject to acceptance by NWP.

3.3 Tests

A. Testing Procedure

The Contractor shall perform specified or required tests to verify that control measures are adequate to complete the work to contract requirements. Upon request, the Contractor shall furnish, at his own expense, duplicate samples of test specimens for testing by NWP. The Contractor shall perform, as necessary, the following activities and permanently record the results:

1. Verify that testing procedures comply with contract requirements.

2. Verify that facilities and testing equipment are available and comply with testing standards.

3. Check test instrument calibration data against certified standards.

4. Verify that recording forms and test identification control number system, including the test documentation requirements, have been prepared.

5. Record the results of tests taken, both passing and failing. Specification paragraph reference, location where tests were taken, and the sequential control number identifying the test will be given. If approved by NWP, actual test reports may be submitted later with a reference to the test number and date taken. An information copy of tests performed by an offsite or commercial test facility will be provided directly to NWP.

6. The Contractor may elect to develop an equipment specification with construction parameters based upon test results of a test section of ROM salt. The equipment specification based upon construction parameters shall be traceable to standard test results identified in the CQCP. Specification paragraph reference, location where construction parameters were taken, and the sequential control number identifying the construction parameters will be given. If approved by NWP, actual construction parameter reports may be submitted later with a reference to the recording of construction parameters, location, time, and date taken.

3.4 Testing Laboratory

The testing laboratory, if used, shall provide qualified personnel to perform specified sampling and testing of products in accordance with specified standards, and the requirements of Contract Documents.

Reports indicating results of tests, and compliance or noncompliance with the contract documents will be submitted in accordance with NWP submittal procedures. Testing by an independent firm does not relieve the Contractor of the responsibility to perform the work to the contract requirements.

3.5 Inspection Services

The inspection firm shall provide qualified personnel to perform specified inspection of products in accordance with specified standards.

Reports indicating results of the inspection and compliance or noncompliance with the contract documents will be submitted in accordance with NWP submittal procedures.

Inspection by the independent firm does not relieve the Contractor of the responsibility to perform the work to the contract requirements.

3.6 Completion Inspection

A. Pre-Final Inspection

At appropriate times and at the completion of the work, the Contractor shall conduct an inspection of the work and develop a punch list of items that do not conform to the Drawings and Specifications. The Contractor shall then notify NWP that the work is ready for inspection. NWP will perform this inspection to verify that the work is satisfactory and appropriately complete. A final punch list will be developed as a result of this inspection. The Contractor shall ensure that the items on this list are corrected and notify NWP so that a final inspection can be scheduled. Any items noted on the final inspection shall be corrected in a timely manner. These inspections and any deficiency corrections required by this paragraph will be accomplished within the time slated for completion of the entire work.

B. Final Acceptance Inspection

The final acceptance inspection will be formally scheduled by NWP based upon notice from the Contractor. This notice will be given to NWP at least 14 days prior to the final acceptance inspection. The Contractor shall assure that the specific items previously identified as unacceptable, along with the remaining work performed under the contract, will be complete and acceptable by the date scheduled for the final acceptance inspection.

3.7 Documentation

The Contractor shall maintain current records providing factual evidence that required quality control activities and/or tests have been performed. These records shall include the work of subcontractors and suppliers and shall be on an acceptable form approved by NWP.

3.8 Notification of Noncompliance

NWP will notify the Contractor of any noncompliance with the foregoing requirements. The Contractor shall take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the worksite, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, NWP may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

END OF SECTION

SECTION 01600
MATERIAL AND EQUIPMENT

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Equipment

B. Products

C. Transportation and Handling

D. Storage and Protection

E. Substitutions

1.2 Related Sections

A. 01010 – Summary of Work

B. 01400 – Contractor Quality Control

C. 02010 – Mobilization and Demobilization

D. 02222 – Excavation

E. 04100 – Run-of-Mine Salt

1.3 Equipment

The Contractor shall specify his proposed equipment in the Work Plan. Power equipment for use underground shall be either electrical or diesel-engine driven. All diesel-engine equipment shall be certified for use underground at the WIPP site.

1.4 Products

The Contractor shall specify in the Work Plan, or in subsequently required submittals, the proposed products including, but not limited to steel bulkheads and ROM salt. The proposed products shall be supported by laboratory test results as required by the Specifications. Products shall be subject to approval by NWP.

1.5 Transportation and Handling

The Contractor shall:

A. Transport and handle products in accordance with manufacturer's instructions.

B. Promptly inspect shipments to ensure that products comply with requirements, quantities are correct, and products are undamaged.

C. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.6 Storage and Protection

The Contractor shall:

A. Store and protect products in accordance with manufacturers' instructions

B. Store with seals and labels intact and legible

C. Store sensitive products in weather-tight, climate-controlled enclosures in an environment favorable to product

D. Provide ventilation to prevent condensation and degradation of products

E. Store loose granular materials (other than ROM salt) on solid flat surfaces in a well-drained area and prevent mixing with foreign matter

F. Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage

G. Arrange storage of products to permit access for inspection and periodically inspect to verify products are undamaged and are maintained in acceptable condition

1.7 Substitutions

A. Equipment Substitutions

The Contractor may substitute equipment for that proposed in the Work Plan subject to NWP approval.

B. Product Substitutions

The Contractor may not substitute products after the proposed products have been approved by NWP unless he can demonstrate that the supplier/source of that product no longer exists in which case he shall submit alternate products with lab test results to NWP for approval.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

Not used.

END OF SECTION

DIVISION 2 – SITE WORK

(This page intentionally blank)

SECTION 02010
MOBILIZATION AND DEMOBILIZATION

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Mobilization of Equipment and Facilities to Site

B. Contractor Use of Site

C. Use of Existing Facilities

D. Demobilization of Equipment and Facilities

E. Site Cleanup

1.2 Related Sections

A. 01010 – Summary of Work

B. 01600 – Material and Equipment

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

3.1 Mobilization of Equipment and Facilities to Site

Upon authorization to proceed, the Contractor shall mobilize his equipment and facilities to the jobsite. Equipment and facilities shall be as specified and as defined in the Contractor's Work Plan.

NWP will provide utilities at designated locations. The Contractor shall be responsible for hookups and tie-ins required for his operations.

The Contractor shall be responsible for providing his own office, storage, and sanitary facilities.

Areas will be designated for the Contractor's use in the underground area near the WPC installation. These areas are limited.

3.2 Contractors Use of Site

The Contractor shall use only those areas specifically designated for his use by NWP. The Contractor shall limit his on-site travel to the specific routes required for performance of his work, and designated by NWP.

3.3 Use of Existing Facilities

Existing facilities available for use by the Contractor are as follows:

A. Waste shaft conveyance

B. Salt skip hoist

C. 460 Volt AC, 3 phase power

D. Water underground at waste shaft only

E. Water on surface at location designated by NWP

The Contractor shall arrange for use of the facilities with NWP and coordinate his actions and requirements with ongoing NWP operations.

Use of water in the underground will be restricted. No washout or cleanup will be permitted in the underground except as designated by NWP. Aboveground washout or cleanup of equipment will be allowed in the areas designated by NWP.

The Contractor is cautioned to be aware of the physical dimensions of the waste conveyance and the air lock.

The Contractor shall be responsible for any damage incurred by the existing site facilities as a result of his operations. Any damage shall be reported immediately to NWP and repaired at the Contractor's cost.

3.4 Demobilization of Equipment and Facilities

At completion of this work, the Contractor shall demobilize his equipment and facilities from the job site. Contractor's equipment and materials shall be removed and disturbed areas restored. Utilities shall be removed to their connection points unless otherwise directed by NWP. Any equipment that becomes radiologically contaminated will be managed in accordance with NWP radiological protection policies.

3.5 Site Cleanup

At conclusion of the work, the Contractor shall remove trash, waste, debris, excess construction materials, and restore the affected areas to their prior condition, to the satisfaction of NWP. A final inspection will be conducted by NWP and the Contractor before final payment is approved. Any trash, waste, debris, excess construction materials that become radiologically contaminated will be managed in accordance with NWP radiological protection policies.

END OF SECTION

SECTION 02222
EXCAVATION

PART 1 – GENERAL

Scope

This section includes the following:

A. Excavation for surface preparation and leveling of areas for the ROM salt and steel bulkhead placement

B. Disposing of excavated materials

C. Field measurement and survey

Related Sections

A. 01010 – Summary of Work

B. 01600 – Material and Equipment

Reference Documents

Krieg, R.D., 1984. Reference Stratigraphy and Rock Properties for the Waste Isolation Pilot Plant, SAND83-1908, Sandia National Laboratories, Albuquerque, New Mexico.

Field Measurements and Survey

Survey required for performance of the work will be provided by NWP.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

Excavation for Surface Preparation and Leveling of Areas for Steel Bulkhead and ROM Salt Placement

The Contractor shall inspect the areas designated for placement of the WPC components (ROM salt and steel bulkheads) and remove any loose material. If loose material is found, the contractor shall excavate and prepare the surface by removing loose material, and cleaning rock surfaces. The surface preparation of the floor shall produce a surface suitable for anchoring the steel bulkhead base components and for placing the first layer of ROM salt (as applicable). Excavation may be performed by either mechanical or manual means. Use of explosives is prohibited.

Disposing of Excavated Materials

The Contractor shall dispose of excavated materials as directed by NWP. No excavated materials from radiologically controlled areas will be disposed of without prior approval of NWP.

Field Measurements and Survey

Survey required for performance of the work will be provided by NWP. The Contractor shall protect survey control points, benchmarks, etc., from damage by his operations. NWP will verify that the Contractor has excavated to the required lines and grades. No salt shall be emplaced until approved by NWP.

END OF SECTION

DIVISION 3 – WPC COMPONENTS

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SECTION 03100
RUN-OF-MINE SALT

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Salt placement

1.2 Related Sections

A. 01010 – Summary of Work
B. 01400 – Contractor Quality Control
C. 01600 – Material and Equipment

1.3 Submittals for Review and Approval

The salt emplacement method, dust control plan and other safety-related material shall be approved by NWP.

1.4 Quality Assurance

The Contractor shall perform the work in accordance with the CQCP.

PART 2 – PRODUCTS

2.1 Salt Material

The salt is ROM salt and requires no grading or compaction. The salt shall be free of foreign organic material.

PART 3 – EXECUTION

3.1 General

The Contractor shall furnish labor, material, equipment, and tools to handle and place the salt.

The Contractor shall use underground equipment and underground mine personnel as required in Part 1.5, Work by Others in Section 01010 Summary of Work. NWP will supply ROM salt. The Contractor shall make suitable arrangements for transporting and placing the ROM salt.

3.2 Installation

Run-of-mine salt shall be transported to the WPC-B installation area north of Panel 10 after the construction of the in-bye steel bulkhead. The ROM salt is not required to achieve a specified density.

Salt may be emplaced in layers to facilitate the construction. The ROM Salt is emplaced in layers to achieve minimum lengths shown in Table 1. The lengths reported in Table 1 do not include sloped ends of the ROM salt plug. Extents of the ROM Salt emplacement are designated in the Drawings.

There shall be no gap left between ROM Salt and roof or sidewalls. Hand placement or push plates can be used to fill the voids if necessary. The approximate lengths and slope inclines are specified in the Drawings. Emplacement of the ROM salt at natural angle of repose is acceptable.

Table 1 Minimum ROM Salt Lengths

Entry Width (feet)	Minimum ROM Salt Length[1] (feet)
14	35
16	40
20	50
25	65

Note:
1. Reported ROM length dimensions do not include end slopes of the ROM salt plug.

3.3 Field Quality Control

The Contractor shall provide a Quality Control Inspector to inspect the emplacement of salt.

END OF SECTION

SECTION 03200
STEEL BULKHEADS

PART 1 – GENERAL

1.1 SCOPE

This section includes the following:

A. Steel bulkhead installation

1.2 RELATED SECTIONS

A. 01010 – Summary of Work
B. 01400 – Contractor Quality Control
C. 01600 – Material and Equipment

1.3 SUBMITTALS FOR REVIEW AND APPROVAL

The method of installation, construction equipment, and construction materials shall be approved by NWP.

1.4 QUALITY ASSURANCE

The Contractor shall perform the work in accordance with the CQCP.

PART 2 – PRODUCTS

2.1 BULKHEAD MATERIAL

Construction material, including steel profiles, sheet metal, flexible flashing, and connectors/bolts shall be approved by NWP prior to construction.

PART 3 – EXECUTION

3.1 GENERAL

The Contractor shall furnish all labor, material, equipment, and tools to install steel bulkheads at the locations specified in the Drawings. The Contractor shall use underground equipment and underground mine personnel as required in Part 1.5, Work by Others in Section 01010 Summary of Work.

3.2 FABRICATION

Bulkheads will be fabricated on the surface or in the underground in a location designated by NWP.

3.3 INSTALLATION

In-bye steel and out-bye steel bulkheads shall be installed in the designated WPC areas approved by the NWP as specified in the Drawings. The contractor shall not commence installation activities without prior inspection of the ground conditions as documented in the HASP per Section 01010 of these Specifications and without prior approval by NWP.

3.4 FIELD QUALITY CONTROL

The Contractor shall provide a Quality Control Inspector to inspect the steel bulkhead installation if requested by NWP prior to contract.

3.5 PRODUCT ACCEPTANCE

The Contractor shall arrange for the pre-final inspection and final product inspection as described in Part 3.6 Section 01400 of these Specifications. The resolution of non-compliance issues will be conducted as described in Part 3.8 Section 01400 of these Specifications.

END OF SECTION

ATTACHMENT G1
APPENDIX G1-B

DRAWINGS

WIPP PANEL CLOSURE
WASTE ISOLATION PILOT PLANT
CARLSBAD, NEW MEXICO

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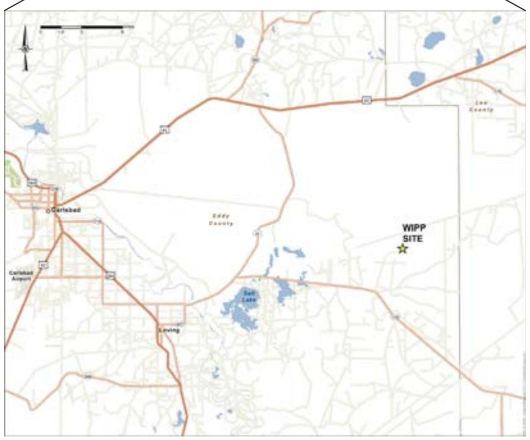
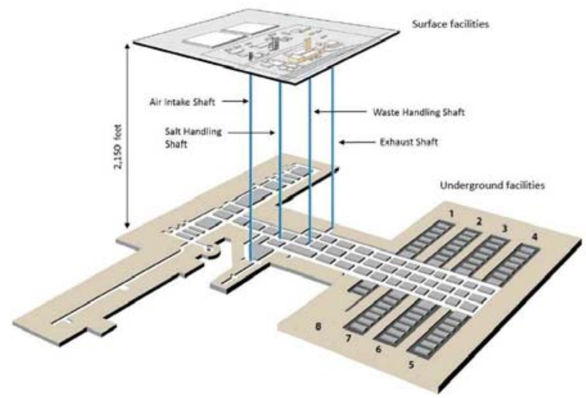
WIPP PANEL CLOSURE
CARLSBAD, NEW MEXICO



INDEX OF DRAWINGS	
DRAWING NO.	TITLE
262-001	WIPP PANEL CLOSURE (WPC) TITLE SHEET
262-002	WPC LOCATIONS
262-003	TYPICAL PANEL LAYOUT AND MINED ENTRY CROSS-SECTIONS
262-004	WPC DETAILS - BULKHEAD AND ROM SALT LOCATIONS
262-005	WPC DETAILS - BULKHEAD FRONT-VIEW AND ATTACHMENT DETAIL



REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2016-07-18	ISSUED FOR CLIENT REVIEW	GG	KJC	WTT	WTT

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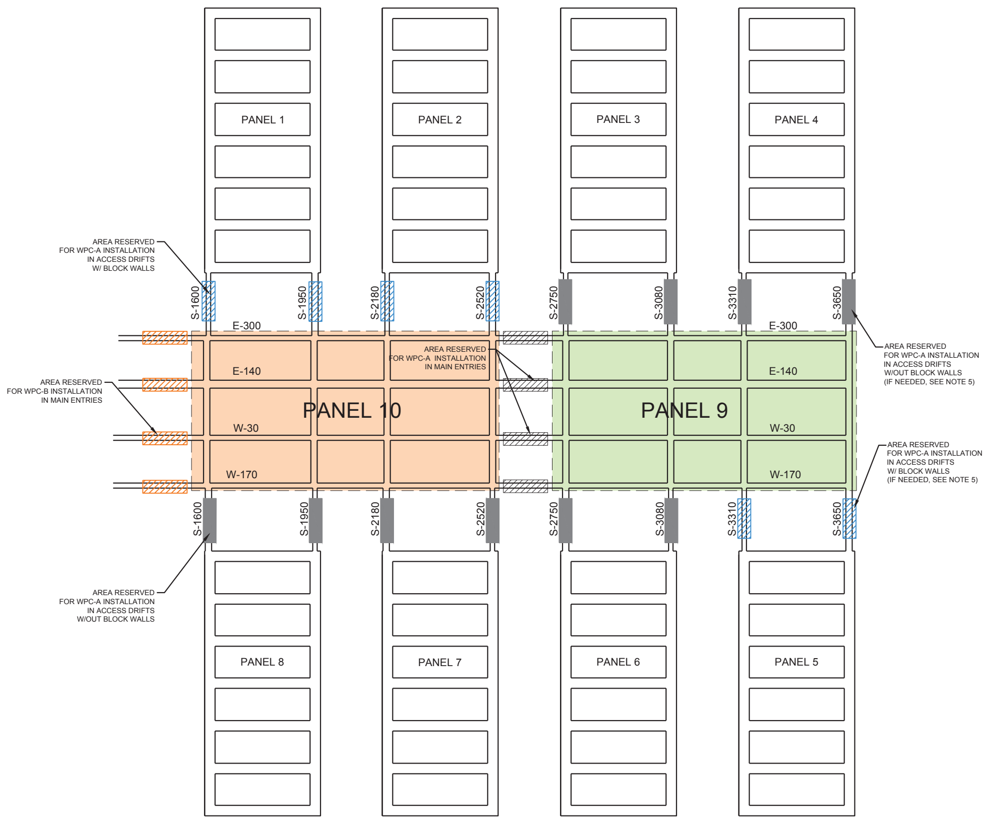
PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

TITLE
WIPP PANEL CLOSURE (WPC) TITLE SHEET

PROJECT NO. 063-2213NEW
REV. A
DRAWING 262-001



LEGEND

- APPROXIMATE EXTENTS OF PANEL 9
- APPROXIMATE EXTENTS OF PANEL 10
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN PANEL ACCESS DRIFTS W/ EXPLOSION-ISOLATION WALLS (NOTES 1, 2, 5)
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN MAIN ENTRIES (NOTES 1, 3, 5)
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN PANEL ACCESS DRIFTS W/OUT EXPLOSION-ISOLATION WALLS (NOTES 1, 2, 5)
- APPROXIMATE AREA RESERVED FOR WPC-B INSTALLATION IN MAIN ENTRIES (NOTES 1, 4)

NOTES

1. SHOWN WIPP PANEL CLOSURE (WPC) LOCATIONS ARE APPROXIMATE.
2. WPC-A IS INSTALLED IN AIR-INTAKE AND AIR-EXHAUST DRIFTS OF PANELS 1 TO 8. WPC-A IN ACCESS DRIFTS CONSISTS OF OUT-BYE BULKHEAD.
3. WPC-A IS INSTALLED IN MAIN ENTRIES BETWEEN S-2520 AND S-2750 FOR PANEL 9 CLOSURE. WPC-A IN MAIN ENTRIES CONSISTS OF OUT-BYE BULKHEAD.
4. WPC-B IS INSTALLED IN MAIN ENTRIES NORTH OF S-1600 FOR PANEL 10 CLOSURE. WPC-B IN MAIN ENTRIES CONSISTS OF ROM SALT BETWEEN IN-BYE AND OUT-BYE BULKHEADS.
5. PANELS 3, 4, 5 AND 6 MAY BE CLOSED BY INSTALLING WPC-A IN MAIN ENTRIES NORTH OF PANEL 9. I.E., WPC-A INSTALLED BETWEEN S-2520 AND S-2750 MAY BE USED TO CLOSE MULTIPLE PANELS SOUTH OF S-2750 AS AN ALTERNATIVE TO WPC-A INSTALLATION IN ACCESS DRIFTS.

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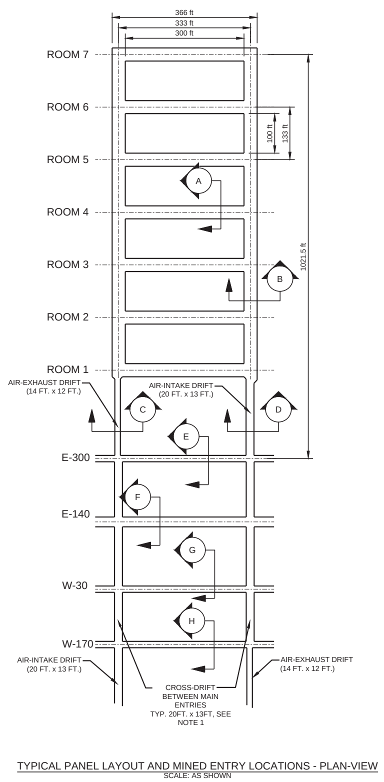
PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

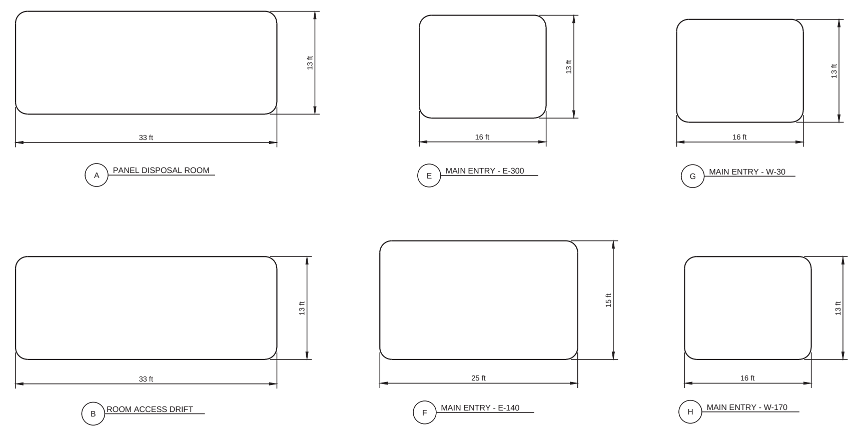
TITLE
WPC LOCATIONS

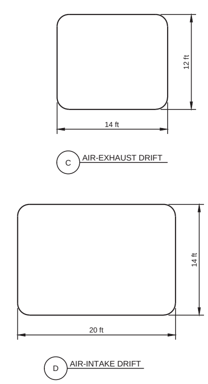
PROJECT NO. 063-2213NEW
REV. A
DRAWING 262-002



TYPICAL PANEL LAYOUT AND MINED ENTRY LOCATIONS - PLAN-VIEW

SCALE: AS SHOWN





NOTE(S)

1. TYPICAL DIMENSIONS OF DISPOSAL ROOMS AND ACCESS DRIFTS SHOWN IN THIS FIGURE ARE APPROXIMATE, I.E., MAY DIFFER AT SPECIFIC LOCATIONS DUE TO CREEP OF SURROUNDING ROCK, CONSTRUCTION TOLERANCES AND DESIGN REQUIREMENTS.
2. MAIN ENTRY E-300 DIMENSIONS VARY FROM APPROXIMATELY 14 FT x 12 FT (WIDTH x HEIGHT) TO 16 FT x 13 FT W/ SMALLER CROSS-SECTIONS GENERALLY LOCATED IN THE NORTHERN PART OF THE REPOSITORY (I.E. CLOSER TO THE INTERSECTION OF E-300 AND S-1600).
3. MAIN ENTRY E-140 DIMENSIONS VARY FROM APPROXIMATELY 25 FT x 20 FT (WIDTH x HEIGHT) TO 25 FT x 15 FT W/ SMALLER CROSS-SECTIONS GENERALLY LOCATED IN THE SOUTHERN PART OF THE REPOSITORY (I.E. CLOSER TO THE INTERSECTION OF E-140 AND S-3650).
4. MAIN ENTRY W-30 DIMENSIONS VARY FROM APPROXIMATELY 14 FT x 12 FT (WIDTH x HEIGHT) TO 21 FT x 13 FT W/ SMALLER CROSS-SECTIONS GENERALLY LOCATED IN THE NORTHERN PART OF THE REPOSITORY (I.E. CLOSER TO INTERSECTION OF W-30 AND S-1600).
5. MAIN ENTRY W-170 DIMENSIONS VARY FROM APPROXIMATELY 14 FT x 12 FT (WIDTH x HEIGHT) TO 30 FT x 13 FT W/ LARGER CROSS-SECTIONS LOCATED ADJACENT TO PANEL 6 (26 FT x 13 FT) AND PANEL 7 (30 FT x 13 FT).

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PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

TITLE
TYPICAL PANEL LAYOUT AND MINED ENTRY CROSS-SECTIONS

PROJECT NO. 063-2213NEW | REV. A | DRAWING 262-003

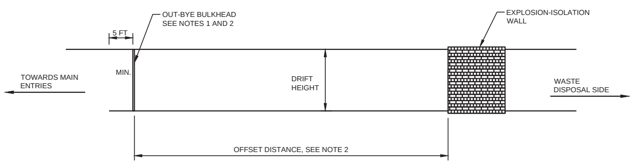
LEGEND

ROM SALT

NOTES

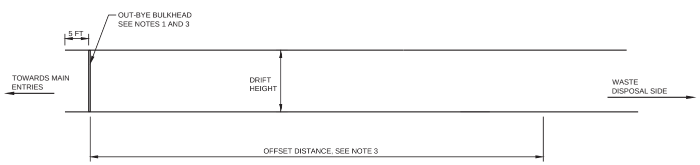
1. RECESS OUT-BYE BULKHEAD MIN. 5 FT FROM INTERSECTION WITH ANOTHER DRIFT OR MAIN ENTRY.
2. OFFSET OUT-BYE BULKHEAD FROM EXPLOSION-ISOLATION WALL. MINIMUM OFFSET DISTANCE IS 2.0 x ACCESS DRIFT HEIGHT.
3. FOR PANELS WITHOUT EXPLOSION-ISOLATION WALLS, OFFSET OUT-BYE BULKHEAD FROM WASTE CONTAINERS. MINIMUM OFFSET DISTANCE IS 22 FT.
4. INSTALL IN-BYE BULKHEAD AT LEAST 22 FT FROM THE NEAREST WASTE CONTAINER.
5. ALL WPC-B BULKHEADS SHOULD BE PLACED AT LEAST 5 FT FROM THE TOE OF ROM SALT ASSUMING ROM SALT END SLOPES OF 2H:1V.
6. MINIMUM LENGTH OF WPC-B ROM SALT IS A FUNCTION OF THE MAIN ENTRY WIDTH AS FOLLOWS:

MINIMUM ROM SALT LENGTH - EXCLUDING END SLOPES	
ENTRY WIDTH (FT)	MIN. ROM SALT LENGTH (FT)
14	35
16	40
20	50
25	65



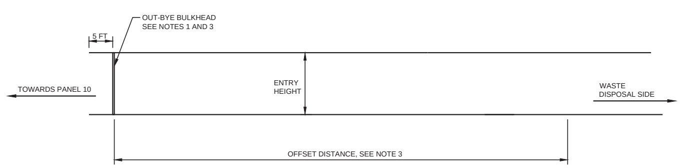
WPC-A FOR PANEL ACCESS DRIFTS WITH EXPLOSION-ISOLATION WALLS - PANELS 1, 2 AND 5

NOT TO SCALE



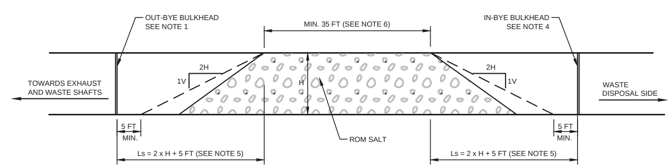
WPC-A FOR PANEL ACCESS DRIFTS W/OUT EXPLOSION-ISOLATION WALLS - PANELS 3, 4, 6, 7 AND 8

NOT TO SCALE



WPC-A FOR PANEL 9 - WASTE PLACEMENT SOUTH OF S-2750

NOT TO SCALE



WPC-B FOR PANEL 10 - WASTE PLACEMENT SOUTH OF S-1600

NOT TO SCALE

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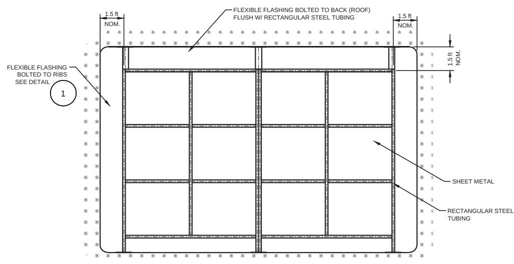
PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

TITLE
WPC DETAILS - BULKHEAD AND ROM SALT LOCATIONS

PROJECT NO. 063-2213NEW

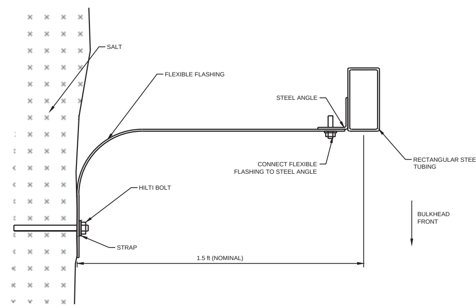
REV. A

DRAWING 262-004



TYPICAL STEEL BULKHEAD FRONT-VIEW

SCALE: NOT TO SCALE (NTS)



1 FLEXIBLE FLASHING ATTACHMENT

SCALE: NOT TO SCALE (NTS)

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

TITLE
WPC DETAILS - BULKHEAD FRONT-VIEW AND ATTACHMENT DETAIL

PROJECT NO.	REV.	DRAWING
063-2213NEW	A	262-005

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H-1 Post-Closure Plan

This post-closure plan focuses on activities following final facility closure. However, some discussion of post-closure following panel closure is warranted since some panel closures will occur long before final facility closure. As discussed in Attachment G (Closure Plan), Section G-1e(1), panel closures have been designed to require no minimum post-closure maintenance of the disposal unit. The Permittees have defined a post-closure care program for closed panels that has three aspects. These are routine inspection of the openings in the vicinity of the closures, the sampling of ventilation air for harmful constituents, and a Repository Volatile Organic Compound Monitoring Program. The rules of the Mine Safety and Health Administration as well as Permit Attachment E (Inspection Schedule, Process and Forms) drive the implementation of the first two programs. These rules require that underground mines monitor air quality to assure good breathing air whenever personnel are underground and that mine operators provide safe ground conditions for personnel in areas that require access. Routine monitoring of the openings in the access ways to panels will be continued and these openings will be maintained for as long as access into them is needed. This includes continued reading of installed geomechanical instrumentation, sounding the areas, visual inspection and maintenance activities such as scaling, mining, or bolting as required and as described in Permit Attachment A2. In addition, all areas in the underground that are occupied by personnel are checked prior to each day's work activities for accumulations of harmful gases, including methane. Action levels for increasing ventilation to areas that show high levels of harmful gases are specified as described in standard operating procedures on file at the WIPP facilityin Permit Attachment D.

ATTACHMENT N

VOLATILE ORGANIC COMPOUND MONITORING PLAN

TABLE OF CONTENTS

N N-3a(3) Ongoing Disposal Room VOC Monitoring in Panels 3 through 8

The Permittees shall continue VOC monitoring in Room 1 of Panels 3 through 8 after completion of waste emplacement until final panel closure unless an explosion-isolation wall is installed in the panel.

ATTACHMENT N1

HYDROGEN AND METHANE MONITORING PLAN

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ATTACHMENT N1

HYDROGEN AND METHANE MONITORING PLAN

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List of Figures

~~ATTACHMENT N1~~

~~VOLATILE ORGANIC COMPOUND MONITORING PLAN~~

~~N1-1 Introduction~~

~~This Permit Attachment describes the monitoring plan for hydrogen and methane generated in Underground Hazardous Waste Disposal Units (**HWDUs**) 3 through 8, also referred to as Panels 3 through 8.~~

~~Monitoring for hydrogen and methane in Panels 3 through 8 until final panel closure, unless an explosion-isolation wall is installed, may be an effective way to gather data to establish realistic gas generation rates. This plan includes the monitoring design, a description of sampling and analysis procedures, quality assurance (**QA**) objectives, and reporting activities.~~

~~N1-2 Parameters to be Analyzed and Monitoring Design~~

~~The Permittees will monitor for hydrogen and methane in filled Panels 3 through 8 until final panel closure, unless an explosion-isolation wall is installed. A "filled panel" is an Underground HWDU that will no longer receive waste for emplacement.~~

~~Monitoring of a filled panel will commence after installation of the following items in each filled panel:~~

- ~~substantial barriers~~
- ~~bulkheads~~
- ~~five additional monitoring locations.~~

~~The substantial barriers serve to protect the waste from events such as ground movement or vehicle impacts. The substantial barrier will be constructed from available non-flammable materials such as mined salt (Figure N1-1).~~

~~The bulkheads (Figure N1-2) serves to block ventilation at the intake and exhaust of the filled panel and prevent personnel access. The bulkhead is constructed as a typical WIPP bulkhead with no access doors or panels. The bulkhead will consist of a steel member frame covered with galvanized sheet metal, and will not allow personnel access. Flexible flashing will be used as a gasket to attach the steel frame to the salt, thereby providing an effective yet flexible blockage to ventilation air. Over time, it is possible that the bulkhead may be damaged by creep closure around it. If the damage is such as to indicate a possible loss of functionality, then the bulkhead will be repaired or an additional bulkhead will be constructed outside of the original one.~~

~~The existing VOC monitoring lines as specified in Attachment N, Section N-3a(2), "Sampling Locations for Disposal Room VOC Monitoring", will be used for sample collection in each disposal room for Panels 3 and 4. The sample lines and their construction are shown in Figure N1-3. In addition to the existing VOC monitoring lines, five more sampling locations will be used to monitor for hydrogen and methane. These additional locations include:~~

- ~~the intake of room 1~~
- ~~the waste side of the exhaust bulkhead,~~

- the accessible side of the exhaust bulkhead,
- the waste side of the intake bulkhead,
- the accessible side of the intake bulkhead.

These additional sampling locations (Figure N1-4) will use a single inlet sampling point placed near the back (roof) of the panel access drifts. This will maximize the sampling efficiency for these lighter compounds.

N1-3 Sampling Frequency

Sampling frequency will vary depending upon the levels of hydrogen and methane that are detected.

- If monitored concentrations are at or below Action Level 1 as specified in Permit Part 4, Table 4.6.5.3, monitoring will be conducted monthly.

- If monitored concentrations exceed Action Level 1 as specified in Permit Part 4, Table 4.6.5.3, monitoring will be conducted weekly in the affected filled panel.

N1-4 Sampling

Samples for hydrogen and methane will be collected using subatmospheric pressure grab sampling as described in Environmental Protection Agency (**EPA**) Compendium Method TO-15 (EPA, 1999). The TO-15 sampling method uses passivated stainless-steel sample canisters to collect integrated air samples at each sample location. Flow rates and sampling duration may be modified as necessary to meet data quality objectives.

Sample lines shall be purged prior to sample collection.

N1-5 Sampling Equipment

N1-5a SUMMA® Canisters

Stainless-steel canisters with passivated or equivalent interior surfaces will be used to collect and store gas samples for hydrogen and methane analyses collected as part of the monitoring processes. These canisters will be cleaned and certified prior to their use in a manner similar to that described by Compendium Method TO-15 (EPA, 1999). The vacuum of certified clean canisters will be verified upon initiation of a sample cycle. Sampling will be conducted using subatmospheric pressure grab sampling techniques as described in TO-15.

N1-5b Sample Tubing

Treated stainless steel tubing shall be used as a sample path and treatment shall prevent the inner walls from absorbing contaminants.

Any loss of the ability to purge a sample line will be evaluated. The criteria used for evaluation are shown in Figure N1-5.

The Permittees will first suspect that a line is not useable when it is purged prior to sampling. If the line cannot be purged, then it will not be used for sampling unless the line is a bulkhead line that can be easily replaced. Replacement of bulkhead lines will occur before the next scheduled sample. Non-bulkhead lines will be evaluated by first determining if adjacent sampling lines are working. If the answer is no, then the previous sample from the failed line will be examined. If the previous sample was between the first and second action levels, then the explosion-isolation wall will be installed since without the ability to monitor it is unknown whether the area is approaching the second action level or decreasing. If the previous sample was below the first action level then continued sampling is acceptable without the lost sample.

If an adjacent line is working, the prior concentrations measured in that line will be evaluated to determine if it is statistically similar to the prior measurements from the lost line. If the prior sampling results are statistically similar, the lines can be grouped. Statistical similarity will be determined using the Student's “t” test to evaluate differences.

The magnitude of *t* will be compared to the critical *t* value from SW-846, Table 9-2 (EPA, 1996), for this statistical test.

If the lost line can be grouped with an adjacent line, no further action is necessary because the unmonitored area is considered to be represented by the adjacent areas. If the lost sample line cannot be grouped with an adjacent line, the previous concentration measurement will be compared to the Action Levels. If the concentration is below Action Level 1, monitoring will continue. If the concentration is between Action Level 1 and Action Level 2, the explosion-isolation wall will be installed in the panel.

N1-6 Sample Management

Sample containers shall be sealed and uniquely marked at the time of collection of the sample. A Request-for-Analysis Form shall be completed to identify the sample canister number(s), sample type, and type of analysis requested.

N1-7 Analytical Procedures

The samples will be analyzed using gas chromatography equipped with the appropriate detector under an established QA/quality control (**QC**) program. Analysis of samples shall be performed by a laboratory that the Permittees select and approve through established QA processes.

N1-8 Data Evaluation and Notifications

Analytical data from sampling events will be evaluated to determine whether the sample concentrations of flammable gases exceed the Action Levels.

If any Action Level is exceeded, notification will be made to NMED and the notification posted to the WIPP web page and accessed through the email notification system within seven calendar days of obtaining validated analytical data.

If any sampling line loss occurs, notification will be made to NMED and the notification posted to the WIPP web page and accessed through the email notification system within seven calendar days of learning of a sampling line loss. After the evaluation of the impact of sampling line loss as shown in Figure N1-5, notification will be made to NMED and the notification posted to the WIPP web page and accessed through the email notification system within seven calendar days of completing the sampling line loss evaluation.

N1-9 References

U.S. Environmental Protection Agency (EPA), 1996. SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*. 3rd Edition. Office of Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1999. *Compendium Method TO-15: Determination of Volatile Organic Compounds (VOCs) In Air Collected in Specially Prepared Canisters and Analyzed by Gas Chromatography/Mas Spectrometry*, EPA 625/R-96/010b. Center for Environmental Research Information, Office of Research and Development, Cincinnati, OH, January 1999.

~~FIGURES~~

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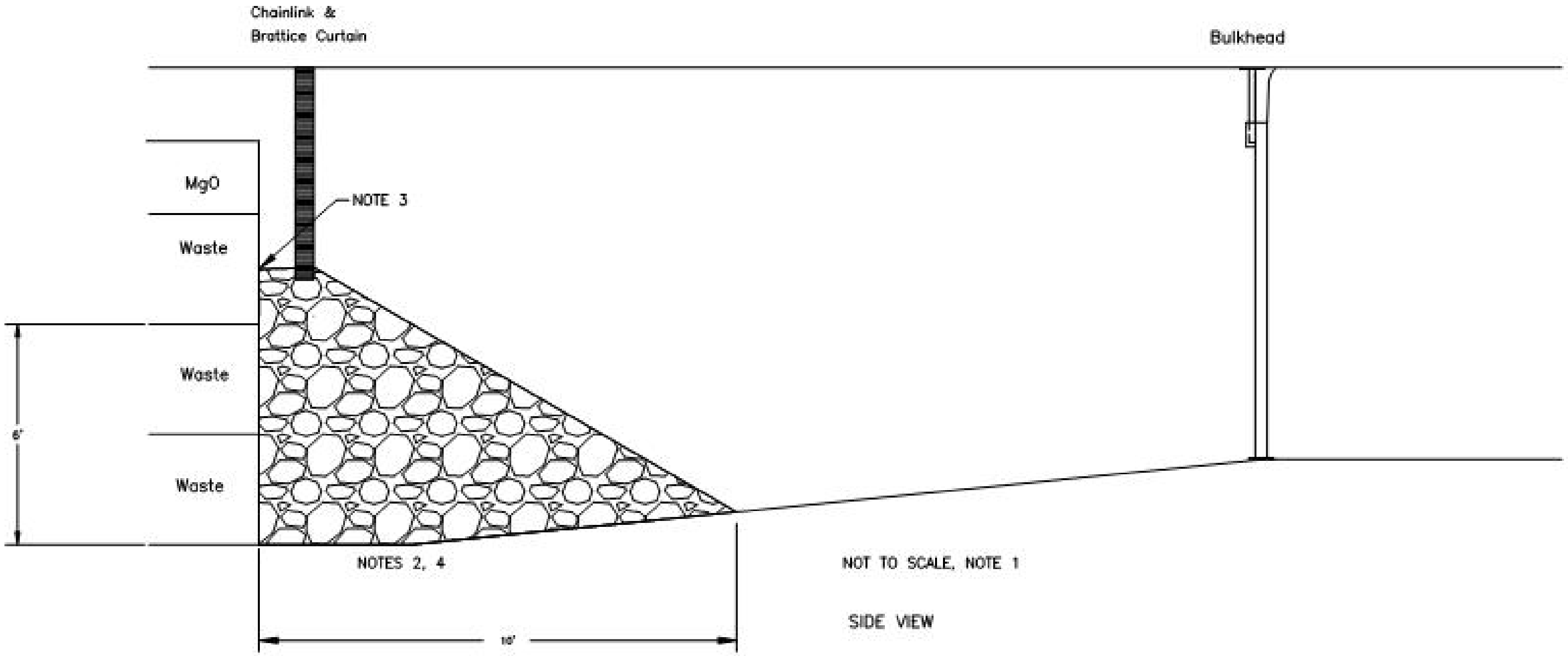


NOTES

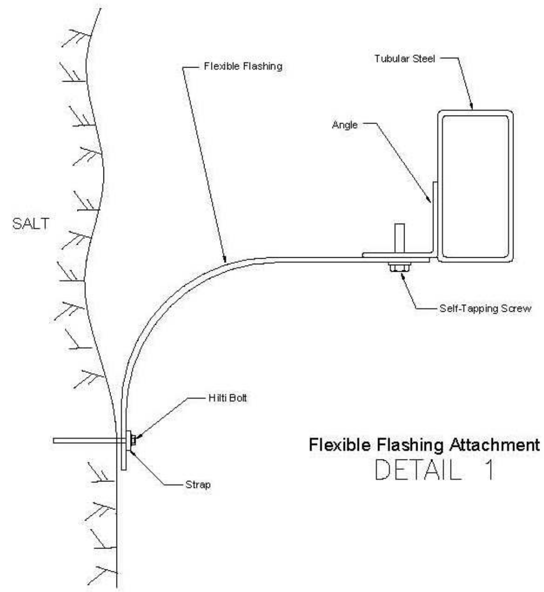
1. CONFIGURATION AND PLACEMENT OF THE SUBSTANTIAL BARRIER AND THE BUL DICTATED BY AS-FOUND (FIELD) CONDITIONS, AS DESIGNATED BY THE COGNIZAN ENGINEER.

2. SUBSTANTIAL BARRIER MATERIAL WILL CONSIST OF RUN-OF-MINE SALT OR OTHE SUITABLE NON-FLAMMABLE MATERIAL AS DESIGNATED BY THE COGNIZANT ENGIN

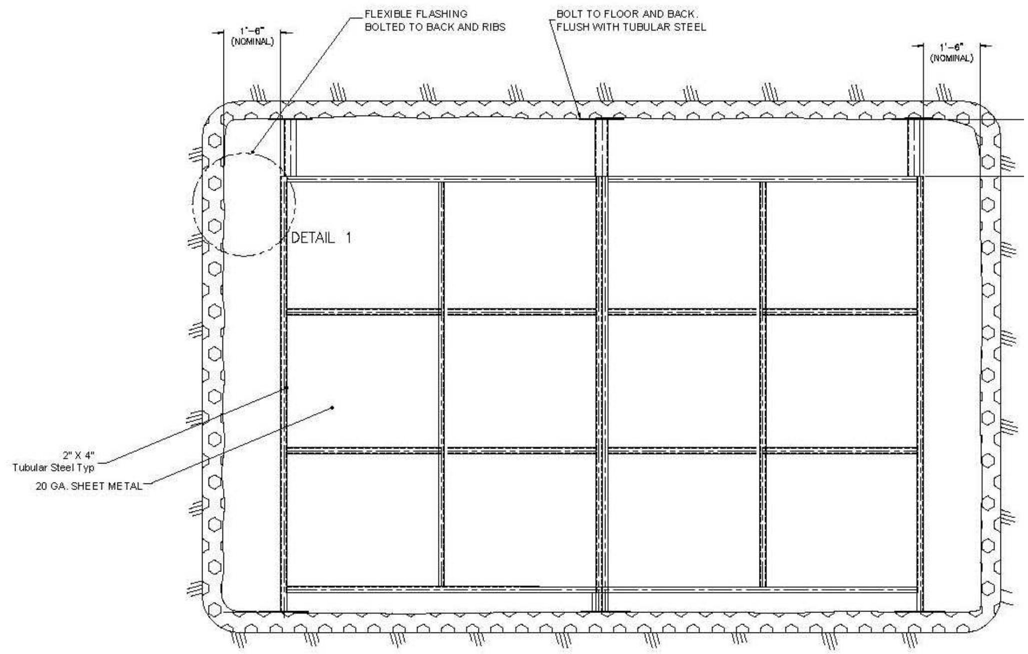
3. SUBSTANTIAL BARRIER MATERIAL SHOULD BE AGAINST THE WASTE FACE. THE H THE SUBSTANTIAL BARRIER NEAR THE WASTE WILL BE AT LEAST EQUAL TO THE H OF THE BOTTOM OF THE TOP ROW OF WASTE.

4. DIMENSIONS INDICATED ARE MINIMUMS. THE HEIGHT OF THE SUBSTANTIAL BARR MEASURED AT THE WASTE FACE. THE LENGTH OF THE SUBSTANTIAL BARRIER IS MEASURED FROM THE BOTTOM OF THE WASTE FACE TO THE TOE OF THE SUBSTA BARRIER MATERIAL.

~~Figure N1-1~~
~~Typical Substantial Barrier and Bulkhead~~

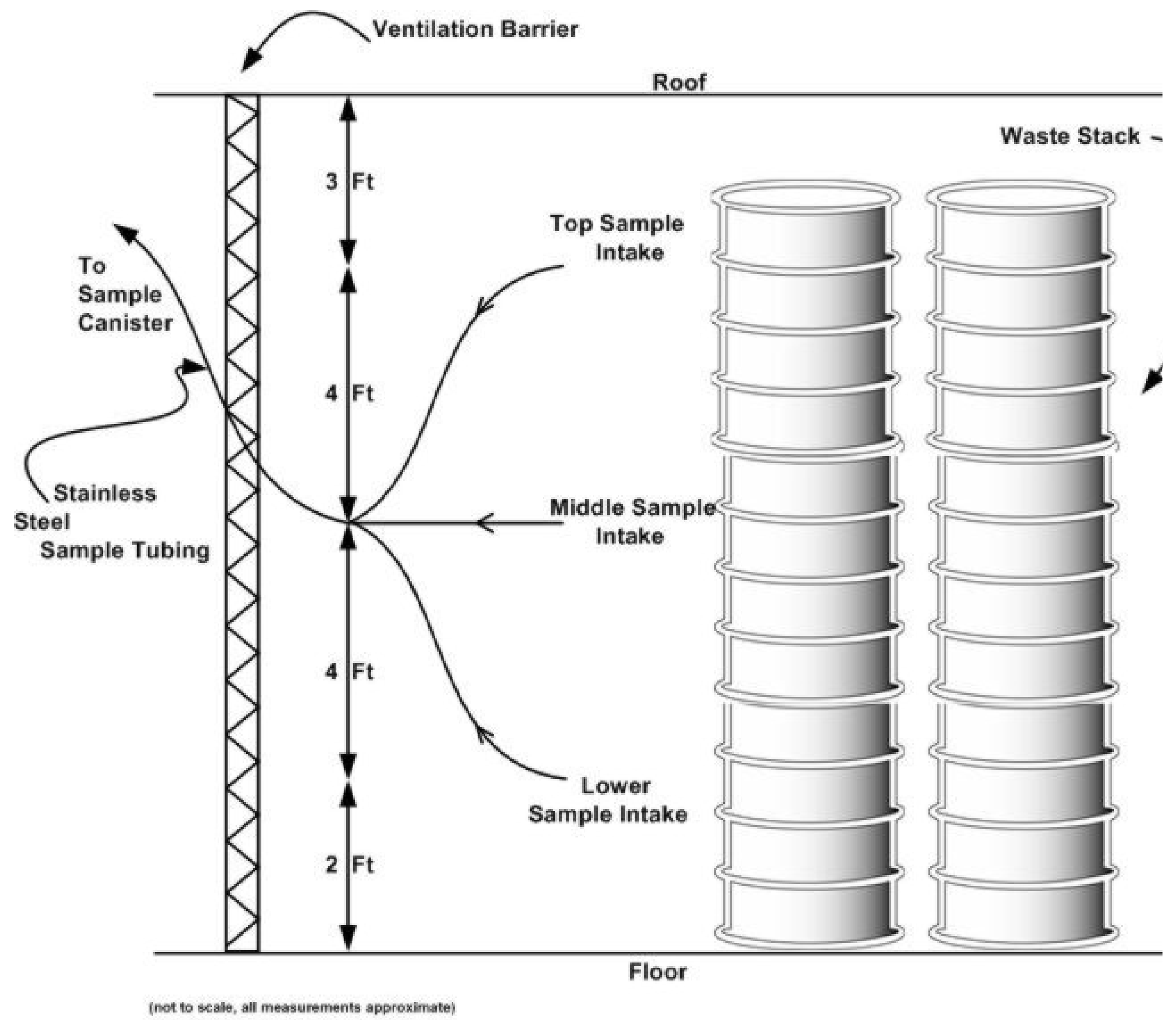


Flexible Flashing Attachment
DETAIL 1

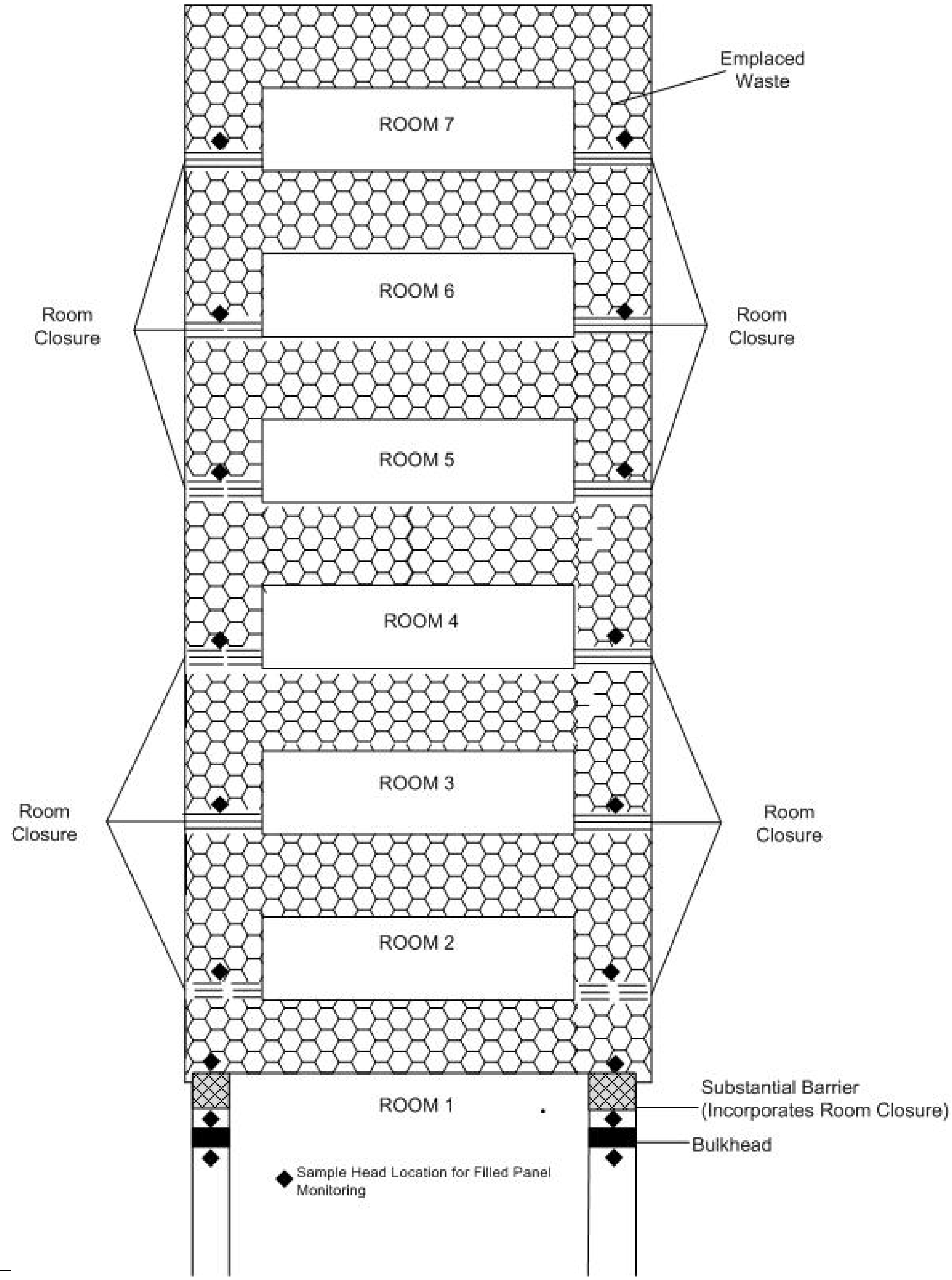


Not to Scale. All dimensions are nominal.

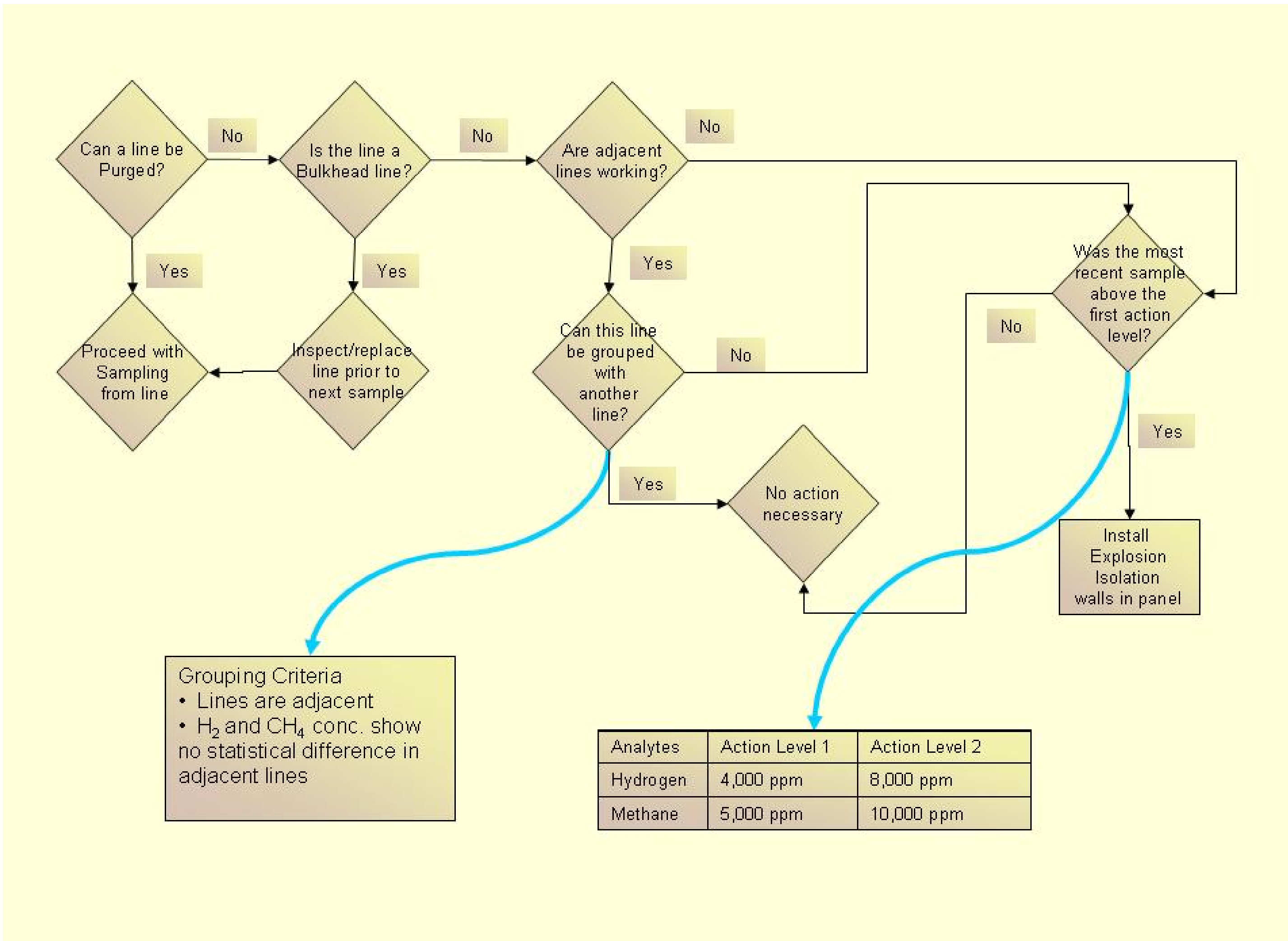
~~**Figure N1-2**~~
~~**Typical Bulkhead**~~



~~**Figure N1-3**~~
~~**Typical Hydrogen and Methane Monitoring System**~~



~~Figure N1-4~~
~~Typical Hydrogen and Methane Sampling Locations~~



Analytes	Action Level 1	Action Level 2
Hydrogen	4,000 ppm	8,000 ppm
Methane	5,000 ppm	10,000 ppm

~~Figure N1-5~~
~~Logic Diagram for Evaluating Sample Line Loss~~

Appendix C
Mine Ventilation Services Memorandum: *IVS without SVS Description*

August 24, 2016

Mine Ventilation Services, Inc.
1625 Shaw Ave, Suite 103, Clovis, CA 93611 U.S.A.
Telephone: (559) 452-0182, Facsimile (559) 452-0184, e-mail: support@mvsengineering.com

Memorandum

To: Jill Farnsworth, Nuclear Waste Partners, LLC

From: Nathan Wineinger

CC: Keith Wallace

Date: August 24, 2016

Re: IVS without SVS Description

This memo describes the Interim Ventilation System (IVS) proposed for the Waste Isolation Pilot Plant (WIPP). This document was provided in support of the calculation package *DC-3590-17 IVS without SVS Description* that was completed to describe the Interim Ventilation System without the SVS Fan running. Currently the SVS Fan is installed but is nonoperational. The IVS is composed of two proposed 960 fans with filters and one existing 860 fan with flow through the current filter banks. The configuration of the surface filtration fans is shown in Figure 1.

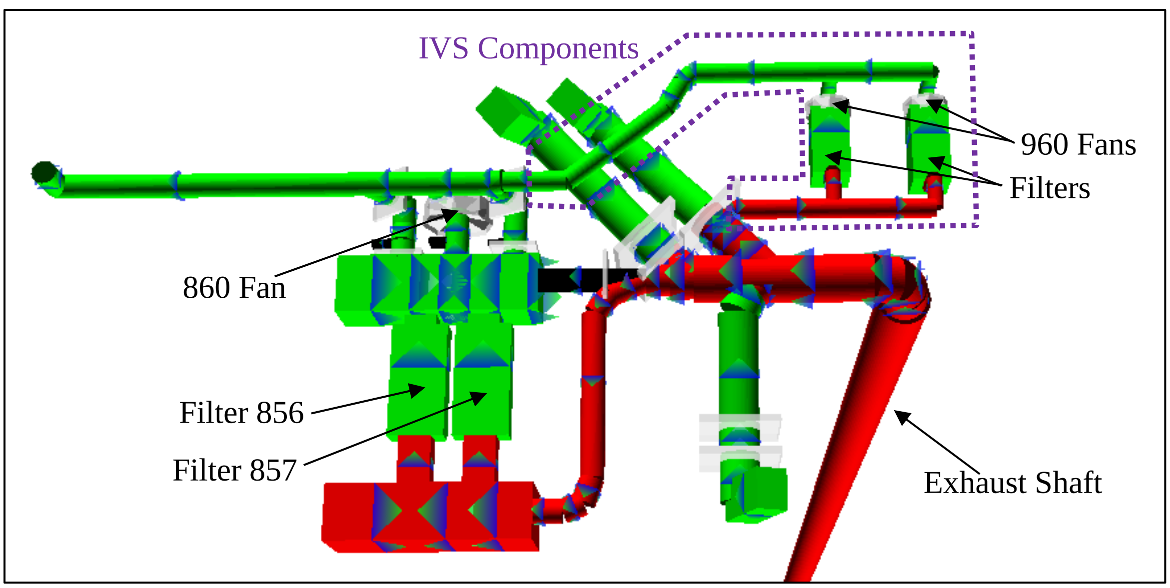


Figure 1: Surface fans and filters (one 860 fan and two new 960 fans)

The IVS fans may incorporate additional 960 fans to minimize downtime due to fan maintenance and filter change outs; however, this will not change the normal operating conditions which is to have two 960 fans running with one 860 fan. The IVS fans will supplement the 860 fan to give approximately 114,000 cfm through the surface fans which equates to between 102,000 cfm and 105,000 cfm in the underground at S-400 to the bottom of the Exhaust Shaft (ES). With IVS, the underground is configured for waste emplacement operations. This configuration provides a split of air through the Waste Shaft Station with the BH313 regulator open to provide upwards of 50,000 cfm to the disposal circuit. Under IVS, the following settings will be used:

- The AIS is covered.
- The SVS Fan is installed, but nonoperational with its regulator closed.
- The overcast at N150 is not configured to handle flow from the SVS fan.
- Most bulkheads between W-30 and W-170 are not reconfigured.
- BH313 regulator is rebuilt and the analysis assumes a similar resistance characteristic as that measured in the 2013 test and balance.
- BH303 and BH310 have new slider regulators that, when opened, have resistances similar to the BH355 regulator as measured during the 2013 test and balance.
- The AAIT dampers are open (this includes two tornado dampers).
- The 415/416 and the 303/310 doors are closed.
- BH308 is open to provide 20,000 cfm to the waste shaft station circuit.
- The regulator in BH313 is open to provide 50,000 cfm to the disposal circuit.
- The SVS fan is off and was modeled with an assumed resistance of 5 P.U.
- The room where waste emplacement is to be disposed does not have a regulator or door at the back of the room. The room is open to airflow. Adjacent rooms have bulkheads with closed regulators and doors.
- NVP settings for neutral, summer, and winter were used to test whether IVS can run at all times of the year. For neutral conditions, NVP was assumed to be zero. For winter, the NVP was assumed to be +2.0 in the SHS and +1.0 in the WS (working to downcast air in both shafts). For summer NVP, a value of -1.0 in the SHS and -0.5 in both the AIS and WS was assumed (working to upcast air in all three shafts).

The criterion for these analyses was to determine if waste emplacement is possible with IVS installed. The criteria for this to occur is that the model needs to show over 42,000 cfm in a single open emplacement room in Panel 7 (assumed to be room 6 but can be any other room in the panel), a flow of 20,000 cfm through BH308, and a differential pressure on BH308 of at least -0.161 in. w.g. (which relates to a flow direction from the waste shaft towards the exhaust shaft). The 42,000 cfm of airflow is maintained by the airflow through the BH313 regulator and leakage between W30 and E140.

Resistances for most underground airways were taken from the 2013 Test and Balance report. For other airways, friction (k) factors were used to approximate actual resistances. A table listing these resistances is given in the calculation package *DC-3590-17 IVS without SVS Description*. To be conservative, bulkheads south of S-2520 in the disposal circuit were modeled with low resistances. This allows for greater leakage south of Panel 7 which reduces flow to the emplacement room. These bulkheads and leakage points are scheduled to be replaced or repaired, but at this point, (January 2016) it is unclear if they will be done before the IVS becomes operational.

The AAIT Dampers are located at the top of the AAIT which connects to the WS below the Tower as shown in Figure 2. Also shown on this figure are the locations for the primary regulators and bulkheads to align the system for waste emplacement operation.

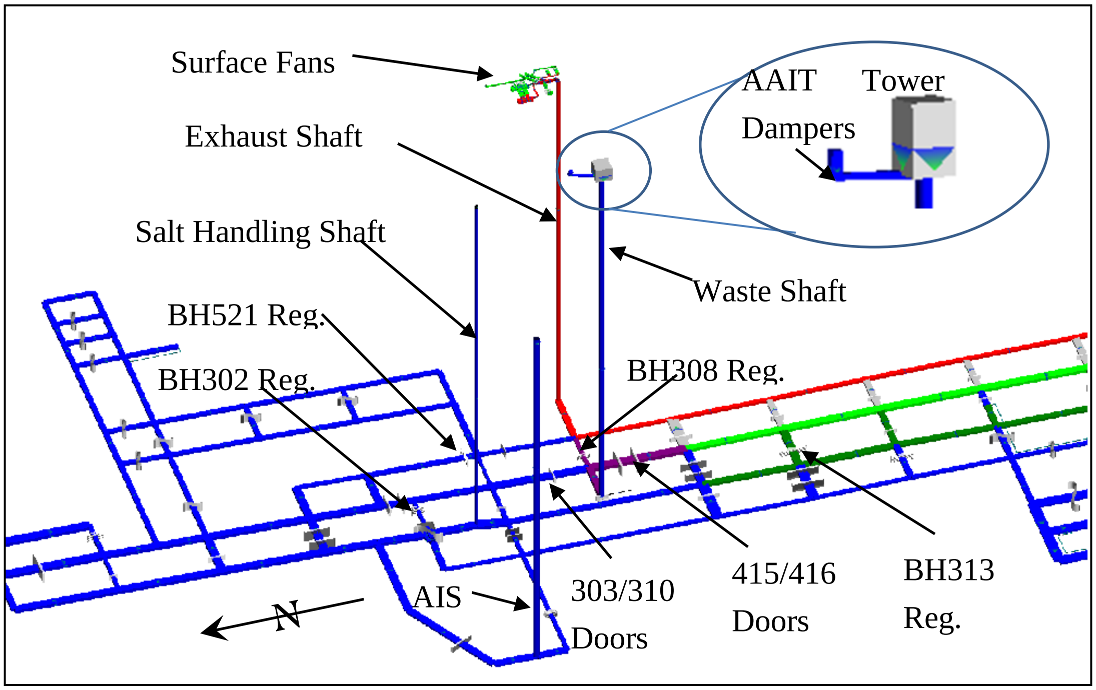


Figure 2: AAIT damper location and underground bulkhead location.

Three models were developed to provide resulting airflow distributions for either neutral, summer, and winter NVP conditions. The results of the models are shown in Figure 3 through Figure 5. For each NVP condition, nearly 50,000 cfm was shown to be delivered to the Panel 7, Room 6. Since the airflow requirements for waste emplacement mode state that at least 42,000 cfm is needed, all models developed for this study meet this requirement. This therefore shows that the Interim Ventilation System provides the underground with enough airflow to emplace waste.

The results of the calculation show that for all NVP conditions and with all three surface fans in operation, waste emplacement operations should be feasible.

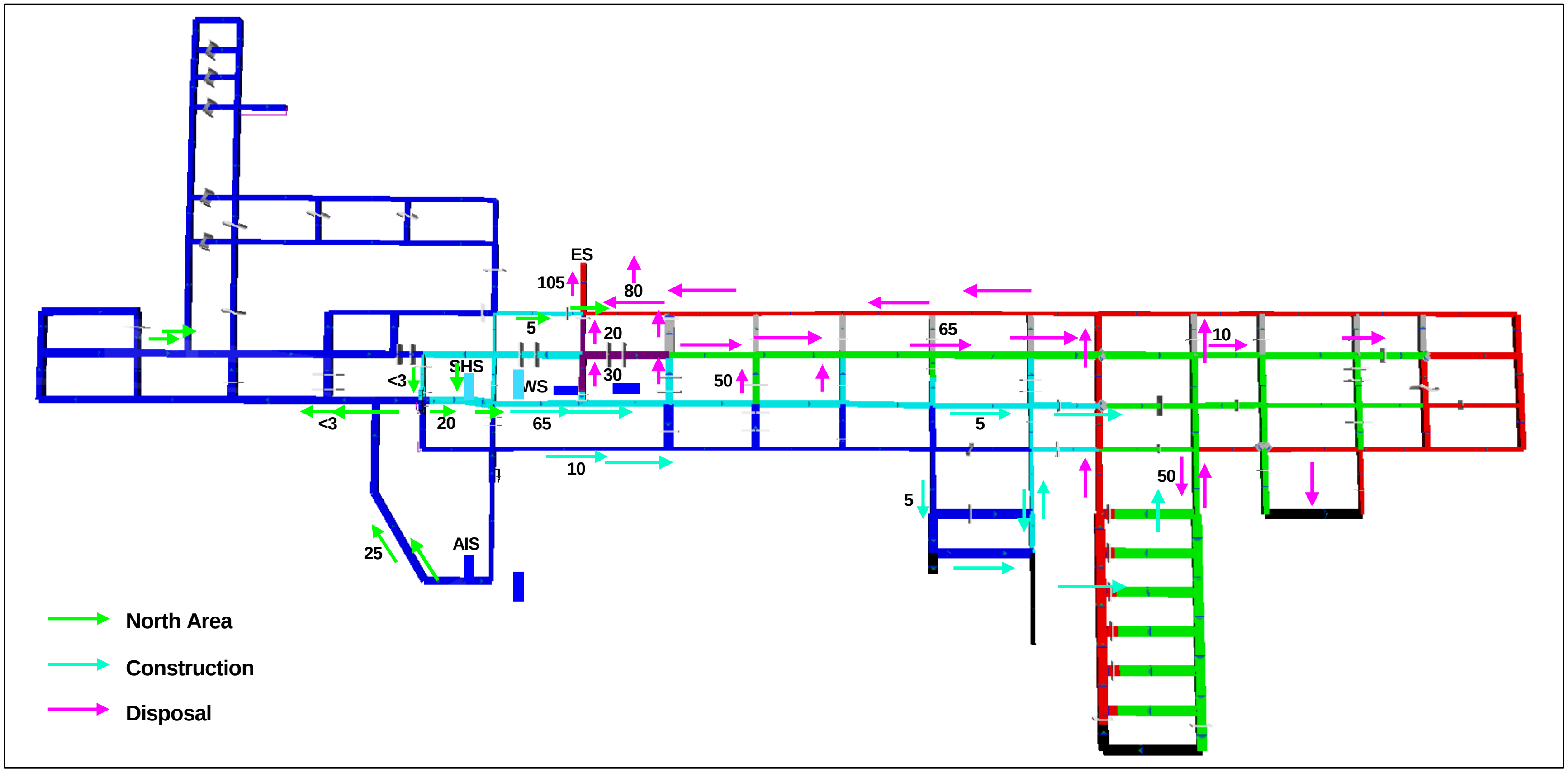


Figure 3: IVS during Waste Emplacement mode with neutral NVP conditions - SVS fan installed, but not running (kcfm).

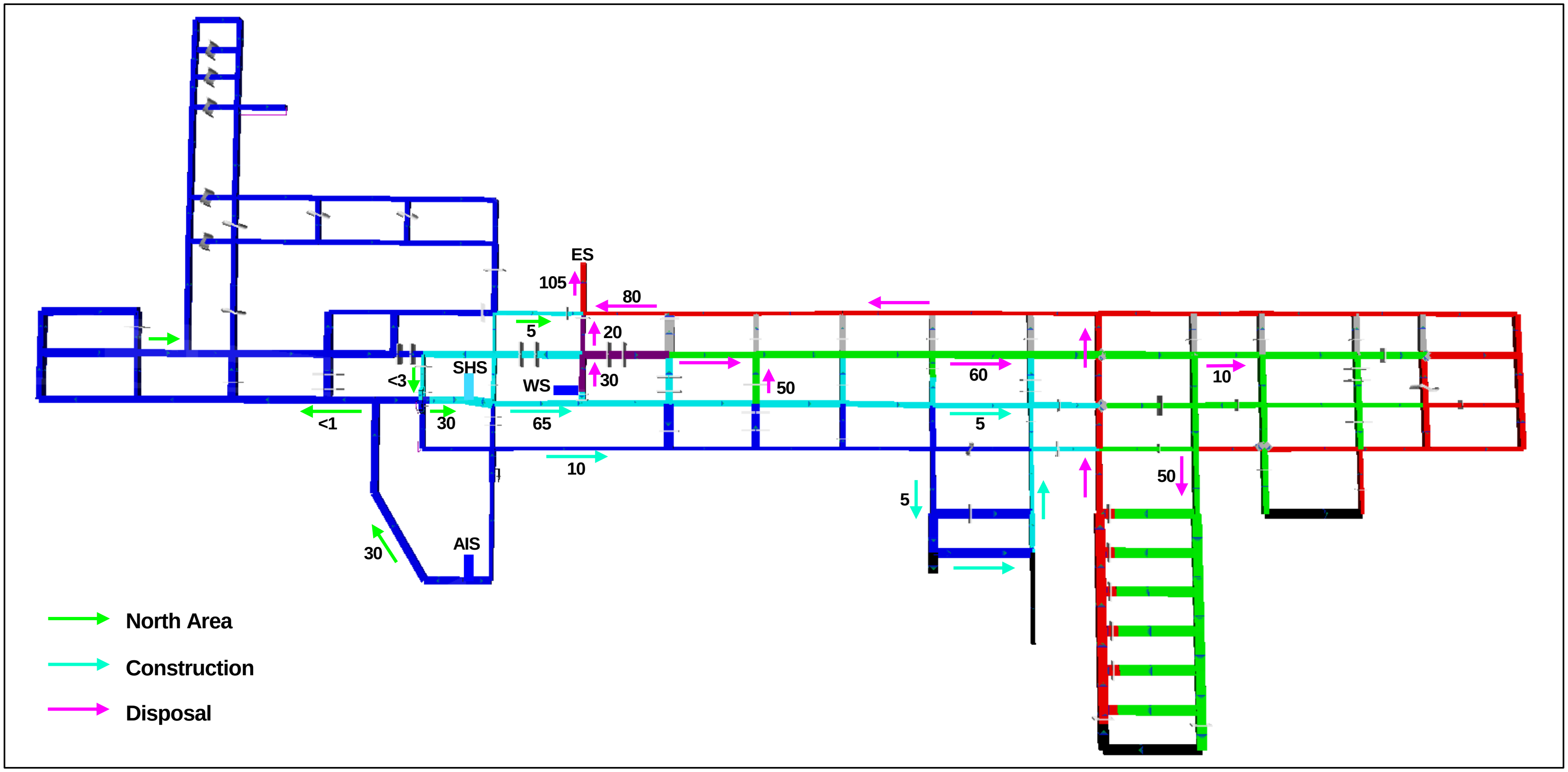


Figure 4: IVS during Waste Emplacement mode with summer NVP conditions - SVS fan installed but not running (kcfm).

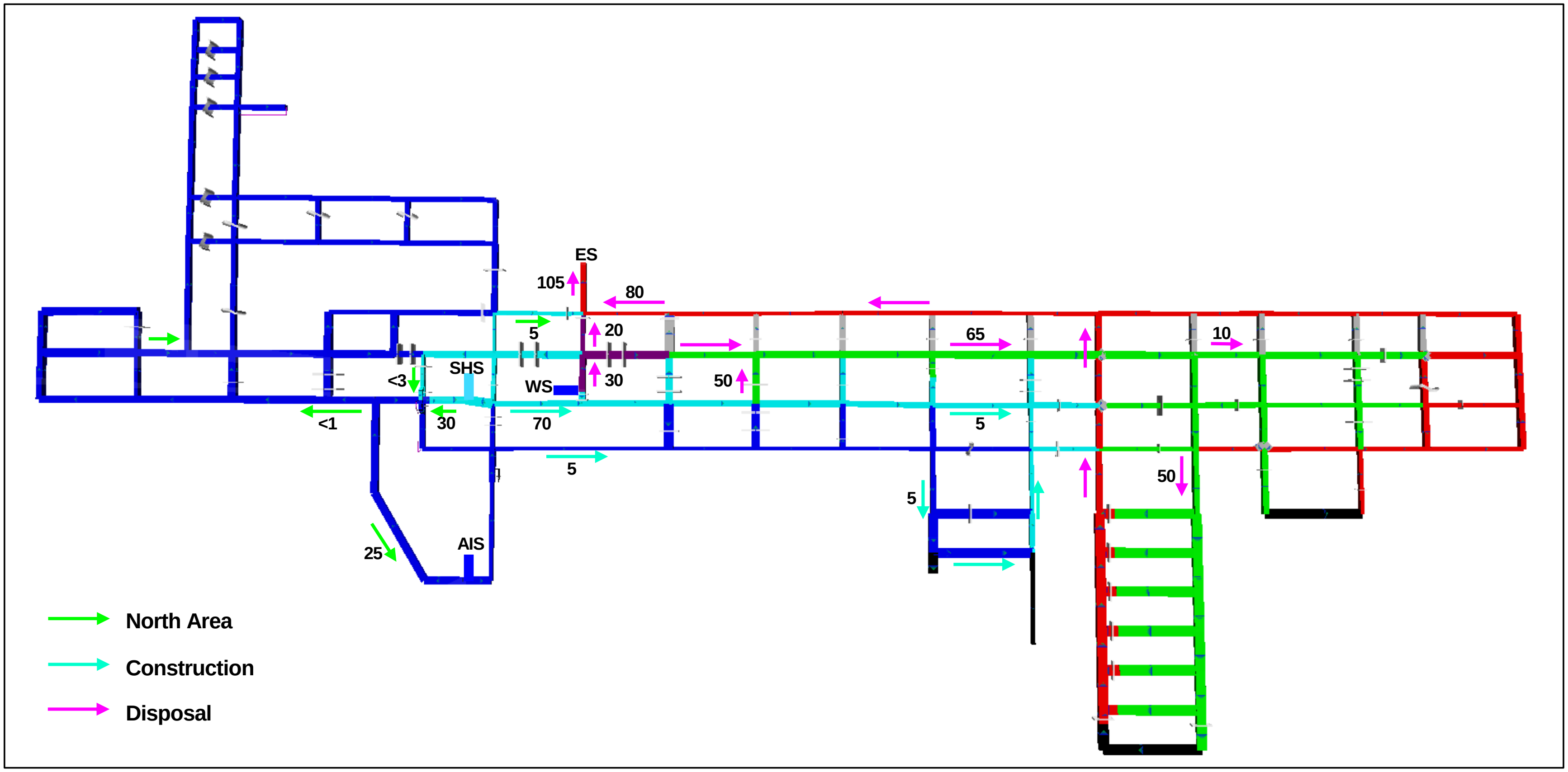


Figure 5: IVS during Waste Emplacement mode with winter NVP conditions - SVS fan installed but not running (kcfm)

Appendix D
***Statistical Analysis to Evaluate Methane and Hydrogen Concentrations in Filled Panels at the Waste Isolation Pilot Plant*, Revision 3, January 13, 2016**

Statistical Analysis to Evaluate Methane and Hydrogen Concentrations in Filled Panels at the Waste Isolation Pilot Plant

Revision 3

January 2016

AECOM
Technical Services

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I. Introduction

The Waste Isolation Pilot Plant (WIPP) Hazardous Waste Facility Permit (Permit) requires monitoring for hydrogen and methane in filled Panels 3 through 8[1], unless an explosion isolation wall is installed. A *filled panel* is an underground Hazardous Waste Disposal Unit (HWDU) that will no longer receive waste for emplacement. The filled panels consist of seven closed rooms filled with vented containers of transuranic (TRU) waste. The monitoring process includes collecting samples of closed room air to determine hydrogen and methane concentrations that may be emitted from the waste containers. The purpose of the monitoring is to determine if changes in hydrogen and methane concentrations in filled panels can be correlated to early gas-generation modeling studies (Wang and Brush 1996, Devarakonda 2006, Golder Associates 2006).

II. Purpose and Scope

The purpose of this report is to evaluate, using statistical methods, the hydrogen and methane data collected to date, in accordance with Permit Part 4.6.5 and as specified in Permit Attachment N1. This evaluation will be used as input to the design of an appropriate panel closure system. The scope of this report covers hydrogen and methane data obtained between April 2008 and January 2014 for Panel 3 and between May 2009 and February 2014 for Panel 4. Panel 5 is a filled panel that does not require monitoring since an explosion isolation wall is installed. Panels 6 is currently closed; Panel 7 is awaiting further waste emplacement activities.

The current panel closure system is designed to withstand a postulated flammable gas explosion. However, this element of the design may not be necessary if a postulated explosion is not likely prior to closure of the WIPP repository.

III. Background

Hydrogen and methane monitoring was conducted in compliance with Permit Attachment N1 because TRU wastes disposed in the WIPP underground panels have the potential to generate hydrogen and methane. Hydrogen can be generated by radiolysis (Devarakonda 2006) and by corrosion of iron-based materials under anoxic conditions (Wang and Brush 1996). Methane can be produced from microbial degradation of organic materials such as cellulosics, plastics, and rubber under humid or inundated conditions (Wang and Brush 1996). However, only humid conditions are expected to occur during operations and closure.

IV. Monitoring Methods and Data

Based on the U.S. Environmental Protection Agency (EPA) Compendium Method TO-15 (EPA 1999), samples were collected in six-liter passivated canisters using passivated

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[1] According to the Nitrate Salt Bearing Waste Isolation Plan, filled Panel 6 does not require hydrogen and methane monitoring.

stainless steel sample lines after purging. Samples were collected using sub-atmospheric sampling methods, which included a pressure dilution by the analytical laboratory with ultra-high purity nitrogen prior to analysis. Hydrogen and methane concentrations were measured with a gas chromatograph/thermal conductivity detector (GC/TCD). Identification of eluted analytes was based solely on known retention times determined during calibration of the instrumentation. Quantitation was based on the results of a 5-point calibration and results were corrected for sample dilutions. The method detection limit (MDL) was determined in accordance with 40 CFR Part 136 and corrected for the sample dilutions. Data for methane and hydrogen in Panels 3 and 4 appear in Appendices C through F. When the reported result is less than the dilution-corrected MDL, the value used for the statistical evaluation is 1/2 the dilution-corrected MDL. The appendices indicate the reported results, dilution factors, MDLs, the dilution-corrected MDLs, and the values used for the statistical evaluation.

An underground HWDU is a single excavated panel consisting of seven rooms and two access drifts designated for disposal of TRU waste. Each room is approximately 300 ft (91 m) long, 33 ft (10 m) wide, and 13 ft (4 m) high. Access drifts connect the rooms and have the same cross-section. Figure 1 is a diagram of an underground disposal panel and room layout at the WIPP facility. The rooms and the two interconnecting access drifts are the areas containing emplaced wastes in Figure 1 (hexagons used to depict waste drums) and have increasing numbers starting with Room 1 for the room closest to the main access drift (known as E-300 for Panels 3 and 4), and culminating in Room 7, the room furthest from the main access drift. Two sample head locations for filled panel monitoring are shown in Figure 1 for each room, corresponding to intake and exhaust locations. Bulkheads separate Room 1 from the main access drift and the bulkhead areas also contains sample heads on both sides (Waste (W) and Accessible (A)). Sample data are identified by the source panel number, room number or “B” for bulkhead, and intake (i) or exhaust (e) function (first and capitalized for bulkheads). For example, the Panel 3 Room 7 exhaust location is coded Panel 3 7e or simply P3 7e. Similarly, Panel 3 Exhaust Bulkhead’s Waste side is coded Panel 3 EBW (or P3 EBW).

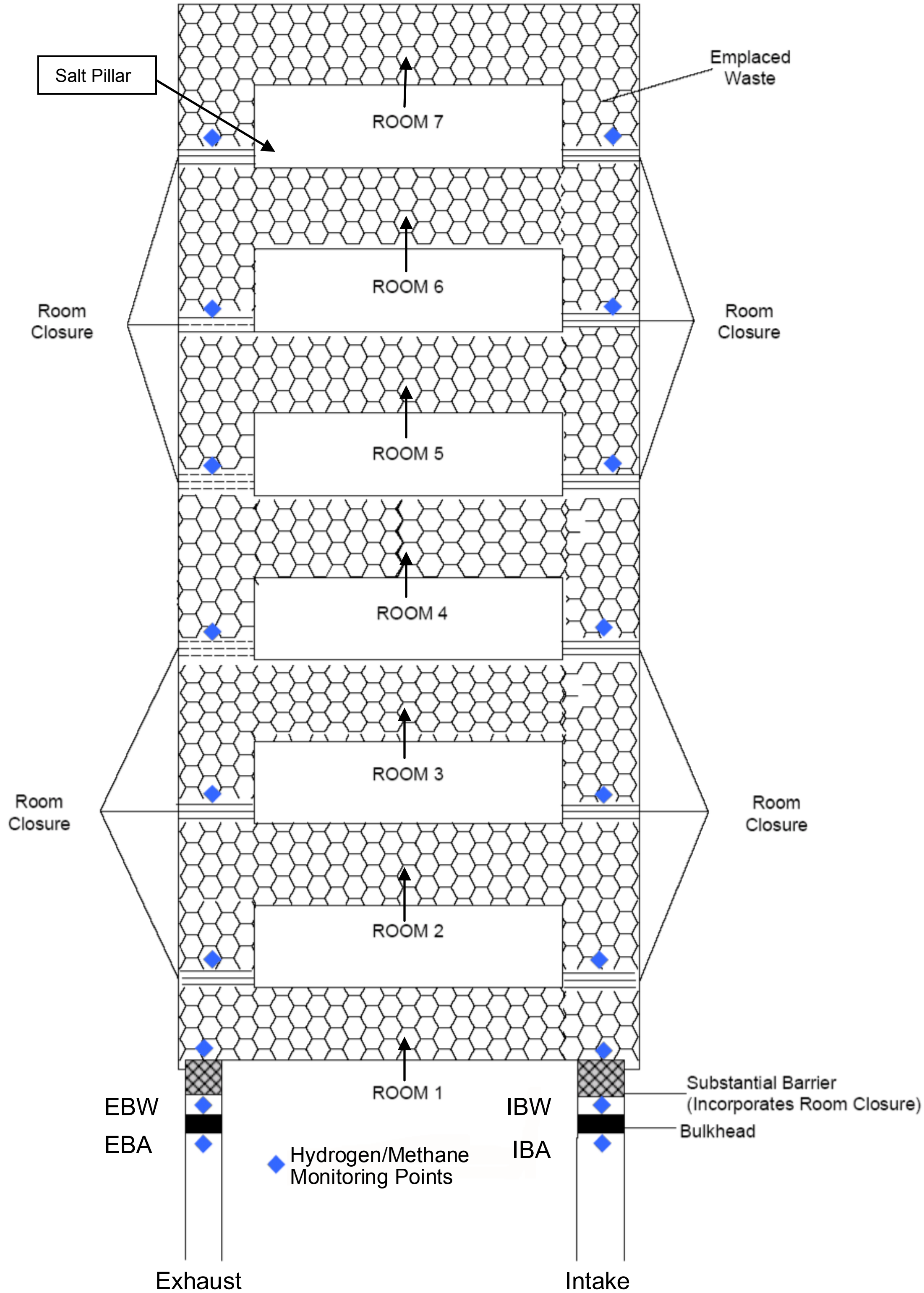


Figure 1: WIPP Disposal Panel Design and Monitoring Locations (Not to Scale)

The data set for this statistical analysis contains 1048 samples in Panel 3 for hydrogen and methane and 986 samples in Panel 4. Sample collection occurs in each panel once per month. All of the samples for methane in both Panels 3 and 4 were reported as below the MDL. As such, a statistical analysis is unnecessary. Hydrogen samples exhibited both detectable and nondetectable concentrations in both Panels 3 and 4, with dilution-corrected MDLs ranging from approximately 14 ppmv to 35 ppmv.

This statistical analysis includes data for a maximum of 70 sampling events for most of the Panel 3 monitoring locations and a maximum of 58 sampling events for most of the Panel 4 monitoring locations. Locations with fewer sampling events are associated with unusable sampling lines. The following sampling lines in Panels 3 and 4 were determined to be unusable:

- Panel 3 7i and 1i sampling lines were determined to be unusable on July 14, 2008 (Note: Only three samples were collected for each of these two lines and the June 2008 sample collected for Panel 3 7i was voided)

- The Panel 3 IBW sampling line was determined to be unusable on April 21, 2010 (Note: The sampling line was replaced and sampling resumed on May 25, 2010)

- The Panel 3 7e sampling line was determined to be unusable on August 30, 2010

- The Panel 3 6i sampling line was determined to be unusable on September 22, 2010

- The Panel 4 4e sampling line was determined to be unusable on April 7, 2011

- The Panel 4 6e sampling line was determined to be unusable on December 13, 2011

- The Panel 4 5e sampling line was determined to be unusable on August 14, 2012

- The Panel 3 6e sampling line was determined to be unusable on October 10, 2012

The sampling line for Panel 3 IBW was replaced because it is in an accessible location. The other unusable sampling line locations listed above are not accessible and were not replaced.

Hydrogen and methane measurement levels are monitored with respect to action levels specified in Table 4.6.5.3 of the Permit. Action Level 1 (the lowest action level) is set at 10 percent of the lower explosive limit (LEL) in air. As such, Action Level 1 is set at 4,000 ppmv for hydrogen and 5,000 ppmv for methane. Specified reporting and remedial actions are initiated if a monitoring level exceeds an action level.

V. Statistical Analysis

A. Monitoring Location Averages

Mean (average) hydrogen concentrations were calculated for each monitoring location in Panels 3 and 4. Each of the seven rooms is represented by two values, an *exhaust mean* and an *intake mean*. This partitioning also applies to each side of the panel bulkhead. Results are presented in Tables 1 and 2 for Panels 3 and 4 respectively. The designations "exhaust" and "intake" only refer to the geographic locations of the respective sampling points. They do not indicate a flow direction for the panel because both Panels 3 and 4 are isolated from the mine ventilation system.

Table 1: Mean Concentrations of Hydrogen in Panel 3 Locations

WIPP - Hydrogen Levels (ppmv)			
Panel	Location	Mean	
		Exhaust	Intake
3	7	104	10.8
	6	58.1	47.9
	5	54.6	34.0
	4	44.3	24.0
	3	41.8	18.2
	2	33.5	15.9
	1	24.3	10.8
	BW	22.1	15.3
	BA	14.8	14.3

The mean data for exhaust measurements in Panel 3 are presented graphically in Figure 2.

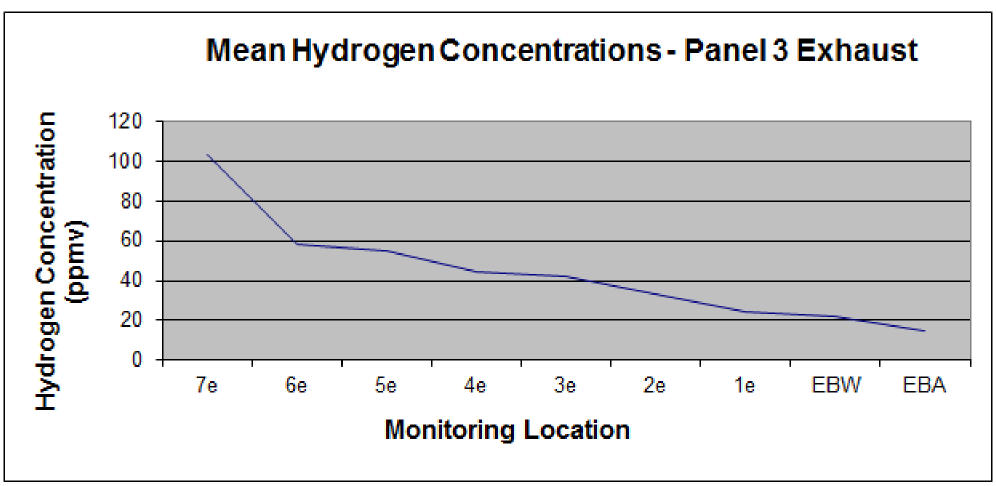


Figure 2: Average Hydrogen Concentrations at Exhaust Locations in Panel 3

The mean data for intake measurements in Panel 3 are presented graphically in Figure 3. Note that the maximum location mean observed for both intake and exhaust locations was 104 ppmv, with the remaining concentrations below 60 ppmv. There is also a general downward trend in hydrogen concentrations from Room 7 toward the E-300 drift.

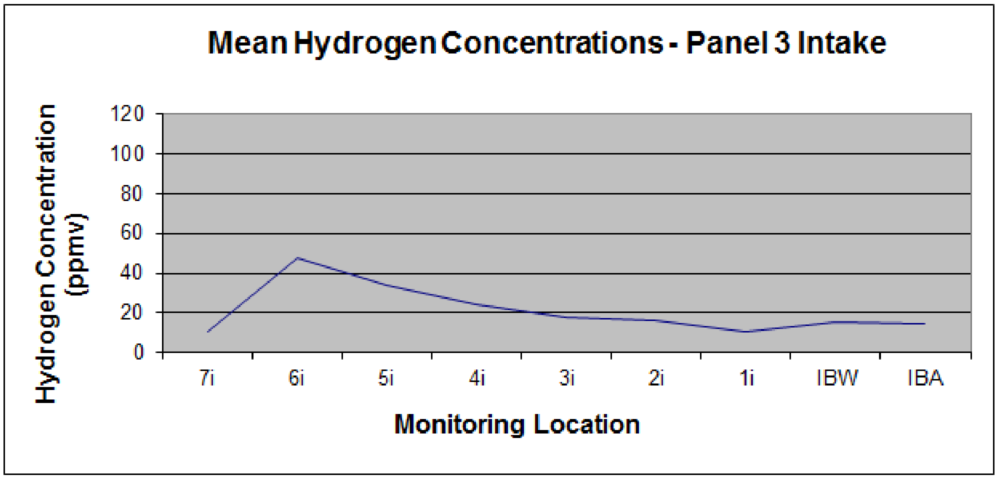


Figure 3: Average Hydrogen Concentrations at Intake Locations in Panel 3

Table 2 and Figures 4 and 5 present the average hydrogen concentrations for monitoring locations in Panel 4, which shows a downward trend in the hydrogen concentration from Room 7 toward the E-300 drift.

Table 2: Mean Concentrations of Hydrogen in Panel 4 Locations

WIPP - Hydrogen Levels (ppmv)			
Panel	Location	Mean	
		Exhaust	Intake
4	7	459	369
	6	531	347
	5	494	367
	4	395	332
	3	375	326
	2	300	271
	1	255	245
	BW	123	165
	BA	14.3	19.4

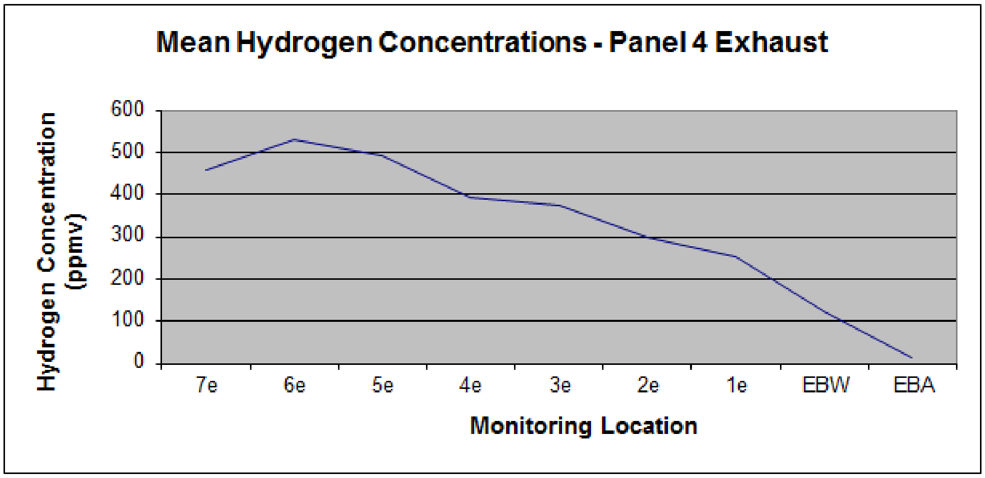


Figure 4: Average Hydrogen Concentrations at Exhaust Locations in Panel 4

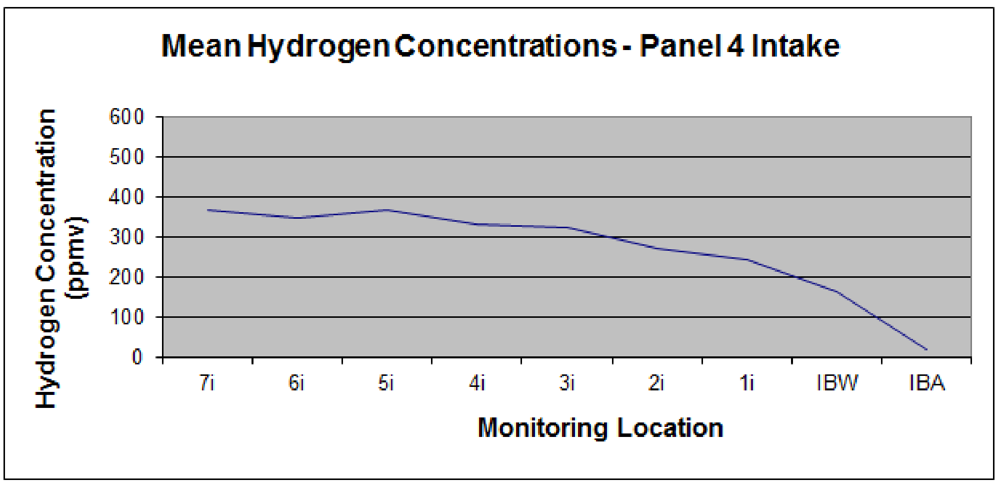


Figure 5: Average Hydrogen Concentrations at Intake Locations in Panel 4

B. Box-and-Whisker Plots

Figure 6 is a *box-and-whisker plot* of the hydrogen concentrations for Panel 3. In contrast to the mean, which describes the central tendency of a data set, a box-and-whisker plot displays the range of concentration values observed in the sample data. A box-and-whisker plot is composed of a central box divided by a median line (50% of sample data above, 50% below), with two lines extending out from the box, called whiskers. The length of the central box indicates the spread of the bulk of the data, the central 50%, which is called the *interquartile range* (IQR). The IQR is bounded by the 25th and 75th percentiles, with the median located at the 50th percentile. The length of the whiskers shows how extensive the tails of the distribution are. The width of the box has no particular meaning.

Unusually small or large data are displayed by white (hollow circles) and red dots (solid circles) on the plot. The white dots indicate data that are less than three IQRs from the 25th and 75th percentiles, whereas the red dots are data that are more than three IQRs from the 25th and 75th percentiles. Using these conventions, the graphs show the relative ranges of the distributions being compared, the central tendencies, outliers, and other aspects that allow for a visual, qualitative comparison of two or more distributions.

Figure 6 displays the distribution of monitoring data from each monitoring location in Panel 3. Sample values range from a high of approximately 350 ppmv in Room 7e to non-detects in rooms and locations closer to the E-300 drift. The general downward trend from Room 7 toward the E-300 drift is also apparent.

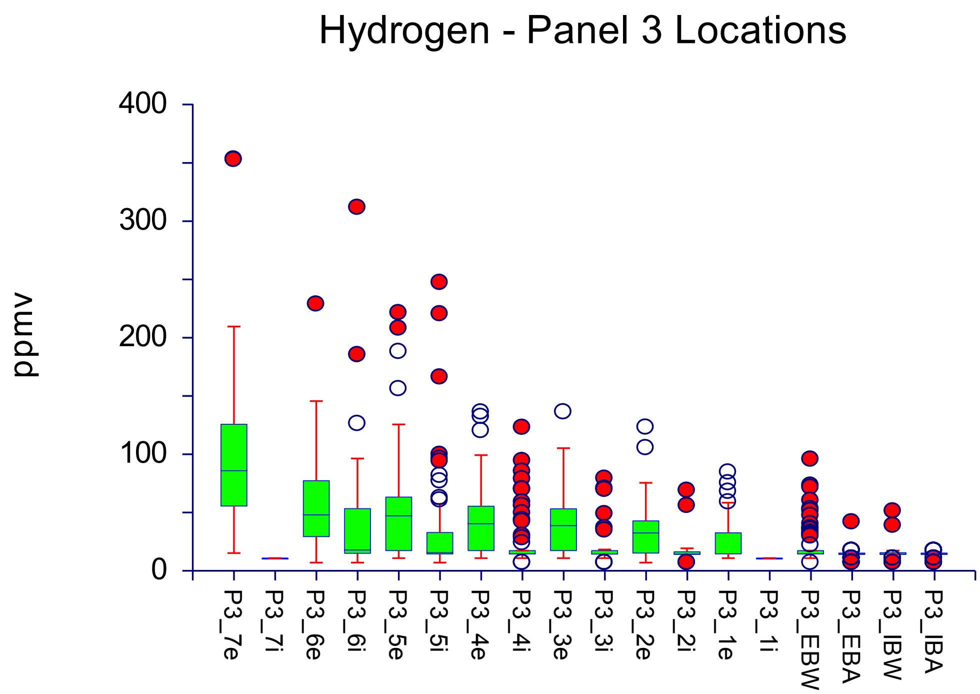


Figure 6: Box-and-Whisker Plot of Hydrogen Concentrations in Panel 3

Figure 7 is a box-and-whisker plot of Panel 3 data with the lower action level (i.e., Action Level 1) plotted on the graph. The lower action level for hydrogen is 4,000 ppmv, which is substantially greater than any concentration observed in Panel 3 monitoring.

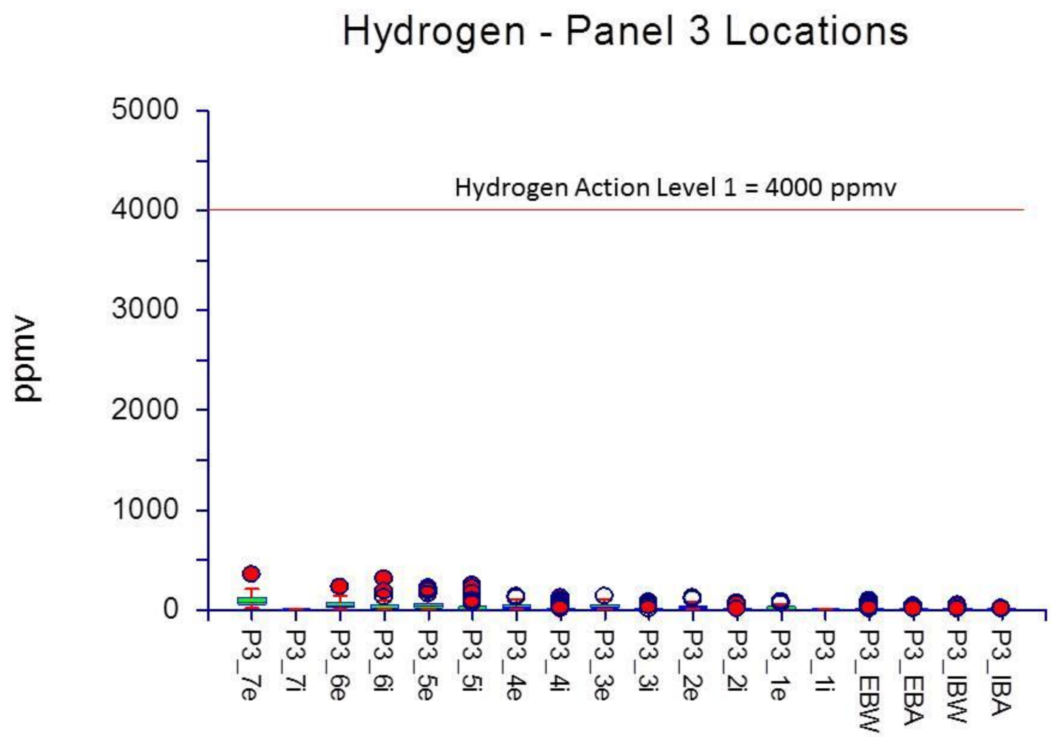


Figure 7: Box-and-Whisker Plot of Hydrogen Concentrations in Panel 3 Compared to Action Level 1

Figure 8 is a box-and-whisker plot of the hydrogen concentrations for Panel 4. Figure 8 shows that the sample data in Panel 4 span a greater range than those for Panel 3, with Panel 4 data slightly exceeding 1,000 ppmv in the Room 6 exhaust monitoring location. The general downward trend from Room 7 toward the E-300 drift is also apparent. Figure 9 plots the Panel 4 data in relation to the hydrogen lower action level. None of the data pose a challenge to the lower action level.

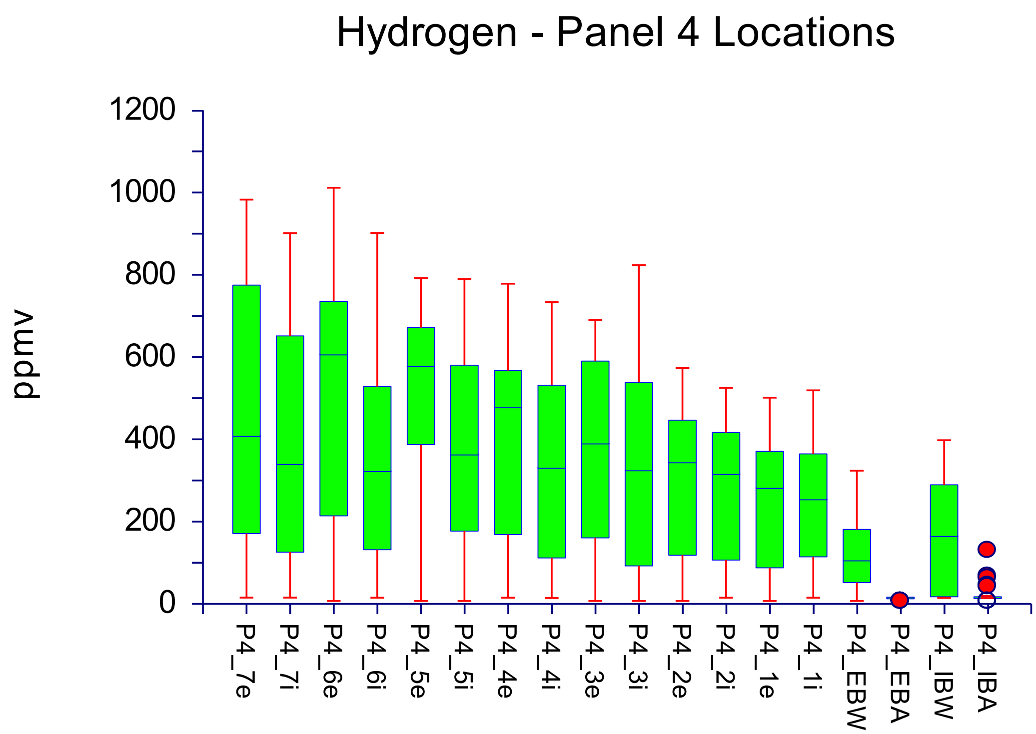


Figure 8: Box-and-Whisker Plot of Hydrogen Concentrations in Panel 4

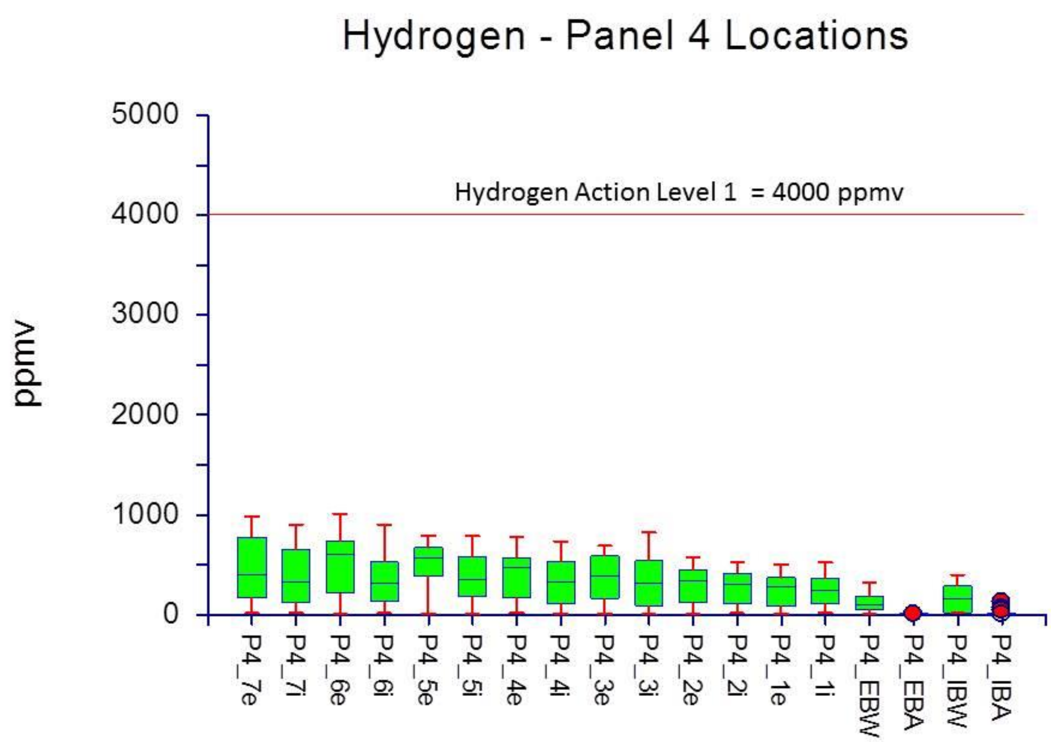


Figure 9: Box-and-Whisker Plot of Hydrogen Concentrations in Panel 4 Compared to Action Level 1

C. Time Series Plots

In addition to the central tendencies and concentration ranges (minimums/maximums), how the data are distributed over time is of interest for correlating concentration data to the early gas-generation modeling studies. Figures 10 and 11 show time series plots for hydrogen concentrations in Panel 3, Room 7. Note that only two samples are available to construct Figure 11, both of which are nondetects and equal in value. Figures 12 and 13 show time series plots for hydrogen concentrations in Panel 4, Room 7. Full suites of time series plots for Panels 3 and 4 appear in Appendices A and B respectively.

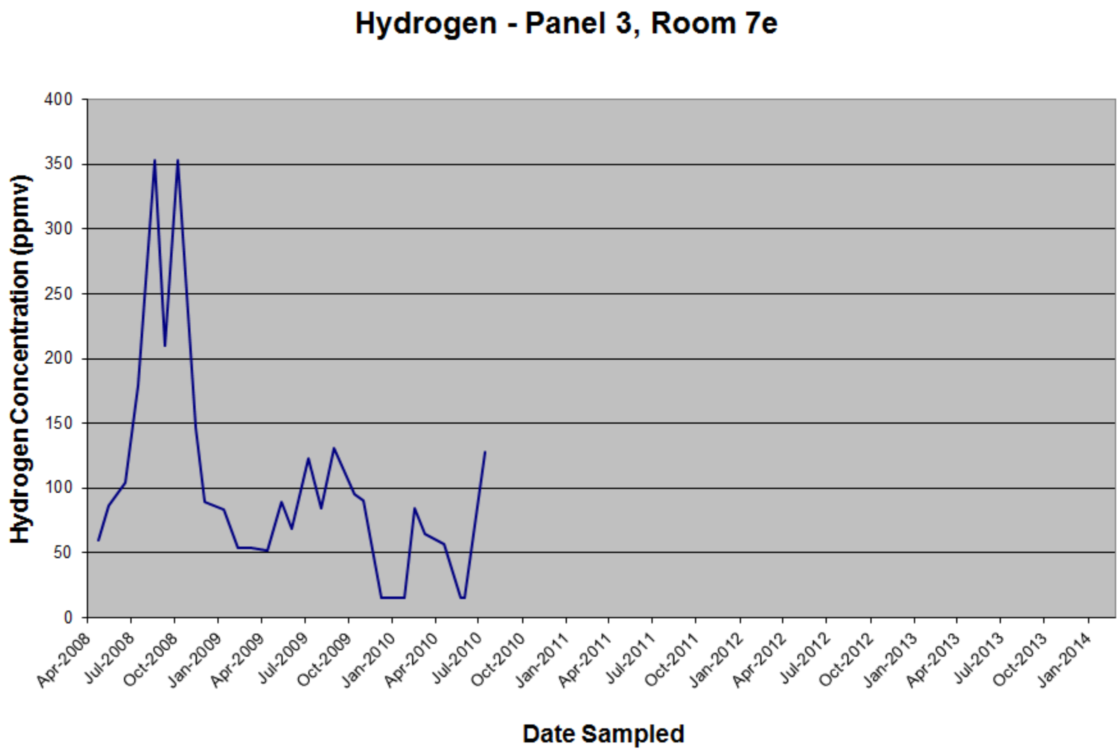


Figure 10: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 7e

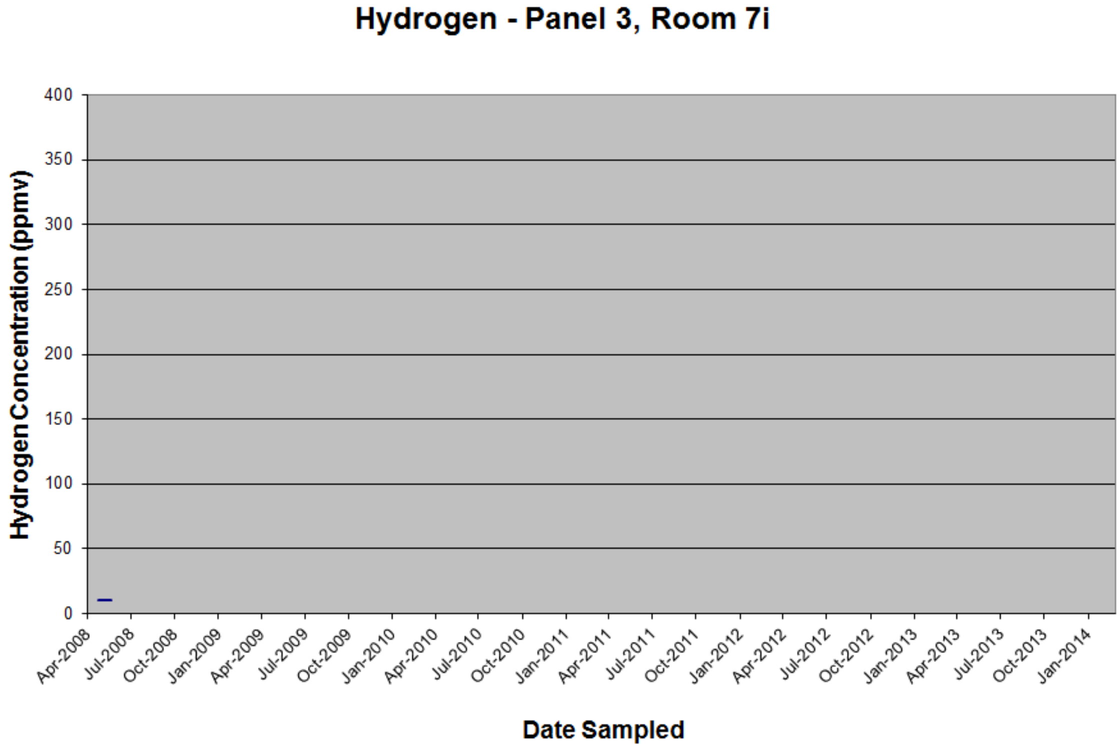


Figure 11: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 7i

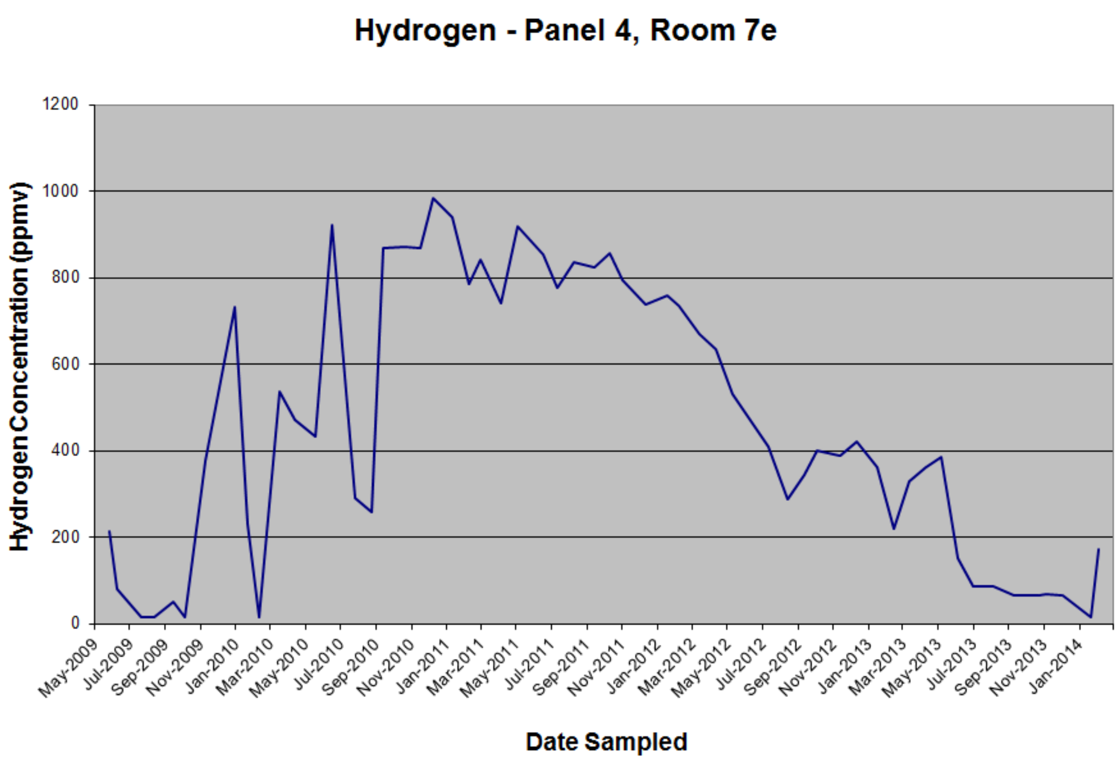


Figure 12: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 7e

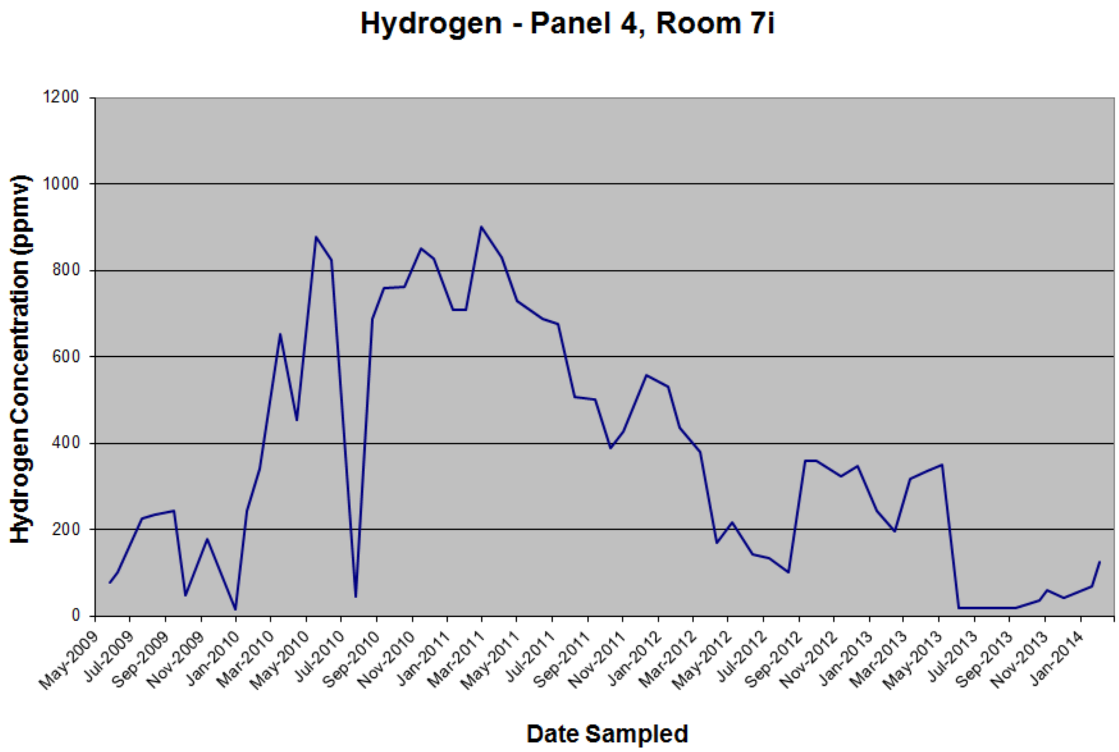


Figure 13: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 7i

D. Hydrogen Concentration Plots

While time series plots show hydrogen concentrations for individual room and bulkhead locations, hydrogen concentration plots present an aggregated picture of these locations simultaneously. Most importantly, hydrogen concentration plots display the degree to which hydrogen concentrations fluctuate from the time a room was closed. Accessible bulkhead locations (IBA and EBA) have been excluded since they are outside the filled panels. Waste side bulkhead locations (IBW and EBW) are plotted using Room 1 closure dates.

1. Panel 3 Hydrogen Concentration Plots

Figure 14 presents the hydrogen concentration data for rooms and waste-side bulkhead locations in Panel 3. The graph plots the number of months since the associated room was closed on the x-axis and the hydrogen concentration on the y-axis. Figures 15 through 17 plot respectively the median, mean, and maximum hydrogen concentrations versus months since the room was closed. Figure 18 overlays the three for ease of comparison.

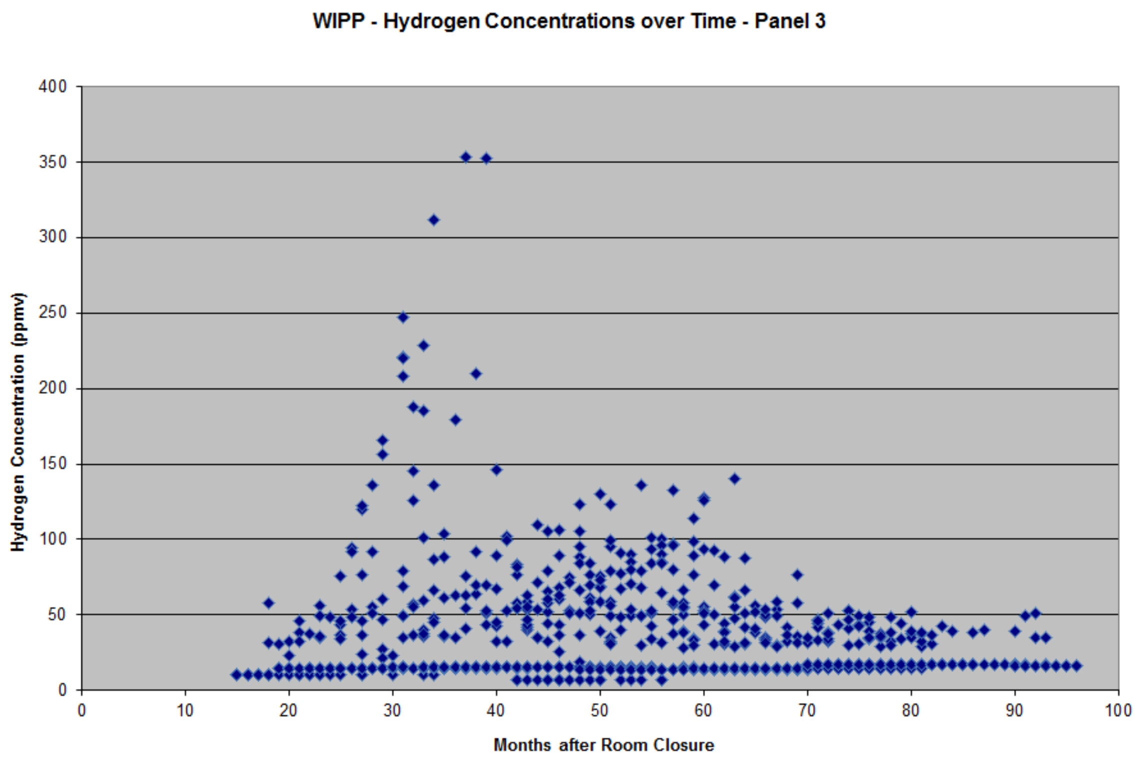


Figure 14: Plot of Hydrogen Concentrations in Panel 3

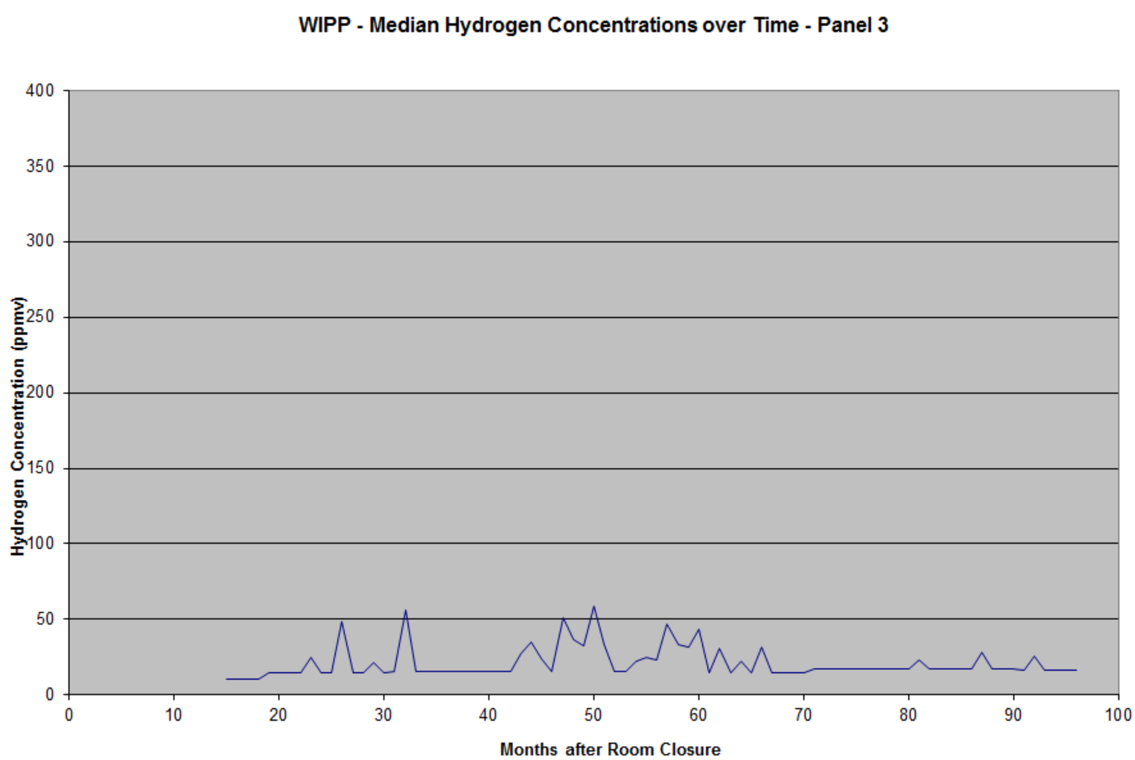


Figure 15: Plot of Median Hydrogen Concentrations in Panel 3

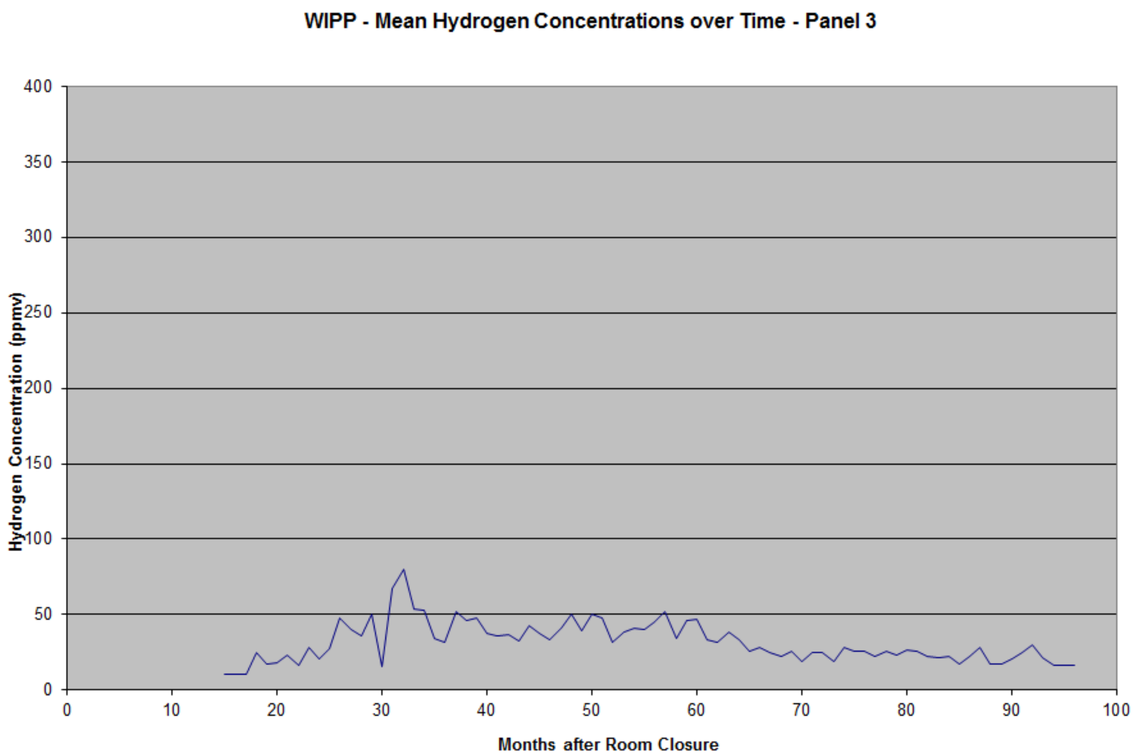


Figure 16: Plot of Mean Hydrogen Concentrations in Panel 3

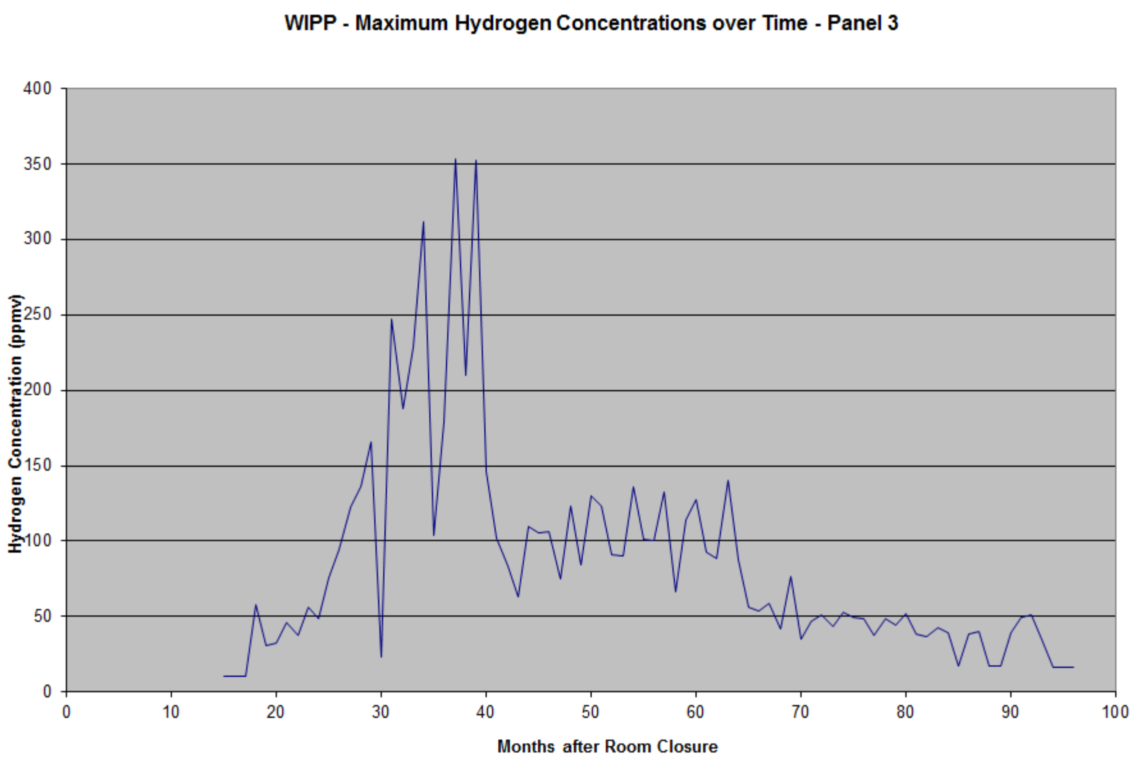


Figure 17: Plot of Maximum Hydrogen Concentrations in Panel 3

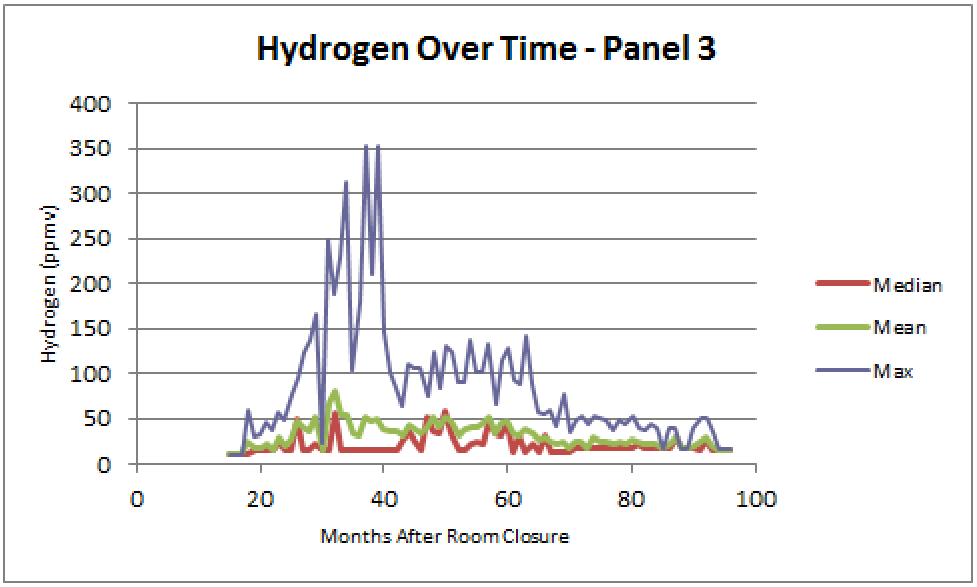


Figure 18: Plot of Median, Mean and Max Hydrogen in Panel 3

2. Panel 4 Hydrogen Concentration Plots

Figure 19 presents the hydrogen concentration data for rooms and waste-side bulkhead locations in Panel 4. Figures 20 through 22 show respectively the median, mean, and maximum hydrogen concentrations versus months since the room was closed. Figure 23 overlays the three for ease of comparison.

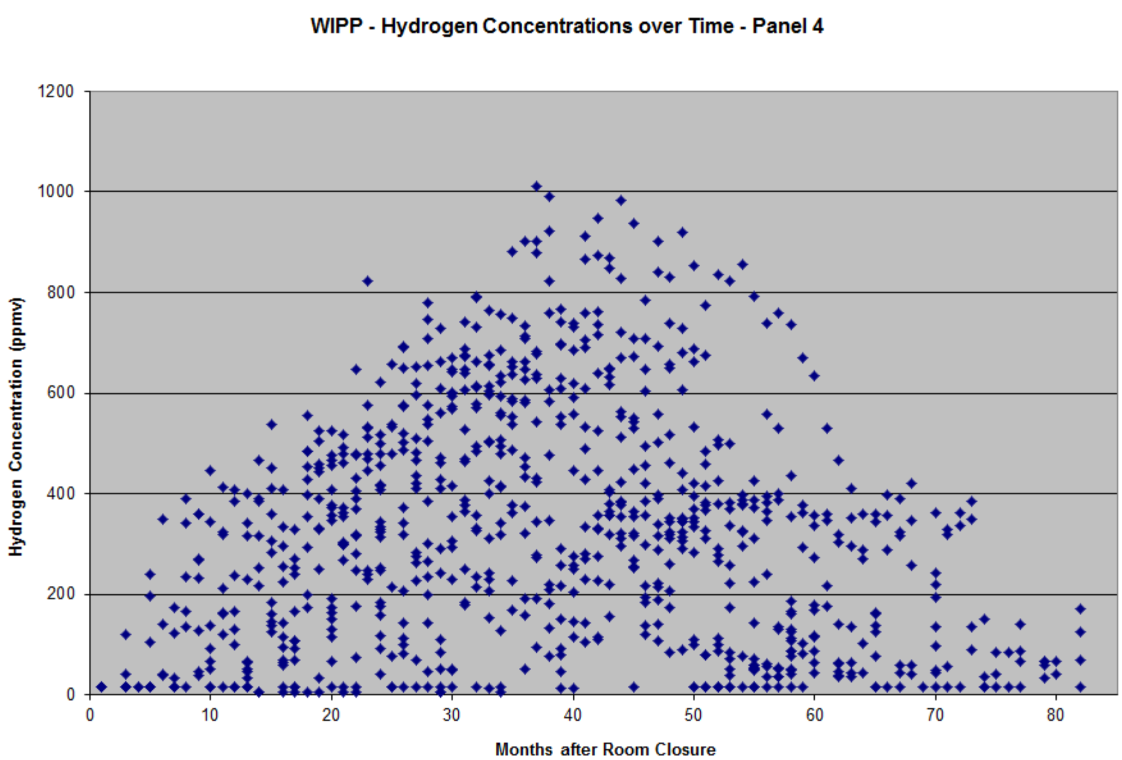


Figure 19: Plot of Hydrogen Concentrations in Panel 4

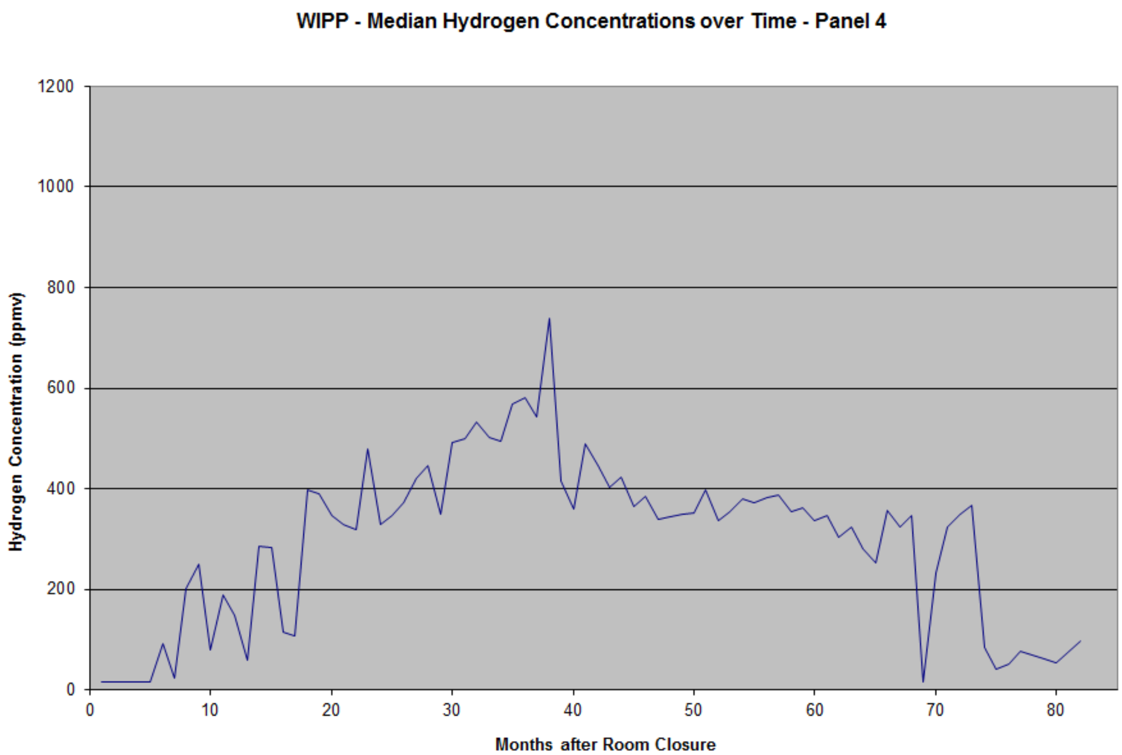


Figure 20: Plot of Median Hydrogen Concentrations in Panel 4

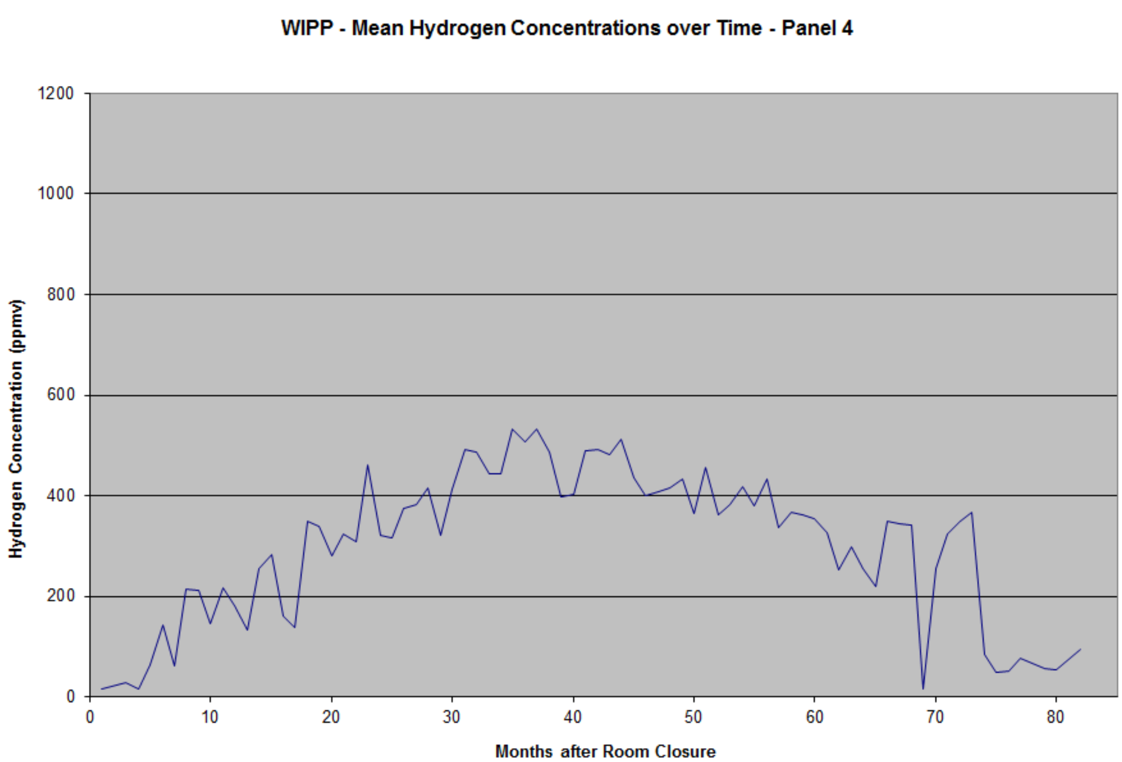


Figure 21: Plot of Mean Hydrogen Concentrations in Panel 4

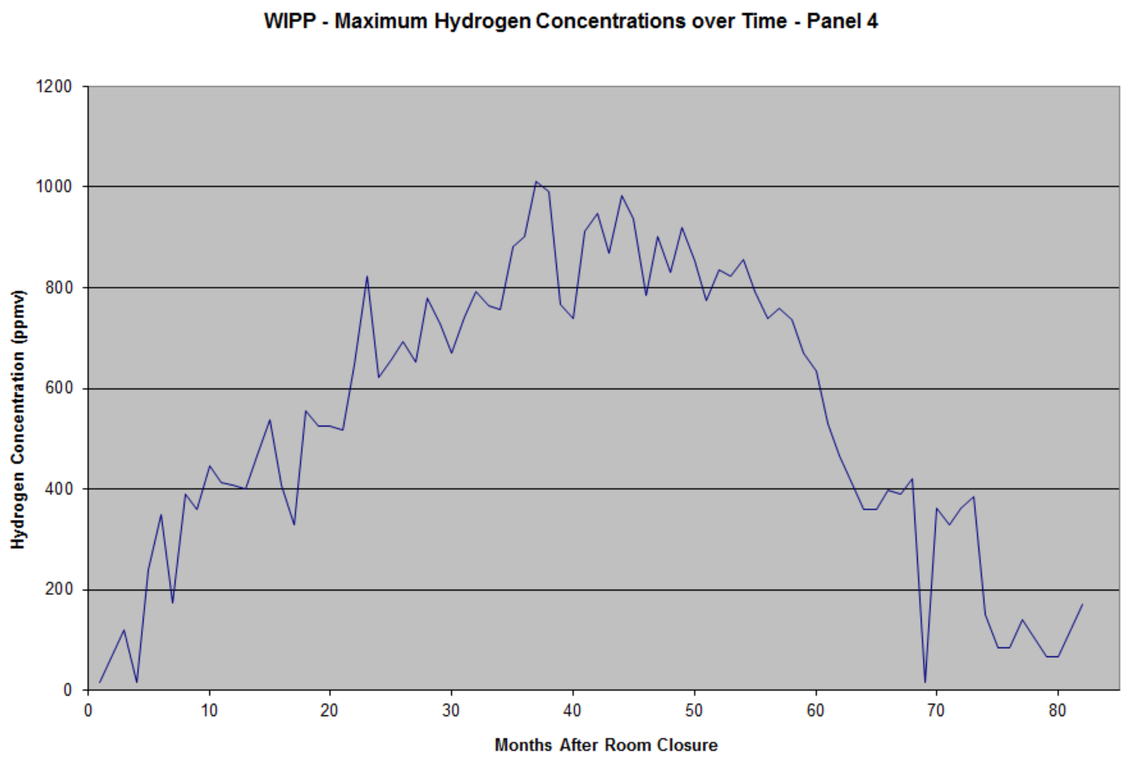


Figure 22: Plot of Maximum Hydrogen Concentrations in Panel 4

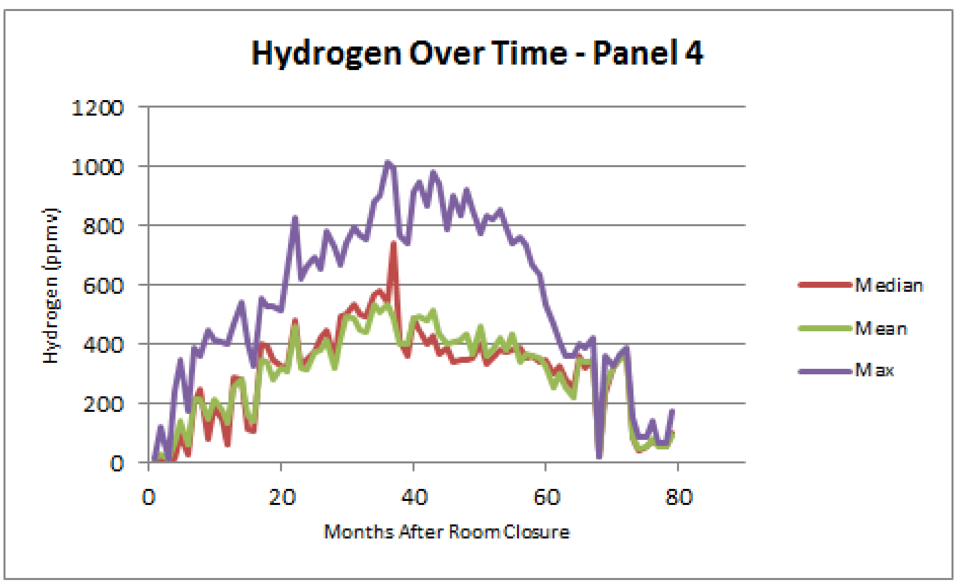


Figure 23: Plot of Median, Mean and Max Hydrogen in Panel 4

E. Linear Regression on Hydrogen Concentration Data

Hydrogen concentration plots show the concentration of hydrogen in closed rooms over time. The change in hydrogen concentration over time is believed to be related to the hydrogen generation rate and the rate at which hydrogen leaves the disposal room. The change in hydrogen concentration over time can be analyzed in a quantitative way to predict the length of time necessary for hydrogen concentrations to accumulate to explosive levels. Linear regression has been used to quantify the change in hydrogen concentration with time in Panels 3 and 4. Accessible bulkhead locations (IBA and EBA) were excluded.

1. Panel 3 Regression Plots

Figures 24 through 26 show respectively the median, mean, and maximum hydrogen concentrations versus the number of months since rooms in Panel 3 were closed. The best-fit line is drawn through each data set. Figures 27 and 28 re-plot the maximum hydrogen concentration in relation to Action Level 1 (4,000 ppmv) and the LEL (40,000 ppmv).

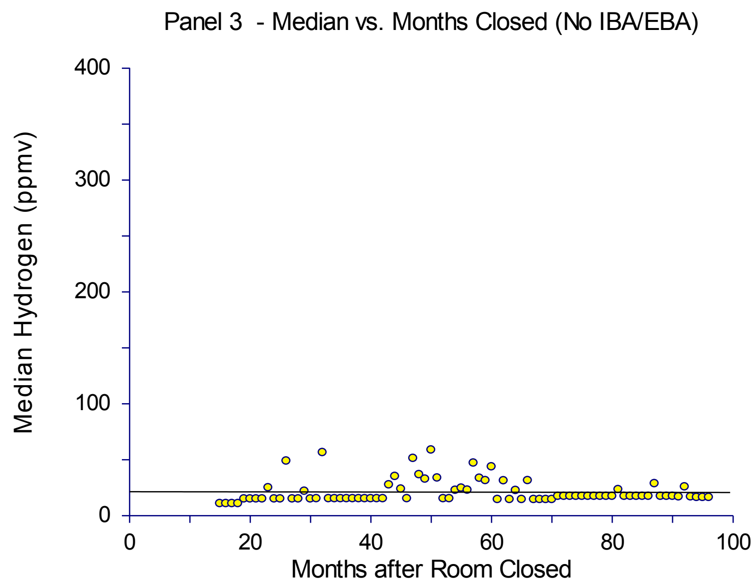


Figure 24: Regression of Median Hydrogen Concentrations in Panel 3

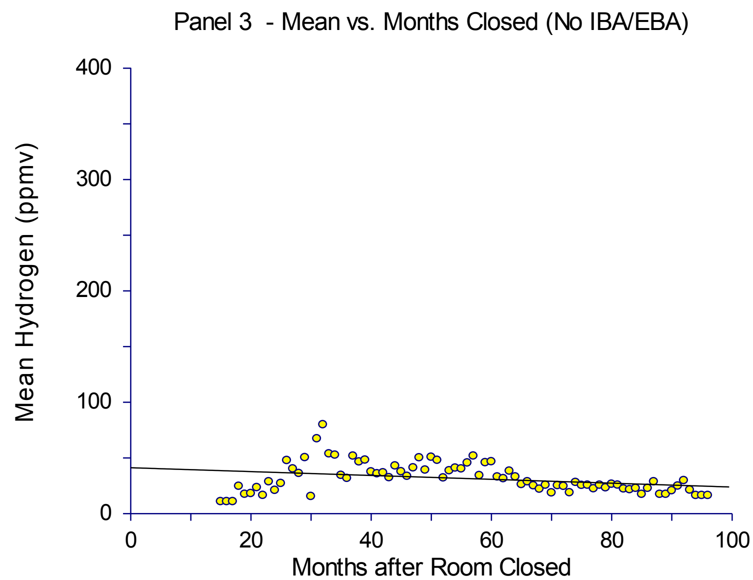


Figure 25: Regression of Mean Hydrogen Concentrations in Panel 3

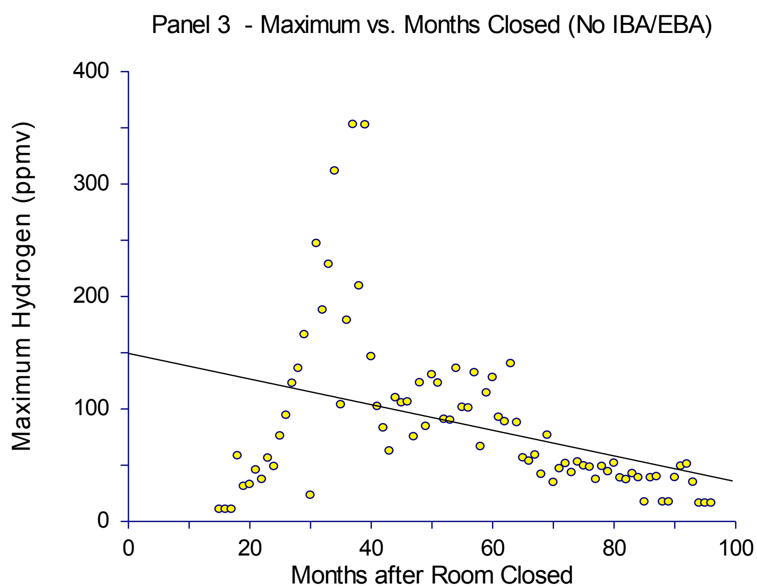


Figure 26: Regression of Maximum Hydrogen Concentrations in Panel 3

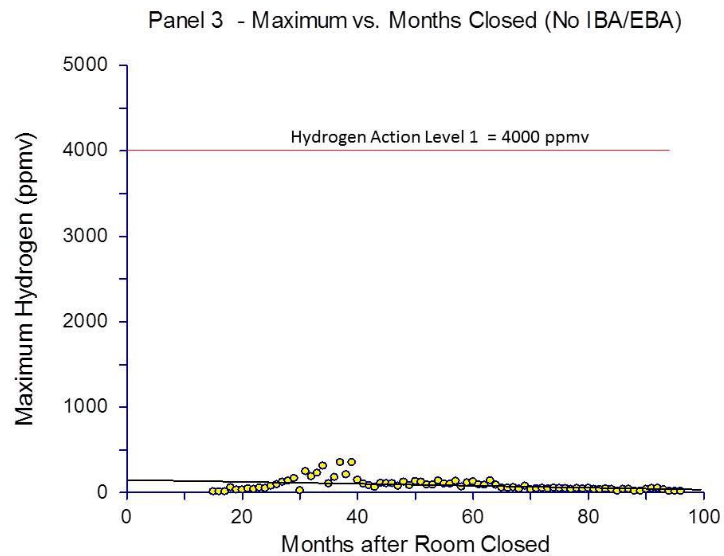


Figure 27: Regression of Maximum Hydrogen Concentrations in Panel 3 Compared to Action Level 1

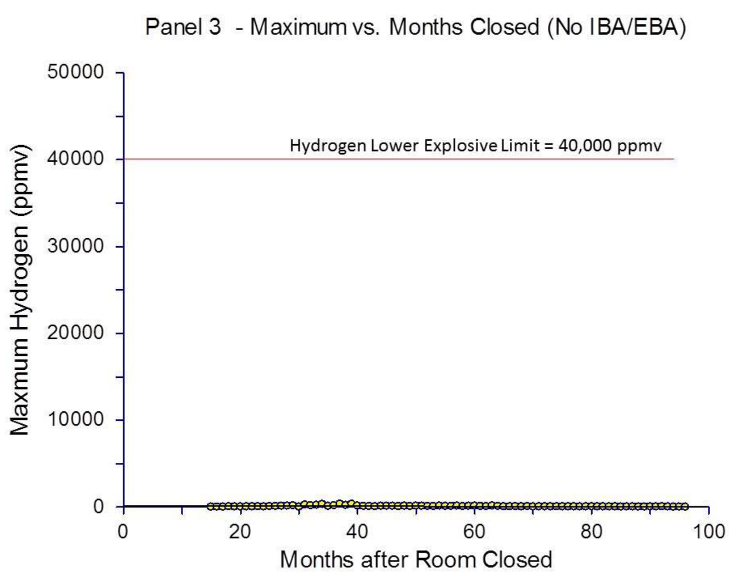


Figure 28: Regression of Maximum Hydrogen Concentrations in Panel 3 Compared to the Lower Explosive Limit

Because the regression equation for the maximum hydrogen concentrations shown in Figures 26 through 28 has a negative slope (downward trend), the hydrogen concentration will not reach Action Level 1 or the LEL.

2. Panel 4 Regression Plots

Figures 29 through 31 show respectively the median, mean, and maximum hydrogen concentrations versus the number of months since rooms in Panel 4 were closed. Figures 32 and 33 plot the maximum hydrogen concentrations in relation to Action Level 1 (4,000 ppmv) and the LEL (40,000 ppmv).

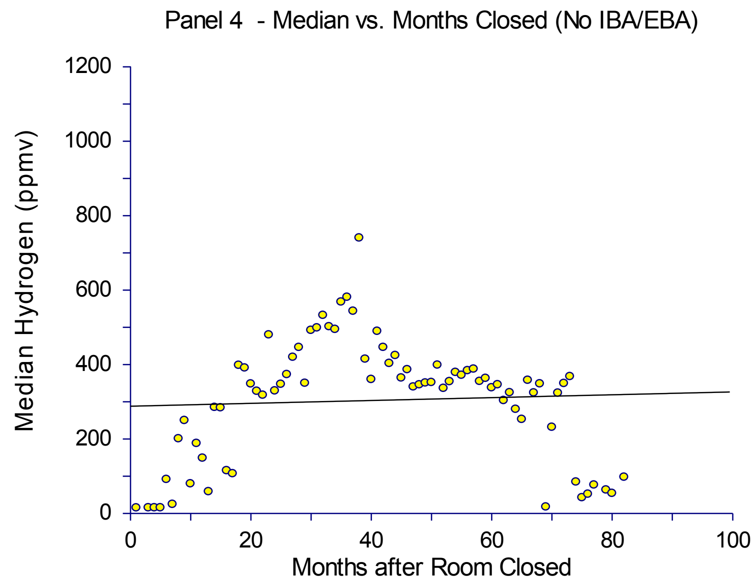


Figure 29: Regression of Median Hydrogen Concentrations in Panel 4

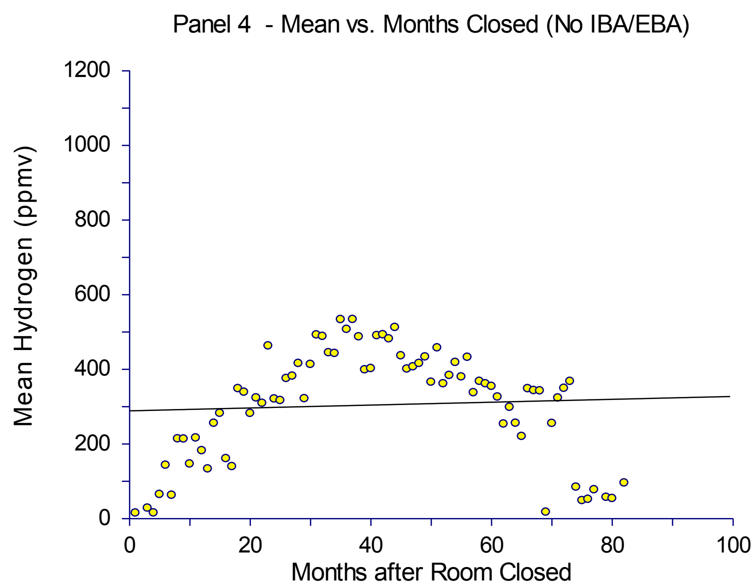


Figure 30: Regression of Mean Hydrogen Concentrations in Panel 4

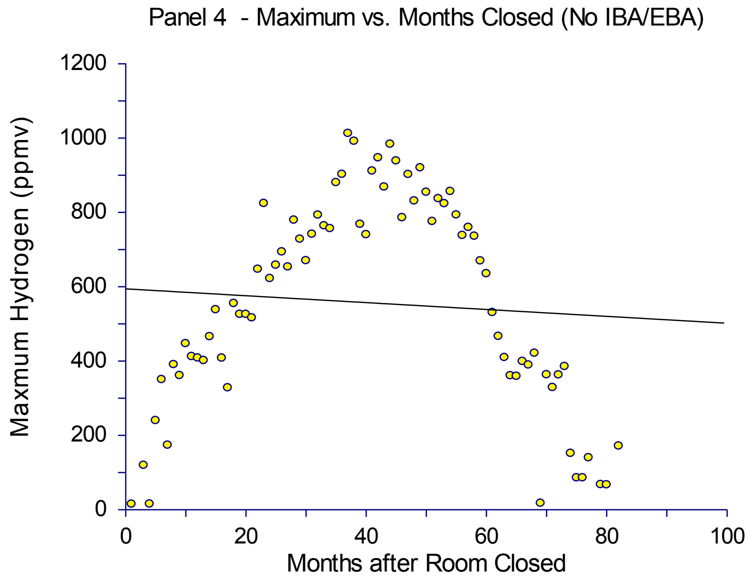


Figure 31: Regression of Maximum Hydrogen Concentrations in Panel 4

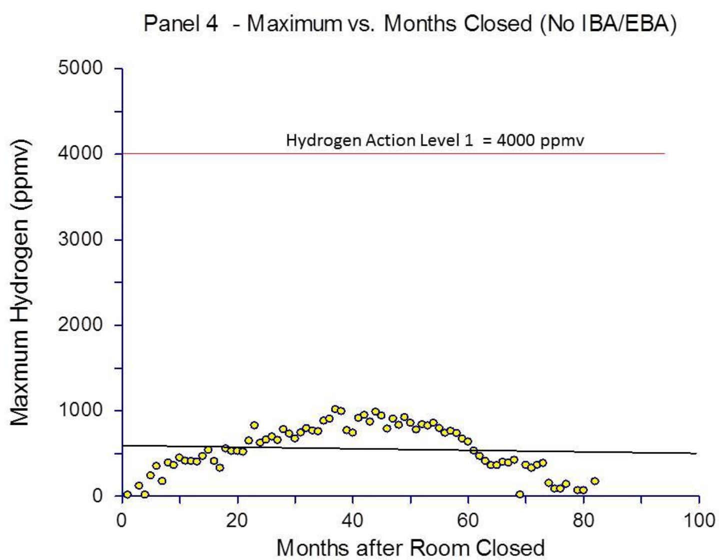


Figure 32: Regression of Maximum Hydrogen Concentrations in Panel 4 Compared to Action Level 1

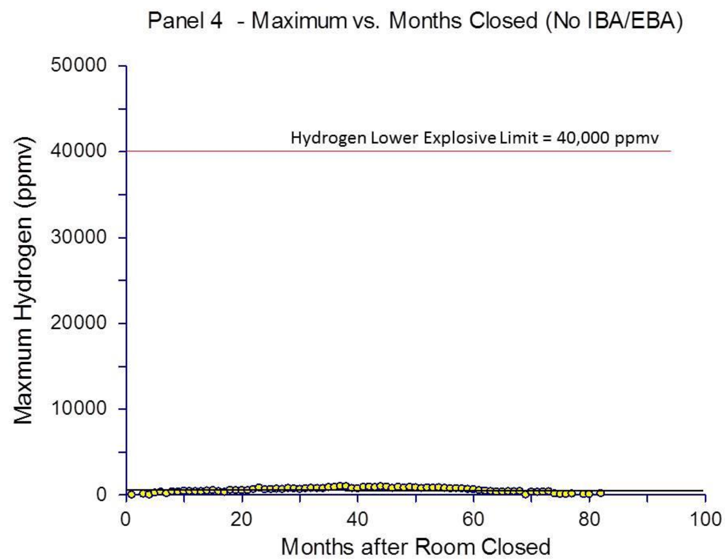


Figure 33: Regression of Maximum Hydrogen Concentrations in Panel 4 Compared to the Lower Explosive Limit

Using the regression equation for the maximum hydrogen concentrations shown in Figures 31 through 33, the hydrogen concentrations will never reach Action Level 1 or the LEL. This conclusion is also based on data continuing to exhibit hydrogen concentrations below 200 ppmv.

VI. Discussion

The statistical analysis has revealed several pertinent results:

- Rooms further from the main access drift tend to show higher average concentrations than rooms closer to the drift. This phenomenon can be seen in Figures 2 through 5. Rooms further from the main access drift have a longer accumulation time period and more ventilation barriers to cross.
- Box-and-whisker plots (Figures 6 through 9) also show that rooms closer to the main access drift generally have lower hydrogen than rooms further away. Box-and-whisker plots including the lower action level show that all sample data are substantially below Action Level 1.
- Time series plots reveal that hydrogen concentration maximums are temporary and that concentrations can fall to near non-detectable levels after peaking.
- Hydrogen concentration plots in Panel 3 rooms show a peak in hydrogen concentrations followed by a sustained period of low hydrogen levels, which is ongoing according to the latest sample data. Hydrogen concentration plots in Panel 4 rooms show generally rising concentrations, with maximum levels exhibiting a leveling off trend or most recently a decline. A small increase in hydrogen concentrations occurred in recent data, but does not challenge Action Level 1 or the LEL.

- Linear regression of panel hydrogen concentration data, excluding accessible-side bulkhead locations, shows consistent results between Panels 3 and 4. The negative slope of the regression models (Figures 26 and 32) predicts a continued decline in hydrogen concentrations for both Panel 3 and Panel 4; thus, neither Action Level 1 nor the LEL will likely ever be reached, as shown in Table 3.

Table 3: Predicted Time to Exceedance of Hydrogen Regulatory Thresholds in Panels 3 and 4 Based on Maximum Measured Values

WIPP - Hydrogen Levels		
Panel	Predicted Time to Exceedance (Years)	
	Action Level 1	Lower Explosive Limit
3	Never	Never
4	Never	Never

Linear regressions for the individual monitoring locations (IBA and EBA not included) similarly produce varying results, from predictions of continual decline to longer or shorter exceedance times. Individual predictions are shown in Table 4 below, while the plots are in Appendices G and H. The soonest time to exceedance prediction within Panel 3 is more than 3300 years for Room 2e to exceed Action Level 1. The corresponding time to LEL is more than 33,000 years. Within Panel 4, excluding the three rooms with static information due to plugged sample lines, the soonest time to exceedance prediction is 440 years for Room 1e to exceed AL1. The corresponding time to LEL is more than 4400 years.

Table 4: Predicted Time to Exceedance of Hydrogen Regulatory Thresholds in Individual Locations of Panels 3 and 4

WIPP - Hydrogen Levels			
Panel	Location	Predicted Time to Exceedance (Years)	
		Action Level 1	Lower Explosive Limit
3	2e	3300+	33,000+
	2i	7600+	76,000+
	1e	3200+	32,000+
	EBW	6900+	69,000+
	IBW	5800+	58,000+
	Others	Never	Never
4	*6e	*16	*160
	*5e	*30	*300
	*4e	*13	*130
	1e	15,000+	150,000+
	EBW	440+	4400+
	Others	Never	Never
* Sample line is plugged; data are static.			

- Because individual locations with sufficient data produced arch-shaped plots indicating a reduction of hydrogen concentration accumulation, it is more appropriate to conduct the linear regressions on data in and after the peak regions for extrapolating to the future. Such later data were plotted for the locations within each panel (Figures 34 to 63) and resulting regression slopes are captured in Table 5 below. All slopes are significantly negative, indicating that these data are trending downward. Based on the current trend, **no exceedance is predicted to likely ever occur at any of these locations**.

Table 5: Linear Regression Slopes for Individual Locations of Panel 3 and 4

WIPP - Hydrogen Decline (ppmv/mo)			
Panel	Location	Slope from Peak	
		Exhaust	Intake
3	7	-7.6	na
	6	-0.95	-1.9
	5	-1.1	-0.85
	4	-0.44	-0.31
	3	-1.3	-0.42
	2	-0.79	-0.26
	1	-0.68	na
	BW	-0.92	-0.08
4	7	-24	-20
	6	-22	-18
	5	-13	-17
	4	-17	-15
	3	-16	-16
	2	-12	-11
	1	-8.4	-9.5
	BW	-2.6	-8.5

- Rooms and panels are not completely sealed to the outside areas of the mine, which may contribute to the fluctuations observed in the room hydrogen levels. Changes in mine ventilation flow, changes in the efficacy of bulkheads in a dynamic environment subject to various factors could influence hydrogen accumulation to an unknown degree.

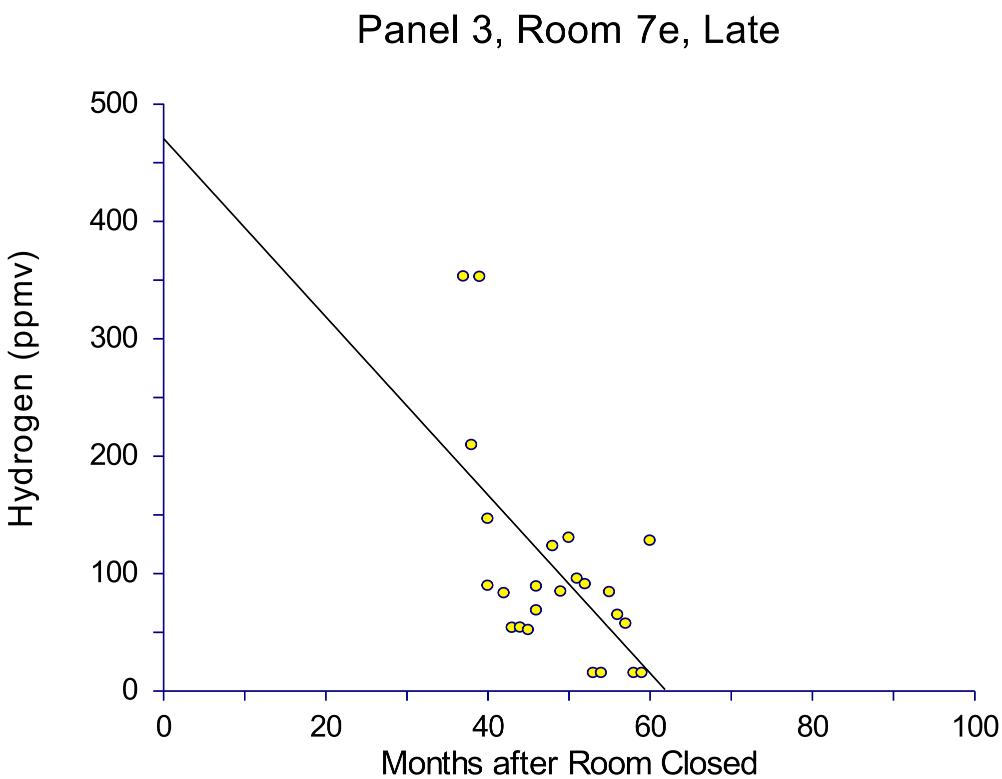


Figure 34: Regression of Later Hydrogen Data in Panel 3 Room 7e

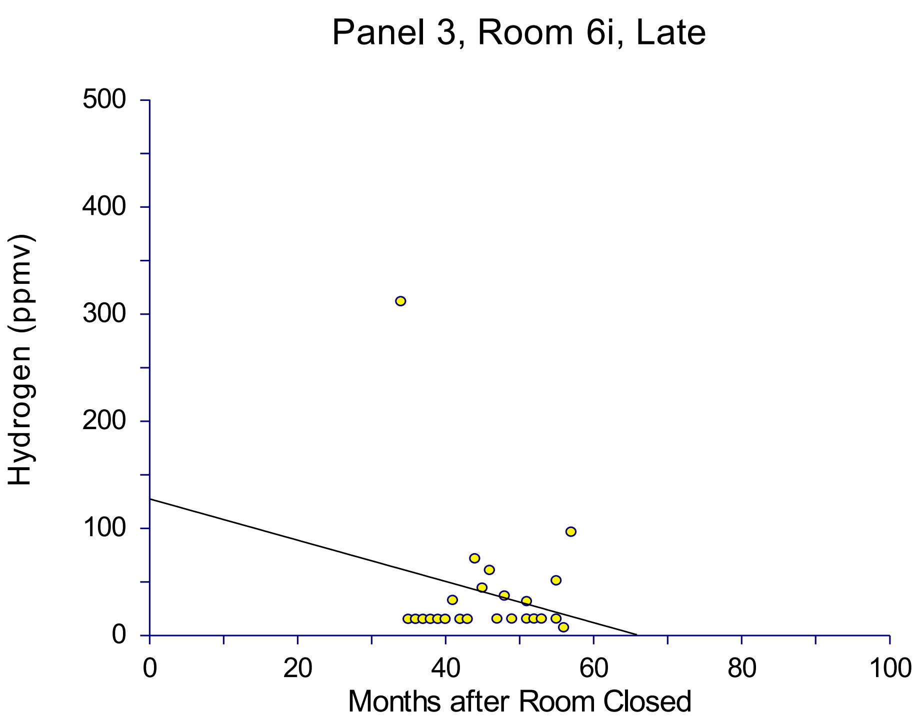


Figure 35: Regression of Later Hydrogen Data in Panel 3 Room 6i

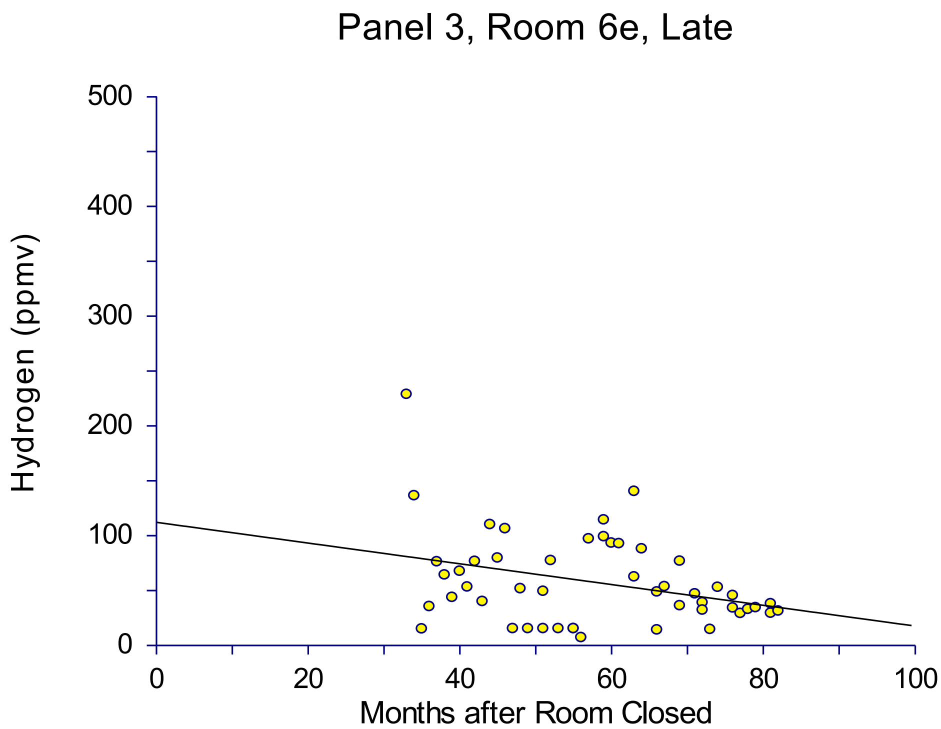


Figure 36: Regression of Later Hydrogen Data in Panel 3 Room 6e

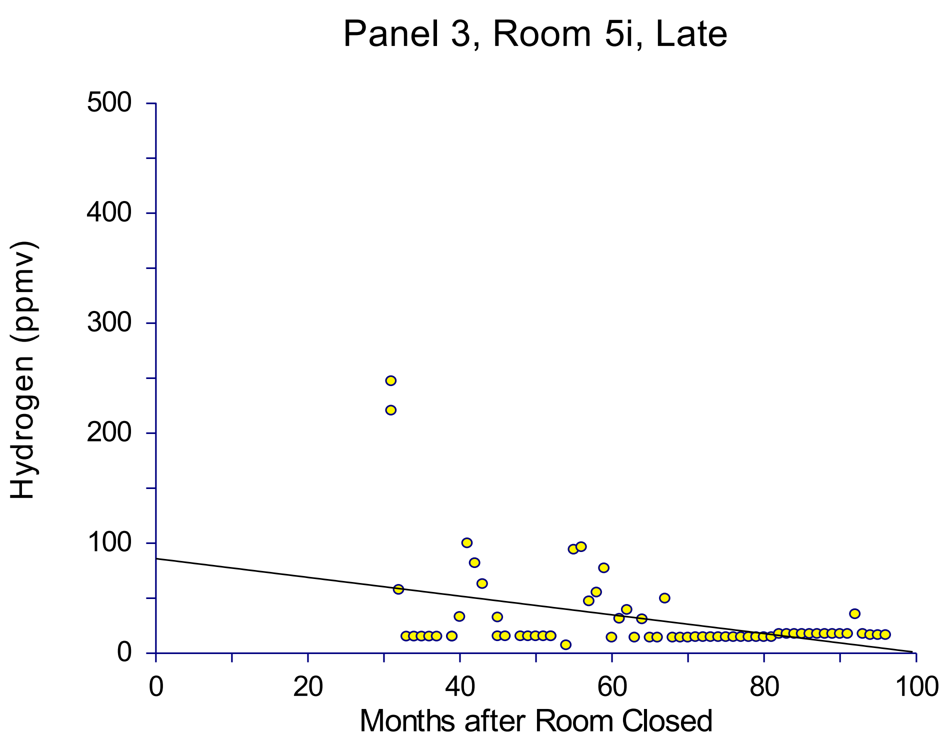


Figure 37: Regression of Later Hydrogen Data in Panel 3 Room 5i

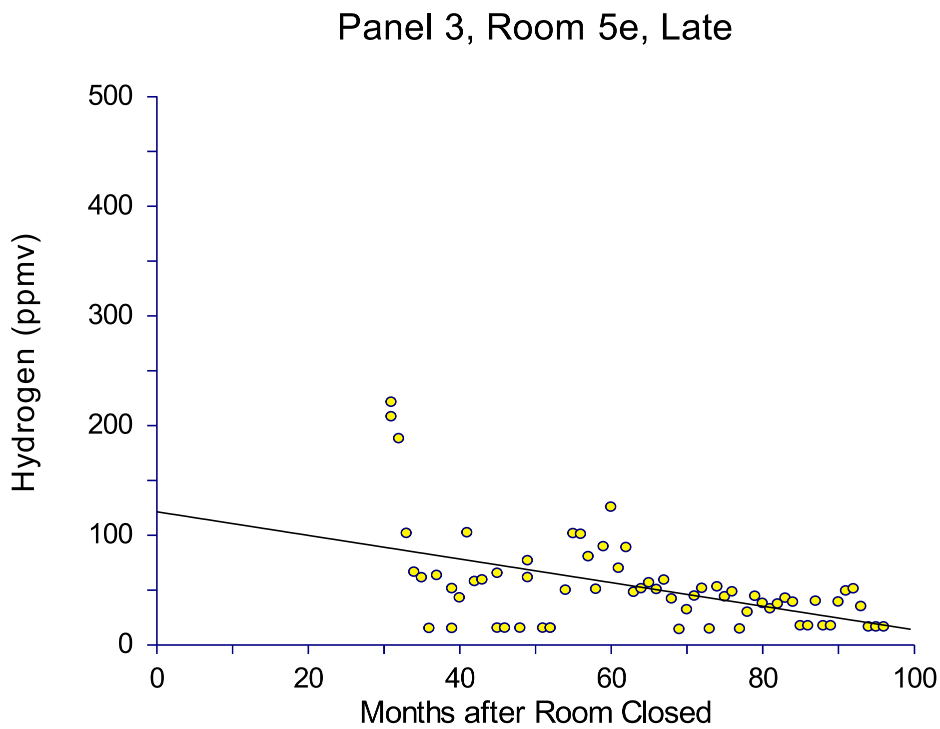


Figure 38: Regression of Later Hydrogen Data in Panel 3 Room 5e

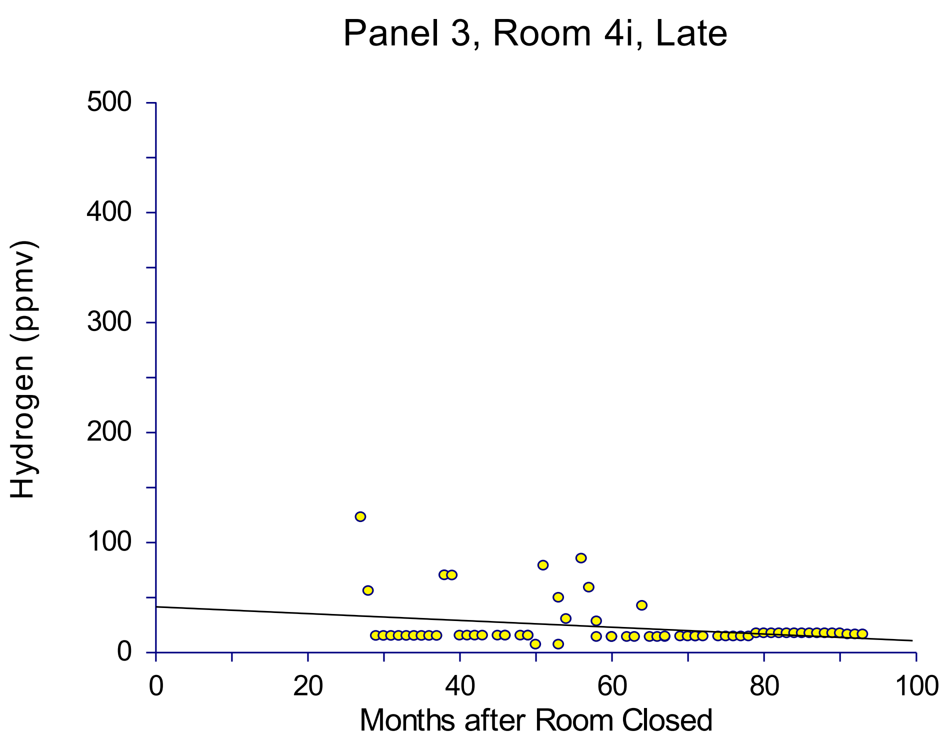


Figure 39: Regression of Later Hydrogen Data in Panel 3 Room 4i

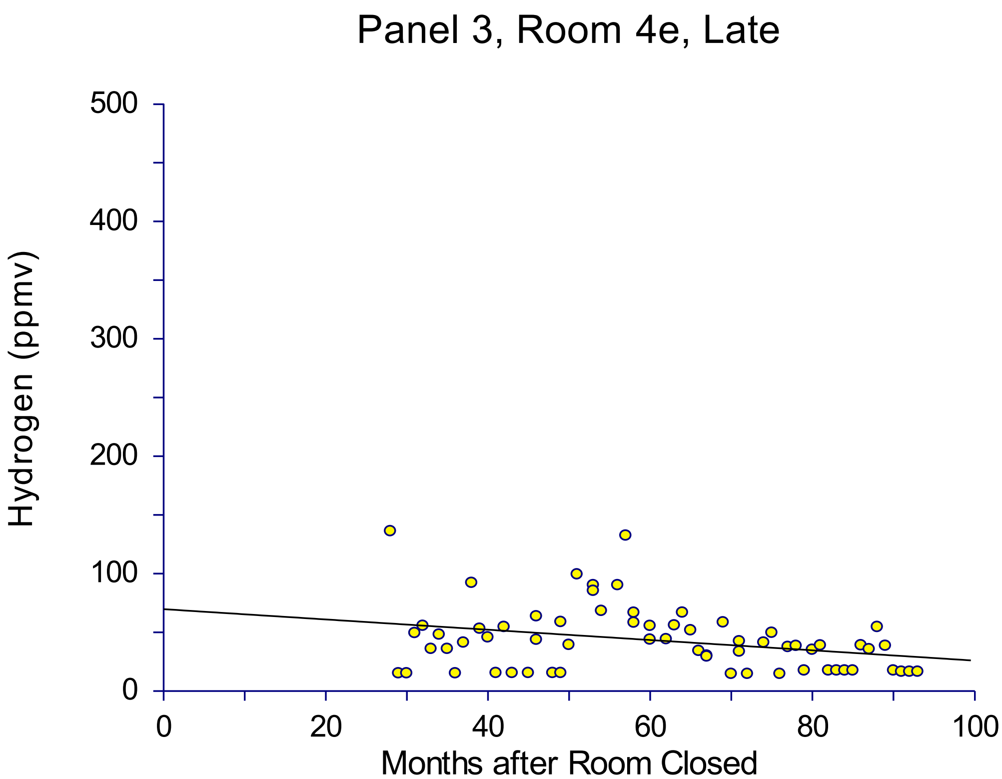


Figure 40: Regression of Later Hydrogen Data in Panel 3 Room 4e

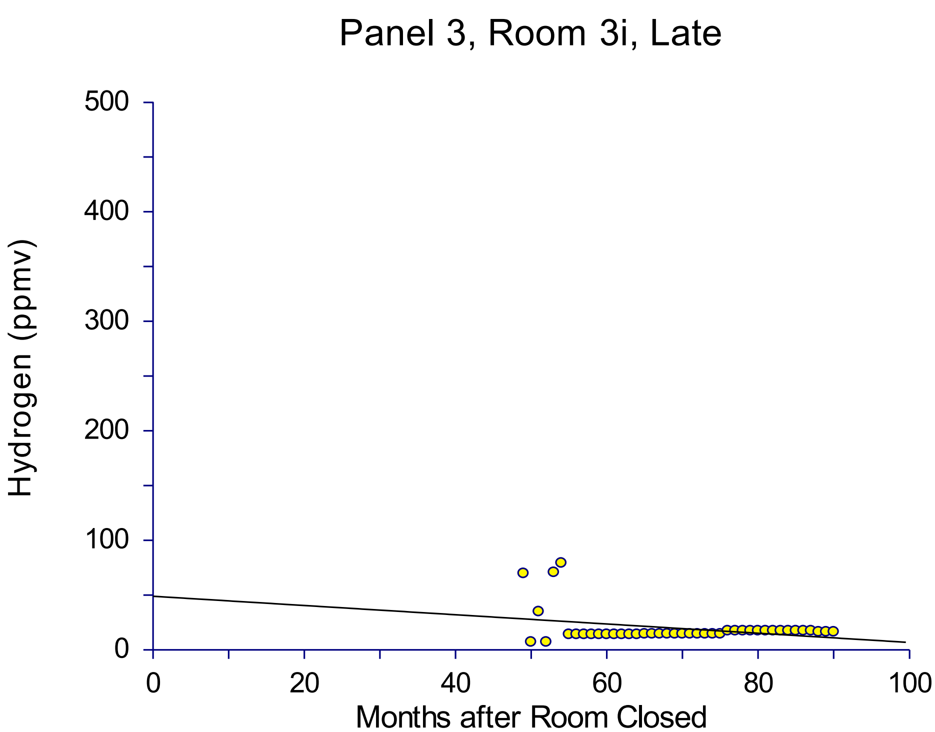


Figure 41: Regression of Later Hydrogen Data in Panel 3 Room 3i

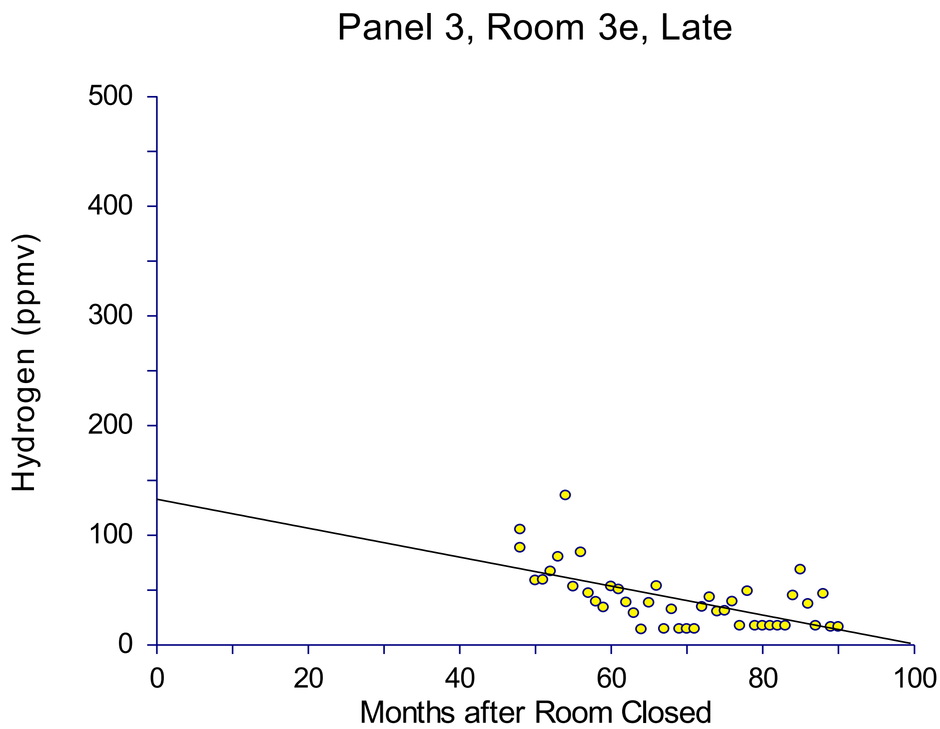


Figure 42: Regression of Later Hydrogen Data in Panel 3 Room 3e

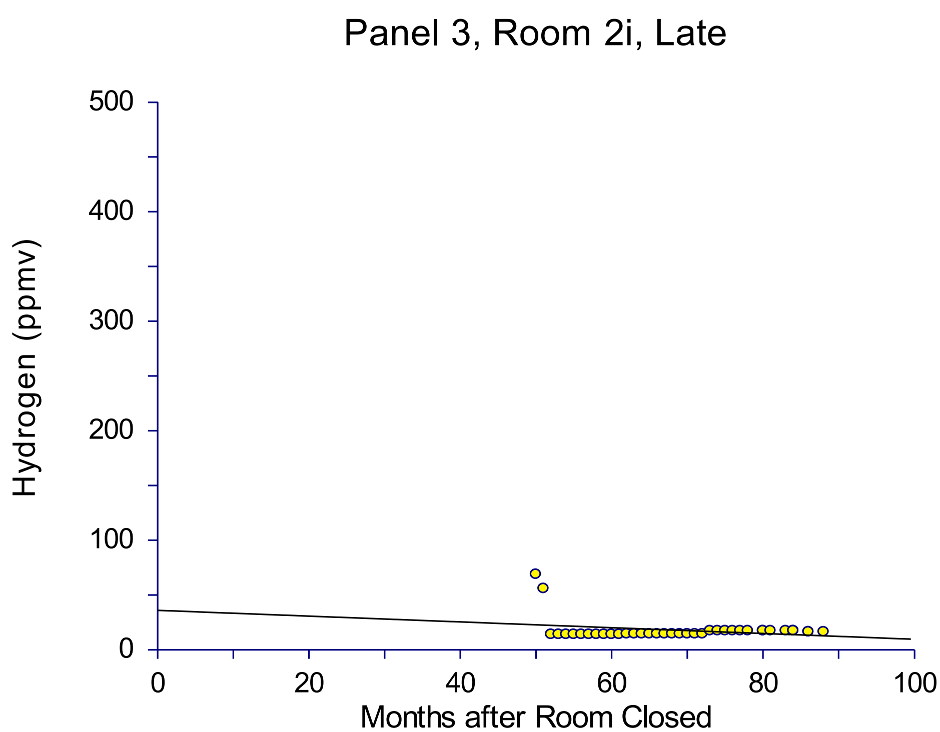


Figure 43: Regression of Later Hydrogen Data in Panel 3 Room 2i

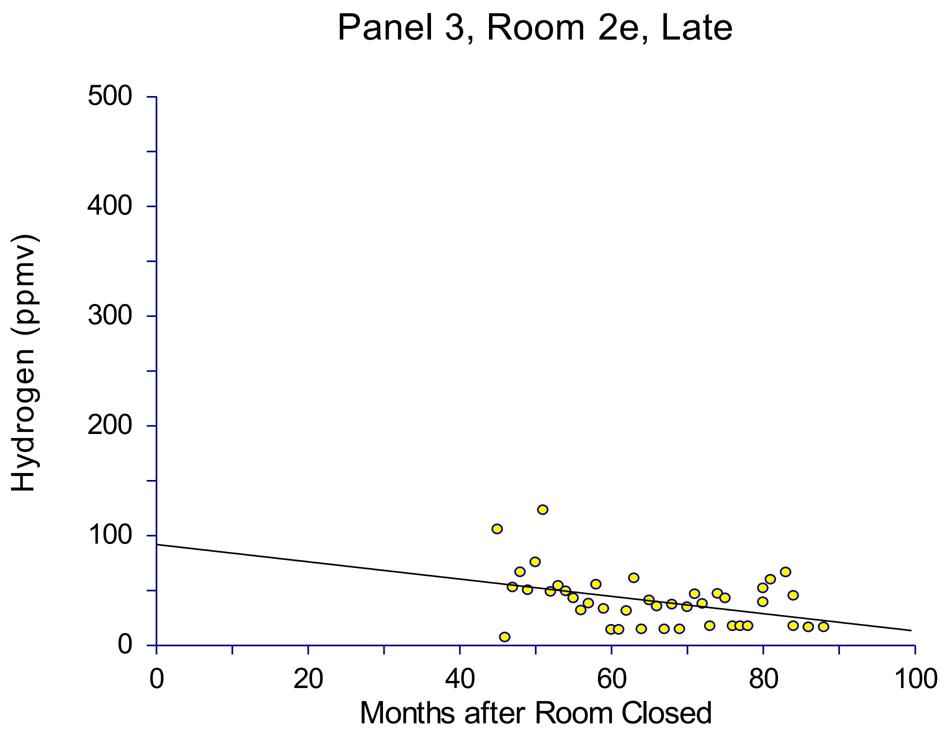


Figure 44: Regression of Later Hydrogen Data in Panel 3 Room 2e

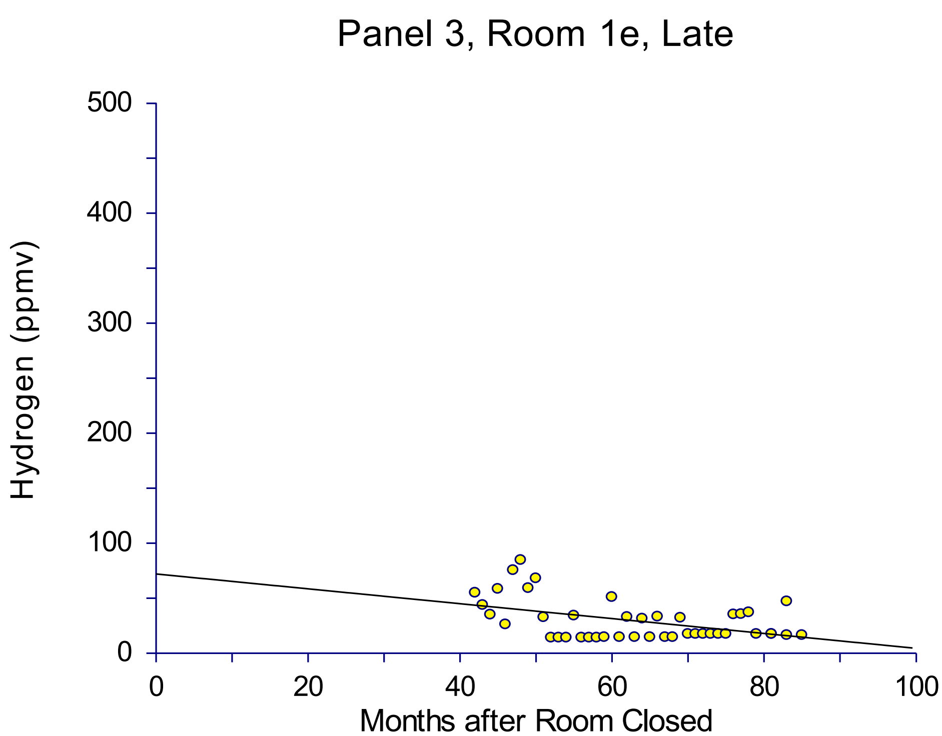


Figure 45: Regression of Later Hydrogen Data in Panel 3 Room 1e

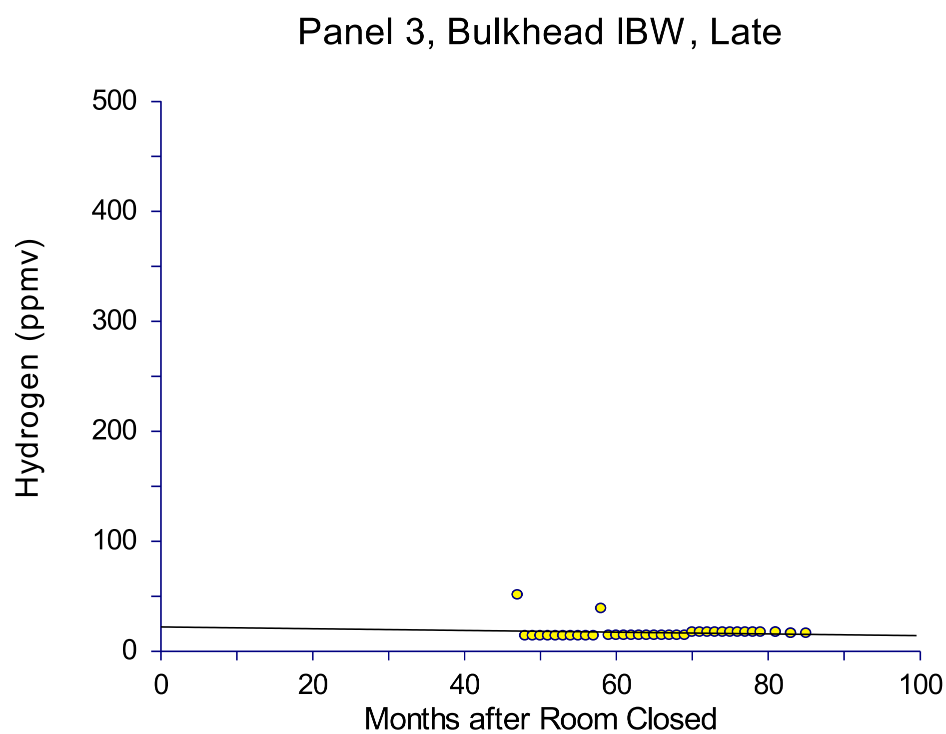


Figure 46: Regression of Later Hydrogen Data at Panel 3 Bulkhead IBW

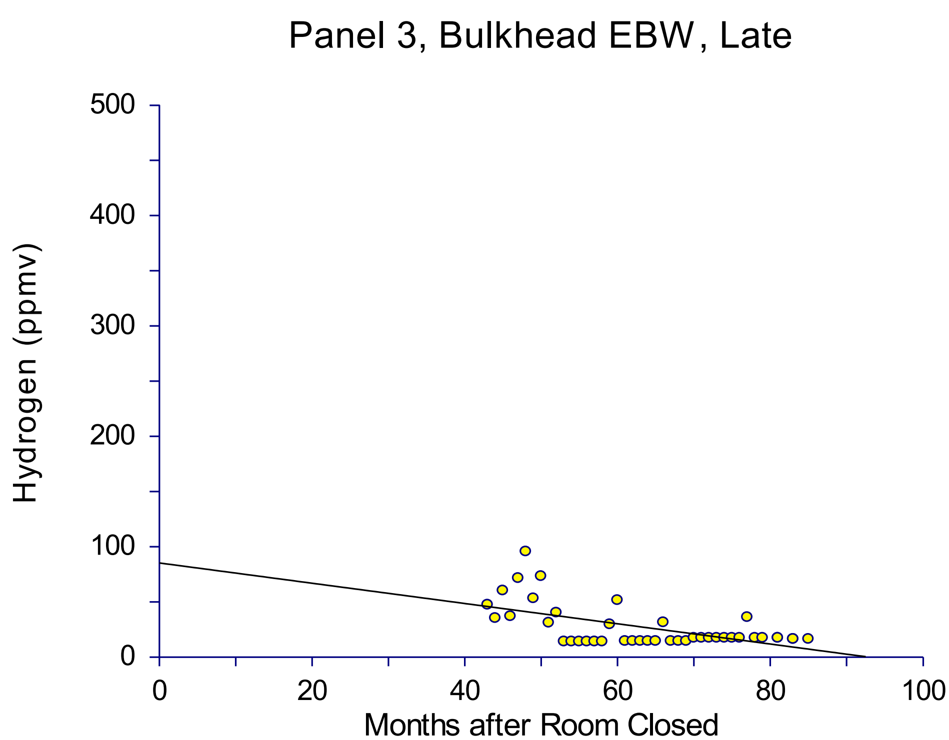


Figure 47: Regression of Later Hydrogen Data at Panel 3 Bulkhead EBW

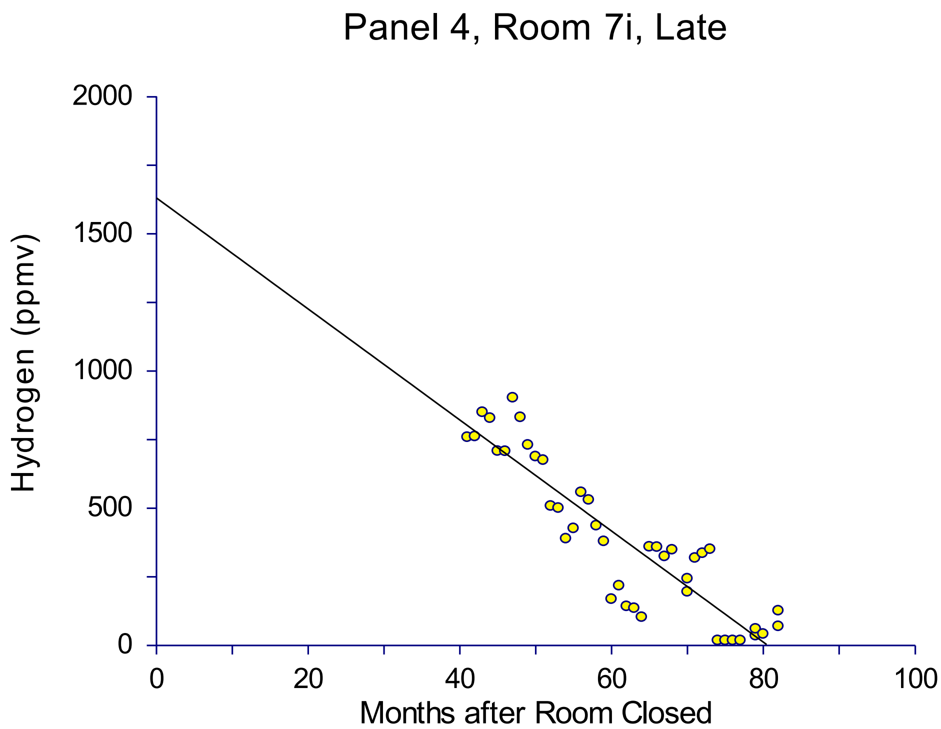


Figure 48: Regression of Later Hydrogen Data in Panel 4 Room 7i

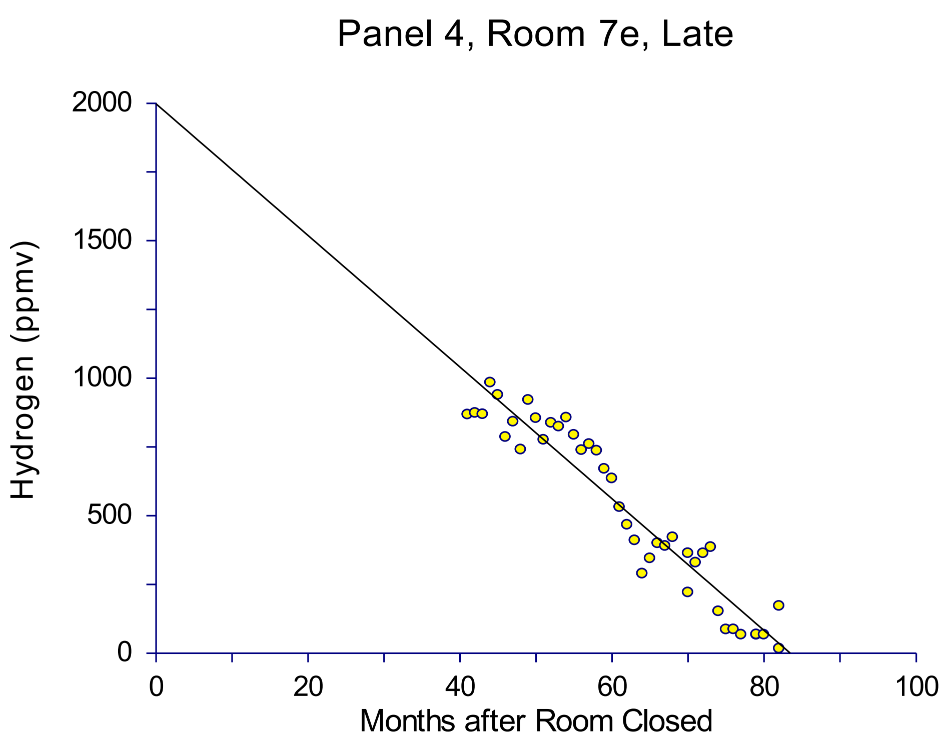


Figure 49: Regression of Later Hydrogen Data in Panel 4 Room 7e

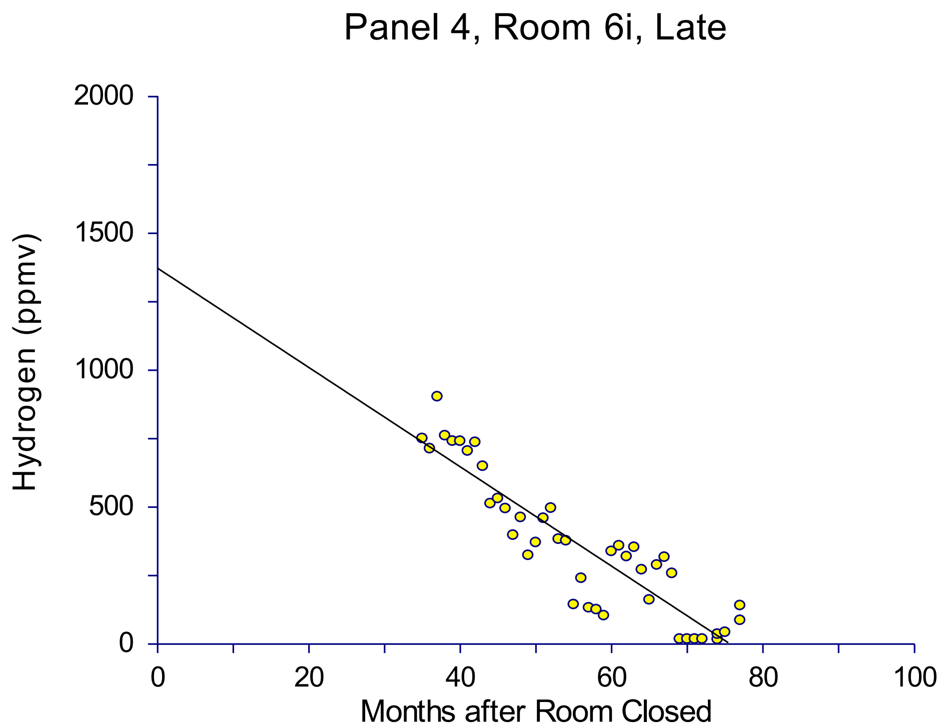


Figure 50: Regression of Later Hydrogen Data in Panel 4 Room 6i

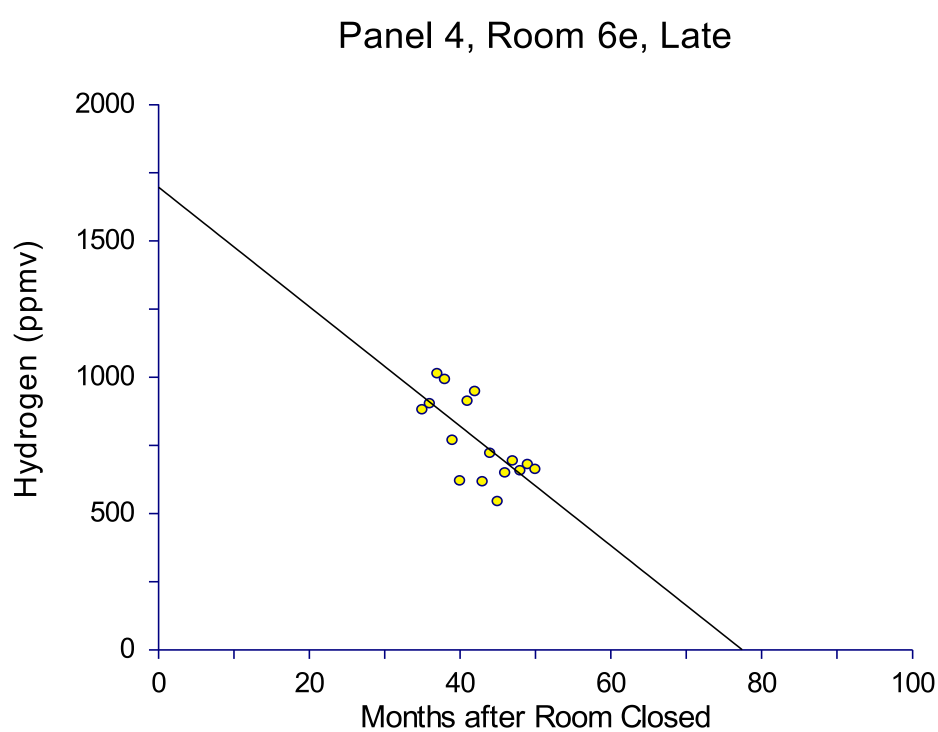


Figure 51: Regression of Later Hydrogen Data in Panel 4 Room 6e

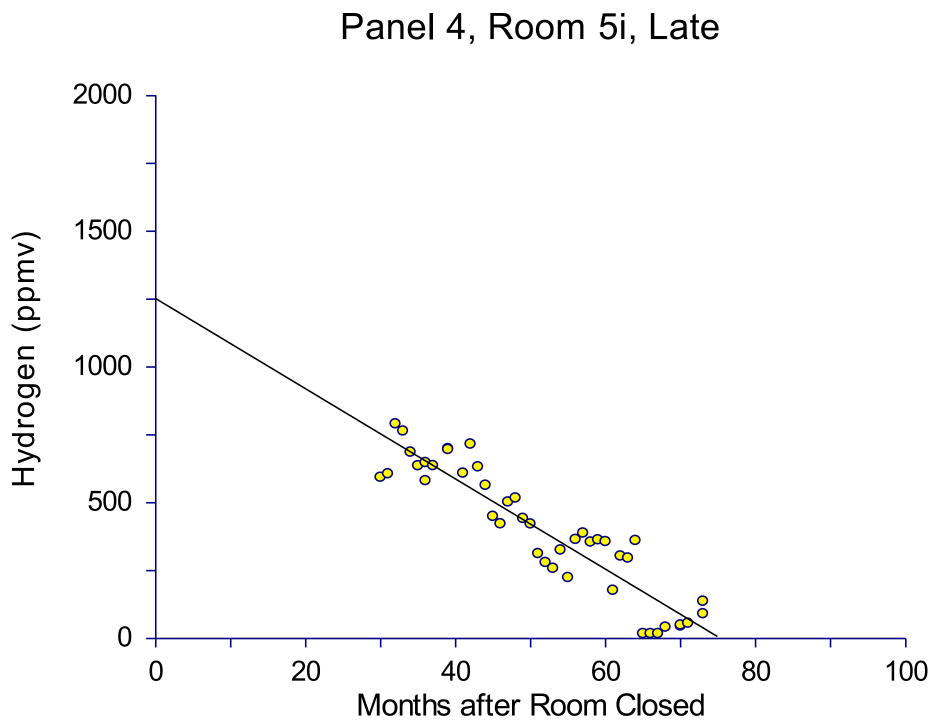


Figure 52: Regression of Later Hydrogen Data in Panel 4 Room 5i

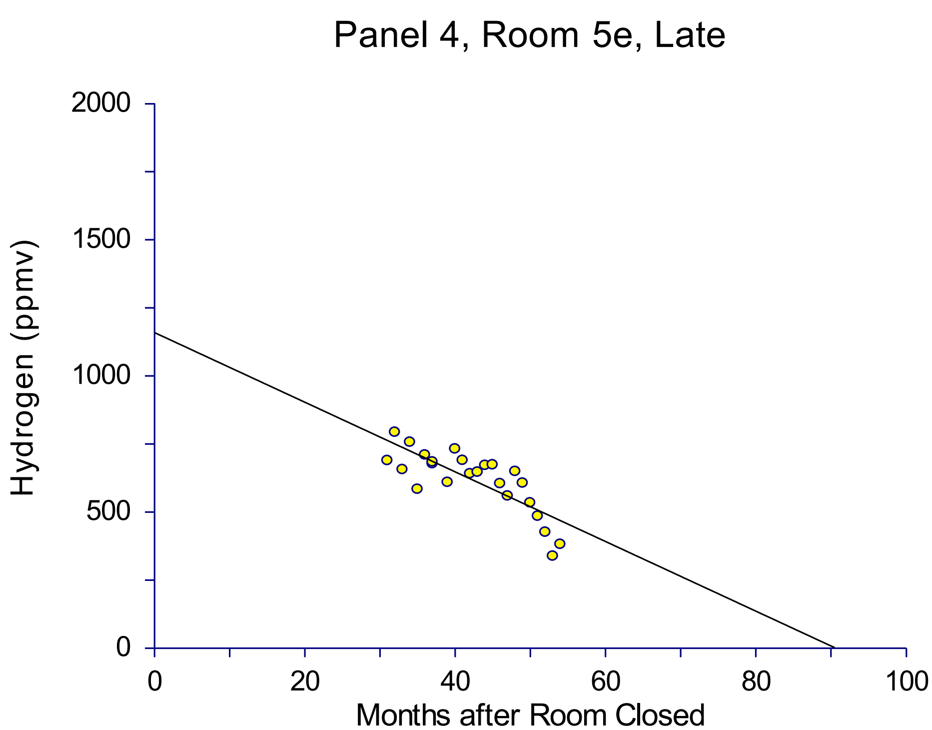


Figure 53: Regression of Later Hydrogen Data in Panel 4 Room 5e

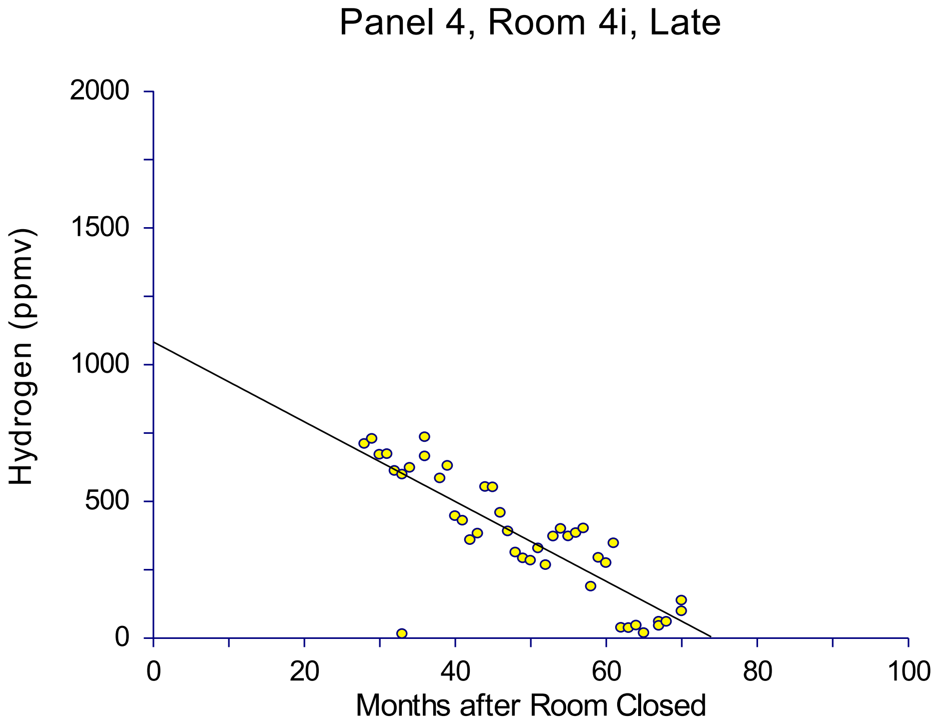


Figure 54: Regression of Later Hydrogen Data in Panel 4 Room 4i

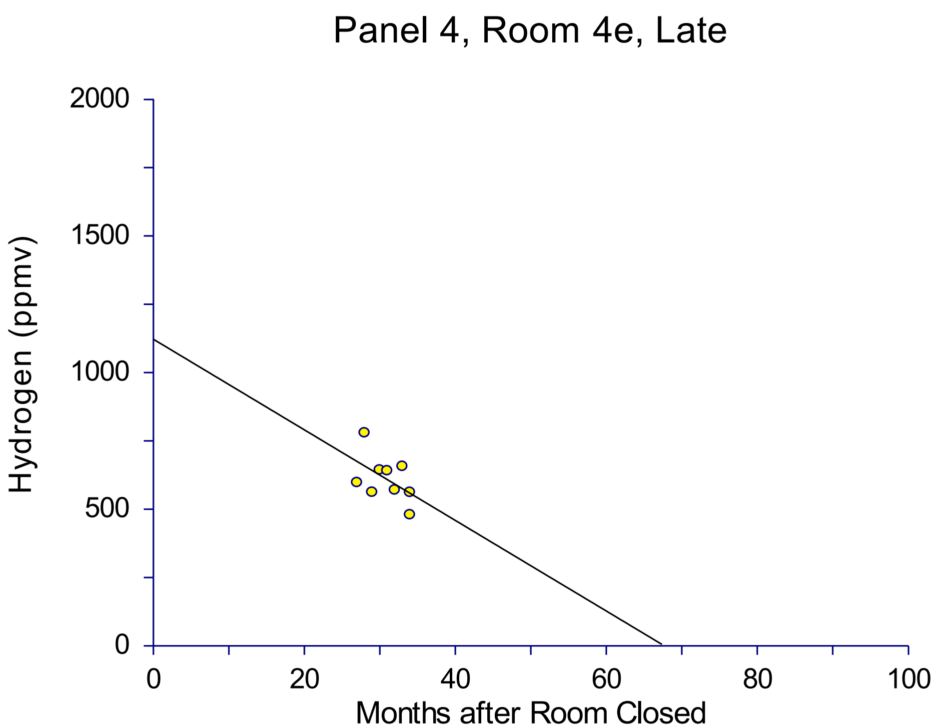


Figure 55: Regression of Later Hydrogen Data in Panel 4 Room 4e

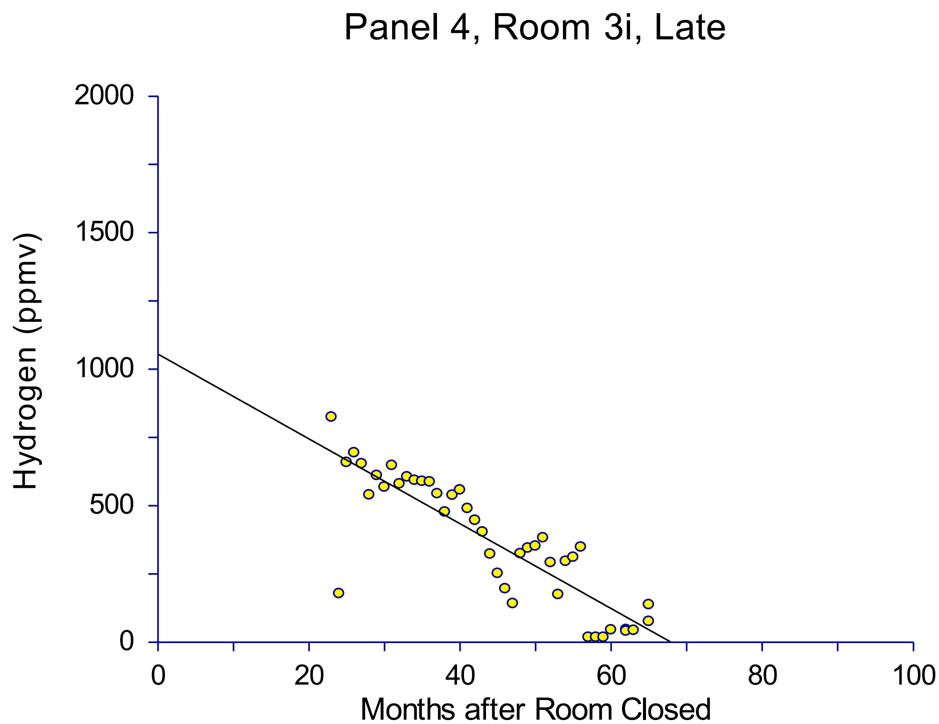


Figure 56: Regression of Later Hydrogen Data in Panel 4 Room 3i

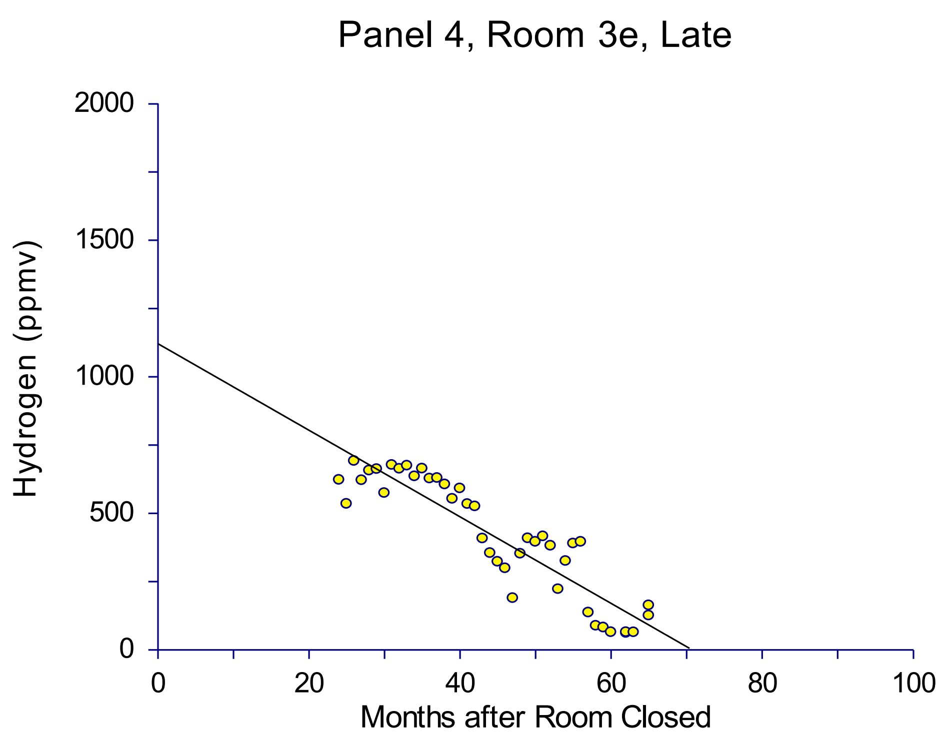


Figure 57: Regression of Later Hydrogen Data in Panel 4 Room 3e

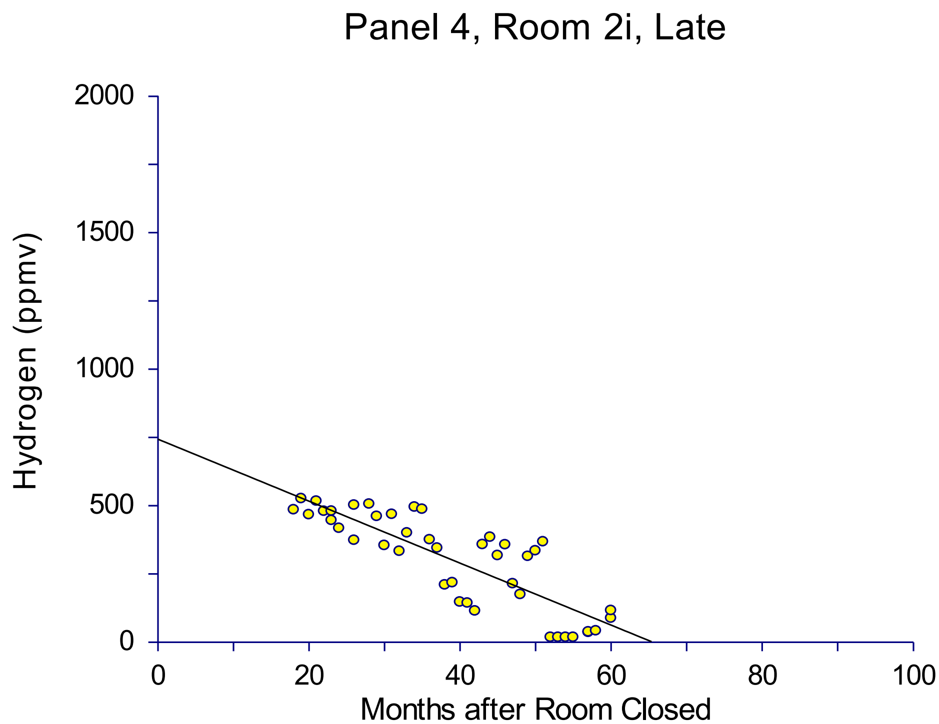


Figure 58: Regression of Later Hydrogen Data in Panel 4 Room 2i

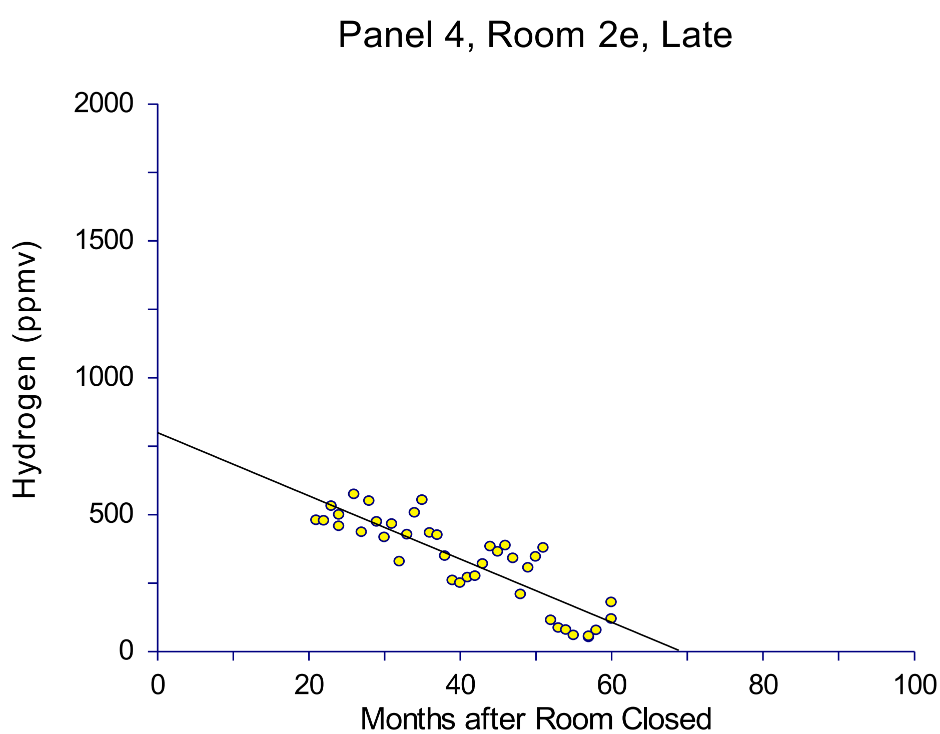


Figure 59: Regression of Later Hydrogen Data in Panel 4 Room 2e

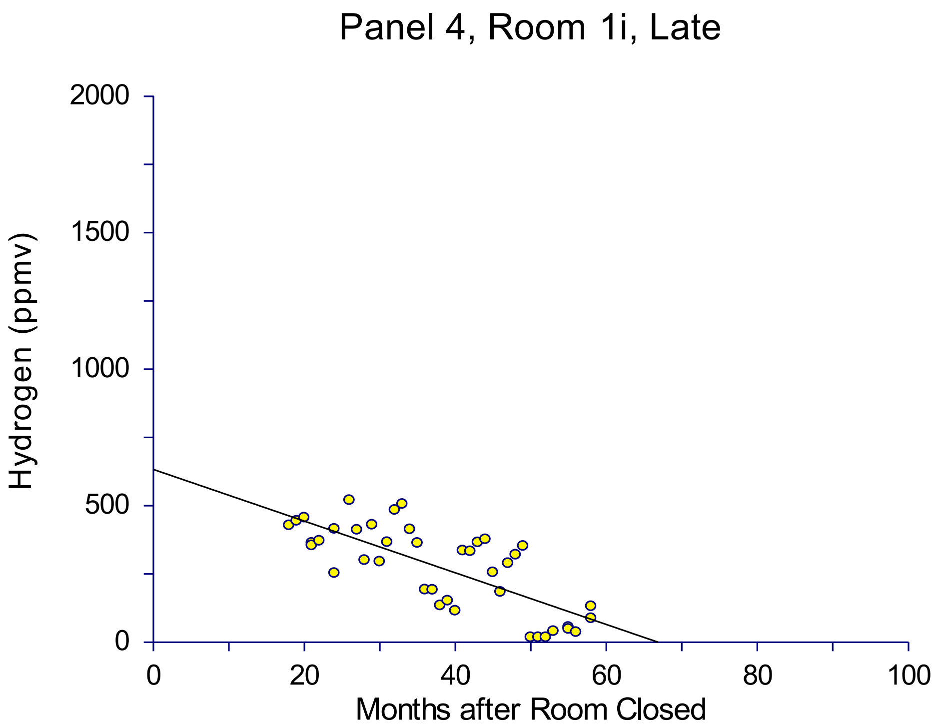


Figure 60: Regression of Later Hydrogen Data in Panel 4 Room 1i

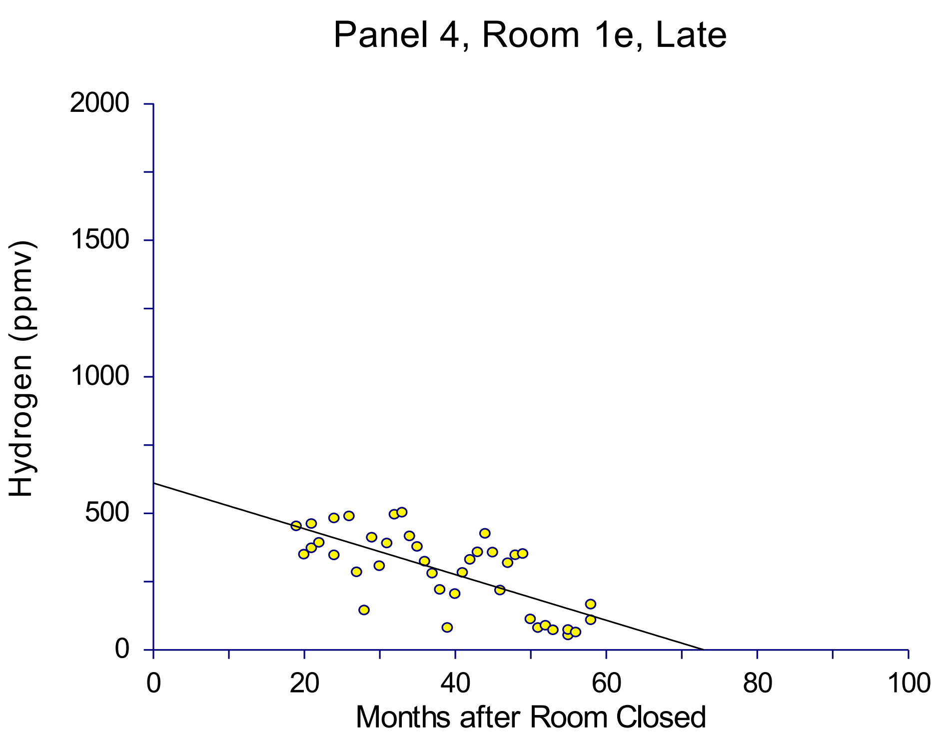


Figure 61: Regression of Later Hydrogen Data in Panel 4 Room 1e

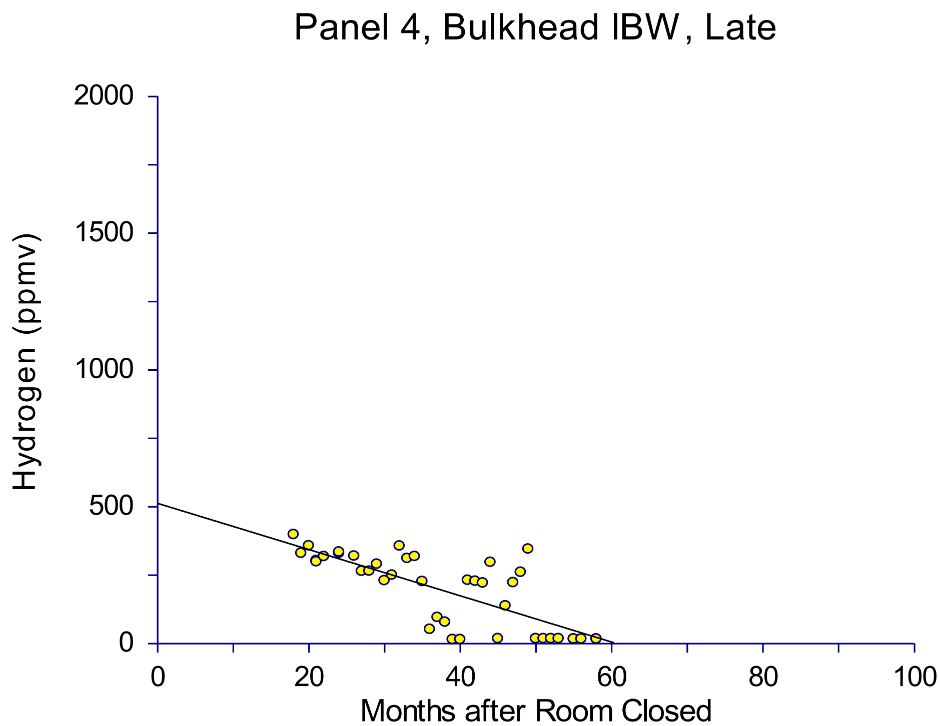


Figure 62: Regression of Later Hydrogen Data at Panel 4 Bulkhead IBW

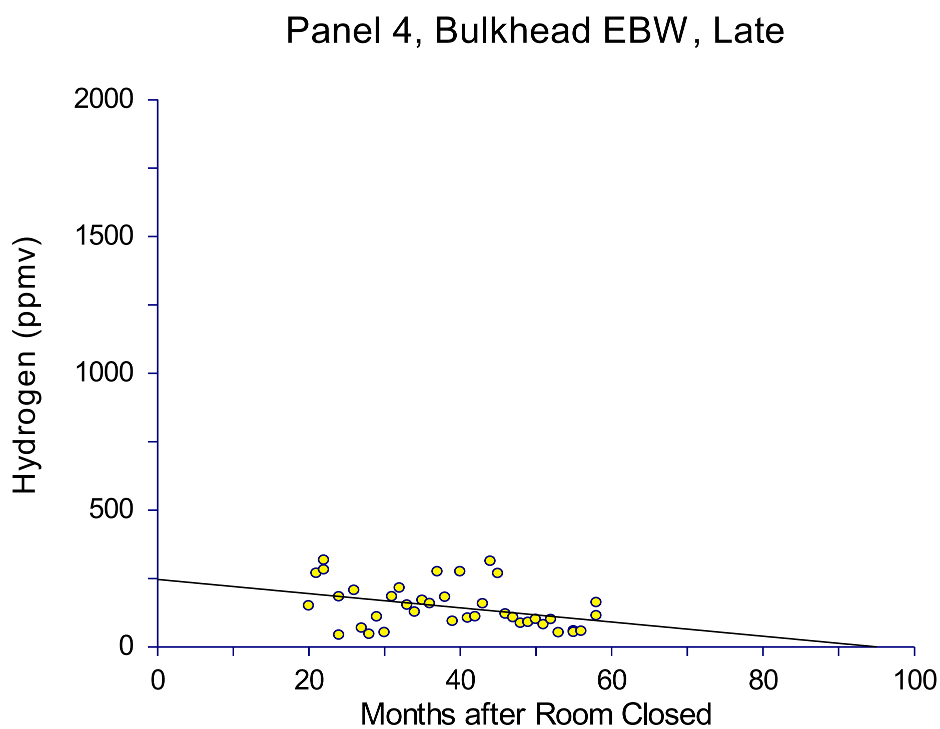


Figure 63: Regression of Later Hydrogen Data at Panel 4 Bulkhead EBW

VII. Summary

The air monitoring data in Panels 3 and 4 indicate methane concentrations are below the MDL, which is three orders of magnitude below the action level.

Hydrogen concentrations in Panels 3 and 4 have remained substantially below the action level of 4,000 ppmv during the entire monitoring program. The maximum hydrogen concentration observed (1,013 ppmv) slightly exceeded 25 percent of the lower action level, indicating no challenge to either the action level or LEL of 4 percent (40,000 ppmv). Conservative regression models indicate that hydrogen levels would not rise to the LEL in Panels 3 or 4 during the operational period of the WIPP (Table 3). Best estimates indicate hydrogen is actually in decline at all locations (Table 5).

VIII. References

Devarakonda, 2006. Letter from M. Devarakonda to D. Mercer: *Estimation of Hydrogen Generation Rates from Radiolysis in WIPP Panels*, Washington TRU Solutions LLC, July 26, 2006.

EPA, 1999. *Compendium Method TO-15: Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry*, EPA 625/R-96/010b. Center for Environmental Research Information, Office of Research and Development, Cincinnati, OH, January 1999.

Golder Associates, 2006. Letter from Golder Associates Inc. to Rick Chavez: *Early Time Generation of Methane and Hydrogen in Filled Panels at the WIPP*, November 30, 2006.

Wang and Brush, 1996. Letter from Yifeng Wang and Larry Brush to Martin S. Tierney: *Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance*, Sandia National Laboratories, January 26, 1996.

Waste Isolation Pilot Plant Hazardous Waste Facility Permit, NM 4890139088-TSDF issued by the New Mexico Environment Department.

Appendix A

Time Series Plots for Hydrogen Concentrations in Panel 3

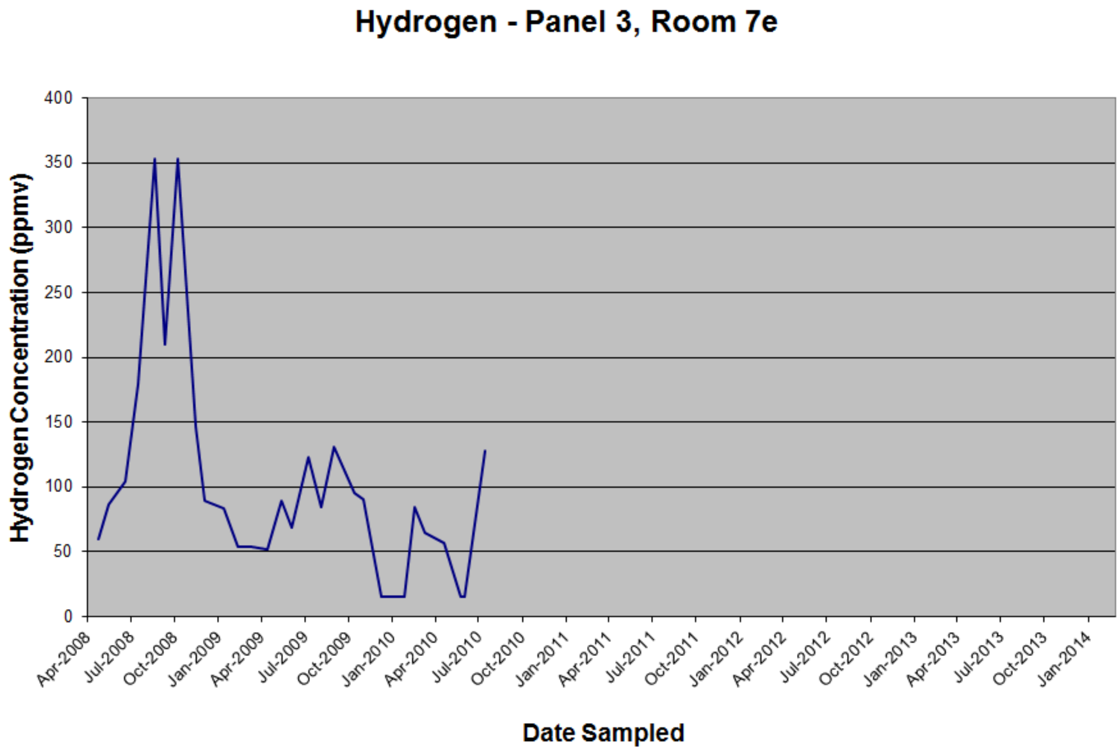


Figure A1: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 7e

The *Time Series Plot of Hydrogen Concentrations in Panel 3, Room 7i* has been omitted here due to a lack of data. The plot does appear in the main body of the report as Figure 11 on page 17. Only two samples are represented, each of which has a statistical evaluation concentration of 10.79 ppmv. These data appear in Appendix E.

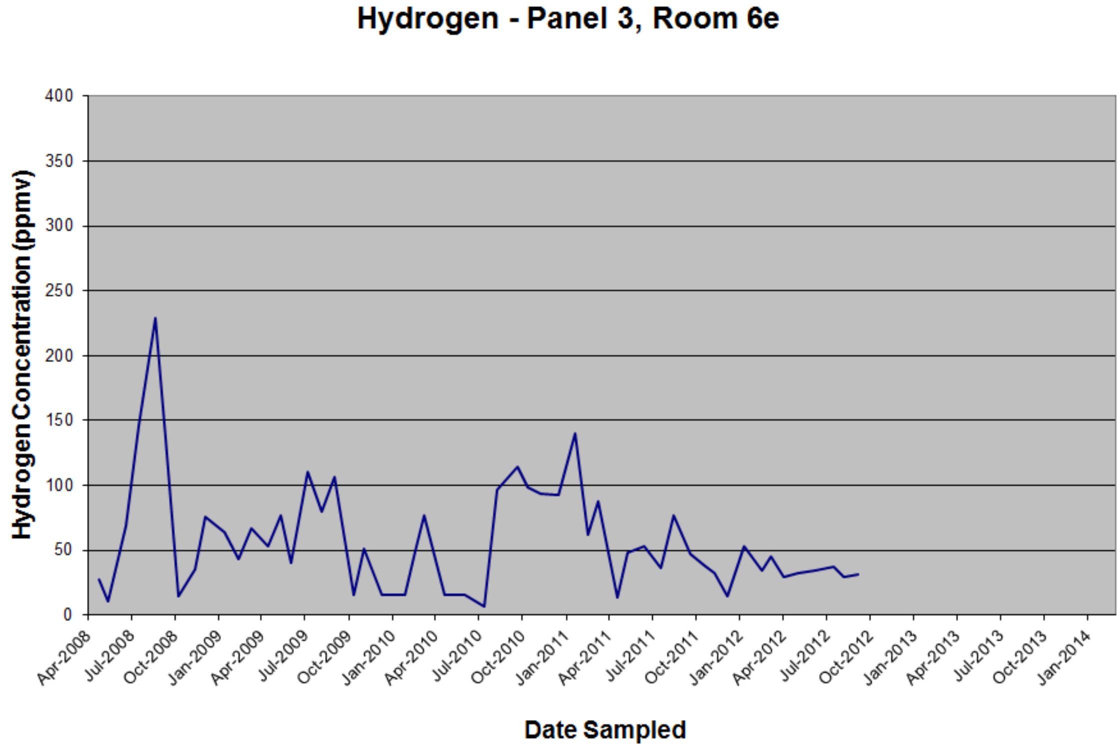


Figure A2: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 6e

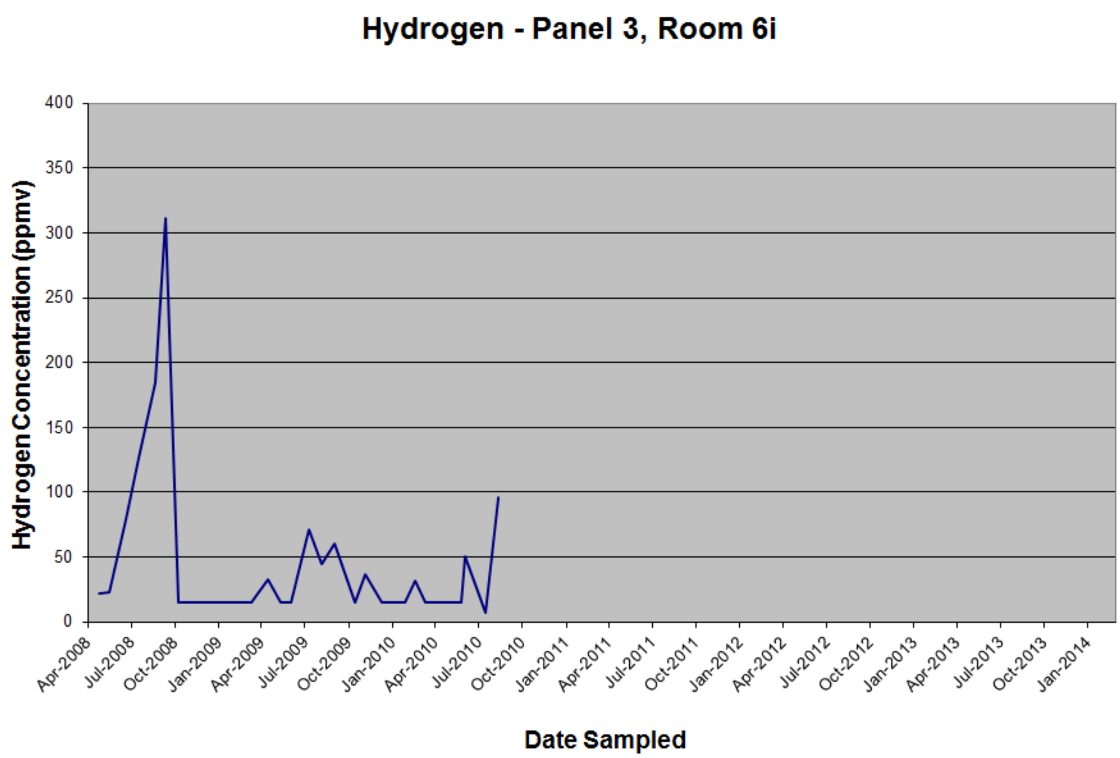


Figure A3: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 6i

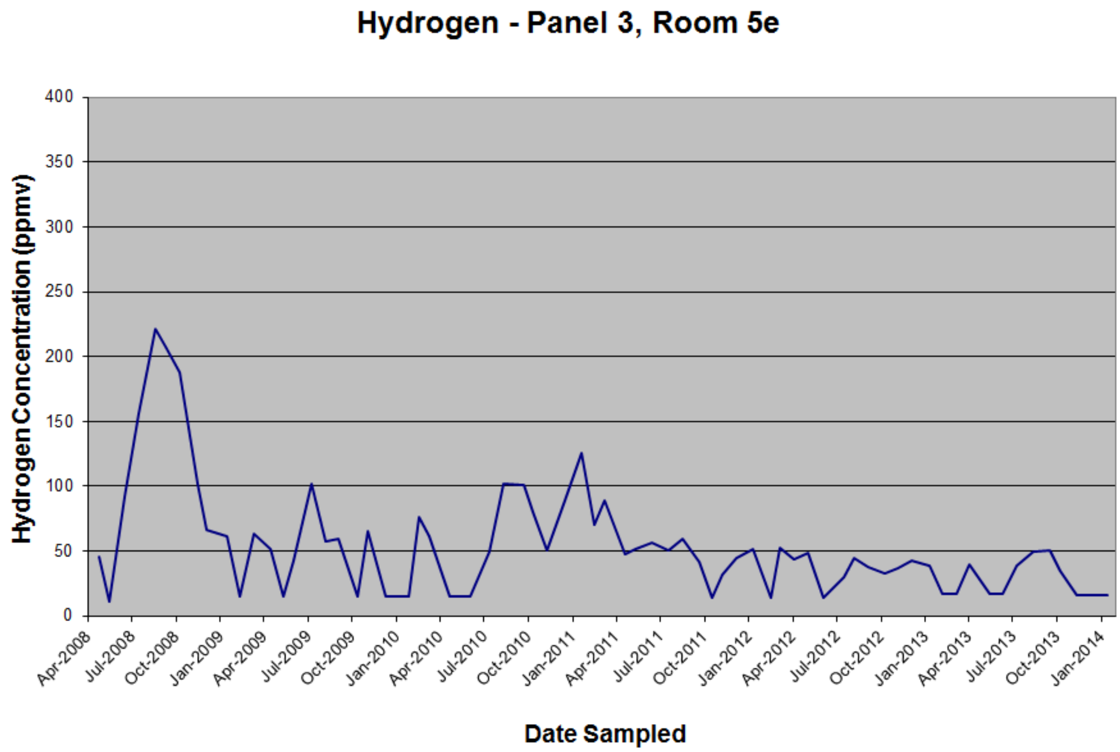


Figure A4: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 5e

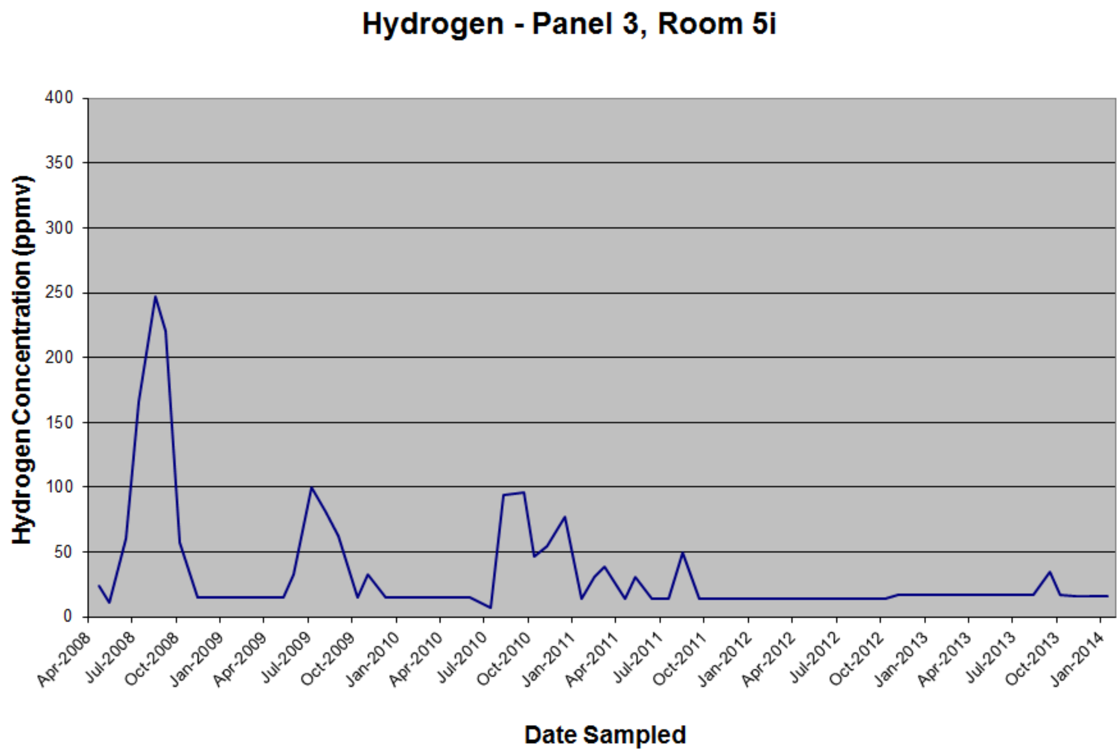


Figure A5: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 5i

Hydrogen - Panel 3, Room 4e

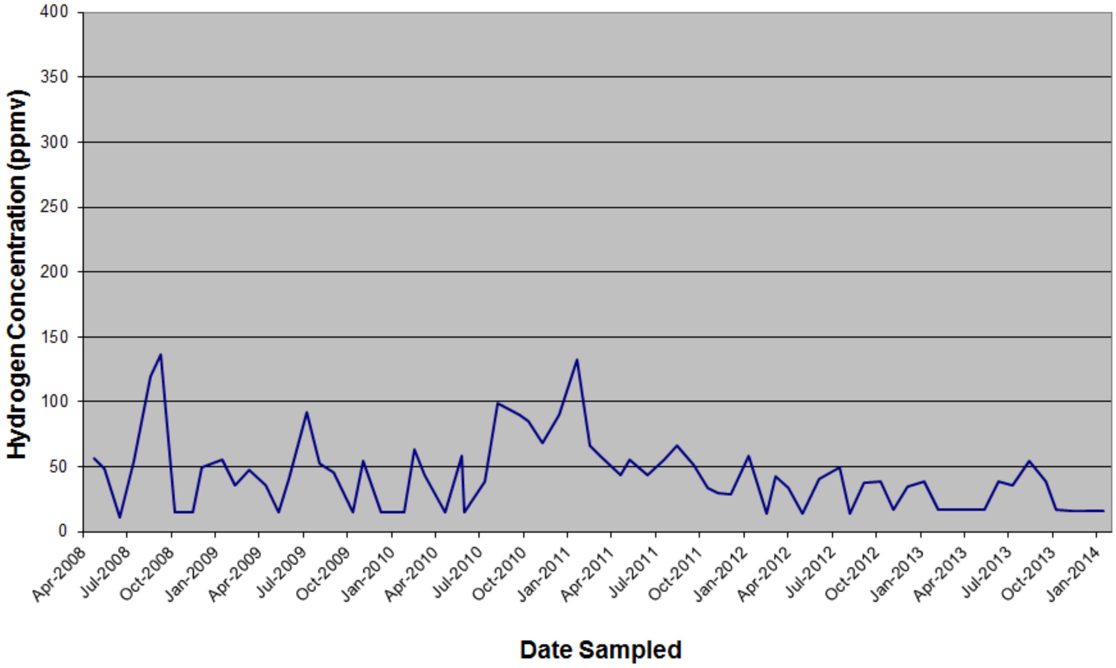


Figure A6: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 4e

Hydrogen - Panel 3, Room 4i

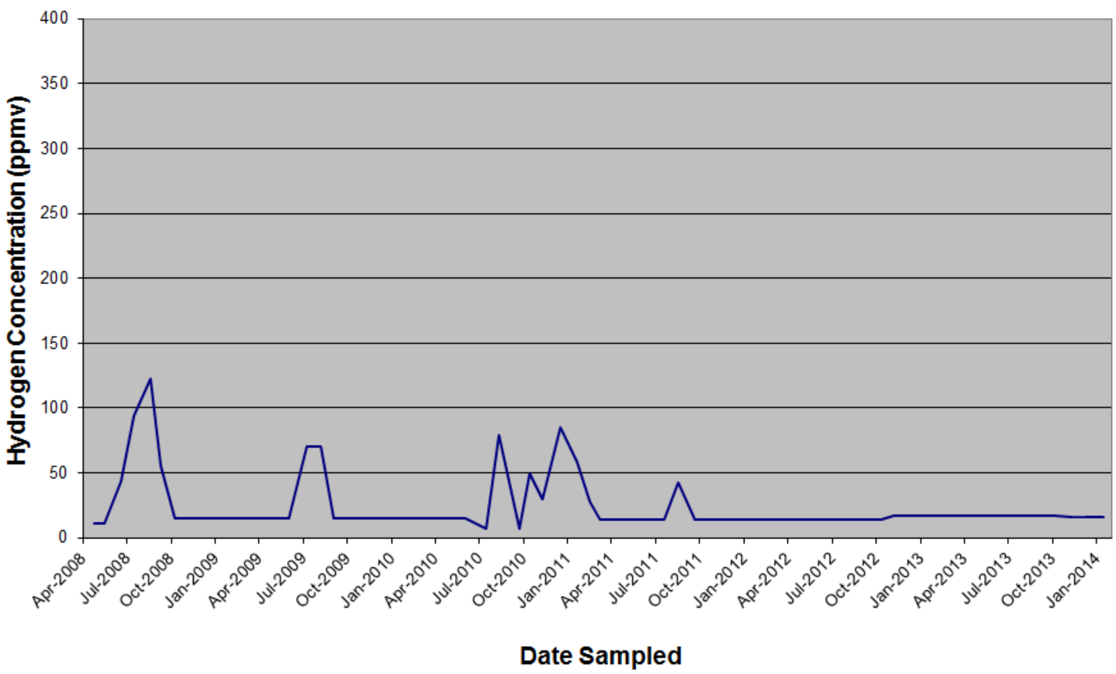


Figure A7: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 4i

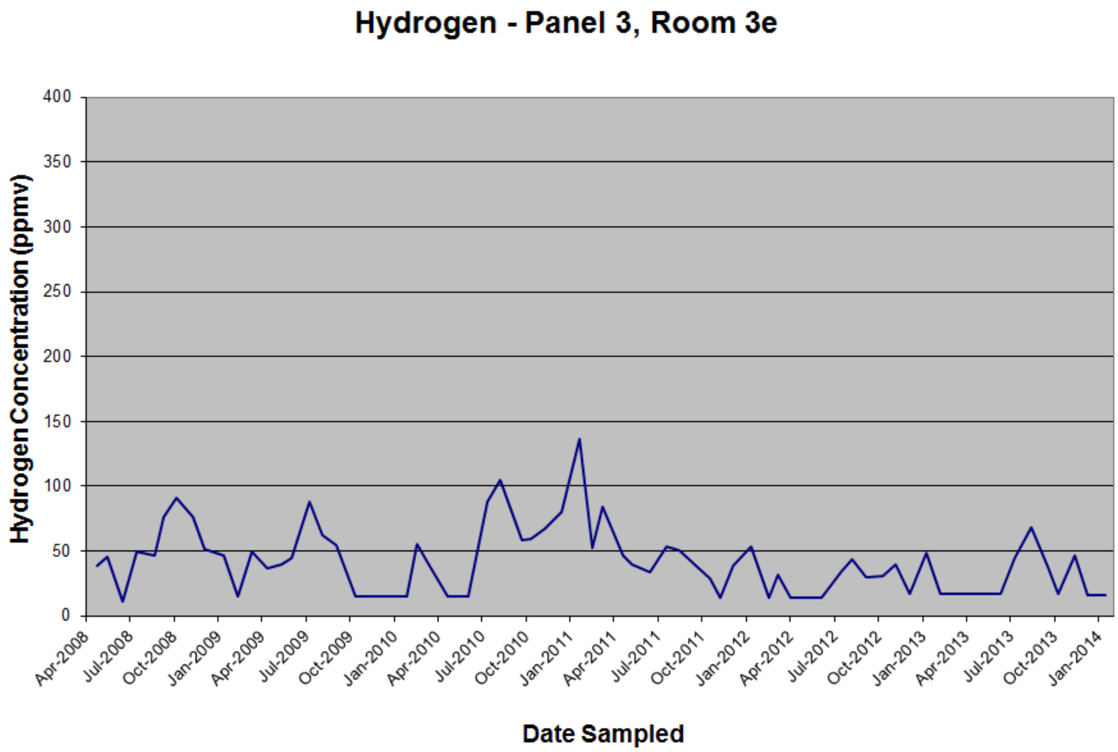


Figure A8: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 3e

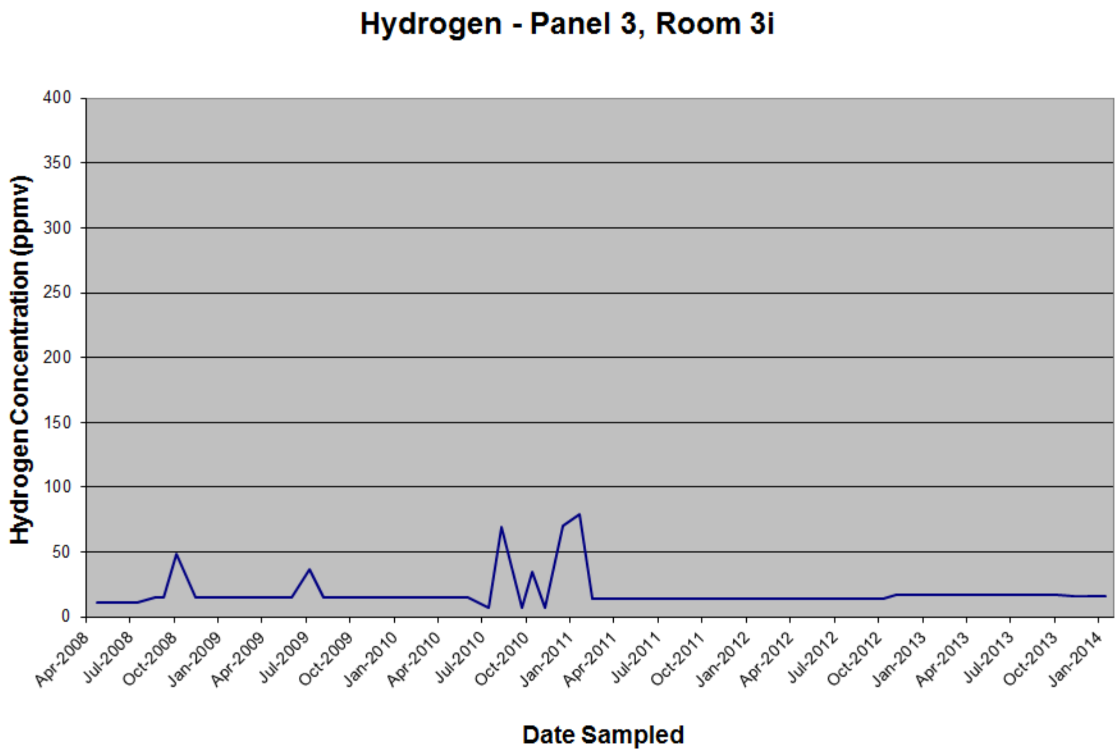


Figure A9: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 3i

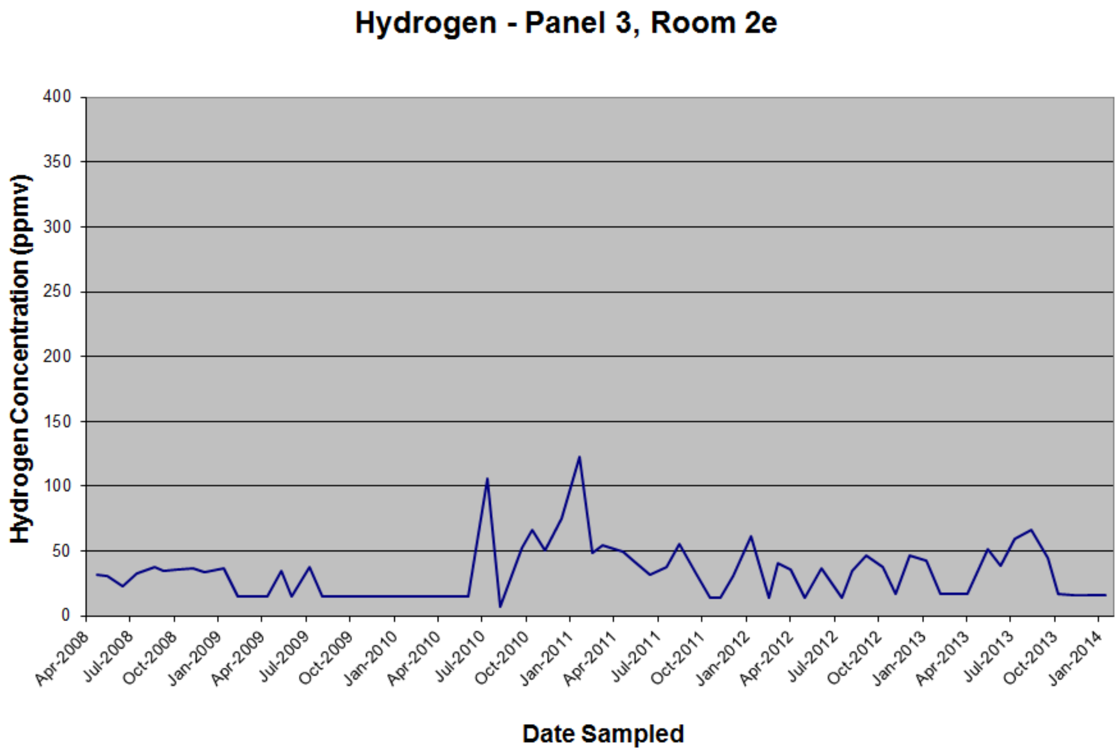


Figure A10: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 2e

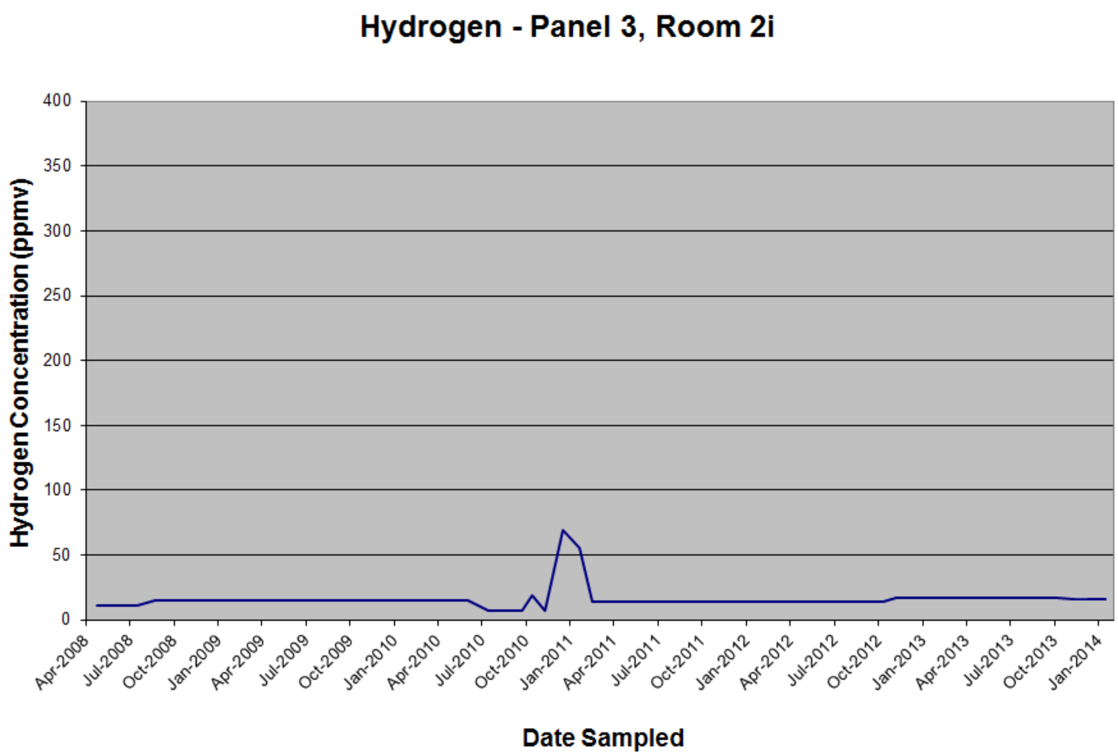


Figure A11: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 2i

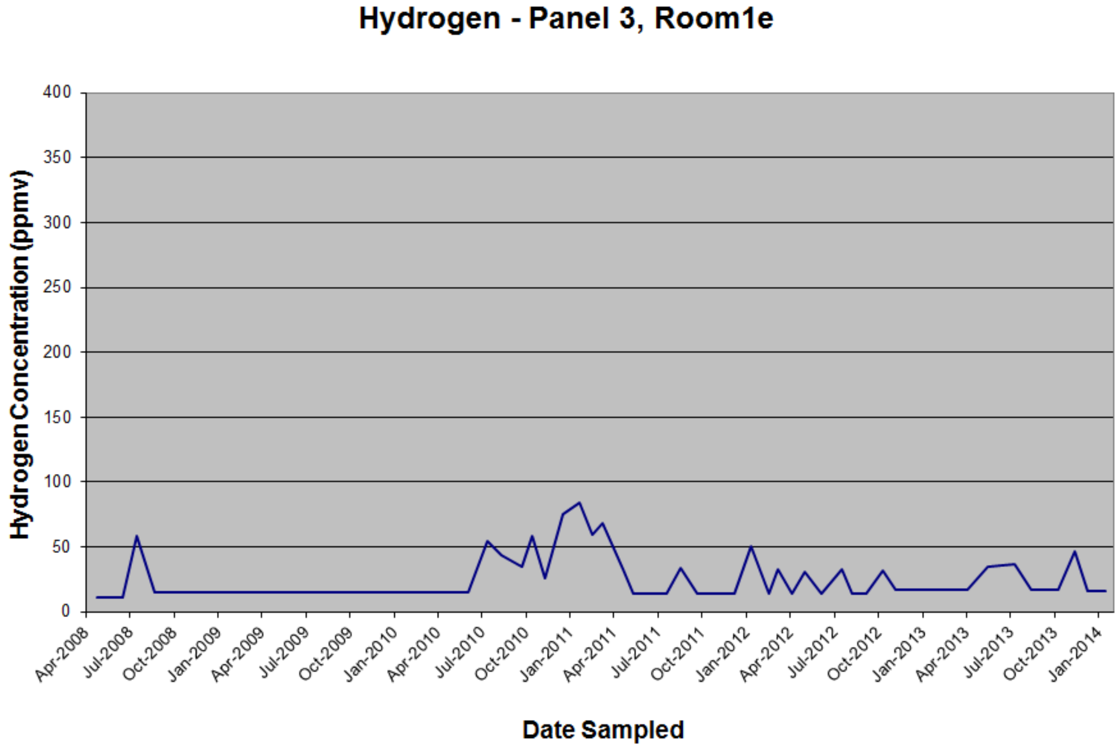


Figure A12: Time Series Plot of Hydrogen Concentrations in Panel 3, Room 1e

The *Time Series Plot of Hydrogen Concentrations in Panel 3, Room 1i* has been omitted due to a lack of data. Only three samples exist at this location, each of which has a statistical evaluation concentration of 10.79 ppmv. These data appear in Appendix E.

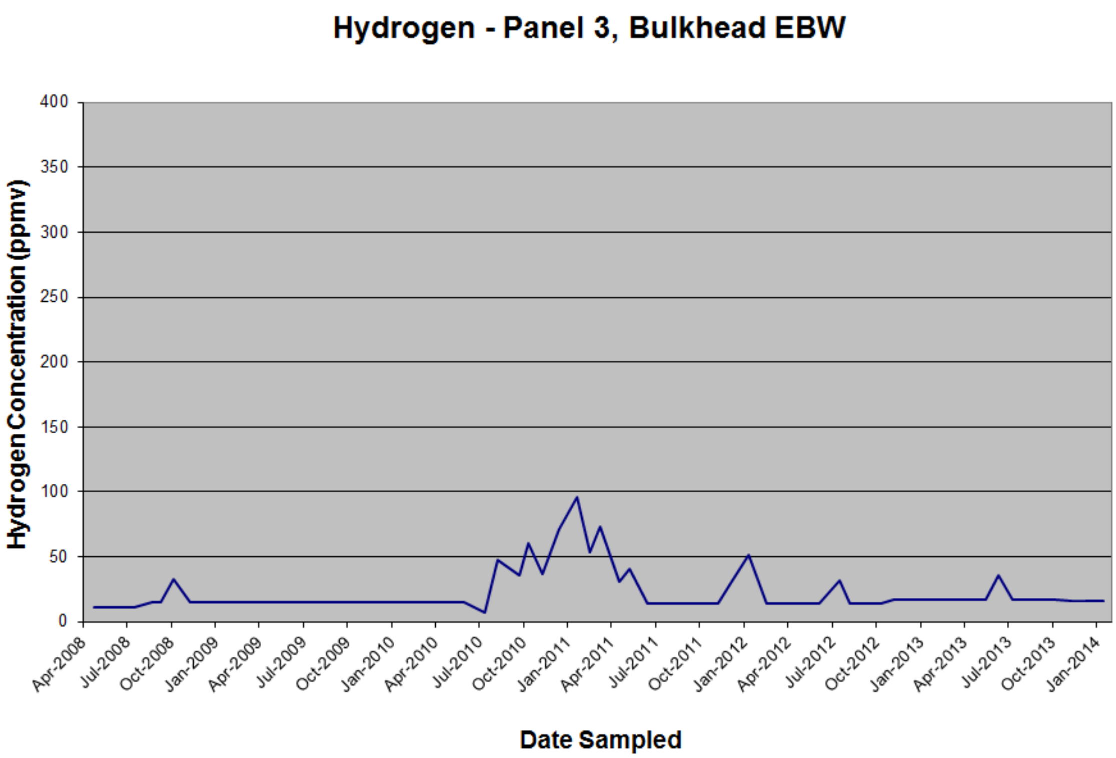


Figure A13: Time Series Plot of Hydrogen Concentrations in Panel 3, Bulkhead EBW

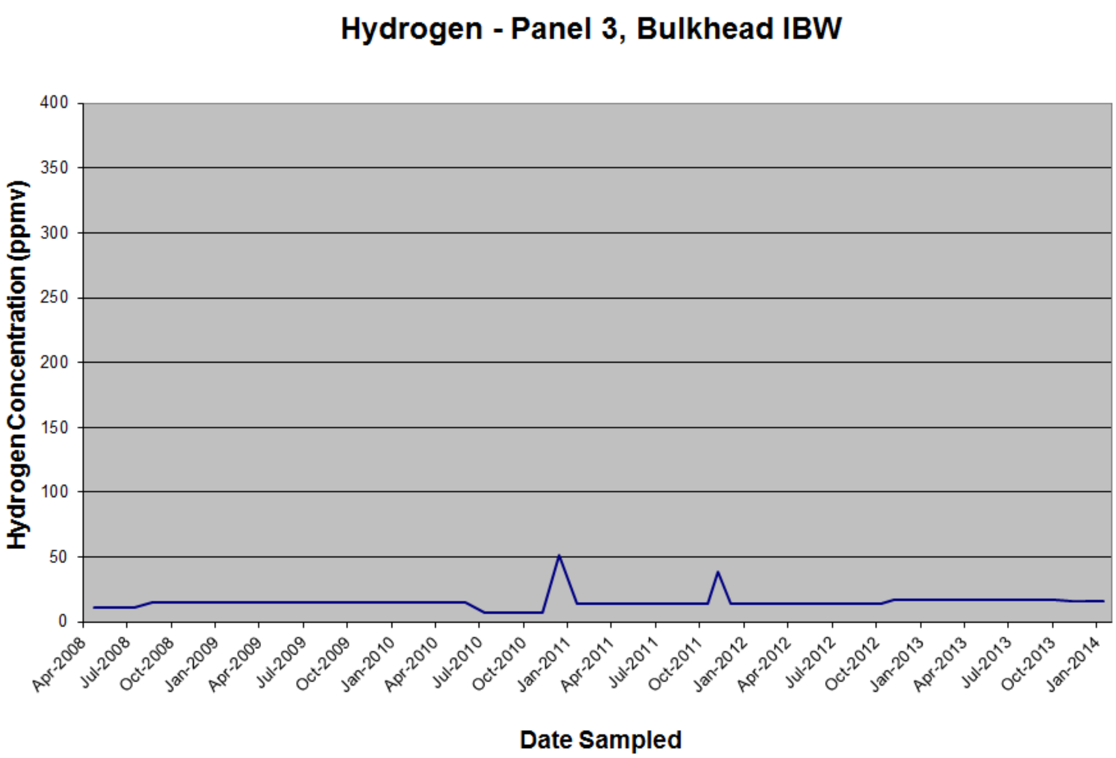


Figure A14: Time Series Plot of Hydrogen Concentrations in Panel 3, Bulkhead IBW

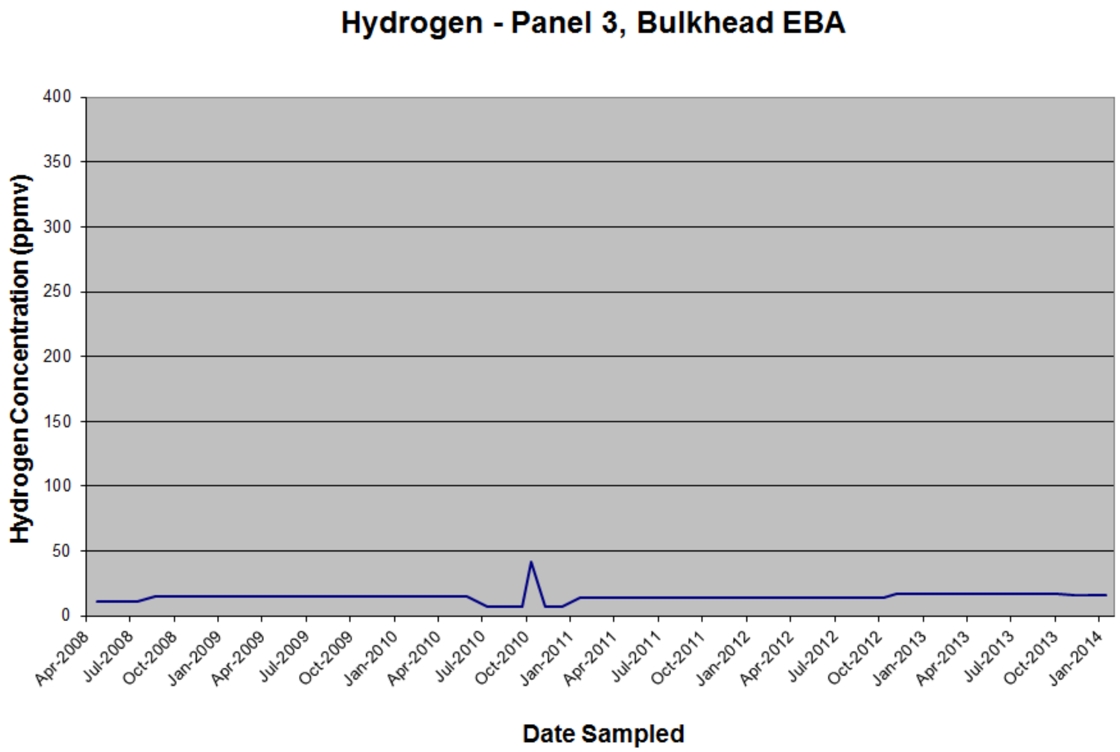


Figure A15: Time Series Plot of Hydrogen Concentrations in Panel 3, Bulkhead EBA

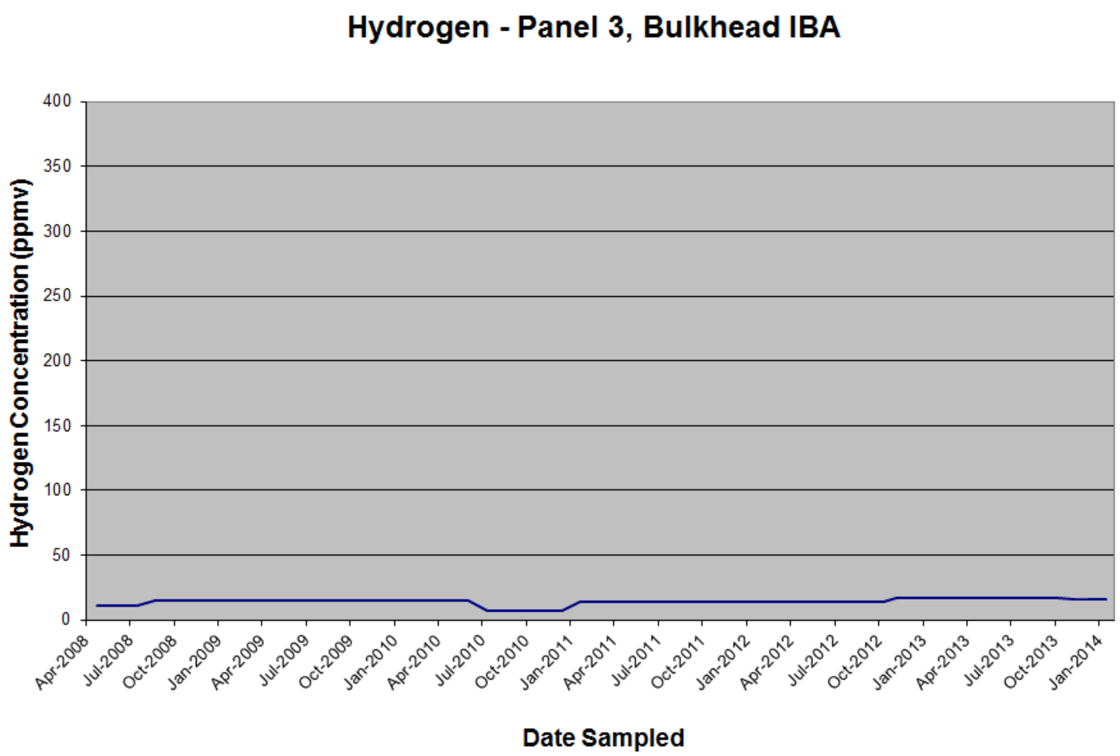


Figure A16: Time Series Plot of Hydrogen Concentrations in Panel 3, Bulkhead IBA

Appendix B

Time Series Plots for Hydrogen Concentrations in Panel 4

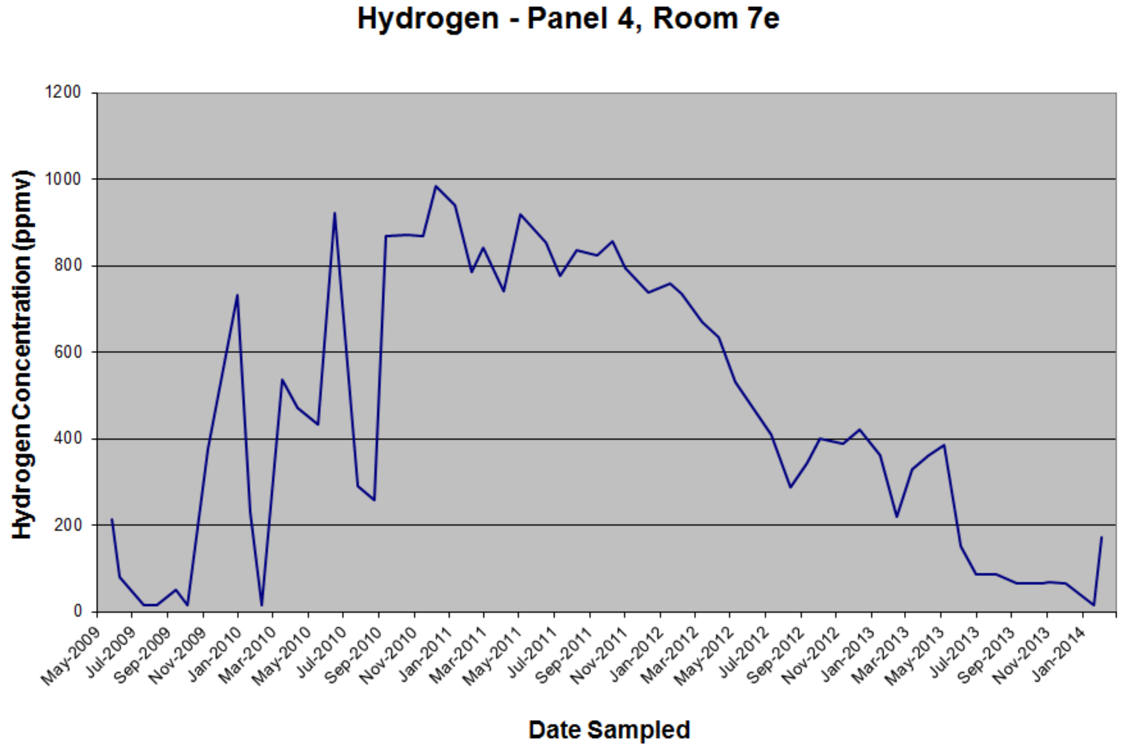


Figure B1: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 7e

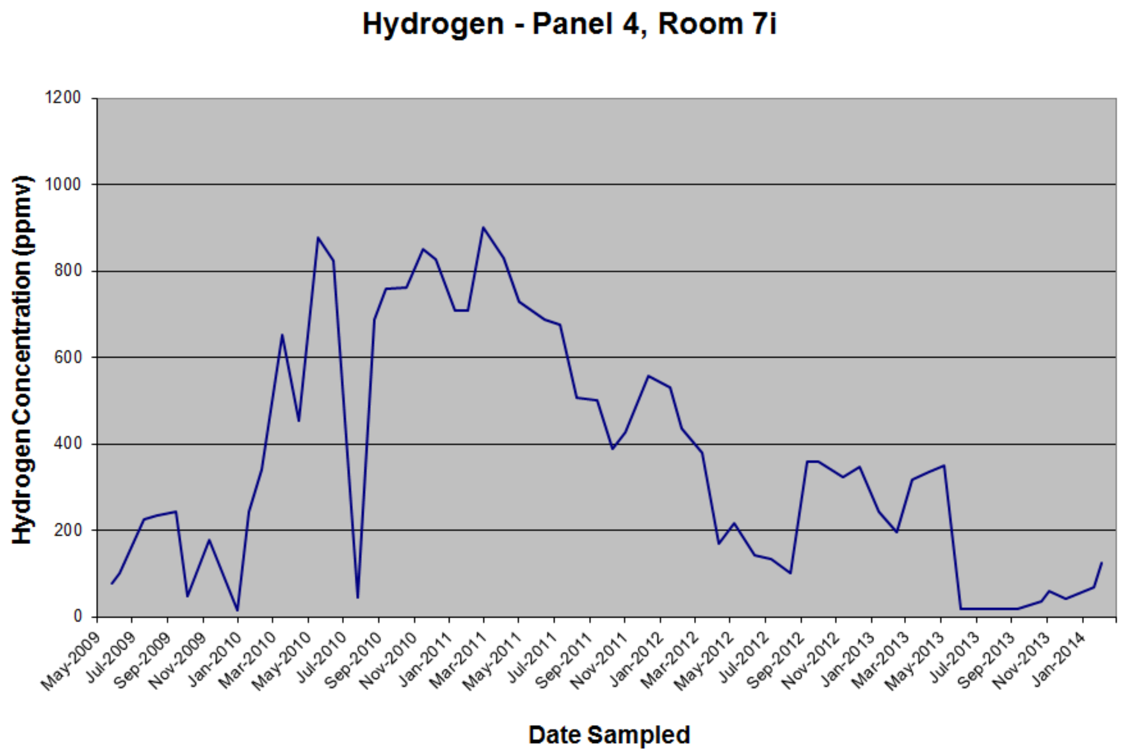


Figure B2: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 7i

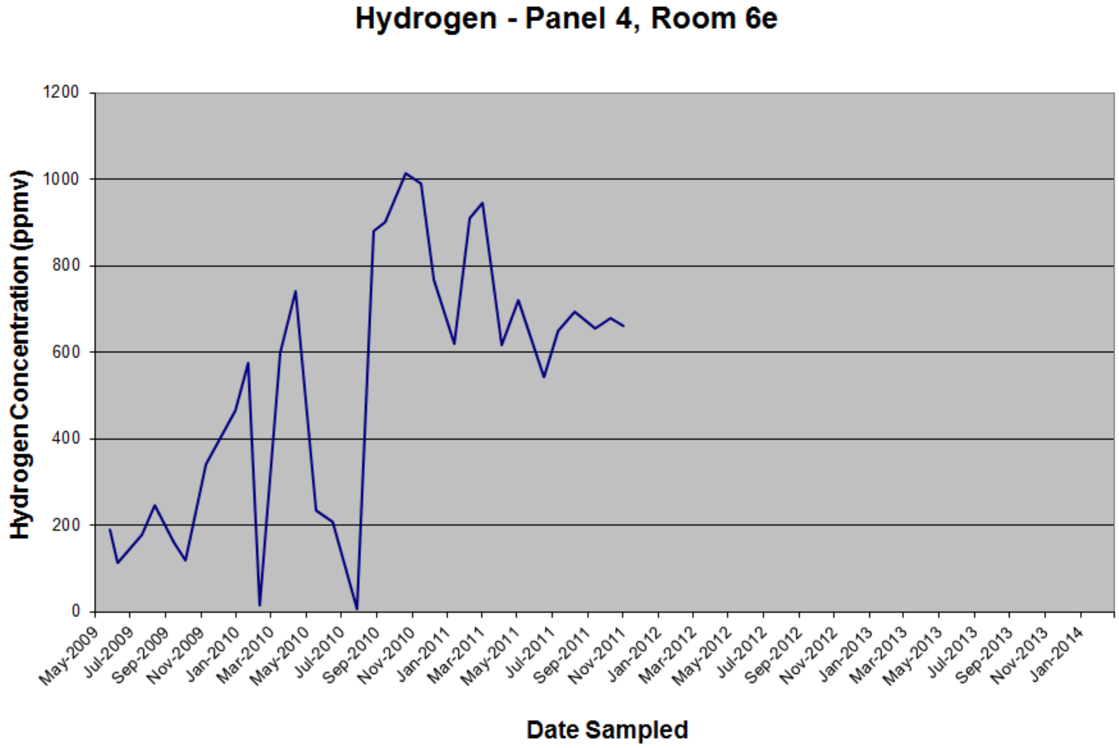


Figure B3: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 6e

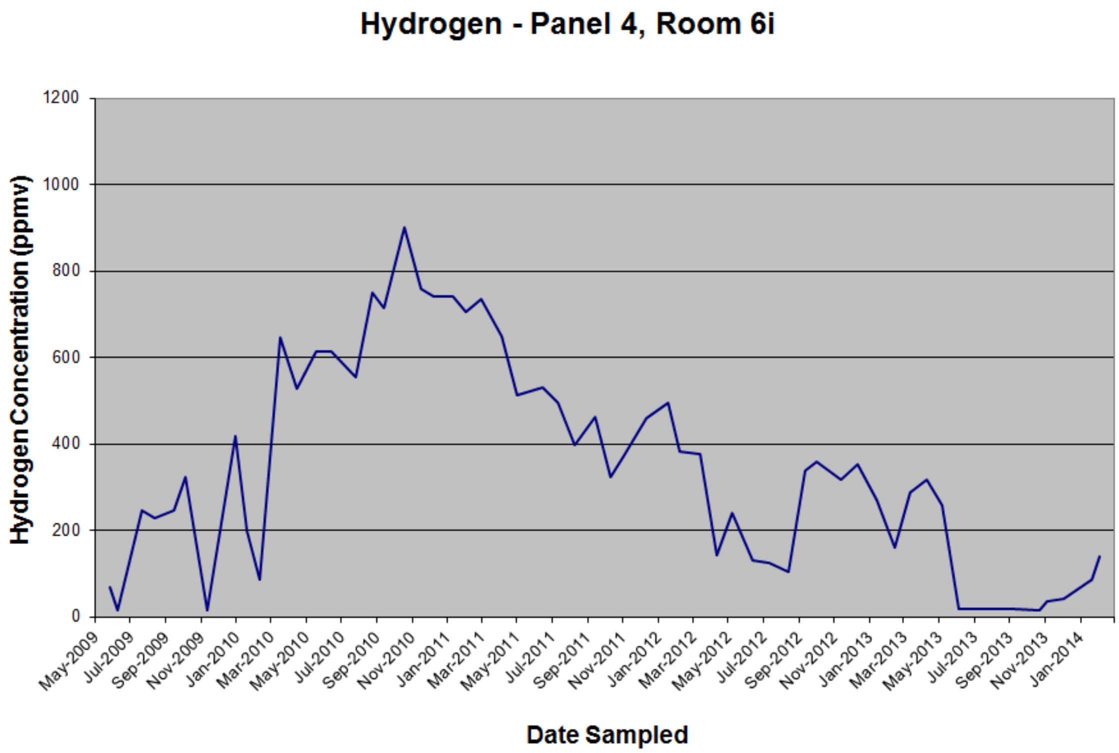


Figure B4: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 6i

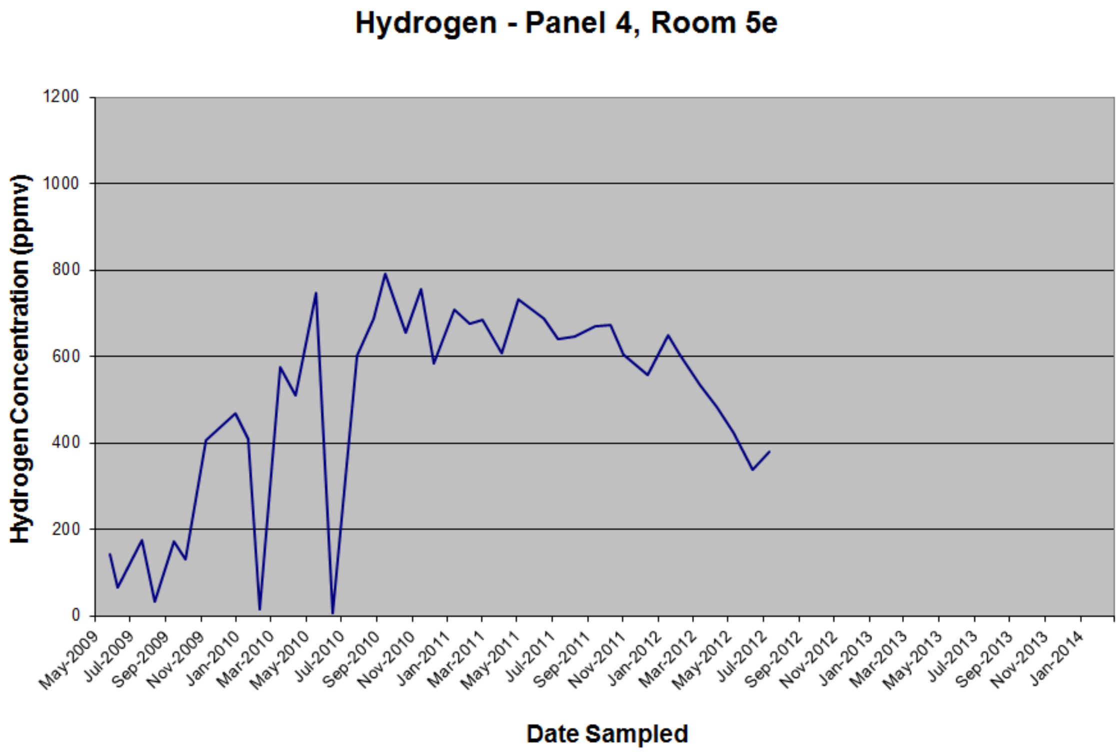


Figure B5: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 5e

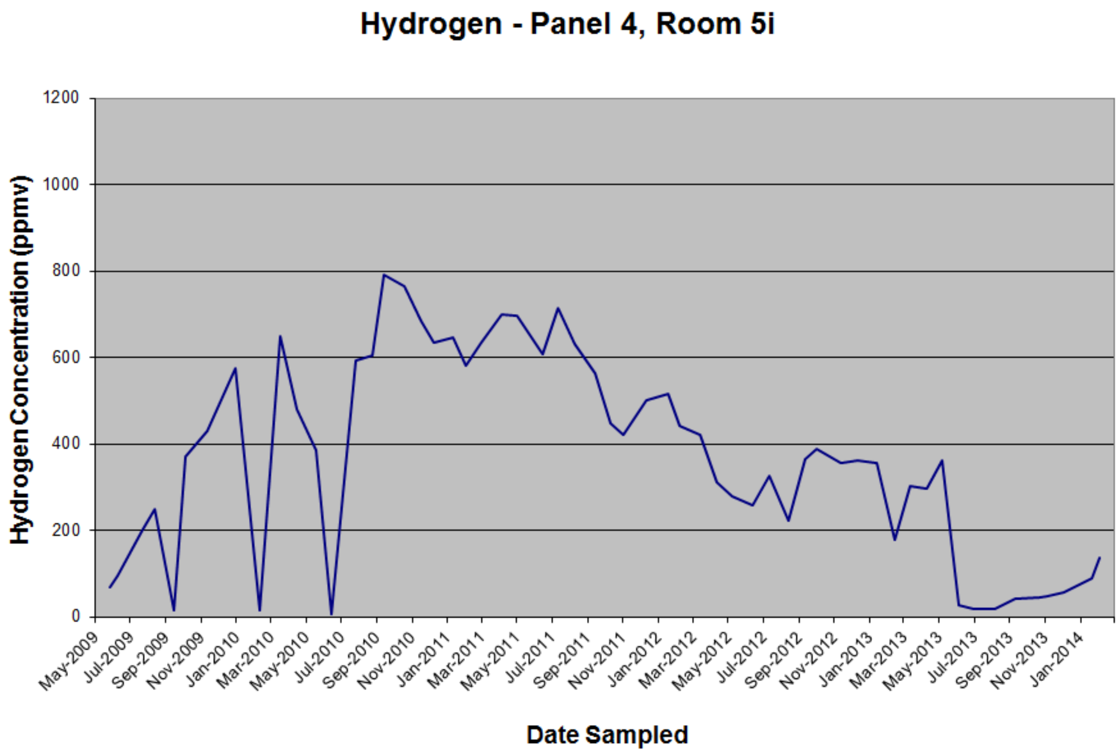


Figure B6: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 5i

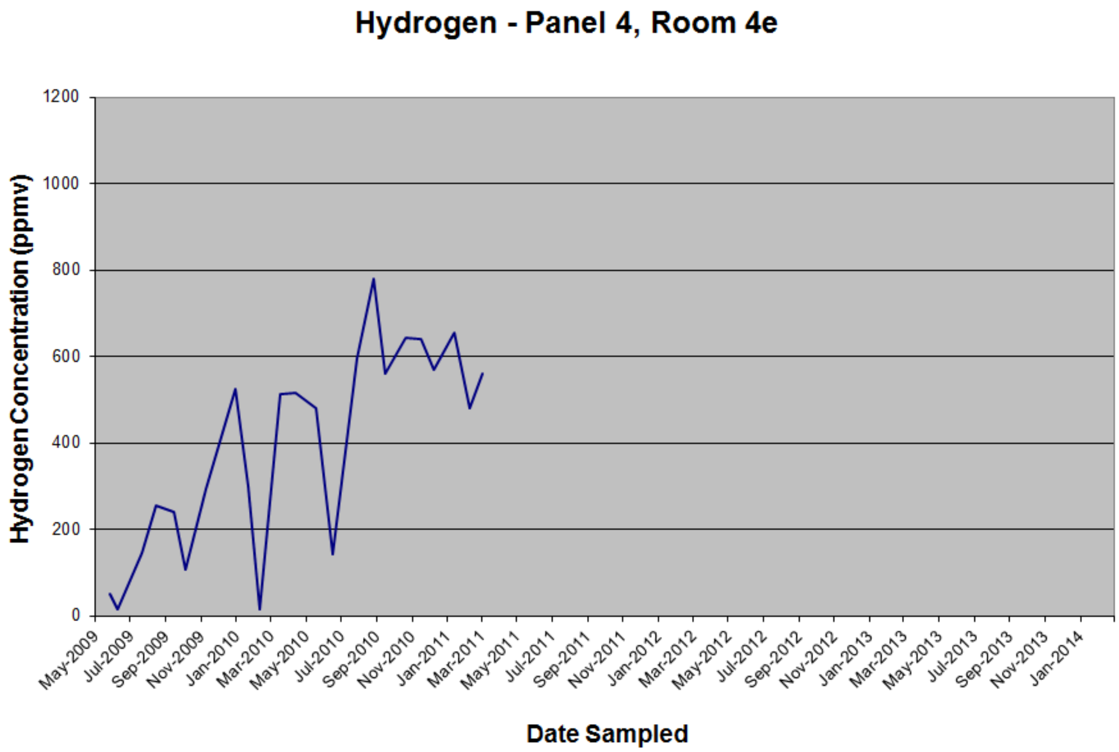


Figure B7: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 4e

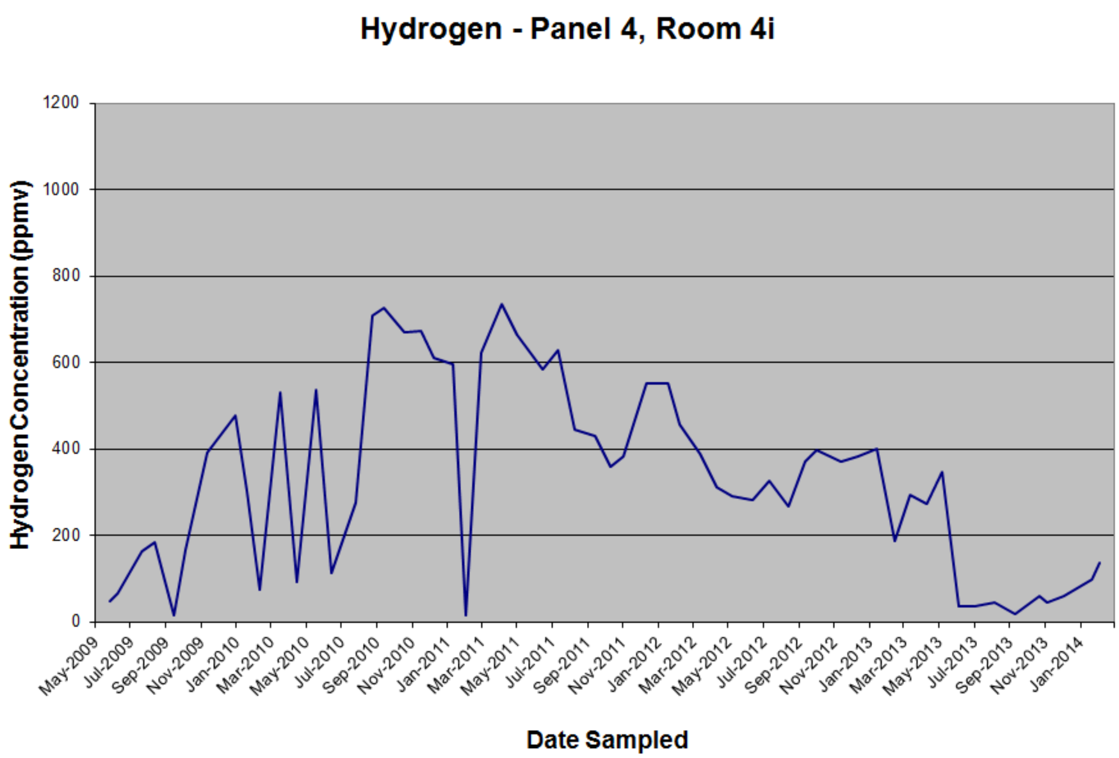


Figure B8: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 4i

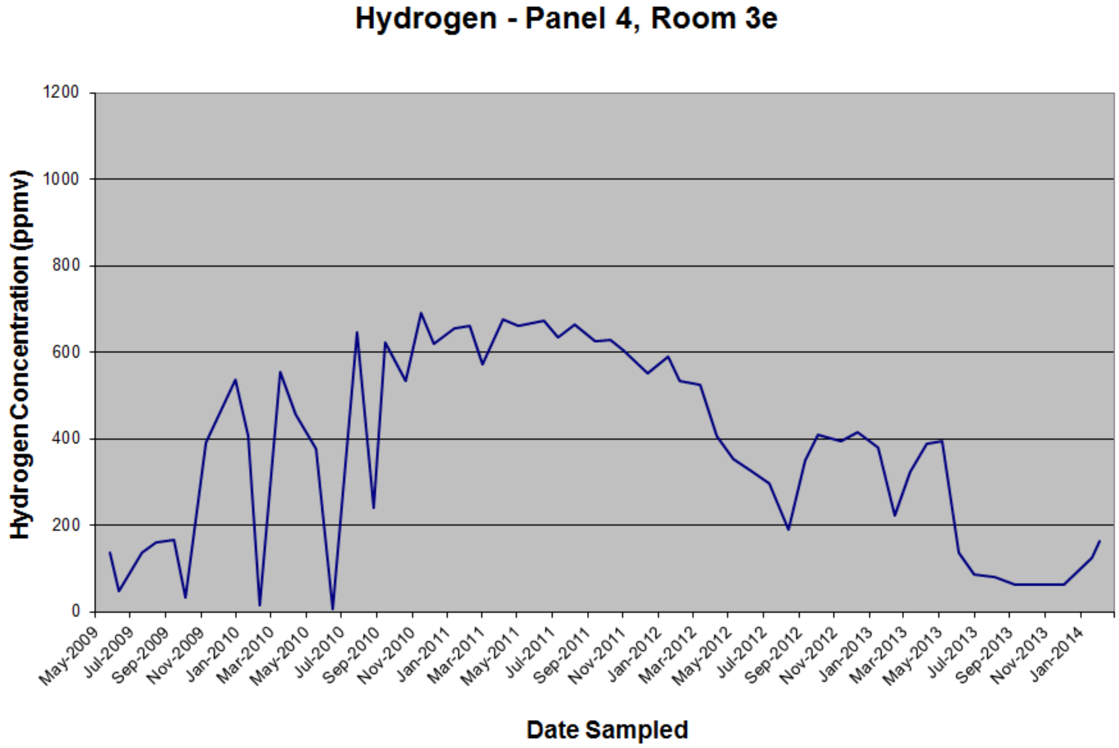


Figure B9: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 3e

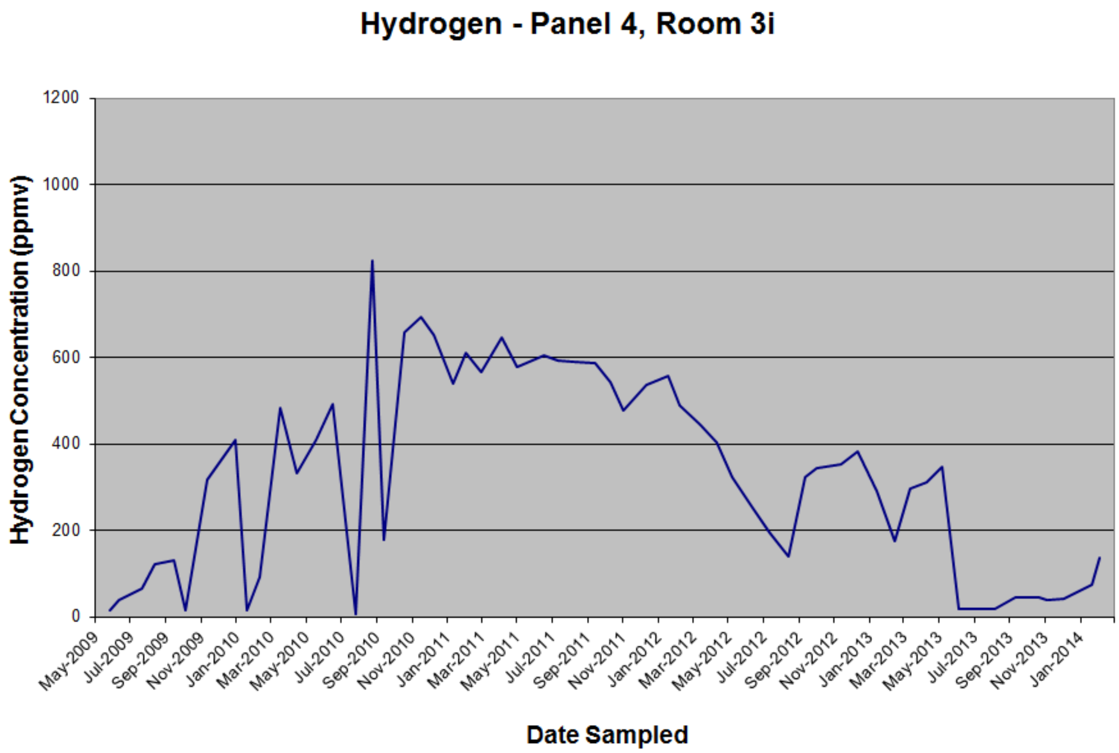


Figure B10: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 3i

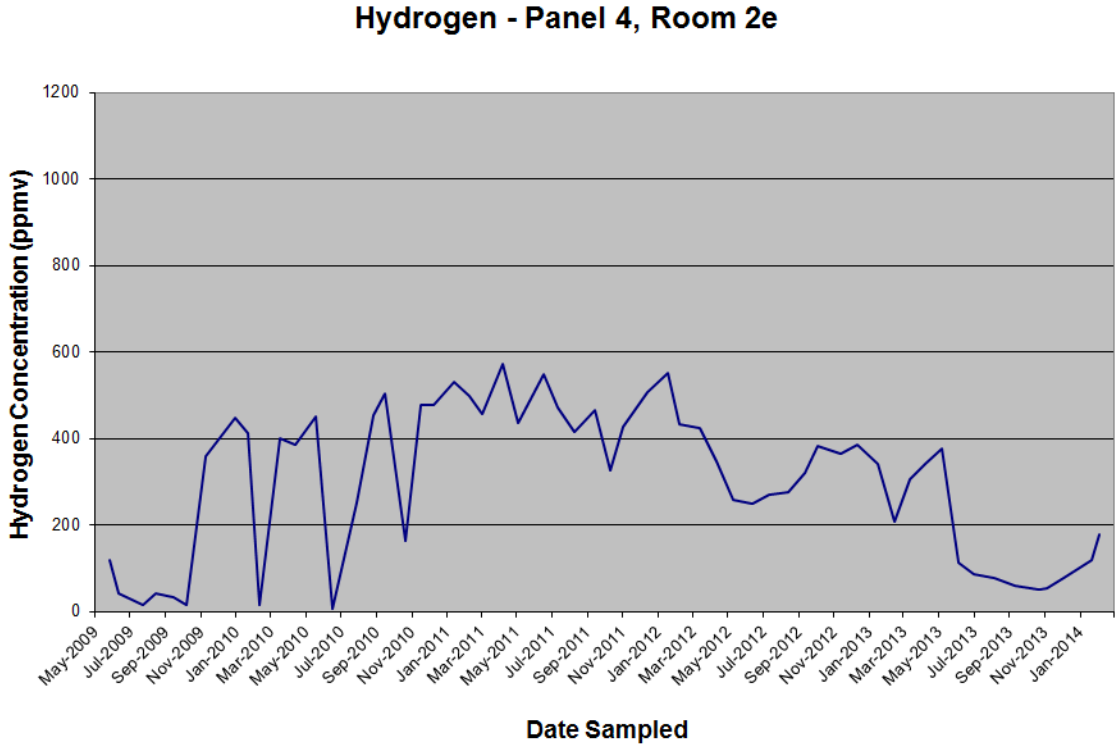


Figure B11: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 2e

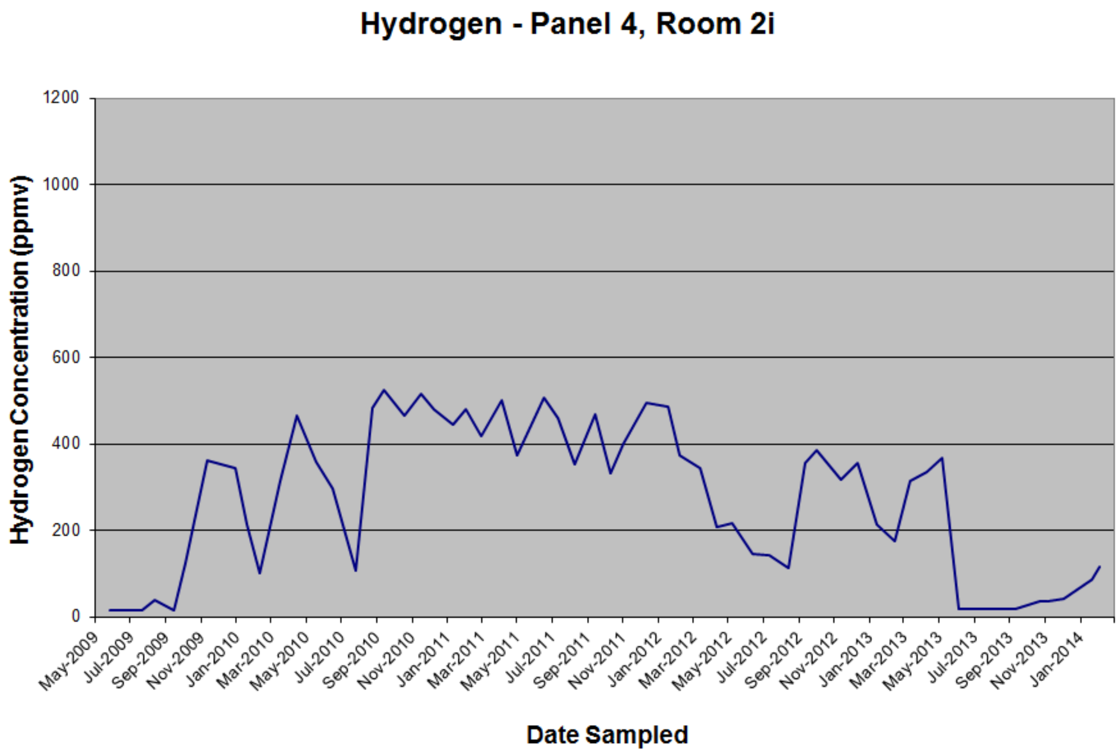


Figure B12: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 2i

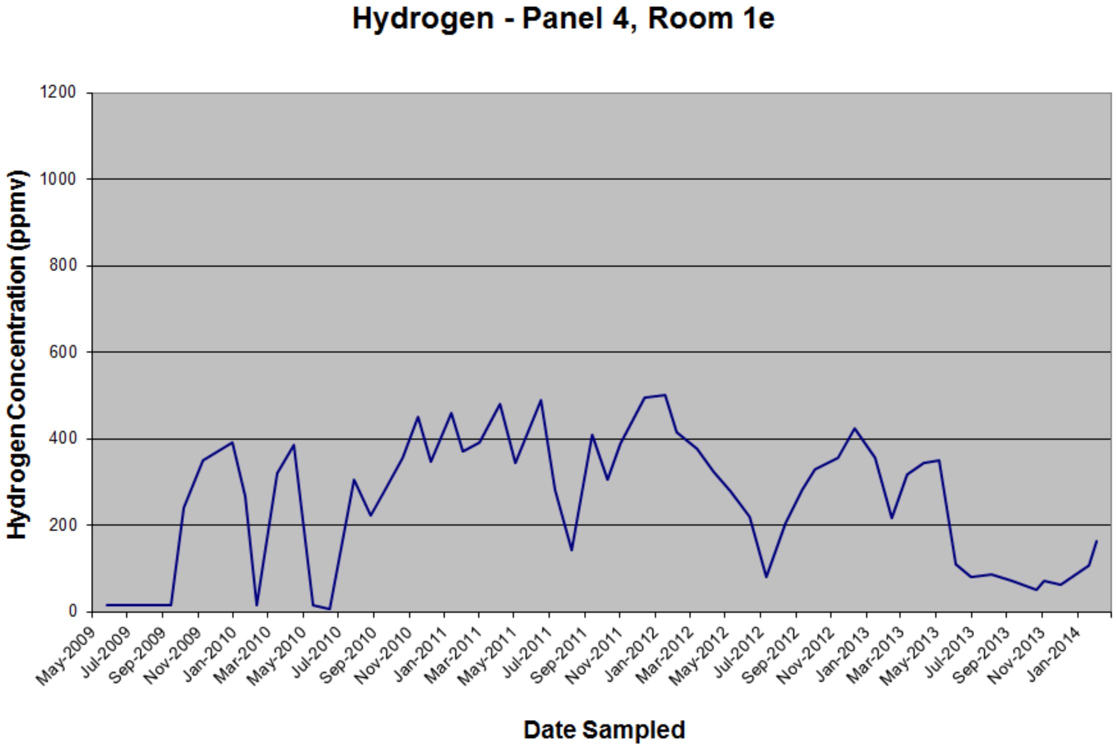


Figure B13: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 1e

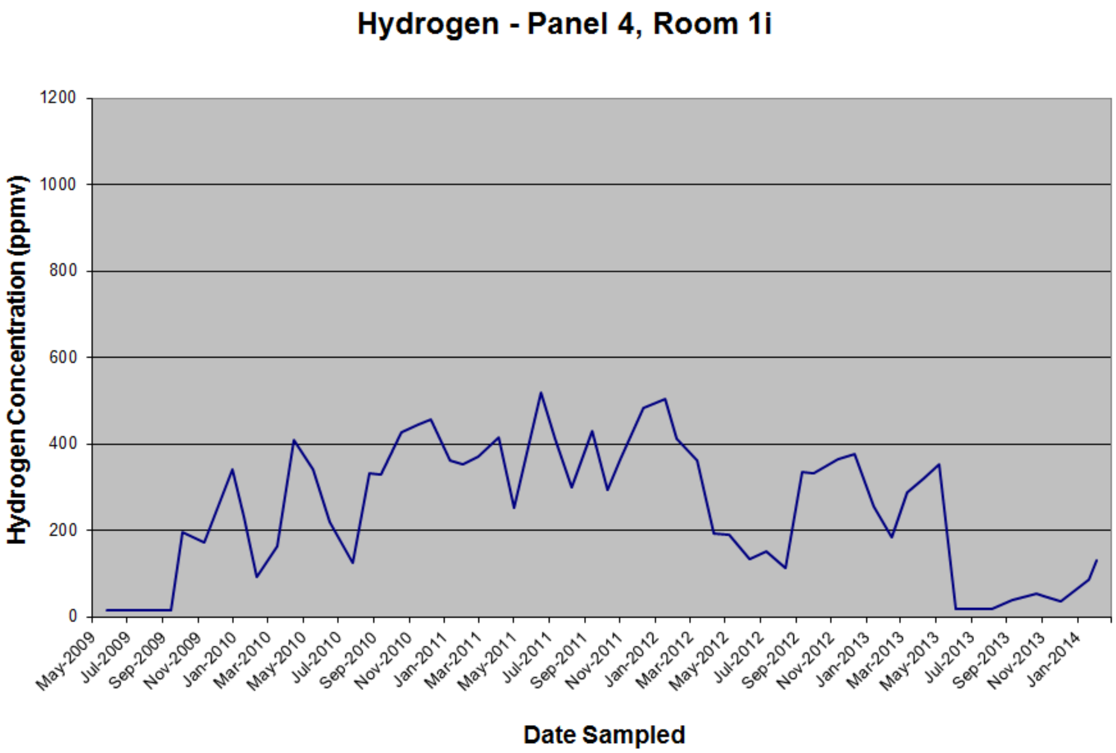


Figure B14: Time Series Plot of Hydrogen Concentrations in Panel 4, Room 1i

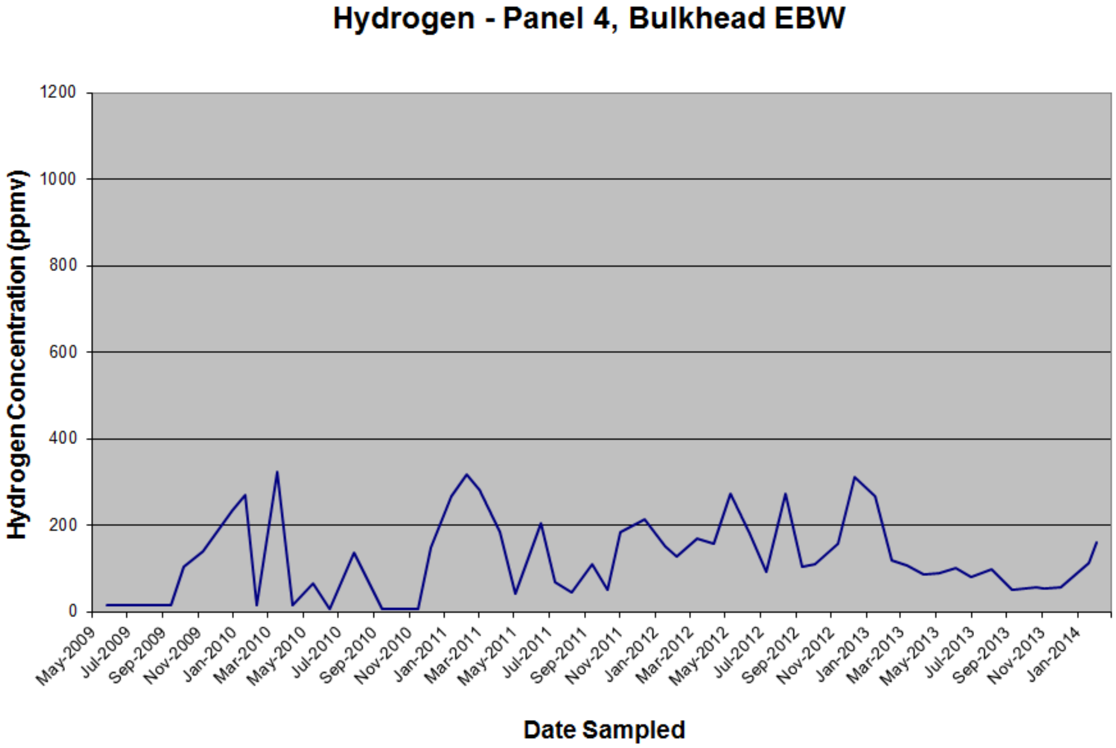


Figure B15: Time Series Plot of Hydrogen Concentrations in Panel 4, Bulkhead EBW

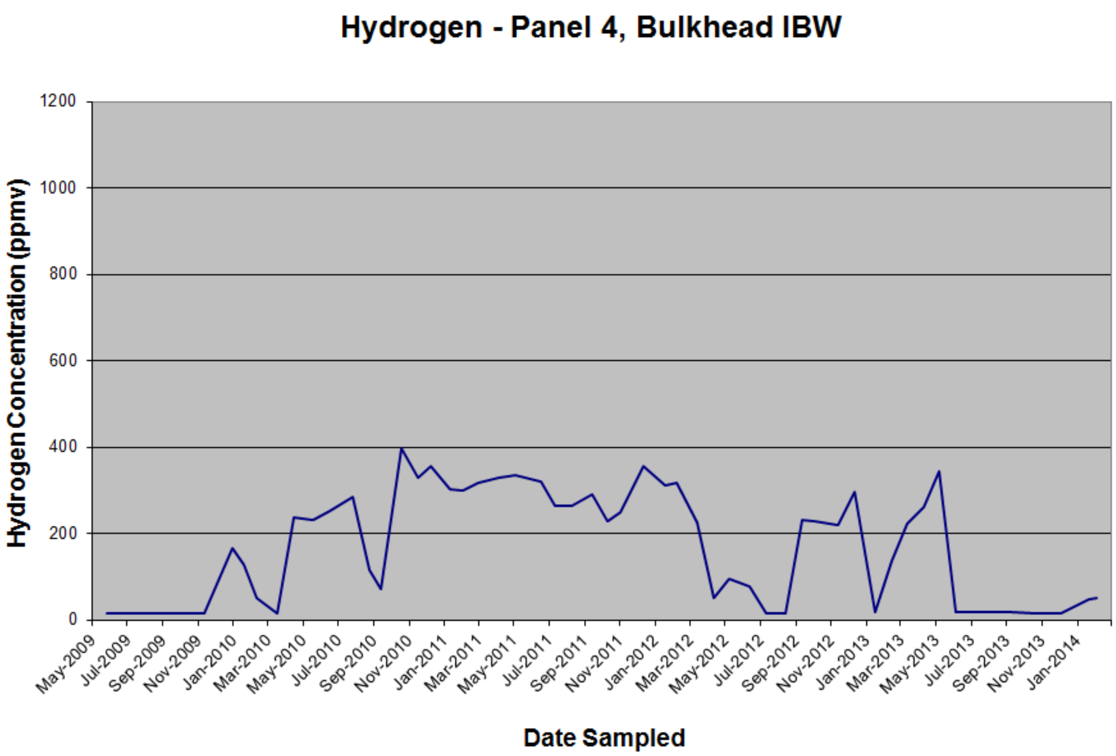


Figure B16: Time Series Plot of Hydrogen Concentrations in Panel 4, Bulkhead IBW

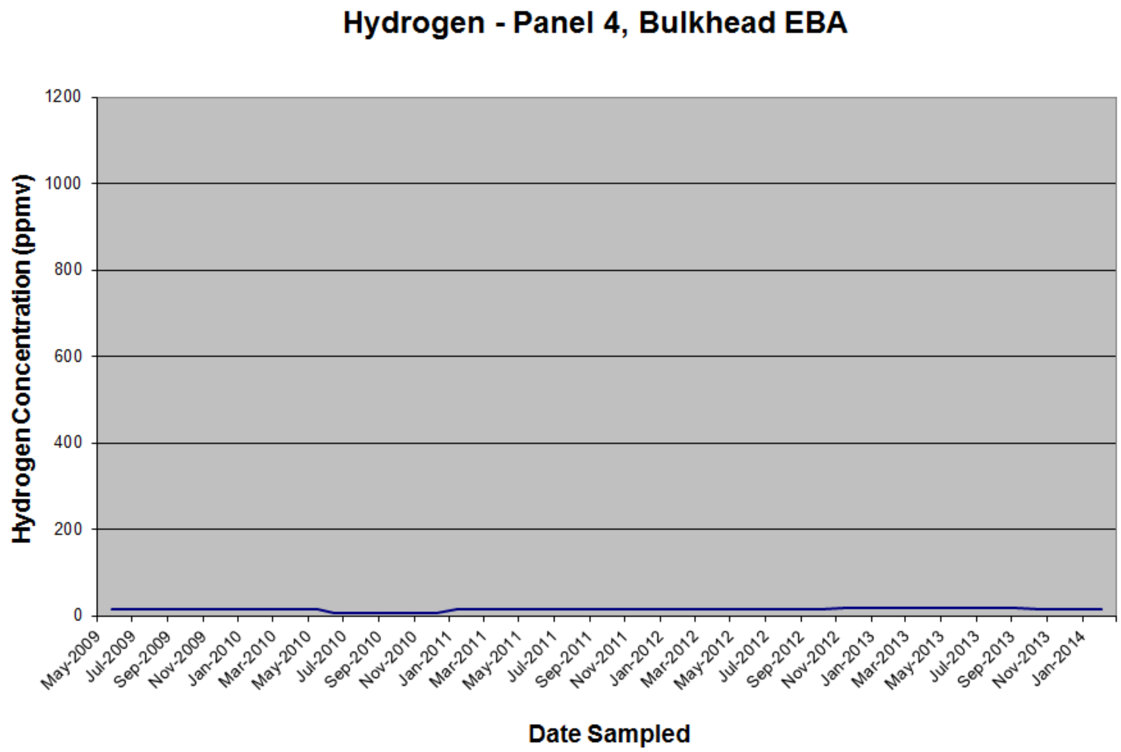


Figure B17: Time Series Plot of Hydrogen Concentrations in Panel 4, Bulkhead EBA

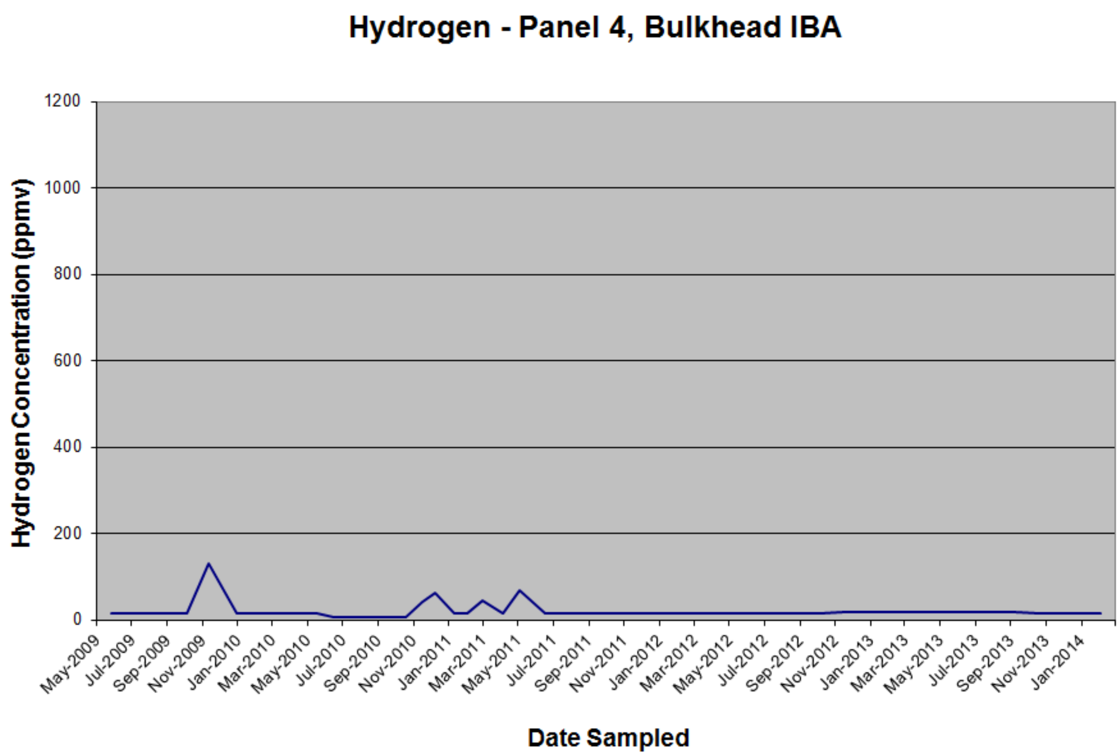


Figure B18: Time Series Plot of Hydrogen Concentrations in Panel 4, Bulkhead IBA

Appendix C

Panel 3 Methane Data

Methane (CH_4) Panel 3, Room 7e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 7e	3176	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3213	5/15/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3281	6/19/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3340	7/16/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3405	8/19/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3453	9/10/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3509	10/8/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3582	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3621	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3720	1/13/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3777	2/10/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3844	3/11/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3919	4/14/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3990	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4048	6/2/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4106	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4165	8/5/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4236	9/1/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4333	10/12/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4375	11/2/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4465	12/8/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4626	1/26/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4724	2/17/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4790	3/9/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4958	4/20/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5082	5/25/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5117	6/1/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5255	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39

Methane (CH_4) Panel 3, Room 7i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 7i	3175	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3222	5/19/2008	5/23/2008	N.D.	2	17.99	35.98	17.99

Methane (CH_4)
Panel 3, Room 6e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 6e	3178	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3212	5/14/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3280	6/19/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3339	7/16/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3426	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3452	9/10/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3508	10/8/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3581	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3620	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3719	1/13/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3776	2/10/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3843	3/10/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3918	4/14/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3989	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4047	6/2/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4107	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4166	8/5/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4237	9/1/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4334	10/12/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4376	11/2/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4466	12/8/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4627	1/26/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4725	2/17/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4791	3/9/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4959	4/20/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5083	5/25/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5118	6/1/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5256	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5349	8/9/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5475	9/21/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5534	10/11/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5627	11/8/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5746	12/14/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5844	1/18/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5930	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6018	3/8/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6131	4/19/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6213	5/9/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6313	6/14/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6427	7/18/2011	7/28/2011	N.D.	2	23.97	47.94	23.97
	6495	8/15/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6573	9/19/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6646	10/17/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6718	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6773	12/5/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6858	1/9/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6961	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7011	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7084	4/2/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7162	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7235	6/4/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7362	7/16/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7420	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7505	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45

Methane (CH_4) Panel 3, Room 6i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 6i	3166	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3221	5/15/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3289	6/19/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3348	7/16/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3412	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3460	9/10/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3516	10/8/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3589	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3628	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3723	1/14/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3784	2/11/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3847	3/11/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3922	4/14/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3986	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4055	6/2/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4114	7/8/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4171	8/5/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4244	9/2/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4341	10/13/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4383	11/3/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4473	12/9/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4634	1/27/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4732	2/18/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4800	3/10/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4966	4/21/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5090	5/26/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5125	6/2/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5263	7/14/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5356	8/10/2010	8/17/2010	N.D.	2	21.39	42.78	21.39

Methane (CH_4)
Panel 3, Room 5e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 5e	3179	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3211	5/14/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3279	6/17/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3338	7/16/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3403	8/19/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3451	9/10/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3507	10/8/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3580	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3619	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3718	1/13/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3775	2/10/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3842	3/10/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3917	4/14/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3988	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4046	6/1/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4108	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4167	8/5/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4238	9/1/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4335	10/12/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4377	11/2/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4467	12/8/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4628	1/26/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4726	2/17/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4792	3/9/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4960	4/20/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5084	5/25/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5119	6/1/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5257	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5350	8/9/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5476	9/21/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5535	10/11/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5628	11/8/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5747	12/14/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5845	1/18/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5931	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6019	3/8/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6132	4/19/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6214	5/9/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6314	6/14/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6428	7/18/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6496	8/15/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6574	9/19/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6647	10/17/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6719	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6774	12/5/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6859	1/9/2012	1/13/2012	N.D.	2	17.45	34.90	17.45
	6962	2/16/2012	2/22/2012	N.D.	2	17.45	34.90	17.45
	7012	3/6/2012	3/9/2012	N.D.	2	17.45	34.90	17.45
	7085	4/2/2012	4/9/2012	N.D.	2	17.45	34.90	17.45
	7163	5/1/2012	5/4/2012	N.D.	2	17.45	34.90	17.45
	7236	6/4/2012	6/8/2012	N.D.	2	17.45	34.90	17.45
	7363	7/16/2012	7/23/2012	N.D.	2	17.45	34.90	17.45
	7421	8/6/2012	8/10/2012	N.D.	2	17.45	34.90	17.45
	7506	9/4/2012	9/7/2012	N.D.	2	17.45	34.90	17.45
	7617	10/8/2012	10/16/2012	N.D.	2	17.45	34.90	17.45
	7687	11/5/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7773	12/3/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7866	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7929	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8002	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8088	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8187	5/13/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8261	6/9/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8336	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8440	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8534	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8579	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8708	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8778	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8854	1/14/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methanе (CH_4) Panel 3, Room 5i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 5i	3177	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3220	5/15/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3288	6/19/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3347	7/16/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3411	8/19/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3459	9/10/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3515	10/8/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3588	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3627	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3722	1/13/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3783	2/11/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3846	3/11/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3921	4/14/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3985	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4054	6/2/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4115	7/8/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4176	8/6/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4245	9/2/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4342	10/13/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4384	11/3/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4474	12/9/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4635	1/27/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4733	2/18/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4801	3/10/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4967	4/21/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5091	5/26/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5126	6/2/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5264	7/14/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5357	8/10/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5483	9/22/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5541	10/12/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5634	11/9/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5753	12/15/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5851	1/19/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5937	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6025	3/9/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6138	4/19/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6220	5/10/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6320	6/15/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6436	7/19/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6502	8/16/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6580	9/20/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6651	10/17/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6725	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6780	12/5/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6865	1/10/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6968	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7018	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7091	4/3/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7169	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7242	6/5/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7369	7/17/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7427	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7512	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7623	10/9/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7693	11/6/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7779	12/4/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7872	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7935	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8008	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8094	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8193	5/14/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8267	6/10/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8342	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8446	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8540	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8585	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8714	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8784	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8860	1/15/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 3, Room 4e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 4e	3174	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3210	5/14/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3278	6/17/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3337	7/16/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3402	8/19/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3450	9/10/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3506	10/8/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3579	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3618	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3717	1/13/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3774	2/10/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3841	3/10/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3916	4/14/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3987	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4045	6/1/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4109	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4168	8/5/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4239	9/1/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4336	10/12/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4378	11/2/2009	11/12/2009	N.D.	2.1	22.21	46.64	23.32
	4468	12/8/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4629	1/26/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4727	2/17/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4793	3/9/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4961	4/20/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5085	5/25/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5120	6/1/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5258	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5351	8/9/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5477	9/21/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5536	10/11/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5629	11/8/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5748	12/14/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5846	1/18/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5932	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6020	3/8/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6133	4/19/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6215	5/9/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6315	6/14/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6429	7/18/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6497	8/15/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6575	9/19/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6648	10/17/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6720	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6775	12/5/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6860	1/9/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6963	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7013	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7086	4/2/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7164	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7237	6/4/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7364	7/16/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7422	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7507	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7618	10/9/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7688	11/5/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7774	12/3/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7867	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7930	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8003	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8089	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8188	5/13/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8262	6/9/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8337	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8441	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8535	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8580	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8709	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8779	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8855	1/14/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4)
Panel 3, Room 4i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 4i	3170	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3219	5/15/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3287	6/19/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3346	7/16/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3410	8/19/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3458	9/10/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3514	10/8/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3587	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3626	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3721	1/13/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3782	2/10/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3845	3/11/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3920	4/14/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3984	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4053	6/2/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4116	7/8/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4177	8/6/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4246	9/2/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4343	10/13/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4385	11/3/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4475	12/9/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4636	1/27/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4734	2/18/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4802	3/10/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4968	4/21/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5092	5/26/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5127	6/2/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5265	7/14/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5358	8/10/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5484	9/22/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5542	10/12/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5635	11/9/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5754	12/15/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5852	1/19/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5938	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6026	3/9/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6139	4/19/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6221	5/10/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6321	6/15/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6437	7/19/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6503	8/16/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6581	9/20/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6656	10/18/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6726	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6781	12/6/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6866	1/10/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6969	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7019	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7092	4/3/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7170	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7243	6/5/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7370	7/17/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7428	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7513	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7624	10/9/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7694	11/6/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7780	12/4/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7873	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7936	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8009	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8095	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8194	5/14/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8268	6/10/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8343	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8447	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8541	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8586	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8715	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8785	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8861	1/15/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 3, Room 3e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 3e	3172	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
Panel 3 Room 3e	3209	5/14/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
Panel 3 Room 3e	3277	6/17/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
Panel 3 Room 3e	3336	7/15/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
Panel 3 Room 3e	3401	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	3449	9/8/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	3505	10/6/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	3578	11/10/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	3617	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	3712	1/12/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	3773	2/9/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	3834	3/12/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	3911	4/13/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	3979	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	4044	6/1/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
Panel 3 Room 3e	4110	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	4169	8/5/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	4240	9/1/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	4337	10/12/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	4379	11/3/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	4469	12/8/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	4630	1/26/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	4728	2/17/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	4796	3/10/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	4962	4/21/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	5086	5/26/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	5121	6/2/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
Panel 3 Room 3e	5259	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
Panel 3 Room 3e	5352	8/9/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
Panel 3 Room 3e	5478	9/21/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
Panel 3 Room 3e	5537	10/11/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
Panel 3 Room 3e	5630	11/8/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
Panel 3 Room 3e	5749	12/14/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
Panel 3 Room 3e	5847	1/18/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	5933	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	6021	3/8/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	6134	4/19/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	6216	5/9/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	6316	6/14/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	6430	7/18/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	6498	8/15/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	6576	9/19/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	6649	10/17/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	6721	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
Panel 3 Room 3e	6776	12/5/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	6861	1/9/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	6964	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	7014	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	7087	4/2/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	7165	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	7238	6/4/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	7365	7/16/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	7423	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	7508	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	7619	10/9/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
Panel 3 Room 3e	7689	11/5/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	7775	12/3/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	7868	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	7931	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	8004	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	8090	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	8189	5/13/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	8263	6/9/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	8338	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	8442	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	8536	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	8581	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
Panel 3 Room 3e	8710	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
Panel 3 Room 3e	8780	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
Panel 3 Room 3e	8856	1/14/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4)
Panel 3, Room 3i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 3i	3171	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3218	5/14/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3286	6/17/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3345	7/15/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3409	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3457	9/8/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3513	10/6/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3586	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3625	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3714	1/12/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3781	2/10/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3836	3/12/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3913	4/13/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3981	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4052	6/2/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4117	7/8/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4178	8/6/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4247	9/2/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4344	10/13/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4386	11/3/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4476	12/9/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4637	1/27/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4735	2/18/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4803	3/10/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4969	4/21/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5093	5/26/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5128	6/2/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5266	7/14/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5359	8/10/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5485	9/22/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5543	10/12/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5636	11/9/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5755	12/15/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5853	1/19/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5939	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6027	3/9/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6140	4/19/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6222	5/10/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6322	6/15/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6438	7/19/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6504	8/16/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6582	9/20/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6657	10/18/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6727	11/8/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6782	12/6/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6867	1/10/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6970	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7020	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7093	4/3/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7171	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7244	6/5/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7371	7/17/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7429	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7514	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7625	10/9/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7695	11/6/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7781	12/4/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7874	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7937	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8010	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8096	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8195	5/14/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8269	6/10/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8344	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8448	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8542	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8587	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8716	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8786	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8862	1/15/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 3, Room 2e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 2e	3164	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3208	5/14/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3276	6/17/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3335	7/15/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3400	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3448	9/8/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3504	10/6/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3577	11/10/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3616	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3711	1/12/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3772	2/9/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3833	3/12/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3910	4/13/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3978	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4043	6/1/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4111	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4170	8/5/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4241	9/1/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4338	10/13/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4380	11/3/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4470	12/8/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4631	1/26/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4729	2/17/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4797	3/10/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4963	4/21/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5087	5/26/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5122	6/2/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5260	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5353	8/9/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5479	9/21/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5538	10/12/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5631	11/8/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5750	12/14/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5848	1/18/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5934	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6022	3/8/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6135	4/19/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6217	5/10/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6317	6/14/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6431	7/18/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6499	8/15/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6577	9/19/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6650	10/17/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6722	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6777	12/5/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6862	1/9/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6965	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7015	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7088	4/2/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7166	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7239	6/4/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7366	7/16/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7424	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7509	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7620	10/9/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7690	11/6/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7776	12/3/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7869	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7932	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8005	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8091	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8190	5/14/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8264	6/9/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8339	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8443	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8537	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8582	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8711	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8781	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8857	1/14/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 3, Room 2i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 2i	3162	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3217	5/14/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3285	6/17/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3344	7/15/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3408	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3456	9/8/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3512	10/6/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3585	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3624	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3713	1/12/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3780	2/10/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3835	3/12/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3912	4/13/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3980	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4051	6/2/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4118	7/8/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4179	8/6/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4248	9/2/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4345	10/13/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4387	11/3/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4477	12/9/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4638	1/27/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4736	2/18/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4804	3/10/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4970	4/21/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5094	5/26/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5129	6/2/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5267	7/14/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5360	8/10/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5486	9/22/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5544	10/12/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5637	11/9/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5756	12/15/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5854	1/19/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5940	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6028	3/9/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6141	4/19/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6223	5/10/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6323	6/15/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6439	7/19/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6505	8/16/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6583	9/20/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6658	10/18/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6728	11/8/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6783	12/6/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6868	1/10/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6971	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7021	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7094	4/3/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7172	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7245	6/5/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7372	7/17/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7430	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7515	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7626	10/9/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7696	11/6/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7782	12/4/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7875	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7938	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8011	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8097	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8196	5/14/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8270	6/10/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8345	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8449	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8543	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8588	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8717	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8787	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8863	1/15/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 3, Room 1e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 1e	3163	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3207	5/14/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3293	6/17/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3334	7/15/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3399	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3447	9/8/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3503	10/6/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3575	11/10/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3614	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3709	1/12/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3770	2/9/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3831	3/11/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3908	4/13/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3976	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4041	6/1/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4112	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4172	8/6/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4242	9/1/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4339	10/13/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4381	11/3/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4471	12/9/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4632	1/26/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4730	2/17/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4798	3/10/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4964	4/21/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5088	5/26/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5123	6/2/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5261	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5354	8/10/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5480	9/21/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5539	10/12/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5632	11/9/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5751	12/15/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5849	1/18/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5935	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6023	3/9/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6136	4/19/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6218	5/10/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6318	6/15/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6433	7/19/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6506	8/16/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6584	9/20/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6659	10/18/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6729	11/8/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6784	12/6/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6869	1/10/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6972	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7022	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7095	4/3/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7173	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7246	6/5/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7373	7/17/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7431	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7516	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7627	10/9/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7697	11/6/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7783	12/4/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7876	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7939	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8012	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8098	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8197	5/14/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8271	6/10/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8346	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8450	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8544	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8589	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8718	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8788	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8864	1/15/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 3, Room 1i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 1i	3169	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3216	5/19/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3284	6/19/2008	6/25/2008	N.D.	2	17.99	35.98	17.99

Methane (CH_4) Panel 3, EBW								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Location EBW	3165	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3215	5/15/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3283	6/17/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3342	7/15/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3407	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3455	9/8/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3511	10/6/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3584	11/10/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3623	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3716	1/12/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3779	2/9/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3838	3/12/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3915	4/13/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3983	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4049	6/2/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4105	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4164	8/5/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4235	9/1/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4332	10/12/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4374	11/2/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4464	12/8/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4625	1/26/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4723	2/17/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4789	3/9/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4957	4/20/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5081	5/25/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5116	6/1/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5254	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5347	8/9/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5474	9/21/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5533	10/11/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5626	11/8/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5745	12/14/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5843	1/18/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5929	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6017	3/8/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6130	4/18/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6212	5/9/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6312	6/14/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6432	7/18/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6500	8/15/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6578	9/19/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6652	10/17/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6723	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6778	12/5/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6863	1/9/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6966	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7016	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7089	4/2/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7167	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7240	6/4/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7367	7/16/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7425	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7510	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7621	10/9/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7691	11/6/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7777	12/4/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7870	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7933	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8006	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8092	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8191	5/14/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8265	6/9/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8340	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8444	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8538	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8583	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8712	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8782	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8858	1/14/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 3, EBA								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Location EBA	3167	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3214	5/15/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3282	6/19/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3341	7/15/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3406	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3454	9/8/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3510	10/6/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3583	11/10/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3622	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3715	1/12/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3778	2/9/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3837	3/12/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3914	4/13/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3982	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4050	6/2/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4104	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4163	8/5/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4234	9/1/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4331	10/12/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4373	11/2/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4463	12/8/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4624	1/26/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4722	2/17/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4788	3/9/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4956	4/20/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5080	5/25/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5115	6/1/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5253	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5346	8/9/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5473	9/21/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5532	10/11/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5625	11/8/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5744	12/14/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5842	1/18/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5928	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6016	3/8/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6129	4/18/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6211	5/9/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6311	6/14/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6435	7/19/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6501	8/16/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6579	9/20/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6653	10/17/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6724	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6779	12/5/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6864	1/10/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6967	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7017	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7090	4/3/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7168	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7241	6/5/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7368	7/16/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7426	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7511	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7622	10/9/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7692	11/6/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7778	12/4/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7871	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7934	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8007	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8093	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8192	5/14/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8266	6/9/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8341	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8445	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8539	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8584	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8713	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8783	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8859	1/14/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 3, IBW								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Location IBW	3173	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3224	5/15/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3292	6/19/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3350	7/16/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3414	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3462	9/10/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3518	10/8/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3591	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3630	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3725	1/14/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3786	2/11/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3840	3/10/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3924	4/15/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3992	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4040	6/1/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4103	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4181	8/6/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4250	9/2/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4347	10/13/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4372	11/2/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4479	12/9/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4640	1/27/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4738	2/18/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4795	3/9/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	5078	5/25/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5130	6/2/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5252	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5362	8/10/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5487	9/22/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5531	10/11/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5624	11/8/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5743	12/14/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5841	1/18/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5927	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6015	3/8/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6128	4/18/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6210	5/9/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6309	6/14/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6426	7/18/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6494	8/15/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6571	9/19/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6654	10/18/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6716	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6771	12/5/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6857	1/9/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6959	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7009	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7083	4/2/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7161	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7234	6/4/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7361	7/16/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7419	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7504	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7615	10/8/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7686	11/5/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7772	12/3/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7865	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7928	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8001	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8087	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8186	5/13/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8260	6/9/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8335	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8439	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8533	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8578	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8707	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8777	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8853	1/14/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 3, IBA								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Location IBA	3168	4/24/2008	4/30/2008	N.D.	2	17.99	35.98	17.99
	3223	5/15/2008	5/23/2008	N.D.	2	17.99	35.98	17.99
	3291	6/19/2008	6/25/2008	N.D.	2	17.99	35.98	17.99
	3349	7/16/2008	7/22/2008	N.D.	2	17.99	35.98	17.99
	3413	8/20/2008	8/22/2008	N.D.	2	23.74	47.48	23.74
	3461	9/10/2008	9/12/2008	N.D.	2	23.74	47.48	23.74
	3517	10/8/2008	10/10/2008	N.D.	2	23.74	47.48	23.74
	3590	11/13/2008	11/18/2008	N.D.	2	23.74	47.48	23.74
	3629	12/3/2008	12/6/2008	N.D.	2	23.74	47.48	23.74
	3724	1/14/2009	1/21/2009	N.D.	2	23.74	47.48	23.74
	3785	2/11/2009	2/13/2009	N.D.	2	23.74	47.48	23.74
	3839	3/10/2009	3/27/2009	N.D.	2	23.74	47.48	23.74
	3923	4/15/2009	4/22/2009	N.D.	2	23.74	47.48	23.74
	3991	5/12/2009	5/15/2009	N.D.	2	23.74	47.48	23.74
	4039	6/1/2009	6/8/2009	N.D.	2	23.74	47.48	23.74
	4102	7/7/2009	7/10/2009	N.D.	2	22.21	44.42	22.21
	4180	8/6/2009	8/13/2009	N.D.	2	22.21	44.42	22.21
	4249	9/2/2009	9/4/2009	N.D.	2	22.21	44.42	22.21
	4346	10/13/2009	10/15/2009	N.D.	2	22.21	44.42	22.21
	4371	11/2/2009	11/12/2009	N.D.	2	22.21	44.42	22.21
	4478	12/9/2009	12/15/2009	N.D.	2	22.21	44.42	22.21
	4639	1/27/2010	2/2/2010	N.D.	2	22.21	44.42	22.21
	4737	2/18/2010	2/23/2010	N.D.	2	22.21	44.42	22.21
	4794	3/9/2010	3/12/2010	N.D.	2	22.21	44.42	22.21
	4954	4/20/2010	4/28/2010	N.D.	2	22.21	44.42	22.21
	5079	5/25/2010	5/28/2010	N.D.	2	22.21	44.42	22.21
	5131	6/2/2010	6/7/2010	N.D.	2	22.21	44.42	22.21
	5251	7/13/2010	7/19/2010	N.D.	2	21.39	42.78	21.39
	5361	8/10/2010	8/17/2010	N.D.	2	21.39	42.78	21.39
	5488	9/22/2010	9/27/2010	N.D.	2	21.39	42.78	21.39
	5530	10/11/2010	10/18/2010	N.D.	2	21.39	42.78	21.39
	5623	11/8/2010	11/15/2010	N.D.	2	21.39	42.78	21.39
	5742	12/14/2010	12/20/2010	N.D.	2	21.39	42.78	21.39
	5840	1/18/2011	1/24/2011	N.D.	2	23.97	47.94	23.97
	5926	2/15/2011	2/21/2011	N.D.	2	23.97	47.94	23.97
	6014	3/8/2011	3/11/2011	N.D.	2	23.97	47.94	23.97
	6127	4/18/2011	4/26/2011	N.D.	2	23.97	47.94	23.97
	6209	5/9/2011	5/13/2011	N.D.	2	23.97	47.94	23.97
	6310	6/14/2011	6/21/2011	N.D.	2	23.97	47.94	23.97
	6425	7/18/2011	7/22/2011	N.D.	2	23.97	47.94	23.97
	6493	8/15/2011	8/22/2011	N.D.	2	23.97	47.94	23.97
	6572	9/19/2011	9/27/2011	N.D.	2	23.97	47.94	23.97
	6655	10/18/2011	10/25/2011	N.D.	2	23.97	47.94	23.97
	6717	11/7/2011	11/11/2011	N.D.	2	23.97	47.94	23.97
	6772	12/5/2011	12/9/2011	N.D.	2	17.45	34.9	17.45
	6856	1/9/2012	1/13/2012	N.D.	2	17.45	34.9	17.45
	6960	2/16/2012	2/22/2012	N.D.	2	17.45	34.9	17.45
	7010	3/6/2012	3/9/2012	N.D.	2	17.45	34.9	17.45
	7082	4/2/2012	4/9/2012	N.D.	2	17.45	34.9	17.45
	7160	5/1/2012	5/4/2012	N.D.	2	17.45	34.9	17.45
	7233	6/4/2012	6/8/2012	N.D.	2	17.45	34.9	17.45
	7360	7/16/2012	7/23/2012	N.D.	2	17.45	34.9	17.45
	7418	8/6/2012	8/10/2012	N.D.	2	17.45	34.9	17.45
	7503	9/4/2012	9/7/2012	N.D.	2	17.45	34.9	17.45
	7614	10/8/2012	10/16/2012	N.D.	2	17.45	34.9	17.45
	7685	11/5/2012	11/9/2012	N.D.	2	15.71	31.42	15.71
	7771	12/3/2012	12/7/2012	N.D.	2	15.71	31.42	15.71
	7864	1/8/2013	1/14/2013	N.D.	2	15.71	31.42	15.71
	7927	2/5/2013	2/8/2013	N.D.	2	15.71	31.42	15.71
	8000	3/5/2013	3/11/2013	N.D.	2	15.71	31.42	15.71
	8086	4/2/2013	4/5/2013	N.D.	2	15.71	31.42	15.71
	8185	5/13/2013	5/17/2013	N.D.	2	15.71	31.42	15.71
	8259	6/9/2013	6/14/2013	N.D.	2	15.71	31.42	15.71
	8334	7/9/2013	7/12/2013	N.D.	2	15.71	31.42	15.71
	8438	8/12/2013	8/19/2013	N.D.	2	15.71	31.42	15.71
	8532	9/16/2013	9/20/2013	N.D.	2	15.71	31.42	15.71
	8577	10/8/2013	10/11/2013	N.D.	2	15.71	31.42	15.71
	8706	11/11/2013	11/18/2013	N.D.	2	14.87	29.74	14.87
	8776	12/9/2013	12/13/2013	N.D.	2	14.87	29.74	14.87
	8852	1/14/2014	1/22/2014	N.D.	2	14.87	29.74	14.87

Appendix D

Panel 4 Methane Data

Methane (CH_4)
Panel 4, Room 7e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 7e	4032	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4069	6/9/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4139	7/21/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4200	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4274	9/15/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4315	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4404	11/9/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4531	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4595	1/20/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4680	2/10/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4833	3/17/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4915	4/13/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5050	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5175	6/15/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5310	7/26/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5396	8/24/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5450	9/13/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5569	10/20/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5661	11/16/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5718	12/7/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5816	1/11/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5892	2/7/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5980	3/1/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6083	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6182	5/3/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6333	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6409	7/12/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6477	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6553	9/14/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6627	10/11/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6700	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6804	12/12/2011	12/16/2011	N.D.	2	17.45	34.9	17.45
	6890	1/17/2012	1/23/2012	N.D.	2	17.45	34.9	17.45
	6942	2/7/2012	2/10/2012	N.D.	2	17.45	34.9	17.45
	7043	3/13/2012	3/16/2012	N.D.	2	17.45	34.9	17.45
	7113	4/10/2012	4/13/2012	N.D.	2	17.45	34.9	17.45
	7191	5/9/2012	5/15/2012	N.D.	2	17.45	34.9	17.45
	7270	6/11/2012	6/18/2012	N.D.	2	17.45	34.9	17.45
	7341	7/10/2012	7/13/2012	N.D.	2	17.45	34.9	17.45
	7457	8/13/2012	8/17/2012	N.D.	2	17.45	34.9	17.45
	7535	9/10/2012	9/14/2012	N.D.	2	17.45	34.9	17.45
	7581	10/2/2012	10/5/2012	N.D.	2	17.45	34.9	17.45
	7721	11/13/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7809	12/11/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7896	1/15/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7963	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8035	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8109	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8168	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8252	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8327	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8404	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8507	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8636	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8681	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8755	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8890	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8919	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4)
Panel 4, Room 7i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 7i	4028	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4073	6/9/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4130	7/20/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4191	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4265	9/14/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4306	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4413	11/11/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4522	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4586	1/19/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4671	2/9/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4824	3/16/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4925	4/14/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5041	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5166	6/14/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5301	7/26/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5387	8/24/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5441	9/13/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5560	10/19/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5652	11/15/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5709	12/7/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5807	1/11/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5881	2/1/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5971	3/1/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6074	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6173	5/2/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6324	6/15/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6400	7/11/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6461	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6544	9/13/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6618	10/10/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6691	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6795	12/12/2011	12/16/2011	N.D.	2	17.45	34.9	17.45
	6881	1/17/2012	1/23/2012	N.D.	2	17.45	34.9	17.45
	6933	2/7/2012	2/10/2012	N.D.	2	17.45	34.9	17.45
	7034	3/13/2012	3/16/2012	N.D.	2	17.45	34.9	17.45
	7104	4/10/2012	4/13/2012	N.D.	2	17.45	34.9	17.45
	7182	5/8/2012	5/15/2012	N.D.	2	17.45	34.9	17.45
	7261	6/11/2012	6/18/2012	N.D.	2	17.45	34.9	17.45
	7332	7/10/2012	7/13/2012	N.D.	2	17.45	34.9	17.45
	7448	8/13/2012	8/17/2012	N.D.	2	17.45	34.9	17.45
	7526	9/10/2012	9/14/2012	N.D.	2	17.45	34.9	17.45
	7572	10/1/2012	10/5/2012	N.D.	2	17.45	34.9	17.45
	7712	11/12/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7800	12/10/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7887	1/14/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7954	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8026	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8100	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8159	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8243	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8318	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8397	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8500	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8629	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8674	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8748	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8881	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8910	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 4, Room 6e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 6e	4031	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4068	6/8/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4140	7/21/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4201	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4275	9/15/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4316	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4403	11/9/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4532	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4596	1/20/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4681	2/10/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4834	3/17/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4916	4/13/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5051	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5176	6/15/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5311	7/27/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5397	8/25/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5451	9/14/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5570	10/20/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5662	11/16/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5719	12/8/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5817	1/12/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5893	2/7/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5981	3/2/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6084	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6183	5/3/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6334	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6410	7/12/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6478	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6554	9/14/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6628	10/11/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6701	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97

Methane (CH_4)
Panel 4, Room 6i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 6i	4027	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4072	6/9/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4131	7/20/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4192	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4266	9/14/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4307	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4412	11/11/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4523	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4587	1/19/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4672	2/9/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4825	3/16/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4926	4/14/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5042	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5167	6/14/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5302	7/26/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5388	8/24/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5442	9/13/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5561	10/19/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5653	11/15/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5710	12/7/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5808	1/11/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5882	2/1/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5972	3/1/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6075	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6174	5/2/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6325	6/15/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6401	7/11/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6469	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6545	9/13/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6619	10/10/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6692	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6796	12/12/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6882	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6934	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7035	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7105	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7183	5/8/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7262	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7333	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7449	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7527	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7573	10/1/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7713	11/12/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7801	12/10/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7888	1/14/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7955	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8027	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8101	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8160	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8244	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8319	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8398	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8501	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8630	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8675	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8749	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8882	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8911	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 4, Room 5e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 5e	4030	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4067	6/8/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4141	7/21/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4202	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4276	9/15/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4317	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4402	11/9/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4533	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4597	1/20/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4682	2/10/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4835	3/17/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4917	4/13/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5052	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5177	6/15/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5312	7/27/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5398	8/25/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5452	9/14/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5571	10/20/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5663	11/16/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5720	12/8/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5818	1/12/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5894	2/7/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5982	3/2/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6085	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6184	5/3/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6335	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6411	7/12/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6479	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6557	9/14/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6629	10/11/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6702	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6806	12/13/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6892	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6943	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7044	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7114	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7192	5/9/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7271	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7342	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45

Methane (CH_4)
Panel 4, Room 5i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 5i	4026	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4071	6/9/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4132	7/20/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4193	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4267	9/14/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4308	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4411	11/11/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4524	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4588	1/19/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4673	2/9/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4826	3/16/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4927	4/14/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5043	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5168	6/14/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5303	7/26/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5389	8/24/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5443	9/13/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5562	10/19/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5654	11/15/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5711	12/7/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5809	1/11/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5883	2/1/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5973	3/1/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6076	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6175	5/2/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6326	6/15/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6402	7/11/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6470	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6546	9/13/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6620	10/10/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6693	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6797	12/12/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6883	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6935	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7036	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7106	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7184	5/8/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7263	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7334	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7450	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7528	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7574	10/1/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7714	11/12/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7802	12/10/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7889	1/14/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7956	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8028	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8102	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8161	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8245	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8320	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8399	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8502	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8631	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8676	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8750	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8883	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8912	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 4, Room 4e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 4e	4029	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4066	6/8/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4142	7/21/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4203	8/13/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4277	9/15/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4318	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4401	11/9/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4534	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4598	1/20/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4683	2/10/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4836	3/17/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4918	4/13/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5053	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5178	6/15/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5313	7/27/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5399	8/25/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5453	9/14/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5572	10/20/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5664	11/16/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5721	12/8/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5819	1/12/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5895	2/7/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5983	3/2/2011	3/4/2011	N.D.	2	23.97	47.94	23.97

Methane (CH_4) Panel 4, Room 4i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 4i	4025	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4070	6/9/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4133	7/20/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4194	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4268	9/14/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4309	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4410	11/11/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4525	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4589	1/19/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4674	2/9/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4827	3/16/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4928	4/14/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5044	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5169	6/14/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5304	7/26/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5390	8/24/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5444	9/13/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5563	10/19/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5655	11/15/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5712	12/7/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5810	1/11/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5884	2/1/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5974	3/1/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6077	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6176	5/2/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6327	6/15/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6403	7/11/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6471	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6547	9/13/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6621	10/10/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6694	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6798	12/12/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6884	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6936	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7037	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7107	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7185	5/8/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7264	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7335	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7451	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7529	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7575	10/1/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7715	11/12/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7803	12/10/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7890	1/14/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7957	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8029	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8103	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8162	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8246	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8321	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8400	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8503	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8632	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8677	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8751	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8884	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8913	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 4, Room 3e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 3e	4019	5/26/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4077	6/10/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4143	7/21/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4204	8/13/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4278	9/15/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4319	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4400	11/9/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4535	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4599	1/20/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4684	2/10/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4837	3/17/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4919	4/13/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5054	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5179	6/15/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5314	7/27/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5400	8/25/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5454	9/14/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5573	10/20/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5665	11/16/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5722	12/8/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5820	1/12/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5896	2/7/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5984	3/2/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6087	4/6/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6185	5/3/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6336	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6412	7/12/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6480	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6558	9/14/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6630	10/11/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6703	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6807	12/13/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6893	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6944	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7045	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7115	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7193	5/9/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7272	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7343	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7459	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7536	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7582	10/2/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7722	11/13/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7810	12/11/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7897	1/15/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7964	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8036	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8110	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8169	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8253	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8328	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8405	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8508	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8637	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8682	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8756	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8891	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8920	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 4, Room 3i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 3i	4024	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4079	6/10/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4134	7/20/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4195	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4269	9/14/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4310	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4409	11/11/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4526	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4590	1/19/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4675	2/9/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4828	3/16/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4929	4/14/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5045	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5170	6/15/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5305	7/26/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5391	8/24/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5445	9/13/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5564	10/19/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5656	11/15/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5713	12/7/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5811	1/11/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5885	2/1/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5975	3/1/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6078	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6177	5/2/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6328	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6404	7/11/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6472	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6548	9/13/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6622	10/10/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6695	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6799	12/12/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6885	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6937	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7038	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7108	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7186	5/8/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7265	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7336	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7452	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7530	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7576	10/1/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7716	11/12/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7804	12/10/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7891	1/14/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7958	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8030	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8104	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8163	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8247	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8322	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8401	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8504	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8633	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8678	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8752	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8885	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8914	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 4, Room 2e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 2e	4018	5/26/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4076	6/10/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4144	7/22/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4205	8/13/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4279	9/15/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4320	10/6/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4399	11/9/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4536	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4600	1/20/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4685	2/10/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4838	3/17/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4920	4/13/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5055	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5180	6/16/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5315	7/27/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5401	8/25/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5455	9/14/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5574	10/20/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5666	11/16/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5723	12/8/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5821	1/12/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5897	2/7/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5985	3/2/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6088	4/6/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6186	5/3/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6337	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6413	7/12/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6481	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6559	9/14/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6631	10/11/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6704	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6808	12/13/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6894	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6945	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7046	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7116	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7194	5/9/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7273	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7344	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7460	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7537	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7583	10/2/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7723	11/13/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7811	12/11/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7898	1/15/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7965	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8037	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8111	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8170	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8254	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8329	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8406	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8509	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8638	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8683	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8757	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8892	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8921	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 4, Room 2i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 2i	4023	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4078	6/10/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4135	7/20/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4196	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4270	9/14/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4311	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4408	11/11/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4527	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4591	1/19/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4676	2/9/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4829	3/16/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4930	4/14/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5046	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5171	6/15/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5306	7/26/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5392	8/24/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5446	9/13/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5565	10/19/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5657	11/15/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5714	12/7/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5812	1/11/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5886	2/1/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5976	3/1/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6079	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6178	5/2/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6329	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6405	7/11/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6473	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6549	9/13/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6623	10/10/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6696	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6800	12/12/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6886	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6938	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7039	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7109	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7187	5/8/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7266	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7337	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7453	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7531	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7577	10/1/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7717	11/12/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7805	12/10/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7892	1/14/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7959	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8031	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8105	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8164	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8248	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8323	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8402	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8505	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8634	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8679	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8753	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8886	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8915	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 4, Room 1e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 1e	4016	5/26/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4074	6/9/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4145	7/22/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4206	8/13/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4280	9/15/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4321	10/6/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4397	11/9/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4537	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4601	1/20/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4686	2/10/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4839	3/17/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4923	4/14/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5056	5/18/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5181	6/16/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5316	7/27/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5402	8/25/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5456	9/14/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5575	10/20/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5667	11/16/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5724	12/8/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5822	1/12/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5890	2/1/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5986	3/2/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6089	4/6/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6187	5/4/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6338	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6414	7/12/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6482	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6560	9/14/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6634	10/11/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6707	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6811	12/13/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6897	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6948	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7049	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7119	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7197	5/9/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7276	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7347	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7463	8/14/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7540	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7586	10/2/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7726	11/13/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7814	12/11/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7901	1/15/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7968	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8040	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8114	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8173	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8257	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8332	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8411	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8514	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8643	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8688	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8762	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8895	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8924	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 4, Room 1i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Room 1i	4020	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4061	6/8/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4136	7/20/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4197	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4271	9/14/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4312	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4407	11/11/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4528	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4592	1/19/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4677	2/9/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4830	3/16/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4931	4/14/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5047	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5172	6/15/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5307	7/26/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5393	8/24/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5447	9/13/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5566	10/19/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5658	11/15/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5715	12/7/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5813	1/11/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5887	2/1/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5977	3/1/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6080	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6179	5/2/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6330	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6406	7/11/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6474	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6550	9/13/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6624	10/10/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6697	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6801	12/12/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6887	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6939	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7040	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7110	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7188	5/8/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7267	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7338	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7454	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7532	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7578	10/1/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7718	11/13/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7806	12/10/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7893	1/14/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7960	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8032	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8106	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8165	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8249	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8324	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8403	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8506	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8635	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8680	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8754	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8887	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8916	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4)
Panel 4, EBW

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Location EBW	4015	5/26/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4065	6/8/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4147	7/22/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4208	8/13/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4282	9/15/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4323	10/6/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4396	11/9/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4539	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4603	1/20/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4688	2/10/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4841	3/17/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4921	4/13/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5058	5/18/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5183	6/16/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5318	7/27/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5404	8/25/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5458	9/14/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5577	10/20/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5669	11/16/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5726	12/8/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5824	1/12/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5898	2/7/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5988	3/2/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6091	4/6/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6189	5/4/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6340	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6416	7/12/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6484	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6562	9/14/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6632	10/11/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6705	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6809	12/13/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6895	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6946	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7047	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7117	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7195	5/9/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7274	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7345	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7461	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7538	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7584	10/2/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7724	11/13/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7812	12/11/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7899	1/15/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7966	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8038	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8112	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8171	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8255	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8330	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8407	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8510	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8639	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8684	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8758	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8893	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8922	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4)
Panel 4, EBA

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Location EBA	4014	5/26/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4064	6/8/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4148	7/22/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4209	8/13/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4283	9/15/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4324	10/6/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4395	11/9/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4540	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4604	1/20/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4689	2/10/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4842	3/17/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4922	4/13/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5059	5/18/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5184	6/16/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5319	7/27/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5405	8/25/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5459	9/14/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5578	10/20/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5670	11/16/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5727	12/8/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5825	1/12/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5899	2/7/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5989	3/2/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6092	4/6/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6190	5/4/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6341	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6417	7/12/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6485	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6563	9/14/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6633	10/11/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6706	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6810	12/13/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6896	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6947	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7048	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7118	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7196	5/9/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7275	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7346	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7462	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7539	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7585	10/2/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7725	11/13/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7813	12/11/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7900	1/15/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7967	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8039	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8113	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8172	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8256	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8331	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8408	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8511	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8640	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8685	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8759	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8894	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8923	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4) Panel 4, IBW								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Location IBW	4022	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4063	6/8/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4137	7/20/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4198	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4272	9/14/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4313	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4406	11/11/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4529	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4593	1/19/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4678	2/9/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4831	3/16/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4932	4/14/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5048	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5173	6/15/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5308	7/26/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5394	8/24/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5448	9/13/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5567	10/19/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5659	11/15/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5716	12/7/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5814	1/11/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5888	2/1/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5978	3/1/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6081	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6180	5/3/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6331	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6407	7/11/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6475	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6551	9/13/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6625	10/10/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6698	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6802	12/12/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6888	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6940	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7041	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7111	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7189	5/8/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7268	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7339	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7455	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7533	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7579	10/2/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7719	11/13/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7807	12/10/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7894	1/15/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7961	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8033	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8107	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8166	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8250	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8325	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8409	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8512	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8641	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8686	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8760	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8888	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8917	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Methane (CH_4)

Panel 4, IBA

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution Corrected MDL (ppmv)	Concentration for Statistical Analysis (ppmv)
Panel 4 Location IBA	4021	5/27/2009	5/29/2009	N.D.	2	23.74	47.48	23.74
	4062	6/8/2009	6/12/2009	N.D.	2	23.74	47.48	23.74
	4138	7/20/2009	7/24/2009	N.D.	2	22.21	44.42	22.21
	4199	8/11/2009	8/17/2009	N.D.	2	22.21	44.42	22.21
	4273	9/14/2009	9/18/2009	N.D.	2	22.21	44.42	22.21
	4314	10/5/2009	10/12/2009	N.D.	2	22.21	44.42	22.21
	4405	11/11/2009	11/16/2009	N.D.	2	22.21	44.42	22.21
	4530	12/30/2009	1/12/2010	N.D.	2	22.21	44.42	22.21
	4594	1/19/2010	1/22/2010	N.D.	2	22.21	44.42	22.21
	4679	2/10/2010	2/12/2010	N.D.	2	22.21	44.42	22.21
	4832	3/16/2010	3/29/2010	N.D.	2	22.21	44.42	22.21
	4933	4/14/2010	4/20/2010	N.D.	2	22.21	44.42	22.21
	5049	5/17/2010	5/24/2010	N.D.	2	22.21	44.42	22.21
	5174	6/15/2010	6/21/2010	N.D.	2	21.39	42.78	21.39
	5309	7/26/2010	8/2/2010	N.D.	2	21.39	42.78	21.39
	5395	8/24/2010	8/30/2010	N.D.	2	21.39	42.78	21.39
	5449	9/13/2010	9/20/2010	N.D.	2	21.39	42.78	21.39
	5568	10/19/2010	10/25/2010	N.D.	2	21.39	42.78	21.39
	5660	11/15/2010	11/22/2010	N.D.	2	21.39	42.78	21.39
	5717	12/7/2010	12/13/2010	N.D.	2	21.39	42.78	21.39
	5815	1/11/2011	1/18/2011	N.D.	2	23.97	47.94	23.97
	5889	2/1/2011	2/10/2011	N.D.	2	23.97	47.94	23.97
	5979	3/1/2011	3/4/2011	N.D.	2	23.97	47.94	23.97
	6082	4/5/2011	4/20/2011	N.D.	2	23.97	47.94	23.97
	6181	5/3/2011	5/6/2011	N.D.	2	23.97	47.94	23.97
	6332	6/16/2011	6/24/2011	N.D.	2	23.97	47.94	23.97
	6408	7/12/2011	7/15/2011	N.D.	2	23.97	47.94	23.97
	6476	8/9/2011	8/19/2011	N.D.	2	23.97	47.94	23.97
	6552	9/14/2011	9/16/2011	N.D.	2	23.97	47.94	23.97
	6626	10/10/2011	10/14/2011	N.D.	2	23.97	47.94	23.97
	6699	11/1/2011	11/4/2011	N.D.	2	23.97	47.94	23.97
	6803	12/12/2011	12/16/2011	N.D.	2	17.45	34.90	17.45
	6889	1/17/2012	1/23/2012	N.D.	2	17.45	34.90	17.45
	6941	2/7/2012	2/10/2012	N.D.	2	17.45	34.90	17.45
	7042	3/13/2012	3/16/2012	N.D.	2	17.45	34.90	17.45
	7112	4/10/2012	4/13/2012	N.D.	2	17.45	34.90	17.45
	7190	5/8/2012	5/15/2012	N.D.	2	17.45	34.90	17.45
	7269	6/11/2012	6/18/2012	N.D.	2	17.45	34.90	17.45
	7340	7/10/2012	7/13/2012	N.D.	2	17.45	34.90	17.45
	7456	8/13/2012	8/17/2012	N.D.	2	17.45	34.90	17.45
	7534	9/10/2012	9/14/2012	N.D.	2	17.45	34.90	17.45
	7580	10/2/2012	10/5/2012	N.D.	2	17.45	34.90	17.45
	7720	11/13/2012	11/16/2012	N.D.	2	15.71	31.42	15.71
	7808	12/11/2012	12/14/2012	N.D.	2	15.71	31.42	15.71
	7895	1/15/2013	1/18/2013	N.D.	2	15.71	31.42	15.71
	7962	2/12/2013	2/15/2013	N.D.	2	15.71	31.42	15.71
	8034	3/12/2013	3/15/2013	N.D.	2	15.71	31.42	15.71
	8108	4/9/2013	4/12/2013	N.D.	2	15.71	31.42	15.71
	8167	5/7/2013	5/10/2013	N.D.	2	15.71	31.42	15.71
	8251	6/3/2013	6/7/2013	N.D.	2	15.71	31.42	15.71
	8326	7/1/2013	7/9/2013	N.D.	2	15.71	31.42	15.71
	8410	8/5/2013	8/9/2013	N.D.	2	15.71	31.42	15.71
	8513	9/9/2013	9/16/2013	N.D.	2	15.71	31.42	15.71
	8642	10/21/2013	10/25/2013	N.D.	2	14.87	29.74	14.87
	8687	11/4/2013	11/8/2013	N.D.	2	14.87	29.74	14.87
	8761	12/2/2013	12/10/2013	N.D.	2	14.87	29.74	14.87
	8889	1/20/2014	1/28/2014	N.D.	2	14.87	29.74	14.87
	8918	2/3/2014	2/11/2014	N.D.	2	14.87	29.74	14.87

Appendix E

Panel 3 Hydrogen Data

Hydrogen (H_2)
Panel 3, Room 7e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 7e	3176	4/24/2008	4/30/2008	59.74	2	10.79	21.58	59.74
	3213	5/15/2008	5/23/2008	86.52	2	10.79	21.58	86.52
	3281	6/19/2008	6/25/2008	103.78	2	10.79	21.58	103.78
	3340	7/16/2008	7/22/2008	178.92	2	10.79	21.58	178.92
	3405	8/19/2008	8/22/2008	353.02	2	14.93	29.86	353.02
	3453	9/10/2008	9/12/2008	209.46	2	14.93	29.86	209.46
	3509	10/8/2008	10/10/2008	352.68	2	14.93	29.86	352.68
	3582	11/13/2008	11/18/2008	146.54	2	14.93	29.86	146.54
	3621	12/3/2008	12/6/2008	89.50	2	14.93	29.86	89.50
	3720	1/13/2009	1/21/2009	83.18	2	14.93	29.86	83.18
	3777	2/10/2009	2/13/2009	53.76	2	14.93	29.86	53.76
	3844	3/11/2009	3/27/2009	53.88	2	14.93	29.86	53.88
	3919	4/14/2009	4/22/2009	51.82	2	14.93	29.86	51.82
	3990	5/12/2009	5/15/2009	88.94	2	14.93	29.86	88.94
	4048	6/2/2009	6/8/2009	68.52	2	14.93	29.86	68.52
	4106	7/7/2009	7/10/2009	123.32	2	15.17	30.34	123.32
	4165	8/5/2009	8/13/2009	84.52	2	15.17	30.34	84.52
	4236	9/1/2009	9/4/2009	130.44	2	15.17	30.34	130.44
	4333	10/12/2009	10/15/2009	95.60	2	15.17	30.34	95.60
	4375	11/2/2009	11/12/2009	90.80	2	15.17	30.34	90.80
	4465	12/8/2009	12/15/2009	23.62	2	15.17	30.34	15.17
	4626	1/26/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4724	2/17/2010	2/23/2010	84.12	2	15.17	30.34	84.12
	4790	3/9/2010	3/12/2010	64.72	2	15.17	30.34	64.72
	4958	4/20/2010	4/28/2010	57.18	2	15.17	30.34	57.18
	5082	5/25/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5117	6/1/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5255	7/13/2010	7/19/2010	127.94	2	7.00	14.00	127.94

Hydrogen (H_2)
Panel 3, Room 7i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 7i	3175	4/24/2008	4/30/2008	N.D.	2	10.79	21.58	10.79
	3222	5/19/2008	5/23/2008	10.40	2	10.79	21.58	10.79

Hydrogen (H_2)

Panel 3, Room 6e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 6e	3178	4/24/2008	4/30/2008	27.34	2	10.79	21.58	27.34
	3212	5/14/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3280	6/19/2008	6/25/2008	69.22	2	10.79	21.58	69.22
	3339	7/16/2008	7/22/2008	145.62	2	10.79	21.58	145.62
	3426	8/20/2008	8/22/2008	228.66	2	14.93	29.86	228.66
	3452	9/10/2008	9/12/2008	136.30	2	14.93	29.86	136.30
	3508	10/8/2008	10/10/2008	12.42	2	14.93	29.86	14.93
	3581	11/13/2008	11/18/2008	35.30	2	14.93	29.86	35.30
	3620	12/3/2008	12/6/2008	76.10	2	14.93	29.86	76.10
	3719	1/13/2009	1/21/2009	64.12	2	14.93	29.86	64.12
	3776	2/10/2009	2/13/2009	43.60	2	14.93	29.86	43.60
	3843	3/10/2009	3/27/2009	67.46	2	14.93	29.86	67.46
	3918	4/14/2009	4/22/2009	53.12	2	14.93	29.86	53.12
	3989	5/12/2009	5/15/2009	76.46	2	14.93	29.86	76.46
	4047	6/2/2009	6/8/2009	39.94	2	14.93	29.86	39.94
	4107	7/7/2009	7/10/2009	110.02	2	15.17	30.34	110.02
	4166	8/5/2009	8/13/2009	79.50	2	15.17	30.34	79.50
	4237	9/1/2009	9/4/2009	106.26	2	15.17	30.34	106.26
	4334	10/12/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4376	11/2/2009	11/12/2009	51.54	2	15.17	30.34	51.54
	4466	12/8/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4627	1/26/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4725	2/17/2010	2/23/2010	49.20	2	15.17	30.34	49.20
	4791	3/9/2010	3/12/2010	77.26	2	15.17	30.34	77.26
	4959	4/20/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5083	5/25/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5118	6/1/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5256	7/13/2010	7/19/2010	N.D.	2	7.00	14.00	7.00
	5349	8/9/2010	8/17/2010	97.04	2	7.00	14.00	97.04
	5475	9/21/2010	9/27/2010	114.26	2	7.00	14.00	114.26
	5534	10/11/2010	10/18/2010	98.94	2	7.00	14.00	98.94
	5627	11/8/2010	11/15/2010	93.20	2	7.00	14.00	93.20
	5746	12/14/2010	12/20/2010	92.60	2	7.00	14.00	92.60
	5844	1/18/2011	1/24/2011	140.32	2	14.03	28.06	140.32
	5930	2/15/2011	2/21/2011	62.32	2	14.03	28.06	62.32
	6018	3/8/2011	3/11/2011	87.88	2	14.03	28.06	87.88
	6131	4/19/2011	4/26/2011	N.D.	2	14.03	28.06	14.03
	6213	5/9/2011	5/13/2011	48.58	2	14.03	28.06	48.58
	6313	6/14/2011	6/21/2011	53.46	2	14.03	28.06	53.46
	6427	7/18/2011	7/28/2011	36.06	2	14.03	28.06	36.06
	6495	8/15/2011	8/22/2011	76.68	2	14.03	28.06	76.68
	6573	9/19/2011	9/27/2011	46.88	2	14.03	28.06	46.88
	6646	10/17/2011	10/25/2011	38.82	2	14.03	28.06	38.82
	6718	11/7/2011	11/11/2011	32.08	2	14.03	28.06	32.08
	6773	12/5/2011	12/9/2011	27.48	2	14.40	28.80	14.40
	6858	1/9/2012	1/13/2012	52.82	2	14.40	28.80	52.82
	6961	2/16/2012	2/22/2012	34.02	2	14.40	28.80	34.02
	7011	3/6/2012	3/9/2012	45.38	2	14.40	28.80	45.38
	7084	4/2/2012	4/9/2012	29.00	2	14.40	28.80	29.00
	7162	5/1/2012	5/4/2012	32.72	2	14.40	28.80	32.72
	7235	6/4/2012	6/8/2012	34.30	2	14.40	28.80	34.30
	7362	7/16/2012	7/23/2012	37.86	2	14.40	28.80	37.86
	7420	8/6/2012	8/10/2012	29.30	2	14.40	28.80	29.30
	7505	9/4/2012	9/7/2012	31.18	2	14.40	28.80	31.18

Hydrogen (H_2) Panel 3, Room 6i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 6i	3166	4/24/2008	4/30/2008	21.80	2	10.79	21.58	21.80
	3221	5/15/2008	5/23/2008	23.28	2	10.79	21.58	23.28
	3289	6/19/2008	6/25/2008	78.90	2	10.79	21.58	78.90
	3348	7/16/2008	7/22/2008	126.18	2	10.79	21.58	126.18
	3412	8/20/2008	8/22/2008	185.26	2	14.93	29.86	185.26
	3460	9/10/2008	9/12/2008	311.62	2	14.93	29.86	311.62
	3516	10/8/2008	10/10/2008	19.46	2	14.93	29.86	14.93
	3589	11/13/2008	11/18/2008	N.D.	2	14.93	29.86	14.93
	3628	12/3/2008	12/6/2008	N.D.	2	14.93	29.86	14.93
	3723	1/14/2009	1/21/2009	25.66	2	14.93	29.86	14.93
	3784	2/11/2009	2/13/2009	22.22	2	14.93	29.86	14.93
	3847	3/11/2009	3/27/2009	27.96	2	14.93	29.86	14.93
	3922	4/14/2009	4/22/2009	32.58	2	14.93	29.86	32.58
	3986	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4055	6/2/2009	6/8/2009	28.90	2	14.93	29.86	14.93
	4114	7/8/2009	7/10/2009	71.36	2	15.17	30.34	71.36
	4171	8/5/2009	8/13/2009	44.14	2	15.17	30.34	44.14
	4244	9/2/2009	9/4/2009	60.60	2	15.17	30.34	60.60
	4341	10/13/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4383	11/3/2009	11/12/2009	36.66	2	15.17	30.34	36.66
	4473	12/9/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4634	1/27/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4732	2/18/2010	2/23/2010	31.48	2	15.17	30.34	31.48
	4800	3/10/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	4966	4/21/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5090	5/26/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5125	6/2/2010	6/7/2010	50.92	2	15.17	30.34	50.92
	5263	7/14/2010	7/19/2010	N.D.	2	7.00	14.00	7.00
	5356	8/10/2010	8/17/2010	96.30	2	7.00	14.00	96.30

Hydrogen (H_2)

Panel 3, Room 5e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 5e	3179	4/24/2008	4/30/2008	45.70	2	10.79	21.58	45.70
	3211	5/14/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3279	6/17/2008	6/25/2008	91.62	2	10.79	21.58	91.62
	3338	7/16/2008	7/22/2008	156.04	2	10.79	21.58	156.04
	3403	8/19/2008	8/22/2008	221.24	2	14.93	29.86	221.24
	3451	9/10/2008	9/12/2008	207.98	2	14.93	29.86	207.98
	3507	10/8/2008	10/10/2008	187.98	2	14.93	29.86	187.98
	3580	11/13/2008	11/18/2008	101.64	2	14.93	29.86	101.64
	3619	12/3/2008	12/6/2008	66.24	2	14.93	29.86	66.24
	3718	1/13/2009	1/21/2009	61.18	2	14.93	29.86	61.18
	3775	2/10/2009	2/13/2009	N.D.	2	14.93	29.86	14.93
	3842	3/10/2009	3/27/2009	63.18	2	14.93	29.86	63.18
	3917	4/14/2009	4/22/2009	51.28	2	14.93	29.86	51.28
	3988	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4046	6/1/2009	6/8/2009	42.80	2	14.93	29.86	42.80
	4108	7/7/2009	7/10/2009	102.20	2	15.17	30.34	102.20
	4167	8/5/2009	8/13/2009	57.74	2	15.17	30.34	57.74
	4238	9/1/2009	9/4/2009	59.18	2	15.17	30.34	59.18
	4335	10/12/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4377	11/2/2009	11/12/2009	65.18	2	15.17	30.34	65.18
	4467	12/8/2009	12/15/2009	12.40	2	15.17	30.34	15.17
	4628	1/26/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4726	2/17/2010	2/23/2010	76.68	2	15.17	30.34	76.68
	4792	3/9/2010	3/12/2010	61.28	2	15.17	30.34	61.28
	4960	4/20/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5084	5/25/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5119	6/1/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5257	7/13/2010	7/19/2010	49.72	2	7.00	14.00	49.72
	5350	8/9/2010	8/17/2010	101.44	2	7.00	14.00	101.44
	5476	9/21/2010	9/27/2010	100.80	2	7.00	14.00	100.80
	5535	10/11/2010	10/18/2010	80.42	2	7.00	14.00	80.42
	5628	11/8/2010	11/15/2010	50.66	2	7.00	14.00	50.66
	5747	12/14/2010	12/20/2010	89.50	2	7.00	14.00	89.50
	5845	1/18/2011	1/24/2011	125.50	2	14.03	28.06	125.50
	5931	2/15/2011	2/21/2011	69.84	2	14.03	28.06	69.84
	6019	3/8/2011	3/11/2011	88.68	2	14.03	28.06	88.68
	6132	4/19/2011	4/26/2011	47.86	2	14.03	28.06	47.86
	6214	5/9/2011	5/13/2011	51.18	2	14.03	28.06	51.18
	6314	6/14/2011	6/21/2011	56.52	2	14.03	28.06	56.52
	6428	7/18/2011	7/22/2011	50.44	2	14.03	28.06	50.44
	6496	8/15/2011	8/22/2011	59.04	2	14.03	28.06	59.04
	6574	9/19/2011	9/27/2011	41.84	2	14.03	28.06	41.84
	6647	10/17/2011	10/25/2011	25.74	2	14.03	28.06	25.74
	6719	11/7/2011	11/11/2011	32.00	2	14.03	28.06	32.00
	6774	12/5/2011	12/9/2011	44.44	2	14.40	28.80	44.44
	6859	1/9/2012	1/13/2012	51.44	2	14.40	28.80	51.44
	6962	2/16/2012	2/22/2012	22.48	2	14.40	28.80	14.40
	7012	3/6/2012	3/9/2012	52.86	2	14.40	28.80	52.86
	7085	4/2/2012	4/9/2012	43.68	2	14.40	28.80	43.68
	7163	5/1/2012	5/4/2012	48.28	2	14.40	28.80	48.28
	7236	6/4/2012	6/8/2012	N.D.	2	14.40	28.80	14.40
	7363	7/16/2012	7/23/2012	29.78	2	14.40	28.80	29.78
	7421	8/6/2012	8/10/2012	44.24	2	14.40	28.80	44.24
	7506	9/4/2012	9/7/2012	37.76	2	14.40	28.80	37.76
	7617	10/8/2012	10/16/2012	32.84	2	14.40	28.80	32.84
	7687	11/5/2012	11/9/2012	37.16	2	17.29	34.58	37.16
	7773	12/3/2012	12/7/2012	42.52	2	17.29	34.58	42.52
	7866	1/8/2013	1/14/2013	38.90	2	17.29	34.58	38.90
	7929	2/5/2013	2/8/2013	24.94	2	17.29	34.58	17.29
	8002	3/5/2013	3/11/2013	18.64	2	17.29	34.58	17.29
	8088	4/2/2013	4/5/2013	39.80	2	17.29	34.58	39.80
	8187	5/13/2013	5/17/2013	26.72	2	17.29	34.58	17.29
	8261	6/9/2013	6/14/2013	25.48	2	17.29	34.58	17.29
	8336	7/9/2013	7/12/2013	39.02	2	17.29	34.58	39.02
	8440	8/12/2013	8/19/2013	49.14	2	17.29	34.58	49.14
	8534	9/16/2013	9/20/2013	51.02	2	17.29	34.58	51.02
	8579	10/8/2013	10/11/2013	34.84	2	17.29	34.58	34.84
	8708	11/11/2013	11/18/2013	26.44	2	16.29	32.58	16.29
	8778	12/9/2013	12/13/2013	29.38	2	16.29	32.58	16.29
	8854	1/14/2014	1/22/2014	23.48	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 3, Room 5i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 5i	3177	4/24/2008	4/30/2008	24.18	2	10.79	21.58	24.18
	3220	5/15/2008	5/23/2008	17.68	2	10.79	21.58	10.79
	3288	6/19/2008	6/25/2008	60.62	2	10.79	21.58	60.62
	3347	7/16/2008	7/22/2008	166.08	2	10.79	21.58	166.08
	3411	8/19/2008	8/22/2008	247.14	2	14.93	29.86	247.14
	3459	9/10/2008	9/12/2008	220.32	2	14.93	29.86	220.32
	3515	10/8/2008	10/10/2008	57.40	2	14.93	29.86	57.40
	3588	11/13/2008	11/18/2008	N.D.	2	14.93	29.86	14.93
	3627	12/3/2008	12/6/2008	N.D.	2	14.93	29.86	14.93
	3722	1/13/2009	1/21/2009	26.62	2	14.93	29.86	14.93
	3783	2/11/2009	2/13/2009	N.D.	2	14.93	29.86	14.93
	3846	3/11/2009	3/27/2009	16.56	2	14.93	29.86	14.93
	3921	4/14/2009	4/22/2009	18.66	2	14.93	29.86	14.93
	3985	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4054	6/2/2009	6/8/2009	32.80	2	14.93	29.86	32.80
	4115	7/8/2009	7/10/2009	99.70	2	15.17	30.34	99.70
	4176	8/6/2009	8/13/2009	81.66	2	15.17	30.34	81.66
	4245	9/2/2009	9/4/2009	62.66	2	15.17	30.34	62.66
	4342	10/13/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4384	11/3/2009	11/12/2009	32.30	2	15.17	30.34	32.30
	4474	12/9/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4635	1/27/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4733	2/18/2010	2/23/2010	N.D.	2	15.17	30.34	15.17
	4801	3/10/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	4967	4/21/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5091	5/26/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5126	6/2/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5264	7/14/2010	7/19/2010	N.D.	2	7.00	14.00	7.00
	5357	8/10/2010	8/17/2010	93.94	2	7.00	14.00	93.94
	5483	9/22/2010	9/27/2010	96.22	2	7.00	14.00	96.22
	5541	10/12/2010	10/18/2010	46.98	2	7.00	14.00	46.98
	5634	11/9/2010	11/15/2010	54.98	2	7.00	14.00	54.98
	5753	12/15/2010	12/20/2010	76.98	2	7.00	14.00	76.98
	5851	1/19/2011	1/24/2011	N.D.	2	14.03	28.06	14.03
	5937	2/15/2011	2/21/2011	31.10	2	14.03	28.06	31.10
	6025	3/9/2011	3/11/2011	39.10	2	14.03	28.06	39.10
	6138	4/19/2011	4/26/2011	N.D.	2	14.03	28.06	14.03
	6220	5/10/2011	5/13/2011	30.62	2	14.03	28.06	30.62
	6320	6/15/2011	6/21/2011	18.64	2	14.03	28.06	14.03
	6436	7/19/2011	7/22/2011	N.D.	2	14.03	28.06	14.03
	6502	8/16/2011	8/22/2011	49.46	2	14.03	28.06	49.46
	6580	9/20/2011	9/27/2011	27.16	2	14.03	28.06	14.03
	6651	10/17/2011	10/25/2011	15.38	2	14.03	28.06	14.03
	6725	11/7/2011	11/11/2011	N.D.	2	14.03	28.06	14.03
	6780	12/5/2011	12/9/2011	N.D.	2	14.40	28.80	14.40
	6865	1/10/2012	1/13/2012	N.D.	2	14.40	28.80	14.40
	6968	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7018	3/6/2012	3/9/2012	N.D.	2	14.40	28.80	14.40
	7091	4/3/2012	4/9/2012	12.68	2	14.40	28.80	14.40
	7169	5/1/2012	5/4/2012	N.D.	2	14.40	28.80	14.40
	7242	6/5/2012	6/8/2012	N.D.	2	14.40	28.80	14.40
	7369	7/17/2012	7/23/2012	N.D.	2	14.40	28.80	14.40
	7427	8/6/2012	8/10/2012	N.D.	2	14.40	28.80	14.40
	7512	9/4/2012	9/7/2012	N.D.	2	14.40	28.80	14.40
	7623	10/9/2012	10/16/2012	N.D.	2	14.40	28.80	14.40
	7693	11/6/2012	11/9/2012	N.D.	2	17.29	34.58	17.29
	7779	12/4/2012	12/7/2012	29.86	2	17.29	34.58	17.29
	7872	1/8/2013	1/14/2013	N.D.	2	17.29	34.58	17.29
	7935	2/5/2013	2/8/2013	N.D.	2	17.29	34.58	17.29
	8008	3/5/2013	3/11/2013	N.D.	2	17.29	34.58	17.29
	8094	4/2/2013	4/5/2013	N.D.	2	17.29	34.58	17.29
	8193	5/14/2013	5/17/2013	29.56	2	17.29	34.58	17.29
	8267	6/10/2013	6/14/2013	N.D.	2	17.29	34.58	17.29
	8342	7/9/2013	7/12/2013	25.30	2	17.29	34.58	17.29
	8446	8/12/2013	8/19/2013	18.22	2	17.29	34.58	17.29
	8540	9/16/2013	9/20/2013	35.20	2	17.29	34.58	35.20
	8585	10/8/2013	10/11/2013	N.D.	2	17.29	34.58	17.29
	8714	11/11/2013	11/18/2013	N.D.	2	16.29	32.58	16.29
	8784	12/9/2013	12/13/2013	N.D.	2	16.29	32.58	16.29
	8860	1/15/2014	1/22/2014	N.D.	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 3, Room 4e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 4e	3174	4/24/2008	4/30/2008	56.32	2	10.79	21.58	56.32
	3210	5/14/2008	5/23/2008	48.84	2	10.79	21.58	48.84
	3278	6/17/2008	6/25/2008	20.00	2	10.79	21.58	10.79
	3337	7/16/2008	7/22/2008	54.12	2	10.79	21.58	54.12
	3402	8/19/2008	8/22/2008	120.12	2	14.93	29.86	120.12
	3450	9/10/2008	9/12/2008	136.06	2	14.93	29.86	136.06
	3506	10/8/2008	10/10/2008	N.D.	2	14.93	29.86	14.93
	3579	11/13/2008	11/18/2008	N.D.	2	14.93	29.86	14.93
	3618	12/3/2008	12/6/2008	49.22	2	14.93	29.86	49.22
	3717	1/13/2009	1/21/2009	55.40	2	14.93	29.86	55.40
	3774	2/10/2009	2/13/2009	35.76	2	14.93	29.86	35.76
	3841	3/10/2009	3/27/2009	47.92	2	14.93	29.86	47.92
	3916	4/14/2009	4/22/2009	35.76	2	14.93	29.86	35.76
	3987	5/12/2009	5/15/2009	15.26	2	14.93	29.86	14.93
	4045	6/1/2009	6/8/2009	41.08	2	14.93	29.86	41.08
	4109	7/7/2009	7/10/2009	91.98	2	15.17	30.34	91.98
	4168	8/5/2009	8/13/2009	52.92	2	15.17	30.34	52.92
	4239	9/1/2009	9/4/2009	45.46	2	15.17	30.34	45.46
	4336	10/12/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4378	11/2/2009	11/12/2009	54.43	2.1	15.17	31.86	54.43
	4468	12/8/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4629	1/26/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4727	2/17/2010	2/23/2010	63.46	2	15.17	30.34	63.46
	4793	3/9/2010	3/12/2010	43.46	2	15.17	30.34	43.46
	4961	4/20/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5085	5/25/2010	5/28/2010	58.64	2	15.17	30.34	58.64
	5120	6/1/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5258	7/13/2010	7/19/2010	39.14	2	7.00	14.00	39.14
	5351	8/9/2010	8/17/2010	99.22	2	7.00	14.00	99.22
	5477	9/21/2010	9/27/2010	90.04	2	7.00	14.00	90.04
	5536	10/11/2010	10/18/2010	85.22	2	7.00	14.00	85.22
	5629	11/8/2010	11/15/2010	68.10	2	7.00	14.00	68.10
	5748	12/14/2010	12/20/2010	89.98	2	7.00	14.00	89.98
	5846	1/18/2011	1/24/2011	132.24	2	14.03	28.06	132.24
	5932	2/15/2011	2/21/2011	66.56	2	14.03	28.06	66.56
	6020	3/8/2011	3/11/2011	58.04	2	14.03	28.06	58.04
	6133	4/19/2011	4/26/2011	43.64	2	14.03	28.06	43.64
	6215	5/9/2011	5/13/2011	55.34	2	14.03	28.06	55.34
	6315	6/14/2011	6/21/2011	43.96	2	14.03	28.06	43.96
	6429	7/18/2011	7/22/2011	55.78	2	14.03	28.06	55.78
	6497	8/15/2011	8/22/2011	66.62	2	14.03	28.06	66.62
	6575	9/19/2011	9/27/2011	51.62	2	14.03	28.06	51.62
	6648	10/17/2011	10/25/2011	34.04	2	14.03	28.06	34.04
	6720	11/7/2011	11/11/2011	30.00	2	14.03	28.06	30.00
	6775	12/5/2011	12/9/2011	29.26	2	14.40	28.80	29.26
	6860	1/9/2012	1/13/2012	58.28	2	14.40	28.80	58.28
	6963	2/16/2012	2/22/2012	14.74	2	14.40	28.80	14.40
	7013	3/6/2012	3/9/2012	42.20	2	14.40	28.80	42.20
	7086	4/2/2012	4/9/2012	33.40	2	14.40	28.80	33.40
	7164	5/1/2012	5/4/2012	N.D.	2	14.40	28.80	14.40
	7237	6/4/2012	6/8/2012	41.10	2	14.40	28.80	41.10
	7364	7/16/2012	7/23/2012	49.44	2	14.40	28.80	49.44
	7422	8/6/2012	8/10/2012	27.22	2	14.40	28.80	14.40
	7507	9/4/2012	9/7/2012	37.36	2	14.40	28.80	37.36
	7618	10/9/2012	10/16/2012	38.28	2	14.40	28.80	38.28
	7688	11/5/2012	11/9/2012	23.10	2	17.29	34.58	17.29
	7774	12/3/2012	12/7/2012	34.96	2	17.29	34.58	34.96
	7867	1/8/2013	1/14/2013	38.68	2	17.29	34.58	38.68
	7930	2/5/2013	2/8/2013	34.48	2	17.29	34.58	17.29
	8003	3/5/2013	3/11/2013	18.38	2	17.29	34.58	17.29
	8089	4/2/2013	4/5/2013	34.22	2	17.29	34.58	17.29
	8188	5/13/2013	5/17/2013	25.96	2	17.29	34.58	17.29
	8262	6/9/2013	6/14/2013	38.84	2	17.29	34.58	38.84
	8337	7/9/2013	7/12/2013	35.48	2	17.29	34.58	35.48
	8441	8/12/2013	8/19/2013	54.42	2	17.29	34.58	54.42
	8535	9/16/2013	9/20/2013	38.42	2	17.29	34.58	38.42
	8580	10/8/2013	10/11/2013	29.88	2	17.29	34.58	17.29
	8709	11/11/2013	11/18/2013	31.28	2	16.29	32.58	16.29
	8779	12/9/2013	12/13/2013	N.D.	2	16.29	32.58	16.29
	8855	1/14/2014	1/22/2014	20.82	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 3, Room 4i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 4i	3170	4/24/2008	4/30/2008	N.D.	2	10.79	21.58	10.79
	3219	5/15/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3287	6/19/2008	6/25/2008	43.70	2	10.79	21.58	43.70
	3346	7/16/2008	7/22/2008	94.38	2	10.79	21.58	94.38
	3410	8/19/2008	8/22/2008	122.86	2	14.93	29.86	122.86
	3458	9/10/2008	9/12/2008	55.78	2	14.93	29.86	55.78
	3514	10/8/2008	10/10/2008	14.80	2	14.93	29.86	14.93
	3587	11/13/2008	11/18/2008	21.26	2	14.93	29.86	14.93
	3626	12/3/2008	12/6/2008	N.D.	2	14.93	29.86	14.93
	3721	1/13/2009	1/21/2009	14.98	2	14.93	29.86	14.93
	3782	2/10/2009	2/13/2009	19.84	2	14.93	29.86	14.93
	3845	3/11/2009	3/27/2009	5.50	2	14.93	29.86	14.93
	3920	4/14/2009	4/22/2009	18.42	2	14.93	29.86	14.93
	3984	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4053	6/2/2009	6/8/2009	N.D.	2	14.93	29.86	14.93
	4116	7/8/2009	7/10/2009	70.10	2	15.17	30.34	70.10
	4177	8/6/2009	8/13/2009	69.88	2	15.17	30.34	69.88
	4246	9/2/2009	9/4/2009	19.66	2	15.17	30.34	15.17
	4343	10/13/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4385	11/3/2009	11/12/2009	N.D.	2	15.17	30.34	15.17
	4475	12/9/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4636	1/27/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4734	2/18/2010	2/23/2010	N.D.	2	15.17	30.34	15.17
	4802	3/10/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	4968	4/21/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5092	5/26/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5127	6/2/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5265	7/14/2010	7/19/2010	N.D.	2	7.00	14.00	7.00
	5358	8/10/2010	8/17/2010	78.80	2	7.00	14.00	78.80
	5484	9/22/2010	9/27/2010	N.D.	2	7.00	14.00	7.00
	5542	10/12/2010	10/18/2010	49.60	2	7.00	14.00	49.60
	5635	11/9/2010	11/15/2010	30.22	2	7.00	14.00	30.22
	5754	12/15/2010	12/20/2010	85.24	2	7.00	14.00	85.24
	5852	1/19/2011	1/24/2011	58.84	2	14.03	28.06	58.84
	5938	2/15/2011	2/21/2011	28.12	2	14.03	28.06	28.12
	6026	3/9/2011	3/11/2011	N.D.	2	14.03	28.06	14.03
	6139	4/19/2011	4/26/2011	N.D.	2	14.03	28.06	14.03
	6221	5/10/2011	5/13/2011	24.72	2	14.03	28.06	14.03
	6321	6/15/2011	6/21/2011	N.D.	2	14.03	28.06	14.03
	6437	7/19/2011	7/22/2011	N.D.	2	14.03	28.06	14.03
	6503	8/16/2011	8/22/2011	42.26	2	14.03	28.06	42.26
	6581	9/20/2011	9/27/2011	N.D.	2	14.03	28.06	14.03
	6656	10/18/2011	10/25/2011	N.D.	2	14.03	28.06	14.03
	6726	11/7/2011	11/11/2011	N.D.	2	14.03	28.06	14.03
	6781	12/6/2011	12/9/2011	N.D.	2	14.40	28.80	14.40
	6866	1/10/2012	1/13/2012	N.D.	2	14.40	28.80	14.40
	6969	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7019	3/6/2012	3/9/2012	N.D.	2	14.40	28.80	14.40
	7092	4/3/2012	4/9/2012	15.68	2	14.40	28.80	14.40
	7170	5/1/2012	5/4/2012	N.D.	2	14.40	28.80	14.40
	7243	6/5/2012	6/8/2012	N.D.	2	14.40	28.80	14.40
	7370	7/17/2012	7/23/2012	N.D.	2	14.40	28.80	14.40
	7428	8/6/2012	8/10/2012	N.D.	2	14.40	28.80	14.40
	7513	9/4/2012	9/7/2012	N.D.	2	14.40	28.80	14.40
	7624	10/9/2012	10/16/2012	N.D.	2	14.40	28.80	14.40
	7694	11/6/2012	11/9/2012	N.D.	2	17.29	34.58	17.29
	7780	12/4/2012	12/7/2012	N.D.	2	17.29	34.58	17.29
	7873	1/8/2013	1/14/2013	29.02	2	17.29	34.58	17.29
	7936	2/5/2013	2/8/2013	N.D.	2	17.29	34.58	17.29
	8009	3/5/2013	3/11/2013	N.D.	2	17.29	34.58	17.29
	8095	4/2/2013	4/5/2013	N.D.	2	17.29	34.58	17.29
	8194	5/14/2013	5/17/2013	N.D.	2	17.29	34.58	17.29
	8268	6/10/2013	6/14/2013	N.D.	2	17.29	34.58	17.29
	8343	7/9/2013	7/12/2013	17.22	2	17.29	34.58	17.29
	8447	8/12/2013	8/19/2013	21.50	2	17.29	34.58	17.29
	8541	9/16/2013	9/20/2013	N.D.	2	17.29	34.58	17.29
	8586	10/8/2013	10/11/2013	N.D.	2	17.29	34.58	17.29
	8715	11/11/2013	11/18/2013	N.D.	2	16.29	32.58	16.29
	8785	12/9/2013	12/13/2013	N.D.	2	16.29	32.58	16.29
	8861	1/15/2014	1/22/2014	N.D.	2	16.29	32.58	16.29

Hydrogen (H_2)
Panel 3, Room 3e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 3e	3172	4/24/2008	4/30/2008	38.24	2	10.79	21.58	38.24
	3209	5/14/2008	5/23/2008	45.78	2	10.79	21.58	45.78
	3277	6/17/2008	6/25/2008	N.D.	2	10.79	21.58	10.79
	3336	7/15/2008	7/22/2008	49.56	2	10.79	21.58	49.56
	3401	8/20/2008	8/22/2008	46.38	2	14.93	29.86	46.38
	3449	9/8/2008	9/12/2008	76.02	2	14.93	29.86	76.02
	3505	10/6/2008	10/10/2008	91.54	2	14.93	29.86	91.54
	3578	11/10/2008	11/18/2008	76.38	2	14.93	29.86	76.38
	3617	12/3/2008	12/6/2008	51.44	2	14.93	29.86	51.44
	3712	1/12/2009	1/21/2009	46.52	2	14.93	29.86	46.52
	3773	2/9/2009	2/13/2009	N.D.	2	14.93	29.86	14.93
	3834	3/12/2009	3/27/2009	49.78	2	14.93	29.86	49.78
	3911	4/13/2009	4/22/2009	36.44	2	14.93	29.86	36.44
	3979	5/12/2009	5/15/2009	40.06	2	14.93	29.86	40.06
	4044	6/1/2009	6/8/2009	44.98	2	14.93	29.86	44.98
	4110	7/7/2009	7/10/2009	88.52	2	15.17	30.34	88.52
	4169	8/5/2009	8/13/2009	62.82	2	15.17	30.34	62.82
	4240	9/1/2009	9/4/2009	54.22	2	15.17	30.34	54.22
	4337	10/12/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4379	11/3/2009	11/12/2009	N.D.	2	15.17	30.34	15.17
	4469	12/8/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4630	1/26/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4728	2/17/2010	2/23/2010	55.36	2	15.17	30.34	55.36
	4796	3/10/2010	3/12/2010	41.42	2	15.17	30.34	41.42
	4962	4/21/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5086	5/26/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5121	6/2/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5259	7/13/2010	7/19/2010	88.48	2	7.00	14.00	88.48
	5352	8/9/2010	8/17/2010	105.14	2	7.00	14.00	105.14
	5478	9/21/2010	9/27/2010	58.68	2	7.00	14.00	58.68
	5537	10/11/2010	10/18/2010	59.18	2	7.00	14.00	59.18
	5630	11/8/2010	11/15/2010	66.94	2	7.00	14.00	66.94
	5749	12/14/2010	12/20/2010	80.20	2	7.00	14.00	80.20
	5847	1/18/2011	1/24/2011	136.16	2	14.03	28.06	136.16
	5933	2/15/2011	2/21/2011	53.02	2	14.03	28.06	53.02
	6021	3/8/2011	3/11/2011	84.28	2	14.03	28.06	84.28
	6134	4/19/2011	4/26/2011	47.04	2	14.03	28.06	47.04
	6216	5/9/2011	5/13/2011	39.22	2	14.03	28.06	39.22
	6316	6/14/2011	6/21/2011	34.02	2	14.03	28.06	34.02
	6430	7/18/2011	7/22/2011	53.20	2	14.03	28.06	53.20
	6498	8/15/2011	8/22/2011	50.46	2	14.03	28.06	50.46
	6576	9/19/2011	9/27/2011	38.60	2	14.03	28.06	38.60
	6649	10/17/2011	10/25/2011	28.86	2	14.03	28.06	28.86
	6721	11/7/2011	11/11/2011	26.00	2	14.03	28.06	14.03
	6776	12/5/2011	12/9/2011	38.26	2	14.40	28.80	38.26
	6861	1/9/2012	1/13/2012	53.60	2	14.40	28.80	53.60
	6964	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7014	3/6/2012	3/9/2012	32.26	2	14.40	28.80	32.26
	7087	4/2/2012	4/9/2012	23.00	2	14.40	28.80	14.40
	7165	5/1/2012	5/4/2012	27.48	2	14.40	28.80	14.40
	7238	6/4/2012	6/8/2012	19.22	2	14.40	28.80	14.40
	7365	7/16/2012	7/23/2012	34.56	2	14.40	28.80	34.56
	7423	8/6/2012	8/10/2012	43.44	2	14.40	28.80	43.44
	7508	9/4/2012	9/7/2012	30.22	2	14.40	28.80	30.22
	7619	10/9/2012	10/16/2012	30.90	2	14.40	28.80	30.90
	7689	11/5/2012	11/9/2012	39.38	2	17.29	34.58	39.38
	7775	12/3/2012	12/7/2012	31.02	2	17.29	34.58	17.29
	7868	1/8/2013	1/14/2013	48.88	2	17.29	34.58	48.88
	7931	2/5/2013	2/8/2013	N.D.	2	17.29	34.58	17.29
	8004	3/5/2013	3/11/2013	25.10	2	17.29	34.58	17.29
	8090	4/2/2013	4/5/2013	33.66	2	17.29	34.58	17.29
	8189	5/13/2013	5/17/2013	31.26	2	17.29	34.58	17.29
	8263	6/9/2013	6/14/2013	33.64	2	17.29	34.58	17.29
	8338	7/9/2013	7/12/2013	44.92	2	17.29	34.58	44.92
	8442	8/12/2013	8/19/2013	68.48	2	17.29	34.58	68.48
	8536	9/16/2013	9/20/2013	37.26	2	17.29	34.58	37.26
	8581	10/8/2013	10/11/2013	30.84	2	17.29	34.58	17.29
	8710	11/11/2013	11/18/2013	46.44	2	16.29	32.58	46.44
	8780	12/9/2013	12/13/2013	N.D.	2	16.29	32.58	16.29
	8856	1/14/2014	1/22/2014	24.30	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 3, Room 3i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 3i	3171	4/24/2008	4/30/2008	N.D.	2	10.79	21.58	10.79
	3218	5/14/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3286	6/17/2008	6/25/2008	N.D.	2	10.79	21.58	10.79
	3345	7/15/2008	7/22/2008	N.D.	2	10.79	21.58	10.79
	3409	8/20/2008	8/22/2008	N.D.	2	14.93	29.86	14.93
	3457	9/8/2008	9/12/2008	N.D.	2	14.93	29.86	14.93
	3513	10/6/2008	10/10/2008	48.84	2	14.93	29.86	48.84
	3586	11/13/2008	11/18/2008	N.D.	2	14.93	29.86	14.93
	3625	12/3/2008	12/6/2008	N.D.	2	14.93	29.86	14.93
	3714	1/12/2009	1/21/2009	N.D.	2	14.93	29.86	14.93
	3781	2/10/2009	2/13/2009	N.D.	2	14.93	29.86	14.93
	3836	3/12/2009	3/27/2009	N.D.	2	14.93	29.86	14.93
	3913	4/13/2009	4/22/2009	N.D.	2	14.93	29.86	14.93
	3981	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4052	6/2/2009	6/8/2009	N.D.	2	14.93	29.86	14.93
	4117	7/8/2009	7/10/2009	36.74	2	15.17	30.34	36.74
	4178	8/6/2009	8/13/2009	N.D.	2	15.17	30.34	15.17
	4247	9/2/2009	9/4/2009	N.D.	2	15.17	30.34	15.17
	4344	10/13/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4386	11/3/2009	11/12/2009	N.D.	2	15.17	30.34	15.17
	4476	12/9/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4637	1/27/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4735	2/18/2010	2/23/2010	N.D.	2	15.17	30.34	15.17
	4803	3/10/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	4969	4/21/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5093	5/26/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5128	6/2/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5266	7/14/2010	7/19/2010	N.D.	2	7.00	14.00	7.00
	5359	8/10/2010	8/17/2010	69.66	2	7.00	14.00	69.66
	5485	9/22/2010	9/27/2010	N.D.	2	7.00	14.00	7.00
	5543	10/12/2010	10/18/2010	34.78	2	7.00	14.00	34.78
	5636	11/9/2010	11/15/2010	N.D.	2	7.00	14.00	7.00
	5755	12/15/2010	12/20/2010	70.66	2	7.00	14.00	70.66
	5853	1/19/2011	1/24/2011	79.18	2	14.03	28.06	79.18
	5939	2/15/2011	2/21/2011	N.D.	2	14.03	28.06	14.03
	6027	3/9/2011	3/11/2011	N.D.	2	14.03	28.06	14.03
	6140	4/19/2011	4/26/2011	N.D.	2	14.03	28.06	14.03
	6222	5/10/2011	5/13/2011	N.D.	2	14.03	28.06	14.03
	6322	6/15/2011	6/21/2011	N.D.	2	14.03	28.06	14.03
	6438	7/19/2011	7/22/2011	N.D.	2	14.03	28.06	14.03
	6504	8/16/2011	8/22/2011	N.D.	2	14.03	28.06	14.03
	6582	9/20/2011	9/27/2011	N.D.	2	14.03	28.06	14.03
	6657	10/18/2011	10/25/2011	N.D.	2	14.03	28.06	14.03
	6727	11/8/2011	11/11/2011	N.D.	2	14.03	28.06	14.03
	6782	12/6/2011	12/9/2011	N.D.	2	14.40	28.80	14.40
	6867	1/10/2012	1/13/2012	N.D.	2	14.40	28.80	14.40
	6970	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7020	3/6/2012	3/9/2012	N.D.	2	14.40	28.80	14.40
	7093	4/3/2012	4/9/2012	N.D.	2	14.40	28.80	14.40
	7171	5/1/2012	5/4/2012	N.D.	2	14.40	28.80	14.40
	7244	6/5/2012	6/8/2012	N.D.	2	14.40	28.80	14.40
	7371	7/17/2012	7/23/2012	N.D.	2	14.40	28.80	14.40
	7429	8/6/2012	8/10/2012	N.D.	2	14.40	28.80	14.40
	7514	9/4/2012	9/7/2012	N.D.	2	14.40	28.80	14.40
	7625	10/9/2012	10/16/2012	N.D.	2	14.40	28.80	14.40
	7695	11/6/2012	11/9/2012	N.D.	2	17.29	34.58	17.29
	7781	12/4/2012	12/7/2012	N.D.	2	17.29	34.58	17.29
	7874	1/8/2013	1/14/2013	N.D.	2	17.29	34.58	17.29
	7937	2/5/2013	2/8/2013	N.D.	2	17.29	34.58	17.29
	8010	3/5/2013	3/11/2013	N.D.	2	17.29	34.58	17.29
	8096	4/2/2013	4/5/2013	N.D.	2	17.29	34.58	17.29
	8195	5/14/2013	5/17/2013	N.D.	2	17.29	34.58	17.29
	8269	6/10/2013	6/14/2013	N.D.	2	17.29	34.58	17.29
	8344	7/9/2013	7/12/2013	N.D.	2	17.29	34.58	17.29
	8448	8/12/2013	8/19/2013	N.D.	2	17.29	34.58	17.29
	8542	9/16/2013	9/20/2013	N.D.	2	17.29	34.58	17.29
	8587	10/8/2013	10/11/2013	N.D.	2	17.29	34.58	17.29
	8716	11/11/2013	11/18/2013	26.98	2	16.29	32.58	16.29
	8786	12/9/2013	12/13/2013	N.D.	2	16.29	32.58	16.29
	8862	1/15/2014	1/22/2014	N.D.	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 3, Room 2e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 2e	3164	4/24/2008	4/30/2008	32.02	2	10.79	21.58	32.02
	3208	5/14/2008	5/23/2008	31.20	2	10.79	21.58	31.20
	3276	6/17/2008	6/25/2008	22.78	2	10.79	21.58	22.78
	3335	7/15/2008	7/22/2008	32.36	2	10.79	21.58	32.36
	3400	8/20/2008	8/22/2008	37.30	2	14.93	29.86	37.30
	3448	9/8/2008	9/12/2008	35.04	2	14.93	29.86	35.04
	3504	10/6/2008	10/10/2008	36.14	2	14.93	29.86	36.14
	3577	11/10/2008	11/18/2008	36.90	2	14.93	29.86	36.90
	3616	12/3/2008	12/6/2008	33.86	2	14.93	29.86	33.86
	3711	1/12/2009	1/21/2009	36.68	2	14.93	29.86	36.68
	3772	2/9/2009	2/13/2009	24.04	2	14.93	29.86	14.93
	3833	3/12/2009	3/27/2009	16.42	2	14.93	29.86	14.93
	3910	4/13/2009	4/22/2009	23.94	2	14.93	29.86	14.93
	3978	5/12/2009	5/15/2009	35.24	2	14.93	29.86	35.24
	4043	6/1/2009	6/8/2009	14.40	2	14.93	29.86	14.93
	4111	7/7/2009	7/10/2009	37.48	2	15.17	30.34	37.48
	4170	8/5/2009	8/13/2009	18.32	2	15.17	30.34	15.17
	4241	9/1/2009	9/4/2009	21.32	2	15.17	30.34	15.17
	4338	10/13/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4380	11/3/2009	11/12/2009	22.38	2	15.17	30.34	15.17
	4470	12/8/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4631	1/26/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4729	2/17/2010	2/23/2010	N.D.	2	15.17	30.34	15.17
	4797	3/10/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	4963	4/21/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5087	5/26/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5122	6/2/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5260	7/13/2010	7/19/2010	105.46	2	7.00	14.00	105.46
	5353	8/9/2010	8/17/2010	N.D.	2	7.00	14.00	7.00
	5479	9/21/2010	9/27/2010	52.60	2	7.00	14.00	52.60
	5538	10/12/2010	10/18/2010	66.54	2	7.00	14.00	66.54
	5631	11/8/2010	11/15/2010	50.14	2	7.00	14.00	50.14
	5750	12/14/2010	12/20/2010	75.48	2	7.00	14.00	75.48
	5848	1/18/2011	1/24/2011	123.08	2	14.03	28.06	123.08
	5934	2/15/2011	2/21/2011	48.58	2	14.03	28.06	48.58
	6022	3/8/2011	3/11/2011	54.10	2	14.03	28.06	54.10
	6135	4/19/2011	4/26/2011	49.12	2	14.03	28.06	49.12
	6217	5/10/2011	5/13/2011	42.72	2	14.03	28.06	42.72
	6317	6/14/2011	6/21/2011	31.62	2	14.03	28.06	31.62
	6431	7/18/2011	7/22/2011	37.94	2	14.03	28.06	37.94
	6499	8/15/2011	8/22/2011	55.18	2	14.03	28.06	55.18
	6577	9/19/2011	9/27/2011	33.10	2	14.03	28.06	33.10
	6650	10/17/2011	10/25/2011	22.14	2	14.03	28.06	14.03
	6722	11/7/2011	11/11/2011	20.36	2	14.03	28.06	14.03
	6777	12/5/2011	12/9/2011	31.18	2	14.40	28.80	31.18
	6862	1/9/2012	1/13/2012	60.96	2	14.40	28.80	60.96
	6965	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7015	3/6/2012	3/9/2012	40.78	2	14.40	28.80	40.78
	7088	4/2/2012	4/9/2012	35.32	2	14.40	28.80	35.32
	7166	5/1/2012	5/4/2012	25.76	2	14.40	28.80	14.40
	7239	6/4/2012	6/8/2012	36.96	2	14.40	28.80	36.96
	7366	7/16/2012	7/23/2012	28.50	2	14.40	28.80	14.40
	7424	8/6/2012	8/10/2012	34.66	2	14.40	28.80	34.66
	7509	9/4/2012	9/7/2012	46.42	2	14.40	28.80	46.42
	7620	10/9/2012	10/16/2012	37.68	2	14.40	28.80	37.68
	7690	11/6/2012	11/9/2012	26.16	2	17.29	34.58	17.29
	7776	12/3/2012	12/7/2012	46.82	2	17.29	34.58	46.82
	7869	1/8/2013	1/14/2013	42.76	2	17.29	34.58	42.76
	7932	2/5/2013	2/8/2013	29.44	2	17.29	34.58	17.29
	8005	3/5/2013	3/11/2013	29.30	2	17.29	34.58	17.29
	8091	4/2/2013	4/5/2013	N.D.	2	17.29	34.58	17.29
	8190	5/14/2013	5/17/2013	51.84	2	17.29	34.58	51.84
	8264	6/9/2013	6/14/2013	39.08	2	17.29	34.58	39.08
	8339	7/9/2013	7/12/2013	59.68	2	17.29	34.58	59.68
	8443	8/12/2013	8/19/2013	66.28	2	17.29	34.58	66.28
	8537	9/16/2013	9/20/2013	44.98	2	17.29	34.58	44.98
	8582	10/8/2013	10/11/2013	27.06	2	17.29	34.58	17.29
	8711	11/11/2013	11/18/2013	31.20	2	16.29	32.58	16.29
	8781	12/9/2013	12/13/2013	31.06	2	16.29	32.58	16.29
	8857	1/14/2014	1/22/2014	19.64	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 3, Room 2i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 2i	3162	4/24/2008	4/30/2008	N.D.	2	10.79	21.58	10.79
	3217	5/14/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3285	6/17/2008	6/25/2008	N.D.	2	10.79	21.58	10.79
	3344	7/15/2008	7/22/2008	N.D.	2	10.79	21.58	10.79
	3408	8/20/2008	8/22/2008	N.D.	2	14.93	29.86	14.93
	3456	9/8/2008	9/12/2008	N.D.	2	14.93	29.86	14.93
	3512	10/6/2008	10/10/2008	13.24	2	14.93	29.86	14.93
	3585	11/13/2008	11/18/2008	N.D.	2	14.93	29.86	14.93
	3624	12/3/2008	12/6/2008	N.D.	2	14.93	29.86	14.93
	3713	1/12/2009	1/21/2009	N.D.	2	14.93	29.86	14.93
	3780	2/10/2009	2/13/2009	N.D.	2	14.93	29.86	14.93
	3835	3/12/2009	3/27/2009	N.D.	2	14.93	29.86	14.93
	3912	4/13/2009	4/22/2009	N.D.	2	14.93	29.86	14.93
	3980	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4051	6/2/2009	6/8/2009	N.D.	2	14.93	29.86	14.93
	4118	7/8/2009	7/10/2009	N.D.	2	15.17	30.34	15.17
	4179	8/6/2009	8/13/2009	N.D.	2	15.17	30.34	15.17
	4248	9/2/2009	9/4/2009	N.D.	2	15.17	30.34	15.17
	4345	10/13/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4387	11/3/2009	11/12/2009	N.D.	2	15.17	30.34	15.17
	4477	12/9/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4638	1/27/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4736	2/18/2010	2/23/2010	N.D.	2	15.17	30.34	15.17
	4804	3/10/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	4970	4/21/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5094	5/26/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5129	6/2/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5267	7/14/2010	7/19/2010	N.D.	2	7.00	14.00	7.00
	5360	8/10/2010	8/17/2010	N.D.	2	7.00	14.00	7.00
	5486	9/22/2010	9/27/2010	N.D.	2	7.00	14.00	7.00
	5544	10/12/2010	10/18/2010	19.24	2	7.00	14.00	19.24
	5637	11/9/2010	11/15/2010	N.D.	2	7.00	14.00	7.00
	5756	12/15/2010	12/20/2010	68.86	2	7.00	14.00	68.86
	5854	1/19/2011	1/24/2011	55.84	2	14.03	28.06	55.84
	5940	2/15/2011	2/21/2011	N.D.	2	14.03	28.06	14.03
	6028	3/9/2011	3/11/2011	N.D.	2	14.03	28.06	14.03
	6141	4/19/2011	4/26/2011	N.D.	2	14.03	28.06	14.03
	6223	5/10/2011	5/13/2011	N.D.	2	14.03	28.06	14.03
	6323	6/15/2011	6/21/2011	N.D.	2	14.03	28.06	14.03
	6439	7/19/2011	7/22/2011	N.D.	2	14.03	28.06	14.03
	6505	8/16/2011	8/22/2011	N.D.	2	14.03	28.06	14.03
	6583	9/20/2011	9/27/2011	N.D.	2	14.03	28.06	14.03
	6658	10/18/2011	10/25/2011	N.D.	2	14.03	28.06	14.03
	6728	11/8/2011	11/11/2011	N.D.	2	14.03	28.06	14.03
	6783	12/6/2011	12/9/2011	N.D.	2	14.40	28.80	14.40
	6868	1/10/2012	1/13/2012	N.D.	2	14.40	28.80	14.40
	6971	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7021	3/6/2012	3/9/2012	N.D.	2	14.40	28.80	14.40
	7094	4/3/2012	4/9/2012	N.D.	2	14.40	28.80	14.40
	7172	5/1/2012	5/4/2012	N.D.	2	14.40	28.80	14.40
	7245	6/5/2012	6/8/2012	N.D.	2	14.40	28.80	14.40
	7372	7/17/2012	7/23/2012	N.D.	2	14.40	28.80	14.40
	7430	8/6/2012	8/10/2012	N.D.	2	14.40	28.80	14.40
	7515	9/4/2012	9/7/2012	N.D.	2	14.40	28.80	14.40
	7626	10/9/2012	10/16/2012	N.D.	2	14.40	28.80	14.40
	7696	11/6/2012	11/9/2012	N.D.	2	17.29	34.58	17.29
	7782	12/4/2012	12/7/2012	N.D.	2	17.29	34.58	17.29
	7875	1/8/2013	1/14/2013	N.D.	2	17.29	34.58	17.29
	7938	2/5/2013	2/8/2013	N.D.	2	17.29	34.58	17.29
	8011	3/5/2013	3/11/2013	N.D.	2	17.29	34.58	17.29
	8097	4/2/2013	4/5/2013	N.D.	2	17.29	34.58	17.29
	8196	5/14/2013	5/17/2013	N.D.	2	17.29	34.58	17.29
	8270	6/10/2013	6/14/2013	N.D.	2	17.29	34.58	17.29
	8345	7/9/2013	7/12/2013	N.D.	2	17.29	34.58	17.29
	8449	8/12/2013	8/19/2013	N.D.	2	17.29	34.58	17.29
	8543	9/16/2013	9/20/2013	N.D.	2	17.29	34.58	17.29
	8588	10/8/2013	10/11/2013	N.D.	2	17.29	34.58	17.29
	8717	11/11/2013	11/18/2013	N.D.	2	16.29	32.58	16.29
	8787	12/9/2013	12/13/2013	N.D.	2	16.29	32.58	16.29
	8863	1/15/2014	1/22/2014	N.D.	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 3, Room 1e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 1e	3163	4/24/2008	4/30/2008	N.D.	2	10.79	21.58	10.79
	3207	5/14/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3293	6/17/2008	6/25/2008	N.D.	2	10.79	21.58	10.79
	3334	7/15/2008	7/22/2008	58.36	2	10.79	21.58	58.36
	3399	8/20/2008	8/22/2008	N.D.	2	14.93	29.86	14.93
	3447	9/8/2008	9/12/2008	19.46	2	14.93	29.86	14.93
	3503	10/6/2008	10/10/2008	21.18	2	14.93	29.86	14.93
	3575	11/10/2008	11/18/2008	14.10	2	14.93	29.86	14.93
	3614	12/3/2008	12/6/2008	23.54	2	14.93	29.86	14.93
	3709	1/12/2009	1/21/2009	N.D.	2	14.93	29.86	14.93
	3770	2/9/2009	2/13/2009	N.D.	2	14.93	29.86	14.93
	3831	3/11/2009	3/27/2009	8.86	2	14.93	29.86	14.93
	3908	4/13/2009	4/22/2009	8.00	2	14.93	29.86	14.93
	3976	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4041	6/1/2009	6/8/2009	N.D.	2	14.93	29.86	14.93
	4112	7/7/2009	7/10/2009	N.D.	2	15.17	30.34	15.17
	4172	8/6/2009	8/13/2009	N.D.	2	15.17	30.34	15.17
	4242	9/1/2009	9/4/2009	N.D.	2	15.17	30.34	15.17
	4339	10/13/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4381	11/3/2009	11/12/2009	N.D.	2	15.17	30.34	15.17
	4471	12/9/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4632	1/26/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4730	2/17/2010	2/23/2010	N.D.	2	15.17	30.34	15.17
	4798	3/10/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	4964	4/21/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5088	5/26/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5123	6/2/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5261	7/13/2010	7/19/2010	54.82	2	7.00	14.00	54.82
	5354	8/10/2010	8/17/2010	43.64	2	7.00	14.00	43.64
	5480	9/21/2010	9/27/2010	34.86	2	7.00	14.00	34.86
	5539	10/12/2010	10/18/2010	58.30	2	7.00	14.00	58.30
	5632	11/9/2010	11/15/2010	26.00	2	7.00	14.00	26.00
	5751	12/15/2010	12/20/2010	75.32	2	7.00	14.00	75.32
	5849	1/18/2011	1/24/2011	84.54	2	14.03	28.06	84.54
	5935	2/15/2011	2/21/2011	58.96	2	14.03	28.06	58.96
	6023	3/9/2011	3/11/2011	67.98	2	14.03	28.06	67.98
	6136	4/19/2011	4/26/2011	32.52	2	14.03	28.06	32.52
	6218	5/10/2011	5/13/2011	N.D.	2	14.03	28.06	14.03
	6318	6/15/2011	6/21/2011	N.D.	2	14.03	28.06	14.03
	6433	7/19/2011	7/22/2011	N.D.	2	14.03	28.06	14.03
	6506	8/16/2011	8/22/2011	34.00	2	14.03	28.06	34.00
	6584	9/20/2011	9/27/2011	N.D.	2	14.03	28.06	14.03
	6659	10/18/2011	10/25/2011	N.D.	2	14.03	28.06	14.03
	6729	11/8/2011	11/11/2011	N.D.	2	14.03	28.06	14.03
	6784	12/6/2011	12/9/2011	N.D.	2	14.40	28.80	14.40
	6869	1/10/2012	1/13/2012	50.88	2	14.40	28.80	50.88
	6972	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7022	3/6/2012	3/9/2012	32.80	2	14.40	28.80	32.80
	7095	4/3/2012	4/9/2012	16.56	2	14.40	28.80	14.40
	7173	5/1/2012	5/4/2012	31.26	2	14.40	28.80	31.26
	7246	6/5/2012	6/8/2012	16.54	2	14.40	28.80	14.40
	7373	7/17/2012	7/23/2012	33.04	2	14.40	28.80	33.04
	7431	8/6/2012	8/10/2012	N.D.	2	14.40	28.80	14.40
	7516	9/4/2012	9/7/2012	N.D.	2	14.40	28.80	14.40
	7627	10/9/2012	10/16/2012	32.06	2	14.40	28.80	32.06
	7697	11/6/2012	11/9/2012	21.14	2	17.29	34.58	17.29
	7783	12/4/2012	12/7/2012	32.90	2	17.29	34.58	17.29
	7876	1/8/2013	1/14/2013	25.30	2	17.29	34.58	17.29
	7939	2/5/2013	2/8/2013	N.D.	2	17.29	34.58	17.29
	8012	3/5/2013	3/11/2013	19.38	2	17.29	34.58	17.29
	8098	4/2/2013	4/5/2013	21.22	2	17.29	34.58	17.29
	8197	5/14/2013	5/17/2013	35.12	2	17.29	34.58	35.12
	8271	6/10/2013	6/14/2013	35.40	2	17.29	34.58	35.40
	8346	7/9/2013	7/12/2013	36.98	2	17.29	34.58	36.98
	8450	8/12/2013	8/19/2013	24.08	2	17.29	34.58	17.29
	8544	9/16/2013	9/20/2013	25.44	2	17.29	34.58	17.29
	8589	10/8/2013	10/11/2013	34.22	2	17.29	34.58	17.29
	8718	11/11/2013	11/18/2013	47.02	2	16.29	32.58	47.02
	8788	12/9/2013	12/13/2013	30.72	2	16.29	32.58	16.29
	8864	1/15/2014	1/22/2014	N.D.	2	16.29	32.58	16.29

Hydrogen (H_2) Panel 3, Room 1i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Room 1i	3169	4/24/2008	4/30/2008	N.D.	2	10.79	21.58	10.79
	3216	5/19/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3284	6/19/2008	6/25/2008	N.D.	2	10.79	21.58	10.79

Hydrogen (H_2)

Panel 3, EBW

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Location EBW	3165	4/24/2008	4/30/2008	N.D.	2	10.79	21.58	10.79
	3215	5/15/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3283	6/17/2008	6/25/2008	N.D.	2	10.79	21.58	10.79
	3342	7/15/2008	7/22/2008	N.D.	2	10.79	21.58	10.79
	3407	8/20/2008	8/22/2008	N.D.	2	14.93	29.86	14.93
	3455	9/8/2008	9/12/2008	N.D.	2	14.93	29.86	14.93
	3511	10/6/2008	10/10/2008	32.88	2	14.93	29.86	32.88
	3584	11/10/2008	11/18/2008	N.D.	2	14.93	29.86	14.93
	3623	12/3/2008	12/6/2008	N.D.	2	14.93	29.86	14.93
	3716	1/12/2009	1/21/2009	N.D.	2	14.93	29.86	14.93
	3779	2/9/2009	2/13/2009	N.D.	2	14.93	29.86	14.93
	3838	3/12/2009	3/27/2009	N.D.	2	14.93	29.86	14.93
	3915	4/13/2009	4/22/2009	N.D.	2	14.93	29.86	14.93
	3983	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4049	6/2/2009	6/8/2009	N.D.	2	14.93	29.86	14.93
	4105	7/7/2009	7/10/2009	N.D.	2	15.17	30.34	15.17
	4164	8/5/2009	8/13/2009	N.D.	2	15.17	30.34	15.17
	4235	9/1/2009	9/4/2009	N.D.	2	15.17	30.34	15.17
	4332	10/12/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4374	11/2/2009	11/12/2009	N.D.	2	15.17	30.34	15.17
	4464	12/8/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4625	1/26/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4723	2/17/2010	2/23/2010	N.D.	2	15.17	30.34	15.17
	4789	3/9/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	4957	4/20/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5081	5/25/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5116	6/1/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5254	7/13/2010	7/19/2010	N.D.	2	7.00	14.00	7.00
	5347	8/9/2010	8/17/2010	47.32	2	7.00	14.00	47.32
	5474	9/21/2010	9/27/2010	35.28	2	7.00	14.00	35.28
	5533	10/11/2010	10/18/2010	60.22	2	7.00	14.00	60.22
	5626	11/8/2010	11/15/2010	36.90	2	7.00	14.00	36.90
	5745	12/14/2010	12/20/2010	71.48	2	7.00	14.00	71.48
	5843	1/18/2011	1/24/2011	95.56	2	14.03	28.06	95.56
	5929	2/15/2011	2/21/2011	53.14	2	14.03	28.06	53.14
	6017	3/8/2011	3/11/2011	73.22	2	14.03	28.06	73.22
	6130	4/18/2011	4/26/2011	31.08	2	14.03	28.06	31.08
	6212	5/9/2011	5/13/2011	40.20	2	14.03	28.06	40.20
	6312	6/14/2011	6/21/2011	N.D.	2	14.03	28.06	14.03
	6432	7/18/2011	7/22/2011	N.D.	2	14.03	28.06	14.03
	6500	8/15/2011	8/22/2011	N.D.	2	14.03	28.06	14.03
	6578	9/19/2011	9/27/2011	N.D.	2	14.03	28.06	14.03
	6652	10/17/2011	10/25/2011	N.D.	2	14.03	28.06	14.03
	6723	11/7/2011	11/11/2011	N.D.	2	14.03	28.06	14.03
	6778	12/5/2011	12/9/2011	29.60	2	14.40	28.80	29.60
	6863	1/9/2012	1/13/2012	51.46	2	14.40	28.80	51.46
	6966	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7016	3/6/2012	3/9/2012	23.10	2	14.40	28.80	14.40
	7089	4/2/2012	4/9/2012	27.82	2	14.40	28.80	14.40
	7167	5/1/2012	5/4/2012	N.D.	2	14.40	28.80	14.40
	7240	6/4/2012	6/8/2012	N.D.	2	14.40	28.80	14.40
	7367	7/16/2012	7/23/2012	31.38	2	14.40	28.80	31.38
	7425	8/6/2012	8/10/2012	N.D.	2	14.40	28.80	14.40
	7510	9/4/2012	9/7/2012	N.D.	2	14.40	28.80	14.40
	7621	10/9/2012	10/16/2012	26.92	2	14.40	28.80	14.40
	7691	11/6/2012	11/9/2012	28.84	2	17.29	34.58	17.29
	7777	12/4/2012	12/7/2012	22.64	2	17.29	34.58	17.29
	7870	1/8/2013	1/14/2013	25.12	2	17.29	34.58	17.29
	7933	2/5/2013	2/8/2013	21.18	2	17.29	34.58	17.29
	8006	3/5/2013	3/11/2013	20.60	2	17.29	34.58	17.29
	8092	4/2/2013	4/5/2013	18.10	2	17.29	34.58	17.29
	8191	5/14/2013	5/17/2013	19.28	2	17.29	34.58	17.29
	8265	6/9/2013	6/14/2013	36.10	2	17.29	34.58	36.10
	8340	7/9/2013	7/12/2013	29.32	2	17.29	34.58	17.29
	8444	8/12/2013	8/19/2013	N.D.	2	17.29	34.58	17.29
	8538	9/16/2013	9/20/2013	30.98	2	17.29	34.58	17.29
	8583	10/8/2013	10/11/2013	19.00	2	17.29	34.58	17.29
	8712	11/11/2013	11/18/2013	21.28	2	16.29	32.58	16.29
	8782	12/9/2013	12/13/2013	17.32	2	16.29	32.58	16.29
	8858	1/14/2014	1/22/2014	21.84	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 3, EBA

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Location EBA	3167	4/24/2008	4/30/2008	N.D.	2	10.79	21.58	10.79
	3214	5/15/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3282	6/19/2008	6/25/2008	N.D.	2	10.79	21.58	10.79
	3341	7/15/2008	7/22/2008	N.D.	2	10.79	21.58	10.79
	3406	8/20/2008	8/22/2008	N.D.	2	14.93	29.86	14.93
	3454	9/8/2008	9/12/2008	N.D.	2	14.93	29.86	14.93
	3510	10/6/2008	10/10/2008	15.14	2	14.93	29.86	14.93
	3583	11/10/2008	11/18/2008	N.D.	2	14.93	29.86	14.93
	3622	12/3/2008	12/6/2008	N.D.	2	14.93	29.86	14.93
	3715	1/12/2009	1/21/2009	N.D.	2	14.93	29.86	14.93
	3778	2/9/2009	2/13/2009	N.D.	2	14.93	29.86	14.93
	3837	3/12/2009	3/27/2009	N.D.	2	14.93	29.86	14.93
	3914	4/13/2009	4/22/2009	N.D.	2	14.93	29.86	14.93
	3982	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4050	6/2/2009	6/8/2009	N.D.	2	14.93	29.86	14.93
	4104	7/7/2009	7/10/2009	N.D.	2	15.17	30.34	15.17
	4163	8/5/2009	8/13/2009	N.D.	2	15.17	30.34	15.17
	4234	9/1/2009	9/4/2009	N.D.	2	15.17	30.34	15.17
	4331	10/12/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4373	11/2/2009	11/12/2009	N.D.	2	15.17	30.34	15.17
	4463	12/8/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4624	1/26/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4722	2/17/2010	2/23/2010	N.D.	2	15.17	30.34	15.17
	4788	3/9/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	4956	4/20/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5080	5/25/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5115	6/1/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5253	7/13/2010	7/19/2010	N.D.	2	7.00	14.00	7.00
	5346	8/9/2010	8/17/2010	N.D.	2	7.00	14.00	7.00
	5473	9/21/2010	9/27/2010	N.D.	2	7.00	14.00	7.00
	5532	10/11/2010	10/18/2010	41.80	2	7.00	14.00	41.80
	5625	11/8/2010	11/15/2010	N.D.	2	7.00	14.00	7.00
	5744	12/14/2010	12/20/2010	N.D.	2	7.00	14.00	7.00
	5842	1/18/2011	1/24/2011	N.D.	2	14.03	28.06	14.03
	5928	2/15/2011	2/21/2011	N.D.	2	14.03	28.06	14.03
	6016	3/8/2011	3/11/2011	N.D.	2	14.03	28.06	14.03
	6129	4/18/2011	4/26/2011	N.D.	2	14.03	28.06	14.03
	6211	5/9/2011	5/13/2011	N.D.	2	14.03	28.06	14.03
	6311	6/14/2011	6/21/2011	N.D.	2	14.03	28.06	14.03
	6435	7/19/2011	7/22/2011	N.D.	2	14.03	28.06	14.03
	6501	8/16/2011	8/22/2011	N.D.	2	14.03	28.06	14.03
	6579	9/20/2011	9/27/2011	N.D.	2	14.03	28.06	14.03
	6653	10/17/2011	10/25/2011	N.D.	2	14.03	28.06	14.03
	6724	11/7/2011	11/11/2011	N.D.	2	14.03	28.06	14.03
	6779	12/5/2011	12/9/2011	N.D.	2	14.40	28.80	14.40
	6864	1/10/2012	1/13/2012	N.D.	2	14.40	28.80	14.40
	6967	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7017	3/6/2012	3/9/2012	N.D.	2	14.40	28.80	14.40
	7090	4/3/2012	4/9/2012	N.D.	2	14.40	28.80	14.40
	7168	5/1/2012	5/4/2012	N.D.	2	14.40	28.80	14.40
	7241	6/5/2012	6/8/2012	N.D.	2	14.40	28.80	14.40
	7368	7/16/2012	7/23/2012	N.D.	2	14.40	28.80	14.40
	7426	8/6/2012	8/10/2012	N.D.	2	14.40	28.80	14.40
	7511	9/4/2012	9/7/2012	N.D.	2	14.40	28.80	14.40
	7622	10/9/2012	10/16/2012	N.D.	2	14.40	28.80	14.40
	7692	11/6/2012	11/9/2012	N.D.	2	17.29	34.58	17.29
	7778	12/4/2012	12/7/2012	N.D.	2	17.29	34.58	17.29
	7871	1/8/2013	1/14/2013	N.D.	2	17.29	34.58	17.29
	7934	2/5/2013	2/8/2013	N.D.	2	17.29	34.58	17.29
	8007	3/5/2013	3/11/2013	N.D.	2	17.29	34.58	17.29
	8093	4/2/2013	4/5/2013	N.D.	2	17.29	34.58	17.29
	8192	5/14/2013	5/17/2013	N.D.	2	17.29	34.58	17.29
	8266	6/9/2013	6/14/2013	N.D.	2	17.29	34.58	17.29
	8341	7/9/2013	7/12/2013	N.D.	2	17.29	34.58	17.29
	8445	8/12/2013	8/19/2013	N.D.	2	17.29	34.58	17.29
	8539	9/16/2013	9/20/2013	N.D.	2	17.29	34.58	17.29
	8584	10/8/2013	10/11/2013	N.D.	2	17.29	34.58	17.29
	8713	11/11/2013	11/18/2013	23.34	2	16.29	32.58	16.29
	8783	12/9/2013	12/13/2013	N.D.	2	16.29	32.58	16.29
	8859	1/14/2014	1/22/2014	N.D.	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 3, IBW

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Location IBW	3173	4/24/2008	4/30/2008	N.D.	2	10.79	21.58	10.79
	3224	5/15/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3292	6/19/2008	6/25/2008	N.D.	2	10.79	21.58	10.79
	3350	7/16/2008	7/22/2008	N.D.	2	10.79	21.58	10.79
	3414	8/20/2008	8/22/2008	N.D.	2	14.93	29.86	14.93
	3462	9/10/2008	9/12/2008	N.D.	2	14.93	29.86	14.93
	3518	10/8/2008	10/10/2008	N.D.	2	14.93	29.86	14.93
	3591	11/13/2008	11/18/2008	N.D.	2	14.93	29.86	14.93
	3630	12/3/2008	12/6/2008	N.D.	2	14.93	29.86	14.93
	3725	1/14/2009	1/21/2009	N.D.	2	14.93	29.86	14.93
	3786	2/11/2009	2/13/2009	N.D.	2	14.93	29.86	14.93
	3840	3/10/2009	3/27/2009	N.D.	2	14.93	29.86	14.93
	3924	4/15/2009	4/22/2009	N.D.	2	14.93	29.86	14.93
	3992	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4040	6/1/2009	6/8/2009	N.D.	2	14.93	29.86	14.93
	4103	7/7/2009	7/10/2009	N.D.	2	15.17	30.34	15.17
	4181	8/6/2009	8/13/2009	N.D.	2	15.17	30.34	15.17
	4250	9/2/2009	9/4/2009	N.D.	2	15.17	30.34	15.17
	4347	10/13/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4372	11/2/2009	11/12/2009	N.D.	2	15.17	30.34	15.17
	4479	12/9/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4640	1/27/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4738	2/18/2010	2/23/2010	N.D.	2	15.17	30.34	15.17
	4795	3/9/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	5078	5/25/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5130	6/2/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5252	7/13/2010	7/19/2010	N.D.	2	7.00	14.00	7.00
	5362	8/10/2010	8/17/2010	N.D.	2	7.00	14.00	7.00
	5487	9/22/2010	9/27/2010	N.D.	2	7.00	14.00	7.00
	5531	10/11/2010	10/18/2010	N.D.	2	7.00	14.00	7.00
	5624	11/8/2010	11/15/2010	N.D.	2	7.00	14.00	7.00
	5743	12/14/2010	12/20/2010	51.16	2	7.00	14.00	51.16
	5841	1/18/2011	1/24/2011	N.D.	2	14.03	28.06	14.03
	5927	2/15/2011	2/21/2011	N.D.	2	14.03	28.06	14.03
	6015	3/8/2011	3/11/2011	N.D.	2	14.03	28.06	14.03
	6128	4/18/2011	4/26/2011	N.D.	2	14.03	28.06	14.03
	6210	5/9/2011	5/13/2011	N.D.	2	14.03	28.06	14.03
	6309	6/14/2011	6/21/2011	N.D.	2	14.03	28.06	14.03
	6426	7/18/2011	7/22/2011	N.D.	2	14.03	28.06	14.03
	6494	8/15/2011	8/22/2011	N.D.	2	14.03	28.06	14.03
	6571	9/19/2011	9/27/2011	N.D.	2	14.03	28.06	14.03
	6654	10/18/2011	10/25/2011	N.D.	2	14.03	28.06	14.03
	6716	11/7/2011	11/11/2011	38.82	2	14.03	28.06	38.82
	6771	12/5/2011	12/9/2011	N.D.	2	14.40	28.80	14.40
	6857	1/9/2012	1/13/2012	N.D.	2	14.40	28.80	14.40
	6959	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7009	3/6/2012	3/9/2012	N.D.	2	14.40	28.80	14.40
	7083	4/2/2012	4/9/2012	N.D.	2	14.40	28.80	14.40
	7161	5/1/2012	5/4/2012	N.D.	2	14.40	28.80	14.40
	7234	6/4/2012	6/8/2012	N.D.	2	14.40	28.80	14.40
	7361	7/16/2012	7/23/2012	N.D.	2	14.40	28.80	14.40
	7419	8/6/2012	8/10/2012	N.D.	2	14.40	28.80	14.40
	7504	9/4/2012	9/7/2012	N.D.	2	14.40	28.80	14.40
	7615	10/8/2012	10/16/2012	N.D.	2	14.40	28.80	14.40
	7686	11/5/2012	11/9/2012	N.D.	2	17.29	34.58	17.29
	7772	12/3/2012	12/7/2012	N.D.	2	17.29	34.58	17.29
	7865	1/8/2013	1/14/2013	N.D.	2	17.29	34.58	17.29
	7928	2/5/2013	2/8/2013	N.D.	2	17.29	34.58	17.29
	8001	3/5/2013	3/11/2013	N.D.	2	17.29	34.58	17.29
	8087	4/2/2013	4/5/2013	N.D.	2	17.29	34.58	17.29
	8186	5/13/2013	5/17/2013	N.D.	2	17.29	34.58	17.29
	8260	6/9/2013	6/14/2013	N.D.	2	17.29	34.58	17.29
	8335	7/9/2013	7/12/2013	N.D.	2	17.29	34.58	17.29
	8439	8/12/2013	8/19/2013	N.D.	2	17.29	34.58	17.29
	8533	9/16/2013	9/20/2013	N.D.	2	17.29	34.58	17.29
	8578	10/8/2013	10/11/2013	N.D.	2	17.29	34.58	17.29
	8707	11/11/2013	11/18/2013	N.D.	2	16.29	32.58	16.29
	8777	12/9/2013	12/13/2013	N.D.	2	16.29	32.58	16.29
	8853	1/14/2014	1/22/2014	N.D.	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 3, IBA

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 3 Location IBA	3168	4/24/2008	4/30/2008	N.D.	2	10.79	21.58	10.79
	3223	5/15/2008	5/23/2008	N.D.	2	10.79	21.58	10.79
	3291	6/19/2008	6/25/2008	N.D.	2	10.79	21.58	10.79
	3349	7/16/2008	7/22/2008	N.D.	2	10.79	21.58	10.79
	3413	8/20/2008	8/22/2008	N.D.	2	14.93	29.86	14.93
	3461	9/10/2008	9/12/2008	N.D.	2	14.93	29.86	14.93
	3517	10/8/2008	10/10/2008	N.D.	2	14.93	29.86	14.93
	3590	11/13/2008	11/18/2008	N.D.	2	14.93	29.86	14.93
	3629	12/3/2008	12/6/2008	N.D.	2	14.93	29.86	14.93
	3724	1/14/2009	1/21/2009	N.D.	2	14.93	29.86	14.93
	3785	2/11/2009	2/13/2009	N.D.	2	14.93	29.86	14.93
	3839	3/10/2009	3/27/2009	N.D.	2	14.93	29.86	14.93
	3923	4/15/2009	4/22/2009	N.D.	2	14.93	29.86	14.93
	3991	5/12/2009	5/15/2009	N.D.	2	14.93	29.86	14.93
	4039	6/1/2009	6/8/2009	N.D.	2	14.93	29.86	14.93
	4102	7/7/2009	7/10/2009	N.D.	2	15.17	30.34	15.17
	4180	8/6/2009	8/13/2009	N.D.	2	15.17	30.34	15.17
	4249	9/2/2009	9/4/2009	N.D.	2	15.17	30.34	15.17
	4346	10/13/2009	10/15/2009	N.D.	2	15.17	30.34	15.17
	4371	11/2/2009	11/12/2009	N.D.	2	15.17	30.34	15.17
	4478	12/9/2009	12/15/2009	N.D.	2	15.17	30.34	15.17
	4639	1/27/2010	2/2/2010	N.D.	2	15.17	30.34	15.17
	4737	2/18/2010	2/23/2010	N.D.	2	15.17	30.34	15.17
	4794	3/9/2010	3/12/2010	N.D.	2	15.17	30.34	15.17
	4954	4/20/2010	4/28/2010	N.D.	2	15.17	30.34	15.17
	5079	5/25/2010	5/28/2010	N.D.	2	15.17	30.34	15.17
	5131	6/2/2010	6/7/2010	N.D.	2	15.17	30.34	15.17
	5251	7/13/2010	7/19/2010	N.D.	2	7.00	14.00	7.00
	5361	8/10/2010	8/17/2010	N.D.	2	7.00	14.00	7.00
	5488	9/22/2010	9/27/2010	N.D.	2	7.00	14.00	7.00
	5530	10/11/2010	10/18/2010	N.D.	2	7.00	14.00	7.00
	5623	11/8/2010	11/15/2010	N.D.	2	7.00	14.00	7.00
	5742	12/14/2010	12/20/2010	N.D.	2	7.00	14.00	7.00
	5840	1/18/2011	1/24/2011	N.D.	2	14.03	28.06	14.03
	5926	2/15/2011	2/21/2011	N.D.	2	14.03	28.06	14.03
	6014	3/8/2011	3/11/2011	N.D.	2	14.03	28.06	14.03
	6127	4/18/2011	4/26/2011	N.D.	2	14.03	28.06	14.03
	6209	5/9/2011	5/13/2011	N.D.	2	14.03	28.06	14.03
	6310	6/14/2011	6/21/2011	N.D.	2	14.03	28.06	14.03
	6425	7/18/2011	7/22/2011	N.D.	2	14.03	28.06	14.03
	6493	8/15/2011	8/22/2011	N.D.	2	14.03	28.06	14.03
	6572	9/19/2011	9/27/2011	N.D.	2	14.03	28.06	14.03
	6655	10/18/2011	10/25/2011	N.D.	2	14.03	28.06	14.03
	6717	11/7/2011	11/11/2011	N.D.	2	14.03	28.06	14.03
	6772	12/5/2011	12/9/2011	N.D.	2	14.40	28.80	14.40
	6856	1/9/2012	1/13/2012	N.D.	2	14.40	28.80	14.40
	6960	2/16/2012	2/22/2012	N.D.	2	14.40	28.80	14.40
	7010	3/6/2012	3/9/2012	N.D.	2	14.40	28.80	14.40
	7082	4/2/2012	4/9/2012	N.D.	2	14.40	28.80	14.40
	7160	5/1/2012	5/4/2012	N.D.	2	14.40	28.80	14.40
	7233	6/4/2012	6/8/2012	N.D.	2	14.40	28.80	14.40
	7360	7/16/2012	7/23/2012	N.D.	2	14.40	28.80	14.40
	7418	8/6/2012	8/10/2012	N.D.	2	14.40	28.80	14.40
	7503	9/4/2012	9/7/2012	N.D.	2	14.40	28.80	14.40
	7614	10/8/2012	10/16/2012	N.D.	2	14.40	28.80	14.40
	7685	11/5/2012	11/9/2012	N.D.	2	17.29	34.58	17.29
	7771	12/3/2012	12/7/2012	N.D.	2	17.29	34.58	17.29
	7864	1/8/2013	1/14/2013	N.D.	2	17.29	34.58	17.29
	7927	2/5/2013	2/8/2013	N.D.	2	17.29	34.58	17.29
	8000	3/5/2013	3/11/2013	N.D.	2	17.29	34.58	17.29
	8086	4/2/2013	4/5/2013	N.D.	2	17.29	34.58	17.29
	8185	5/13/2013	5/17/2013	N.D.	2	17.29	34.58	17.29
	8259	6/9/2013	6/14/2013	N.D.	2	17.29	34.58	17.29
	8334	7/9/2013	7/12/2013	N.D.	2	17.29	34.58	17.29
	8438	8/12/2013	8/19/2013	N.D.	2	17.29	34.58	17.29
	8532	9/16/2013	9/20/2013	N.D.	2	17.29	34.58	17.29
	8577	10/8/2013	10/11/2013	N.D.	2	17.29	34.58	17.29
	8706	11/11/2013	11/18/2013	N.D.	2	16.29	32.58	16.29
	8776	12/9/2013	12/13/2013	N.D.	2	16.29	32.58	16.29
	8852	1/14/2014	1/22/2014	N.D.	2	16.29	32.58	16.29

Appendix F

Panel 4 Hydrogen Data

Hydrogen (H_2) Panel 4, Room 7e								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 7e	4032	5/27/2009	5/29/2009	214.50	2	14.93	29.86	214.50
	4069	6/9/2009	6/12/2009	81.40	2	14.93	29.86	81.40
	4139	7/21/2009	7/24/2009	N.D.	2	15.17	30.34	15.17
	4200	8/11/2009	8/17/2009	N.D.	2	15.17	30.34	15.17
	4274	9/15/2009	9/18/2009	52.08	2	15.17	30.34	52.08
	4315	10/5/2009	10/12/2009	29.58	2	15.17	30.34	15.17
	4404	11/9/2009	11/16/2009	376.32	2	15.17	30.34	376.32
	4531	12/30/2009	1/12/2010	732.38	2	15.17	30.34	732.38
	4595	1/20/2010	1/22/2010	230.68	2	15.17	30.34	230.68
	4680	2/10/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4833	3/17/2010	3/29/2010	538.04	2	15.17	30.34	538.04
	4915	4/13/2010	4/20/2010	470.54	2	15.17	30.34	470.54
	5050	5/17/2010	5/24/2010	432.10	2	15.17	30.34	432.10
	5175	6/15/2010	6/21/2010	923.52	2	7.00	14.00	923.52
	5310	7/26/2010	8/2/2010	291.14	2	7.00	14.00	291.14
	5396	8/24/2010	8/30/2010	257.50	2	7.00	14.00	257.50
	5450	9/13/2010	9/20/2010	867.36	2	7.00	14.00	867.36
	5569	10/20/2010	10/25/2010	873.20	2	7.00	14.00	873.20
	5661	11/16/2010	11/22/2010	868.52	2	7.00	14.00	868.52
	5718	12/7/2010	12/13/2010	983.72	2	7.00	14.00	983.72
	5816	1/11/2011	1/18/2011	938.74	2	14.03	28.06	938.74
	5892	2/7/2011	2/10/2011	785.90	2	14.03	28.06	785.90
	5980	3/1/2011	3/4/2011	841.20	2	14.03	28.06	841.20
	6083	4/5/2011	4/20/2011	739.96	2	14.03	28.06	739.96
	6182	5/3/2011	5/6/2011	920.04	2	14.03	28.06	920.04
	6333	6/16/2011	6/24/2011	854.28	2	14.03	28.06	854.28
	6409	7/12/2011	7/15/2011	775.72	2	14.03	28.06	775.72
	6477	8/9/2011	8/19/2011	837.04	2	14.03	28.06	837.04
	6553	9/14/2011	9/16/2011	823.62	2	14.03	28.06	823.62
	6627	10/11/2011	10/14/2011	856.32	2	14.03	28.06	856.32
	6700	11/1/2011	11/4/2011	793.36	2	14.03	28.06	793.36
	6804	12/12/2011	12/16/2011	737.98	2	14.40	28.80	737.98
	6890	1/17/2012	1/23/2012	759.70	2	14.40	28.80	759.70
	6942	2/7/2012	2/10/2012	735.92	2	14.40	28.80	735.92
	7043	3/13/2012	3/16/2012	669.68	2	14.40	28.80	669.68
	7113	4/10/2012	4/13/2012	635.18	2	14.40	28.80	635.18
	7191	5/9/2012	5/15/2012	530.68	2	14.40	28.80	530.68
	7270	6/11/2012	6/18/2012	466.46	2	14.40	28.80	466.46
	7341	7/10/2012	7/13/2012	409.74	2	14.40	28.80	409.74
	7457	8/13/2012	8/17/2012	288.84	2	14.40	28.80	288.84
	7535	9/10/2012	9/14/2012	344.36	2	14.40	28.80	344.36
	7581	10/2/2012	10/5/2012	399.12	2	14.40	28.80	399.12
	7721	11/13/2012	11/16/2012	389.44	2	17.29	34.58	389.44
	7809	12/11/2012	12/14/2012	421.08	2	17.29	34.58	421.08
	7896	1/15/2013	1/18/2013	363.00	2	17.29	34.58	363.00
	7963	2/12/2013	2/15/2013	220.44	2	17.29	34.58	220.44
	8035	3/12/2013	3/15/2013	328.82	2	17.29	34.58	328.82
	8109	4/9/2013	4/12/2013	362.76	2	17.29	34.58	362.76
	8168	5/7/2013	5/10/2013	385.40	2	17.29	34.58	385.40
	8252	6/3/2013	6/7/2013	151.62	2	17.29	34.58	151.62
	8327	7/1/2013	7/9/2013	85.80	2	17.29	34.58	85.80
	8404	8/5/2013	8/9/2013	85.92	2	17.29	34.58	85.92
	8507	9/9/2013	9/16/2013	66.72	2	17.29	34.58	66.72
	8636	10/21/2013	10/25/2013	66.24	2	16.29	32.58	66.24
	8681	11/4/2013	11/8/2013	67.68	2	16.29	32.58	67.68
	8755	12/2/2013	12/10/2013	66.82	2	16.29	32.58	66.82
	8890	1/20/2014	1/28/2014	N.D.	2	16.29	32.58	16.29
	8919	2/3/2014	2/11/2014	171.18	2	16.29	32.58	171.18

Hydrogen (H_2)

Panel 4, Room 7i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 7i	4028	5/27/2009	5/29/2009	77.78	2	14.93	29.86	77.78
	4073	6/9/2009	6/12/2009	100.20	2	14.93	29.86	100.20
	4130	7/20/2009	7/24/2009	226.46	2	15.17	30.34	226.46
	4191	8/11/2009	8/17/2009	235.94	2	15.17	30.34	235.94
	4265	9/14/2009	9/18/2009	242.14	2	15.17	30.34	242.14
	4306	10/5/2009	10/12/2009	48.62	2	15.17	30.34	48.62
	4413	11/11/2009	11/16/2009	179.38	2	15.17	30.34	179.38
	4522	12/30/2009	1/12/2010	N.D.	2	15.17	30.34	15.17
	4586	1/19/2010	1/22/2010	242.94	2	15.17	30.34	242.94
	4671	2/9/2010	2/12/2010	341.44	2	15.17	30.34	341.44
	4824	3/16/2010	3/29/2010	652.14	2	15.17	30.34	652.14
	4925	4/14/2010	4/20/2010	453.88	2	15.17	30.34	453.88
	5041	5/17/2010	5/24/2010	879.08	2	15.17	30.34	879.08
	5166	6/14/2010	6/21/2010	823.70	2	7.00	14.00	823.70
	5301	7/26/2010	8/2/2010	45.56	2	7.00	14.00	45.56
	5387	8/24/2010	8/30/2010	686.82	2	7.00	14.00	686.82
	5441	9/13/2010	9/20/2010	758.66	2	7.00	14.00	758.66
	5560	10/19/2010	10/25/2010	761.02	2	7.00	14.00	761.02
	5652	11/15/2010	11/22/2010	849.62	2	7.00	14.00	849.62
	5709	12/7/2010	12/13/2010	828.18	2	7.00	14.00	828.18
	5807	1/11/2011	1/18/2011	708.12	2	14.03	28.06	708.12
	5881	2/1/2011	2/10/2011	707.46	2	14.03	28.06	707.46
	5971	3/1/2011	3/4/2011	902.20	2	14.03	28.06	902.20
	6074	4/5/2011	4/20/2011	831.04	2	14.03	28.06	831.04
	6173	5/2/2011	5/6/2011	729.88	2	14.03	28.06	729.88
	6324	6/15/2011	6/24/2011	687.94	2	14.03	28.06	687.94
	6400	7/11/2011	7/15/2011	674.94	2	14.03	28.06	674.94
	6461	8/9/2011	8/19/2011	507.68	2	14.03	28.06	507.68
	6544	9/13/2011	9/16/2011	500.24	2	14.03	28.06	500.24
	6618	10/10/2011	10/14/2011	388.58	2	14.03	28.06	388.58
	6691	11/1/2011	11/4/2011	425.88	2	14.03	28.06	425.88
	6795	12/12/2011	12/16/2011	557.70	2	14.40	28.80	557.70
	6881	1/17/2012	1/23/2012	529.76	2	14.40	28.80	529.76
	6933	2/7/2012	2/10/2012	435.94	2	14.40	28.80	435.94
	7034	3/13/2012	3/16/2012	378.74	2	14.40	28.80	378.74
	7104	4/10/2012	4/13/2012	168.24	2	14.40	28.80	168.24
	7182	5/8/2012	5/15/2012	217.16	2	14.40	28.80	217.16
	7261	6/11/2012	6/18/2012	141.74	2	14.40	28.80	141.74
	7332	7/10/2012	7/13/2012	135.10	2	14.40	28.80	135.10
	7448	8/13/2012	8/17/2012	102.58	2	14.40	28.80	102.58
	7526	9/10/2012	9/14/2012	358.82	2	14.40	28.80	358.82
	7572	10/1/2012	10/5/2012	357.82	2	14.40	28.80	357.82
	7712	11/12/2012	11/16/2012	323.84	2	17.29	34.58	323.84
	7800	12/10/2012	12/14/2012	348.26	2	17.29	34.58	348.26
	7887	1/14/2013	1/18/2013	242.66	2	17.29	34.58	242.66
	7954	2/12/2013	2/15/2013	194.70	2	17.29	34.58	194.70
	8026	3/12/2013	3/15/2013	317.90	2	17.29	34.58	317.90
	8100	4/9/2013	4/12/2013	335.64	2	17.29	34.58	335.64
	8159	5/7/2013	5/10/2013	350.10	2	17.29	34.58	350.10
	8243	6/3/2013	6/7/2013	N.D.	2	17.29	34.58	17.29
	8318	7/1/2013	7/9/2013	N.D.	2	17.29	34.58	17.29
	8397	8/5/2013	8/9/2013	N.D.	2	17.29	34.58	17.29
	8500	9/9/2013	9/16/2013	N.D.	2	17.29	34.58	17.29
	8629	10/21/2013	10/25/2013	34.82	2	16.29	32.58	34.82
	8674	11/4/2013	11/8/2013	59.82	2	16.29	32.58	59.82
	8748	12/2/2013	12/10/2013	41.00	2	16.29	32.58	41.00
	8881	1/20/2014	1/28/2014	68.98	2	16.29	32.58	68.98
	8910	2/3/2014	2/11/2014	125.84	2	16.29	32.58	125.84

Hydrogen (H_2)

Panel 4, Room 6e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 6e	4031	5/27/2009	5/29/2009	190.82	2	14.93	29.86	190.82
	4068	6/8/2009	6/12/2009	114.46	2	14.93	29.86	114.46
	4140	7/21/2009	7/24/2009	177.58	2	15.17	30.34	177.58
	4201	8/11/2009	8/17/2009	247.88	2	15.17	30.34	247.88
	4275	9/15/2009	9/18/2009	159.46	2	15.17	30.34	159.46
	4316	10/5/2009	10/12/2009	117.88	2	15.17	30.34	117.88
	4403	11/9/2009	11/16/2009	341.80	2	15.17	30.34	341.80
	4532	12/30/2009	1/12/2010	466.88	2	15.17	30.34	466.88
	4596	1/20/2010	1/22/2010	576.72	2	15.17	30.34	576.72
	4681	2/10/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4834	3/17/2010	3/29/2010	599.50	2	15.17	30.34	599.50
	4916	4/13/2010	4/20/2010	741.36	2	15.17	30.34	741.36
	5051	5/17/2010	5/24/2010	234.98	2	15.17	30.34	234.98
	5176	6/15/2010	6/21/2010	207.18	2	7.00	14.00	207.18
	5311	7/27/2010	8/2/2010	N.D.	2	7.00	14.00	7.00
	5397	8/25/2010	8/30/2010	880.34	2	7.00	14.00	880.34
	5451	9/14/2010	9/20/2010	902.54	2	7.00	14.00	902.54
	5570	10/20/2010	10/25/2010	1012.68	2	7.00	14.00	1012.68
	5662	11/16/2010	11/22/2010	991.58	2	7.00	14.00	991.58
	5719	12/8/2010	12/13/2010	768.08	2	7.00	14.00	768.08
	5817	1/12/2011	1/18/2011	619.40	2	14.03	28.06	619.40
	5893	2/7/2011	2/10/2011	911.52	2	14.03	28.06	911.52
	5981	3/2/2011	3/4/2011	946.96	2	14.03	28.06	946.96
	6084	4/5/2011	4/20/2011	616.24	2	14.03	28.06	616.24
	6183	5/3/2011	5/6/2011	720.54	2	14.03	28.06	720.54
	6334	6/16/2011	6/24/2011	543.56	2	14.03	28.06	543.56
	6410	7/12/2011	7/15/2011	648.56	2	14.03	28.06	648.56
	6478	8/9/2011	8/19/2011	692.68	2	14.03	28.06	692.68
	6554	9/14/2011	9/16/2011	656.56	2	14.03	28.06	656.56
	6628	10/11/2011	10/14/2011	679.30	2	14.03	28.06	679.30
	6701	11/1/2011	11/4/2011	661.62	2	14.03	28.06	661.62

Hydrogen (H_2)

Panel 4, Room 6i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 6i	4027	5/27/2009	5/29/2009	67.96	2	14.93	29.86	67.96
	4072	6/9/2009	6/12/2009	N.D.	2	14.93	29.86	14.93
	4131	7/20/2009	7/24/2009	247.58	2	15.17	30.34	247.58
	4192	8/11/2009	8/17/2009	230.00	2	15.17	30.34	230.00
	4266	9/14/2009	9/18/2009	247.62	2	15.17	30.34	247.62
	4307	10/5/2009	10/12/2009	324.08	2	15.17	30.34	324.08
	4412	11/11/2009	11/16/2009	N.D.	2	15.17	30.34	15.17
	4523	12/30/2009	1/12/2010	419.66	2	15.17	30.34	419.66
	4587	1/19/2010	1/22/2010	199.04	2	15.17	30.34	199.04
	4672	2/9/2010	2/12/2010	85.18	2	15.17	30.34	85.18
	4825	3/16/2010	3/29/2010	647.86	2	15.17	30.34	647.86
	4926	4/14/2010	4/20/2010	528.88	2	15.17	30.34	528.88
	5042	5/17/2010	5/24/2010	613.98	2	15.17	30.34	613.98
	5167	6/14/2010	6/21/2010	613.10	2	7.00	14.00	613.10
	5302	7/26/2010	8/2/2010	555.22	2	7.00	14.00	555.22
	5388	8/24/2010	8/30/2010	750.22	2	7.00	14.00	750.22
	5442	9/13/2010	9/20/2010	713.28	2	7.00	14.00	713.28
	5561	10/19/2010	10/25/2010	902.74	2	7.00	14.00	902.74
	5653	11/15/2010	11/22/2010	760.56	2	7.00	14.00	760.56
	5710	12/7/2010	12/13/2010	740.56	2	7.00	14.00	740.56
	5808	1/11/2011	1/18/2011	740.30	2	14.03	28.06	740.30
	5882	2/1/2011	2/10/2011	704.76	2	14.03	28.06	704.76
	5972	3/1/2011	3/4/2011	736.38	2	14.03	28.06	736.38
	6075	4/5/2011	4/20/2011	648.88	2	14.03	28.06	648.88
	6174	5/2/2011	5/6/2011	512.20	2	14.03	28.06	512.20
	6325	6/15/2011	6/24/2011	531.00	2	14.03	28.06	531.00
	6401	7/11/2011	7/15/2011	494.48	2	14.03	28.06	494.48
	6469	8/9/2011	8/19/2011	397.04	2	14.03	28.06	397.04
	6545	9/13/2011	9/16/2011	461.88	2	14.03	28.06	461.88
	6619	10/10/2011	10/14/2011	323.52	2	14.03	28.06	323.52
	6692	11/1/2011	11/4/2011	370.18	2	14.03	28.06	370.18
	6796	12/12/2011	12/16/2011	459.02	2	14.40	28.80	459.02
	6882	1/17/2012	1/23/2012	496.08	2	14.40	28.80	496.08
	6934	2/7/2012	2/10/2012	382.54	2	14.40	28.80	382.54
	7035	3/13/2012	3/16/2012	376.90	2	14.40	28.80	376.90
	7105	4/10/2012	4/13/2012	143.80	2	14.40	28.80	143.80
	7183	5/8/2012	5/15/2012	239.76	2	14.40	28.80	239.76
	7262	6/11/2012	6/18/2012	131.74	2	14.40	28.80	131.74
	7333	7/10/2012	7/13/2012	125.18	2	14.40	28.80	125.18
	7449	8/13/2012	8/17/2012	103.14	2	14.40	28.80	103.14
	7527	9/10/2012	9/14/2012	337.64	2	14.40	28.80	337.64
	7573	10/1/2012	10/5/2012	358.46	2	14.40	28.80	358.46
	7713	11/12/2012	11/16/2012	318.78	2	17.29	34.58	318.78
	7801	12/10/2012	12/14/2012	352.86	2	17.29	34.58	352.86
	7888	1/14/2013	1/18/2013	270.80	2	17.29	34.58	270.80
	7955	2/12/2013	2/15/2013	160.74	2	17.29	34.58	160.74
	8027	3/12/2013	3/15/2013	288.12	2	17.29	34.58	288.12
	8101	4/9/2013	4/12/2013	316.54	2	17.29	34.58	316.54
	8160	5/7/2013	5/10/2013	257.66	2	17.29	34.58	257.66
	8244	6/3/2013	6/7/2013	N.D.	2	17.29	34.58	17.29
	8319	7/1/2013	7/9/2013	N.D.	2	17.29	34.58	17.29
	8398	8/5/2013	8/9/2013	N.D.	2	17.29	34.58	17.29
	8501	9/9/2013	9/16/2013	22.06	2	17.29	34.58	17.29
	8630	10/21/2013	10/25/2013	24.02	2	16.29	32.58	16.29
	8675	11/4/2013	11/8/2013	35.40	2	16.29	32.58	35.40
	8749	12/2/2013	12/10/2013	42.32	2	16.29	32.58	42.32
	8882	1/20/2014	1/28/2014	86.12	2	16.29	32.58	86.12
	8911	2/3/2014	2/11/2014	139.82	2	16.29	32.58	139.82

Hydrogen (H_2)
Panel 4, Room 5e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 5e	4030	5/27/2009	5/29/2009	143.28	2	14.93	29.86	143.28
	4067	6/8/2009	6/12/2009	65.66	2	14.93	29.86	65.66
	4141	7/21/2009	7/24/2009	175.06	2	15.17	30.34	175.06
	4202	8/11/2009	8/17/2009	33.02	2	15.17	30.34	33.02
	4276	9/15/2009	9/18/2009	172.86	2	15.17	30.34	172.86
	4317	10/5/2009	10/12/2009	129.82	2	15.17	30.34	129.82
	4402	11/9/2009	11/16/2009	406.36	2	15.17	30.34	406.36
	4533	12/30/2009	1/12/2010	468.60	2	15.17	30.34	468.60
	4597	1/20/2010	1/22/2010	408.40	2	15.17	30.34	408.40
	4682	2/10/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4835	3/17/2010	3/29/2010	575.58	2	15.17	30.34	575.58
	4917	4/13/2010	4/20/2010	510.30	2	15.17	30.34	510.30
	5052	5/17/2010	5/24/2010	747.14	2	15.17	30.34	747.14
	5177	6/15/2010	6/21/2010	N.D.	2	7.00	14.00	7.00
	5312	7/27/2010	8/2/2010	601.06	2	7.00	14.00	601.06
	5398	8/25/2010	8/30/2010	688.94	2	7.00	14.00	688.94
	5452	9/14/2010	9/20/2010	792.94	2	7.00	14.00	792.94
	5571	10/20/2010	10/25/2010	655.86	2	7.00	14.00	655.86
	5663	11/16/2010	11/22/2010	756.48	2	7.00	14.00	756.48
	5720	12/8/2010	12/13/2010	583.38	2	7.00	14.00	583.38
	5818	1/12/2011	1/18/2011	709.40	2	14.03	28.06	709.40
	5894	2/7/2011	2/10/2011	677.24	2	14.03	28.06	677.24
	5982	3/2/2011	3/4/2011	683.92	2	14.03	28.06	683.92
	6085	4/5/2011	4/20/2011	608.70	2	14.03	28.06	608.70
	6184	5/3/2011	5/6/2011	731.70	2	14.03	28.06	731.70
	6335	6/16/2011	6/24/2011	689.48	2	14.03	28.06	689.48
	6411	7/12/2011	7/15/2011	640.36	2	14.03	28.06	640.36
	6479	8/9/2011	8/19/2011	646.18	2	14.03	28.06	646.18
	6557	9/14/2011	9/16/2011	671.18	2	14.03	28.06	671.18
	6629	10/11/2011	10/14/2011	673.00	2	14.03	28.06	673.00
	6702	11/1/2011	11/4/2011	604.10	2	14.03	28.06	604.10
	6806	12/13/2011	12/16/2011	558.76	2	14.40	28.80	558.76
	6892	1/17/2012	1/23/2012	648.78	2	14.40	28.80	648.78
	6943	2/7/2012	2/10/2012	606.14	2	14.40	28.80	606.14
	7044	3/13/2012	3/16/2012	533.38	2	14.40	28.80	533.38
	7114	4/10/2012	4/13/2012	484.22	2	14.40	28.80	484.22
	7192	5/9/2012	5/15/2012	425.66	2	14.40	28.80	425.66
	7271	6/11/2012	6/18/2012	337.64	2	14.40	28.80	337.64
	7342	7/10/2012	7/13/2012	381.12	2	14.40	28.80	381.12

Hydrogen (H_2)

Panel 4, Room 5i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 5i	4026	5/27/2009	5/29/2009	68.62	2	14.93	29.86	68.62
	4071	6/9/2009	6/12/2009	95.90	2	14.93	29.86	95.90
	4132	7/20/2009	7/24/2009	198.24	2	15.17	30.34	198.24
	4193	8/11/2009	8/17/2009	250.44	2	15.17	30.34	250.44
	4267	9/14/2009	9/18/2009	N.D.	2	15.17	30.34	15.17
	4308	10/5/2009	10/12/2009	371.50	2	15.17	30.34	371.50
	4411	11/11/2009	11/16/2009	429.94	2	15.17	30.34	429.94
	4524	12/30/2009	1/12/2010	576.48	2	15.17	30.34	576.48
	4588	1/19/2010	1/22/2010	312.66	2	15.17	30.34	312.66
	4673	2/9/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4826	3/16/2010	3/29/2010	649.22	2	15.17	30.34	649.22
	4927	4/14/2010	4/20/2010	480.98	2	15.17	30.34	480.98
	5043	5/17/2010	5/24/2010	386.14	2	15.17	30.34	386.14
	5168	6/14/2010	6/21/2010	N.D.	2	7.00	14.00	7.00
	5303	7/26/2010	8/2/2010	593.42	2	7.00	14.00	593.42
	5389	8/24/2010	8/30/2010	606.30	2	7.00	14.00	606.30
	5443	9/13/2010	9/20/2010	790.44	2	7.00	14.00	790.44
	5562	10/19/2010	10/25/2010	764.12	2	7.00	14.00	764.12
	5654	11/15/2010	11/22/2010	686.16	2	7.00	14.00	686.16
	5711	12/7/2010	12/13/2010	636.06	2	7.00	14.00	636.06
	5809	1/11/2011	1/18/2011	647.44	2	14.03	28.06	647.44
	5883	2/1/2011	2/10/2011	580.90	2	14.03	28.06	580.90
	5973	3/1/2011	3/4/2011	636.12	2	14.03	28.06	636.12
	6076	4/5/2011	4/20/2011	698.90	2	14.03	28.06	698.90
	6175	5/2/2011	5/6/2011	695.86	2	14.03	28.06	695.86
	6326	6/15/2011	6/24/2011	608.70	2	14.03	28.06	608.70
	6402	7/11/2011	7/15/2011	715.64	2	14.03	28.06	715.64
	6470	8/9/2011	8/19/2011	631.96	2	14.03	28.06	631.96
	6546	9/13/2011	9/16/2011	564.12	2	14.03	28.06	564.12
	6620	10/10/2011	10/14/2011	449.38	2	14.03	28.06	449.38
	6693	11/1/2011	11/4/2011	421.78	2	14.03	28.06	421.78
	6797	12/12/2011	12/16/2011	502.48	2	14.40	28.80	502.48
	6883	1/17/2012	1/23/2012	517.00	2	14.40	28.80	517.00
	6935	2/7/2012	2/10/2012	442.04	2	14.40	28.80	442.04
	7036	3/13/2012	3/16/2012	421.60	2	14.40	28.80	421.60
	7106	4/10/2012	4/13/2012	312.30	2	14.40	28.80	312.30
	7184	5/8/2012	5/15/2012	279.52	2	14.40	28.80	279.52
	7263	6/11/2012	6/18/2012	258.10	2	14.40	28.80	258.10
	7334	7/10/2012	7/13/2012	325.82	2	14.40	28.80	325.82
	7450	8/13/2012	8/17/2012	223.98	2	14.40	28.80	223.98
	7528	9/10/2012	9/14/2012	364.56	2	14.40	28.80	364.56
	7574	10/1/2012	10/5/2012	387.78	2	14.40	28.80	387.78
	7714	11/12/2012	11/16/2012	354.74	2	17.29	34.58	354.74
	7802	12/10/2012	12/14/2012	362.94	2	17.29	34.58	362.94
	7889	1/14/2013	1/18/2013	356.84	2	17.29	34.58	356.84
	7956	2/12/2013	2/15/2013	177.06	2	17.29	34.58	177.06
	8028	3/12/2013	3/15/2013	303.32	2	17.29	34.58	303.32
	8102	4/9/2013	4/12/2013	296.04	2	17.29	34.58	296.04
	8161	5/7/2013	5/10/2013	360.62	2	17.29	34.58	360.62
	8245	6/3/2013	6/7/2013	26.42	2	17.29	34.58	17.29
	8320	7/1/2013	7/9/2013	28.90	2	17.29	34.58	17.29
	8399	8/5/2013	8/9/2013	N.D.	2	17.29	34.58	17.29
	8502	9/9/2013	9/16/2013	41.32	2	17.29	34.58	41.32
	8631	10/21/2013	10/25/2013	45.26	2	16.29	32.58	45.26
	8676	11/4/2013	11/8/2013	49.32	2	16.29	32.58	49.32
	8750	12/2/2013	12/10/2013	55.78	2	16.29	32.58	55.78
	8883	1/20/2014	1/28/2014	90.82	2	16.29	32.58	90.82
	8912	2/3/2014	2/11/2014	136.82	2	16.29	32.58	136.82

Hydrogen (H_2)
Panel 4, Room 4e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 4e	4029	5/27/2009	5/29/2009	52.26	2	14.93	29.86	52.26
	4066	6/8/2009	6/12/2009	29.26	2	14.93	29.86	14.93
	4142	7/21/2009	7/24/2009	145.02	2	15.17	30.34	145.02
	4203	8/13/2009	8/17/2009	256.40	2	15.17	30.34	256.40
	4277	9/15/2009	9/18/2009	239.74	2	15.17	30.34	239.74
	4318	10/5/2009	10/12/2009	107.02	2	15.17	30.34	107.02
	4401	11/9/2009	11/16/2009	293.96	2	15.17	30.34	293.96
	4534	12/30/2009	1/12/2010	525.70	2	15.17	30.34	525.70
	4598	1/20/2010	1/22/2010	298.72	2	15.17	30.34	298.72
	4683	2/10/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4836	3/17/2010	3/29/2010	512.92	2	15.17	30.34	512.92
	4918	4/13/2010	4/20/2010	516.80	2	15.17	30.34	516.80
	5053	5/17/2010	5/24/2010	479.40	2	15.17	30.34	479.40
	5178	6/15/2010	6/21/2010	144.16	2	7.00	14.00	144.16
	5313	7/27/2010	8/2/2010	597.18	2	7.00	14.00	597.18
	5399	8/25/2010	8/30/2010	779.30	2	7.00	14.00	779.30
	5453	9/14/2010	9/20/2010	561.66	2	7.00	14.00	561.66
	5572	10/20/2010	10/25/2010	643.42	2	7.00	14.00	643.42
	5664	11/16/2010	11/22/2010	640.36	2	7.00	14.00	640.36
	5721	12/8/2010	12/13/2010	570.10	2	7.00	14.00	570.10
	5819	1/12/2011	1/18/2011	656.70	2	14.03	28.06	656.70
	5895	2/7/2011	2/10/2011	479.42	2	14.03	28.06	479.42
	5983	3/2/2011	3/4/2011	561.46	2	14.03	28.06	561.46

Hydrogen (H_2)

Panel 4, Room 4i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 4i	4025	5/27/2009	5/29/2009	46.62	2	14.93	29.86	46.62
	4070	6/9/2009	6/12/2009	66.00	2	14.93	29.86	66.00
	4133	7/20/2009	7/24/2009	162.30	2	15.17	30.34	162.30
	4194	8/11/2009	8/17/2009	184.72	2	15.17	30.34	184.72
	4268	9/14/2009	9/18/2009	N.D.	2	15.17	30.34	15.17
	4309	10/5/2009	10/12/2009	167.38	2	15.17	30.34	167.38
	4410	11/11/2009	11/16/2009	390.88	2	15.17	30.34	390.88
	4525	12/30/2009	1/12/2010	476.76	2	15.17	30.34	476.76
	4589	1/19/2010	1/22/2010	302.16	2	15.17	30.34	302.16
	4674	2/9/2010	2/12/2010	73.90	2	15.17	30.34	73.90
	4827	3/16/2010	3/29/2010	532.06	2	15.17	30.34	532.06
	4928	4/14/2010	4/20/2010	91.48	2	15.17	30.34	91.48
	5044	5/17/2010	5/24/2010	537.96	2	15.17	30.34	537.96
	5169	6/14/2010	6/21/2010	111.78	2	7.00	14.00	111.78
	5304	7/26/2010	8/2/2010	275.10	2	7.00	14.00	275.10
	5390	8/24/2010	8/30/2010	709.50	2	7.00	14.00	709.50
	5444	9/13/2010	9/20/2010	728.04	2	7.00	14.00	728.04
	5563	10/19/2010	10/25/2010	670.12	2	7.00	14.00	670.12
	5655	11/15/2010	11/22/2010	672.26	2	7.00	14.00	672.26
	5712	12/7/2010	12/13/2010	610.84	2	7.00	14.00	610.84
	5810	1/11/2011	1/18/2011	597.58	2	14.03	28.06	597.58
	5884	2/1/2011	2/10/2011	N.D.	2	14.03	28.06	14.03
	5974	3/1/2011	3/4/2011	622.32	2	14.03	28.06	622.32
	6077	4/5/2011	4/20/2011	734.34	2	14.03	28.06	734.34
	6176	5/2/2011	5/6/2011	663.88	2	14.03	28.06	663.88
	6327	6/15/2011	6/24/2011	583.40	2	14.03	28.06	583.40
	6403	7/11/2011	7/15/2011	629.18	2	14.03	28.06	629.18
	6471	8/9/2011	8/19/2011	445.40	2	14.03	28.06	445.40
	6547	9/13/2011	9/16/2011	428.76	2	14.03	28.06	428.76
	6621	10/10/2011	10/14/2011	357.76	2	14.03	28.06	357.76
	6694	11/1/2011	11/4/2011	381.34	2	14.03	28.06	381.34
	6798	12/12/2011	12/16/2011	552.18	2	14.40	28.80	552.18
	6884	1/17/2012	1/23/2012	550.82	2	14.40	28.80	550.82
	6936	2/7/2012	2/10/2012	457.42	2	14.40	28.80	457.42
	7037	3/13/2012	3/16/2012	389.74	2	14.40	28.80	389.74
	7107	4/10/2012	4/13/2012	312.08	2	14.40	28.80	312.08
	7185	5/8/2012	5/15/2012	290.96	2	14.40	28.80	290.96
	7264	6/11/2012	6/18/2012	282.70	2	14.40	28.80	282.70
	7335	7/10/2012	7/13/2012	327.42	2	14.40	28.80	327.42
	7451	8/13/2012	8/17/2012	266.40	2	14.40	28.80	266.40
	7529	9/10/2012	9/14/2012	370.90	2	14.40	28.80	370.90
	7575	10/1/2012	10/5/2012	398.82	2	14.40	28.80	398.82
	7715	11/12/2012	11/16/2012	371.26	2	17.29	34.58	371.26
	7803	12/10/2012	12/14/2012	383.66	2	17.29	34.58	383.66
	7890	1/14/2013	1/18/2013	400.52	2	17.29	34.58	400.52
	7957	2/12/2013	2/15/2013	187.84	2	17.29	34.58	187.84
	8029	3/12/2013	3/15/2013	292.78	2	17.29	34.58	292.78
	8103	4/9/2013	4/12/2013	273.76	2	17.29	34.58	273.76
	8162	5/7/2013	5/10/2013	345.92	2	17.29	34.58	345.92
	8246	6/3/2013	6/7/2013	36.88	2	17.29	34.58	36.88
	8321	7/1/2013	7/9/2013	35.70	2	17.29	34.58	35.70
	8400	8/5/2013	8/9/2013	45.08	2	17.29	34.58	45.08
	8503	9/9/2013	9/16/2013	31.24	2	17.29	34.58	17.29
	8632	10/21/2013	10/25/2013	59.20	2	16.29	32.58	59.20
	8677	11/4/2013	11/8/2013	43.96	2	16.29	32.58	43.96
	8751	12/2/2013	12/10/2013	58.80	2	16.29	32.58	58.80
	8884	1/20/2014	1/28/2014	97.24	2	16.29	32.58	97.24
	8913	2/3/2014	2/11/2014	136.58	2	16.29	32.58	136.58

Hydrogen (H_2)

Panel 4, Room 3e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 3e	4019	5/26/2009	5/29/2009	135.72	2	14.93	29.86	135.72
	4077	6/10/2009	6/12/2009	46.60	2	14.93	29.86	46.60
	4143	7/21/2009	7/24/2009	137.72	2	15.17	30.34	137.72
	4204	8/13/2009	8/17/2009	160.64	2	15.17	30.34	160.64
	4278	9/15/2009	9/18/2009	166.84	2	15.17	30.34	166.84
	4319	10/5/2009	10/12/2009	33.06	2	15.17	30.34	33.06
	4400	11/9/2009	11/16/2009	391.36	2	15.17	30.34	391.36
	4535	12/30/2009	1/12/2010	538.14	2	15.17	30.34	538.14
	4599	1/20/2010	1/22/2010	407.96	2	15.17	30.34	407.96
	4684	2/10/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4837	3/17/2010	3/29/2010	554.86	2	15.17	30.34	554.86
	4919	4/13/2010	4/20/2010	458.06	2	15.17	30.34	458.06
	5054	5/17/2010	5/24/2010	377.58	2	15.17	30.34	377.58
	5179	6/15/2010	6/21/2010	N.D.	2	7.00	14.00	7.00
	5314	7/27/2010	8/2/2010	647.24	2	7.00	14.00	647.24
	5400	8/25/2010	8/30/2010	241.08	2	7.00	14.00	241.08
	5454	9/14/2010	9/20/2010	622.18	2	7.00	14.00	622.18
	5573	10/20/2010	10/25/2010	533.98	2	7.00	14.00	533.98
	5665	11/16/2010	11/22/2010	691.12	2	7.00	14.00	691.12
	5722	12/8/2010	12/13/2010	620.50	2	7.00	14.00	620.50
	5820	1/12/2011	1/18/2011	656.18	2	14.03	28.06	656.18
	5896	2/7/2011	2/10/2011	661.56	2	14.03	28.06	661.56
	5984	3/2/2011	3/4/2011	573.94	2	14.03	28.06	573.94
	6087	4/6/2011	4/20/2011	676.52	2	14.03	28.06	676.52
	6185	5/3/2011	5/6/2011	662.62	2	14.03	28.06	662.62
	6336	6/16/2011	6/24/2011	674.22	2	14.03	28.06	674.22
	6412	7/12/2011	7/15/2011	635.28	2	14.03	28.06	635.28
	6480	8/9/2011	8/19/2011	663.40	2	14.03	28.06	663.40
	6558	9/14/2011	9/16/2011	626.82	2	14.03	28.06	626.82
	6630	10/11/2011	10/14/2011	628.78	2	14.03	28.06	628.78
	6703	11/1/2011	11/4/2011	605.58	2	14.03	28.06	605.58
	6807	12/13/2011	12/16/2011	552.70	2	14.40	28.80	552.70
	6893	1/17/2012	1/23/2012	590.80	2	14.40	28.80	590.80
	6944	2/7/2012	2/10/2012	533.58	2	14.40	28.80	533.58
	7045	3/13/2012	3/16/2012	524.88	2	14.40	28.80	524.88
	7115	4/10/2012	4/13/2012	407.36	2	14.40	28.80	407.36
	7193	5/9/2012	5/15/2012	353.58	2	14.40	28.80	353.58
	7272	6/11/2012	6/18/2012	322.22	2	14.40	28.80	322.22
	7343	7/10/2012	7/13/2012	298.32	2	14.40	28.80	298.32
	7459	8/13/2012	8/17/2012	188.78	2	14.40	28.80	188.78
	7536	9/10/2012	9/14/2012	351.60	2	14.40	28.80	351.60
	7582	10/2/2012	10/5/2012	408.14	2	14.40	28.80	408.14
	7722	11/13/2012	11/16/2012	395.10	2	17.29	34.58	395.10
	7810	12/11/2012	12/14/2012	415.32	2	17.29	34.58	415.32
	7897	1/15/2013	1/18/2013	380.88	2	17.29	34.58	380.88
	7964	2/12/2013	2/15/2013	221.86	2	17.29	34.58	221.86
	8036	3/12/2013	3/15/2013	324.78	2	17.29	34.58	324.78
	8110	4/9/2013	4/12/2013	388.98	2	17.29	34.58	388.98
	8169	5/7/2013	5/10/2013	395.20	2	17.29	34.58	395.20
	8253	6/3/2013	6/7/2013	136.12	2	17.29	34.58	136.12
	8328	7/1/2013	7/9/2013	87.56	2	17.29	34.58	87.56
	8405	8/5/2013	8/9/2013	81.20	2	17.29	34.58	81.20
	8508	9/9/2013	9/16/2013	64.12	2	17.29	34.58	64.12
	8637	10/21/2013	10/25/2013	61.56	2	16.29	32.58	61.56
	8682	11/4/2013	11/8/2013	64.18	2	16.29	32.58	64.18
	8756	12/2/2013	12/10/2013	63.64	2	16.29	32.58	63.64
	8891	1/20/2014	1/28/2014	125.06	2	16.29	32.58	125.06
	8920	2/3/2014	2/11/2014	162.46	2	16.29	32.58	162.46

Hydrogen (H_2) Panel 4, Room 3i								
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 3i	4024	5/27/2009	5/29/2009	15.48	2	14.93	29.86	14.93
	4079	6/10/2009	6/12/2009	40.10	2	14.93	29.86	40.10
	4134	7/20/2009	7/24/2009	65.92	2	15.17	30.34	65.92
	4195	8/11/2009	8/17/2009	120.62	2	15.17	30.34	120.62
	4269	9/14/2009	9/18/2009	130.34	2	15.17	30.34	130.34
	4310	10/5/2009	10/12/2009	23.22	2	15.17	30.34	15.17
	4409	11/11/2009	11/16/2009	317.70	2	15.17	30.34	317.70
	4526	12/30/2009	1/12/2010	410.20	2	15.17	30.34	410.20
	4590	1/19/2010	1/22/2010	N.D.	2	15.17	30.34	15.17
	4675	2/9/2010	2/12/2010	92.42	2	15.17	30.34	92.42
	4828	3/16/2010	3/29/2010	484.76	2	15.17	30.34	484.76
	4929	4/14/2010	4/20/2010	331.22	2	15.17	30.34	331.22
	5045	5/17/2010	5/24/2010	408.70	2	15.17	30.34	408.70
	5170	6/15/2010	6/21/2010	491.76	2	7.00	14.00	491.76
	5305	7/26/2010	8/2/2010	N.D.	2	7.00	14.00	7.00
	5391	8/24/2010	8/30/2010	824.28	2	7.00	14.00	824.28
	5445	9/13/2010	9/20/2010	177.42	2	7.00	14.00	177.42
	5564	10/19/2010	10/25/2010	658.14	2	7.00	14.00	658.14
	5656	11/15/2010	11/22/2010	693.76	2	7.00	14.00	693.76
	5713	12/7/2010	12/13/2010	653.24	2	7.00	14.00	653.24
	5811	1/11/2011	1/18/2011	539.18	2	14.03	28.06	539.18
	5885	2/1/2011	2/10/2011	610.30	2	14.03	28.06	610.30
	5975	3/1/2011	3/4/2011	567.88	2	14.03	28.06	567.88
	6078	4/5/2011	4/20/2011	647.26	2	14.03	28.06	647.26
	6177	5/2/2011	5/6/2011	579.32	2	14.03	28.06	579.32
	6328	6/16/2011	6/24/2011	604.84	2	14.03	28.06	604.84
	6404	7/11/2011	7/15/2011	592.78	2	14.03	28.06	592.78
	6472	8/9/2011	8/19/2011	589.06	2	14.03	28.06	589.06
	6548	9/13/2011	9/16/2011	586.56	2	14.03	28.06	586.56
	6622	10/10/2011	10/14/2011	543.54	2	14.03	28.06	543.54
	6695	11/1/2011	11/4/2011	476.68	2	14.03	28.06	476.68
	6799	12/12/2011	12/16/2011	538.20	2	14.40	28.80	538.20
	6885	1/17/2012	1/23/2012	557.32	2	14.40	28.80	557.32
	6937	2/7/2012	2/10/2012	489.38	2	14.40	28.80	489.38
	7038	3/13/2012	3/16/2012	446.26	2	14.40	28.80	446.26
	7108	4/10/2012	4/13/2012	403.18	2	14.40	28.80	403.18
	7186	5/8/2012	5/15/2012	322.48	2	14.40	28.80	322.48
	7265	6/11/2012	6/18/2012	251.78	2	14.40	28.80	251.78
	7336	7/10/2012	7/13/2012	195.46	2	14.40	28.80	195.46
	7452	8/13/2012	8/17/2012	141.14	2	14.40	28.80	141.14
	7530	9/10/2012	9/14/2012	324.08	2	14.40	28.80	324.08
	7576	10/1/2012	10/5/2012	344.38	2	14.40	28.80	344.38
	7716	11/12/2012	11/16/2012	351.76	2	17.29	34.58	351.76
	7804	12/10/2012	12/14/2012	381.98	2	17.29	34.58	381.98
	7891	1/14/2013	1/18/2013	291.36	2	17.29	34.58	291.36
	7958	2/12/2013	2/15/2013	174.32	2	17.29	34.58	174.32
	8030	3/12/2013	3/15/2013	296.12	2	17.29	34.58	296.12
	8104	4/9/2013	4/12/2013	310.82	2	17.29	34.58	310.82
	8163	5/7/2013	5/10/2013	348.24	2	17.29	34.58	348.24
	8247	6/3/2013	6/7/2013	N.D.	2	17.29	34.58	17.29
	8322	7/1/2013	7/9/2013	N.D.	2	17.29	34.58	17.29
	8401	8/5/2013	8/9/2013	21.54	2	17.29	34.58	17.29
	8504	9/9/2013	9/16/2013	44.82	2	17.29	34.58	44.82
	8633	10/21/2013	10/25/2013	45.98	2	16.29	32.58	45.98
	8678	11/4/2013	11/8/2013	40.12	2	16.29	32.58	40.12
	8752	12/2/2013	12/10/2013	43.28	2	16.29	32.58	43.28
	8885	1/20/2014	1/28/2014	75.88	2	16.29	32.58	75.88
	8914	2/3/2014	2/11/2014	137.14	2	16.29	32.58	137.14

Hydrogen (H_2)
Panel 4, Room 2e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 2e	4018	5/26/2009	5/29/2009	119.42	2	14.93	29.86	119.42
	4076	6/10/2009	6/12/2009	40.70	2	14.93	29.86	40.70
	4144	7/22/2009	7/24/2009	21.58	2	15.17	30.34	15.17
	4205	8/13/2009	8/17/2009	41.80	2	15.17	30.34	41.80
	4279	9/15/2009	9/18/2009	33.74	2	15.17	30.34	33.74
	4320	10/6/2009	10/12/2009	N.D.	2	15.17	30.34	15.17
	4399	11/9/2009	11/16/2009	360.32	2	15.17	30.34	360.32
	4536	12/30/2009	1/12/2010	447.06	2	15.17	30.34	447.06
	4600	1/20/2010	1/22/2010	412.04	2	15.17	30.34	412.04
	4685	2/10/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4838	3/17/2010	3/29/2010	401.50	2	15.17	30.34	401.50
	4920	4/13/2010	4/20/2010	384.86	2	15.17	30.34	384.86
	5055	5/17/2010	5/24/2010	450.50	2	15.17	30.34	450.50
	5180	6/16/2010	6/21/2010	N.D.	2	7.00	14.00	7.00
	5315	7/27/2010	8/2/2010	252.22	2	7.00	14.00	252.22
	5401	8/25/2010	8/30/2010	453.70	2	7.00	14.00	453.70
	5455	9/14/2010	9/20/2010	505.30	2	7.00	14.00	505.30
	5574	10/20/2010	10/25/2010	164.70	2	7.00	14.00	164.70
	5666	11/16/2010	11/22/2010	478.96	2	7.00	14.00	478.96
	5723	12/8/2010	12/13/2010	477.24	2	7.00	14.00	477.24
	5821	1/12/2011	1/18/2011	530.64	2	14.03	28.06	530.64
	5897	2/7/2011	2/10/2011	498.90	2	14.03	28.06	498.90
	5985	3/2/2011	3/4/2011	456.92	2	14.03	28.06	456.92
	6088	4/6/2011	4/20/2011	573.66	2	14.03	28.06	573.66
	6186	5/3/2011	5/6/2011	435.26	2	14.03	28.06	435.26
	6337	6/16/2011	6/24/2011	549.10	2	14.03	28.06	549.10
	6413	7/12/2011	7/15/2011	472.86	2	14.03	28.06	472.86
	6481	8/9/2011	8/19/2011	416.32	2	14.03	28.06	416.32
	6559	9/14/2011	9/16/2011	465.28	2	14.03	28.06	465.28
	6631	10/11/2011	10/14/2011	327.84	2	14.03	28.06	327.84
	6704	11/1/2011	11/4/2011	426.68	2	14.03	28.06	426.68
	6808	12/13/2011	12/16/2011	506.18	2	14.40	28.80	506.18
	6894	1/17/2012	1/23/2012	552.66	2	14.40	28.80	552.66
	6945	2/7/2012	2/10/2012	432.98	2	14.40	28.80	432.98
	7046	3/13/2012	3/16/2012	424.60	2	14.40	28.80	424.60
	7116	4/10/2012	4/13/2012	348.22	2	14.40	28.80	348.22
	7194	5/9/2012	5/15/2012	259.10	2	14.40	28.80	259.10
	7273	6/11/2012	6/18/2012	249.62	2	14.40	28.80	249.62
	7344	7/10/2012	7/13/2012	269.48	2	14.40	28.80	269.48
	7460	8/13/2012	8/17/2012	274.92	2	14.40	28.80	274.92
	7537	9/10/2012	9/14/2012	319.26	2	14.40	28.80	319.26
	7583	10/2/2012	10/5/2012	382.74	2	14.40	28.80	382.74
	7723	11/13/2012	11/16/2012	363.98	2	17.29	34.58	363.98
	7811	12/11/2012	12/14/2012	386.38	2	17.29	34.58	386.38
	7898	1/15/2013	1/18/2013	339.92	2	17.29	34.58	339.92
	7965	2/12/2013	2/15/2013	207.92	2	17.29	34.58	207.92
	8037	3/12/2013	3/15/2013	305.26	2	17.29	34.58	305.26
	8111	4/9/2013	4/12/2013	345.36	2	17.29	34.58	345.36
	8170	5/7/2013	5/10/2013	377.98	2	17.29	34.58	377.98
	8254	6/3/2013	6/7/2013	113.44	2	17.29	34.58	113.44
	8329	7/1/2013	7/9/2013	85.50	2	17.29	34.58	85.50
	8406	8/5/2013	8/9/2013	78.16	2	17.29	34.58	78.16
	8509	9/9/2013	9/16/2013	58.60	2	17.29	34.58	58.60
	8638	10/21/2013	10/25/2013	51.20	2	16.29	32.58	51.20
	8683	11/4/2013	11/8/2013	55.22	2	16.29	32.58	55.22
	8757	12/2/2013	12/10/2013	77.06	2	16.29	32.58	77.06
	8892	1/20/2014	1/28/2014	118.32	2	16.29	32.58	118.32
	8921	2/3/2014	2/11/2014	178.98	2	16.29	32.58	178.98

Hydrogen (H_2)

Panel 4, Room 2i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 2i	4023	5/27/2009	5/29/2009	N.D.	2	14.93	29.86	14.93
	4078	6/10/2009	6/12/2009	9.74	2	14.93	29.86	14.93
	4135	7/20/2009	7/24/2009	18.58	2	15.17	30.34	15.17
	4196	8/11/2009	8/17/2009	39.14	2	15.17	30.34	39.14
	4270	9/14/2009	9/18/2009	27.80	2	15.17	30.34	15.17
	4311	10/5/2009	10/12/2009	123.80	2	15.17	30.34	123.80
	4408	11/11/2009	11/16/2009	360.98	2	15.17	30.34	360.98
	4527	12/30/2009	1/12/2010	345.20	2	15.17	30.34	345.20
	4591	1/19/2010	1/22/2010	212.78	2	15.17	30.34	212.78
	4676	2/9/2010	2/12/2010	100.50	2	15.17	30.34	100.50
	4829	3/16/2010	3/29/2010	315.38	2	15.17	30.34	315.38
	4930	4/14/2010	4/20/2010	465.72	2	15.17	30.34	465.72
	5046	5/17/2010	5/24/2010	359.90	2	15.17	30.34	359.90
	5171	6/15/2010	6/21/2010	297.24	2	7.00	14.00	297.24
	5306	7/26/2010	8/2/2010	106.64	2	7.00	14.00	106.64
	5392	8/24/2010	8/30/2010	484.80	2	7.00	14.00	484.80
	5446	9/13/2010	9/20/2010	525.82	2	7.00	14.00	525.82
	5565	10/19/2010	10/25/2010	466.74	2	7.00	14.00	466.74
	5657	11/15/2010	11/22/2010	516.38	2	7.00	14.00	516.38
	5714	12/7/2010	12/13/2010	479.42	2	7.00	14.00	479.42
	5812	1/11/2011	1/18/2011	445.86	2	14.03	28.06	445.86
	5886	2/1/2011	2/10/2011	479.84	2	14.03	28.06	479.84
	5976	3/1/2011	3/4/2011	417.06	2	14.03	28.06	417.06
	6079	4/5/2011	4/20/2011	501.76	2	14.03	28.06	501.76
	6178	5/2/2011	5/6/2011	373.08	2	14.03	28.06	373.08
	6329	6/16/2011	6/24/2011	505.80	2	14.03	28.06	505.80
	6405	7/11/2011	7/15/2011	460.76	2	14.03	28.06	460.76
	6473	8/9/2011	8/19/2011	353.70	2	14.03	28.06	353.70
	6549	9/13/2011	9/16/2011	468.10	2	14.03	28.06	468.10
	6623	10/10/2011	10/14/2011	332.94	2	14.03	28.06	332.94
	6696	11/1/2011	11/4/2011	399.78	2	14.03	28.06	399.78
	6800	12/12/2011	12/16/2011	494.62	2	14.40	28.80	494.62
	6886	1/17/2012	1/23/2012	486.72	2	14.40	28.80	486.72
	6938	2/7/2012	2/10/2012	375.26	2	14.40	28.80	375.26
	7039	3/13/2012	3/16/2012	344.34	2	14.40	28.80	344.34
	7109	4/10/2012	4/13/2012	209.40	2	14.40	28.80	209.40
	7187	5/8/2012	5/15/2012	217.40	2	14.40	28.80	217.40
	7266	6/11/2012	6/18/2012	146.80	2	14.40	28.80	146.80
	7337	7/10/2012	7/13/2012	142.92	2	14.40	28.80	142.92
	7453	8/13/2012	8/17/2012	114.18	2	14.40	28.80	114.18
	7531	9/10/2012	9/14/2012	357.32	2	14.40	28.80	357.32
	7577	10/1/2012	10/5/2012	384.32	2	14.40	28.80	384.32
	7717	11/12/2012	11/16/2012	317.22	2	17.29	34.58	317.22
	7805	12/10/2012	12/14/2012	356.80	2	17.29	34.58	356.80
	7892	1/14/2013	1/18/2013	213.82	2	17.29	34.58	213.82
	7959	2/12/2013	2/15/2013	174.24	2	17.29	34.58	174.24
	8031	3/12/2013	3/15/2013	314.18	2	17.29	34.58	314.18
	8105	4/9/2013	4/12/2013	334.40	2	17.29	34.58	334.40
	8164	5/7/2013	5/10/2013	367.36	2	17.29	34.58	367.36
	8248	6/3/2013	6/7/2013	N.D.	2	17.29	34.58	17.29
	8323	7/1/2013	7/9/2013	N.D.	2	17.29	34.58	17.29
	8402	8/5/2013	8/9/2013	24.02	2	17.29	34.58	17.29
	8505	9/9/2013	9/16/2013	N.D.	2	17.29	34.58	17.29
	8634	10/21/2013	10/25/2013	35.58	2	16.29	32.58	35.58
	8679	11/4/2013	11/8/2013	37.18	2	16.29	32.58	37.18
	8753	12/2/2013	12/10/2013	41.22	2	16.29	32.58	41.22
	8886	1/20/2014	1/28/2014	87.40	2	16.29	32.58	87.40
	8915	2/3/2014	2/11/2014	115.78	2	16.29	32.58	115.78

Hydrogen (H_2)

Panel 4, Room 1e

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 1e	4016	5/26/2009	5/29/2009	N.D.	2	14.93	29.86	14.93
	4074	6/9/2009	6/12/2009	N.D.	2	14.93	29.86	14.93
	4145	7/22/2009	7/24/2009	N.D.	2	15.17	30.34	15.17
	4206	8/13/2009	8/17/2009	N.D.	2	15.17	30.34	15.17
	4280	9/15/2009	9/18/2009	N.D.	2	15.17	30.34	15.17
	4321	10/6/2009	10/12/2009	239.96	2	15.17	30.34	239.96
	4397	11/9/2009	11/16/2009	350.24	2	15.17	30.34	350.24
	4537	12/30/2009	1/12/2010	390.52	2	15.17	30.34	390.52
	4601	1/20/2010	1/22/2010	267.72	2	15.17	30.34	267.72
	4686	2/10/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4839	3/17/2010	3/29/2010	319.58	2	15.17	30.34	319.58
	4923	4/14/2010	4/20/2010	384.86	2	15.17	30.34	384.86
	5056	5/18/2010	5/24/2010	N.D.	2	15.17	30.34	15.17
	5181	6/16/2010	6/21/2010	N.D.	2	7.00	14.00	7.00
	5316	7/27/2010	8/2/2010	307.08	2	7.00	14.00	307.08
	5402	8/25/2010	8/30/2010	223.64	2	7.00	14.00	223.64
	5456	9/14/2010	9/20/2010	270.82	2	7.00	14.00	270.82
	5575	10/20/2010	10/25/2010	355.54	2	7.00	14.00	355.54
	5667	11/16/2010	11/22/2010	451.70	2	7.00	14.00	451.70
	5724	12/8/2010	12/13/2010	347.96	2	7.00	14.00	347.96
	5822	1/12/2011	1/18/2011	460.36	2	14.03	28.06	460.36
	5890	2/1/2011	2/10/2011	371.40	2	14.03	28.06	371.40
	5986	3/2/2011	3/4/2011	391.48	2	14.03	28.06	391.48
	6089	4/6/2011	4/20/2011	480.62	2	14.03	28.06	480.62
	6187	5/4/2011	5/6/2011	345.60	2	14.03	28.06	345.60
	6338	6/16/2011	6/24/2011	488.10	2	14.03	28.06	488.10
	6414	7/12/2011	7/15/2011	283.24	2	14.03	28.06	283.24
	6482	8/9/2011	8/19/2011	143.48	2	14.03	28.06	143.48
	6560	9/14/2011	9/16/2011	410.04	2	14.03	28.06	410.04
	6634	10/11/2011	10/14/2011	305.92	2	14.03	28.06	305.92
	6707	11/1/2011	11/4/2011	388.88	2	14.03	28.06	388.88
	6811	12/13/2011	12/16/2011	494.32	2	14.40	28.80	494.32
	6897	1/17/2012	1/23/2012	501.80	2	14.40	28.80	501.80
	6948	2/7/2012	2/10/2012	414.88	2	14.40	28.80	414.88
	7049	3/13/2012	3/16/2012	376.52	2	14.40	28.80	376.52
	7119	4/10/2012	4/13/2012	322.28	2	14.40	28.80	322.28
	7197	5/9/2012	5/15/2012	278.46	2	14.40	28.80	278.46
	7276	6/11/2012	6/18/2012	219.08	2	14.40	28.80	219.08
	7347	7/10/2012	7/13/2012	79.50	2	14.40	28.80	79.50
	7463	8/14/2012	8/17/2012	203.66	2	14.40	28.80	203.66
	7540	9/10/2012	9/14/2012	281.34	2	14.40	28.80	281.34
	7586	10/2/2012	10/5/2012	329.02	2	14.40	28.80	329.02
	7726	11/13/2012	11/16/2012	356.44	2	17.29	34.58	356.44
	7814	12/11/2012	12/14/2012	424.38	2	17.29	34.58	424.38
	7901	1/15/2013	1/18/2013	355.52	2	17.29	34.58	355.52
	7968	2/12/2013	2/15/2013	216.66	2	17.29	34.58	216.66
	8040	3/12/2013	3/15/2013	316.90	2	17.29	34.58	316.90
	8114	4/9/2013	4/12/2013	345.72	2	17.29	34.58	345.72
	8173	5/7/2013	5/10/2013	350.46	2	17.29	34.58	350.46
	8257	6/3/2013	6/7/2013	110.94	2	17.29	34.58	110.94
	8332	7/1/2013	7/9/2013	79.12	2	17.29	34.58	79.12
	8411	8/5/2013	8/9/2013	87.68	2	17.29	34.58	87.68
	8514	9/9/2013	9/16/2013	70.86	2	17.29	34.58	70.86
	8643	10/21/2013	10/25/2013	52.26	2	16.29	32.58	52.26
	8688	11/4/2013	11/8/2013	72.10	2	16.29	32.58	72.10
	8762	12/2/2013	12/10/2013	63.00	2	16.29	32.58	63.00
	8895	1/20/2014	1/28/2014	107.80	2	16.29	32.58	107.80
	8924	2/3/2014	2/11/2014	164.98	2	16.29	32.58	164.98

Hydrogen (H_2)

Panel 4, Room 1i

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Room 1i	4020	5/27/2009	5/29/2009	N.D.	2	14.93	29.86	14.93
	4061	6/8/2009	6/12/2009	N.D.	2	14.93	29.86	14.93
	4136	7/20/2009	7/24/2009	N.D.	2	15.17	30.34	15.17
	4197	8/11/2009	8/17/2009	N.D.	2	15.17	30.34	15.17
	4271	9/14/2009	9/18/2009	N.D.	2	15.17	30.34	15.17
	4312	10/5/2009	10/12/2009	197.06	2	15.17	30.34	197.06
	4407	11/11/2009	11/16/2009	173.66	2	15.17	30.34	173.66
	4528	12/30/2009	1/12/2010	340.76	2	15.17	30.34	340.76
	4592	1/19/2010	1/22/2010	231.74	2	15.17	30.34	231.74
	4677	2/9/2010	2/12/2010	93.12	2	15.17	30.34	93.12
	4830	3/16/2010	3/29/2010	163.52	2	15.17	30.34	163.52
	4931	4/14/2010	4/20/2010	408.26	2	15.17	30.34	408.26
	5047	5/17/2010	5/24/2010	342.24	2	15.17	30.34	342.24
	5172	6/15/2010	6/21/2010	218.42	2	7.00	14.00	218.42
	5307	7/26/2010	8/2/2010	125.26	2	7.00	14.00	125.26
	5393	8/24/2010	8/30/2010	333.46	2	7.00	14.00	333.46
	5447	9/13/2010	9/20/2010	328.02	2	7.00	14.00	328.02
	5566	10/19/2010	10/25/2010	427.46	2	7.00	14.00	427.46
	5658	11/15/2010	11/22/2010	443.82	2	7.00	14.00	443.82
	5715	12/7/2010	12/13/2010	455.58	2	7.00	14.00	455.58
	5813	1/11/2011	1/18/2011	362.94	2	14.03	28.06	362.94
	5887	2/1/2011	2/10/2011	353.66	2	14.03	28.06	353.66
	5977	3/1/2011	3/4/2011	370.72	2	14.03	28.06	370.72
	6080	4/5/2011	4/20/2011	414.54	2	14.03	28.06	414.54
	6179	5/2/2011	5/6/2011	252.54	2	14.03	28.06	252.54
	6330	6/16/2011	6/24/2011	519.66	2	14.03	28.06	519.66
	6406	7/11/2011	7/15/2011	411.26	2	14.03	28.06	411.26
	6474	8/9/2011	8/19/2011	300.02	2	14.03	28.06	300.02
	6550	9/13/2011	9/16/2011	429.54	2	14.03	28.06	429.54
	6624	10/10/2011	10/14/2011	294.66	2	14.03	28.06	294.66
	6697	11/1/2011	11/4/2011	365.72	2	14.03	28.06	365.72
	6801	12/12/2011	12/16/2011	483.68	2	14.40	28.80	483.68
	6887	1/17/2012	1/23/2012	505.60	2	14.40	28.80	505.60
	6939	2/7/2012	2/10/2012	412.76	2	14.40	28.80	412.76
	7040	3/13/2012	3/16/2012	362.80	2	14.40	28.80	362.80
	7110	4/10/2012	4/13/2012	192.06	2	14.40	28.80	192.06
	7188	5/8/2012	5/15/2012	191.24	2	14.40	28.80	191.24
	7267	6/11/2012	6/18/2012	134.02	2	14.40	28.80	134.02
	7338	7/10/2012	7/13/2012	151.34	2	14.40	28.80	151.34
	7454	8/13/2012	8/17/2012	114.52	2	14.40	28.80	114.52
	7532	9/10/2012	9/14/2012	334.94	2	14.40	28.80	334.94
	7578	10/1/2012	10/5/2012	332.66	2	14.40	28.80	332.66
	7718	11/13/2012	11/16/2012	364.88	2	17.29	34.58	364.88
	7806	12/10/2012	12/14/2012	376.58	2	17.29	34.58	376.58
	7893	1/14/2013	1/18/2013	255.32	2	17.29	34.58	255.32
	7960	2/12/2013	2/15/2013	183.22	2	17.29	34.58	183.22
	8032	3/12/2013	3/15/2013	288.84	2	17.29	34.58	288.84
	8106	4/9/2013	4/12/2013	319.72	2	17.29	34.58	319.72
	8165	5/7/2013	5/10/2013	351.74	2	17.29	34.58	351.74
	8249	6/3/2013	6/7/2013	N.D.	2	17.29	34.58	17.29
	8324	7/1/2013	7/9/2013	N.D.	2	17.29	34.58	17.29
	8403	8/5/2013	8/9/2013	27.04	2	17.29	34.58	17.29
	8506	9/9/2013	9/16/2013	39.90	2	17.29	34.58	39.90
	8635	10/21/2013	10/25/2013	54.86	2	16.29	32.58	54.86
	8680	11/4/2013	11/8/2013	47.92	2	16.29	32.58	47.92
	8754	12/2/2013	12/10/2013	36.28	2	16.29	32.58	36.28
	8887	1/20/2014	1/28/2014	86.78	2	16.29	32.58	86.78
	8916	2/3/2014	2/11/2014	131.16	2	16.29	32.58	131.16

Hydrogen (H_2)

Panel 4, EBW

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Location EBW	4015	5/26/2009	5/29/2009	N.D.	2	14.93	29.86	14.93
	4065	6/8/2009	6/12/2009	N.D.	2	14.93	29.86	14.93
	4147	7/22/2009	7/24/2009	N.D.	2	15.17	30.34	15.17
	4208	8/13/2009	8/17/2009	N.D.	2	15.17	30.34	15.17
	4282	9/15/2009	9/18/2009	N.D.	2	15.17	30.34	15.17
	4323	10/6/2009	10/12/2009	105.10	2	15.17	30.34	105.10
	4396	11/9/2009	11/16/2009	141.00	2	15.17	30.34	141.00
	4539	12/30/2009	1/12/2010	235.40	2	15.17	30.34	235.40
	4603	1/20/2010	1/22/2010	270.16	2	15.17	30.34	270.16
	4688	2/10/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4841	3/17/2010	3/29/2010	324.28	2	15.17	30.34	324.28
	4921	4/13/2010	4/20/2010	N.D.	2	15.17	30.34	15.17
	5058	5/18/2010	5/24/2010	64.70	2	15.17	30.34	64.70
	5183	6/16/2010	6/21/2010	N.D.	2	7.00	14.00	7.00
	5318	7/27/2010	8/2/2010	137.54	2	7.00	14.00	137.54
	5404	8/25/2010	8/30/2010	60.18	2	7.00	14.00	60.18
	5458	9/14/2010	9/20/2010	N.D.	2	7.00	14.00	7.00
	5577	10/20/2010	10/25/2010	N.D.	2	7.00	14.00	7.00
	5669	11/16/2010	11/22/2010	N.D.	2	7.00	14.00	7.00
	5726	12/8/2010	12/13/2010	149.84	2	7.00	14.00	149.84
	5824	1/12/2011	1/18/2011	268.54	2	14.03	28.06	268.54
	5898	2/7/2011	2/10/2011	316.50	2	14.03	28.06	316.50
	5988	3/2/2011	3/4/2011	281.32	2	14.03	28.06	281.32
	6091	4/6/2011	4/20/2011	182.90	2	14.03	28.06	182.90
	6189	5/4/2011	5/6/2011	42.48	2	14.03	28.06	42.48
	6340	6/16/2011	6/24/2011	206.20	2	14.03	28.06	206.20
	6416	7/12/2011	7/15/2011	68.52	2	14.03	28.06	68.52
	6484	8/9/2011	8/19/2011	45.78	2	14.03	28.06	45.78
	6562	9/14/2011	9/16/2011	109.38	2	14.03	28.06	109.38
	6632	10/11/2011	10/14/2011	51.88	2	14.03	28.06	51.88
	6705	11/1/2011	11/4/2011	183.10	2	14.03	28.06	183.10
	6809	12/13/2011	12/16/2011	214.68	2	14.40	28.80	214.68
	6895	1/17/2012	1/23/2012	152.46	2	14.40	28.80	152.46
	6946	2/7/2012	2/10/2012	126.92	2	14.40	28.80	126.92
	7047	3/13/2012	3/16/2012	169.86	2	14.40	28.80	169.86
	7117	4/10/2012	4/13/2012	158.14	2	14.40	28.80	158.14
	7195	5/9/2012	5/15/2012	274.44	2	14.40	28.80	274.44
	7274	6/11/2012	6/18/2012	181.18	2	14.40	28.80	181.18
	7345	7/10/2012	7/13/2012	93.14	2	14.40	28.80	93.14
	7461	8/13/2012	8/17/2012	274.60	2	14.40	28.80	274.60
	7538	9/10/2012	9/14/2012	105.10	2	14.40	28.80	105.10
	7584	10/2/2012	10/5/2012	110.02	2	14.40	28.80	110.02
	7724	11/13/2012	11/16/2012	157.24	2	17.29	34.58	157.24
	7812	12/11/2012	12/14/2012	312.46	2	17.29	34.58	312.46
	7899	1/15/2013	1/18/2013	268.06	2	17.29	34.58	268.06
	7966	2/12/2013	2/15/2013	119.78	2	17.29	34.58	119.78
	8038	3/12/2013	3/15/2013	106.72	2	17.29	34.58	106.72
	8112	4/9/2013	4/12/2013	85.90	2	17.29	34.58	85.90
	8171	5/7/2013	5/10/2013	89.32	2	17.29	34.58	89.32
	8255	6/3/2013	6/7/2013	100.18	2	17.29	34.58	100.18
	8330	7/1/2013	7/9/2013	80.88	2	17.29	34.58	80.88
	8407	8/5/2013	8/9/2013	99.66	2	17.29	34.58	99.66
	8510	9/9/2013	9/16/2013	51.58	2	17.29	34.58	51.58
	8639	10/21/2013	10/25/2013	58.14	2	16.29	32.58	58.14
	8684	11/4/2013	11/8/2013	52.94	2	16.29	32.58	52.94
	8758	12/2/2013	12/10/2013	56.80	2	16.29	32.58	56.80
	8893	1/20/2014	1/28/2014	113.38	2	16.29	32.58	113.38
	8922	2/3/2014	2/11/2014	161.62	2	16.29	32.58	161.62

Hydrogen (H_2)

Panel 4, EBA

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Location EBA	4014	5/26/2009	5/29/2009	N.D.	2	14.93	29.86	14.93
	4064	6/8/2009	6/12/2009	N.D.	2	14.93	29.86	14.93
	4148	7/22/2009	7/24/2009	N.D.	2	15.17	30.34	15.17
	4209	8/13/2009	8/17/2009	N.D.	2	15.17	30.34	15.17
	4283	9/15/2009	9/18/2009	N.D.	2	15.17	30.34	15.17
	4324	10/6/2009	10/12/2009	N.D.	2	15.17	30.34	15.17
	4395	11/9/2009	11/16/2009	N.D.	2	15.17	30.34	15.17
	4540	12/30/2009	1/12/2010	N.D.	2	15.17	30.34	15.17
	4604	1/20/2010	1/22/2010	N.D.	2	15.17	30.34	15.17
	4689	2/10/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4842	3/17/2010	3/29/2010	N.D.	2	15.17	30.34	15.17
	4922	4/13/2010	4/20/2010	N.D.	2	15.17	30.34	15.17
	5059	5/18/2010	5/24/2010	N.D.	2	15.17	30.34	15.17
	5184	6/16/2010	6/21/2010	N.D.	2	7.00	14.00	7.00
	5319	7/27/2010	8/2/2010	N.D.	2	7.00	14.00	7.00
	5405	8/25/2010	8/30/2010	N.D.	2	7.00	14.00	7.00
	5459	9/14/2010	9/20/2010	N.D.	2	7.00	14.00	7.00
	5578	10/20/2010	10/25/2010	N.D.	2	7.00	14.00	7.00
	5670	11/16/2010	11/22/2010	N.D.	2	7.00	14.00	7.00
	5727	12/8/2010	12/13/2010	N.D.	2	7.00	14.00	7.00
	5825	1/12/2011	1/18/2011	N.D.	2	14.03	28.06	14.03
	5899	2/7/2011	2/10/2011	N.D.	2	14.03	28.06	14.03
	5989	3/2/2011	3/4/2011	N.D.	2	14.03	28.06	14.03
	6092	4/6/2011	4/20/2011	N.D.	2	14.03	28.06	14.03
	6190	5/4/2011	5/6/2011	N.D.	2	14.03	28.06	14.03
	6341	6/16/2011	6/24/2011	N.D.	2	14.03	28.06	14.03
	6417	7/12/2011	7/15/2011	N.D.	2	14.03	28.06	14.03
	6485	8/9/2011	8/19/2011	N.D.	2	14.03	28.06	14.03
	6563	9/14/2011	9/16/2011	N.D.	2	14.03	28.06	14.03
	6633	10/11/2011	10/14/2011	N.D.	2	14.03	28.06	14.03
	6706	11/1/2011	11/4/2011	N.D.	2	14.03	28.06	14.03
	6810	12/13/2011	12/16/2011	N.D.	2	14.40	28.80	14.40
	6896	1/17/2012	1/23/2012	N.D.	2	14.40	28.80	14.40
	6947	2/7/2012	2/10/2012	N.D.	2	14.40	28.80	14.40
	7048	3/13/2012	3/16/2012	N.D.	2	14.40	28.80	14.40
	7118	4/10/2012	4/13/2012	N.D.	2	14.40	28.80	14.40
	7196	5/9/2012	5/15/2012	N.D.	2	14.40	28.80	14.40
	7275	6/11/2012	6/18/2012	N.D.	2	14.40	28.80	14.40
	7346	7/10/2012	7/13/2012	N.D.	2	14.40	28.80	14.40
	7462	8/13/2012	8/17/2012	N.D.	2	14.40	28.80	14.40
	7539	9/10/2012	9/14/2012	N.D.	2	14.40	28.80	14.40
	7585	10/2/2012	10/5/2012	N.D.	2	14.40	28.80	14.40
	7725	11/13/2012	11/16/2012	N.D.	2	17.29	34.58	17.29
	7813	12/11/2012	12/14/2012	31.60	2	17.29	34.58	17.29
	7900	1/15/2013	1/18/2013	N.D.	2	17.29	34.58	17.29
	7967	2/12/2013	2/15/2013	N.D.	2	17.29	34.58	17.29
	8039	3/12/2013	3/15/2013	N.D.	2	17.29	34.58	17.29
	8113	4/9/2013	4/12/2013	N.D.	2	17.29	34.58	17.29
	8172	5/7/2013	5/10/2013	N.D.	2	17.29	34.58	17.29
	8256	6/3/2013	6/7/2013	29.10	2	17.29	34.58	17.29
	8331	7/1/2013	7/9/2013	N.D.	2	17.29	34.58	17.29
	8408	8/5/2013	8/9/2013	N.D.	2	17.29	34.58	17.29
	8511	9/9/2013	9/16/2013	N.D.	2	17.29	34.58	17.29
	8640	10/21/2013	10/25/2013	N.D.	2	16.29	32.58	16.29
	8685	11/4/2013	11/8/2013	N.D.	2	16.29	32.58	16.29
	8759	12/2/2013	12/10/2013	N.D.	2	16.29	32.58	16.29
	8894	1/20/2014	1/28/2014	N.D.	2	16.29	32.58	16.29
	8923	2/3/2014	2/11/2014	N.D.	2	16.29	32.58	16.29

Hydrogen (H_2)

Panel 4, IBW

Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Location IBW	4022	5/27/2009	5/29/2009	N.D.	2	14.93	29.86	14.93
	4063	6/8/2009	6/12/2009	N.D.	2	14.93	29.86	14.93
	4137	7/20/2009	7/24/2009	N.D.	2	15.17	30.34	15.17
	4198	8/11/2009	8/17/2009	N.D.	2	15.17	30.34	15.17
	4272	9/14/2009	9/18/2009	N.D.	2	15.17	30.34	15.17
	4313	10/5/2009	10/12/2009	12.56	2	15.17	30.34	15.17
	4406	11/11/2009	11/16/2009	N.D.	2	15.17	30.34	15.17
	4529	12/30/2009	1/12/2010	166.08	2	15.17	30.34	166.08
	4593	1/19/2010	1/22/2010	129.08	2	15.17	30.34	129.08
	4678	2/9/2010	2/12/2010	50.74	2	15.17	30.34	50.74
	4831	3/16/2010	3/29/2010	N.D.	2	15.17	30.34	15.17
	4932	4/14/2010	4/20/2010	236.70	2	15.17	30.34	236.70
	5048	5/17/2010	5/24/2010	230.88	2	15.17	30.34	230.88
	5173	6/15/2010	6/21/2010	252.06	2	7.00	14.00	252.06
	5308	7/26/2010	8/2/2010	283.86	2	7.00	14.00	283.86
	5394	8/24/2010	8/30/2010	114.94	2	7.00	14.00	114.94
	5448	9/13/2010	9/20/2010	70.54	2	7.00	14.00	70.54
	5567	10/19/2010	10/25/2010	398.20	2	7.00	14.00	398.20
	5659	11/15/2010	11/22/2010	329.56	2	7.00	14.00	329.56
	5716	12/7/2010	12/13/2010	357.10	2	7.00	14.00	357.10
	5814	1/11/2011	1/18/2011	302.90	2	14.03	28.06	302.90
	5888	2/1/2011	2/10/2011	298.64	2	14.03	28.06	298.64
	5978	3/1/2011	3/4/2011	317.72	2	14.03	28.06	317.72
	6081	4/5/2011	4/20/2011	329.26	2	14.03	28.06	329.26
	6180	5/3/2011	5/6/2011	334.28	2	14.03	28.06	334.28
	6331	6/16/2011	6/24/2011	319.28	2	14.03	28.06	319.28
	6407	7/11/2011	7/15/2011	263.72	2	14.03	28.06	263.72
	6475	8/9/2011	8/19/2011	264.52	2	14.03	28.06	264.52
	6551	9/13/2011	9/16/2011	289.72	2	14.03	28.06	289.72
	6625	10/10/2011	10/14/2011	229.52	2	14.03	28.06	229.52
	6698	11/1/2011	11/4/2011	249.70	2	14.03	28.06	249.70
	6802	12/12/2011	12/16/2011	356.14	2	14.40	28.80	356.14
	6888	1/17/2012	1/23/2012	310.84	2	14.40	28.80	310.84
	6940	2/7/2012	2/10/2012	318.06	2	14.40	28.80	318.06
	7041	3/13/2012	3/16/2012	226.60	2	14.40	28.80	226.60
	7111	4/10/2012	4/13/2012	51.64	2	14.40	28.80	51.64
	7189	5/8/2012	5/15/2012	95.04	2	14.40	28.80	95.04
	7268	6/11/2012	6/18/2012	77.72	2	14.40	28.80	77.72
	7339	7/10/2012	7/13/2012	16.24	2	14.40	28.80	14.40
	7455	8/13/2012	8/17/2012	N.D.	2	14.40	28.80	14.40
	7533	9/10/2012	9/14/2012	230.78	2	14.40	28.80	230.78
	7579	10/2/2012	10/5/2012	227.70	2	14.40	28.80	227.70
	7719	11/13/2012	11/16/2012	220.86	2	17.29	34.58	220.86
	7807	12/10/2012	12/14/2012	296.50	2	17.29	34.58	296.50
	7894	1/15/2013	1/18/2013	33.08	2	17.29	34.58	17.29
	7961	2/12/2013	2/15/2013	137.52	2	17.29	34.58	137.52
	8033	3/12/2013	3/15/2013	222.48	2	17.29	34.58	222.48
	8107	4/9/2013	4/12/2013	260.22	2	17.29	34.58	260.22
	8166	5/7/2013	5/10/2013	344.92	2	17.29	34.58	344.92
	8250	6/3/2013	6/7/2013	N.D.	2	17.29	34.58	17.29
	8325	7/1/2013	7/9/2013	N.D.	2	17.29	34.58	17.29
	8409	8/5/2013	8/9/2013	N.D.	2	17.29	34.58	17.29
	8512	9/9/2013	9/16/2013	N.D.	2	17.29	34.58	17.29
	8641	10/21/2013	10/25/2013	N.D.	2	16.29	32.58	16.29
	8686	11/4/2013	11/8/2013	N.D.	2	16.29	32.58	16.29
	8760	12/2/2013	12/10/2013	N.D.	2	16.29	32.58	16.29
	8888	1/20/2014	1/28/2014	49.12	2	16.29	32.58	49.12
	8917	2/3/2014	2/11/2014	51.62	2	16.29	32.58	51.62

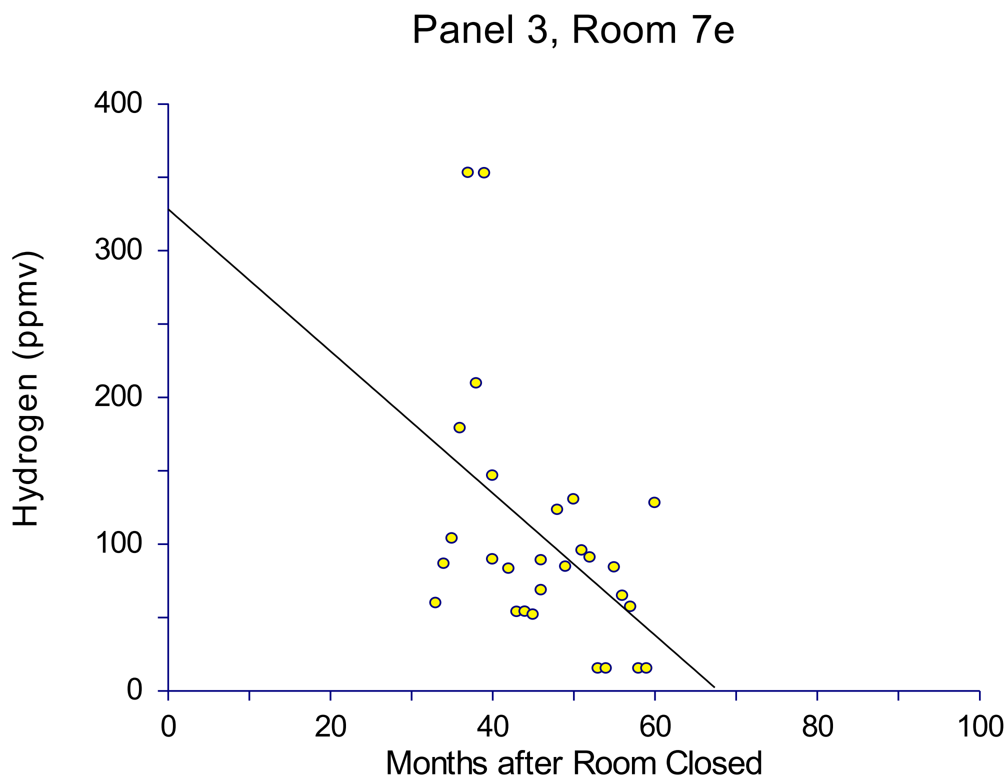
Hydrogen (H_2)

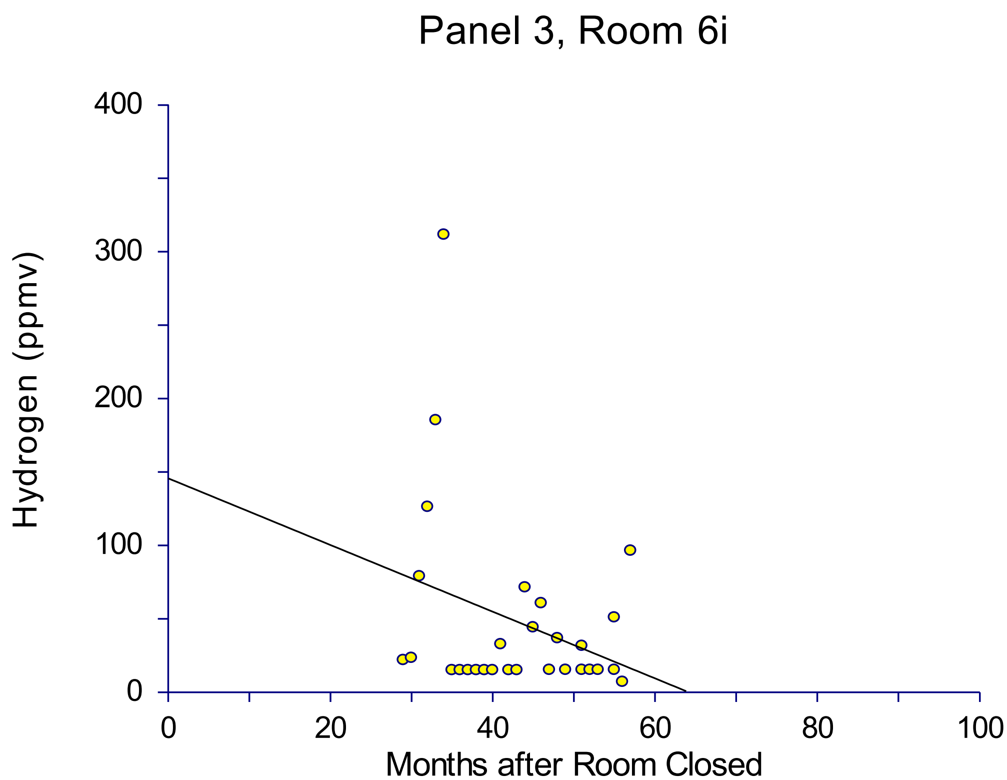
Panel 4, IBA

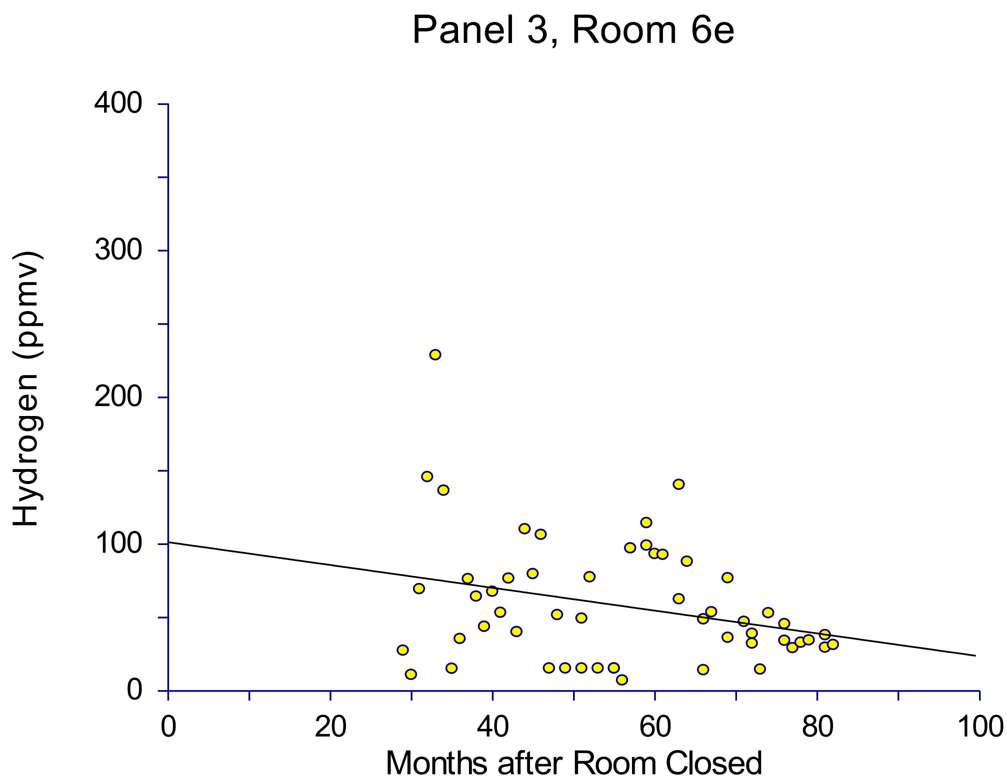
Location	Sample ID	Sample Date	Analysis Date	Reported Results (ppmv)	Dilution Factor	MDL (ppmv)	Dilution corrected MDL (ppmv)	Concentration for Statistical Evaluation (ppmv)
Panel 4 Location IBA	4021	5/27/2009	5/29/2009	N.D.	2	14.93	29.86	14.93
	4062	6/8/2009	6/12/2009	N.D.	2	14.93	29.86	14.93
	4138	7/20/2009	7/24/2009	N.D.	2	15.17	30.34	15.17
	4199	8/11/2009	8/17/2009	N.D.	2	15.17	30.34	15.17
	4273	9/14/2009	9/18/2009	N.D.	2	15.17	30.34	15.17
	4314	10/5/2009	10/12/2009	N.D.	2	15.17	30.34	15.17
	4405	11/11/2009	11/16/2009	130.72	2	15.17	30.34	130.72
	4530	12/30/2009	1/12/2010	N.D.	2	15.17	30.34	15.17
	4594	1/19/2010	1/22/2010	N.D.	2	15.17	30.34	15.17
	4679	2/10/2010	2/12/2010	N.D.	2	15.17	30.34	15.17
	4832	3/16/2010	3/29/2010	N.D.	2	15.17	30.34	15.17
	4933	4/14/2010	4/20/2010	N.D.	2	15.17	30.34	15.17
	5049	5/17/2010	5/24/2010	N.D.	2	15.17	30.34	15.17
	5174	6/15/2010	6/21/2010	N.D.	2	7.00	14.00	7.00
	5309	7/26/2010	8/2/2010	N.D.	2	7.00	14.00	7.00
	5395	8/24/2010	8/30/2010	N.D.	2	7.00	14.00	7.00
	5449	9/13/2010	9/20/2010	N.D.	2	7.00	14.00	7.00
	5568	10/19/2010	10/25/2010	N.D.	2	7.00	14.00	7.00
	5660	11/15/2010	11/22/2010	42.12	2	7.00	14.00	42.12
	5717	12/7/2010	12/13/2010	63.50	2	7.00	14.00	63.50
	5815	1/11/2011	1/18/2011	N.D.	2	14.03	28.06	14.03
	5889	2/1/2011	2/10/2011	N.D.	2	14.03	28.06	14.03
	5979	3/1/2011	3/4/2011	45.52	2	14.03	28.06	45.52
	6082	4/5/2011	4/20/2011	N.D.	2	14.03	28.06	14.03
	6181	5/3/2011	5/6/2011	67.86	2	14.03	28.06	67.86
	6332	6/16/2011	6/24/2011	N.D.	2	14.03	28.06	14.03
	6408	7/12/2011	7/15/2011	N.D.	2	14.03	28.06	14.03
	6476	8/9/2011	8/19/2011	N.D.	2	14.03	28.06	14.03
	6552	9/14/2011	9/16/2011	N.D.	2	14.03	28.06	14.03
	6626	10/10/2011	10/14/2011	N.D.	2	14.03	28.06	14.03
	6699	11/1/2011	11/4/2011	N.D.	2	14.03	28.06	14.03
	6803	12/12/2011	12/16/2011	N.D.	2	14.40	28.80	14.40
	6889	1/17/2012	1/23/2012	N.D.	2	14.40	28.80	14.40
	6941	2/7/2012	2/10/2012	N.D.	2	14.40	28.80	14.40
	7042	3/13/2012	3/16/2012	N.D.	2	14.40	28.80	14.40
	7112	4/10/2012	4/13/2012	N.D.	2	14.40	28.80	14.40
	7190	5/8/2012	5/15/2012	N.D.	2	14.40	28.80	14.40
	7269	6/11/2012	6/18/2012	N.D.	2	14.40	28.80	14.40
	7340	7/10/2012	7/13/2012	N.D.	2	14.40	28.80	14.40
	7456	8/13/2012	8/17/2012	N.D.	2	14.40	28.80	14.40
	7534	9/10/2012	9/14/2012	N.D.	2	14.40	28.80	14.40
	7580	10/2/2012	10/5/2012	20.80	2	14.40	28.80	14.40
	7720	11/13/2012	11/16/2012	N.D.	2	17.29	34.58	17.29
	7808	12/11/2012	12/14/2012	N.D.	2	17.29	34.58	17.29
	7895	1/15/2013	1/18/2013	N.D.	2	17.29	34.58	17.29
	7962	2/12/2013	2/15/2013	N.D.	2	17.29	34.58	17.29
	8034	3/12/2013	3/15/2013	N.D.	2	17.29	34.58	17.29
	8108	4/9/2013	4/12/2013	N.D.	2	17.29	34.58	17.29
	8167	5/7/2013	5/10/2013	24.58	2	17.29	34.58	17.29
	8251	6/3/2013	6/7/2013	N.D.	2	17.29	34.58	17.29
	8326	7/1/2013	7/9/2013	N.D.	2	17.29	34.58	17.29
	8410	8/5/2013	8/9/2013	N.D.	2	17.29	34.58	17.29
	8513	9/9/2013	9/16/2013	N.D.	2	17.29	34.58	17.29
	8642	10/21/2013	10/25/2013	N.D.	2	16.29	32.58	16.29
	8687	11/4/2013	11/8/2013	N.D.	2	16.29	32.58	16.29
	8761	12/2/2013	12/10/2013	N.D.	2	16.29	32.58	16.29
	8889	1/20/2014	1/28/2014	N.D.	2	16.29	32.58	16.29
	8918	2/3/2014	2/11/2014	N.D.	2	16.29	32.58	16.29

Appendix G

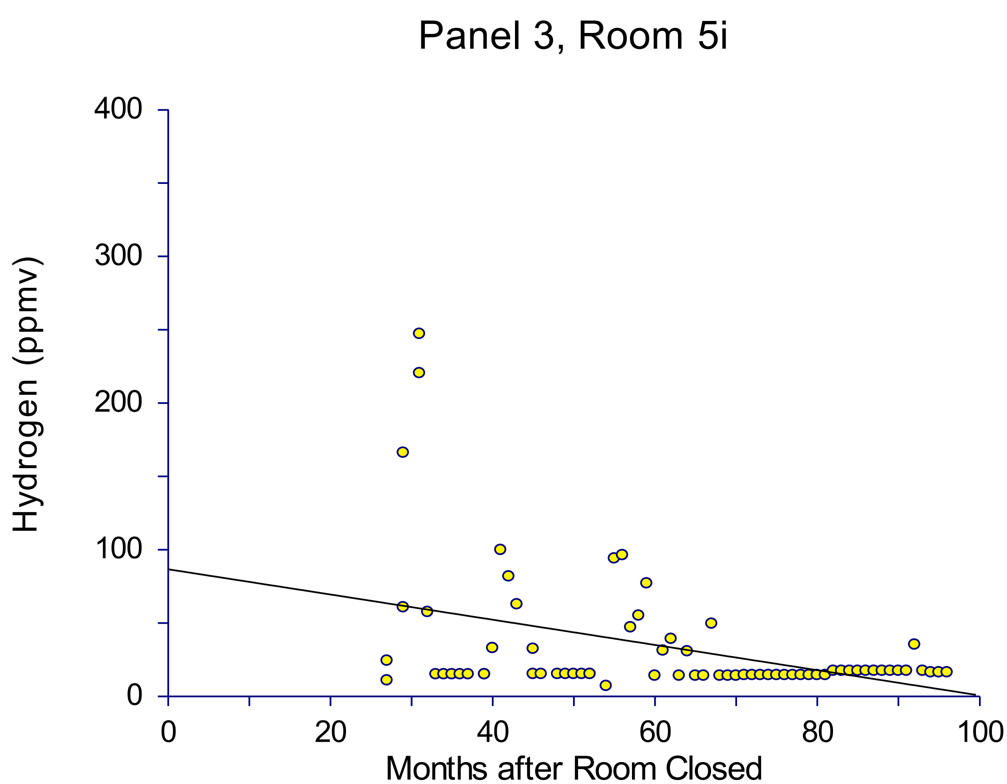
Panel 3 Individual Linear Regression Plots


Panel 3, Room 7e
Hydrogen (ppmv)
400
300
200
100
0
0
20
40
60
80
100
Months after Room Closed

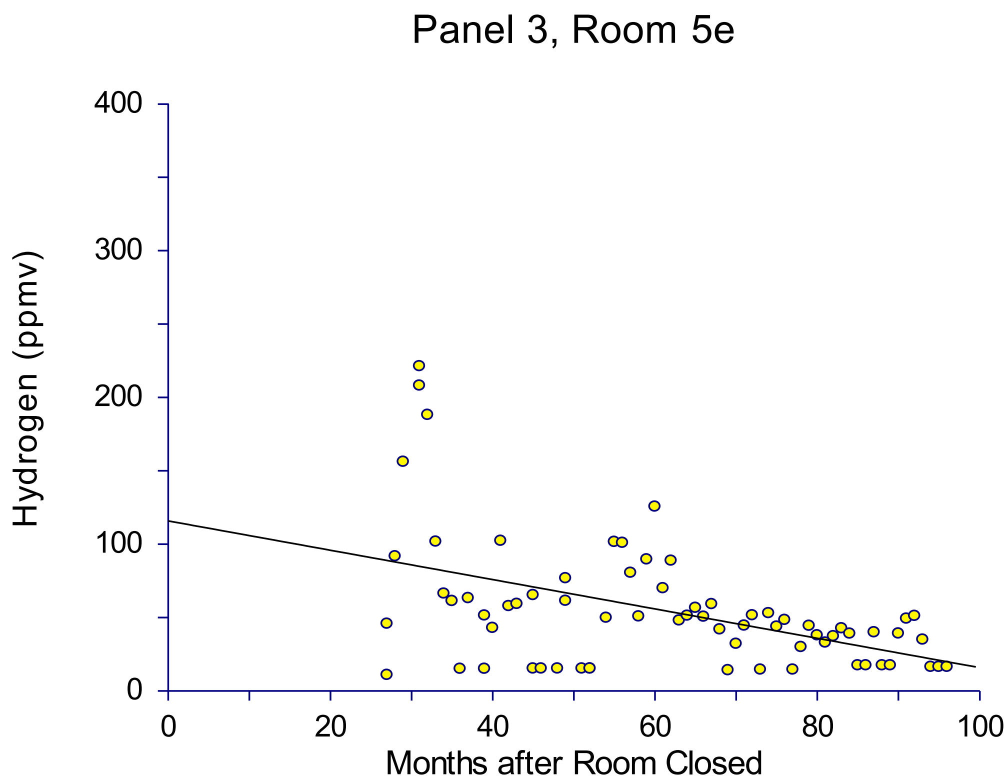

Panel 3, Room 6i
Hydrogen (ppmv)
400
300
200
100
0
0
20
40
60
80
100
Months after Room Closed

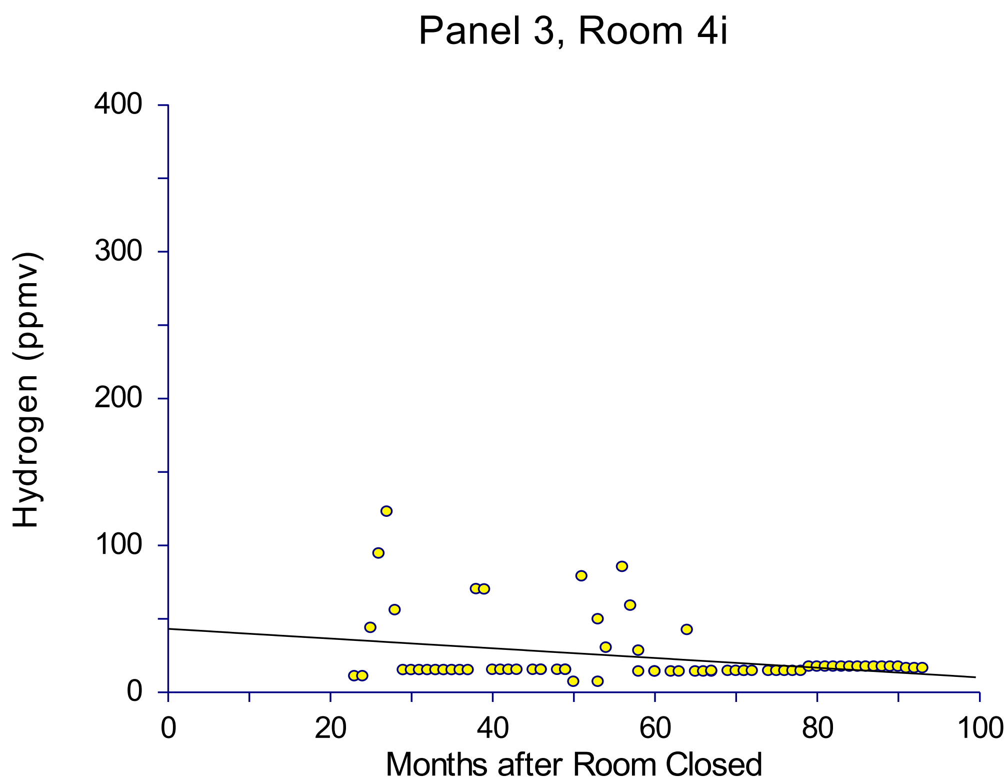


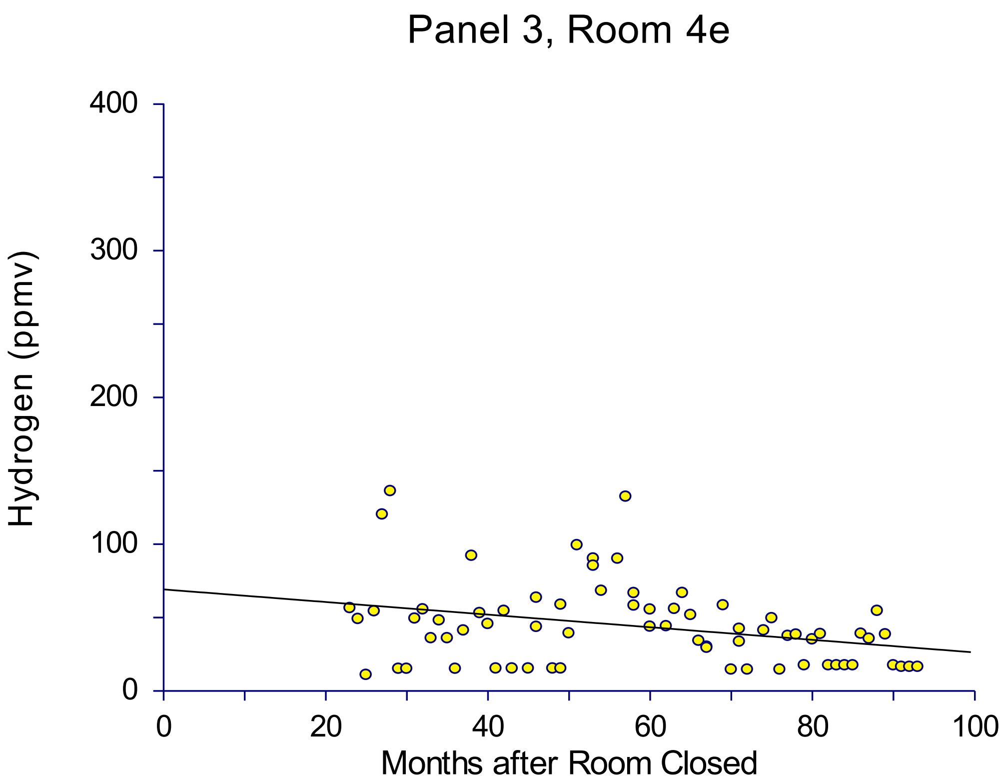
Panel 3, Room 6e
Hydrogen (ppmv)
400
300
200
100
0
0
20
40
60
80
100
Months after Room Closed

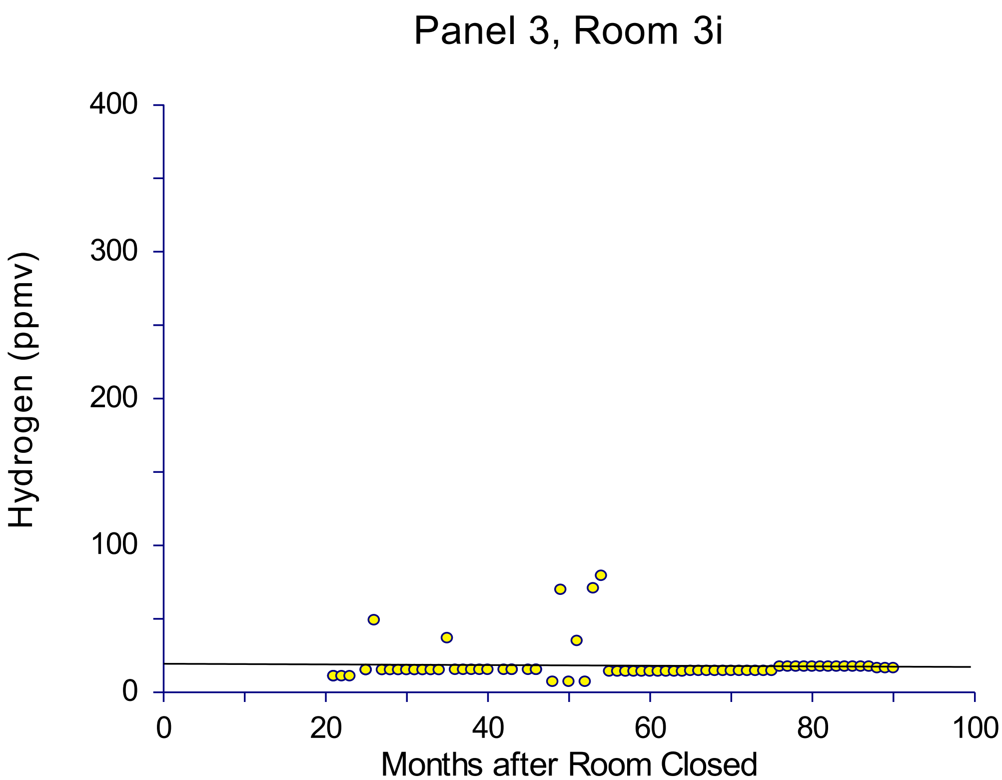


Panel 3, Room 5i
Hydrogen (ppmv)
400
300
200
100
0
0
20
40
60
80
100
Months after Room Closed

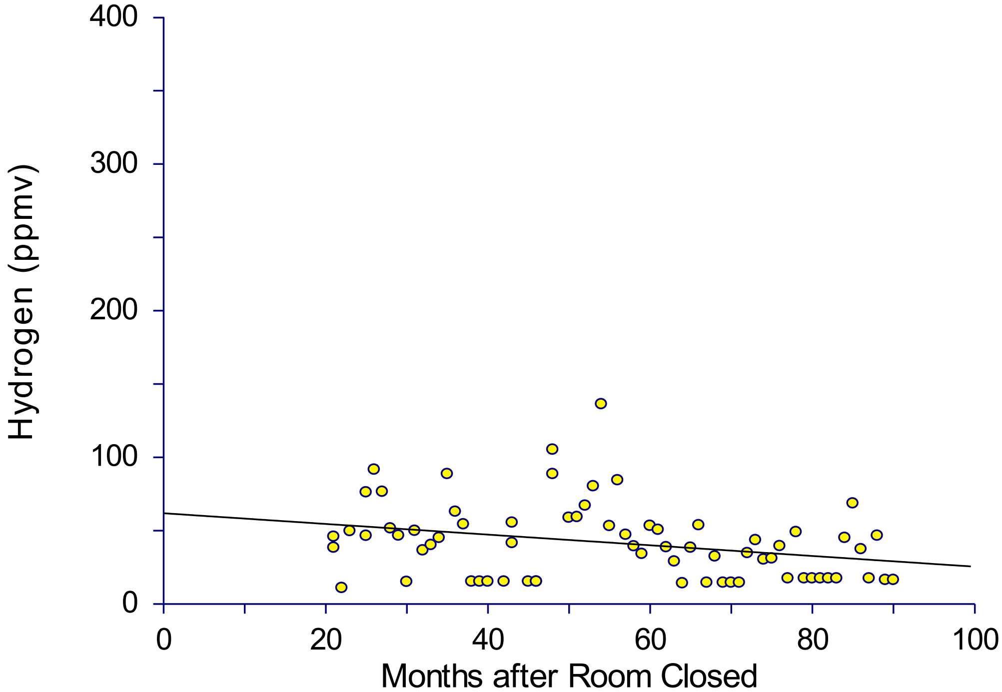

Panel 3, Room 5e
400
300
200
100
0
Hydrogen (ppmv)
0
20
40
60
80
100
Months after Room Closed


Panel 3, Room 4i
400
300
200
100
0
Hydrogen (ppmv)
0
20
40
60
80
100
Months after Room Closed

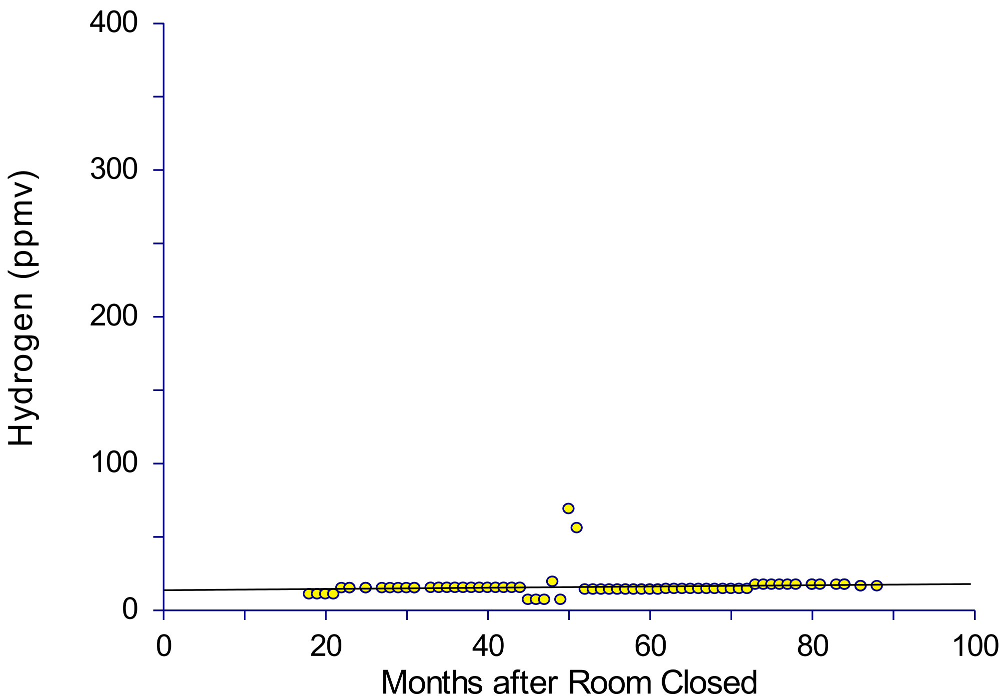

Panel 3, Room 4e
Hydrogen (ppmv)
400
300
200
100
0
0
20
40
60
80
100
Months after Room Closed

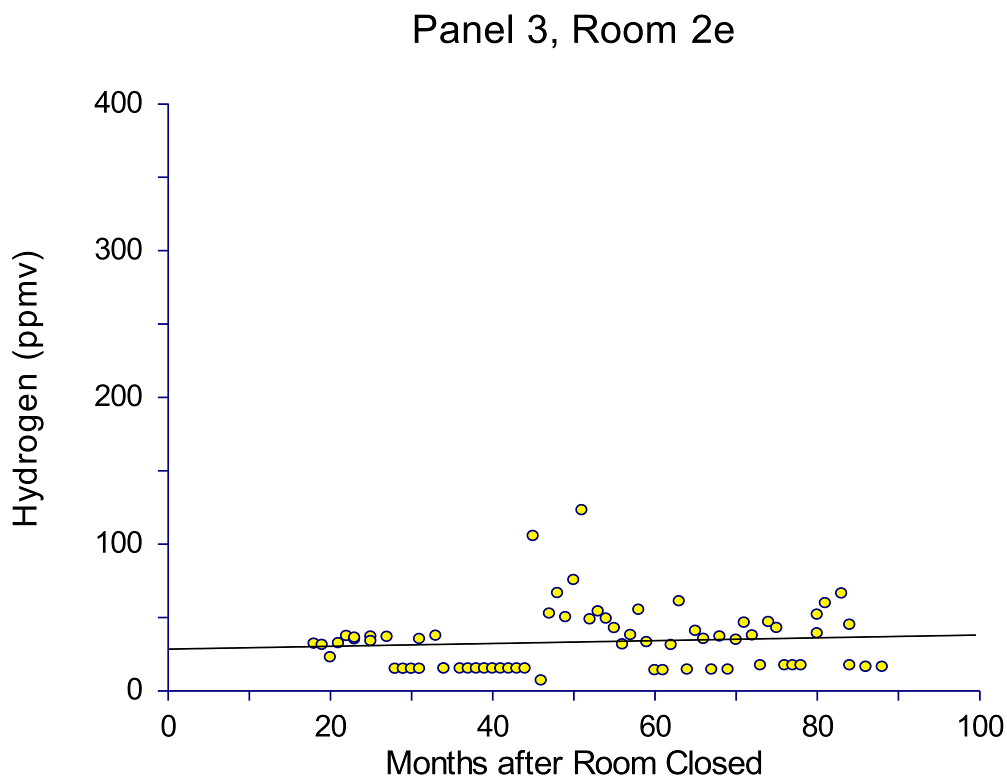

Panel 3, Room 3i
Hydrogen (ppmv)
400
300
200
100
0
0
20
40
60
80
100
Months after Room Closed

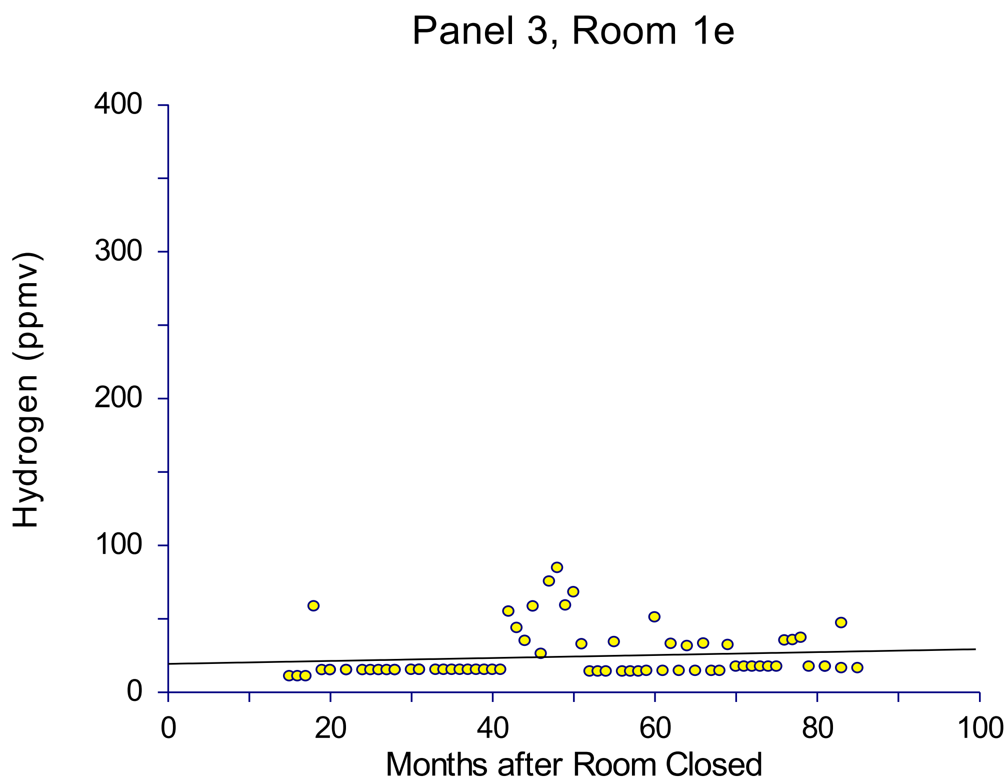
Panel 3, Room 3e

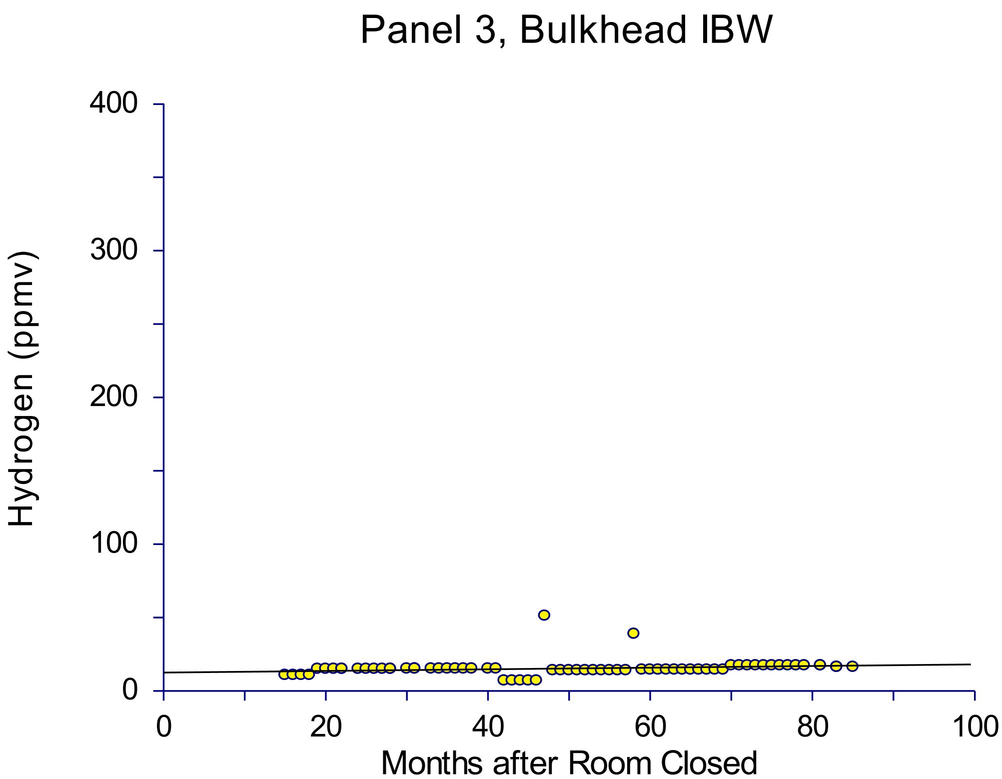


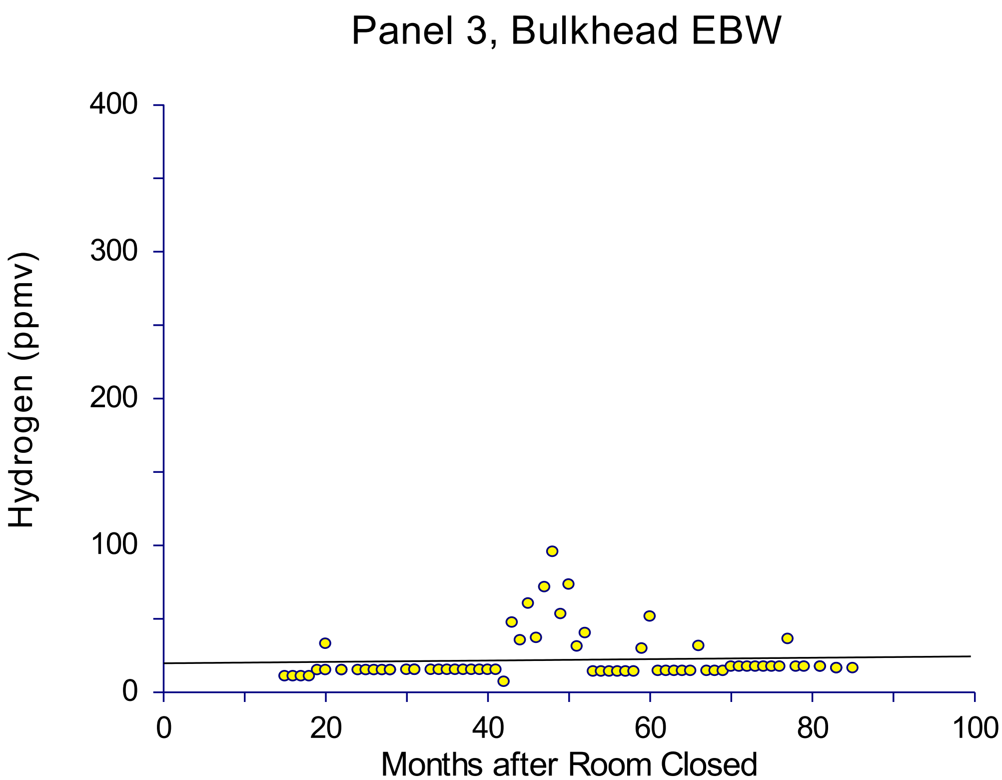
Panel 3, Room 2i




Panel 3, Room 2e
Hydrogen (ppmv)
400
300
200
100
0
0
20
40
60
80
100
Months after Room Closed

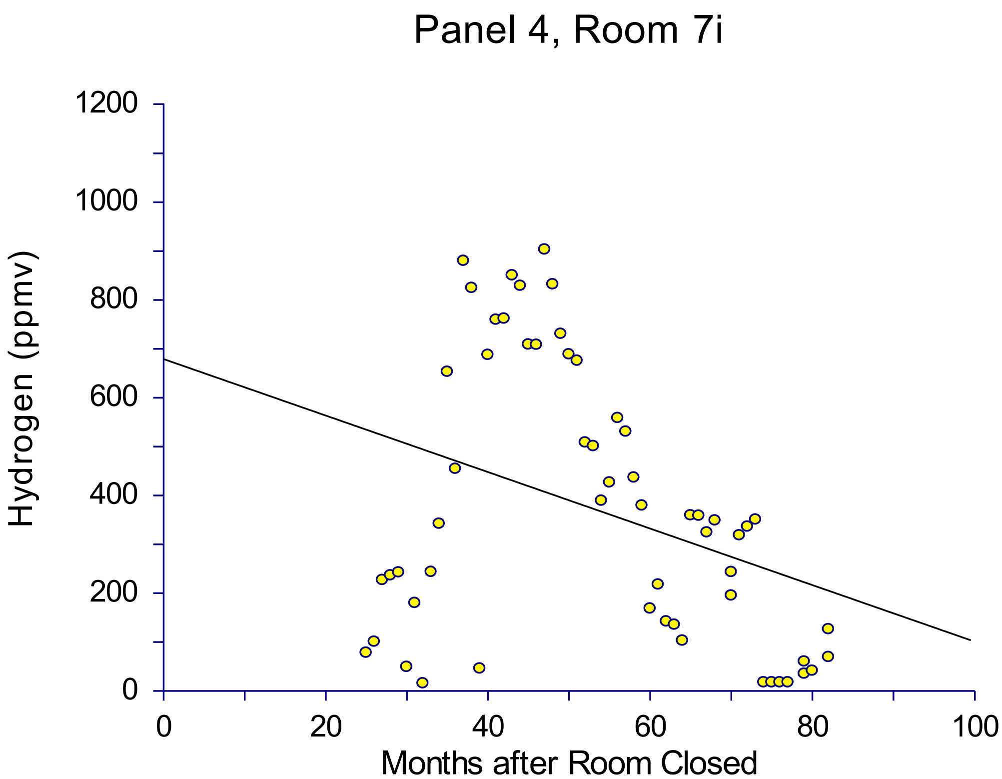

Panel 3, Room 1e
Hydrogen (ppmv)
400
300
200
100
0
0
20
40
60
80
100
Months after Room Closed


Panel 3, Bulkhead IBW
Hydrogen (ppmv)
400
300
200
100
0
0
20
40
60
80
100
Months after Room Closed


Panel 3, Bulkhead EBW
Hydrogen (ppmv)
400
300
200
100
0
0
20
40
60
80
100
Months after Room Closed

Appendix H

Panel 4 Individual Linear Regression Plots



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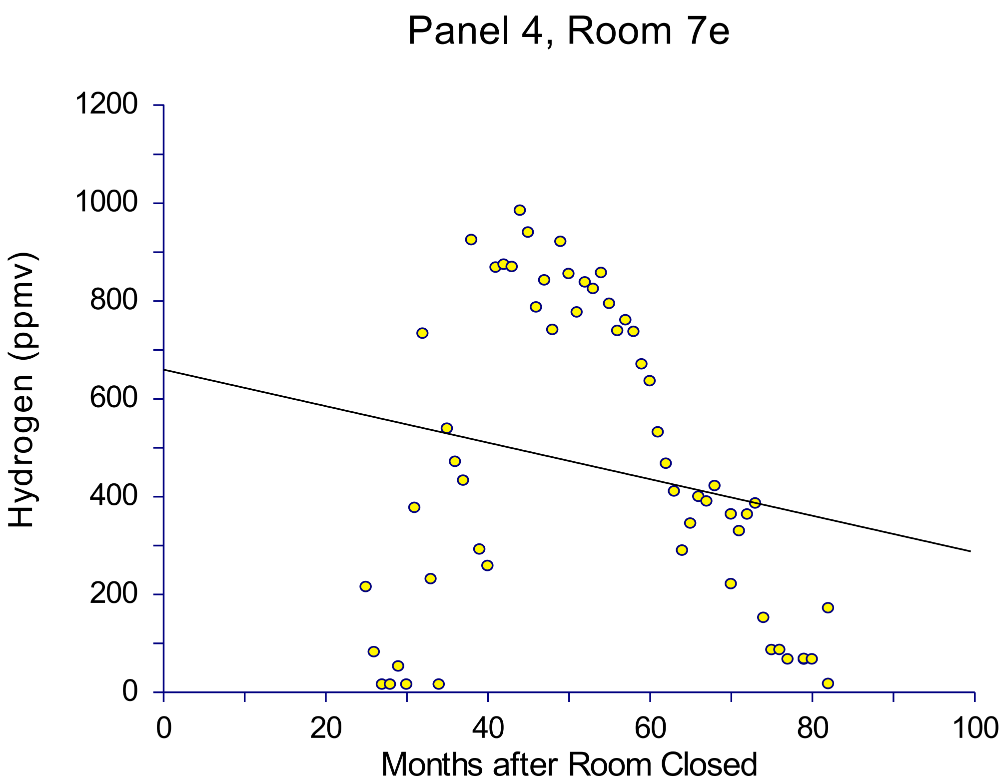

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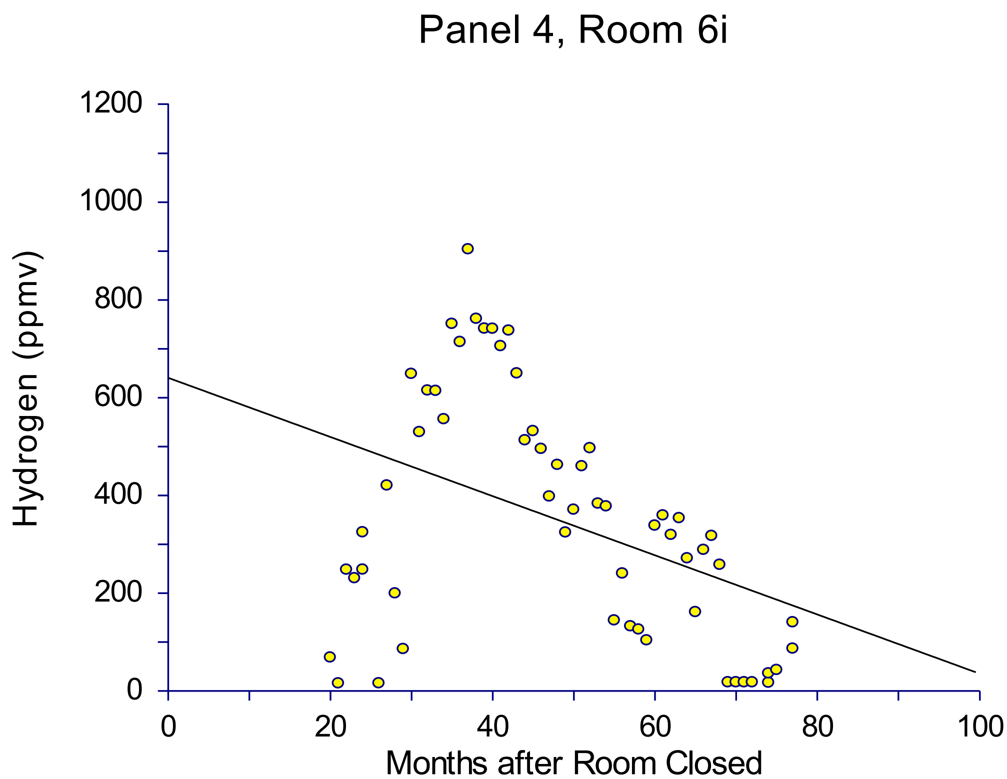
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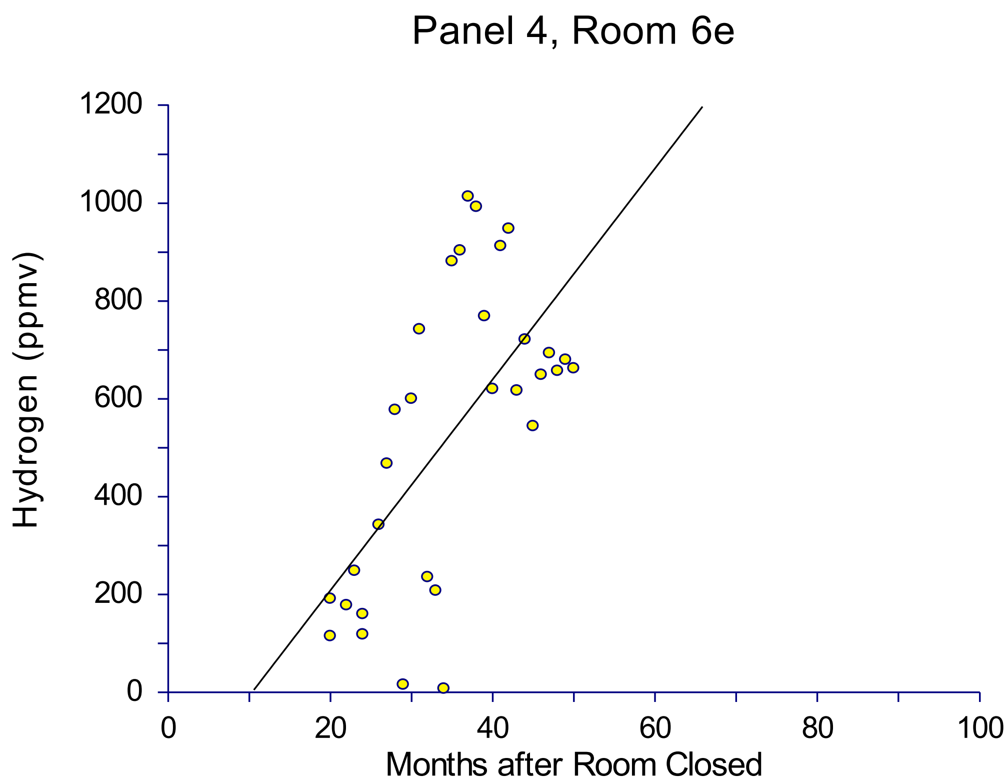
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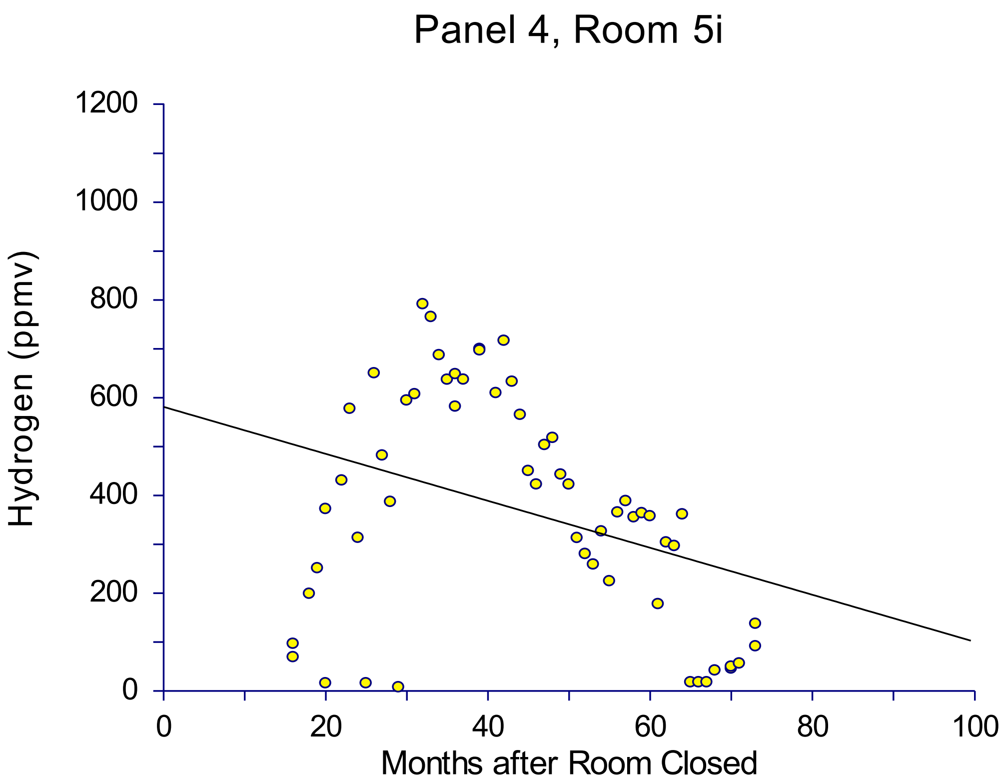
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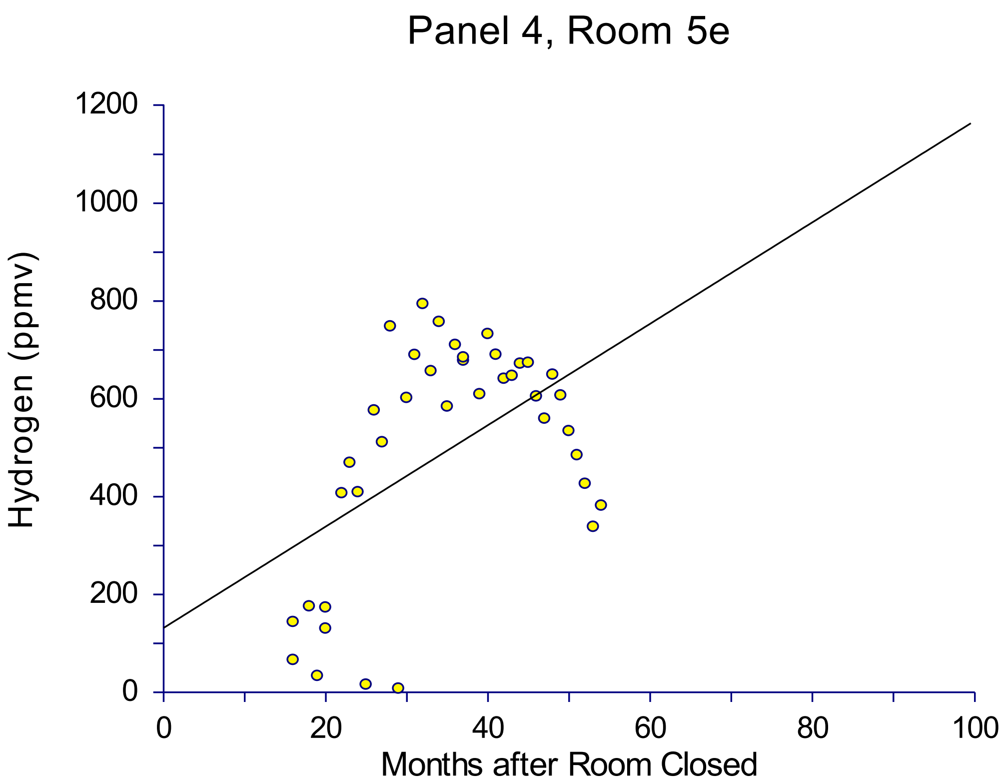
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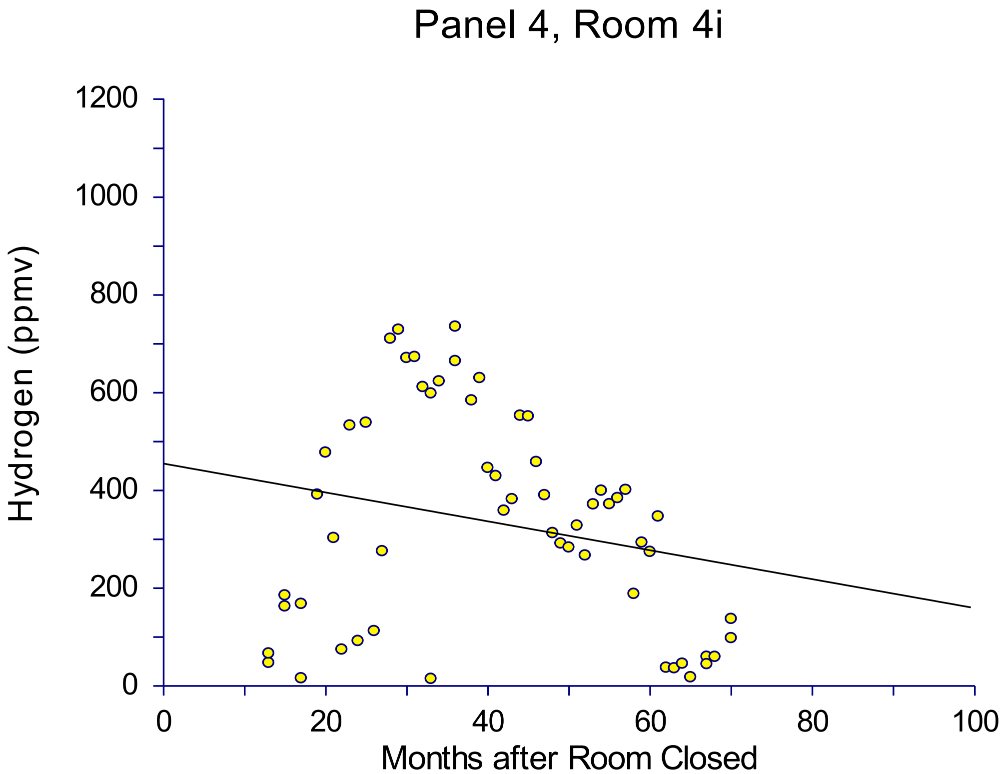
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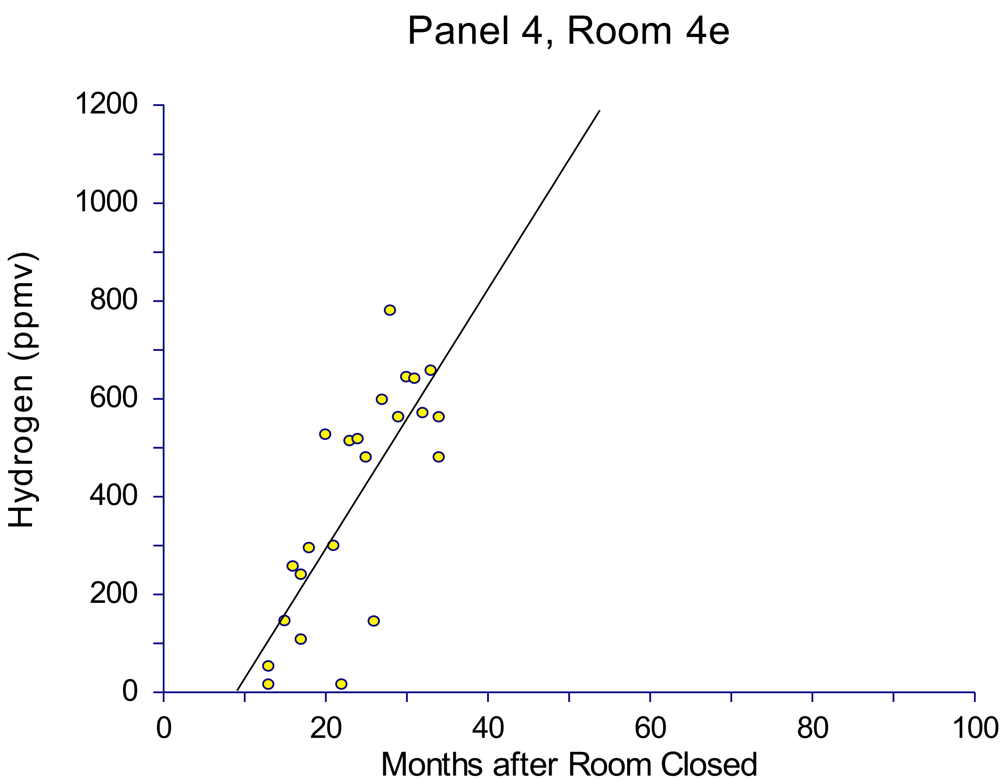
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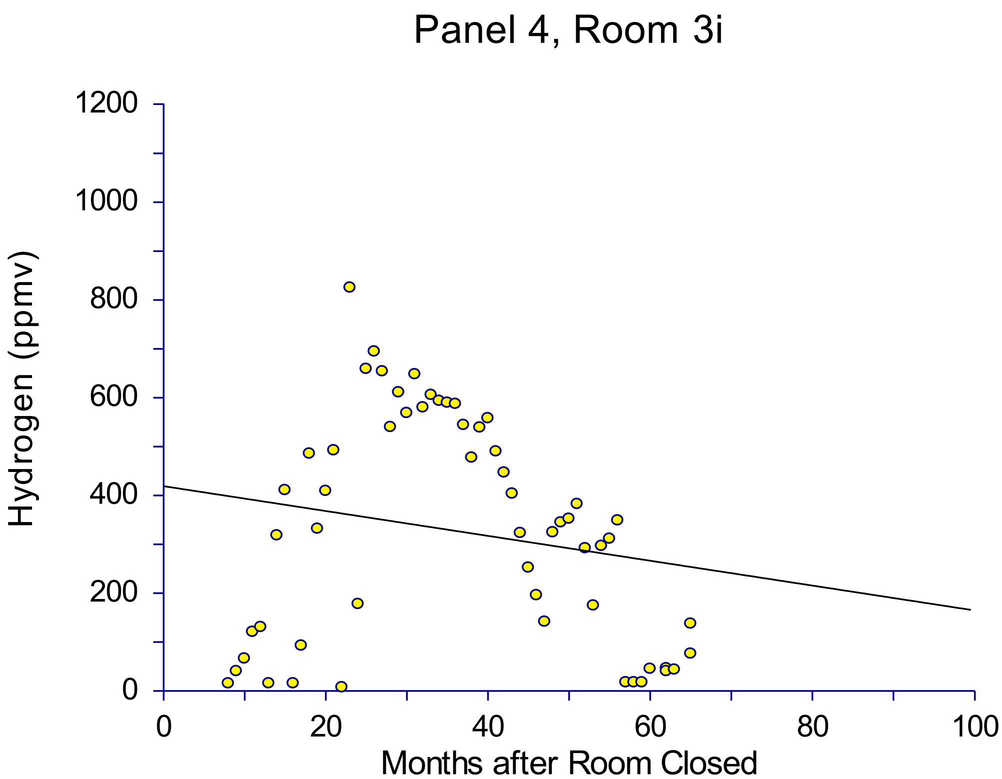
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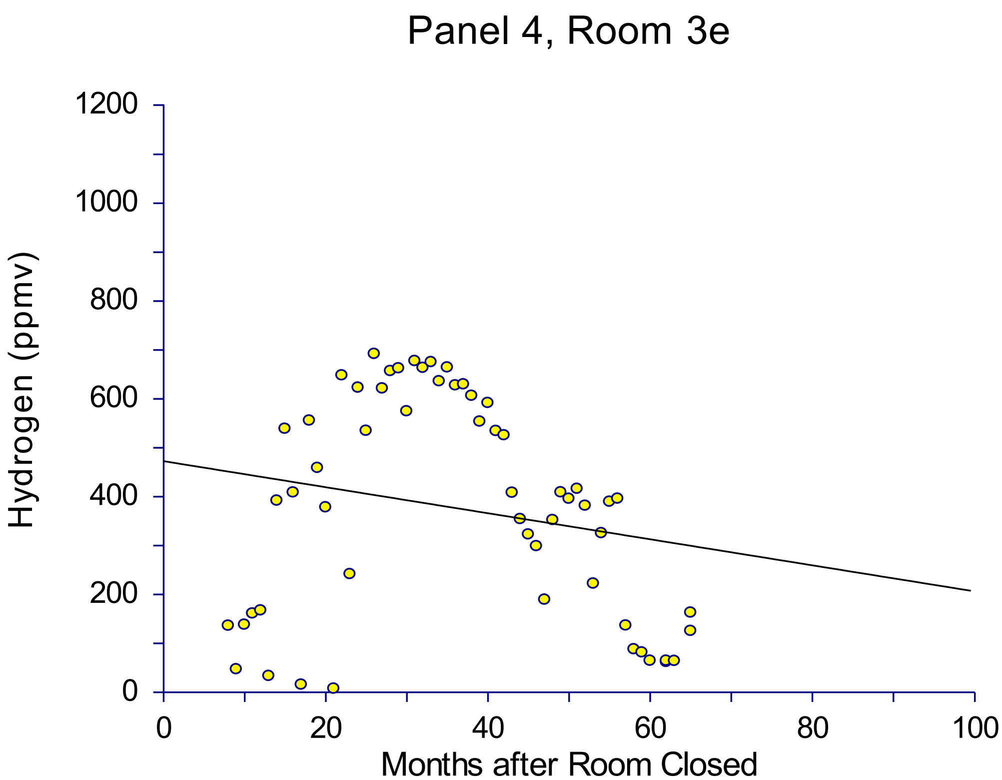
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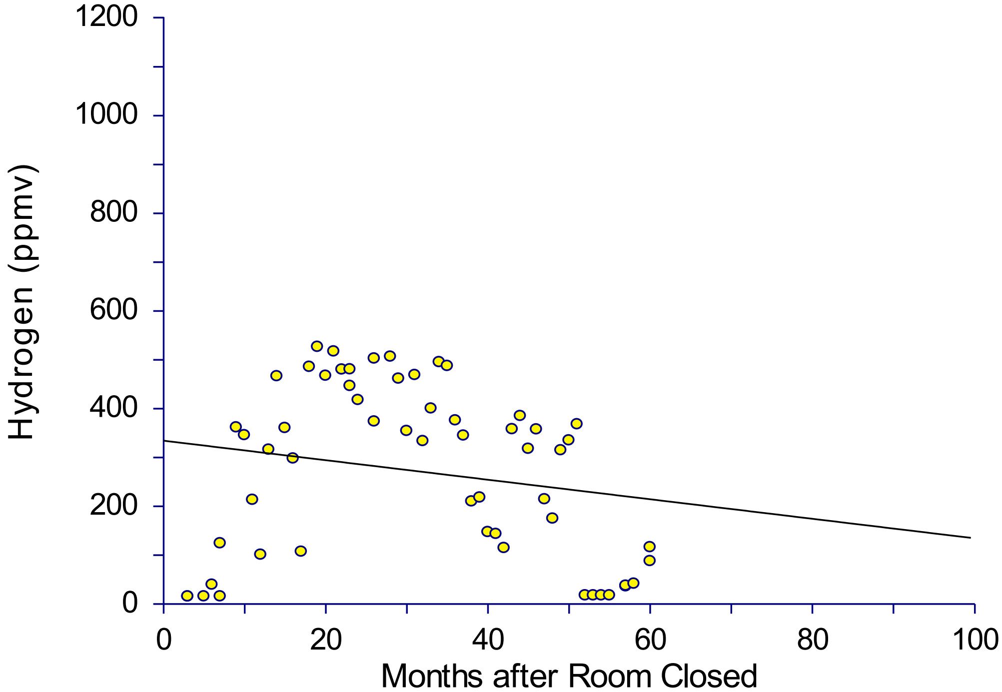
Panel 4, Room 2i



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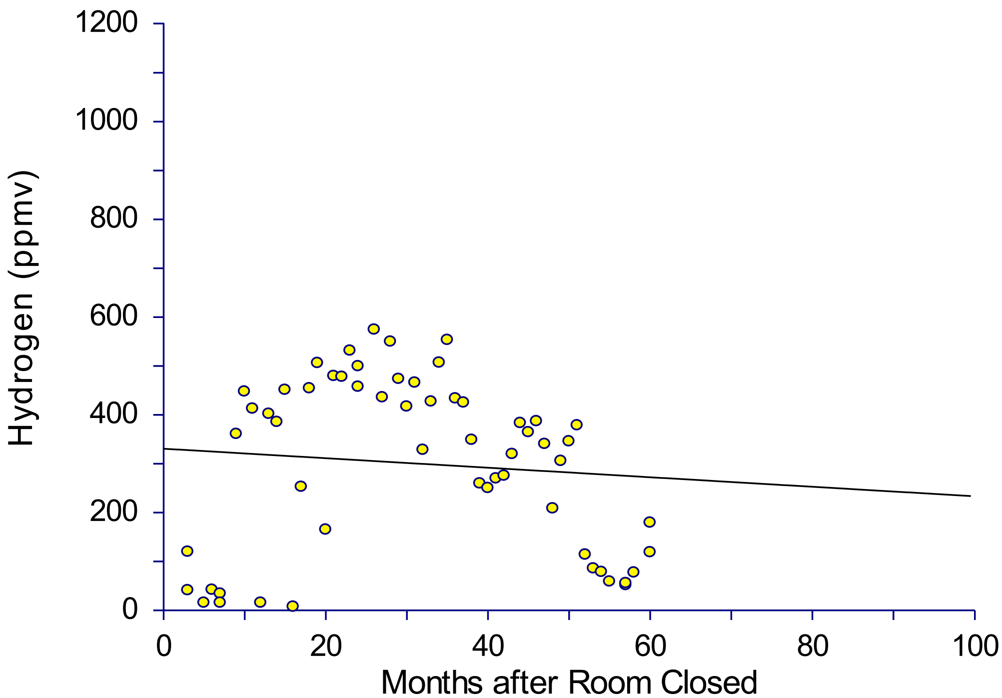

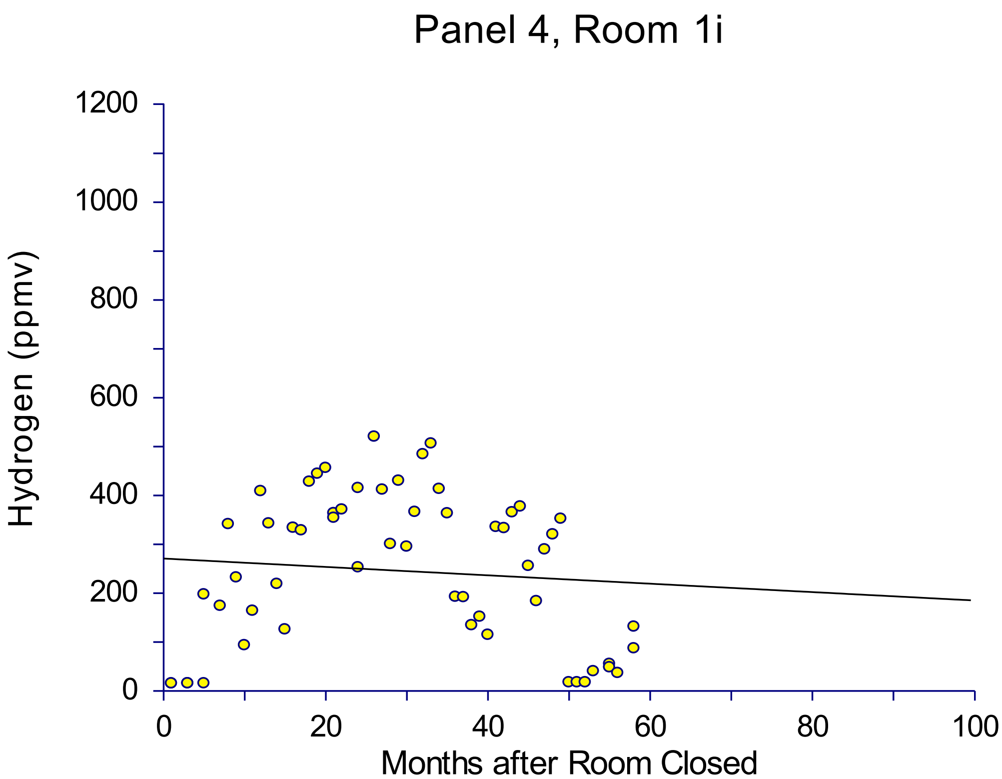
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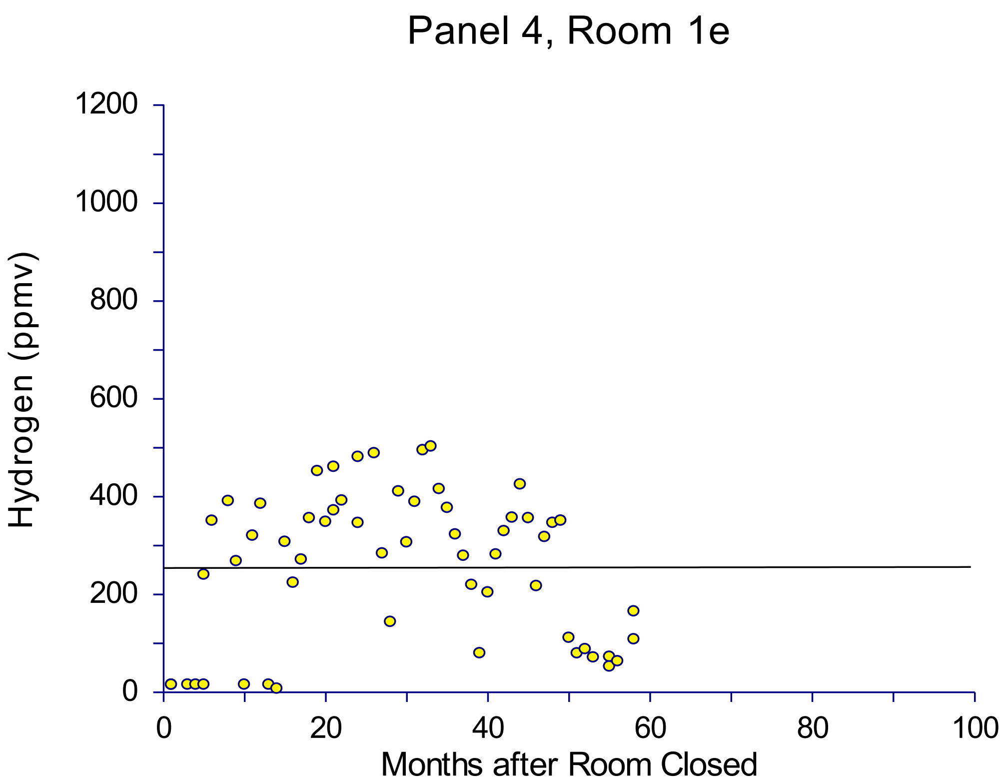
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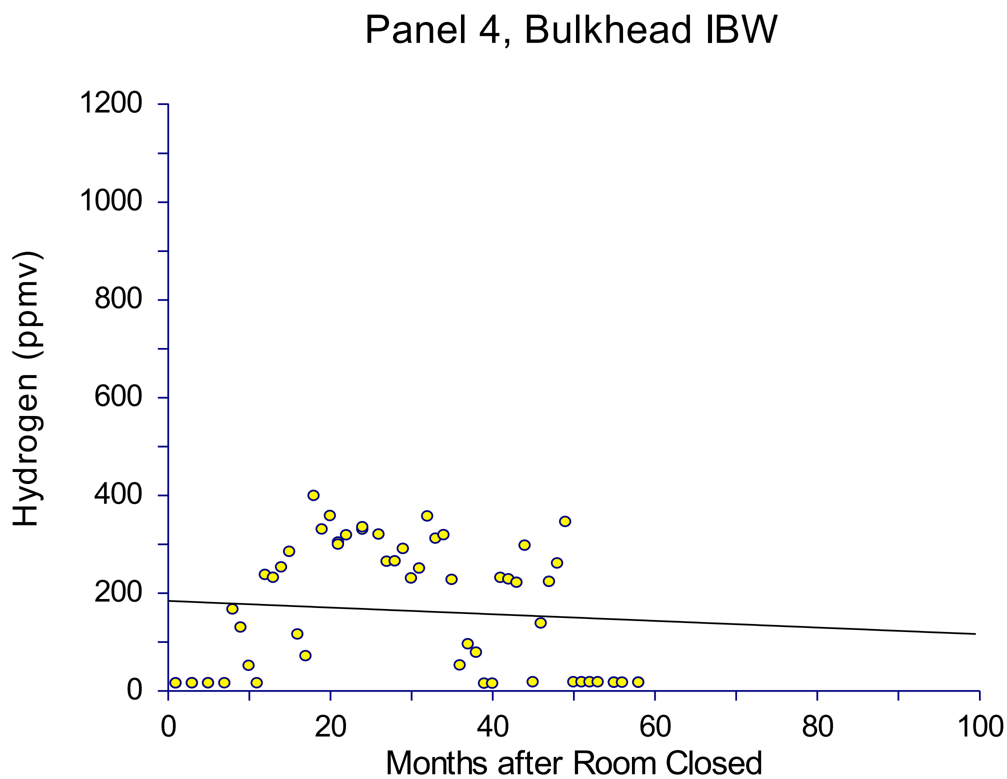
Months after Room Closed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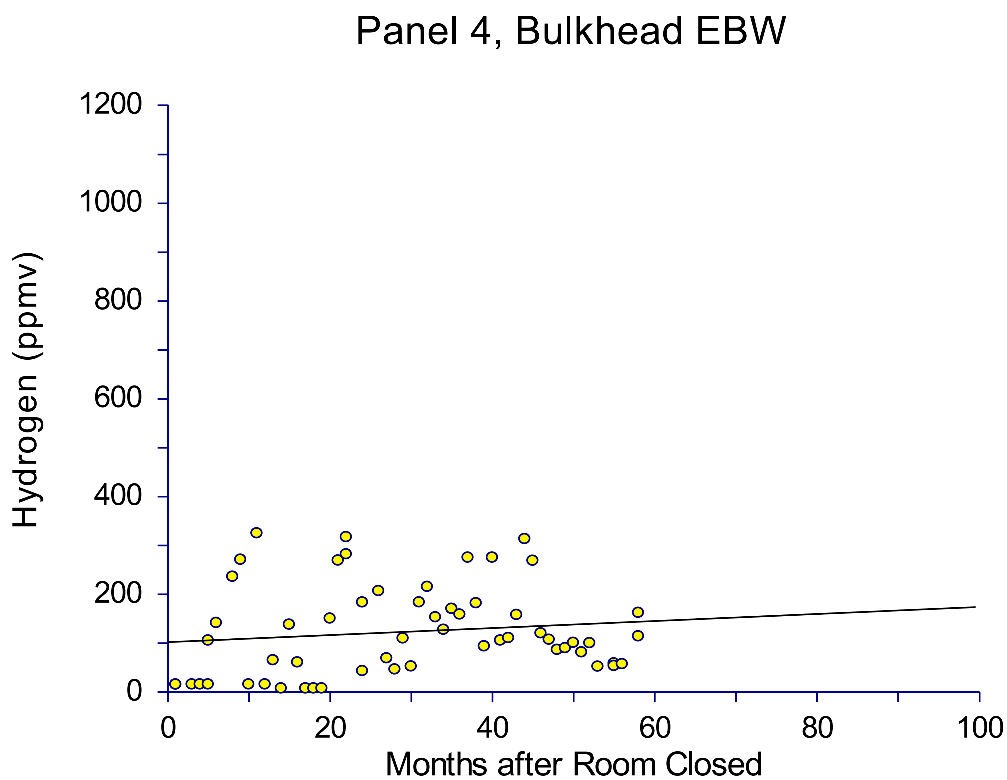
Months after Room Closed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Months after Room Closed

Appendix E
Supplemental Information

DESIGN REPORT

DESIGN REPORT

WIPP Panel Closure

Waste Isolation Pilot Plant (WIPP) Closure Project
Carlsbad, New Mexico

Submitted To: Waste Isolation Pilot Plant
Engineering File Room
Attention: Rey Carrasco
Nuclear Waste Partnership LLC
PO Box 2078, MS 486-02
Carlsbad, New Mexico 88220

Submitted By: Golder Associates Inc.
44 Union Boulevard, Suite 300
Lakewood, Colorado 80228

DOE13-PO415183

October 28, 2016 **0632213 R1 Rev1**

Golder Associates

ENGINEER'S CERTIFICATION

WIPP Panel Closure System
Waste Isolation Pilot Plant (WIPP) Closure Project
Carlsbad, New Mexico

I hereby certify that this Design Report for the WIPP Panel Closure System was prepared by me or under my direct supervision for Nuclear Waste Partnership LLC and that I am a duly licensed Professional Engineer under the laws of the State of New Mexico.

GORDAN GJERAPIC
NEW MEXICO
22242
PROFESSIONAL ENGINEER

G. Gjerapic

Gordan Gjerapic

Gordan Gjerapic, PE License # 22242

October 28, 2016

State Engineer's Approval

Approved on this ________ day of ____________________, 20___.

State Engineer

By: ______________________________

EXECUTIVE SUMMARY

This report describes the design and evaluation of a WIPP Panel Closure (**WPC**) consisting of steel bulkheads installed in Panels 1 through 9 (WPC-A) and steel bulkheads and run-of-mine (**ROM**) salt installed in the main entries north of Panel 10 (WPC-B). This report provides the technical specifications and drawings for construction. The purpose of the WPC during the operational period is to comply with the closure performance standard in the WIPP Hazardous Waste Facility Permit (**Permit**) Attachment G, Section G-1a pursuant to 20.4.1.500 NMAC (incorporating 40 CFR 264.111 and 40 CFR 264 Subpart X).

This report is an update of the previous panel closure design documents prepared by DOE (1996) and RockSol (2012) to address current facility conditions including the following:

- A WPC using steel bulkheads for the closure of Panels 1 through 9, referred to as WPC-A
- A WPC using steel bulkheads and ROM salt for the closure of main entries north of Panel 10, referred to as WPC-B
- Closure alternatives that allow multiple panels to be closed simultaneously by placing WPC-A in the north-south mains instead of in individual panel entries
- Calculations addressing structural (i.e., geomechanical) requirements and impacts to volatile organic compound (**VOC**) emissions using current and expected ventilation parameters, an air-dispersion model, and geotechnical monitoring data

This report concludes that the WPC design complies with the design requirements established for the closure of WIPP facility waste disposal panels, and the design can be constructed in the underground environment at the WIPP facility with no special requirements. To investigate key aspects of the design and its implementation, design evaluations were performed. The conclusions reached from the evaluations are as follows:

- The calculated concentration of VOCs at the compliance point at the WIPP site boundary is well below health-based levels (**HBLs**) when steel bulkheads only are used in the entries for Panels 1 through 9.
- For the WPC-B, an air gap forms between the excavation roof and the top of the ROM salt due to the settlement of the ROM salt. After closure of the air gap, the ROM salt consolidates to approximately 90% of the intact salt density approximately 24 to 42 years after installation, reducing the air conductivity and airflow rates through the ROM salt component. Structural calculations indicate that the minimum required length of ROM salt depends on the geometry of the entry, and is approximately 2.5 to 3 times the entry width.
- A VOC Flow Model accounts for VOC releases from the panels due to gas generation, panel-creep closure, and the effects of underground ventilation of the adjacent drifts. The airflow through steel bulkheads installed in Panels 1 through 9 is caused primarily by the pressure drop from ventilation in the adjacent main entry. The same is true for Panel 10 while an air gap exists above the ROM salt. After the air gap closes, the VOC Flow Model evaluates the subsequent reduction in air conductivity that occurs with the increase in salt density, and reduction in ROM salt porosity.

- The design components of the WPC are passive and will require minimal routine maintenance during the nominal operational life.

In addition to the design requirements presented above, the design includes a construction quality assurance/quality control (**QA/QC**) program.

The predicted mass flow rates for carbon tetrachloride (**CCl_4**) and other VOCs through the WPC (including flow through the disturbed rock zone (**DRZ**), the steel bulkheads, and the ROM salt in Panel 10) will result in concentrations that are at least a factor of 24 less than the HBLs established for members of the public residing beyond the WIPP site boundary. In spite of this substantial margin of compliance, the calculations should be re-evaluated if there are substantial changes in the model input parameters.

The design evaluations also concluded that the WPC provides flexibility over the remaining operational life in construction scheduling and construction material transportation and, therefore, minimizes the impact of WPC construction on operations. The existing shafts, ventilation, and underground access can accommodate the construction of the WPC.

While no specific requirements exist for closing disposal areas under Mine Safety and Health Administration (**MSHA**) regulations, the intent of the regulations is to safely isolate abandoned areas from active workings using barricades of substantial construction. Both the bulkheads and the ROM salt are considered substantial construction and meet the MSHA requirements.

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1.0 INTRODUCTION

The Waste Isolation Pilot Plant (**WIPP**) is a U.S. Department of Energy (**DOE**) facility located near Carlsbad, New Mexico, established for the safe disposal of defense-generated transuranic (**TRU**) waste. The disposed waste also contains hazardous constituents regulated by the Resource Conservation and Recovery Act (**RCRA**), and thus is subject to permitting by the New Mexico Environment Department (**NMED**) as well as subject to disposal standards for radiation protection issued by the US Environmental Protection Agency (**EPA**). The WIPP repository is located 2,150 feet (655 meters) below the surface, in the Salado Formation (**Salado**).

One important aspect of repository operations at the WIPP facility is the closure of filled waste-disposal panels. Approximate locations designated for installation of the WIPP Panel Closure (**WPC**) are shown in Figure 1. Alternative closure of Panels 3, 4, 5 and 6 includes installation of the WPC in main entries north of Panel 9 as shown in Figure 1. Each of Panels 1 through 8 consists of a panel air-intake drift, a panel air-exhaust drift, and seven rooms as shown in Figure 2. Panels 9 and 10 consist of the main entries (running North-South) and the cross entries (running East-West), as shown in Figure 1. The stratigraphy of the Salado, where the panels are located, is illustrated in Figure 3.

After completion of waste disposal activities, a panel must be closed in such a way as to protect human health and the environment from health risks associated with the RCRA-regulated hazardous waste. The closure of individual panels during the operational period is conducted in compliance with the WIPP Hazardous Waste Facility Permit (the **Permit**). In 1996, a report entitled *Detailed Design Report for an Operational Phase Panel-Closure System* (DOE 1996) was prepared. That design was submitted as part of the original Permit application to the NMED. The NMED subsequently selected portions of the 1996 report and included them in the Permit. Since that time, some of the parameters and underground conditions included in that design analysis have changed, and the practicality and necessity of constructing the original closure system has been re-evaluated. As a result, a revised closure design has been developed; the latest version of this design is called the WPC.

This report describes the design and evaluation of the WPC systems consisting of steel bulkheads (WPC-A), and steel bulkheads with run-of-mine (**ROM**) salt (WPC-B), and provides the technical specifications and drawings for construction. The purpose of the WPC is to comply with the closure performance standard in Permit Attachment G, Section G-1a pursuant to 20.4.1.500 NMAC (incorporating 40 CFR 264.111 and 40 CFR 264 Subpart X). The design goals and the calculation methodology in this Design Report account for current ventilation levels, for WIPP facility-specific health based levels (**HBLs**)[1]

[1] WIPP facility-specific health-based levels (HBLs) are calculated similar to EPA Regional Screening Levels for Residential Air exposure as found at https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search using the site-specific exposure factors. This approach was proposed in the 1996 Permit Application.

for volatile organic compounds (**VOC**), and for the latest ground conditions in the panels. This Design Report includes the following:

- A WPC using steel bulkheads for the closure of Panels 1 through 9, referred to as WPC-A
- A WPC using steel bulkheads and ROM salt for the closure of main entries north of Panel 10, referred to as WPC-B
- Closure alternatives that allow multiple panels to be closed simultaneously by placing WPC-A in the north-south mains instead of in individual panel entries
- Calculations addressing structural (i.e., geomechanical) requirements and impacts to volatile organic compound (**VOC**) emissions using current and expected ventilation parameters, an air-dispersion model, and geotechnical monitoring data

Permit Part 4, Section 4.6.2 establishes limits and action levels for VOCs of concern for Repository VOC Monitoring. These VOCs include carbon tetrachloride (**CCl_4**), chlorobenzene, chloroform, 1,1-dichloroethene, 1,2-dichloroethane, methylene chloride, 1,1,2,2-tetrachloroethane, toluene, trichloroethylene, and 1,1,1-trichloroethane. Analyses of VOC flow demonstrate that VOC concentrations will not exceed the HBLs at the WIPP site boundary as shown in Table 4.

The WPCs will be located in the panel air-intake and panel air-exhaust drifts of Panels 1 through 8 and will consist of a single steel bulkhead placed in each panel access drift, near the main entries. Alternatively, the WPCs for closure of Panels 1 to 8 may be relocated to main entries and cross-drifts if such relocation is the best alternative for greater worker protection due to poor ground conditions in the panel entries.

The alternative WPC placement options for Panels 3, 4, 5 and 6 include installation of WPC-A in the main entries north of Panel 9 (see Figure 1).

In addition, the WPCs will be placed in the main entries between Panels 9 and 10 (WPC-A); and the steel bulkheads and the ROM salt will be placed at the north end of Panel 10 (WPC-B) as shown in Figure 1. The closures for Panel 9 will consist of a single steel bulkhead in each of the four main entries between S-2520 and S-2750 cross-drifts. The closures for Panel 10 will consist of ROM salt placed between two steel bulkheads as shown in Figure 4. The closure for Panel 10 minimizes the need for further maintenance of the closure system and the Hazardous Waste Disposal Units pursuant to 40 CFR 264.111 and provides additional worker safety during construction of the shaft seals after all panels have been filled with waste. In addition to meeting the required VOC containment, the WPC satisfies the requirements of the Mine Safety and Health Administration (**MSHA**) for the use of barriers with substantial construction to prevent personnel access into waste-filled areas of the mine during operations.

The WPC will use common construction practices and will use existing standards to the extent practicable. The fabrication, installation, and maintenance of ventilation bulkheads are standard practice and no special requirements are identified for these components. The construction methods and materials used in the design for the ROM salt represent available technologies from previous mining projects (Fernandez et al. 1994, pp. 5-11 to 5-20). A variety of techniques is available for placing the salt and recent *in situ* testing (Zimmerly & Zavicar 2012; and Zimmerly et al. 2012) has demonstrated that salt can be pushed reasonably tightly against the surfaces of the underground drifts. These construction methods are simple and allow flexibility in construction scheduling and in transportation of construction materials.

As noted above, there has been an evolution in the proposed design of the panel closures since the original design permitted in 1996. This has been driven by changes in the design parameters controlling VOC release, monitoring results to evaluate the accumulation of hydrogen and methane in waste-filled panels, recent data related to performance of the underground, and considerations of the practicality of emplacement. The current design can be viewed as an update of earlier designs because it adopts the same design methodology (i.e., it considers the same physical processes and applies a similar analytical approach) as used in the earlier design reports [DOE (1996) and RockSol (2012)].

1.1 Scope

This report describes the design of the WPC, presents engineering analyses relating to structural (geomechanical) response and VOC flow, and provides an evaluation of the closure systems against the design requirements presented in Chapter 2. The WPC-A consists of a single steel bulkhead installed in each of the panel access drifts (or in the main entries and cross-drifts when considering alternative placement options) for Panels 1 through 8, and in the main entries between S-2520 and S-2750 for Panel 9. The WPC-B for Panel 10 consists of in-bye and out-bye steel bulkheads and ROM salt installed in the main entries north of S-1600. The design complies with the design requirements established for the WPC. The WPC is of substantial construction and satisfies requirements promulgated by MSHA. The analyses included here show that the WPC-A and/or WPC-B are sufficient to control VOC emissions to meet HBLs at and beyond the WIPP site boundary during the operational period.

1.2 Regulatory Requirements

The following subsections discuss the regulatory requirements specified by RCRA and MSHA that apply to closure.

1.2.1 Resource Conservation and Recovery Act (40 CFR 264 and 270)

The underground hazardous waste disposal unit (**HWDU**) portion of the Closure Plan in the Permit (NMED 2014) was prepared in accordance with the requirements of 20.4.1.500 New Mexico Administrative Code (**NMAC**) (incorporating Title 40, Code of Federal Regulations [**CFR**], Part 264, Subparts G and X). The Closure Plan requires measures to mitigate VOC migration from the underground disposal facility for compliance with HBLs in Table 4.

1.2.2 Mine Safety and Health Administration

Under 30 CFR 57 (MSHA 2012), “seals and stoppings” must be constructed of noncombustible materials appropriate for the specific mine category and must be of “substantial construction.” “Substantial construction” implies construction of such strength, material, and workmanship that the barrier could withstand conditions expected in the mining environment. As discussed subsequently in this report, the WPC satisfies the relevant requirements.

1.3 Report Organization

This report presents the engineering analysis of the WPC. Section 2.0 presents the Permit Design Requirements and a description of the design in terms of design components. Section 3.0 presents the design evaluations addressing the structural adequacy of the WPC and the VOC flow through the WPC components to the WIPP site boundary. Section 4.0 presents a list of the technical specifications for the design. Section 5.0 presents a list of the design drawings. Section 6.0 presents conclusions. Section 7.0 presents the closing statements, and Section 8.0 presents supporting references.

The full specifications for standard steel bulkheads and ROM salt are included as Appendix A, *Technical Specifications* and Appendix B, *Drawings*.

The supporting calculations documented in Appendices C, D, E, and F provide the technical basis for the design discussed in this report. Room and entry closure evaluations and a summary of the recorded closure measurements are included in Appendix C, *Creep Rate Calculations*. Airflow calculations based on the current and expected ventilation flow rates and the WPC geometry are included in Appendix D, *Air Flow Calculations*. Calculations demonstrating compliance with the VOC emission standards are included in Appendix E, *VOC Calculations*. Calculations addressing the structural response of the WPC-B include an assessment of the required length of the ROM salt component and are included in Appendix F, *ROM Salt Length Calculations.*

2.0 DESIGN DESCRIPTIONS

This section presents the Permit design requirements for the WPC; description of design components; and information regarding constructability, protection of human health and the environment, operational considerations, and longevity.

2.1 Permit Design Requirements

The original design requirements were presented in Table 7-1 of DOE 1996 and were incorporated into the Permit. Since then, the Permittees have collected data on hydrogen and methane accumulation, VOC emissions and mined opening performance that have greatly increased the understanding of current and future conditions in the repository. This increased understanding has led to a revision of the Permit design requirements for a panel closure system. The WPC was designed to meet the following revised Permit design requirements:

- The panel closure system shall contribute to meeting the HBLs in Permit Part 6 Section 6.10.1 by mitigating the migration of VOCs from closed panels
- The panel closure system shall consider potential flow of VOCs through the disturbed rock zone (**DRZ**) in addition to flow through closure components
- The panel closure system shall perform its intended functions under loads generated by creep closure of the tunnels
- The panel closure system shall perform its intended function under the conditions of a postulated thermal runaway involving nitrate salt-bearing waste
- The nominal operational life of the closure system is 35 years
- The panel closure system may require minimal maintenance per 20.4.1.500 NMAC (incorporating 40 CFR 264.111)
- The panel closure system shall address the expected ground conditions in the waste disposal area
- The panel closure system shall be built of substantial construction and non-combustible material except for flexible flashing used to accommodate salt movement
- The design and construction shall follow conventional mining practices
- Structural analysis shall use data acquired from the WIPP underground
- Materials shall be compatible with their emplacement environment and function
- Treatment of surfaces in the closure areas shall be considered in the design
- A quality assurance/quality control (**QA/QC**) program shall verify material properties and construction
- Construction of the panel closure system shall consider shaft and underground access and services for materials handling

Section 6.0 demonstrates compliance of the WPC with the above Permit design requirements and identifies the sections of this report where each is addressed.

Figure 1 and Figure 2 display the WPC locations and typical entry cross-sections evaluated in this report. The WIPP repository stratigraphy used to evaluate the WPC performance is shown in Figure 3. The WPC components are shown in Figure 4, with the steel bulkhead construction details shown in Figure 5.

2.2 Design Components

The following subsections present system and component design features. Appendices A and B present specifications and drawings, respectively, for the WPC. Individual specifications address shaft and underground access and materials handling, construction quality control, treatment of surfaces in the closure areas, and applicable design and construction standards.

The WPC-A design consists of a standard steel bulkhead (see Figure 5) in the air-intake and air-exhaust panel access drifts near the intersections with the main entries. Alternatively, the WPC-A may be installed in the main entries and cross-drifts if necessary to avoid poor ground conditions in the panel entries. This bulkhead is referred to as the closure/out-bye bulkhead and it will be maintained for as long as it is accessible. Additional ventilation barriers that were installed in panels as part of the operational controls prior to WPC installation will remain in place. These ventilation barriers include steel bulkheads, brattice cloth and chain link, as well as concrete block walls in Panels 1, 2 and 5. These ventilation barriers are not part of the WPC design, and will not impact the WPC-A closure bulkheads nor will they impede construction and maintenance of closure bulkheads. WPC-A will also be emplaced in the main entries between Panels 9 and 10 (between S-2520 and S-2750).

The WPC-B design for the closure installed in the main entries north of Panel 10 (north of S-1600) consists of ROM salt between in-bye and out-bye steel bulkheads, as shown in Figure 4. The WPC-B closure for Panel 10 provides additional worker safety during construction of the shaft seals at the end of the repository operational life after all panels have been filled with waste.

The WPC components are described below.

2.2.1 Steel Bulkhead

The steel bulkhead (Figure 5) serves to close panels by blocking ventilation airflow and preventing personnel access. This use of a bulkhead is a standard practice at the WIPP facility and the closure bulkhead will be constructed as a typical WIPP facility bulkhead. The bulkhead will consist of a noncombustible steel member frame covered with sheet metal. Telescoping steel tubing is used to bolt the bulkhead to the floor and roof. Flexible flashing material such as a rubber conveyor belt (or other appropriate material) will be attached to the steel frame and the salt as a gasket, thereby providing an effective yet flexible blockage to ventilation air. The steel bulkheads will be maintained for as long as they are accessible to workers. In this regard, accessible bulkheads will be repaired, renovated, or replaced as required.

2.2.2 ROM Salt

Run-of-mine salt material from mining operations will be delivered to the Panel 10 closure area in a loose, ungraded state. The ROM salt will be emplaced to a specified design length: the length of the sloped ends is not included in determining the minimum length of the ROM salt component. The minimum design length of the ROM component is based on the structural integrity of the material; this varies depending on the width of the entry in which it is placed. These ROM salt design lengths are based on the geomechanical analysis described in Section 3.3.5 and discussed in more detail in Appendix F.

The ROM salt will be emplaced as it is received from the mining operations. A fractional density of approximately 65% for ROM salt is typical for ungraded mined salt from the WIPP facility and other salt mining operations throughout the world (Hansen, et al. 1998; Rothfuchs and Wieczorek 2010), and is assumed for the as-emplaced ROM salt in the design analyses presented in Section 3.0. Some compaction of the salt may occur due to equipment passage and self-weight of the material, thereby reducing the air gap above the ROM salt fill; however, this beneficial effect is expected to be minimal and is ignored in the design analyses.

2.3 Constructability, Protection of Human Health and the Environment, Operational Considerations, and Longevity

The following subsections present information on the constructability, protection of human health and the environment, operational considerations, and longevity of the WPC. More detailed information is presented in the supporting Appendices A and B that present specifications and engineering drawings.

2.3.1 Constructability

The WPC can be constructed using available technologies for the construction of steel bulkheads and placement of ROM salt. The construction methods and materials used in the design represent available technologies from previous mining projects (Fernandez et al. 1994, pp. 5-11 to 5-20) which have been demonstrated by in situ testing of ROM salt at the WIPP facility (Zimmerly & Zavicar 2012, Zimmerly et al. 2012). The steel bulkheads are commonly used at the WIPP facility.

Conventional mining practices will be used in construction of the WPC bulkheads. Work packages prepared for the fabrication and installation of steel bulkheads will list the materials used, the equipment used, special precautions, and limitations. Each work package will address prerequisites for installing the WPC components, will stipulate the bulkhead specifications, will identify the WPC location in the panel access drift or the main entry or cross-drift, and will specify the length of ROM salt in the main entries for the Panel 10 WPC-B.

ROM salt for the Panel 10 closures is available in sufficient quantities at minimum cost from WIPP mining operations. The ROM salt can be emplaced using conventional mining equipment in such a manner as to maintain a natural angle of repose at the ends. The ROM salt can be emplaced as is from the mining operations at an assumed fractional density of 65% (Zimmerly & Zavicar 2012; Zimmerly et al. 2012). For the WPC-B, the in-bye bulkhead will be installed first, followed by emplacement of the ROM salt to its required length, with the out-bye bulkhead installed last.

Further construction details are given in the Technical Specifications included in Appendix A.

2.3.2 Protection of Human Health and the Environment

The WPC will not adversely impact human health or the environment. The construction materials are steel bulkheads, which are already used throughout the underground, or natural material removed from the host rock. The construction methods use equipment identical or similar to those used in day-to-day mining operations and construction in the WIPP underground facility.

The VOC analysis presented in this report addresses compliance with applicable health standards for members of the public who reside at or beyond the WIPP site boundary. Worker exposure at the WIPP facility during installation and maintenance of the WPC will be managed under the WIPP facility worker safety program and is addressed in the work activity health and safety plan.

The current design is easy to construct, as there is no need for complex formwork or the production and placement of mixed materials such as concrete. The period for construction is estimated to be 30 days or less for a single steel bulkhead and 180 days or less for the WPC-B with ROM salt (40 CFR 264.113 (b)). The WPC construction uses common materials for the steel bulkheads and ROM salt, thus minimizing the number of workers required and the time required for workers to be in the construction area. Shorter construction time translates to an increase in worker safety and lower risk to workers. Experience in the WIPP underground with radiological work indicates that the tasks required for construction of the WPC can be performed while wearing personal protective equipment (**PPE**) and other protective clothing, if necessary. The WPC design minimizes the time workers will have to spend in radiological areas, this in turn minimizes the amount of time workers must wear PPE and other protective clothing.

2.3.3 Operational Considerations

The construction of the WPC can be stopped and re-started as necessary to accommodate operational limitations (such as ventilation) and to reduce or eliminate impacts on waste handling. Temporarily stopping construction will not affect the performance of the WPC. The equipment used to construct the WPC can be quickly mobilized and demobilized to accommodate waste handling and other operational needs. Shaft schedules would not be impacted as the majority of the construction materials are readily staged in the underground. There will be sufficient ventilation air to support the activities required to construct the WPC. In particular, the WPC can be constructed while in filtration mode.

2.3.4 Longevity

As demonstrated in Section 3.0, the airflow resistance for closures in the panel access drifts, in the cross-drifts and in the main entries is derived primarily from steel bulkheads. During the period of time that steel bulkheads are relied upon to provide airflow resistance, these structures will be maintained until they are no longer accessible. The WPC-B ROM salt is compatible with the underground environment and its performance improves with time. Eventually, the WPC-B ROM salt will become structurally indistinguishable from the surrounding intact salt.

3.0 ANALYSIS

To evaluate the effectiveness of the WPC, structural and displacement analyses were performed to examine the performance of the WPC over the operational period of the repository. Airflow analyses were then performed to evaluate the range of airflow resistance for different closure scenarios, followed by analyses to determine VOC emissions through the WPC. Predicted concentrations of VOCs at the WIPP site boundary are compared to HBLs to demonstrate compliance with the VOC air emission standards.

This section presents evaluations of the WPC:

1. Displacement analyses for steel bulkheads and structural analyses for the ROM salt installed as a part of the WPC-B in the main entries north of Panel 10
2. Projected VOC emissions based on the unrestricted flow model (DOE 1996, RockSol 2012)
3. A material compatibility evaluation
4. An evaluation relative to nitrate salt-bearing waste

3.1 Analyses Addressing Operational Requirements

The main factor affecting the stability of steel bulkheads is the creep closure of underground openings accommodated by flexible flashing (see Figure 5). Differential pressures on steel bulkheads caused by the airflows in the underground (MVS 2015) or by the potential thermal runaway event (DOE 2015) will have an insignificant effect on the structural stability of the steel bulkheads. The stability of the steel bulkheads is discussed in Section 3.2.

Structural analyses conducted for the WPC-B in the main entries north of Panel 10, predict an initial gap forms between the roof and top of the ROM salt due to settlement of the ROM salt. Over time, this gap reduces and is finally closed due to creep closure of the main entries. The gap closure is followed by further increases in the ROM salt fractional density due to continuing creep closure of the main entries and associated compressive loading of the ROM salt.

Airflow analyses were conducted to predict the release of VOCs through the WPC over time due to gas generation, panel creep closure and the effects of underground ventilation. The results of these analyses support the WPC design for the protection of human health and the environment at the WIPP site boundary. The effects of a thermal runaway event due to the spontaneous ignition of nitrate salt-bearing waste on the WPC were analyzed in a separate report to support the initial closure of Panel 6 and the closure of Panel 7, Room 7 (DOE 2015) and are summarized here. However, the effects of a hydrogen or methane explosion were not analyzed because monitoring of hydrogen and methane concentrations indicates that they will not reach minimum explosive concentrations during the operational period (Myers 2016 and Nelson 2011).

3.2 Displacement Tolerances for Steel Bulkheads

The maximum predicted differential pressures on steel bulkheads during operation range from 0.03 psi (MVS 2015) to 0.47 psi (NWP 2015). The pressure from the potential thermal runaway event is of similar magnitude, i.e., approximately 0.5 psi (DOE 2015). Hence, the stability of steel bulkheads is not likely to be affected by the pressure exerted by the ventilation system or by the design thermal runaway event.

The main factor affecting structural stability of the bulkhead is creep closure of the surrounding rock because the bulkhead steel frame is not capable of resisting compressive forces exerted by the rock mass without buckling. The flexible flashing and modular tubing is incorporated to allow for differential movement between the steel frame and the surrounding rock mass. The flexible flashing design on a typical WIPP underground bulkhead, as shown in Figure 5, accommodates approximately 24 inches of creep closure. Considering the median convergence rate in the main entries of 2 inches per year and even smaller average displacement rates measured in the panel access drifts (see Appendix C), the steel bulkhead is expected to perform its function without the need for maintenance for several years after installation. For locations with relatively small rates of floor heave, the bulkhead may not need maintenance for over 10 years. However, routine inspections should be conducted to confirm the performance of the bulkheads. Creep closure rates are discussed in more detail in Appendix C.

3.3 Structural Analyses of ROM Salt Emplacements for Panel 10

Updated geomechanical analyses have been conducted to evaluate ROM salt performance of WPC-B in the main entries north of Panel 10, including an evaluation of the minimum ROM salt length requirements for different entry sizes. These analyses are reported in Appendix F and are summarized here. The following subsections describe the properties of the ROM salt, the structural modeling method used, model geometry, modeling sequence, and modeling results.

3.3.1 ROM Salt Properties

Geomechanical models require that the initial densities and material properties of the ROM salt be specified. As discussed previously, the initial ROM salt density of approximately 65% of the intact density of salt was adopted for geomechanical evaluations. The intact density used in this study ranges from 2,160 kilograms (**kg**)/m^3 (Callahan 1999) to 2,300 kg/m^3 (DOE 1996). The constitutive model for ROM salt calculations was the crushed salt model discussed in the Fast Lagrangian Analysis of Continua (FLAC) manual (Itasca 2000). The modeling was conducted by using the intact salt density of 2,160 kg/m^3 for the lower bound simulations, and 2,300 kg/m^3 for the upper bound simulations (see e.g., Figures 6 and 7). Model parameters are discussed in more detail in Appendix C.

3.3.2 Structural Modeling Method

The settlement and change in density with time (and implicitly the intrinsic permeability) of the ROM salt was calculated using the three-dimensional geomechanical modeling program FLAC3D (Itasca 2012) and supplemented with two-dimensional FLAC and analytical calculations. FLAC3D implements the Callahan and DeVries (1991) crushed salt creep constitutive model. This model is based on Sjaardema and Krieg (1987) and was verified by Callahan (1999) through comparisons of numerical analysis predictions with laboratory test results. Material properties for the other materials in the surrounding salt are from Krieg (1984). The deformation of the intact salt surrounding the entries was determined using the WIPP salt model and parameters included in the FLAC manual, see Itasca (2000). The modeling was conducted by using the intact salt density of 2,160 kg/m^3 for the lower bound simulations, and 2,300 kg/m^3 for the upper bound simulations (e.g., see Figures 6 and 7).

3.3.3 Model Geometry

The ROM salt model geometry was based on the nominal dimensions of the various main entries in Panels 9 and 10 (Figure 2). The host rock stratigraphy used for FLAC3D and FLAC analyses was adopted from DOE (2011, 2013) and previous modeling efforts, as discussed in Appendix C.

3.3.4 Modeling Sequence

Closure of the initial air gap and ROM salt compaction after gap closure strongly depend on the deformation properties of the surrounding rock mass. Therefore, a series of FLAC analyses were performed to validate the convergence rates in the model against the observed rates of convergence in the main entries. ROM salt displacement analyses for the various entries were then performed to predict the closure of the air gap between the ROM salt and surrounding rock mass.

ROM salt behavior after the closure of the air gap was determined from FLAC3D analyses assuming unrestricted movement of the salt roof before the closure of the air gap, and restricted movement of the salt roof when the ROM salt is in contact with the roof (i.e., after the gap closes) due to the ROM salt resistance.

3.3.5 Structural Modeling Results

After emplacement of the ROM salt and until the initial air gap is closed, the ROM salt consolidates under its own weight resulting in an increase in fractional density. After the air gap is closed, the creep movement of the salt roof is impeded by the increasing stiffness of ROM salt resulting in the diminishing convergence rates and a further increase in fractional density of the ROM salt, as shown in Figures 6 and 7. These values of fractional density were used to determine air conductivities for the airflow calculations after closure of the air gap, when the ROM salt component has a meaningful effect on the overall airflow through the WPC-B at Panel 10.

Figure 8 shows the air gap magnitude versus time in the middle of the main entries. The gap reaches a maximum of approximately 20 inches (50 centimeters (cm)) for the 25-foot-wide by 15-foot-high entry and 19 inches (48 cm) for the 16-foot-wide by 13-foot-high entry. The air gap in the 25-by-15-foot entry closes after approximately 17 years after ROM salt placement, and after approximately 31 years for the 16-by-13-foot entry.

Additional FLAC3D calculations have been conducted to determine the minimum ROM salt length for the WPC-B stability in the E-300, E-140, W-30, and W-170 main entries. The criterion chosen to determine the minimum length of the ROM salt is that an adequate percentage of ROM salt will maintain its structural integrity under loads imparted by creep closure of the surrounding rock. The critical percentage of ROM salt is determined for the ROM salt length for which a relatively small or no change in the geomechanical behavior occurs as the length of the plug increases. Criteria selected for this performance evaluation were as follows:

- The strength-stress ratio, Fs, used to determine the percentage of ROM salt exhibiting failure
- The confinement ratio, Fc, used to determine the percentage of ROM salt with the reduced ductility and strength

Geomechanical definitions of Fs and Fc parameters are provided in Appendix F. Noting that the geomechanical performance of the ROM salt is affected by the surrounding rock salt properties, as well as the dimensions of underground openings, the ROM salt performance has been evaluated for the entries with the dimensions 16 by 13 feet and 25 by 15 feet (width by height). ROM salt lengths that are required for installation in entries with different dimensions were interpolated between the two analyzed cases.

FLAC3D analyses demonstrated that the minimum ROM salt length is a function of the drift geometry. The minimum ROM salt length was selected based on the requirement that the critical percentage of ROM salt exhibiting Fs<1 and Fc<1 is less than approximately 5% for 15 years after construction and less than approximately 3% approximately 35 years after construction. Assuming the nominal operational life of the WPC of 35 years, geomechanical performance of the ROM salt closure components is expected to be satisfactory for ROM salt lengths approximately 2.5 to 3 times the width of the underground opening. Consequently, the minimum ROM salt length for the 16-foot-wide main entries is approximately 40 feet. Similarly, the minimum recommended ROM salt length for the 25-foot-wide main entry is approximately 65 feet as shown in Table 1.

Table 1 Minimum ROM Salt Lengths

Entry Width (ft.)	ROM Salt Length[1] (ft.)
14	35
16	40
20	50
25	65

Note:
1. Reported lengths are minimum dimensions and exclude sloped ends.

3.4 VOC Flow Analyses

VOCs that escape the waste containers can be released from the panels by a few different mechanisms. Principal transfer mechanisms are as follows:

- The air flow induced by the difference in ventilation air pressure between the air-intake and air-exhaust drifts for WPC-A in Panels 1 to 8 (see Figure 2)
- The air flow induced by the difference in ventilation air pressure between main entries for WPC-A in Panel 9 and for WPC-B in Panel 10
- The air flow induced by the difference in ventilation air pressure between main entries and cross-drifts for WPC-A for Panels 1 to 8 if considering the WPC relocation alternatives.
- The air flow induced by gas generation
- The air flow induced by creep closure of the rooms leading to a loss of gas volume
- The airflow induced by differences in the atmospheric pressure

The methodology used in this analysis followed that previously used by RockSol (2012) but with updated parameters. The VOC flow analysis by RockSol (2012) was prepared using the assumption that the WIPP facility would be operating in normal ventilation mode, with a total airflow rate of 260,000 standard cubic feet per minute (**scfm**). This is no longer the case since the overall ventilation flow rate through the disposal area is significantly reduced as the result of operation in continuous filtration mode. In addition, there exists a considerable quantity of recent closure data allowing for an update of the expected creep closure rates. To evaluate the cumulative impact of these changes on VOC compliance, a new set of VOC analyses was conducted. To verify the new VOC model, a comparison between the updated VOC model and the RockSol (2012) model was evaluated as Case 1, with four additional cases (Cases 2 to 5) evaluated to examine the effect of various parameter changes. The five cases are as follows:

- **Case 1 – Model Verification.** Case 1 was performed to establish equivalency between the current methodology and the RockSol (2012) model.
- **Case 2 – IVS and Modified Air Dispersion Factor (ADF).** This case is similar to Case 1 but with a revised ventilation flow rate and an updated air dispersion factor. Case 2 used

the flow rate for the new Interim Ventilation System (**IVS**), 106,000 scfm, and the updated value for air dispersion of $9.82x10^{-6}$ per URS (2014) calculations.

- **Case 3 – Base Case for WPC-A with Nominal Bulkhead Resistance.** Case 3 incorporates all the recent changes in mine conditions into the VOC release calculations.
- **Case 4 – WPC-A Performance with Low Bulkhead Resistance**. Case 4 is the same as Case 3, but with a reduced bulkhead flow resistance of 200 Practical Units (**P.U.**)[2] Case 4 evaluates the performance of the WPC with degraded steel bulkheads in all panels.
- **Case 5 – WPC-B Performance.** Case 5 evaluates the performance of the WPC-B after the air gap has closed and the ROM salt near Panel 10 has consolidated to 90% of its intact density, leading to reduced flow through the closure and throughout the whole repository.

The design criteria for the VOC calculations are included in Attachment 2 of Appendix E. Details on the input parameters for Cases 1 to 5 are given below.

3.4.1 Creep Closure Rate

The creep-induced volumetric rate of 812 m^3/yr per panel for Cases 1 and 2 was adopted from DOE (1996) and RockSol (2012), based upon the best closure information available at the time of the Permit Application. Since that time, there have been many measurements of closure in the various panels, and the revised volumetric creep rate of 1,262 m^3/yr per panel for Panels 1 to 8 is based on an average convergence rate of 3.9 in/yr estimated from the updated DOE (2011, 2013) convergence data for the rooms in Panel 5. Creep closure data for Panels 9 and 10 between 2010 and 2012, as reported in DOE (2011, 2013) result in a median convergence rate for the main entries of 2 inches per year, which converts to a volumetric creep rate of 950 m^3/yr/panel for Panels 9 and 10. The revised volumetric creep rates have been used for Cases 3, 4 and 5.

3.4.2 Pressure Drop across Individual Panels

This parameter is a measure of the difference in pressure in the exhaust main between the air-intake and air-exhaust access drifts to an individual panel (Figure 2). This difference is the driving force for advective flow through the WPC and panel. The initial value of 170 milli-inch water gage (**w.g.**) was adopted from RockSol (2012) based on the ventilation characteristics in the East-300 main entry for a 260,000 scfm total flow rate. This pressure drop has been used for Cases 1 and 2 to establish equivalency.

A recent analysis by Mine Ventilation Systems (**MVS**) in 2015 indicates that, for the modified ventilation rate for the IVS, the maximum airflow in the access drifts (cross-drifts) is not likely to exceed 90,000 scfm. The estimated pressure drop for closures installed at the north end of Panel 9, between S-2520 and S-2750, is then 3.4 milli-inch w.g. assuming the airflow resistance in the cross-drift is 0.00042 P.U. This value is used in calculations for Cases 3 and 4 because this value represents the base case pressure

2 A Practical Unit is 1 milli-inch of water gage divided by 1.0 kcfm (1,000 cubic feet per minute).

drop with the IVS installed. The value of 3.4 milli-inch w.g. was also adopted as a lower bound pressure drop between entries when considering air flow for the WPC relocation alternatives. For Cases 1 to 4, the calculated air flow through panels is sufficiently large to trigger maximum diffusion rate through the filters, i.e., the VOC emission rates for Case 1 to 4 models are the same as for the open panels. Consequently, calculated VOC emissions can be viewed as conservative estimates for both the modeled base case scenarios and for the considered closure alternatives, including ventilation updates (e.g., when considering VOC emissions for the Supplemental Ventilation System conditions). It is worth noting that MVS (2015) states that the airflows across bulkhead closures are likely to be dominated by changes in the barometric pressure, which would result in greater flows in the panels. However, these will be transient effects and should not impact the long-term average VOC releases, which are dominated by the diffusion rate of the VOCs through the filters on the waste containers. The MVS (2015) report is included in Attachment 1 of Appendix D.

The pressure drop across the WPC-B used for Case 5 is 856 milli-inch w.g. This is based on the maximum pressure drop across the WPCs in the main entries predicted by MVS (2015). The use of the maximum pressure drop provides an upper bound for the CCl_4 compliance ratio calculated for Case 5.

3.4.3 Airflow Resistance

The RockSol (2012) calculations are based on a total ventilation flow rate of 260,000 scfm in normal ventilation mode and assumed that flow resistance would be determined by the two out-bye bulkheads when the air gap above the ROM salt had not closed. Given the nominal flow resistance of 2,200 P.U. for each bulkhead, the flow resistance for each panel is then (2 x 2,200 P.U.) = 4,400 P.U. per panel. To establish equivalency, Case 1 is based on a total ventilation flow rate of 260,000 scfm and an airflow resistance of 4,400 P.U. per panel.

Cases 2, 3, 4, and 5 simulate the impact of the IVS flow rate of 106,000 scfm on the VOC compliance ratio. Cases 2 and 3 use the nominal flow resistance of 2,200 P.U. for a bulkhead, resulting in a flow resistance of 4,400 P.U. for each panel. Case 4 examines the impact of degraded bulkheads in each panel on the compliance ratio. A degraded bulkhead is assumed to have a flow resistance of 200 P.U., less than one-tenth the nominal bulkhead resistance, resulting in a flow resistance of 2 x (200 P.U.) = 400 P.U. per panel. Finally, the flow resistance for Case 5 represents the impact of the reconsolidated salt in WPC-B on the airflows throughout the ten panels. Note that WPC-B affects airflows in all panels of the repository because ventilation air cannot reach Panels 1 through 9 without first passing through Panel 10 closure. This effect will be greatest after the air gap closes and the ROM salt consolidates in WPC-B, leading to very low flows throughout the repository. This effect has been represented by assigning a flow resistance of 1×10^{12} P.U. to each panel in the current model. The resistance value of 1×10^{12} P.U. was determined for the ROM salt fractional density of 90% and the corresponding permeability value based on the relationship proposed by Kelsall et al. (1983), see Appendix D. For the assumed pressure drop of 856 milli-inch w.g.

and the estimated ratio between the area and flow-length of 0.3, one can determine the flow rate of approximately 0.03 cfm by applying Darcy's law [i.e., the ROM salt airflow resistance used for Case 5 calculations was determined from the maximum estimated pressure differential based on MVS (2015) report and the minimum estimated advection flow rate based on Darcy's law]. The change of the ROM salt air conductivity with time is illustrated in Figure 9. Estimated airflows for various WPC components are presented in Figure 10.

3.4.4 Other VOC Model Parameters

The RockSol (2012) calculations are based on 40,233 drums per panel, corresponding to 95% drum loading efficiency, and an air dispersion factor (**ADF**) at the WIPP site boundary of 8.78×10^{-5} (Kehrman 2012). To establish equivalency, Case 1 is based on these same values.

Cases 2, 3, 4, and 5 are based on 42,350 drums per panel, corresponding to 100% loading efficiency, and an updated ADF at the WIPP site boundary of 9.82×10^{-6} (URS 2014). The use of the 100% loading efficiency provides a slight conservatism, on the order of 5%, to the calculated compliance ratio for CCl_4.

3.4.5 Summary of Case Descriptions and Input Parameters

Table 2 summarizes the descriptions and numerical values of the model input parameters for Cases 1 through 5.

Table 2 Descriptions and Input Parameters for Cases 1 Through 5

Case No. – Description	No. Filled Panels	Volumetric Creep Rate (m^3/yr/panel)	Pressure Drop across Panel/Bulkhead (milli-inch w.g.)	Air Flow Resistance (P.U.)
1 – Model Verification	9	812	170	4,400
2 – IVS and Modified ADF	9	812	170	4,400
3 – Base Case for WPC-A	9	1,262 (Panels 1 to 8) 950 (Panel 9)	3.4	4,400
4 – Base Case for WPC-A with Low Bulkhead Resistance	9	1,262 (Panels 1 to 8) 950 (Panel 9)	3.4	200
5 – WPC-B Performance after Air Gap Closure	10	1,262 (Panels 1 to 8) 950 (Panels 9 and 10)	856	ROM salt w/closed gap (~10^{12} P.U.)

3.4.6 Results

The results of the five cases are shown in Table 3 in terms of the calculated Compliance Ratio, which is defined as a ratio between the calculated VOC concentration at the WIPP site boundary and the HBL concentration for the same constituent. The VOC calculation results are presented graphically in Figure 11. In all cases using the updated ventilation data and updated mine conditions, the compliance ratio is approximately 0.04 or less indicating that the estimated releases of CCl_4 at any compliance point beyond the WIPP site boundary are at least a factor of 24 less than the HBLs.

Table 3 Calculated Compliance Ratio for Cases 1 Through 5

Case No. – Description	No. Active Panels	Compliance Ratio[1] for CCl_4
1 – Model Verification	9	0.15
2 – IVS and Modified ADF	9	0.042
3 – Base Case for WPC-A	9	0.042
4 – Base Case for WPC-A with Low Bulkhead Resistance	9	0.042
5 – WPC-B Performance after Air Gap Closure	10	0.0014

Note:
1. Case 1 results were determined for the air dispersion factor (ADF) of 8.78×10^{-5} consistent with RockSol (2012). Case 2 to 5 results were determined for ADF=9.82×10^{-6} per updated URS (2014) air quality model.

As noted previously, Case 1 was developed to establish equivalency between the RockSol (2012) results and the current methodology. To demonstrate equivalency, Case 1 has a total ventilation rate of 260,000 scfm for the ventilation system in normal mode, a flow resistance of 2,200 P.U. for each bulkhead, a volumetric closure rate of 812 m^3/year/panel, and a pressure drop of 170 milli-inches w.g. between the panel access drifts. The CCl_4 compliance ratio of 0.15 for the nine waste-filled panels in Case 1 agrees favorably with the results from RockSol (2012), which had a compliance ratio of 0.16 for ten waste-filled panels.

Case 2 uses the same inputs as Case 1, except the ventilation rate is set to 106,000 scfm for the IVS, the air dispersion factor (ADF) is set to 9.82×10^{-6} based on the updated air quality model (URS 2014), and the number of containers per panel is set to 42,350, based on 100% efficiency for panel loading. The CCl_4 compliance ratio of 0.042 for Case 2 is significantly smaller than the Case 1 value, largely due to the decrease in the ADF, which increases the VOC dispersion relative to that assumed by the RockSol (2012) model.

Case 3 for WPC-A incorporates the recent changes in mine conditions into the VOC release calculations. Case 3 uses the new IVS flow rate of 106,000 scfm, a revised pressure drop for the IVS of 3.4 milli-inches w.g., 42,350 drums per panel (100% loading efficiency), and revised volumetric closure rates based on recent geotechnical data (1,262 m^3/year/panel for Panels 1 to 8 and 950 m^3/year for Panel 9). The bulkhead flow resistance is 2,200 P.U., unchanged from Case 1. Case 3 assumes that nine panels are filled with waste and closed with steel bulkheads.

Case 4 for WPC-A is the same as Case 3, but with a reduced bulkhead flow resistance of 200 P.U. Case 4 evaluates the performance of the WPC-A with degraded steel bulkheads in all panels. Case 4 also assumes that nine panels are filled with waste and closed with steel bulkheads.

The CCl_4 compliance ratios for Cases 2, 3, and 4 are essentially identical, implying that the compliance ratio is insensitive to volumetric closure rate, pressure drop, or bulkhead flow resistance (see Table 2).

The compliance ratios for Cases 2, 3, and 4 are the same because release of CCl_4 is limited by the filter(s) on each container, and the air flow for Cases 2, 3, or 4 is always sufficient (i.e., high enough) to remove the VOCs that diffuse from the individual drums. In other words, the release of VOCs is governed by a limiting emission rate (i.e., calculated for the maximum diffusion rate through the filters for fully ventilated rooms), which is not affected by closure rate, pressure drop, or flow resistance.

Case 5 examines the situation when the air gap above the ROM salt for the WPC-B for Panel 10 is closed, i.e., when the ROM salt is in close contact with the entry roof and walls. In this situation, the flows across the WPC-B will be very small, and the concentration of VOCs in the panels is expected to reach the headspace concentration in the containers because the emission of VOCs from the panels is significantly reduced due to a relatively large resistance to air flow through the ROM salt. Case 5 results were determined for the air resistance of ROM salt at the fractional density of 90% (Kelsall et al. 1983) and the bounding pressure drop of 856 milli-inch w.g. across WPC-B, based on (MVS 2015). Details of the VOC calculations are presented in Appendix E.

3.4.7 Compliance Ratios for Other VOCs

Calculated compliance ratios of other target VOCs based on Case 3 model parameters are summarized in Table 4**.** Case 3 parameters were used since these are the best representative of "average" conditions based on the MVS (2015) report.

Table 4 WIPP Facility HBLs and Compliance Ratios at WIPP Site Boundary for VOCs in Waste Repository

VOC	WIPP Facility HBLs (µg/m^3)		Compliance Ratio[1] (Carcinogenic)	Compliance Ratio (Non-Carcinogenic)
	Carcinogenic	Non-Carcinogenic		
Carbon Tetrachloride	0.333	100	4.24E-02	1.41E-04
Chlorobenzene	N/A	50.0	N/A	5.83E-07
Chloroform	0.09	97.7	2.35E-03	2.16E-06
1,2-Dichloroethane	0.077	7	5.33E-04	5.85E-06
1,1-Dichloroethylene	N/A	200	N/A	7.18E-07
Methylene Chloride	101.2	600	3.66E-06	6.17E-07
1,1,2,2-Tetrachloroethane	0.035	N/A	1.31E-03	N/A
Toluene	N/A	5,000	N/A	2.21E-08
1,1,1-Trichloroethane	N/A	5,000	N/A	1.97E-06
Trichloroethylene	0.394	2	1.75E-03	3.44E-04
Total	**-**	**-**	**4.86E-02**	**5.10E-04**

Note:
1. N/A indicates that there is no regulatory limit for the VOC.

3.4.8 Summary of VOC Calculations

A series of five cases have been examined by varying input parameters for the flow calculations. These cases investigate the compliance ratio for CCl_4 and other VOCs at the compliance point for two scenarios: 1) nine panels are filled with waste and closed with the WPC-A, and 2) ten panels are filled with waste and Panel 10 is closed with the WPC-B. In addition, the analyzed cases look at the effect of changes in the ventilation rate due to the IVS system and changes in creep closure rates based on the updated convergence data. The updated flow model accounts for different geometries in the main entries for Panel 10, and takes into account variations in the air flow resistance of the steel bulkhead and ROM salt closure system.

The results indicate that the WIPP facility will be in compliance with the HBLs in Table 4 using steel bulkheads alone, and that the ROM salt component for Panel 10 does not contribute additional protection for public health and the environment until after the air gap above the ROM salt closes. The VOC model provides an upper bound to the chronic health effects to the public. This is because:

- The predicted airflow through each panel is maximized by ignoring the resistance to flow created by the presence of internal barriers, such as steel bulkheads, brattice cloth/chain link, and the presence of the waste containers and backfill
- The total VOC source term available for diffusion out of the containers is maximized

3.5 Material Compatibility Evaluation

The WPC-A consists of steel bulkheads in Panels 1 through 9. The WPC-B consists of steel bulkheads with ROM salt used for closing Panel 10. The steel bulkheads are subject to repository ventilation, but only trace amounts of brine would contact the steel bulkheads during the operational period because of the low moisture content of the halite, so they are not affected by this (although they may be deformed by salt creep closure). Additional steel from the closure bulkheads for individual panels will not affect repository modeling and analysis because the repository inventory already has large masses of iron-based alloys in the waste containers and in the waste itself. The steel bulkheads can be replaced or repaired if needed, as long as they are accessible. The ROM salt is obtained from, and is therefore entirely compatible with, the underground environment.

3.6 Bulkhead Performance during a Thermal Runaway due to Nitrate Salt-Bearing Waste

In accordance with an Administrative Order (NMED 2014) issued by the NMED, the Permittees were required to prepare a Nitrate Salt-Bearing Waste Isolation Plan (**Isolation Plan**), see DOE (2015), that addressed the initial and final closure of Panel 6 and the closure of Panel 7, Room 7. The Permittees evaluated the consequences of a single bounding event involving simultaneous thermal runaway reactions in three drums to determine if the WPC specifications are sufficient or if additional specifications are needed to deal with the heat and pressure from a thermal runaway event. The results of that evaluation are included in three calculation notes attached to the Isolation Plan. The calculations document that there will be no thermal impacts and the impacts of pressure changes will be insignificant on the steel bulkheads installed as a part of the WPC. Based on the calculations of thermal runaway due to nitrate salt-bearing waste, the WPC design requires that the distance between the waste container and the steel bulkhead is at least 22 feet.

4.0 TECHNICAL SPECIFICATIONS

The specifications are in the Engineering File Room at the WIPP facility. These specifications are included in Appendix A and are listed in Table 5.

Table 5 Technical Specifications for the WPC

Division 1 – General Requirements	
Section 01010	Summary of Work
Section 01090	Reference Standards
Section 01400	Contractor Quality Control
Section 01600	Material and Equipment
Division 2 – Site Work	
Section 02010	Mobilization and Demobilization
Section 02222	Excavation
Division 3 – WPC Components	
Section 03100	Run-of-Mine Salt
Section 03200	Steel Bulkheads

5.0 DRAWINGS

The Drawings (Appendix B) are in the Engineering File Room at the WIPP facility and are listed in Table 6.

Table 6 WPC Drawings

Drawing Number	Title
262-001	WIPP Panel Closure (WPC) Title Sheet
262-002	WPC Locations
262-003	Typical Panel Layout and Mined Entry Cross-Sections
262-004	WPC Details – Bulkhead and ROM Salt Locations
262-005	WPC Details – Bulkhead Front-View and Attachment Detail

6.0 CONCLUSIONS AND COMPLIANCE WITH DESIGN REQUIREMENTS

This chapter presents the conclusions for the design activities for the WPC and provides a summary table (see Table 7 below) that demonstrates compliance of the WPC designs with the design requirements. The design configuration and essential features for the WPC include steel bulkheads and ROM salt.

This report describes the design and evaluation of a WPC-A consisting of steel bulkheads for Panels 1 through 9 and WPC-B consisting of steel bulkheads and ROM salt for the closure of main entries north of Panel 10, and provides the technical specifications and drawings for construction. The purpose of the WPC during the operational period is to comply with the closure performance standard in Permit Attachment G, Section G-1a pursuant to 20.4.1.500 NMAC (incorporating 40 CFR 264 Subpart X).

This report is an update of the previous panel closure design documents prepared by DOE (1996) and RockSol (2012) to address current facility conditions including the following:

- A WPC using steel bulkheads for the closure of Panels 1 through 9, referred to as WPC-A
- A WPC using steel bulkheads and ROM salt for the closure of main entries north of Panel 10, referred to as WPC-B
- Calculations addressing structural (i.e., geomechanical) requirements and impacts to VOC emissions using current and expected ventilation parameters, an air-dispersion model, and geotechnical monitoring data

This report concludes that the WPC design complies with the design requirements established for the closure of WIPP facility waste disposal panels, and the design can be constructed in the underground environment at the WIPP facility with no special requirements. To investigate key aspects of the design and its implementation, design evaluations were performed. The conclusions reached from the evaluations are as follows:

- The calculated concentration of VOCs at the compliance point at the WIPP site boundary is well below HBLs when steel bulkheads only are used in the entries for Panels 1 through 9.
- For the WPC-B, an air gap forms between the excavation roof and the top of the ROM salt due to the settlement of the ROM salt. After closure of the air gap, the ROM salt consolidates to approximately 90% of the intact salt density approximately 24 to 42 years after installation. The air conductivity and airflow rates through the ROM salt are continuously reduced as the ROM salt consolidates. Structural calculations indicate that the minimum required length of ROM salt depends on the geometry of the entry, and is approximately 2.5 to 3 times the entry width.
- A VOC Flow Model accounts for VOC releases from the panels due to gas generation, panel-creep closure, and the effects of underground ventilation of the adjacent drifts. The airflow through steel bulkheads installed in Panels 1 through 9 is caused primarily by the pressure drop from ventilation in the adjacent entry. The same is true for Panel 10 while an air gap exists above the ROM salt. After the air gap closes, the VOC Flow Model

evaluates the subsequent reduction in air conductivity that occurs with the increase in salt density, and reduction in ROM salt porosity.

- The design components of the WPC are passive and will require minimal routine maintenance during the nominal operational life.

In addition to the design requirements presented above, the design includes a construction QA/QC program.

The predicted mass flow rates for CCl_4 and other VOCs through the WPC (including flow through the DRZ, the steel bulkheads, and the ROM salt in Panel 10) will result in concentrations that are at least a factor of 24 less than the HBLs established for members of the public residing beyond the WIPP site boundary. In spite of this substantial margin of compliance, the calculations should be re-evaluated if there are substantial changes in the model input parameters.

The design evaluations also concluded that the WPC provides flexibility over the remaining operational life in construction scheduling and construction material transportation and, therefore, minimizes the impact of WPC construction on operations. The existing shafts, ventilation, and underground access can accommodate the construction of the WPC.

While no specific requirements exist for closing disposal areas under MSHA regulations, the intent of the regulations is to safely isolate abandoned areas from active workings using barricades of substantial construction. Both the bulkheads and the ROM salt are considered substantial construction and meet the MSHA requirements.

Table 7 Compliance with Design Requirements

No.	Current Design Requirement	Expected Compliance with Requirement	Section in Report
1	The panel closure system shall contribute to meeting the HBLs in Permit Part 6 Section 6.10.1 by mitigating the migration of VOCs from closed panels	Complies	3.4
2	The panel closure system shall consider potential flow of VOCs through the DRZ in addition to flow through closure components.	Complies	Appendix D
3	The panel closure system shall perform its intended function under the conditions of a postulated thermal runaway involving nitrate salt-bearing waste	Complies	3.6
4	The panel closure system shall perform its intended functions under loads generated by creep closure of the tunnels	Complies	3.3
5	The nominal operational life of the closure system is 35 years	Complies	2.3.4, 3.3, 3.4
6	The panel closure system may require minimal maintenance per 20.4.1.500 NMAC (incorporating 40 CFR 264.111)	Complies	2.2.1
7	The panel closure system addresses the expected ground conditions in the waste disposal area	Complies	2.2, 3.2, 3.3.4, 3.4.1
8	The panel closure system shall be built of substantial construction and non-combustible material except for flexible flashing used to accommodate salt movement	Complies	Appendix A, Section 01400
9	The design and construction shall follow conventional mining practices	Complies	2.3
10	Structural analysis shall use data acquired from the WIPP underground	Complies	3.3, 3.4 3.2, 3.3.4, 3.4.1
11	Materials shall be compatible with their emplacement environment and function	Complies	3.5
12	Treatment of surfaces in the closure areas shall be considered in the design	Complies	2.1, Appendix A Section 02222
13	A QA/QC program shall verify material properties and construction	Complies	2.1, Appendix A Section 01400
14	The construction of the panel closure system shall consider shaft and underground access and services for materials handling	Complies	2.1, Appendix A Section 01010

7.0 CLOSING

This report was prepared for Nuclear Waste Partnership LLC under WP13-1 Nuclear Waste Partnership LLC Quality Assurance Program Description.

The work in this report was performed by Golder Associates, Inc. in accordance with generally accepted professional engineering principles and practices.

Sincerely,

GOLDER ASSOCIATES INC.

Gordan Gjerapic, PhD, PE
Senior Project Engineer

William Thompson, PhD
Principal, Project Manager

GG/TWT/dls

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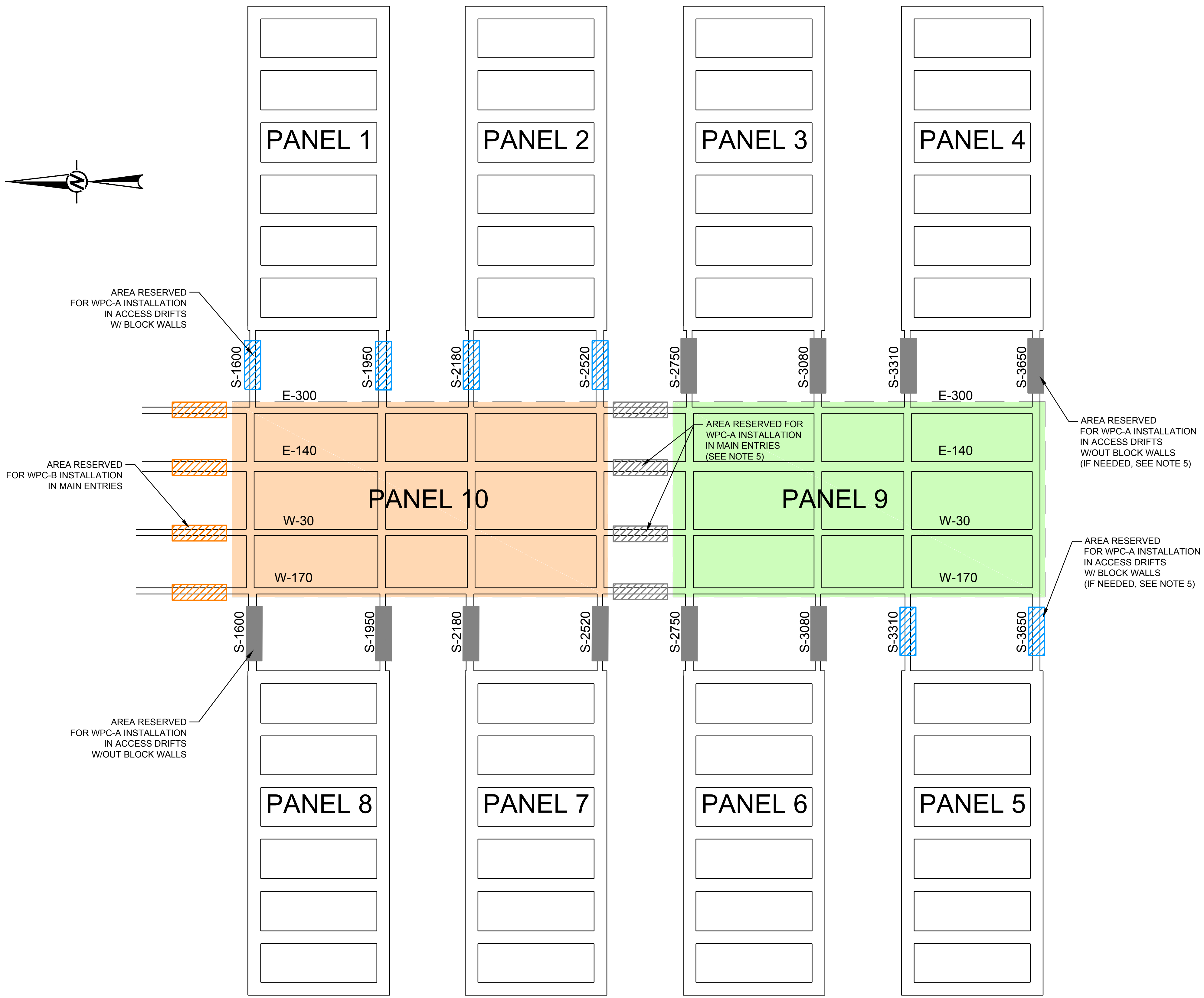
FIGURES



LEGEND

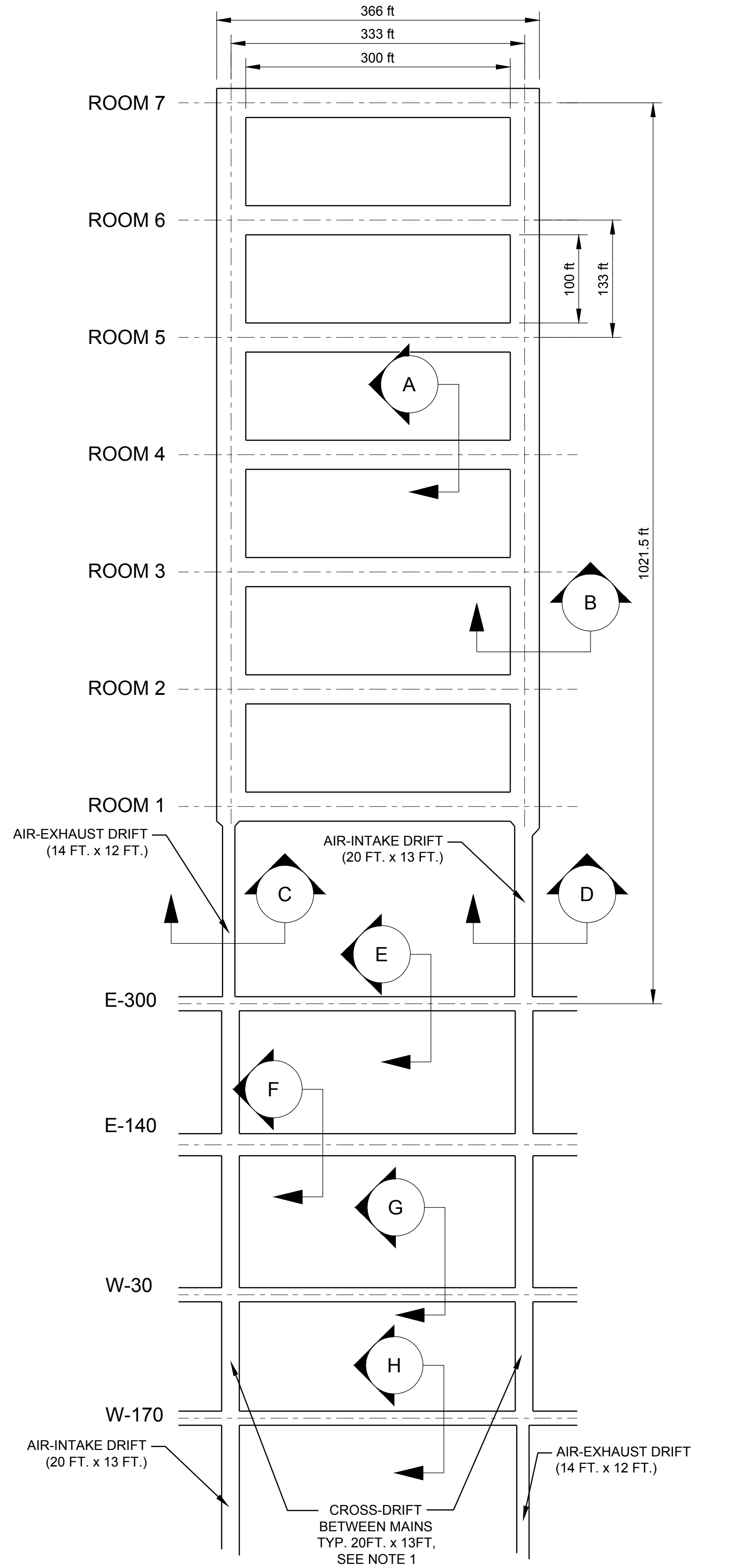
- APPROXIMATE EXTENTS OF PANEL 9
- APPROXIMATE EXTENTS OF PANEL 10
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN PANEL ACCESS DRIFTS W/ EXPLOSION-ISOLATION WALLS (NOTES 1, 2, 5)
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN MAIN ENTRIES (NOTES 1, 3, 5)
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN PANEL ACCESS DRIFTS W/OUT EXPLOSION-ISOLATION WALLS (NOTES 1, 2, 5)
- APPROXIMATE AREA RESERVED FOR WPC-B INSTALLATION IN MAIN ENTRIES (NOTES 1, 4)

NOTES

1. SHOWN WIPP PANEL CLOSURE (WPC) LOCATIONS ARE APPROXIMATE.
2. WPC-A IS INSTALLED IN AIR-INTAKE AND AIR-EXHAUST DRIFTS OF PANELS 1 TO 8. WPC-A IN ACCESS DRIFTS CONSISTS OF OUT-BYE BULKHEAD.
3. WPC-A IS INSTALLED IN MAIN ENTRIES BETWEEN S-2520 AND S-2750 FOR PANEL 9 CLOSURE. WPC-A IN MAIN ENTRIES CONSISTS OF OUT-BYE BULKHEAD.
4. WPC-B IS INSTALLED IN MAIN ENTRIES NORTH OF S-1600 FOR PANEL 10 CLOSURE. WPC-B IN MAIN ENTRIES CONSISTS OF ROM SALT BETWEEN IN-BYE AND OUT-BYE BULKHEADS.
5. PANELS 3, 4, 5 AND 6 MAY BE CLOSED BY INSTALLING WPC-A IN MAIN ENTRIES NORTH OF PANEL 9. I.E., WPC-A INSTALLED BETWEEN S-2520 AND S-2750 MAY BE USED TO CLOSE MULTIPLE PANELS SOUTH OF S-2750 AS AN ALTERNATIVE TO WPC-A INSTALLATION IN ACCESS DRIFTS.

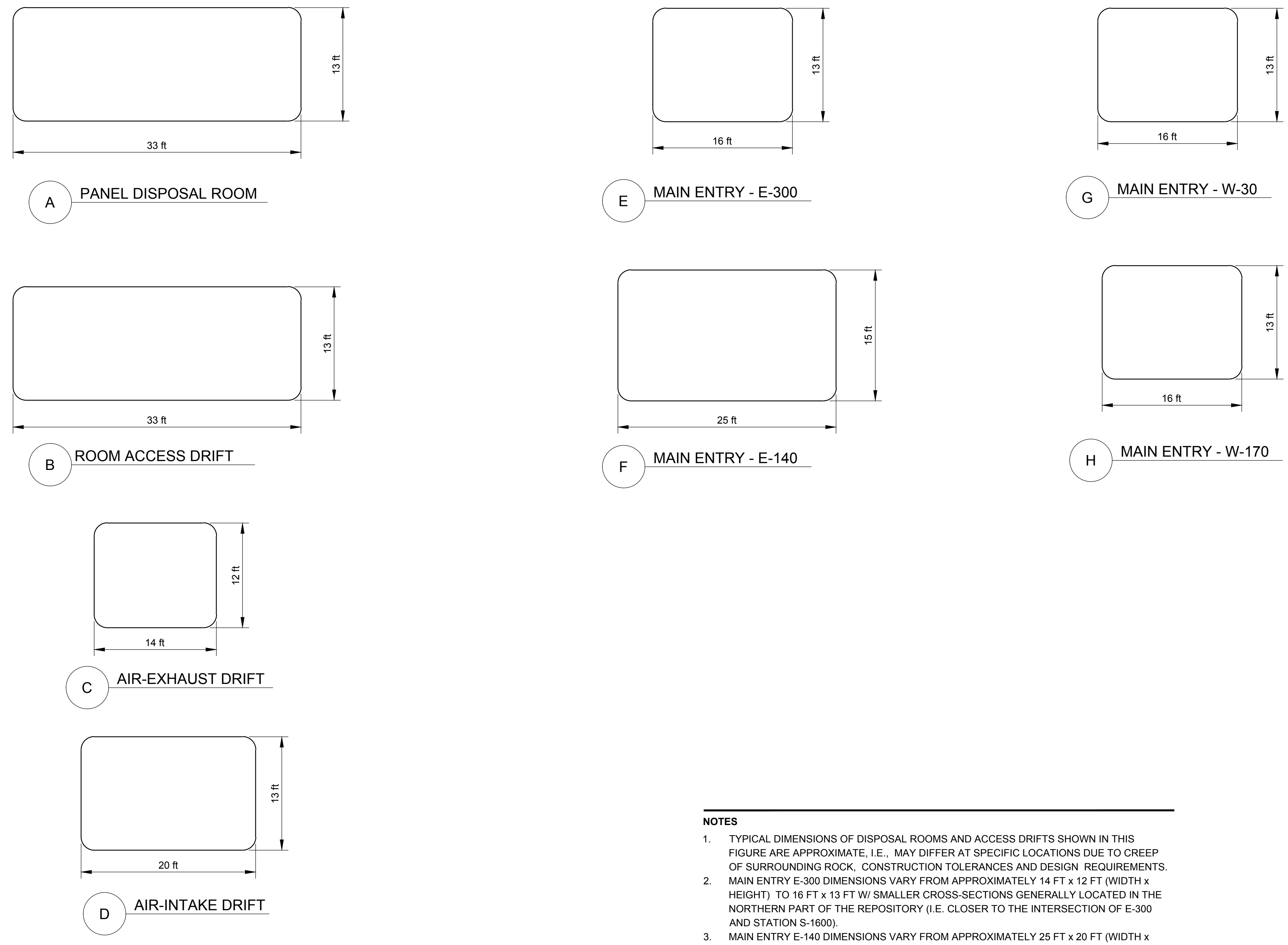
0 150 300 450
FEET

CLIENT NUCLEAR WASTE PARTNERSHIP LLC		PROJECT WIPP CLOSURE GEO-MECHANICAL COMPLIANCE	
CONSULTANT Golder Associates	YYYY-MM-DD: 2016-10-27 PREPARED: GG DESIGN: GG REVIEW: WTT APPROVED: WTT	TITLE **WIPP PANEL CLOSURE (WPC) LOCATIONS**	
		PROJECT No. 063-2213NEW	CONTROL / Rev. ---- / FIGURE 1



TYPICAL PANEL LAYOUT AND MINED ENTRY LOCATIONS - PLAN-VIEW

SCALE: AS SHOWN



NOTES

1. TYPICAL DIMENSIONS OF DISPOSAL ROOMS AND ACCESS DRIFTS SHOWN IN THIS FIGURE ARE APPROXIMATE, I.E., MAY DIFFER AT SPECIFIC LOCATIONS DUE TO CREEP OF SURROUNDING ROCK, CONSTRUCTION TOLERANCES AND DESIGN REQUIREMENTS.
2. MAIN ENTRY E-300 DIMENSIONS VARY FROM APPROXIMATELY 14 FT x 12 FT (WIDTH x HEIGHT) TO 16 FT x 13 FT W/ SMALLER CROSS-SECTIONS GENERALLY LOCATED IN THE NORTHERN PART OF THE REPOSITORY (I.E. CLOSER TO THE INTERSECTION OF E-300 AND STATION S-1600).
3. MAIN ENTRY E-140 DIMENSIONS VARY FROM APPROXIMATELY 25 FT x 20 FT (WIDTH x HEIGHT) TO 25 FT x 15 FT W/ SMALLER CROSS-SECTIONS GENERALLY LOCATED IN THE SOUTHERN PART OF THE REPOSITORY (I.E. CLOSER TO THE INTERSECTION OF E-140 AND S-3650).
4. MAIN ENTRY W-30 DIMENSIONS VARY FROM APPROXIMATELY 14 FT x 12 FT (WIDTH x HEIGHT) TO 21 FT x 13 FT W/ SMALLER CROSS-SECTIONS GENERALLY LOCATED IN THE NORTHERN PART OF THE REPOSITORY (I.E. CLOSER TO THE INTERSECTION OF W-30 AND S-1600).
5. MAIN ENTRY W-170 DIMENSIONS VARY FROM APPROXIMATELY 14 FT x 12 FT (WIDTH x HEIGHT) TO 30 FT x 13 FT W/ LARGER CROSS-SECTIONS LOCATED ADJACENT TO PANEL 6 (26 FT x 13 FT) AND PANEL 7 (30 FT x 13 FT).

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GEO-MECHANICAL COMPLIANCE

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TITLE
TYPICAL PANEL LAYOUT AND MINED ENTRY CROSS-SECTIONS

PROJECT No.	CONTROL	Rev.	FIGURE
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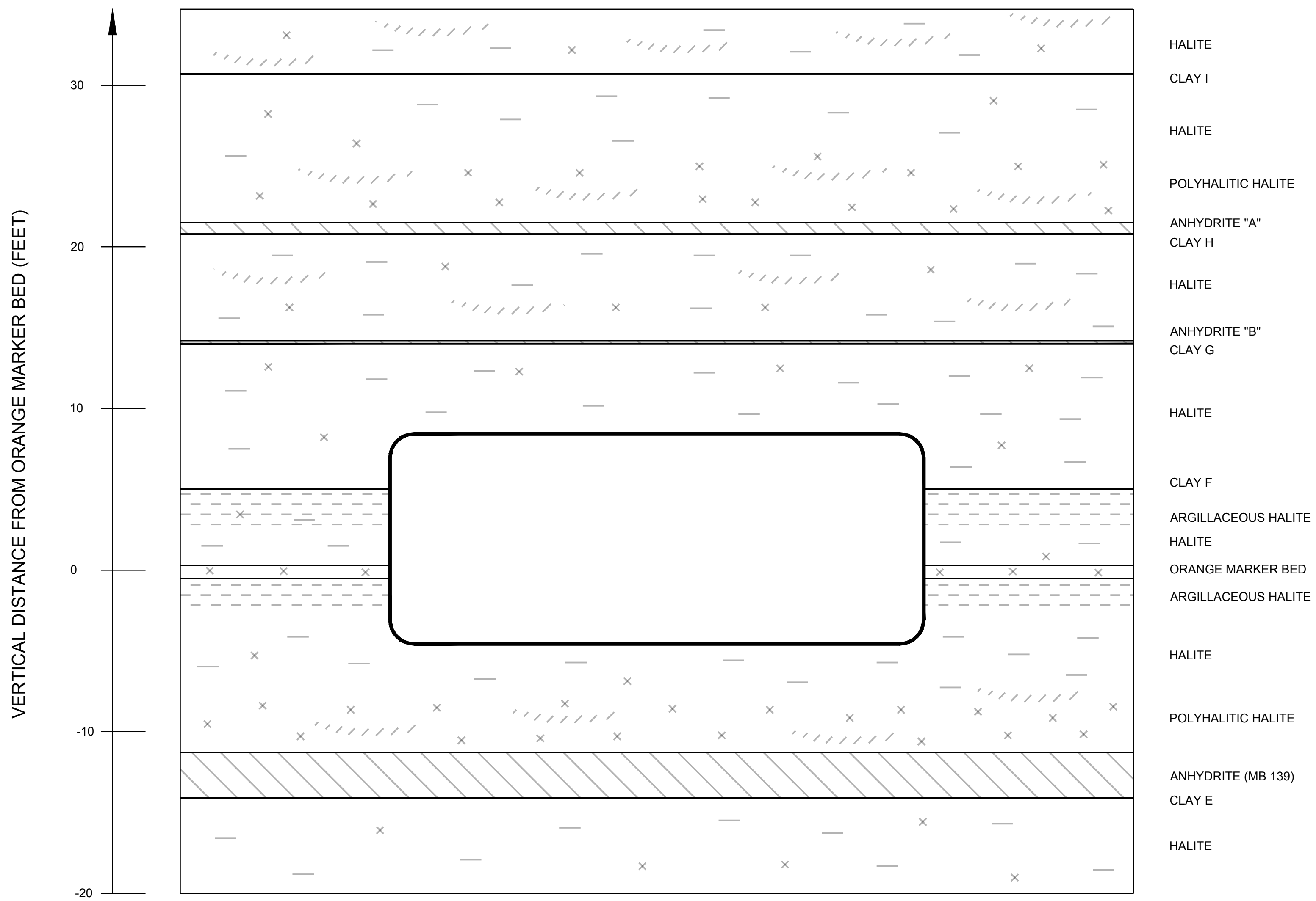

REPOSITORY LEVEL STRATIGRAPHY FOR PANELS 1, 2, 7, 8 AND 10

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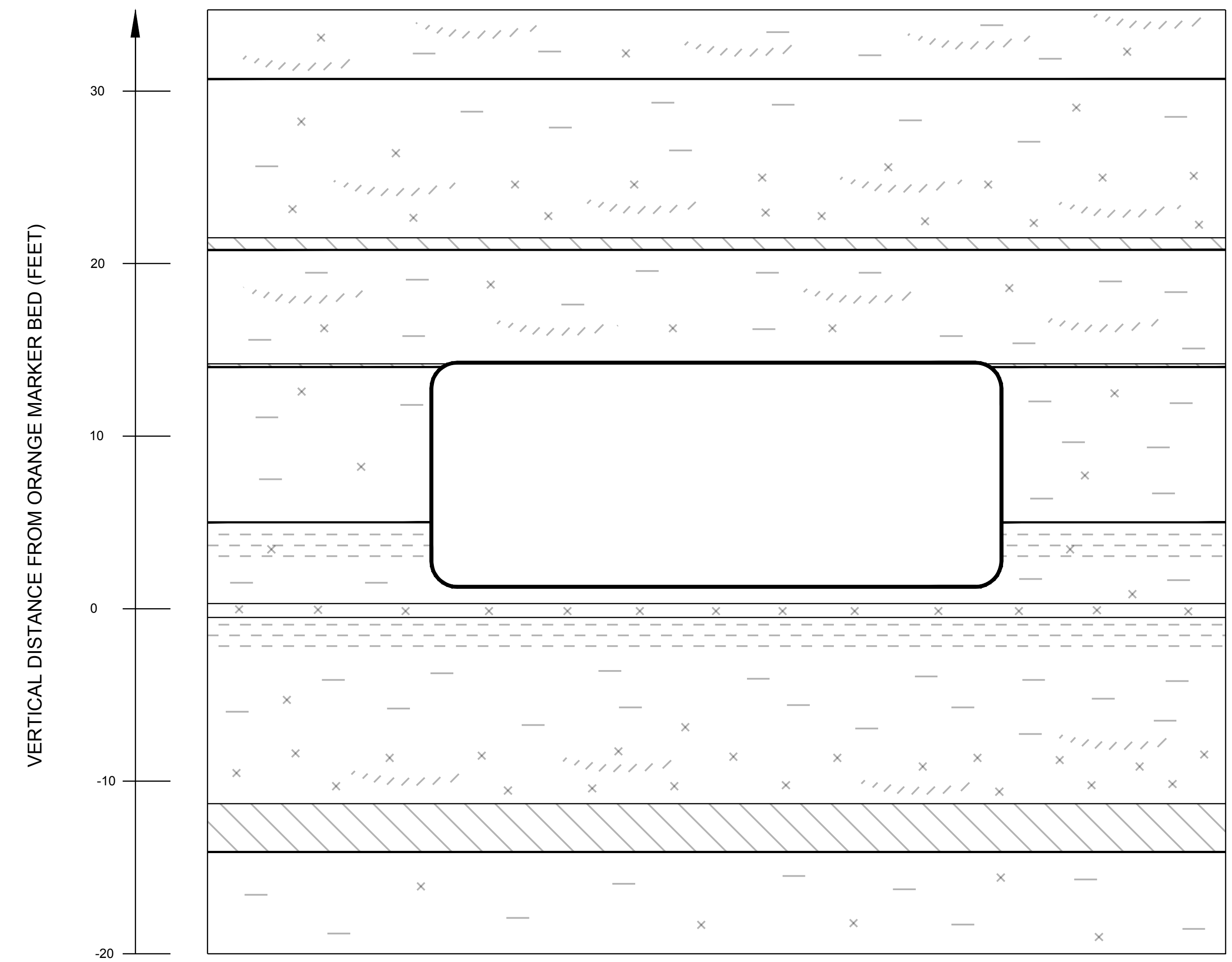

REPOSITORY LEVEL STRATIGRAPHY FOR PANELS 3, 4, 5, 6 AND 9

SCALE: NOT TO SCALE

LEGEND

- HALITE
- POLYHALITIC HALITE
- ARGILLACEOUS HALITE
- ANHYDRITE STRINGERS
- ANHYDRITE

REFERENCES

1. STRATIGRAPHY BASED ON DOE (2013) GEOTECHNICAL ANALYSIS REPORT.

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PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

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DESIGN	GG
REVIEW	WTT
APPROVED	WTT

TITLE
REPOSITORY LEVEL STRATIGRAPHY

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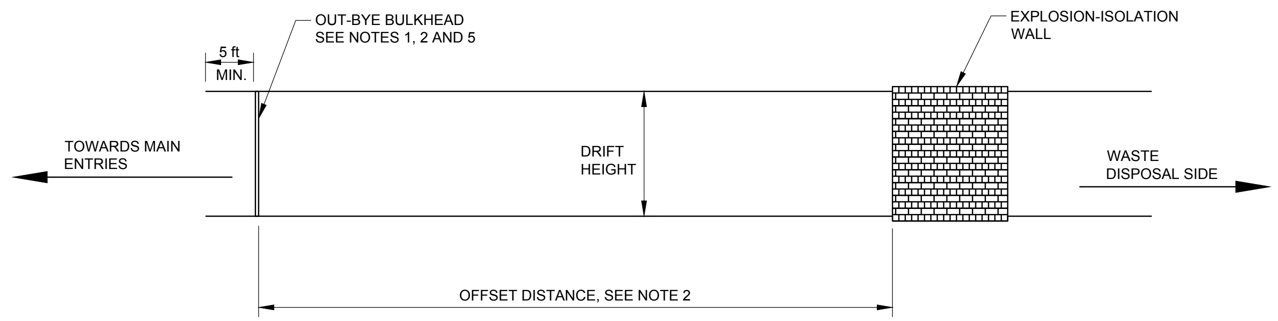
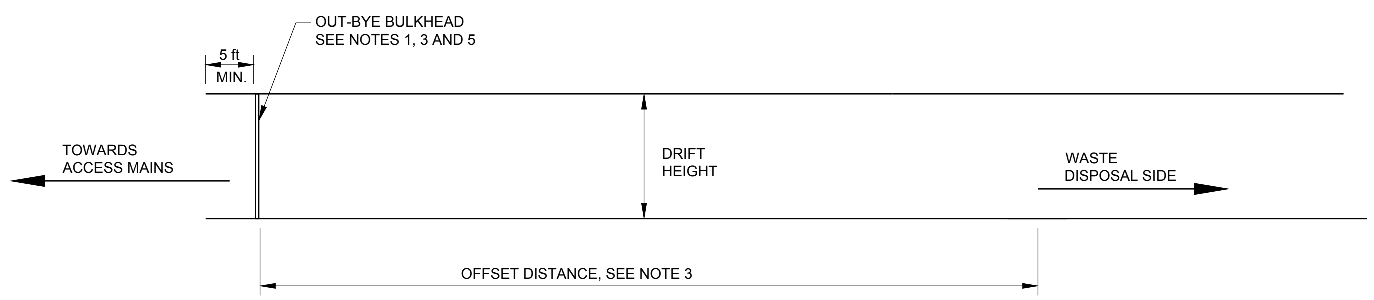


WPC-A FOR PANEL ACCESS DRIFTS WITH EXPLOSION-ISOLATION WALLS - PANELS 1, 2 AND 5

NOT TO SCALE



WPC-A FOR PANEL ACCESS DRIFTS W/OUT EXPLOSION-ISOLATION WALLS - PANELS 3, 4, 6, 7 AND 8

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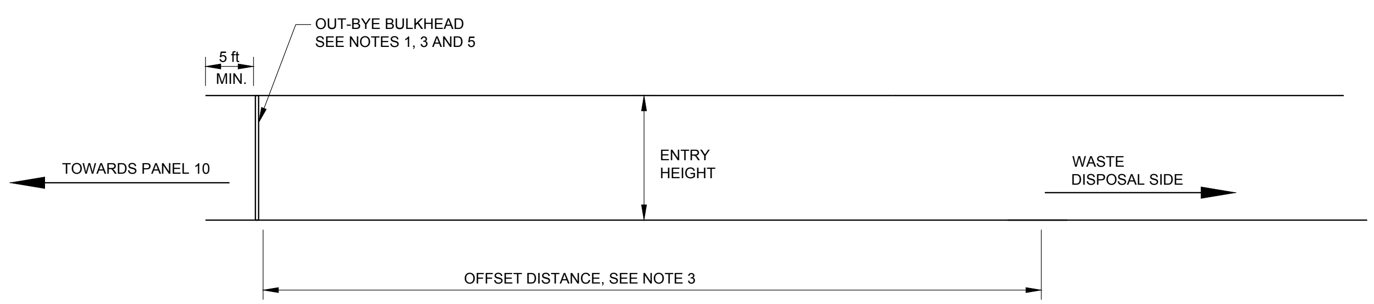


WPC-A FOR PANEL 9 - WASTE PLACEMENT SOUTH OF S2750

NOT TO SCALE

LEGEND

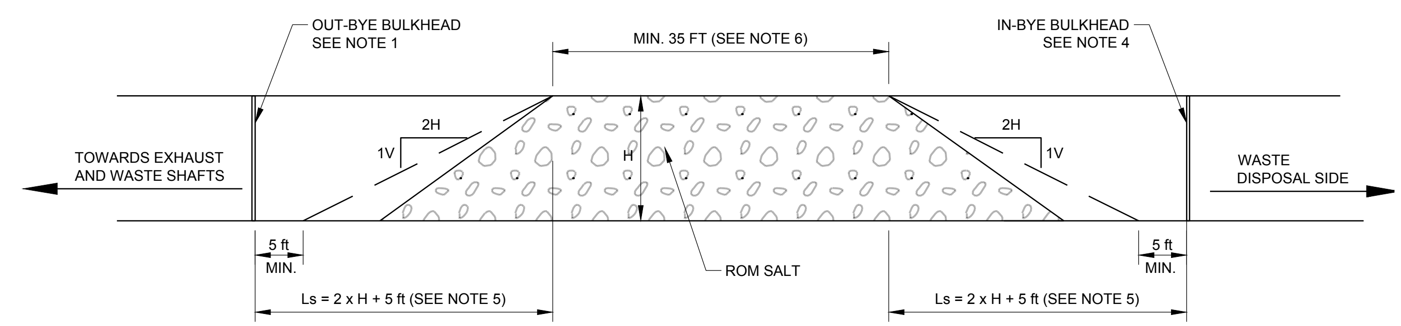
ROM SALT

NOTES

1. RECESS OUT-BYE BULKHEAD MIN. 5 FT FROM INTERSECTION WITH ANOTHER DRIFT OR MAIN ENTRY.
2. OFFSET OUT-BYE BULKHEAD FROM EXPLOSION-ISOLATION WALL. MINIMUM OFFSET DISTANCE IS 2.0 x ACCESS DRIFT HEIGHT.
3. FOR PANELS WITHOUT EXPLOSION-ISOLATION WALLS, OFFSET OUT-BYE BULKHEAD FROM WASTE CONTAINERS. MINIMUM OFFSET DISTANCE IS 22 FT.
4. INSTALL IN-BYE BULKHEAD AT LEAST 22 FT FROM THE NEAREST WASTE CONTAINER.
5. WPC-B BULKHEADS SHOULD BE PLACED AT LEAST 5 FT FROM THE TOE OF ROM SALT (IF APPLICABLE) ASSUMING ROM SALT END SLOPES OF 2H:1V.
6. MINIMUM LENGTH OF WPC-B ROM SALT IS A FUNCTION OF THE MAIN ENTRY WIDTH AS FOLLOWS:

MINIMUM ROM SALT LENGTH - EXLUDING END SLOPES

ENTRY WIDTH (ft)	MIN. ROM SALT LENGTH (ft)
14	35
16	40
20	50
25	65



WPC-B FOR PANEL 10 - WASTE PLACEMENT SOUTH OF S1600

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GEO-MECHANICAL COMPLIANCE

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TITLE
WPC DETAILS
BULKHEAD AND ROM SALT LOCATIONS

PROJECT No.	CONTROL	Rev.	FIGURE
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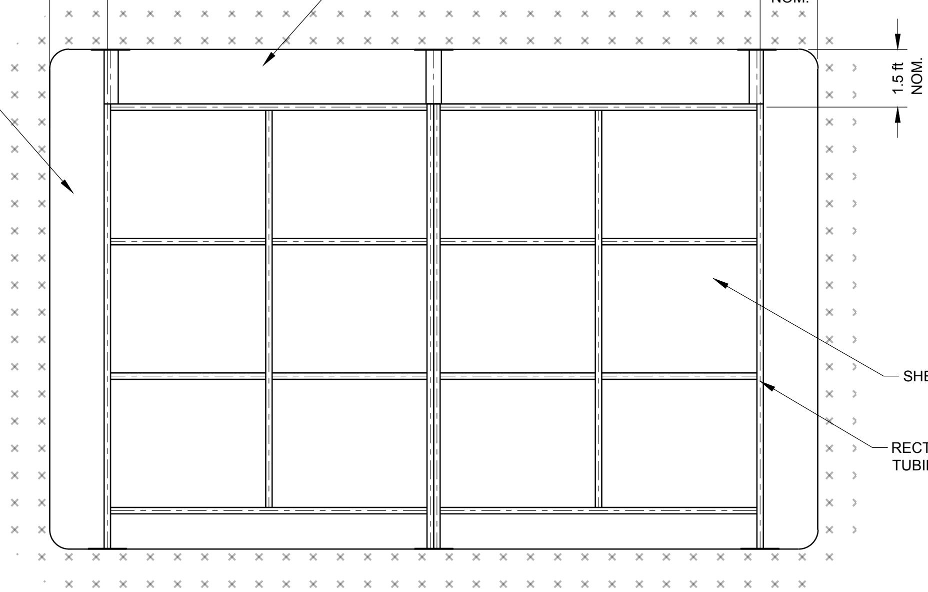
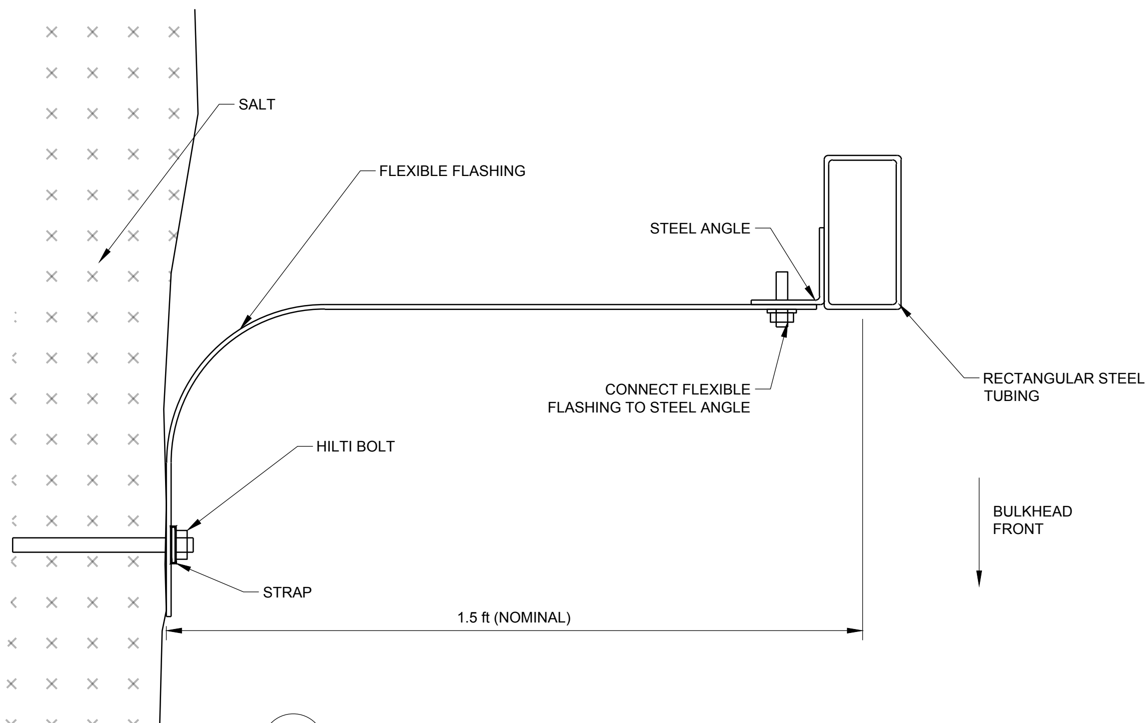


TYPICAL STEEL BULKHEAD FRONT-VIEW

SCALE: NOT TO SCALE (NTS)



1 FLEXIBLE FLASHING ATTACHMENT

SCALE: NTS

CLIENT NUCLEAR WASTE PARTNERSHIP LLC		PROJECT WIPP CLOSURE GEO-MECHANICAL COMPLIANCE	
CONSULTANT	YYYY-MM-DD: 2016-07-18	TITLE **WPC DETAILS** *BULKHEAD FRONT–VIEW AND ATTACHMENT DETAIL*	
Golder Associates	PREPARED: GG		
	DESIGN: GG		
	REVIEW: WTT	PROJECT No.: 063-2213NEW	CONTROL:
	APPROVED: WTT	Rev.: ----	FIGURE: 5

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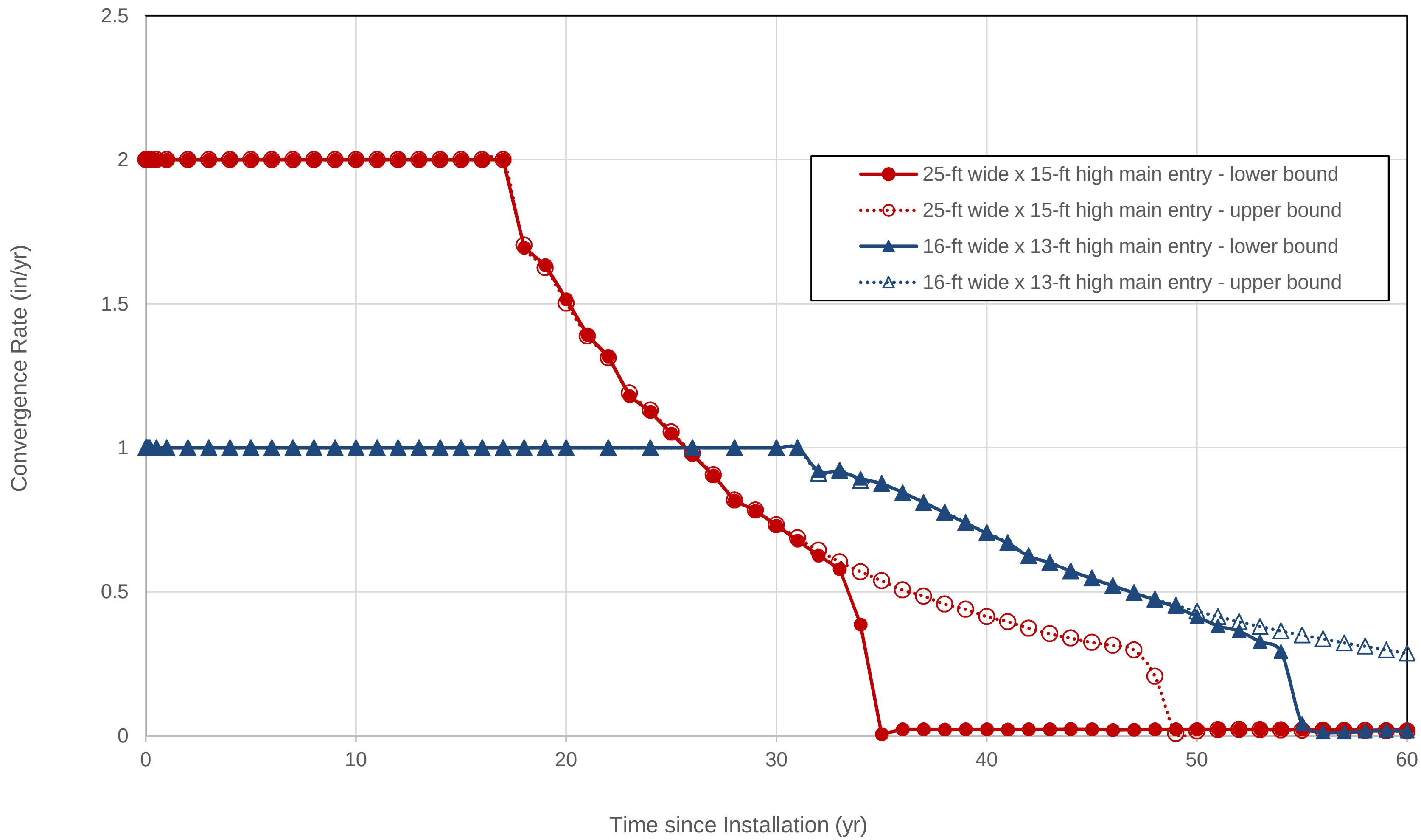

Figure 6

Calculated Vertical Convergence Rates after ROM Salt Emplacement

Nuclear Waste Partnership LLC

WIPP Closure - Geomechanical Compliance

Golder Associates

Denver, Colorado, USA

063-2213NEW

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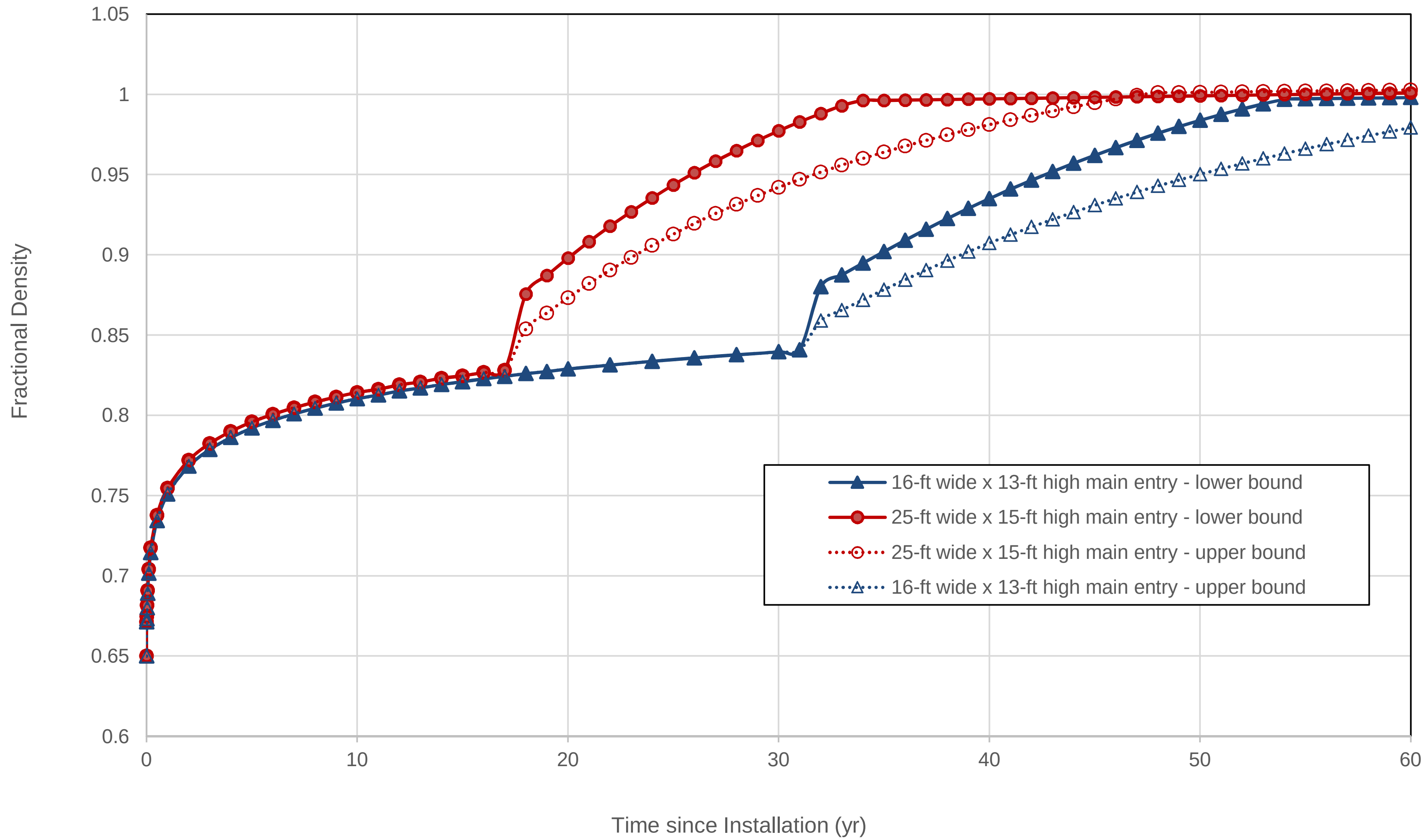

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Figure 7

Fractional Density of ROM Salt vs. Time

Nuclear Waste Partnership LLC

WIPP Closure - Geomechanical Compliance

Golder Associates

Denver, Colorado, USA

8/22/2016

063-2213NEW

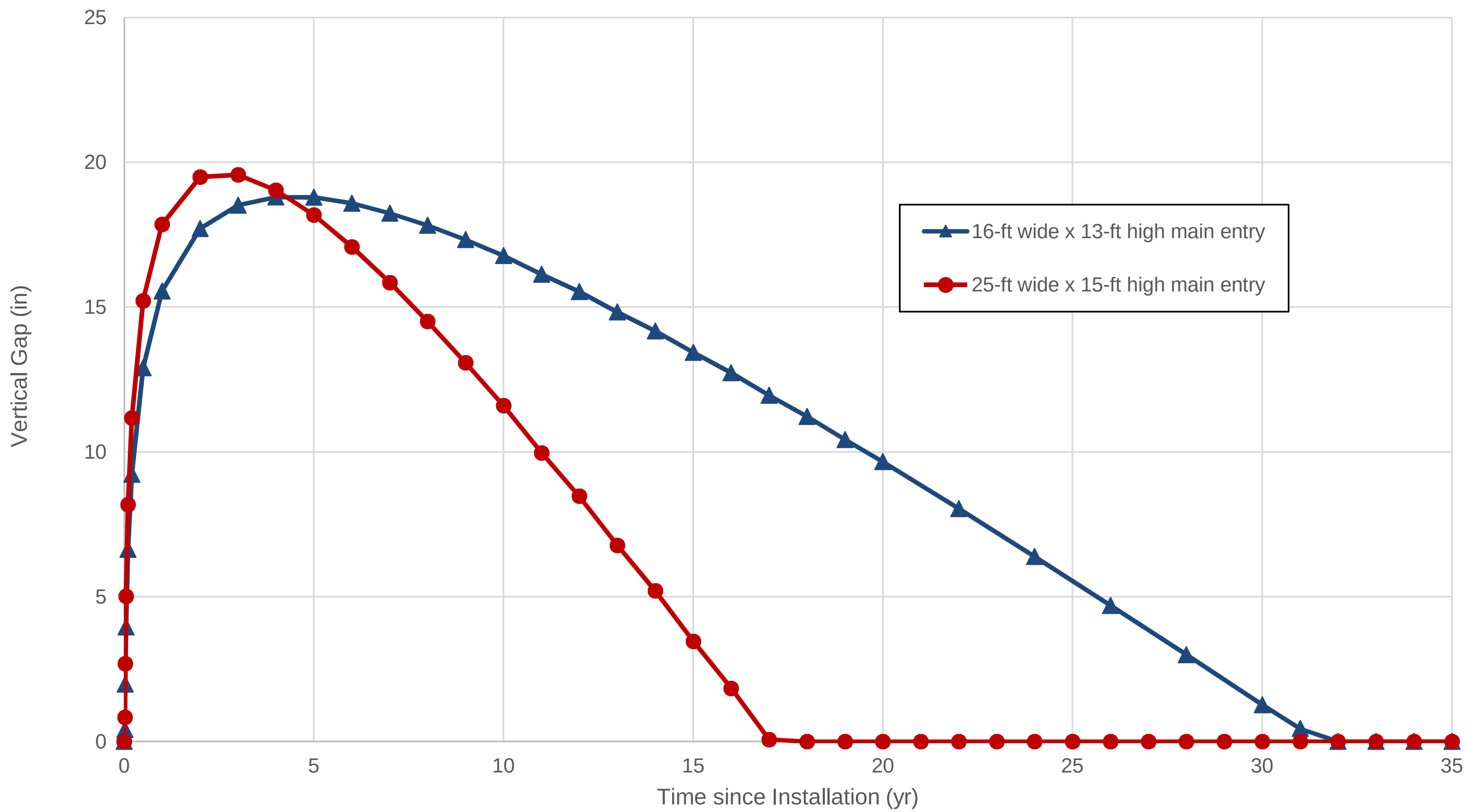

Figure 8

Air Gap Magnitude vs. Time

Nuclear Waste Partnership LLC

WIPP Closure - Geomechanical Compliance

Golder Associates

Denver, Colorado, USA

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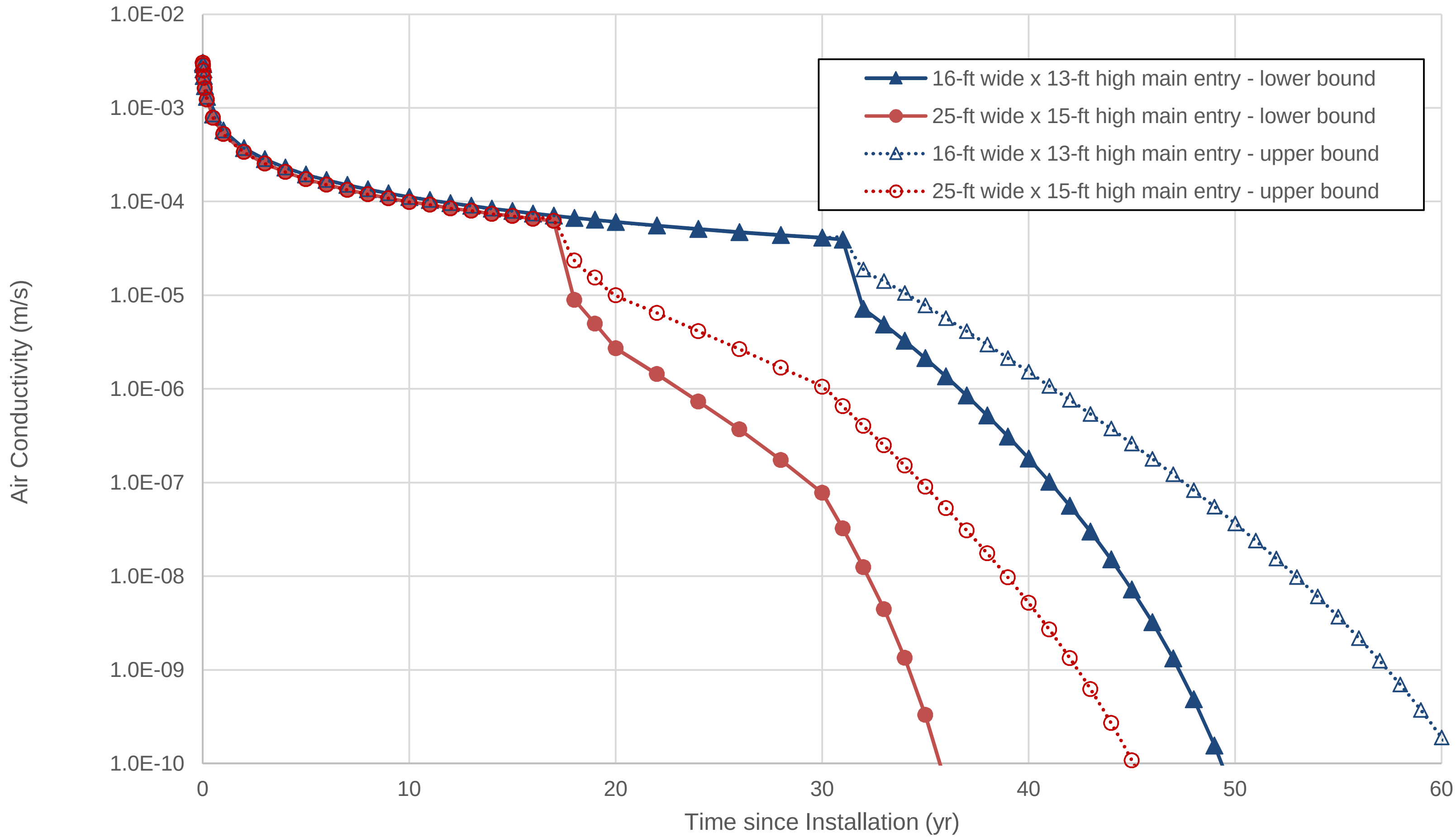

Figure 9

Air Conductivity of ROM Salt vs. Time

Nuclear Waste Partnership LLC

WIPP Closure - Geomechanical Compliance

Golder Associates

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Denver, Colorado, USA

8/22/2016

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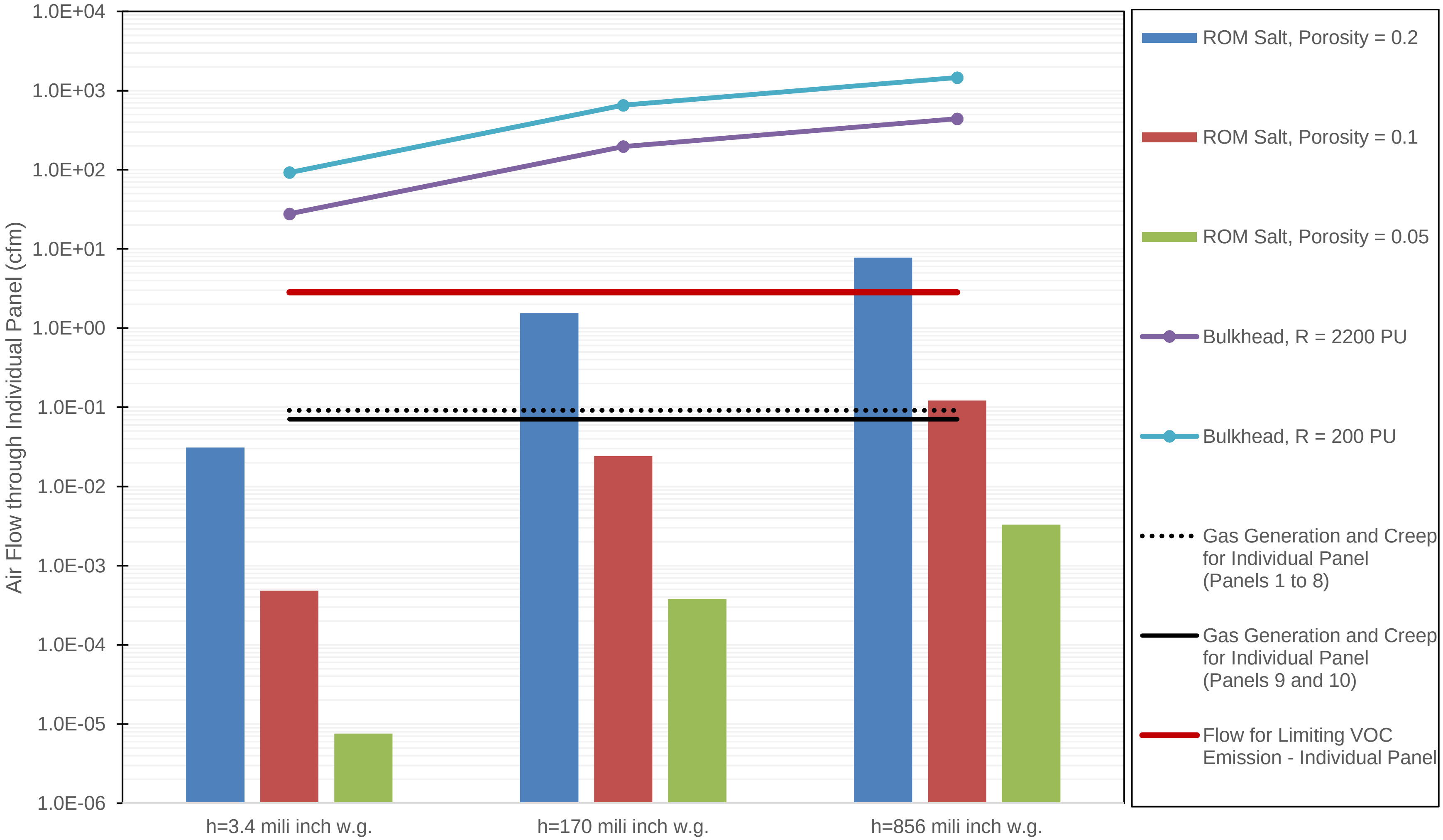


Figure 10

Estimated Air Flow through WPC Components

Nuclear Waste Partnership LLC

WIPP Closure - Geomechanical Compliance

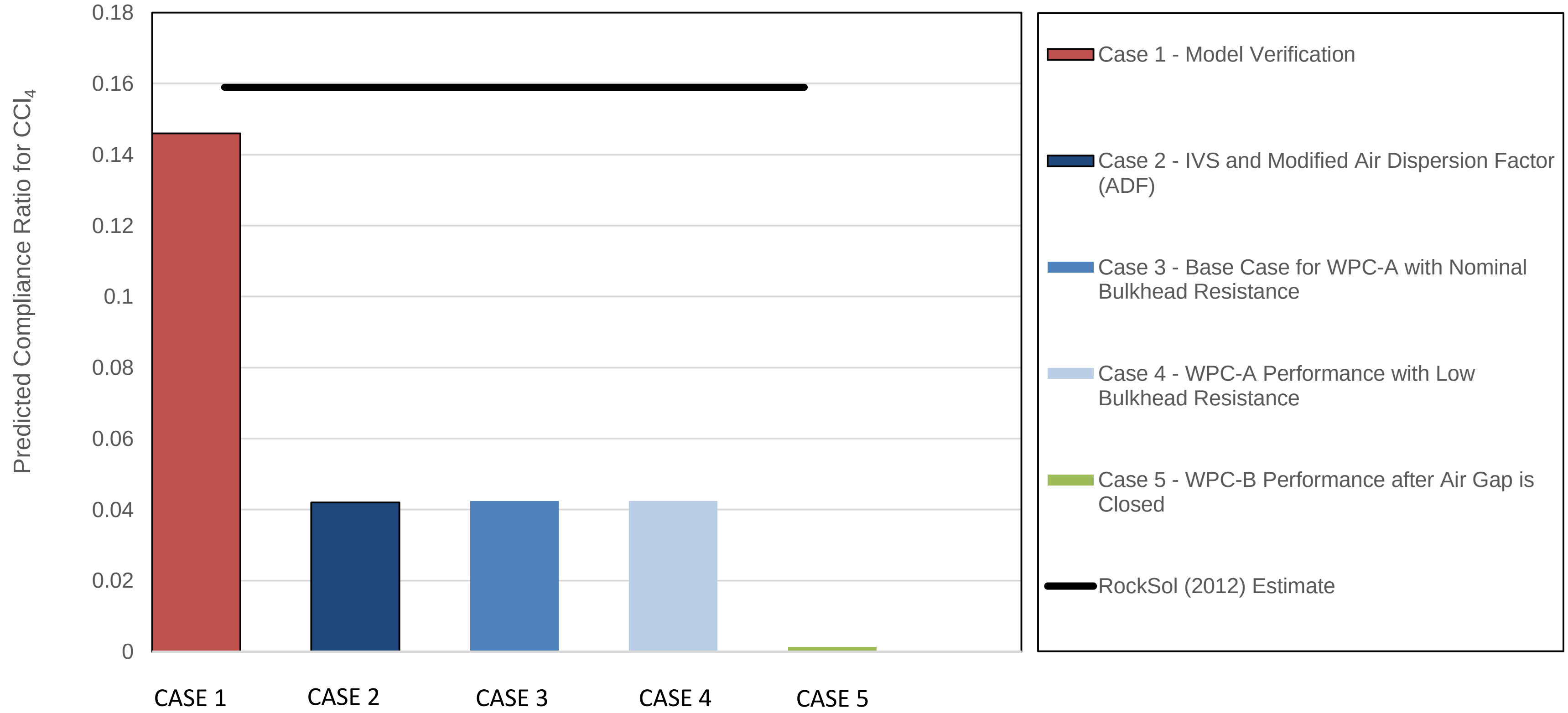
Golder Associates

Denver, Colorado, USA

063-2213NEW

8/22/2016

F:\YEAR2016\063-2213-WIPP\DESIGN-REPORT-rev5\FIGURES\Fig6-



Notes:

1) Compliance ratio of 0.159 (RockSol, 2012) was determined for ten panels. The equivalent compliance ratio for nine panels is 0.143, displaying favorable agreement with the value for Case 1 of current analysis, which is 0.146.
2) Cases 1 to 4 have nine waste-filled panels. Case 5 has ten waste-filled panels.

Figure 11

Compliance Ratio for CCl_4 at WIPP Site Boundary

Nuclear Waste Partnership LLC

WIPP Closure - Geomechanical Compliance

Golder Associates

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APPENDIX A
TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

WIPP Panel Closure (WPC)

Waste Isolation Pilot Plant (WIPP) Closure Project
Carlsbad, New Mexico

Submitted To: Waste Isolation Pilot Plant
Engineering File Room
Attention: Rey Carrasco
Nuclear Waste Partnership LLC
PO Box 2078, MS 486-02
Carlsbad, New Mexico 88220

Submitted By: Golder Associates Inc.
44 Union Boulevard, Suite 300
Lakewood, Colorado 80228

DOE13-PO415183

October 28, 2016 **0632213 SPEC RevC**

Waste Isolation Pilot Plant (WIPP)
Technical Specifications

Revision History

Section	Section	Status/ Issue Date	Rev.[1,2]
Division 1	General Requirements		
01010	Summary of Work	10/28/2016	C, Ver. 1
01090	Reference Standards	8/26/2016	C, Ver. 0
01400	Contractor Quality Control	8/26/2016	C, Ver. 0
01600	Material and Equipment	8/26/2016	C, Ver. 0
Division 2	Site Work		
02010	Mobilization and Demobilization	8/26/2016	C, Ver. 0
02222	Excavation	8/26/2016	C, Ver. 0
Division 3	WPC Components		
03100	Run-of-Mine Salt	8/26/2016	C, Ver. 0
03200	Steel Bulkheads	8/26/2016	C, Ver. 0

Notes:
1. Revision A of Technical Specifications is included in DOE (1996)
2. Revision B of Technical Specifications is included in RockSol (2012)

Table of Contents

List of Tables

DIVISION 1
GENERAL REQUIREMENTS

SECTION 01010
SUMMARY OF WORK

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Scope of Work
B. Definitions and Abbreviations
C. List of Drawings
D. Work by Others
E. Contractors Use of Site
F. Contractors Use of Facilities
G. Work Sequence
H. Work Plan
I. Health and Safety Plan (**HASP**)
J. Contractor Quality Control Plan (**CQCP**)
K. Submittals

1.2 Scope of Work

The Contractor shall furnish all labor, materials, equipment, and tools to construct WIPP panel closure (WPC), including the WPC-A for Panels 1 through 9, and the WPC-B to the north of Panel 10. Each WPC-A in each of Panels 1-9 consists of a single steel bulkhead while the WPC-B north of Panel 10 will include dual bulkheads with ROM salt installed between. Details are as follows:

A. Install WPC-A in the air-intake and the air-exhaust drifts of Panel 1, 2 and 5 with the explosion-isolation walls (block walls), as shown on the Drawings and described in these Specifications. The WPC-A consists of an out-bye steel bulkhead. Alternatively, install WPC-A in the main entries and cross-drifts in order to close multiple panels simultaneously based on the direction of the geotechnical engineer.

B. Install WPC-A in the air-intake and the air-exhaust drifts of Panel 3, 4, 6, 7, and 8 without the explosion-isolation walls (block walls), as shown on the Drawings and described in these Specifications. The WPC-A consists of an out-bye steel bulkhead. Alternatively, install WPC-A in access mains and cross-drifts in order to close multiple panels simultaneously based on the direction of the geotechnical engineer.

C. Install WPC-A in the main entries between Panels 9 and 10, as shown on the Drawings and described in these Specifications. The WPC-A consists of an out-bye steel bulkhead.

D. Install WPC-B in the main entries north of Panel 10, as shown on the Drawings and described in these Specifications. The WPC-B consists of an in-bye and an out-bye steel bulkhead with ROM salt installed between.

Unless otherwise agreed by Nuclear Waste Partnership LLC (**NWP**), the Contractor shall use NWP supplied equipment underground. Such use shall be coordinated with NWP and may include the use of NWP qualified operators.

The scope of work shall include but not necessarily be limited to the following units of work:

A. Develop work plan, health and safety plan (HASP) and contractor quality control plan (CQCP) and submit for approval

B. Prepare and submit any other plans requiring approval

C. Mobilize to site

D. Coordinate construction with WIPP operations

E. Perform the following operations for the air-intake drift and the air-exhaust drift that do not contain block walls (Panels 3, 4, 6, 7 and 8):

   1. Prepare the surfaces for the out-bye steel bulkhead placement
   2. Construct the out-bye steel bulkhead
   3. Clean up construction areas in underground and above ground
   4. Submit required record documents
   5. Demobilize from site

F. Perform the following operations for the air-intake drift and the air-exhaust drift with block walls (Panels 1, 2 and 5):

   1. Prepare the surfaces for the out-bye steel bulkhead placement
   2. Construct the out-bye steel bulkhead
   3. Clean up construction areas in underground and above ground
   4. Submit required record documents
   5. Demobilize from site

G. Perform the following operations for the main entries between Panels 9 and 10:

   1. Prepare the surfaces for the out-bye steel bulkhead placement
   2. Construct the out-bye steel bulkhead
   3. Clean up construction areas in underground and above ground
   4. Submit required record documents
   5. Demobilize from site

H. Perform the following operations for the main entries north of Panel 10:

   1. Prepare the surfaces for the in-bye steel bulkhead placement
   2. Construct the in-bye steel bulkhead
   3. Prepare the surfaces for the ROM salt placement
   4. Place ROM salt material in multiple layers
   5. Prepare surfaces for the out-bye steel bulkhead placement
   6. Construct the out-bye steel bulkhead

7. Clean up construction areas in underground and above ground
8. Submit required record documents
9. Demobilize from site

1.3 Definitions and Abbreviations

A. Definitions

1. Block wall – Existing mortared concrete block wall adjacent to the panel waste disposal area as shown in the Drawings; also known as explosion-isolation wall
2. Creep – Viscoplastic deformation of salt under deviatoric stress
3. Partial closure – The process of rendering a part of the hazardous waste management unit in the underground repository inactive and closed according to approved facility closure plans
4. Run-of-mine salt (ROM) – A salt backfill obtained from mining operations and emplaced in an uncompacted state
5. Volatile organic compound (**VOC**) – Any VOC with Hazardous Waste Facility Permit emission limits
6. Nuclear Waste Partnership LLC (NWP) – the construction management authority

B. Abbreviations/Acronyms

1.	ACI	American Concrete Institute
2.	ANSI	American National Standards Institute
3.	ASTM	American Society for Testing and Materials
4.	CFR	Code of Federal Regulations
5.	CQCP	Contractor Quality Control Plan
6.	DOE	U.S. Department of Energy
7.	DWG	drawing
8.	EPA	U.S. Environmental Protection Agency
9.	HASP	Health and Safety Plan
10.	JHA	Job Hazard Analysis
11.	LHD	load haul dump
12.	LLC	Limited Liability Corporation
13.	MSHA	U.S. Mine Safety and Health Administration
14.	NWP	Nuclear Waste Partnership LLC
15.	USACE	U.S. Army Corps of Engineers
16.	VOC	volatile organic compound
17.	WIPP	Waste Isolation Pilot Plant
18.	WPC	WIPP Panel Closure

1.4 List of Drawings

The following drawings were prepared as a part of the WPC design report (Drawings):

A. DWG 262-001 WIPP Panel Closure (WPC) Title Sheet

B. DWG 262-002 WPC Locations

C. DWG 262-003 Typical Panel Layout and Mined Entry Cross-Sections

D. DWG 262-004 WPC Details – Bulkhead and ROM Salt Locations

E. DWG 262-005 WPC Details – Bulkhead Front-View and Attachment Detail

1.5 Work by Others

A. Survey

All survey work to locate, control, confirm, and complete the work will be performed by NWP. All survey work for record purposes will be performed by NWP. NWP may elect to perform certain portions or all of the work. The work performed by the NWP will be defined prior to the contract. Unless otherwise agreed by NWP, the Contractor shall use underground equipment furnished by NWP for construction of the steel bulkheads and placement of ROM salt. Underground mining personnel who are qualified for the operation of such underground construction equipment may be made available to the Contractor. The use of NWP equipment shall be coordinated with NWP.

1.6 Contractor's Use of Site

A. Site Conditions

The WIPP site is located near Carlsbad in southeastern New Mexico, as shown on the Drawings. The underground arrangements and location of the WIPP waste disposal panels are shown on the Drawings. The work is to construct steel bulkheads in the air-intake drifts, air-exhaust drifts, and main access drifts between Panels 9 and 10 after cessation of the disposal phase in the specific panel. The work may include installation of steel bulkheads at alternative locations. Alternative locations will be specified by the NWP geotechnical engineer prior to installation activities. Dual bulkheads will be emplaced in the main entries north of Panel 10 after cessation of all disposal activities, and ROM salt placed between these bulkheads at a length to be specified by NWP. The waste disposal panels are located approximately 2,150 feet (655 meters) below the ground surface. The Contractor shall visit the site, and become familiar with the site and site conditions, prior to preparing a bid proposal.

B. Contractor's Use of Site

Areas at the ground surface will be designated for the Contractor's use in assembling and storing his equipment and materials. The Contractor shall utilize only those areas so designated.

Limited space within the underground area will be designated for the Contractor's use for storage of material and setup of equipment.

1.7 Contractor's Use of Facilities

Existing facilities at the site available for use by the Contractor are:

A. Waste shaft conveyance
B. Salt skip hoist
C. 460 volt AC, 3 phase power
D. Water (underground, at waste shaft only) (above ground, at a location designated by NWP)

Additional information on mobilization and demobilization to these facilities is presented in Section 02010.

1.8 Work Sequence

Work Sequence shall be as shown on the Drawings and as directed by NWP. NWP will designate the order in which panels are to be closed.

1.9 Work Plans

The Contractor shall prepare Work Plans fully describing the proposed fabrication, installation, and construction for each WIPP Panel Closure. The work plan shall define proposed materials, equipment and construction methods. The Work Plan shall state supporting processes, procedures, materials safety data sheets, and regulations by reference. The work plans shall address precautions related to the Job Hazards Check List. The Work Plan shall address limitations such as hold and witness points. The Work Plans shall address prerequisites for work. NWP shall approve the Work Plan and no work shall be performed prior to approval of the Work Plan.

1.10 Health and Safety Plan (HASP)

The Contractor shall obtain, review, and agree to applicable portions of the existing WIPP Safety Manual, WP 12-1. The Contractor shall prepare a project-specific HASP taking into account applicable sections of the WIPP Safety Manual. Personnel performing work shall be qualified to work underground. Personnel operating heavy construction equipment shall be qualified to operate such equipment. The Contractor shall also perform a Job Hazard Analysis (JHA) in accordance with WP 12-111. NWP shall approve the HASP and JHA and no work shall be performed prior to approval of the HASP and JHA.

1.11 Contractor Quality Control Plan (CQCP)

The Contractor shall prepare a CQCP identifying all personnel and procedures necessary to produce an end product that complies with the contract requirements. The CQCP shall comply with applicable NWP requirements, including operator training and qualification; and Section 01400, Contractor Quality Control, of this Specification. NWP shall approve the CQCP and no work shall be performed prior to approval of the CQCP.

1.12 Submittals

Submittals shall be in accordance with NWP Submittal Procedures and as required by the individual Specifications.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

Not used.

END OF SECTION

SECTION 01090
REFERENCE STANDARDS

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Provision of Reference Standards at Site

B. Acronyms used in Contract Documents for Reference Standards

1.2 Quality Assurance

For products or workmanship specified by association, trade, or Federal Standards, the Contractor shall comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

Conform to reference by date of issue current on the date of the owner-contractor agreement.

The Contractor shall obtain, at his own expense, a copy of the standards referenced in the individual Specification sections and shall maintain that copy at the job site until completion and acceptance of the work.

Should specified Reference Standards conflict with the contract documents, the Contractor shall request clarification from NWP before proceeding.

1.3 Schedule of References

Various publications referenced in other sections of the Specifications establish requirements for the work. These references are identified by document number and title. The addresses of the organizations responsible for these publications are listed below.

A. **ANSI** – American National Standards Institute
25 West 43rd Street
New York, New York 10036
Ph: 212-642-4900
Fax: 212-398-0023

B. **ASTM** – ASTM International
100 Barr Harbor Drive
P.O. Box C700
West Conshohocken, Pennsylvania 19428-2959
Ph: 610-832-9585
Fax: 610-832-9555

C. **CFR** – Code of Federal Regulations
Government Printing Office
732 North Capital Street, NW
Washington, District of Columbia 20401-0001
Ph: 202-512-1800
Fax: 202 512-2104

D. **EPA** – Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733
Ph: 214-665-2200

E. **FTM-STD** – Federal Test Method Standards
Standardization Documents Order Desk, Building 4D
700 Robbins Avenue
Philadelphia, Pennsylvania 19111-5094
Ph: 215-697-2179
Fax: 215-697-2978

F. **NIST** – National Institute of Standards and Technology
100 Bureau Drive, Stop 1000
Gaithersburg, Maryland 20899-1000
Ph: 301-975-6478
Fax: 301-975-8295

G. **NTIS** – National Technical Information Service
U.S. Department of Commerce
5301 Shawnee Road
Alexandria, Virginia 22312
Ph: 703-605-6000
Fax: 703-605-6900

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

Not used.

END OF SECTION

SECTION 01400
CONTRACTOR QUALITY CONTROL

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Contractor Quality Control Plan (**CQCP**)
B. Reference Standards
C. Quality Assurance
D. Tolerances
E. Testing Services
F. Inspection Services
G. Submittals

1.2 Related Sections

A. 01090 – Reference Standards
B. 01600 – Material and Equipment
C. 02222 – Excavation
D. 04100 – Run-of-Mine Salt

1.3 Contractor Quality Control Plan (CQCP)

The Contractor shall prepare a Contractor Quality Control Plan (CQCP) describing the methods to be used to verify the performance of the engineered components of the WPC. The quality control plan for the run-of-mine (ROM) salt shall detail the methods the Contractor proposes to meet the minimum requirements, and the standard quality control test methods to be used to verify compliance with minimum requirements. Equipment methods employed shall be traceable to standard quality control tests as approved in the CQCP. No work shall be performed prior to NWP approval of the CQCP.

1.4 References and Standards

Refer to individual specification sections for standards referenced therein, and to Section 01090, Reference Standards, for general listing. Additional standards will be identified in the CQCP.

Standards referenced in this section are as follows:

A. ASTM E 329-01b – Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
B. ASTM E 543-02 – Standard Practice for Agencies Performing Nondestructive Testing

1.5 Quality Assurance

The Contractor shall:

A. Monitor suppliers, manufacturers, products, services, site conditions, and workmanship to produce work of specified quality
B. Comply with specified standards as minimum quality for the work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship
C. Perform work with qualified persons to produce required and specified quality

1.6 Tolerances

The Contractor shall:

A. Monitor excavation, fabrication, and tolerances to produce acceptable work. The Contractor shall not permit tolerances to accumulate.

1.7 Testing Services

Unless otherwise agreed by NWP, the Contractor shall employ an independent firm qualified to perform the testing services and other services specified in the individual Specification sections, and as may otherwise be required by NWP. Testing and source quality control may occur on or off the project site.

The testing laboratory, if used, shall comply with applicable sections of the Reference Standards and shall be authorized to operate in the State of New Mexico.

Testing equipment shall be calibrated at reasonable intervals traceable either to the standards from the National Institute of Standards and Technology or to accepted values of natural physical constants.

1.8 Inspection Services

The Contractor may employ an independent firm to perform inspection services as a supplement to the Contractor's quality control as specified in the individual Specification sections, and as may be required by NWP. Inspection may occur on or off the project site.

The inspection firm shall comply with applicable sections of the Reference Standards.

1.9 Submittals

The Contractor shall submit a CQCP as described herein.

Prior to start of work, if a testing laboratory is used, the Contractor shall submit for approval the testing laboratory name, address, telephone number, and name of responsible officer of the firm, as well as a copy of the testing laboratory compliance with the referenced ASTM standards, and a copy of the report of laboratory facilities inspection made by Materials Reference Laboratory of National Institute of Standards and Technology with memorandum of remedies of any deficiencies reported by the inspection.

The Contractor shall submit the names and qualifications of personnel proposed to perform the required inspections, along with their individual qualifications and certifications. Once approved by NWP, these personnel shall be available as may be required to promptly and efficiently complete the work.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

3.1 General

The Contractor is responsible for quality control and shall establish and maintain an effective quality control system. The quality control system shall consist of plans, procedures, and organization necessary to produce an end product that complies with the contract requirements. The quality control system shall cover construction operations, both on site and off site, and shall be keyed to the proposed construction sequence. The project superintendent will be held responsible for the quality of work on the job. The project superintendent in this context is the individual with the responsibility for the overall management of the project, including quality and production.

3.2 Contractor Quality Control Plan

A. General

The Contractor shall supply, not later than 30 days after receipt of notice to proceed, the Contractor Quality Control Plan (CQCP), which implements the requirements of the Contract. The CQCP shall identify personnel, procedures, control, instructions, tests, records, and forms to be used. Construction shall not begin until the CQCP is approved by NWP.

B. Content of the Contractor Quality Control Plan (CQCP)

The CQCP shall cover construction operations, both on site and off site, including work by subcontractors, fabricators, suppliers, and purchasing agents and shall include, as a minimum, the following items:

1. A description of the quality control organization, including a chart showing lines of authority and acknowledgment that the Contractor Quality Control (CQC) staff shall implement the control system for all aspects of the work specified.
2. The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a CQC function.
3. A description of CQCP responsibilities and a delegation of authority to adequately perform the functions described in the CQCP, including authority to stop work.
4. Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, off-site fabricators, suppliers, and purchasing agents. These procedures shall be in accordance with NWP Submittal Procedures.
5. Control, verification, and acceptance testing procedures as may be necessary to ensure that the work is completed to the requirements of the Drawings and Specifications.
6. Procedures for tracking deficiencies from identification, through acceptable corrective action, to verification that identified deficiencies have been corrected.
7. Reporting procedures, including proposed reporting formulas.

C. Acceptance of Plan

Acceptance of the Contractor's plan is conditional. NWP reserves the right to require the Contractor to make changes in the CQCP and operations, including removal of personnel, if necessary, to obtain the quality specified.

D. Notification of Changes

After acceptance of the CQCP, the Contractor shall notify NWP in writing of any proposed change. Proposed changes are subject to acceptance by NWP.

3.3 Tests

A. Testing Procedure

The Contractor shall perform specified or required tests to verify that control measures are adequate to complete the work to contract requirements. Upon request, the Contractor shall furnish, at his own expense, duplicate samples of test specimens for testing by NWP. The Contractor shall perform, as necessary, the following activities and permanently record the results:

1. Verify that testing procedures comply with contract requirements.
2. Verify that facilities and testing equipment are available and comply with testing standards.

3. Check test instrument calibration data against certified standards.
4. Verify that recording forms and test identification control number system, including the test documentation requirements, have been prepared.
5. Record the results of tests taken, both passing and failing. Specification paragraph reference, location where tests were taken, and the sequential control number identifying the test will be given. If approved by NWP, actual test reports may be submitted later with a reference to the test number and date taken. An information copy of tests performed by an offsite or commercial test facility will be provided directly to NWP.
6. The Contractor may elect to develop an equipment specification with construction parameters based upon test results of a test section of ROM salt. The equipment specification based upon construction parameters shall be traceable to standard test results identified in the CQCP. Specification paragraph reference, location where construction parameters were taken, and the sequential control number identifying the construction parameters will be given. If approved by NWP, actual construction parameter reports may be submitted later with a reference to the recording of construction parameters, location, time, and date taken.

3.4 Testing Laboratory

The testing laboratory, if used, shall provide qualified personnel to perform specified sampling and testing of products in accordance with specified standards, and the requirements of Contract Documents.

Reports indicating results of tests, and compliance or noncompliance with the contract documents will be submitted in accordance with NWP submittal procedures. Testing by an independent firm does not relieve the Contractor of the responsibility to perform the work to the contract requirements.

3.5 Inspection Services

The inspection firm shall provide qualified personnel to perform specified inspection of products in accordance with specified standards.

Reports indicating results of the inspection and compliance or noncompliance with the contract documents will be submitted in accordance with NWP submittal procedures.

Inspection by the independent firm does not relieve the Contractor of the responsibility to perform the work to the contract requirements.

3.6 Completion Inspection

A. Pre-Final Inspection

At appropriate times and at the completion of the work, the Contractor shall conduct an inspection of the work and develop a punch list of items that do not conform to the Drawings and Specifications. The Contractor shall then notify NWP that the work is ready for inspection. NWP will perform this inspection to verify that the work is satisfactory and appropriately complete. A final punch list will be developed as a result of this inspection. The Contractor shall ensure that the items on this list are corrected and notify NWP so that a final inspection can be scheduled. Any items noted on the final inspection shall be corrected in a timely manner. These inspections and any deficiency corrections required by this paragraph will be accomplished within the time slated for completion of the entire work.

B. Final Acceptance Inspection

The final acceptance inspection will be formally scheduled by NWP based upon notice from the Contractor. This notice will be given to NWP at least 14 days prior to the final acceptance inspection. The Contractor shall assure that the specific items previously identified as unacceptable, along with the remaining work performed under the contract, will be complete and acceptable by the date scheduled for the final acceptance inspection.

3.7 Documentation

The Contractor shall maintain current records providing factual evidence that required quality control activities and/or tests have been performed. These records shall include the work of subcontractors and suppliers and shall be on an acceptable form approved by NWP.

3.8 Notification of Noncompliance

NWP will notify the Contractor of any noncompliance with the foregoing requirements. The Contractor shall take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the worksite, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, NWP may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

END OF SECTION

SECTION 01600
MATERIAL AND EQUIPMENT

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Equipment
B. Products
C. Transportation and Handling
D. Storage and Protection
E. Substitutions

1.2 Related Sections

A. 01010 – Summary of Work
B. 01400 – Contractor Quality Control
C. 02010 – Mobilization and Demobilization
D. 02222 – Excavation
E. 04100 – Run-of-Mine Salt

1.3 Equipment

The Contractor shall specify his proposed equipment in the Work Plan. Power equipment for use underground shall be either electrical or diesel-engine driven. All diesel-engine equipment shall be certified for use underground at the WIPP site.

1.4 Products

The Contractor shall specify in the Work Plan, or in subsequently required submittals, the proposed products including, but not limited to steel bulkheads and ROM salt. The proposed products shall be supported by laboratory test results as required by the Specifications. Products shall be subject to approval by NWP.

1.5 Transportation and Handling

The Contractor shall:

A. Transport and handle products in accordance with manufacturer's instructions.

B. Promptly inspect shipments to ensure that products comply with requirements, quantities are correct, and products are undamaged.

C. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.6 Storage and Protection

The Contractor shall:

A. Store and protect products in accordance with manufacturers' instructions

B. Store with seals and labels intact and legible

C. Store sensitive products in weather-tight, climate-controlled enclosures in an environment favorable to product

D. Provide ventilation to prevent condensation and degradation of products

E. Store loose granular materials (other than ROM salt) on solid flat surfaces in a well-drained area and prevent mixing with foreign matter

F. Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage

G. Arrange storage of products to permit access for inspection and periodically inspect to verify products are undamaged and are maintained in acceptable condition

1.7 Substitutions

A. Equipment Substitutions

The Contractor may substitute equipment for that proposed in the Work Plan subject to NWP approval.

B. Product Substitutions

The Contractor may not substitute products after the proposed products have been approved by NWP unless he can demonstrate that the supplier/source of that product no longer exists in which case he shall submit alternate products with lab test results to NWP for approval.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

Not used.

END OF SECTION

DIVISION 2
SITE WORK

SECTION 02010
MOBILIZATION AND DEMOBILIZATION

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Mobilization of Equipment and Facilities to Site
B. Contractor Use of Site
C. Use of Existing Facilities
D. Demobilization of Equipment and Facilities
E. Site Cleanup

1.2 Related Sections

A. 01010 – Summary of Work
B. 01600 – Material and Equipment

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

3.1 Mobilization of Equipment and Facilities to Site

Upon authorization to proceed, the Contractor shall mobilize his equipment and facilities to the jobsite. Equipment and facilities shall be as specified and as defined in the Contractor's Work Plan.

NWP will provide utilities at designated locations. The Contractor shall be responsible for hookups and tie-ins required for his operations.

The Contractor shall be responsible for providing his own office, storage, and sanitary facilities.

Areas will be designated for the Contractor's use in the underground area near the WPC installation. These areas are limited.

3.2 Contractors Use of Site

The Contractor shall use only those areas specifically designated for his use by NWP. The Contractor shall limit his on-site travel to the specific routes required for performance of his work, and designated by NWP.

3.3 Use of Existing Facilities

Existing facilities available for use by the Contractor are as follows:

A. Waste shaft conveyance
B. Salt skip hoist
C. 460 Volt AC, 3 phase power
D. Water underground at waste shaft only
E. Water on surface at location designated by NWP

The Contractor shall arrange for use of the facilities with NWP and coordinate his actions and requirements with ongoing NWP operations.

Use of water in the underground will be restricted. No washout or cleanup will be permitted in the underground except as designated by NWP. Aboveground washout or cleanup of equipment will be allowed in the areas designated by NWP.

The Contractor is cautioned to be aware of the physical dimensions of the waste conveyance and the air lock.

The Contractor shall be responsible for any damage incurred by the existing site facilities as a result of his operations. Any damage shall be reported immediately to NWP and repaired at the Contractor's cost.

3.4 Demobilization of Equipment and Facilities

At completion of this work, the Contractor shall demobilize his equipment and facilities from the job site. Contractor's equipment and materials shall be removed and disturbed areas restored. Utilities shall be removed to their connection points unless otherwise directed by NWP. Any equipment that becomes radiologically contaminated will be managed in accordance with NWP radiation protection policies.

3.5 Site Cleanup

At conclusion of the work, the Contractor shall remove trash, waste, debris, excess construction materials, and restore the affected areas to their prior condition, to the satisfaction of NWP. A final inspection will be conducted by NWP and the Contractor before final payment is approved. Any trash, waste, debris, excess construction materials that become radiologically contaminated will be managed in accordance with NWP radiation protection policies.

END OF SECTION

SECTION 02222
EXCAVATION

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Excavation for surface preparation and leveling of areas for the ROM salt and steel bulkhead placement

B. Disposing of excavated materials

C. Field measurement and survey

1.2 Related Sections

A. 01010 – Summary of Work

B. 01400 – Contractor Quality Control

C. 01600 – Material and Equipment

1.3 Reference Documents

Krieg, R.D., 1984. *Reference Stratigraphy and Rock Properties for the Waste Isolation Pilot Plant*, SAND83-1908, Sandia National Laboratories, Albuquerque, New Mexico.

1.4 Field Measurements and Survey

Survey required for performance of the work will be provided by NWP.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

3.1 Excavation for Surface Preparation and Leveling of Areas for Steel Bulkhead and ROM Salt Placement

The Contractor shall inspect the areas designated for placement of the WPC components (ROM salt and steel bulkheads) and remove any loose material. If loose material is found, the contractor shall excavate and prepare the surface by removing loose material, and cleaning rock surfaces. The surface preparation of the floor shall produce a surface suitable for anchoring the steel bulkhead base components and for placing the first layer of ROM salt (as applicable). Excavation may be performed by either mechanical or manual means. Use of explosives is prohibited.

3.2 Disposing of Excavated Materials

The Contractor shall dispose of excavated materials as directed by NWP. No excavated materials from radiologically controlled areas will be disposed of without prior approval of NWP.

3.3 Field Measurements and Survey

Survey required for performance of the work will be provided by NWP. The Contractor shall protect survey control points, benchmarks, etc., from damage by his operations. NWP will verify that the Contractor has excavated to the required lines and grades. No salt shall be emplaced until approved by NWP.

END OF SECTION

DIVISION 3
WPC COMPONENTS

SECTION 03100
RUN-OF-MINE SALT

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Salt placement

1.2 Related Sections

A. 01010 – Summary of Work

B. 01400 – Contractor Quality Control

C. 01600 – Material and Equipment

1.3 Submittals for Review and Approval

The salt emplacement method, dust control plan and other safety-related material shall be approved by NWP.

1.4 Quality Assurance

The Contractor shall perform the work in accordance with the CQCP.

PART 2 – PRODUCTS

2.1 Salt Material

The salt is ROM salt and requires no grading or compaction. The salt shall be free of foreign organic material.

PART 3 – EXECUTION

3.1 General

The Contractor shall furnish labor, material, equipment, and tools to handle and place the salt.

The Contractor shall use underground equipment and underground mine personnel as required in Part 1.5, Work by Others in Section 01010 Summary of Work. NWP will supply ROM salt. The Contractor shall make suitable arrangements for transporting and placing the ROM salt.

3.2 Installation

ROM salt shall be transported to the WPC-B installation area north of Panel 10 after the construction of the in-bye steel bulkhead. The ROM salt is not required to achieve a specified density. The salt shall be free of foreign organic material.

Salt may be emplaced in layers to facilitate the construction. The ROM Salt is emplaced in layers to achieve minimum lengths shown in Table 1. The lengths reported in Table 1 do not include sloped ends of the ROM salt plug. Extents of the ROM Salt emplacement are designated in the Drawings.

There shall be no gap left between ROM Salt and roof or sidewalls. Hand placement or push plates can be used to fill the voids if necessary. The approximate lengths and slope inclines are specified in the Drawings. Emplacement of the ROM salt at natural angle of repose is acceptable.

Table 1 Minimum ROM Salt Lengths

Entry Width (feet)	Minimum ROM Salt Length[1] (feet)
14	35
16	40
20	50
25	65

Note:
1. Reported ROM length dimensions do not include end slopes of the ROM salt.

3.3 Field Quality Control

The Contractor shall provide a Quality Control Inspector to inspect the emplacement of salt.

END OF SECTION

SECTION 03200
STEEL BULKHEADS

PART 1 – GENERAL

1.1 Scope

This section includes the following:

A. Steel bulkhead installation

1.2 Related Sections

A. 01010 – Summary of Work
B. 01400 – Contractor Quality Control
C. 01600 – Material and Equipment

1.3 Submittals for Review and Approval

The method of installation, construction equipment, and construction materials shall be approved by NWP.

1.4 Quality Assurance

The Contractor shall perform the work in accordance with the CQCP.

PART 2 – PRODUCTS

2.1 Bulkhead Material

Construction material, including steel profiles, sheet metal, flexible flashing, and connectors/bolts shall be approved by NWP prior to construction.

PART 3 – EXECUTION

3.1 General

The Contractor shall furnish all labor, material, equipment, and tools to install steel bulkheads at the locations specified in the Drawings. The Contractor shall use underground equipment and underground mine personnel as required in Part 1.5, Work by Others in Section 01010 Summary of Work.

3.2 Fabrication

Bulkheads will be fabricated on the surface or in the underground in a location designated by NWP.

3.3 Installation

In-bye steel and out-bye steel bulkheads shall be installed in the designated WPC areas approved by the NWP as specified in the Drawings. The contractor shall not commence installation activities without prior inspection of the ground conditions as documented in the HASP per Section 01010 of these Specifications and without prior approval by NWP.

3.4 Field Quality Control

The Contractor shall provide a Quality Control Inspector to inspect the steel bulkhead installation if requested by NWP prior to contract.

3.5 Product Acceptance

The Contractor shall arrange for the pre-final inspection and final product inspection as described in Part 3.6 Section 01400 of these Specifications. The resolution of non-compliance issues will be conducted as described in Part 3.8 Section 01400 of these Specifications.

END OF SECTION

APPENDIX A.1
REFERENCES

REFERENCES

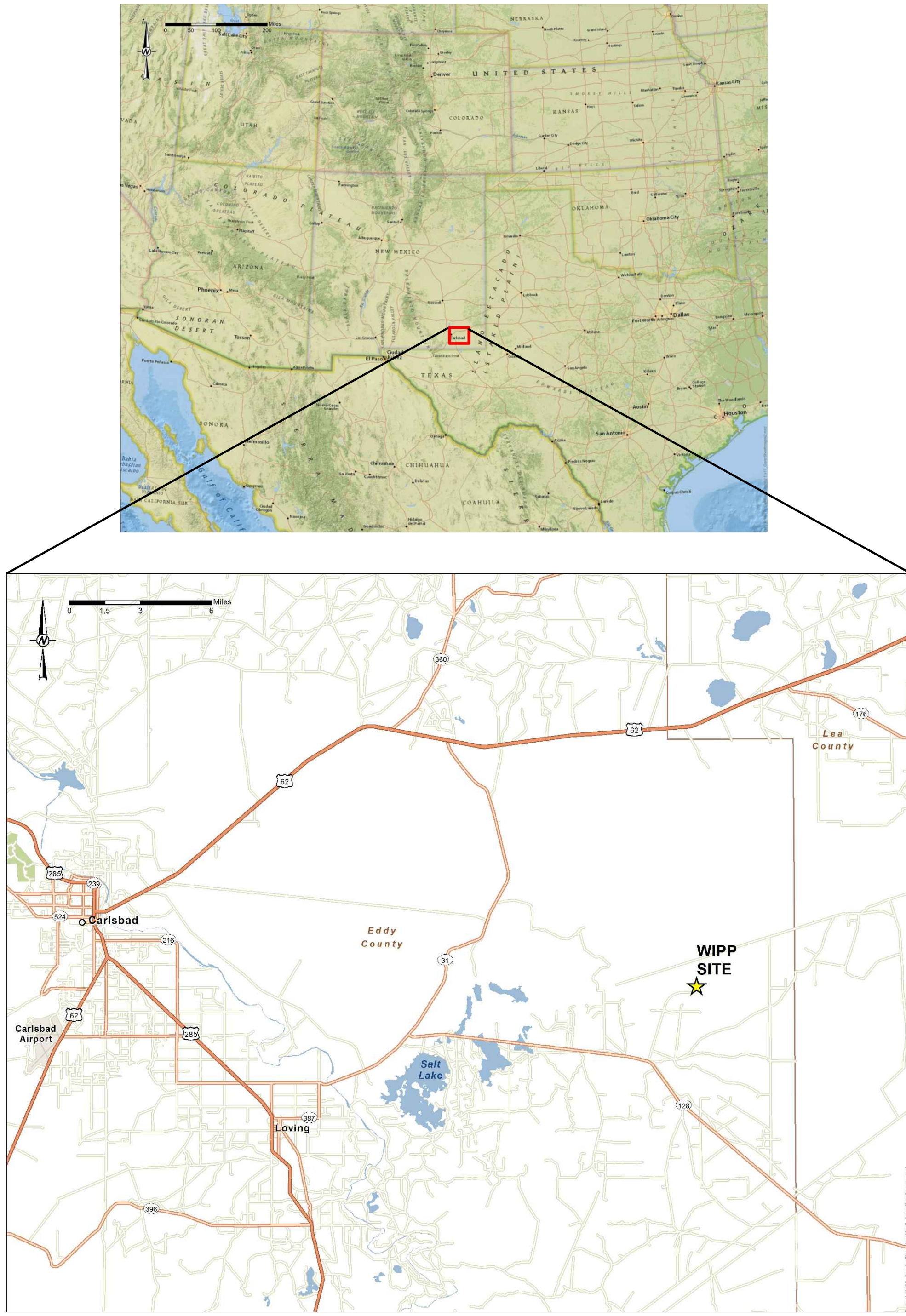
RockSol Consulting Group, Inc. (RockSol). 2012. “Design Report for a Panel Closure System at the Waste Isolation Pilot Plant,” report prepared for NWP, Westminster, Colorado, October.

U.S. Department of Energy (DOE). 1996. “*Detailed Design Report for an Operational Phase Panel-Closure System,”* DOE/WIPP 96-2150, U.S. Department of Energy, WIPP Project Office, Carlsbad, New Mexico.

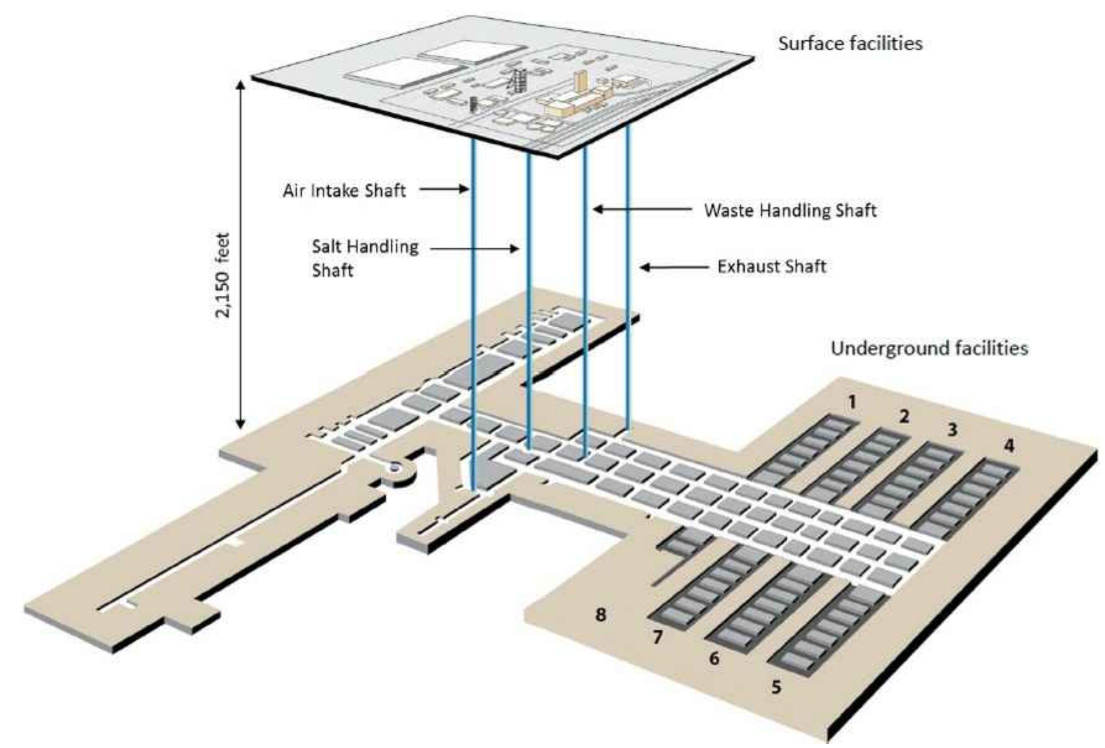
Krieg, R.D., 1984. Reference Stratigraphy and Rock Properties for the Waste Isolation Pilot Plant, SAND83-1908, Sandia National Laboratories, Albuquerque, New Mexico.

APPENDIX B
DESIGN DRAWINGS

WIPP PANEL CLOSURE
CARLSBAD, NEW MEXICO



INDEX OF DRAWINGS	
DRAWING NO.	TITLE
262-001	WIPP PANEL CLOSURE (WPC) TITLE SHEET
262-002	WPC LOCATIONS
262-003	TYPICAL PANEL LAYOUT AND MINED ENTRY CROSS-SECTIONS
262-004	WPC DETAILS - BULKHEAD AND ROM SALT LOCATIONS
262-005	WPC DETAILS - BULKHEAD FRONT-VIEW AND ATTACHMENT DETAIL



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CLIENT
NUCLEAR WASTE PARTNERSHIP LLC

PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

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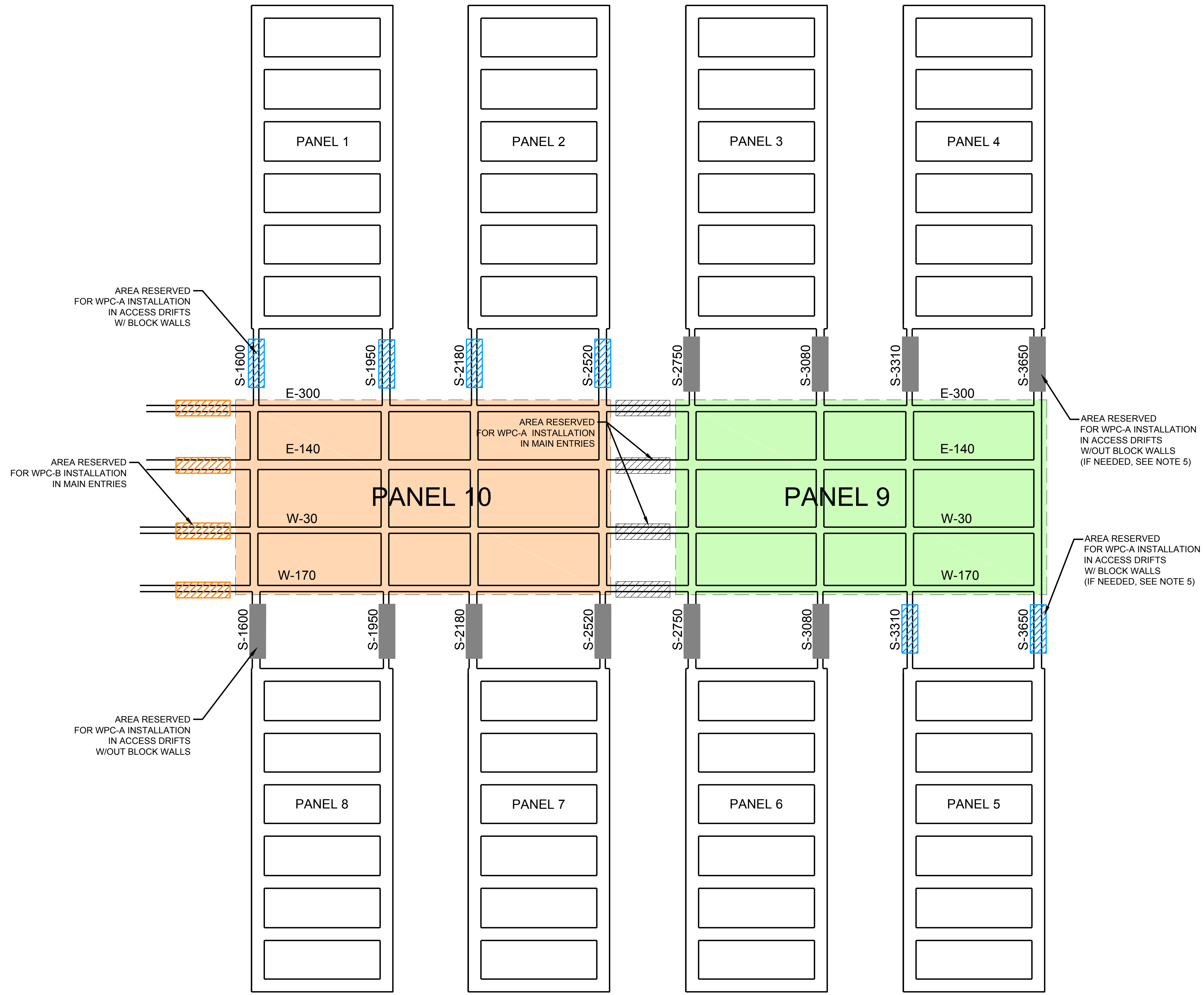
TITLE
WIPP PANEL CLOSURE (WPC) TITLE SHEET

PROJECT NO. 063-2213NEW
REV. A
DRAWING 262-001

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



LEGEND

- APPROXIMATE EXTENTS OF PANEL 9
- APPROXIMATE EXTENTS OF PANEL 10
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN PANEL ACCESS DRIFTS W/ EXPLOSION-ISOLATION WALLS (NOTES 1, 2, 5)
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN MAIN ENTRIES (NOTES 1, 3, 5)
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN PANEL ACCESS DRIFTS W/OUT EXPLOSION-ISOLATION WALLS (NOTES 1, 2, 5)
- APPROXIMATE AREA RESERVED FOR WPC-B INSTALLATION IN MAIN ENTRIES (NOTES 1, 4)

NOTES

1. SHOWN WIPP PANEL CLOSURE (WPC) LOCATIONS ARE APPROXIMATE.
2. WPC-A IS INSTALLED IN AIR-INTAKE AND AIR-EXHAUST DRIFTS OF PANELS 1 TO 8. WPC-A IN ACCESS DRIFTS CONSISTS OF OUT-BYE BULKHEAD.
3. WPC-A IS INSTALLED IN MAIN ENTRIES BETWEEN S-2520 AND S-2750 FOR PANEL 9 CLOSURE. WPC-A IN MAIN ENTRIES CONSISTS OF OUT-BYE BULKHEAD.
4. WPC-B IS INSTALLED IN MAIN ENTRIES NORTH OF S-1600 FOR PANEL 10 CLOSURE. WPC-B IN MAIN ENTRIES CONSISTS OF ROM SALT BETWEEN IN-BYE AND OUT-BYE BULKHEADS.
5. PANELS 3, 4, 5 AND 6 MAY BE CLOSED BY INSTALLING WPC-A IN MAIN ENTRIES NORTH OF PANEL 9. I.E., WPC-A INSTALLED BETWEEN S-2520 AND S-2750 MAY BE USED TO CLOSE MULTIPLE PANELS SOUTH OF S-2750 AS AN ALTERNATIVE TO WPC-A INSTALLATION IN ACCESS DRIFTS.

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PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

TITLE
WPC LOCATIONS

PROJECT NO. 063-2213NEW | REV. A | DRAWING 262-002

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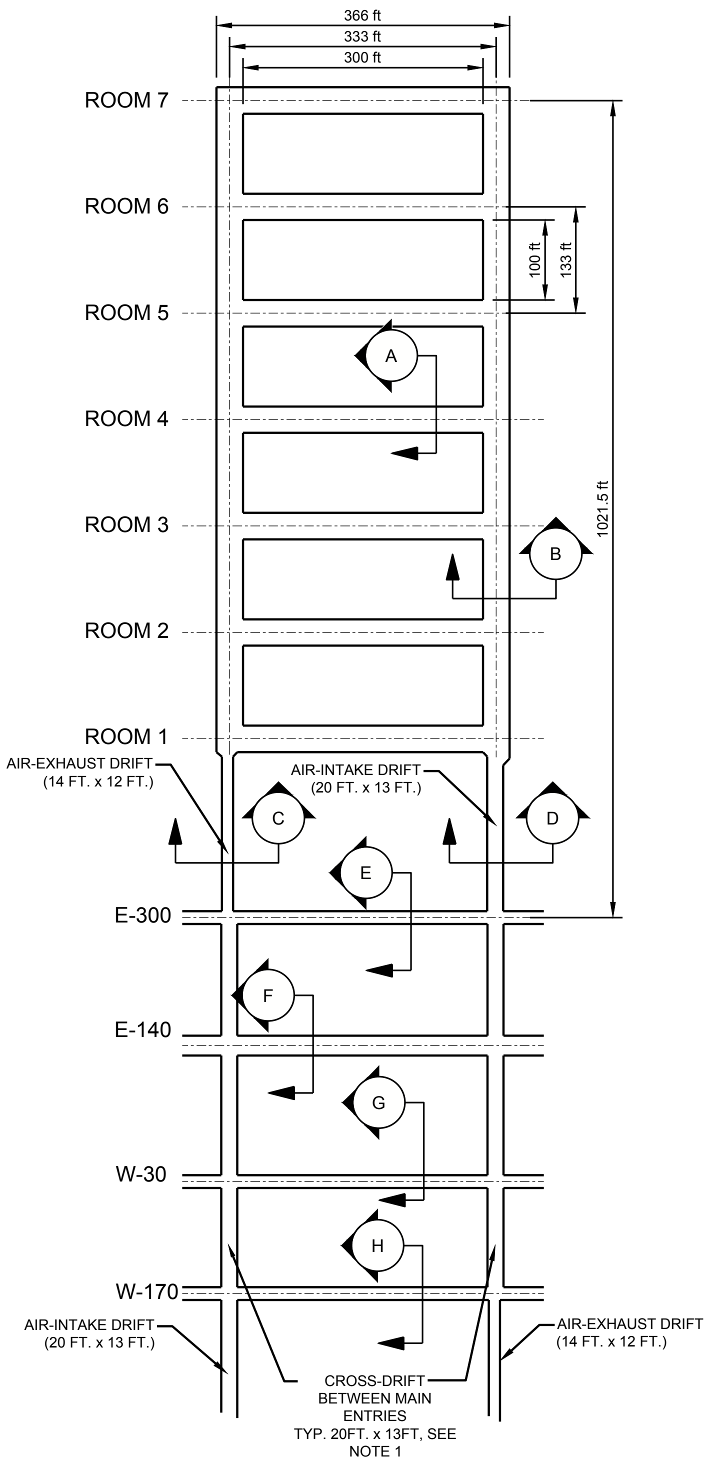
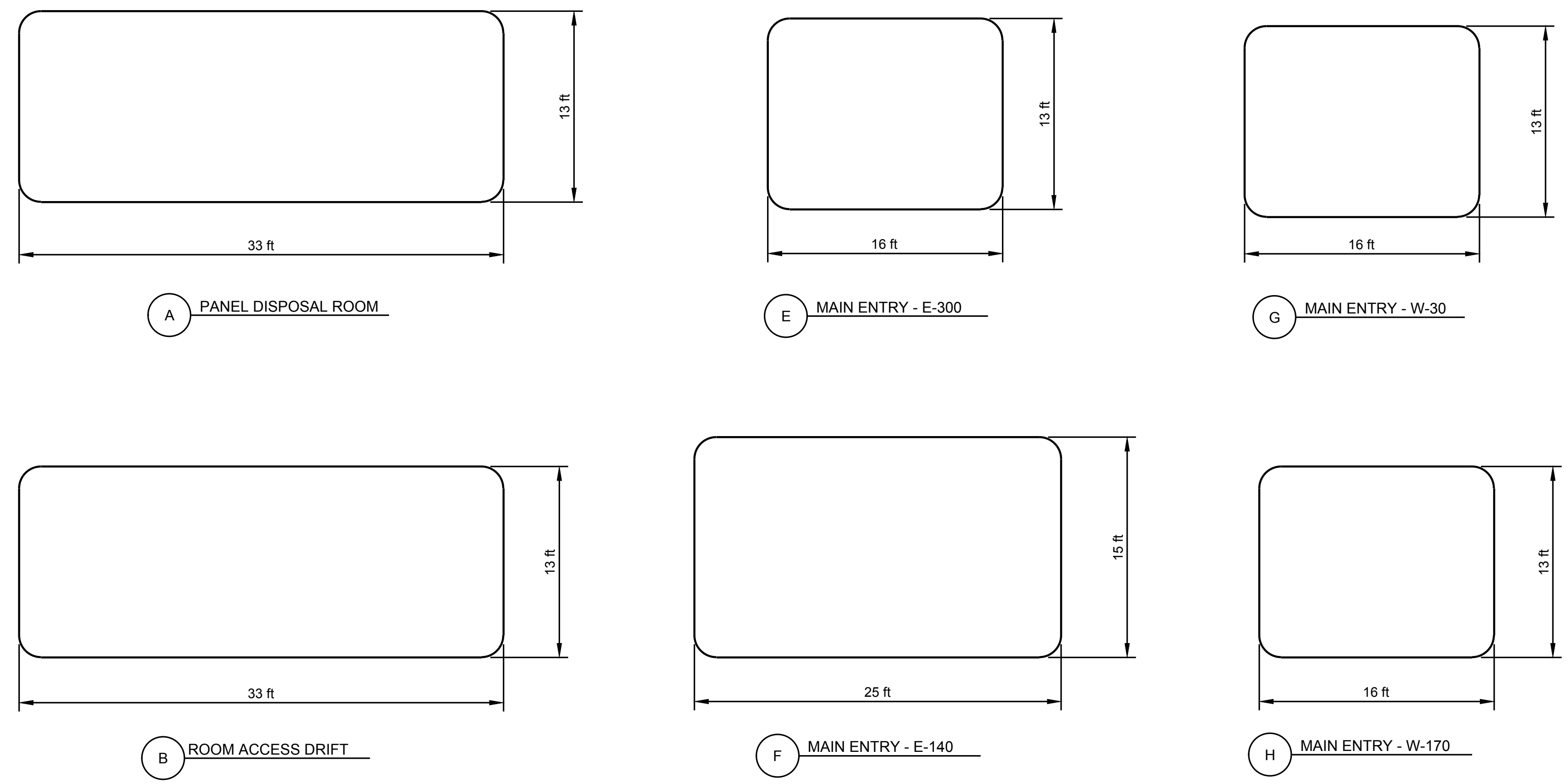
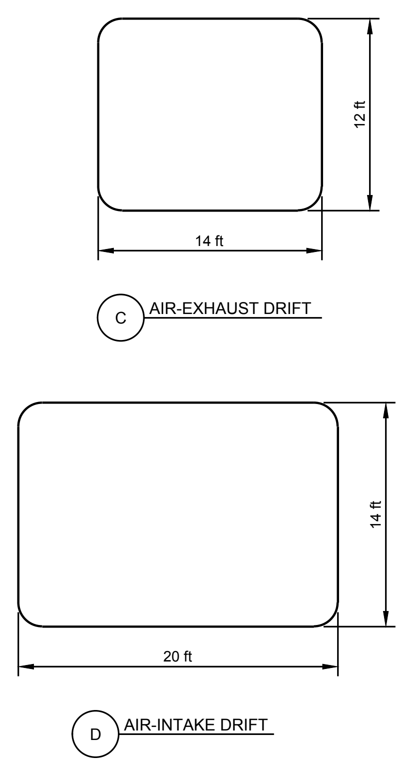


TYPICAL PANEL LAYOUT AND MINED ENTRY LOCATIONS - PLAN-VIEW
SCALE: AS SHOWN





NOTE(S)

1. TYPICAL DIMENSIONS OF DISPOSAL ROOMS AND ACCESS DRIFTS SHOWN IN THIS FIGURE ARE APPROXIMATE, I.E., MAY DIFFER AT SPECIFIC LOCATIONS DUE TO CREEP OF SURROUNDING ROCK, CONSTRUCTION TOLERANCES AND DESIGN REQUIREMENTS.
2. MAIN ENTRY E-300 DIMENSIONS VARY FROM APPROXIMATELY 14 FT x 12 FT (WIDTH x HEIGHT) TO 16 FT x 13 FT W/ SMALLER CROSS-SECTIONS GENERALLY LOCATED IN THE NORTHERN PART OF THE REPOSITORY (I.E. CLOSER TO THE INTERSECTION OF E-300 AND S-1600).
3. MAIN ENTRY E-140 DIMENSIONS VARY FROM APPROXIMATELY 25 FT x 20 FT (WIDTH x HEIGHT) TO 25 FT x 15 FT W/ SMALLER CROSS-SECTIONS GENERALLY LOCATED IN THE SOUTHERN PART OF THE REPOSITORY (I.E. CLOSER TO THE INTERSECTION OF E-140 AND S-3650).
4. MAIN ENTRY W-30 DIMENSIONS VARY FROM APPROXIMATELY 14 FT x 12 FT (WIDTH x HEIGHT) TO 21 FT x 13 FT W/ SMALLER CROSS-SECTIONS GENERALLY LOCATED IN THE NORTHERN PART OF THE REPOSITORY (I.E. CLOSER TO INTERSECTION OF W-30 AND S-1600).
5. MAIN ENTRY W-170 DIMENSIONS VARY FROM APPROXIMATELY 14 FT x 12 FT (WIDTH x HEIGHT) TO 30 FT x 13 FT W/ LARGER CROSS-SECTIONS LOCATED ADJACENT TO PANEL 6 (26 FT x 13 FT) AND PANEL 7 (30 FT x 13 FT).

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PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

TITLE
TYPICAL PANEL LAYOUT AND MINED ENTRY CROSS-SECTIONS

PROJECT NO. 063-2213NEW
REV. A
DRAWING 262-003

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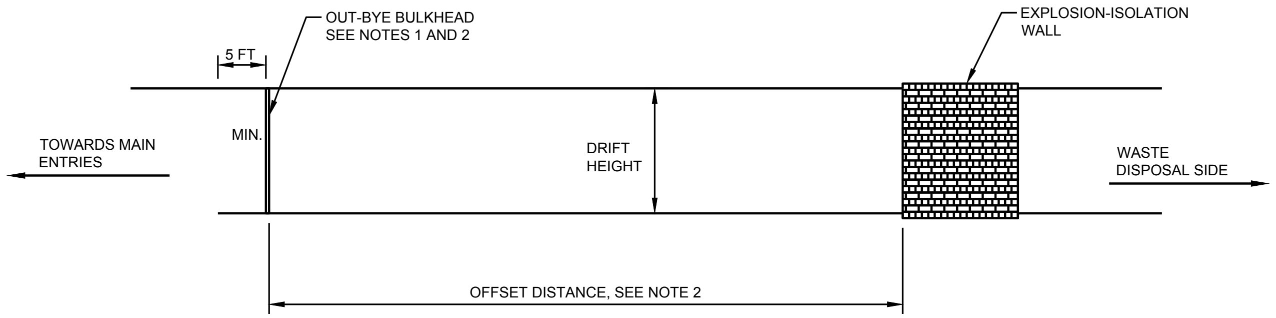
LEGEND

ROM SALT

NOTES

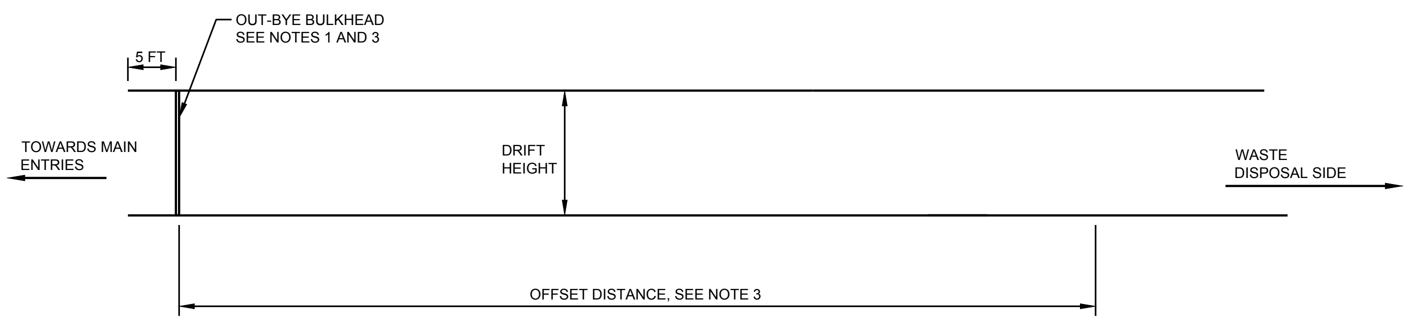
1. RECESS OUT-BYE BULKHEAD MIN. 5 FT FROM INTERSECTION WITH ANOTHER DRIFT OR MAIN ENTRY.
2. OFFSET OUT-BYE BULKHEAD FROM EXPLOSION-ISOLATION WALL. MINIMUM OFFSET DISTANCE IS 2.0 x ACCESS DRIFT HEIGHT.
3. FOR PANELS WITHOUT EXPLOSION-ISOLATION WALLS, OFFSET OUT-BYE BULKHEAD FROM WASTE CONTAINERS. MINIMUM OFFSET DISTANCE IS 22 FT.
4. INSTALL IN-BYE BULKHEAD AT LEAST 22 FT FROM THE NEAREST WASTE CONTAINER.
5. ALL WPC-B BULKHEADS SHOULD BE PLACED AT LEAST 5 FT FROM THE TOE OF ROM SALT ASSUMING ROM SALT END SLOPES OF 2H:1V.
6. MINIMUM LENGTH OF WPC-B ROM SALT IS A FUNCTION OF THE MAIN ENTRY WIDTH AS FOLLOWS:

MINIMUM ROM SALT LENGTH - EXCLUDING END SLOPES	
ENTRY WIDTH (FT)	MIN. ROM SALT LENGTH (FT)
14	35
16	40
20	50
25	65



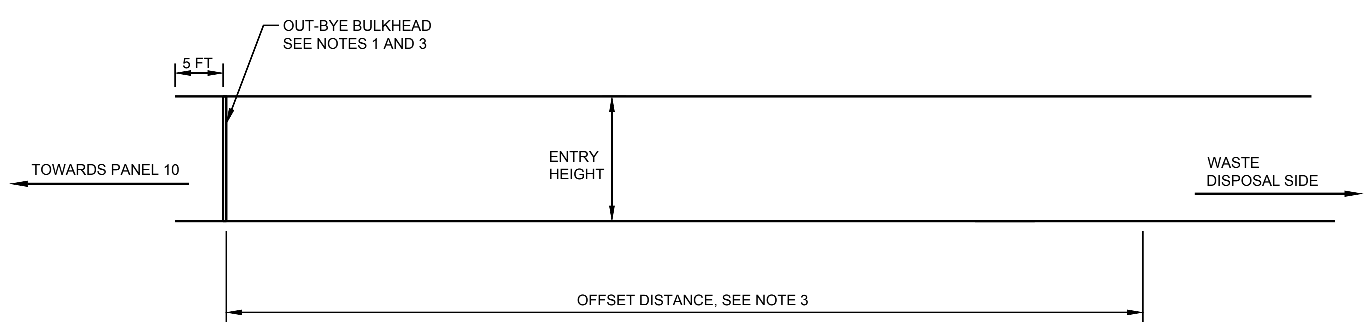
WPC-A FOR PANEL ACCESS DRIFTS WITH EXPLOSION-ISOLATION WALLS - PANELS 1, 2 AND 5

NOT TO SCALE



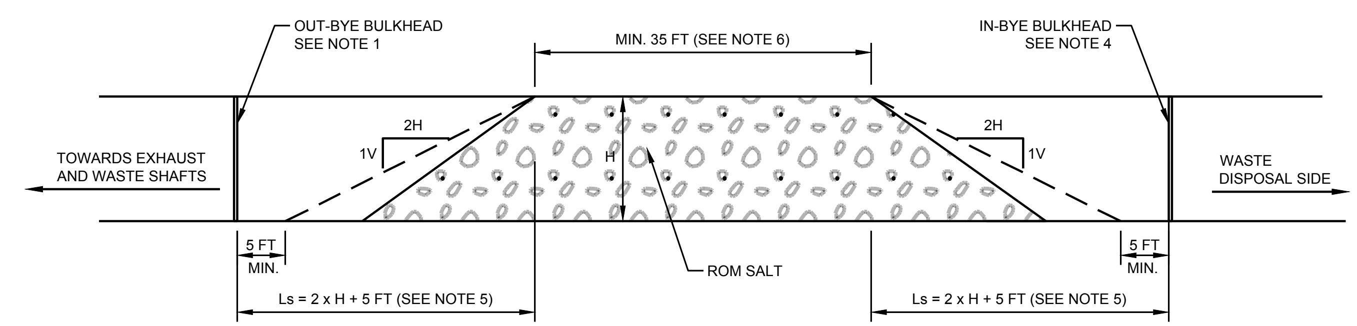
WPC-A FOR PANEL ACCESS DRIFTS W/OUT EXPLOSION-ISOLATION WALLS - PANELS 3, 4, 6, 7 AND 8

NOT TO SCALE



WPC-A FOR PANEL 9 - WASTE PLACEMENT SOUTH OF S-2750

NOT TO SCALE



WPC-B FOR PANEL 10 - WASTE PLACEMENT SOUTH OF S-1600

NOT TO SCALE

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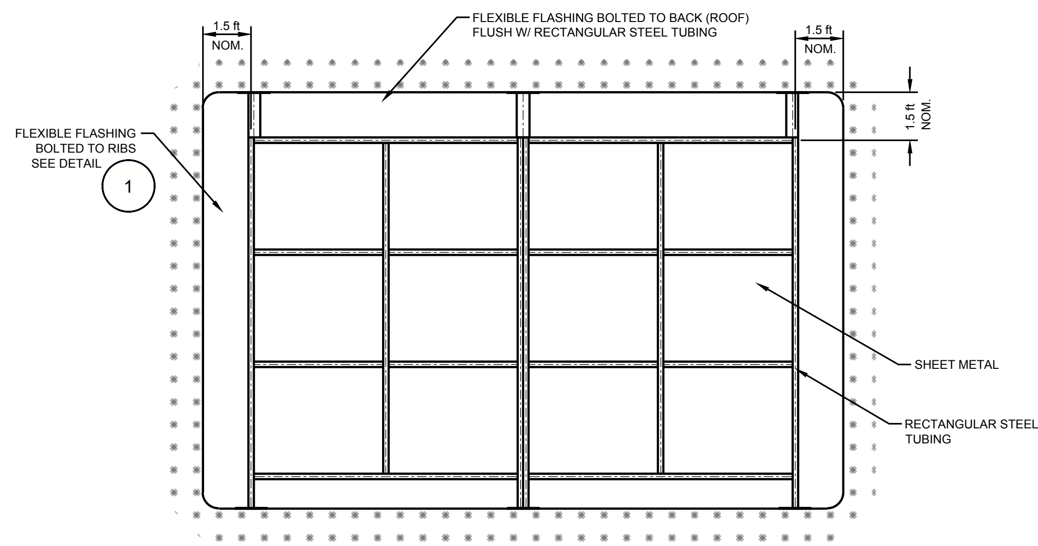
PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

TITLE
WPC DETAILS - BULKHEAD AND ROM SALT LOCATIONS

PROJECT NO. 063-2213NEW
REV. A
DRAWING 262-004



TYPICAL STEEL BULKHEAD FRONT-VIEW

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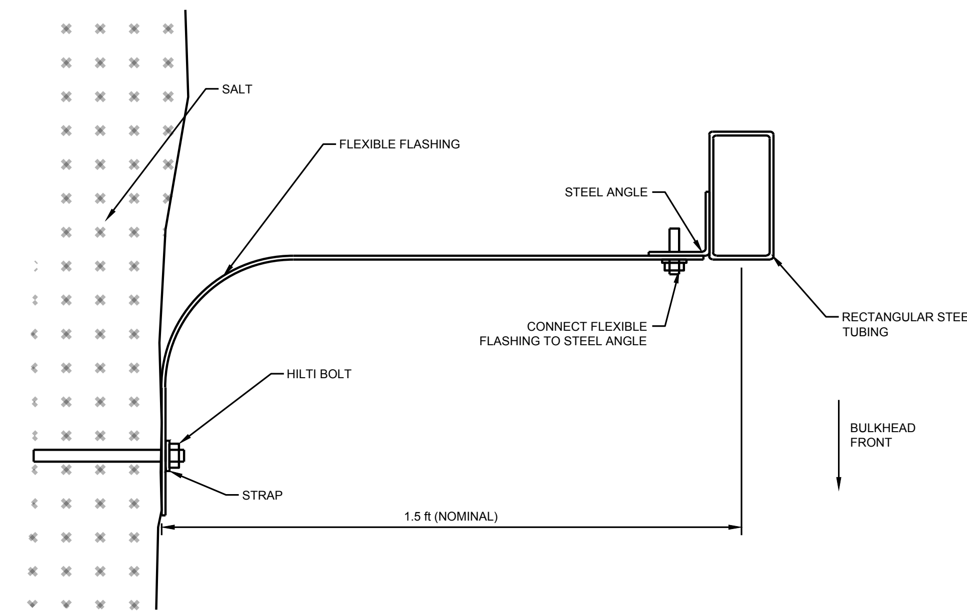

1 FLEXIBLE FLASHING ATTACHMENT

SCALE: NOT TO SCALE (NTS)

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PROJECT
WIPP CLOSURE
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TITLE
WPC DETAILS - BULKHEAD FRONT-VIEW AND ATTACHMENT DETAIL

PROJECT NO. 063-2213NEW
REV. A
DRAWING 262-005

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APPENDIX C
CREEP RATE CALCULATIONS

TECHNICAL MEMORANDUM

Date: August 30, 2016

Project No.: 063-2213NEW

To: Rey Carrasco

Company: Nuclear Waste Partnership LLC

From: Gordan Gjerapic and Bill Thompson

Email: GGjerapic@Golder.com

cc: bthompson@golder.com

RE: **WIPP PANEL CLOSURE SYSTEM – CREEP CALCULATIONS**

1.0 OBJECTIVE

Calculate creep displacements based on the input parameters used in previous geo-mechanical models (DOE 1996 and RockSol 2012), and compare numerical results to recorded convergence measurements presented in DOE (2011, 2013) reports. Based on the convergence measurements and results of the geo-mechanical models, select representative convergence rates to determine the volume loss in the WIPP repository due to salt creep. In addition, evaluate deformations of the run-of-mine (ROM) salt used for construction of the WIPP Panel Closure (WPC) installed north of Panel 10. The WPC for Panel 10 consists of ROM salt installed between the in-bye and out-bye steel bulkheads and is referred to as WPC-B.

2.0 CONVERGENCE RATES AND VOLUMETRIC CREEP CLOSURE

To determine the loss of available repository volume due to creep of the surrounding rock, Golder analyzed available convergence records from DOE (2011, 2013) reports. Average rates of convergence for Panel 5, determined at the center of the room, are summarized in Table 1 and shown in Figure 1.

Table 1: Convergence Measurements Used to Estimate Creep Closure for Panels 1 to 8

Panel	Room	Convergence Rate (inch/yr)
5	1	4.4
5	2	4.2
5	3	4.1
5	4	4.0
5	5	3.5
5	6	3.3
Average		**3.9**

More information on the measured convergence rates that were used to estimate creep closure rates for Panels 1 to 8 is included in Attachment 1 (Tables A1-1 to A1-4).

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To estimate the volumetric creep for Panels 9 and 10, Golder analyzed convergence records for the main entries as summarized in Table 2 and Figure 2.

Table 2: Convergence Measurements Used to Estimate Creep Closure for Panels 9 and 10

Probability of Non-Exceedance	Convergence Rate Year 2010-2011 (inch/year)	Convergence Rate Year 2011-2012 (inch/year)
1%	0.5	0.5
5%	0.7	0.7
10%	0.9	0.9
25%	1.4	1.3
50%	2.0	1.9
75%	2.6	2.6
90%	3.6	3.8
95%	4.0	4.4
99%	6.5	6.5

More information on the convergence measurements used to estimate creep closure rates for Panel 9 geometry is included in Attachment 1 (Table A1-5).

In addition to convergence measurements, creep calculations were used to evaluate the range of deformations for panel rooms and main entries using Itasca's (2011) FLAC (Fast Lagrangian Analysis of Continua) modeling software. FLAC software has been used for geo-mechanical evaluations at the WIPP site since 1991 (DOE 1996). Model stratigraphy used for two-dimensional FLAC analyses is presented in Figure 3. Results from the FLAC analyses for a typical panel room geometry (cross-section area: 33-ft wide by 13-ft high) are presented in Figures 4 and 5. Results from the FLAC analyses for typical main entry geometries (16-ft wide by 13-ft high and 25-ft wide by 15-ft high) are presented in Figures 6 and 7. The range of recorded vertical and horizontal convergence rates for main entries and cross-drifts in Panel 9 and Panel 10 areas are presented in Figures 8 and 9. Figure 10 illustrates the ratio between the vertical and the horizontal convergence rates for entries in Panel 9 and Panel 10 areas.

Available measurement records indicate that smaller entries (entries with smaller cross-sectional areas) are likely to exhibit smaller convergence rates. This finding is supported by the conducted FLAC analyses indicating long-term convergence rates between 3.5 and 4.7 inch/year for 33-ft wide by 13-ft high entries (Figures 4 and 5), values that are 2 to 4 times larger than the convergence rates between 0.9 and 2.1 inch/year calculated for 16-ft wide by 13-ft high and 25-ft by 15-ft high entries in Panel 9 (Figures 6 and 7).

Based on the average creep rate of 2 inch/year, selected for entries in the Panel 9 and Panel 10 areas, the volumetric creep is approximately 950 m^3/yr/panel (Panels 9 and 10). Based on the average creep rate of

3.9 inch/year, selected for the panel openings (room closure), the volumetric creep rate is 1,262 m^3/yr/panel (Panels 1 to 8). Details of the creep closure calculation are presented in Attachment 2.

3.0 ROM SALT CALCULATIONS

ROM salt creep calculations were conducted by using the crushed salt model developed by Sjaardema and Krieg (1987) and implemented in FLAC3D (Fast Lagrangian Analysis of Continua in Three Dimensions) computer model (Itasca 2012). Immediately after installation, the rate of ROM salt consolidation is faster than the creep rate of the surrounding rock. Consequently, the model predicts that the air-gap will be created between the top of the crushed salt and the roof of the main entry immediately after the ROM salt installation. With time, the ROM salt consolidation rate decreases below the creep rate of the rock salt allowing for the air-gap to close.

Assuming that the contact between the ROM salt and the sides of the main entry is frictionless, one can calculate the ROM salt displacement from the analytical expression for the fractional density (Itasca 2000). The average fractional density calculated for the moment of air-gap closure can then be used as an initial density for FLAC3D simulations. Based on the range of selected material properties, FLAC3D simulations were conducted to identify the time required for the ROM salt to fully consolidate. I.e., FLAC3D simulations provided the upper and lower bounds for the time of consolidation during which the ROM salt density increases until reaching the intact salt density. After considering the range of convergence measurements, and potential variability in material properties required to achieve agreement between calculated and measured deformation at the WIPP site (see e.g., Morgan 1987), Golder adopted the default crushed salt properties for FLAC3D formulation (Itasca 2000) with the intact salt density varying from 2,160 to 2,300 kg/m^3. Adopted parameters are expected to provide a reasonable upper and lower bound estimates for the ROM salt performance based on the results in previous studies (see e.g., Callahan and DeVries 1991). Results of the benchmark calculations for panel rooms from previous studies (Callahan and De Vries 1991, Weatherby 1989, Weatherby and Brown 1990, and RockSol 2012) are compared to the current approach in Figure 11.

The WPC-B including the ROM salt component will be placed in the main entries north of Panel 10. Consequently, FLAC3D calculations were performed for 16-ft wide by 13-ft high and 25-ft wide by 15-ft high main entries. Based on the convergence measurements reported by DOE (2011, 2013), the calculated rates of ROM salt convergence were scaled to account for the initial convergence rates of 2 inch/year for 25-ft wide by 15-ft high entries, and 1 inch/year for 16-ft wide by 13-ft high entries prior to the WPC-B installation. Selected convergence rates are expected to provide a conservative estimate for the increase in the ROM salt fractional density with time, therefore resulting in a conservative estimate of the ROM salt hydraulic performance, i.e., the selected convergence rates are likely underestimating the ROM salt fractional density and overestimating the ROM salt permeability values.

3.1 FLAC3D Model Geometry and Stratification

The FLAC3D model was developed based on the geometry provided by DOE (2011, 2013) and previous FLAC and FLAC3D models by WTS (2003), RockSol (2005) and NWP (2014). The model consists of halite layers divided by clay seams. Clay seams are modeled using FLAC interface elements as summarized in Table 3.

Table 3: Model Stratification

Unit	Depth Below Surface (m)	Halite Layer Thickness between Units (m)	FLAC Model Elevation (m)
Model Top	532.3	108.7	114
Clay H	641.00	1.00	5.16
Clay G	642.00	2.16 (1.59)	4.16
Entry Roof	644.16 (643.59)	4.00 (4.57)	2 (2.57)
Entry Floor	648.16	2.25	-2
Clay E	650.41	110.75	-4.25
Model Bottom	761.16	n/a	-115

Notes:

1. Reported values represent model geometry for the main entry width of 16 ft. Values in parentheses denote changed (updated) values for the main entry width of 25 ft.

All FLAC3D models simulating ROM salt placement in the main entries are based on the minimum pillar dimensions (width by length) of: 125 ft (38.1 m) by 211 ft (64.3 m), i.e., the total width of the FLAC model is 70.5 feet (for the main entry width of 16 feet), or 75 feet (for the main entry width of 25 feet) based on the assumed lines of symmetry outlined in Figure 12. The main entry cross-sections used for FLAC3D analyses are: 16-ft wide by 13-ft high, and 25-ft wide by 15-ft high. The ROM salt length used for the 16-ft wide by 13-ft high main entry calculations was 40 feet. The ROM salt length used for the 25-ft by 15-ft high main entry calculations was 65 feet (see Figure 12).

3.2 Material Properties

Material properties for FLAC3D calculations are summarized in Table 4.

Table 4: Material Properties

Parameter	FLAC Property	Halite	Anhydrite	Crushed Salt	Clay Interface
Bulk Modulus (Pa)	bulk	2.07e+10	8.34e+10	1.19e+08	
Shear Modulus (Pa)	shear	1.24e+10	2.78e+10	7.14e+07	
Density (kg/m^3)	den	2,300	2,300	1,350[1]	
Friction (degree)	fric		29		5
Cohesion (Pa)	coh		2.70e+07		
Temperature (K)	temp	300		300	
Ideal gas constant (cal/K/mol)	gas	1.987		1.987	
Q constant (cal/mol)	act	12,000		12,000	
N constant (-)	n_wipp	4.90		4.90	
A constant (-)	a_wipp	4.56		4.56	
B constant (-)	b_wipp	127		127	
D constant (Pa^{-n} s^{-1})	d_wipp	5.79e-36		5.79e-36	
Critical Strain Rate (1/sec)	e_dot	5.39e-08		5.39e-08	
rho_initial (kg/m^3)	rho			1,404[1,2]	
B0 constant (crushed salt)	b0_sk			1.30e+08	
B1 constant (crushed salt)	b1_sk			8.20e-07	
B2 constant (crushed salt)	b2_sk			-1.72e-02	
Maximum bulk modulus (Pa)	b_f			5.86e10	
Maximum shear modulus (Pa)	s_f			3.53e10	
Maximum density (kg/m^3)	d_f			2,160 to 2,300[3]	
Normal Stiffness (Pa/m)	kn				1e+11
Shear Stiffness (Pa/m)	ks				5e+10

Notes:
1. Initial density for FLAC3D simulations with crushed salt is the average density of ROM salt at the end analytical simulation used to determine air gap closure.
2. Assume that the ROM salt is placed at the fractional density of 65%, i.e., at the initial density of 1,404 kg/m^3 (based on the intact salt density of 2,160 kg/m^3). During construction, the initial density increases to 1,450 kg/m^3.
3. Use the intact salt density of 2,160 kg/m^3 for the lower bound simulations and the intact density of 2,300 kg/m^3 for the upper bound simulations.

Model inputs for FLAC and FLAC3D calculations are discussed in more detail in Attachment 3.

3.3 Boundary Conditions

Horizontal displacements are set to zero for both sides of the model, i.e., sides of the model are allowed to move only in the vertical direction. Vertical displacements are set to zero at the bottom boundary. The top of the model has a constant stress boundary condition equal to the weight of the overburden.

3.4 Initial Conditions

The initial conditions are the in-situ stresses throughout the model equal to the weight of the overburden at each zone. The ROM salt is placed at the initial fractional density of approximately 65%.

4.0 RESULTS

ROM salt calculation results for main entries are presented in Figures 13, 14 and 15 and discussed in the main body of this report, i.e., the Design Report (Golder 2016).

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FIGURES

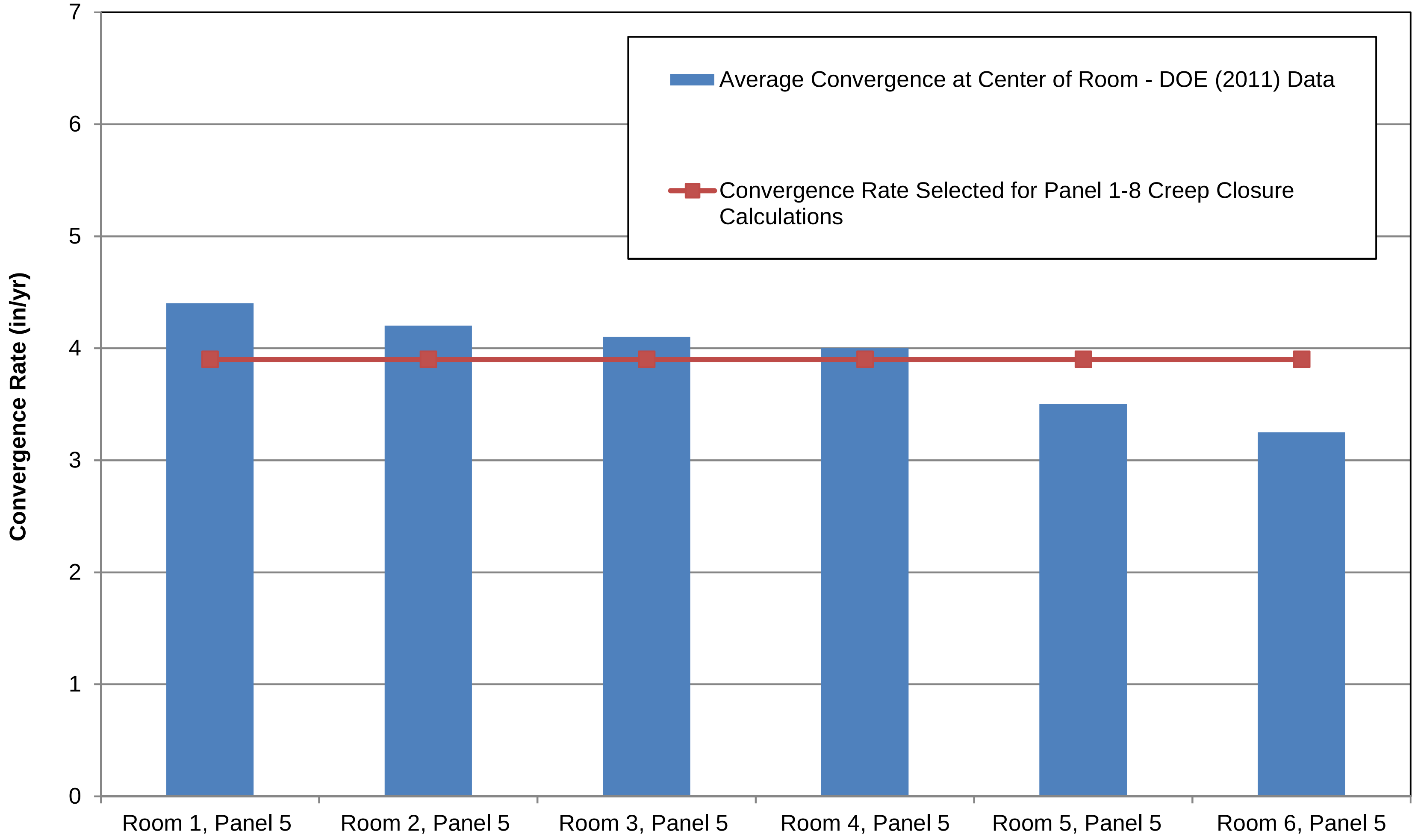

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Figure 1

Convergence Rates - Panel 5 - Center of Room

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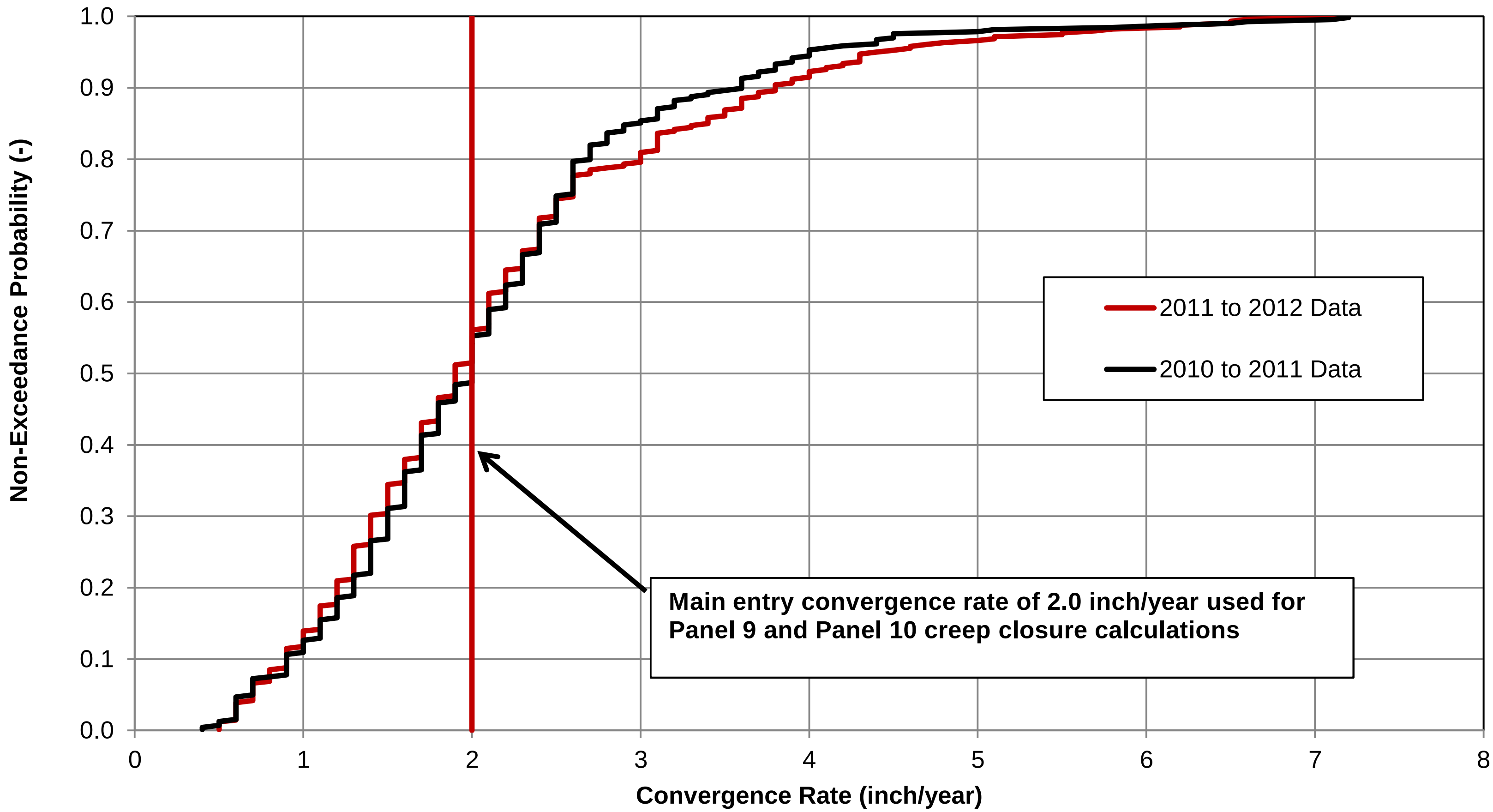

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Note: GAR data compiled by Mike Gross in June, 2014

Figure 2

Convergence Rates - Main Entries

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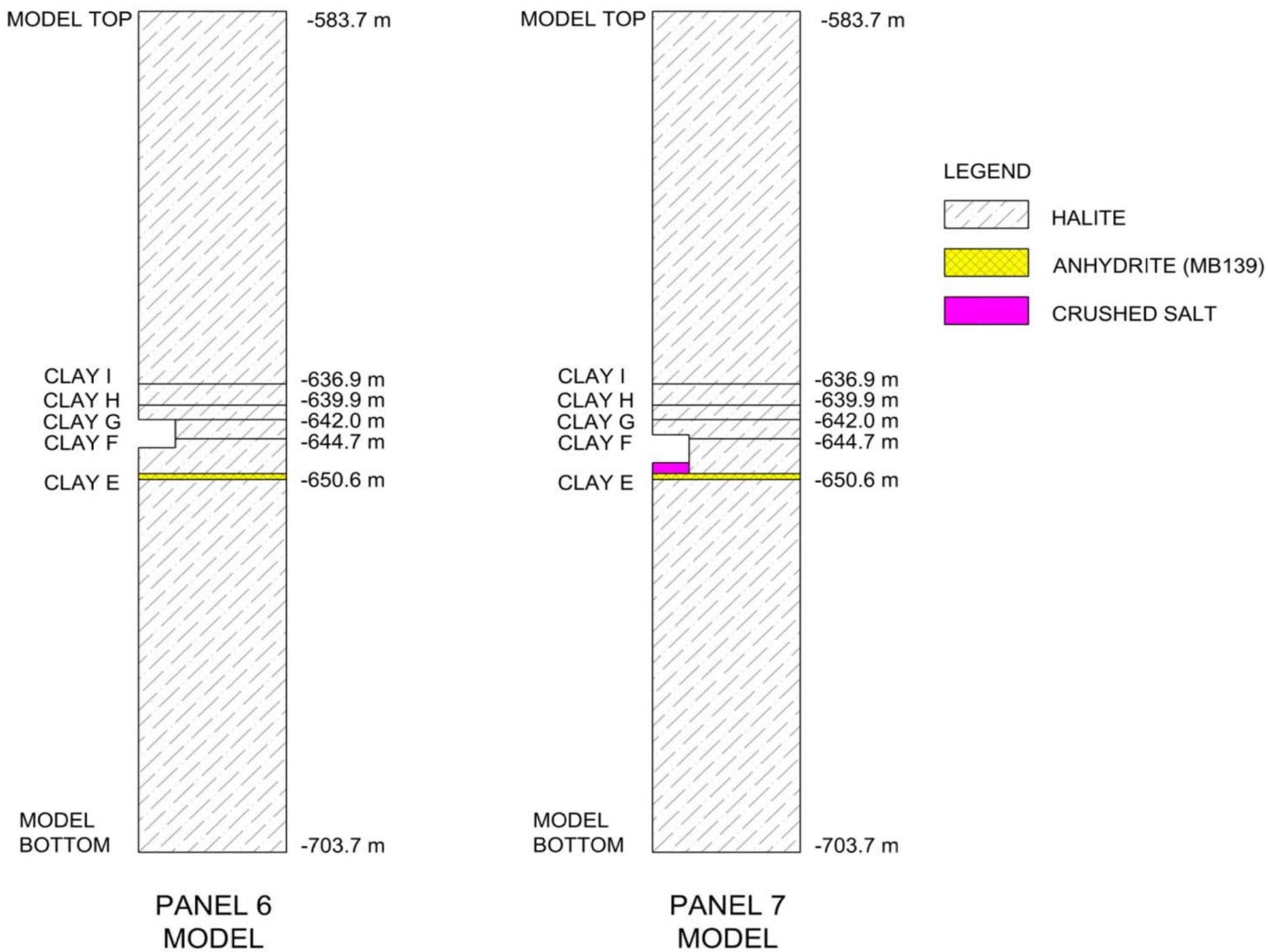

Figure 3

FLAC Model Geometry

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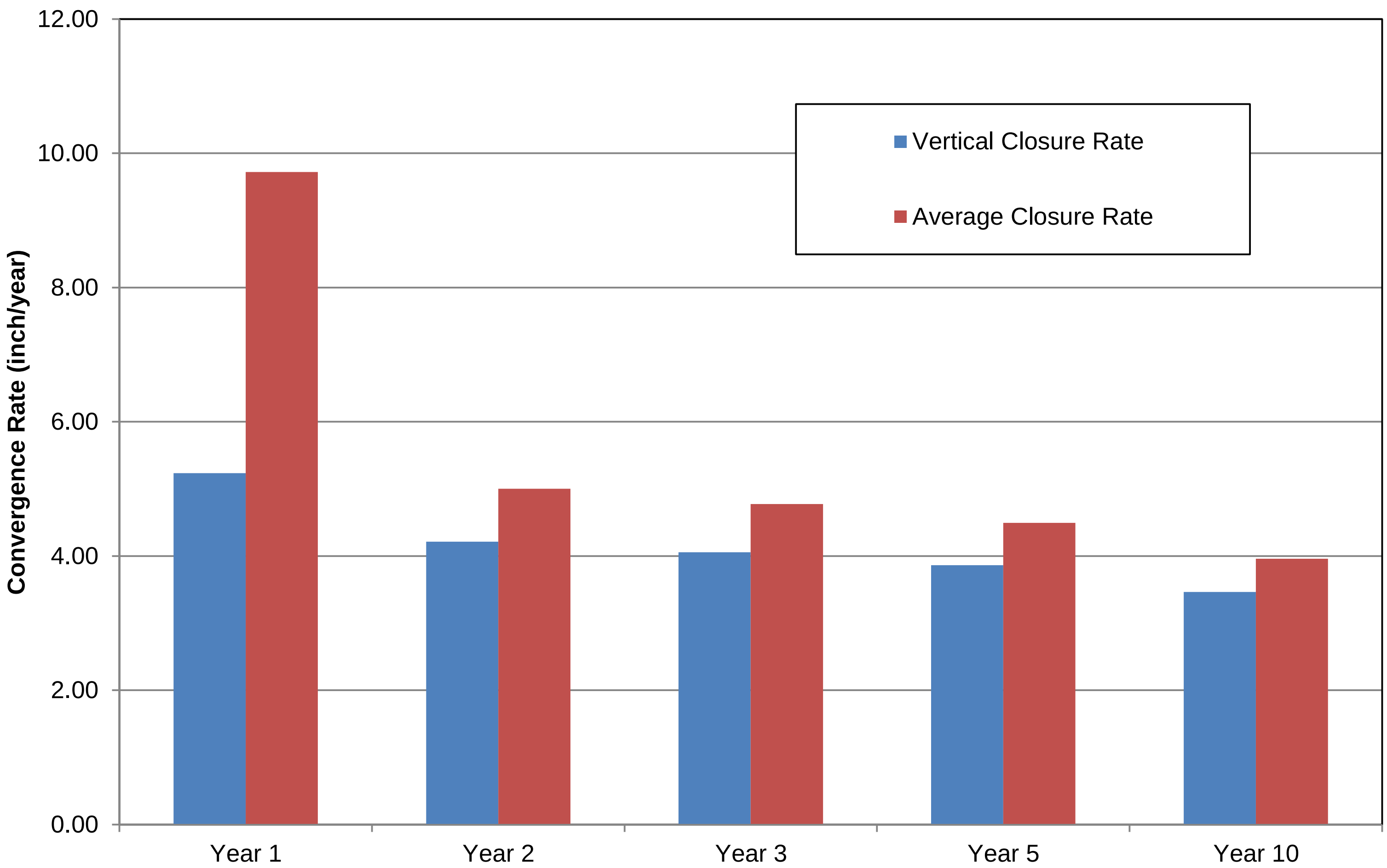

Notes: 1) Average convergence rate calculated based on the equivalent circular area for the available air-space of deformed openings
2) Horizontal axis denotes the elapsed time from excavation of each individual room, i.e. time zero varies for each room.

Figure 4

FLAC - Vertical vs. Average Convergence for Panel 6 Geometry - 33-ft Wide x 13-ft High

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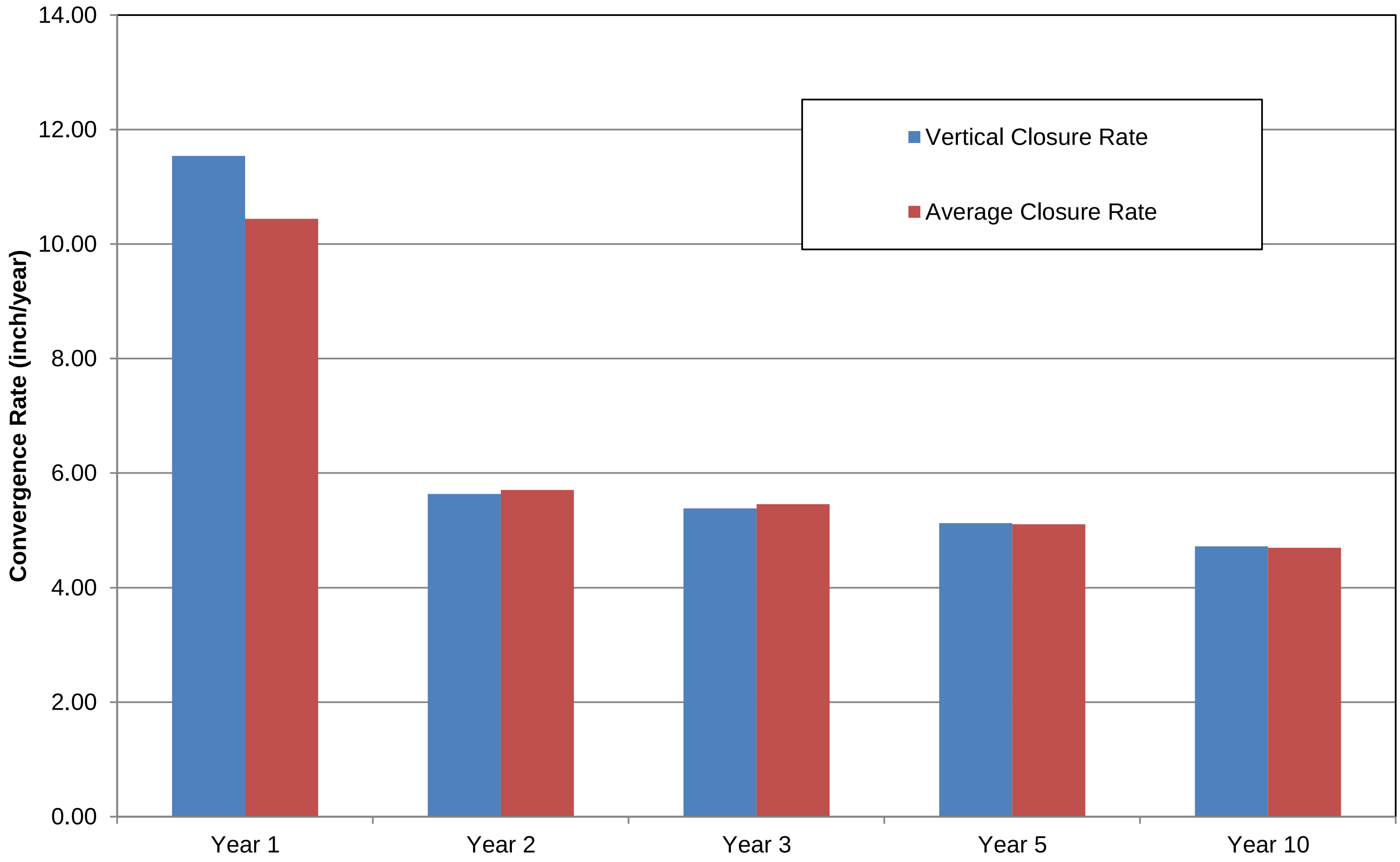

Notes: 1) Average convergence rate calculated based on the equivalent circular area for the available air-space of deformed openings
2) Horizontal axis denotes the elapsed time from excavation of each individual room, i.e. time zero varies for each room.

Figure 5

FLAC - Vertical vs. Average Convergence for Panel 7 Geometry - 33-ft Wide x 13-ft High

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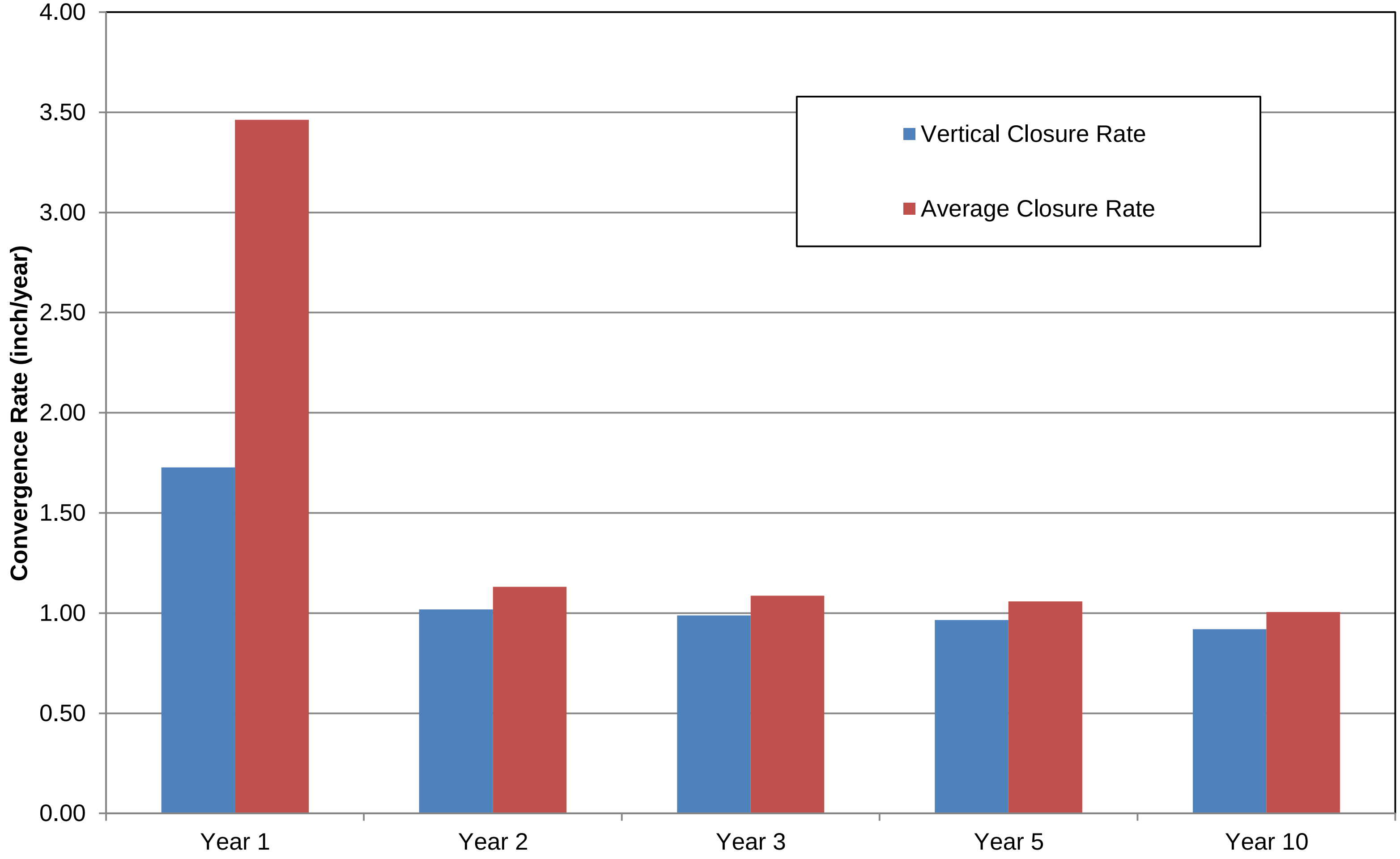

Note: 1) Average convergence rate calculated based on the equivalent circular area for the available air-space of deformed openings
2) Horizontal axis denotes the elapsed time from excavation of each individual room, i.e. time zero varies for each room.

Figure 6

FLAC - Vertical vs. Average Convergence for Panel 9 Geometry - 16-ft Wide x 13-ft High

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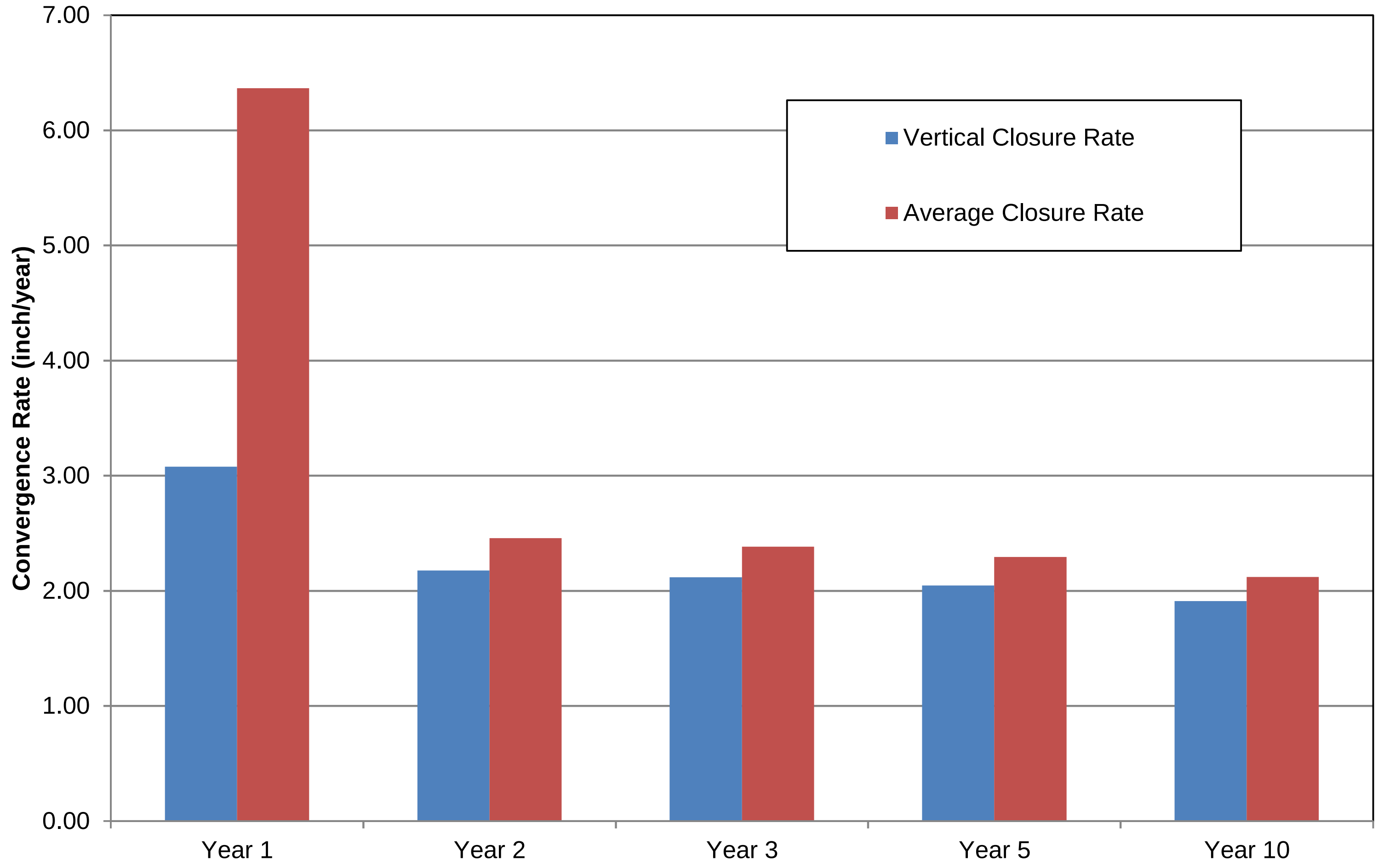

Notes: 1) Average convergence rate calculated based on the equivalent circular area for the available air-space of deformed openings
2) Horizontal axis denotes the elapsed time from excavation of each individual room, i.e. time zero varies for each room.

Figure 7

FLAC - Vertical vs. Average Convergence for Panel 9 Geometry - 25-ft Wide x 15-ft High

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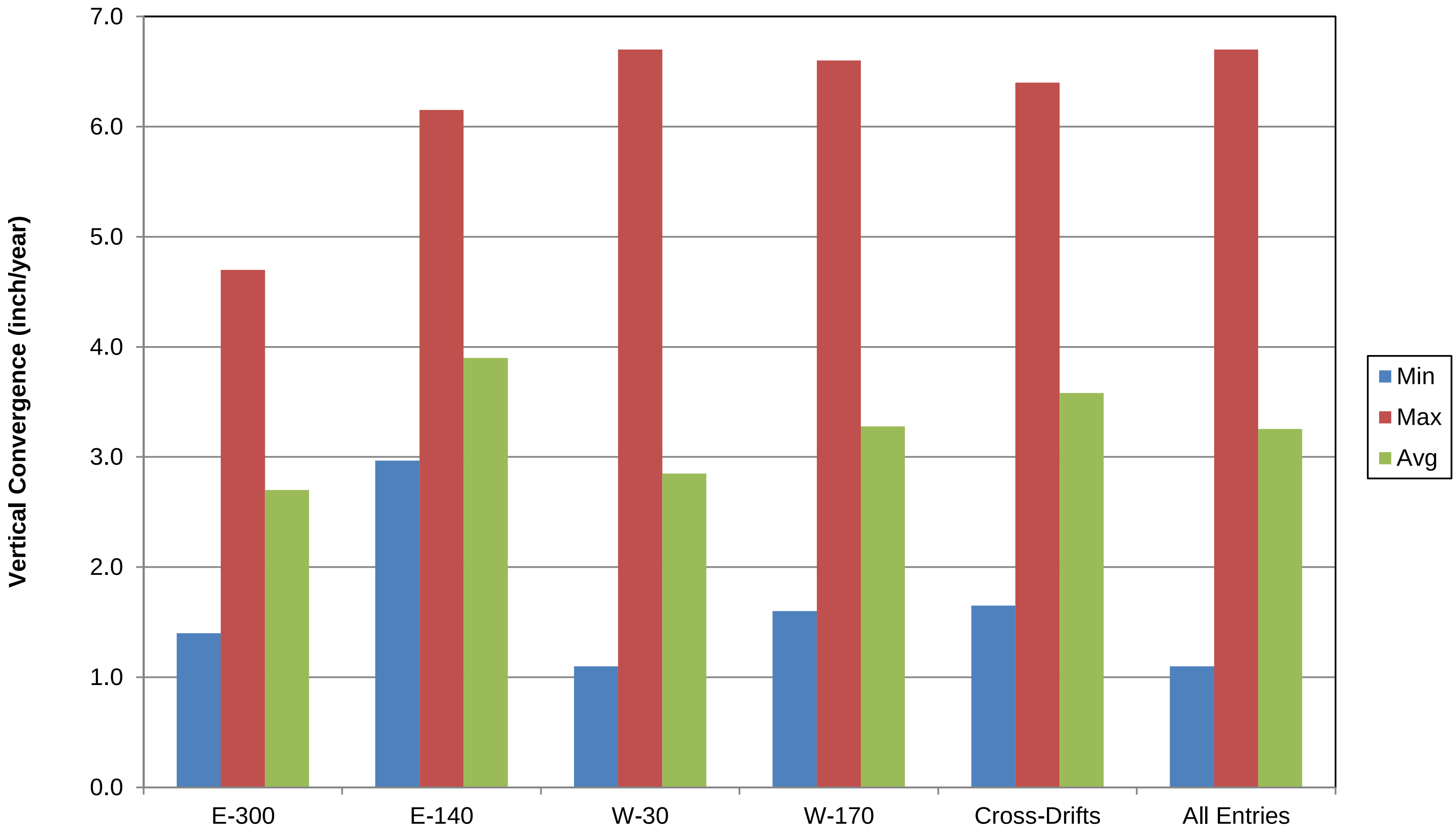

Note: Plot based on convergence data for Panel 9 and 10 locations containing records from 2010 to 2012 for vertical convergence

Figure 8

Vertical Convergence - Panel 9 and 10 Measurements

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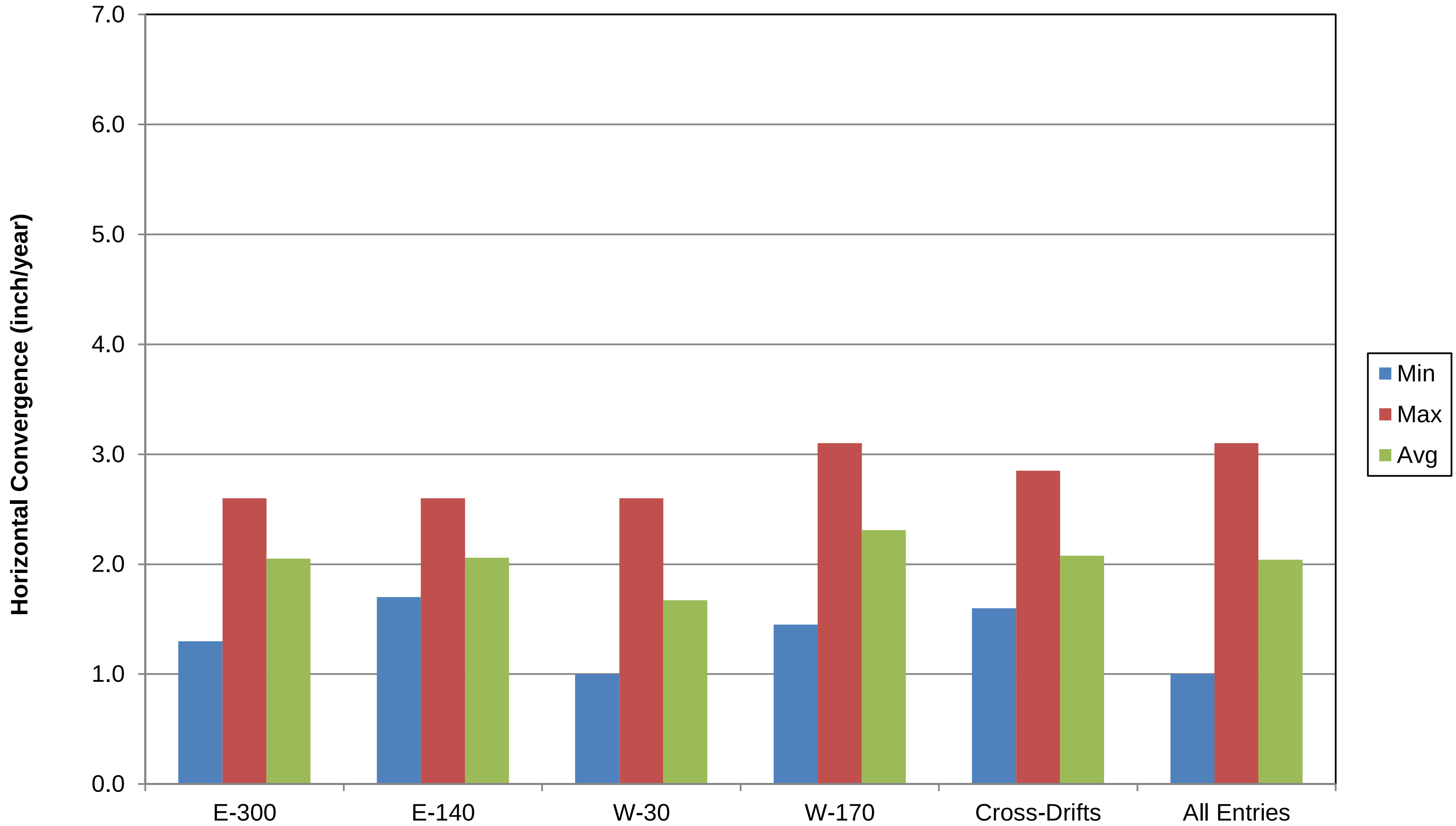

Note: Plot based on convergence data for Panel 9 and 10 locations containing records from 2010 to 2012 for horizontal convergence

Figure 9

Horizontal Convergence - Panel 9 and 10 Measurements

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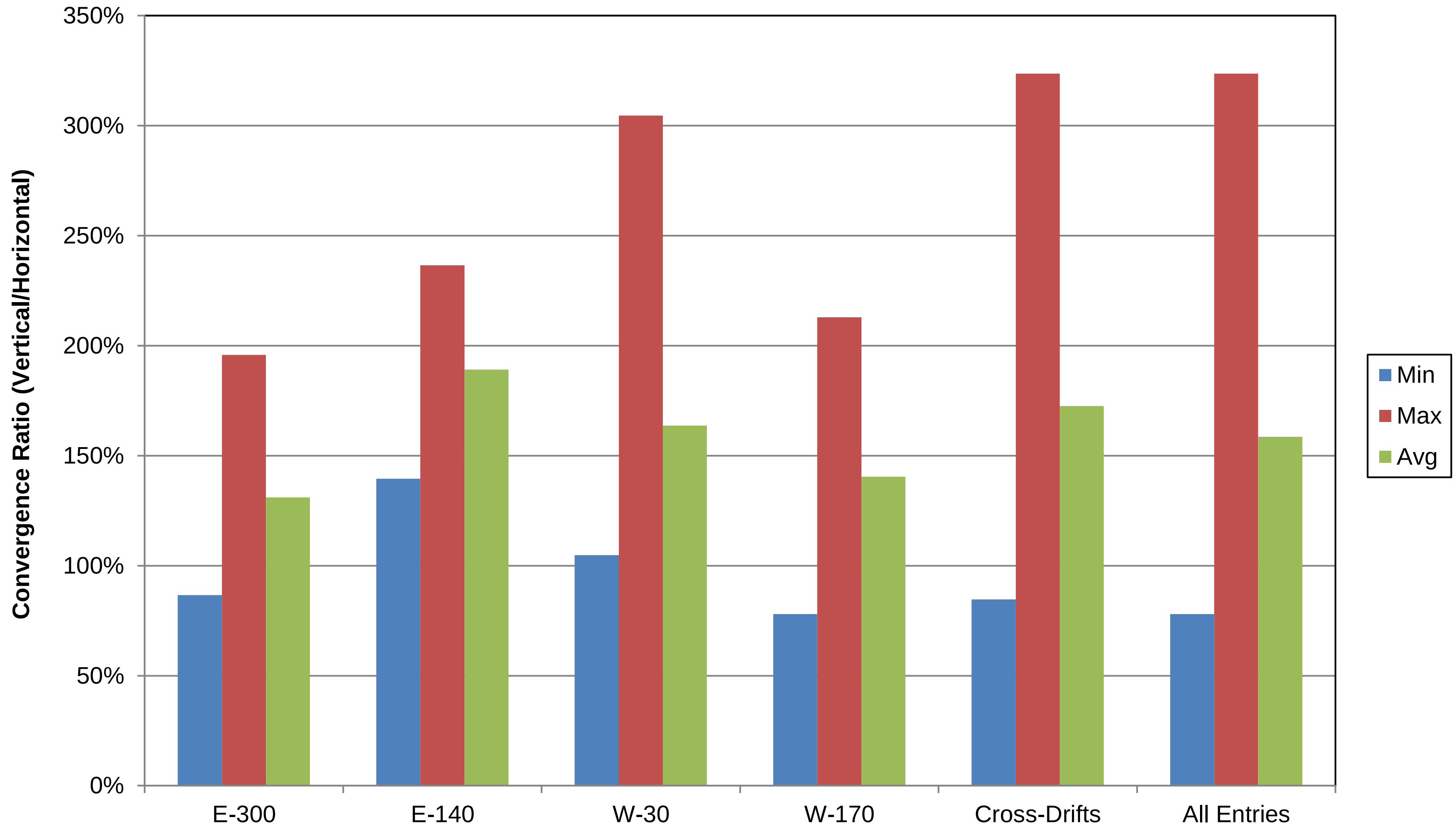

Note: Plot based on convergence data for Panel 9 and 10 locations containing records from 2010 to 2012

Figure 10

Ratio between Vertical and Horizontal Convergence - Panel 9 and 10 Measurements

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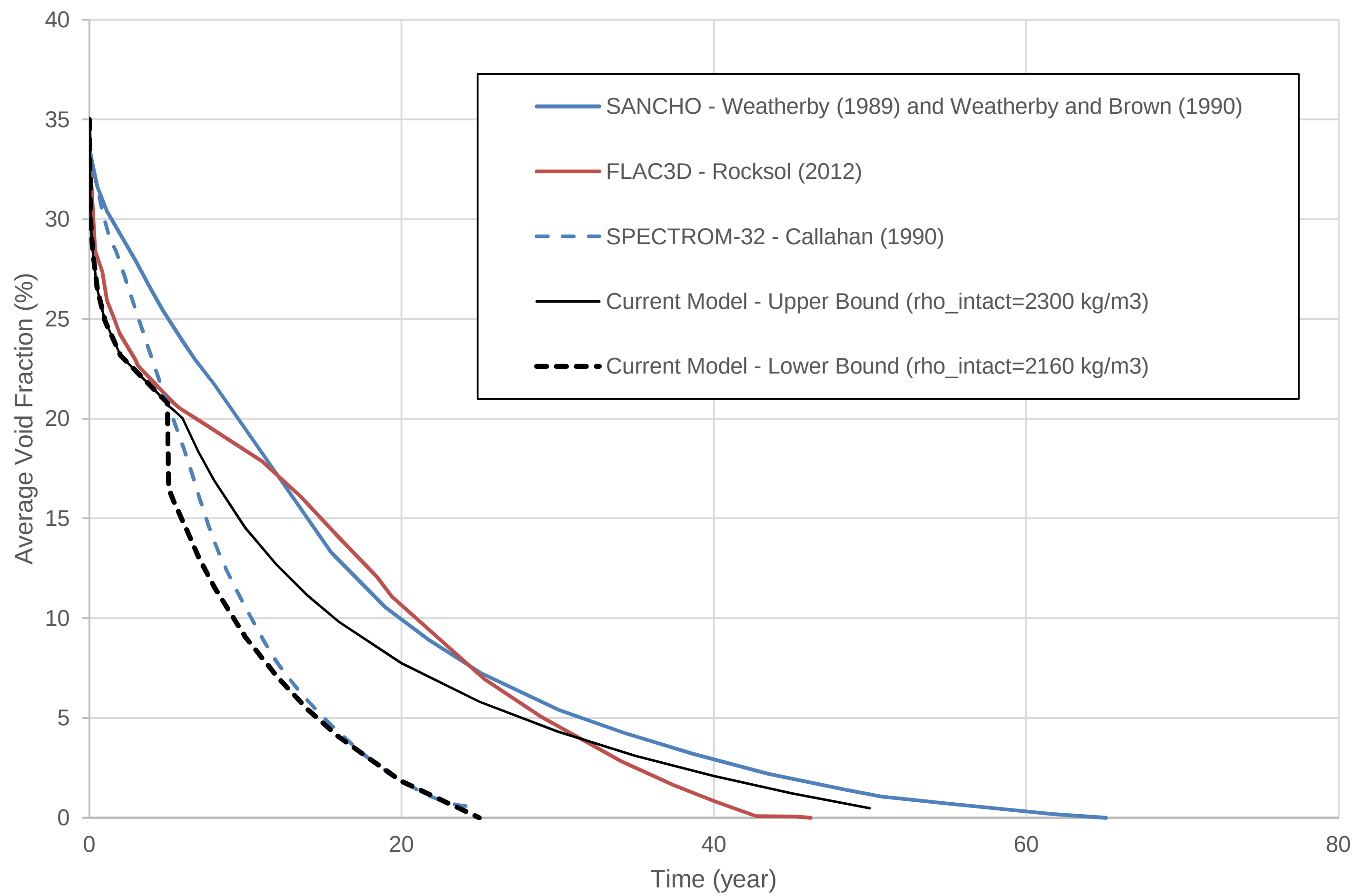

Figure 11

Crushed Salt Model - Comparison w/ Previous Models

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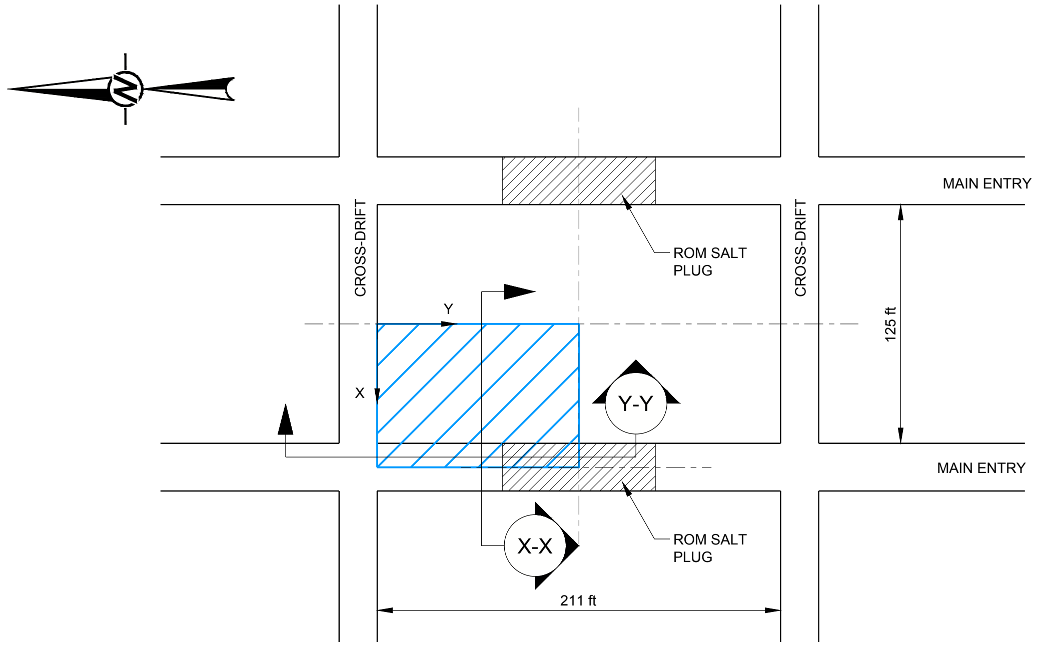


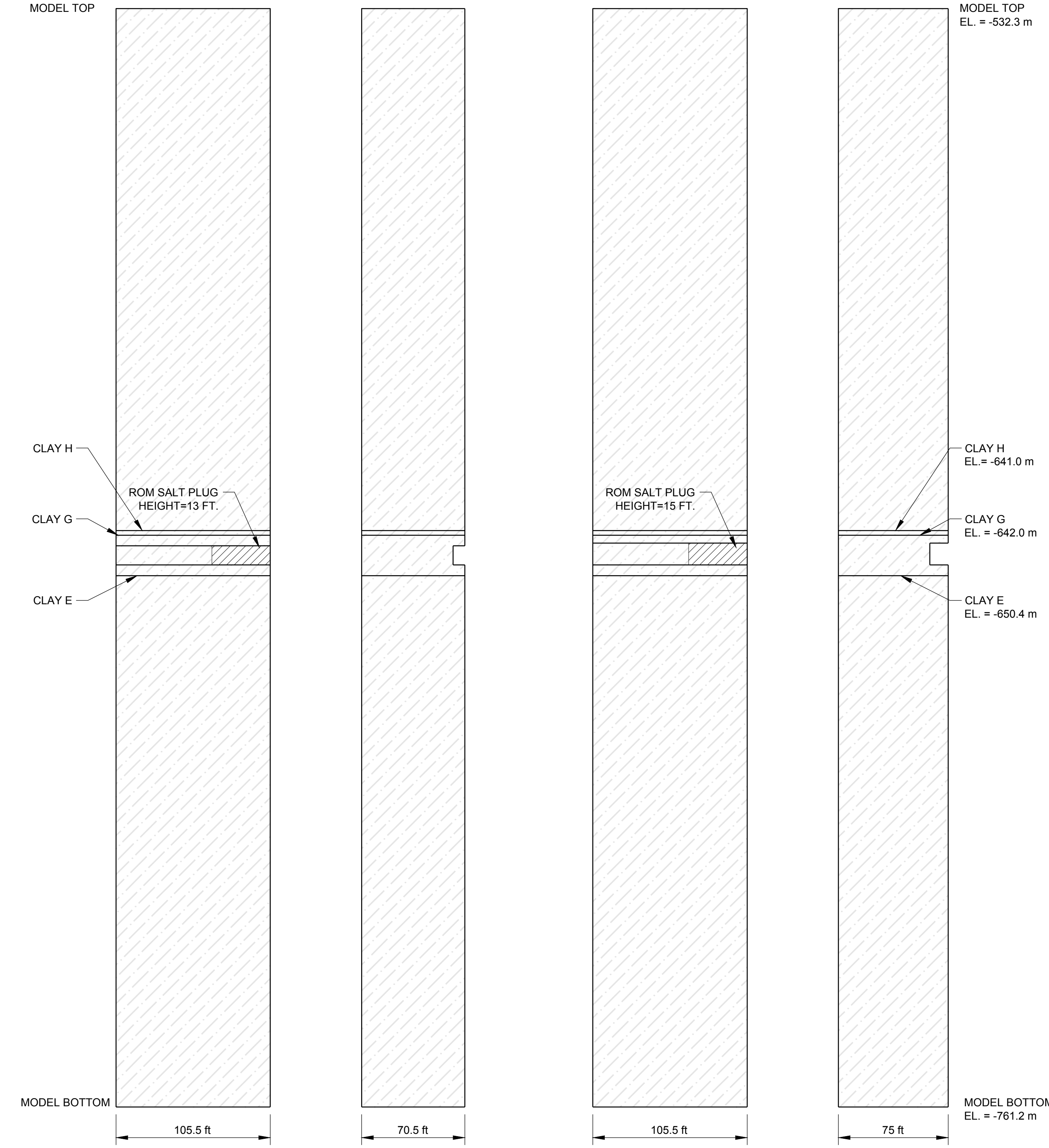
SCHEMATICS OF MODEL EXTENTS - PLAN-VIEW
(NOT TO SCALE)

LEGEND

- ROM SALT LOCATION - PANEL 10 CLOSURE SYSTEM (WPC-B)
- PLAN-VIEW EXTENTS OF MODEL GEOMETRY (SEE NOTES 1 AND 2)

NOTES

1. FOR SIMPLICITY AND CONSERVATISM, MODEL GEOMETRY WAS BASED ON THE PILLAR DIMENSIONS OF 211 FT x 125 FT (LENGTH X WIDTH), I.E. APPROXIMATE DIMENSIONS OF THE MINIMUM PILLAR BETWEEN ENTRIES, AND ASSUMING MODEL SYMMETRY DEFINED BY ROM SALT PLUG CENTERLINES IN BOTH LONGITUDINAL AND TRANSVERSE DIRECTIONS.
2. TO IMPROVE NUMERICAL PERFORMANCE, THE MODEL DOES NOT DOES NOT ACCOUNT FOR THE CROSS-DRIFT GEOMETRY. TO SIMULATE INCREASES IN ROM SALT STRESSES DUE TO THE PRESENCE OF CROSS-DRIFTS, THE SELF WEIGHT OF SALT MATERIALS IN THE MODEL WAS INCREASED BY 10 PERCENT.



SECTION Y-Y SECTION X-X

MAIN ENTRY WIDTH = 16 FT

SECTION Y-Y SECTION X-X

MAIN ENTRY WIDTH = 25 FT

CLIENT	NUCLEAR WASTE PARTNERSHIP LLC
PROJECT	WIPP CLOSURE GEO-MECHANICAL COMPLIANCE
CONSULTANT	Golder Associates
YYYY-MM-DD	2016-07-20
PREPARED	GG
DESIGN	GG
REVIEW	WTT
APPROVED	WTT
TITLE	**CREEP CALCULATIONS** *MODEL GEOMETRY FOR ROM SALT ANALYSES USING FLAC3D*
PROJECT No.	063-2213NEW
CONTROL	
Rev.	----
FIGURE	12

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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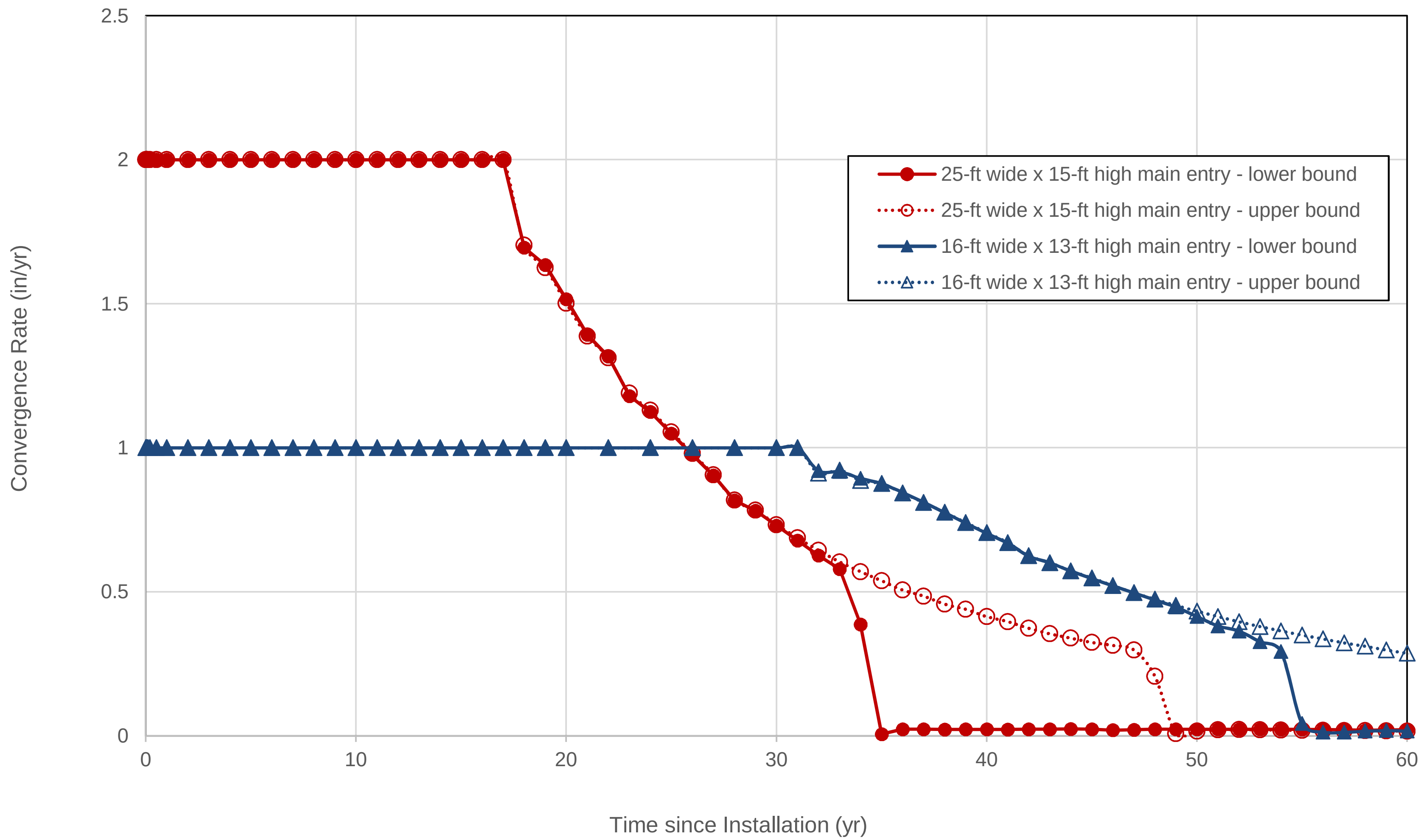

Figure 13

Calculated Vertical Convergence Rates after ROM Salt Emplacement

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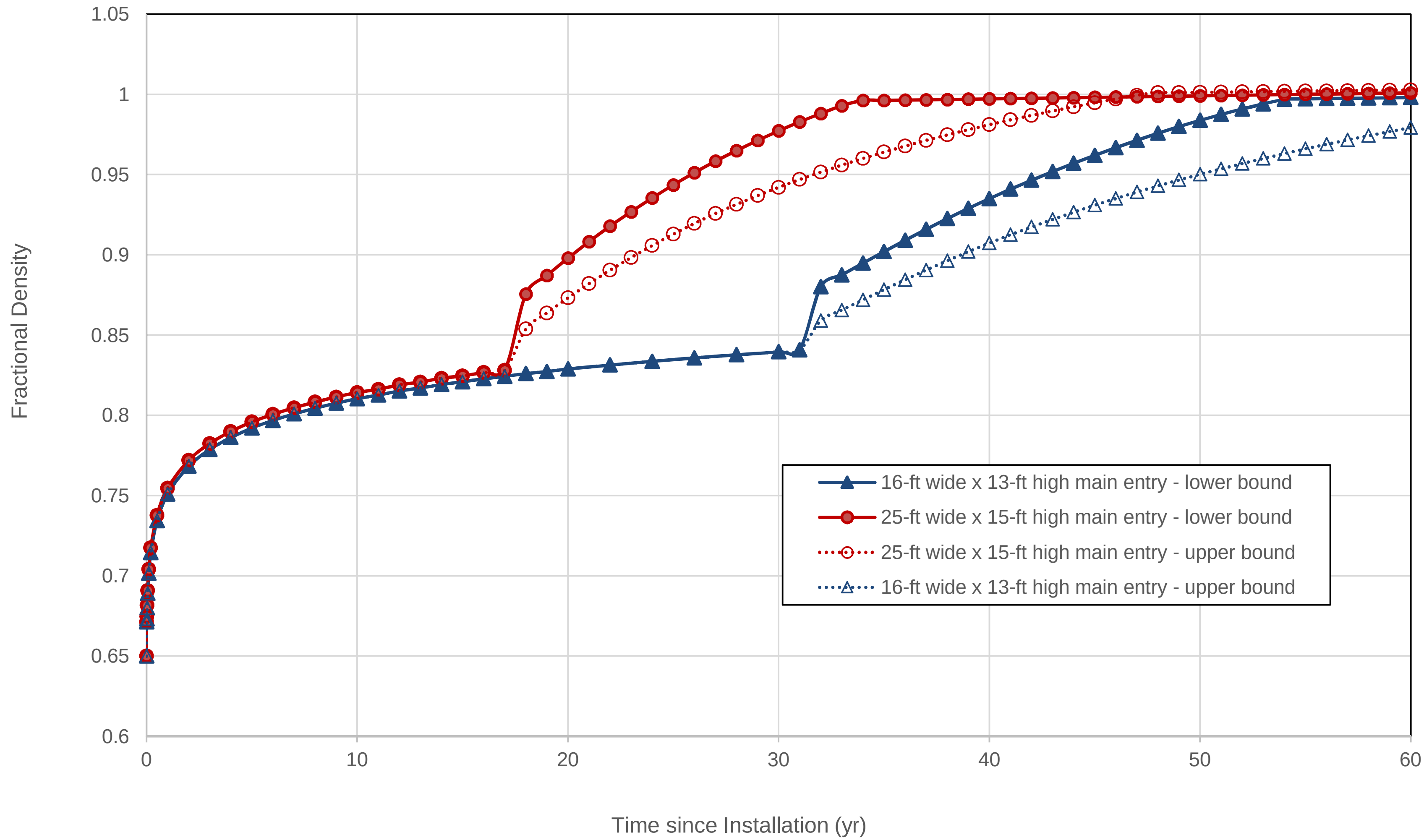

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Figure 14

Fractional Density of ROM Salt vs. Time

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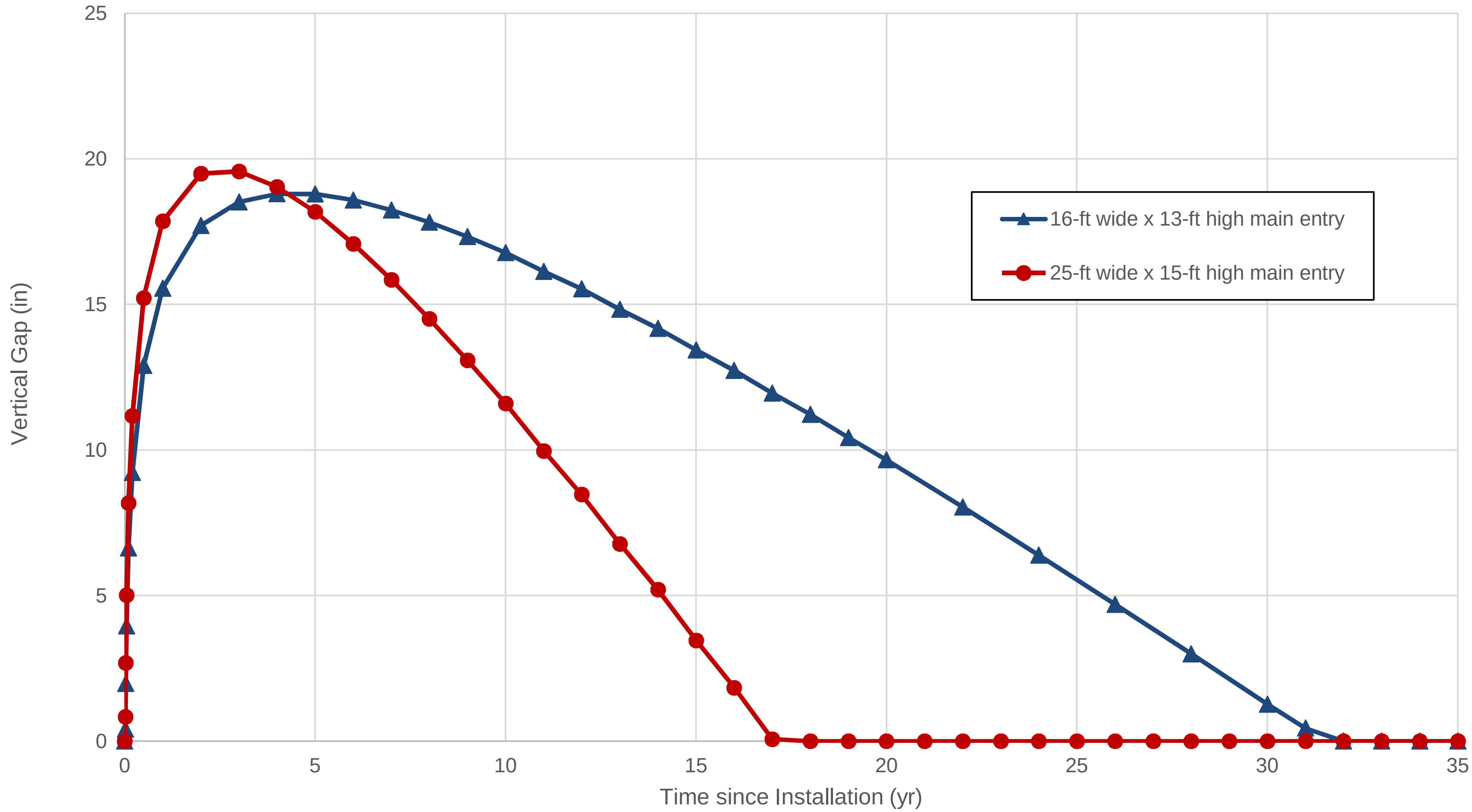

Figure 15

Air Gap Magnitude vs. Time

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ATTACHMENT 1
CONVERGENCE MEASUREMENTS (DOE 2011, 2013)

Table A1-1 Convergence Measurements Used to Estimate Creep Closure for Panels 1 to 8

Room 1 Panel 5 - room center	4.4	inch/yr	pg 5-41	DOE 2011
Room 2 Panel 5 - room center	4.2	inch/yr	pg 5-42	DOE 2011
Room 3 Panel 5 - room center	4.1	inch/yr	pg 5-44	DOE 2011
Room 4 Panel 5 - room center	4	inch/yr	pg 5-45	DOE 2011
Room 5 Panel 5 - room center	3.5	inch/yr	pg 5-47	DOE 2011
Room 6 Panel 5 - room center	3.25	inch/yr	pg 5-48	DOE 2011
Average	**3.9**	inch/yr		

Table A1-2 Panel 5 - Extensometer and Convergence Measurements - WIPP GAR Report for July 2009 to June 2010 (DOE 2011)

				Collar displacements relative to deepest anchor			
Extensometers - Room Center, Roof				Displacement rates (inch/yr)			
Room	Location	Extensometer ID	Figure	2009-2010	2008-2009	Ref	Excavation Date
1	W390 S3480	51X-GE-00389	5-32	2.67	1.87	DOE 2011, pg 5-21	Sep, 2006
2	W520 S3480	51X-GE-00390	5-33	2.12	1.86	DOE 2011, pg 5-21	Jan, 2007
3	W660 S3480	51X-GE-00391	5-34	2.07	1.66	DOE 2011, pg 5-21	Feb, 2007
4	W790 S3480	51X-GE-00392	5-35	1.77	1.47	DOE 2011, pg 5-21	Apr, 2007
5	W920 S3480	51X-GE-00393	5-36	0.97	1.03	DOE 2011, pg 5-21	Apr, 2007
6	W1050 S3480	51X-GE-00394	5-37	0.94	0.96	DOE 2011, pg 5-21	May, 2007
7	W1190 S3480	51X-GE-00395	5-38	0.98	1.04	DOE 2011, pg 5-21	Jun, 2007

Convergence Points - Room Center, Roof to Floor				Convergence rates (inch/yr)			
Room	Location	Convergence Array ID	Figure	2009-2010	2008-2009		
1	W390 S3480	W390 S3480-2 A-C	5-64	4.88	4.22	DOE 2011, pg 5-22	Aug, 2006
2	W520 S3480	W520 S3480-2 A-C	5-67	4.24	3.98	DOE 2011, pg 5-22	Aug, 2006
3	W660 S3480	W660 S3480-2 A-C	5-70	4.24	3.8	DOE 2011, pg 5-22	Feb, 2007
4	W790 S3480	W790 S3480-2 A-C	5-73	3.93	3.64	DOE 2011, pg 5-22	Apr, 2007
5	W920 S3480	W920 S3480-2 A-C	5-76	3.34	3.25	DOE 2011, pg 5-22	May, 2007
6	W1050 S3480	W1050 S3480-2 A-C	5-79	3.38	3.12	DOE 2011, pg 5-23	May, 2007

Table A1-3 Panel 6 - Extensometer and Convergence Measurements, WIPP GAR Report for July 2009 to June 2010 (DOE 2011)

Extensometers - Room Center, Roof				Collar displacements relative to deepest anchor Displacement rates (inch/yr)			
Room	Location	Extensometer ID	Figure	2009-2010	2008-2009	Ref	Excavation Date
1	W390 S2916	51X-GE-00403	5-97	3.87	2.41	DOE 2011, pg 5-57	Aug, 2008
2	W520 S2916	51X-GE-00405	5-98	3.1	n/a	DOE 2011, pg 5-57	Feb, 2009
3	W660 S3916	51X-GE-00406	5-99	2.81	n/a	DOE 2011, pg 5-57	Apr, 2009
4	W790 S2916	51X-GE-00407	5-100	2.7	n/a	DOE 2011, pg 5-57	Jun, 2009
5	W920 S2916	51X-GE-00408	5-101	1.79	n/a	DOE 2011, pg 5-57	Aug, 2009
6	W1050 S2916	51X-GE-00409	5-102	3.11	n/a	DOE 2011, pg 5-57	Aug, 2009
7	W1190 S2916	51X-GE-00410	5-103	2.16	n/a	DOE 2011, pg 5-57	Sep, 2009

Convergence Points - Room Center, Roof to Floor				Convergence rates (inch/yr)			
Room	Location	Convergence Array ID	Figure	2009-2010	2008-2009	Ref	Excavation Date
1	W390 S2916	W390 S2916 A-C	5-121	11	7.03	DOE 2011, pg 5-58	Aug, 2008
2	W520 S2916	W520 S2916 A-C	5-124	8.12	8.27	DOE 2011, pg 5-58	Feb, 2009
3	W660 S3916	W660 S3916 A-C	5-127	7.51	11.58	DOE 2011, pg 5-58	Apr, 2009
4	W790 S2916	W790 S2916 A-C	5-130	6.57	n/a	DOE 2011, pg 5-58	Jun, 2009
5	W920 S2916	W920 S2916 A-C	5-133	5.4	n/a	DOE 2011, pg 5-58	Jun, 2009
6	W1050 S2916	W1050 S2916 A-C	5-136	6.06	n/a	DOE 2011, Fig. 5-136	Aug, 2009
7	W1190 S2916	W1190 S2916 A-C	5-139	5.84	n/a	DOE 2011, pg 5-59	Sep, 2009

Table A1-4 Panel 5 Convergence Measurements at Room And Drift S-3650 Intersection , WIPP GAR Report for July 2009 to June 2010 (DOE 2011)

Location	Convergence rate		Ref
S3650 W390 Intersection (R1P5)	3.3	inch/yr	DOE 2011, pg 5-50
S3650-W-0520 Intersection (R2P5)	3.8	inch/yr	DOE 2011, pg 5-51
S3650 - W0660 Intersection (R3,P5)	3.3	inch/yr	DOE 2011, pg5-52
S3650-W-0790 Intersection (R4P5)	4	inch/yr	DOE 2011, pg 5-53
S3650-W920 Intersection (R5P5)	3.5	inch/yr	DOE 2011, pg 5-54
S3650 - W1050 Intersection (R6P5)	3.2	inch/yr	DOE 2011, pg 5-55
S3650 - W1190 Intersection (R7P5)	2.1	inch/yr	DOE, 2011 pg 5-56
Average convergence	3.31	inch/yr	

Table A1-5 Convergence Rates to Estimate Creep Closure for Panel 9

Convergence Points									
		Figure	Last Reading 2011-2012		Cumulative Displacement	Closure Rate 2011 to 2012	Closure Rate 2010 to 2011	Rate Change	
Field Tag	Location	Number	Date	Inches	(inches)	(in/year)	(in/year)	(%)	Comments
CORE-W10 A-C	Core Storage W10	12875	5/10/2012	22.813	22.813	0.9	0.9	0%	
CORE-W20 A-C	Core Storage W20	12875	5/10/2012	21.632	21.632	0.9	0.9	0%	
CORE-W30 A-C	Core Storage W30	12875	5/10/2012	22.808	22.808	1	1.1	-9%	
CORE-W51 A-C	Core Storage W51	12875	5/10/2012	26.465	26.465	1.3	1.4	-7%	
CORE-W62 A-C	Core Storage W62	12875	5/10/2012	27.742	27.742	1.4	1.5	-7%	
CORE-W73 A-C	Core Storage W73	12875	5/10/2012	28.009	28.009	1.4	1.5	-7%	
CORE-W101 A-C	Core Storage W101	12875	5/10/2012	27.008	27.008	1.3	N/A	N/A	
CORE-W117 A-C	Core Storage W117	12875	5/10/2012	24.224	24.224	1.1	1.1	0%	
CORE-W133 A-C	Core Storage W133	12875	5/10/2012	20.247	20.247	0.9	0.9	0%	
E0-N75 A-C	E0-N75	13241	6/6/2012	19.634	19.634	1.8	2	-10%	
E0-N75 B-D	E0-N75	13241	6/6/2012	13.703	13.703	1.1	1.4	-21%	
E0-N225-2 A-C	E0-N225	13606	6/5/2012	19.43	19.477	1.7	2	-15%	
E0-N225-2 B-D	E0-N225	13606	6/5/2012	2.882	15.187	1.3	1.6	-19%	
E0-N300-6 A-C	E0-N300	13971	6/5/2012	2.993	19.33	1.7	2.8	-39%	Cumulative is from N300 only (N290 not included).
E0-N460-3 A-C	E0-N460	Apr-39	6/5/2012	23.014	43.103	2.2	2.4	-8%	
E0-N562 A-C	E0-N562	Apr-40	6/5/2012	17.485	17.485	2.2	2	10%	
E0-N562 B-D	E0-N562	Apr-40	6/5/2012	14.815	14.815	1.5	1.6	-6%	
E0-N626-4 A-C	E0-N626	Apr-41	6/6/2012	22.053	63.012	3.1	2	55%	
E0-N686 A-C	E0-N686	Apr-42	6/6/2012	24.337	24.337	4	2	100%	
E0-N686 B-D	E0-N686	Apr-42	6/6/2012	13.743	13.743	1.3	1.3	0%	
E0-N780-2 A-C	E0-N780	Apr-43	6/6/2012	18.928	39.35	2	2.3	-13%	
E0-N940-5 A-C	E0-N940	Apr-44	6/6/2012	19.395	67.447	2.4	3.2	-25%	
E0-N1110-5 A-C	E0-N1110	Apr-45	6/6/2012	13.078	47.502	1.4	1.8	-22%	
E0-N1266-4 A-C	E0-N1266	Apr-46	6/6/2012	21.3	58.207	2.1	2.2	-5%	
E140-N5-6 A-C	E140-N5	Apr-47	6/12/2012	13.262	45.104	2.4	2.3	4%	
E140-N5-3 B-D	E140-N5	Apr-47	6/12/2012	17.392	32.633	1.1	1.2	-8%	
E140-N220-3 A-C	E140-N220	Apr-48	6/12/2012	14.58	40.379	2.5	2.5	0%	
E140-N355-2 A-C	E140-N355	Apr-49	6/12/2012	11.91	20.454	2.4	2.2	9%	
E140-N355 B-D	E140-N355	Apr-49	6/12/2012	17.186	17.186	1.6	1.7	-6%	
E140-N460-3 A-C	E140-N460	Apr-50	6/12/2012	21.47	42.301	2.1	2.3	-9%	
E140-N150-4 A-C	E140-N150	Apr-51	6/12/2012	11.066	30.124	1.8	1.7	6%	
E140-N562-2 A-C	E140-N562	Apr-52	6/12/2012	20.739	32.556	2.6	2.5	4%	
E140-N562-2 B-D	E140-N562	Apr-52	6/12/2012	14.714	22.91	1.6	1.7	-6%	
E140-N626-3 A-C	E140-N626	Apr-53	6/12/2012	28.56	61.13	3.8	3.4	12%	
E140-N626-4 B-D	E140-N626	Apr-53	6/12/2012	14.072	35.379	1.5	1.6	-6%	
E140-N686-2 A-C	E140-N686	Apr-54	6/12/2012	22.895	36.034	3.1	2.8	11%	
E140-N686-2 B-D	E140-N686	Apr-54	6/12/2012	14.148	22.982	1.6	1.6	0%	
E140-N780-2 A-C	E140-N780	Apr-55	6/12/2012	27.118	58.875	3.1	2.9	7%	

Table A1-5 Convergence Rates to Estimate Creep Closure for Panel 9

Convergence Points									
			Last Reading 2011-2012		Cumulative Displacement	Closure Rate 2011 to 2012	Closure Rate 2010 to 2011	Rate Change	
Field Tag	Location	Figure Number	Date	Inches	(inches)	(in/year)	(in/year)	(%)	Comments
E140-N940-2 A-C	E140-N940	Apr-56	6/12/2012	25.613	25.613	4.6	3.6	28%	Initial installations were at N952.
E140-N940-2 B-D	E140-N940	Apr-56	2/22/2012	9.278	9.278	1.2	1.3	-8%	
E140-N1100-2 A-C	E140 -N1100	Apr-57	6/12/2012	12.255	36.123	1.7	1.7	0%	
E140-N1266-3 A-C	E140-N1266	Apr-58	6/12/2012	19.944	57.699	2.5	2.4	4%	
E140-N1266-4 B-D	E140-N1266	Apr-58	6/12/2012	9.977	31.982	1.3	1.3	0%	
E140-N1420-2 A-C	E140-N1420	Apr-59	6/13/2012	13.529	29.999	1.9	1.7	12%	
E140-S90-4 A-C	E140-S90	Apr-60	5/22/2012	9.246	26.959	1.5	1.6	-6%	
E140-S262-4 A-C	E140-S262	Apr-61	5/22/2012	15.685	36.596	2.1	2.3	-9%	
E140-S262-3 B-D	E140-S262	Apr-61	5/22/2012	20.866	22.219	1	1.2	-17%	
E140-S460-6 A-C	E140-S460	Apr-62	5/22/2012	2.731	53.467	2.1	2.2	-5%	
E140-S460-2 B-D	E140-S460	Apr-62	5/22/2012	26.948	32.892	1.2	1.3	-8%	
E140-S550-6 A-C	E140-S550	Apr-63	5/22/2012	2.567	44.534	1.9	2.2	-14%	
E140-S550-4 B-D	E140-S550	Apr-63	5/22/2012	29.418	38.06	1.5	1.7	-12%	
E140-S700-8 A-D	E140-S700	Apr-64	5/22/2012	3.111	33.151	2.2	2.8	-21%	
E140-S700-6 B-C	E140-S700	Apr-65	5/22/2012	5.595	35.627	2.8	2.7	4%	
E140-S700-6 E-F	E140-S700	Apr-66	5/22/2012	3.077	23.074	1.4	1.6	-13%	
E140-S850-9 A-C	E140-S850	Apr-67	5/22/2012	4.942	56.455	2.5	2.6	-4%	
E140-S850-4 B-D	E140-S850	Apr-68	5/22/2012	19.621	35.568	1.3	1.3	0%	
E140-S1000-3 A-C	E140-S1000	Apr-69	5/22/2012	3.565	39.213	1.4	1.9	-26%	
E140-S1025-4 A-C	E140-S1025	Apr-70	6/19/2012	4.137	26.314	2	2	0%	
E140-S1075-4 A-E	E140-S1075	Apr-71	6/19/2012	5.262	27.492	2.5	2.5	0%	
E140-S1075-4 B-D	E140-S1075	Apr-72	6/19/2012	2.566	21.475	1.2	1.2	0%	
E140-S1075-4 F-H	E140-S1075	Apr-72	6/19/2012	3.585	20.444	1.7	1.7	0%	
E140-S1075-2 C-G	E140-S1075	Apr-73	6/19/2012	18.187	19.009	1.4	1.5	-7%	
E140-S1150-4 A-G	E140-S1150	Apr-74	6/19/2012	8.773	66.803	4.2	4.4	-5%	
E140-S1150-2 D-J	E140-S1150	Apr-75	6/19/2012	19.721	37.642	1.6	1.6	0%	
E140-S1150 C-K	E140-S1150	Apr-75	6/19/2012	18.517	18.517	1.3	1.4	-7%	
E140-S1150-2 E-I	E140-S1150	Apr-75	6/19/2012	17.841	18.702	1.5	1.5	0%	
E140-S1150-6 B-F	E140-S1150	Apr-76	6/19/2012	1.633	31.37	2.1	N/A	N/A	
E140-S1150-5 L-H	E140-S1150	Apr-76	6/19/2012	4.564	24.757	2.1	2.3	-9%	
E140-S1225-4 A-E	E140-S1225	Apr-77	6/19/2012	7.83	34.527	4	3.6	11%	
E140-S1225-2 C-G	E140-S1225	Apr-77	6/19/2012	25.601	26.508	2.3	2.4	-4%	
E140-S1225-4 B-D	E140-S1225	Apr-78	6/19/2012	1.531	34.132	3.7	N/A	N/A	
E140-S1225-3 H-F	E140-S1225	Apr-78	6/19/2012	4.661	24.095	2.5	2.3	9%	
E140-S1300-4 A-C	E140-S1300	Apr-79	6/19/2012	20.468	37.051	1.7	1.7	0%	
E140-S1378-3 A-E	E140-S1378	Apr-80	6/19/2012	6.27	40.707	3.5	2.9	21%	
E140-S1378-3 B-D	E140-S1378	Apr-81	6/19/2012	3.49	28.592	1.9	1.7	12%	
E140-S1378-3 H-F	E140-S1378	Apr-81	6/19/2012	6.09	43.86	3.8	2.6	46%	

Table A1-5 Convergence Rates to Estimate Creep Closure for Panel 9

Convergence Points									
		Figure	Last Reading 2011-2012		Cumulative Displacement	Closure Rate 2011 to 2012	Closure Rate 2010 to 2011	Rate Change	
Field Tag	Location	Number	Date	Inches	(inches)	(in/year)	(in/year)	(%)	Comments
E140-S1378 C-G	E140-S1378	Apr-82	6/19/2012	22.195	26.365	1.7	1.7	0%	
E140-S1450-5 A-G	E140-S1450	Apr-83	6/19/2012	7.698	79.068	3.8	4.1	-7%	
E140-S1450-3 B-F	E140-S1450	Apr-84	6/19/2012	6.131	46.115	3.2	3.1	3%	
E140-S1450-3 L-H	E140-S1450	Apr-84	6/19/2012	6.036	40.304	3	3.2	-6%	
E140-S1456 K-C	E140-S1456	Apr-85	6/19/2012	21.075	21.075	1.5	1.5	0%	
E140-S1450-3 I-E	E140-S1450	Apr-85	6/19/2012	2.654	20.746	1.5	1.5	0%	
E140-S1456-2 D-J	E140-S1456	Apr-86	6/19/2012	23.675	44.97	1.9	2	-5%	
E140-S1534-3 A-E	E140-S1534	Apr-87	6/19/2012	5.87	52.033	3.1	3.1	0%	
E140-S1534-2 C-G	E140-S1534	Apr-87	6/19/2012	21.02	22.491	1.7	1.7	0%	
E140-S1534-4 B-D	E140-S1534	Apr-88	6/19/2012	4.593	33.468	2.5	2.3	9%	
E140-S1534-3 H-F	E140-S1534	Apr-88	6/19/2012	4.985	36.544	2.6	2.6	0%	
E140-S1600-6 A-C	E140-S1600	Apr-89	6/19/2012	4.063	40.8	2.1	2	5%	
E140-S1687-3 A-E	E140-S1687	Apr-90	6/19/2012	7.148	47.404	3.6	3.8	-5%	
E140-S1687-3 B-D	E140-S1687	Apr-90	6/19/2012	4.725	35.586	2.4	2.5	-4%	
E140-S1687 C-G	E140-S1687	Apr-90	6/19/2012	23.318	23.318	1.9	1.9	0%	
E140-S1687-3 H-F	E140-S1687	Apr-90	6/19/2012	5.344	35.401	2.9	2.6	12%	
E140-S1775-3 A-G	E140-S1775	Apr-91	6/19/2012	8.139	66.197	4.3	4.4	-2%	
E140-S1775-4 B-F	E140-S1775	Apr-91	6/19/2012	7.401	55.489	3.9	4	-3%	
E140-S1775-3 L-H	E140-S1775	Apr-91	6/19/2012	4.497	31.48	2.3	2.3	0%	
E140-S1775 C-K	E140-S1775	Apr-92	6/19/2012	22.317	22.317	1.7	1.7	0%	
E140-S1775-2 D-J	E140-S1775	Apr-92	6/19/2012	23.867	25.118	2.2	2.1	5%	
E140-S1775-3 I-E	E140-S1775	Apr-92	6/19/2012	9.333	23.554	1.9	2.1	-10%	
E140-S1862-3 A-E	E140-S1862	Apr-93	6/19/2012	7.407	51.09	3.9	4	-3%	
E140-S1862-3 C-G	E140-S1862	Apr-93	6/19/2012	17.236	23.541	2.2	2.1	5%	
E140-S1862-3 B-D	E140-S1862	Apr-94	6/19/2012	7.517	46.606	4.1	4	2%	
E140-S1862-3 H-F	E140-S1862	Apr-94	6/19/2012	3.829	25.288	2	2.1	-5%	
E140-S1950-6 A-C	E140-S1950	Apr-95	6/19/2012	6.343	54.527	3.3	3.2	3%	
E140-S2007-7 A-C	E140-S2007	Apr-96	6/19/2012	2.318	41.836	4.6	N/A	N/A	
E140-S2065-6 A-C	E140-S2065	Apr-97	6/19/2012	2.775	49.77	5.5	N/A	N/A	
E140-S2065-2 B-D	E140-S2065	Apr-97	6/19/2012	17.272	23.92	2.2	2.2	0%	
E140-S2122-5 A-C	E140-S2122	Apr-98	6/19/2012	2.499	47.353	5	N/A	N/A	
E140-S2275-6 A-C	E140-S2275	Apr-99	6/18/2012	1.987	75.702	7.2	N/A	N/A	
E140-S2275 B-D	E140-S2275	Apr-99	6/18/2012	25.737	25.737	2.4	2.5	-4%	
E140-S2350-6 A-C	E140-S2350	4-100	6/18/2012	3.186	79.516	6.5	N/A	N/A	
E140-S2350-2 B-D	E140-S2350	4-100	6/18/2012	27.188	34.079	2.6	2.6	0%	
E140-S2425-5 A-C	E140-S2425	4-101	6/18/2012	1.34	52.874	4.8	N/A	N/A	
E140-S2425 B-D	E140-S2425	4-101	6/18/2012	26.76	26.76	2.6	2.6	0%	
E140-S2520-3 A-C	E140-S2520	4-102	6/18/2012	6.965	38.986	3.6	3.7	-3%	

Table A1-5 Convergence Rates to Estimate Creep Closure for Panel 9

Convergence Points									
			Last Reading 2011-2012		Cumulative Displacement	Closure Rate 2011 to 2012	Closure Rate 2010 to 2011	Rate Change	
Field Tag	Location	Figure Number	Date	Inches	(inches)	(in/year)	(in/year)	(%)	Comments
E140-S2634 A-C	E140-S2634	4-103	6/18/2012	53.737	53.737	5.8	6.5	-11%	
E140-S2634 B-D	E140-S2634	4-103	6/18/2012	20.787	20.787	2.6	2.6	0%	
E140-S2750-3 A-C	E140-S2750	4-104	6/18/2012	5.352	24.523	3.1	2.8	11%	
E140-S2833-3 A-C	E140-S2833	4-105	6/18/2012	16.073	36.872	5.1	5	2%	
E140-S2833 B-D	E140-S2833	4-105	6/18/2012	18.305	18.305	2.2	2.3	-4%	
E140-S2915-3 A-C	E140-S2915	4-106	6/18/2012	12.195	38.411	3.1	3.6	-14%	
E140-S2915 B-D	E140-S2915	4-106	6/18/2012	19.819	19.819	2.4	2.4	0%	
E140-S2998-3 A-C	E140-S2998	4-107	6/18/2012	12.581	39.736	3.7	3.9	-5%	
E140-S2998 B-D	E140-S2998	1-107	6/18/2012	18.238	18.238	2.1	2.1	0%	
E140-S3080-2 A-C	E140-S3080	4-108	6/18/2012	10.984	27.123	3.5	3.3	6%	
E140-S3195-2 A-C	E140-S3195	4-109	6/18/2012	13.09	39.345	4.1	3.8	8%	
E140-S3195 B-D	E140-S3195	4-109	6/18/2012	18.083	18.083	2.1	2	5%	
E140-S3295-2 A-C	E140-S3295	4-110	6/18/2012	8.286	15.991	2.5	2.5	0%	
E140-S3325 A-C	E140-S3325	4-111	6/18/2012	15.592	15.592	2.4	2.4	0%	
E140-S3395-2 A-C	E140-S3395	4-112	6/18/2012	12.438	27.596	3.6	3.7	-3%	
E140-S3395 B-D	E140-S3395	4-112	6/18/2012	12.717	12.717	1.7	1.8	-6%	
E140-S3480-2 A-C	E140-S3480	4-113	6/18/2012	13.474	27.774	4.2	4	5%	
E140-S3480 B-D	E140-S3480	4-113	6/18/2012	13.052	13.052	1.8	1.8	0%	
E140-S3565-2 A-C	E140-S3565	4-114	4/23/2012	9.409	20.737	3.1	2.9	7%	
E140-S3565 B-D	E140-S3565	4-114	4/23/2012	12.047	12.047	1.6	1.8	-11%	
E140-S3650-2 A-C	E140-S3650	4-115	6/11/2012	6.873	13.493	1.9	2.1	-10%	
E300-N45 A-E	E300-N45	4-116	5/30/2012	31.637	31.637	1.3	1.5	-13%	
E300-N45 H-F	E300-N45	4-116	4/2/2012	28.155	28.155	1.2	1.4	-14%	
E300-N45 C-G	E300-N45	4-116	5/30/2012	23.468	23.468	1.2	1.3	-8%	
E300-N170-2 A-E	E300-N170	4-117	5/30/2012	9.462	31.956	1.7	1.8	-6%	
E300-N170-2 C-G	E300-N170	4-117	5/30/2012	10.093	24.937	1.3	1.5	-13%	
E300-N170-2 H-F	E300-N170	4-117	5/30/2012	8.732	28.792	1.6	1.7	-6%	
E300-N250-3 A-C	E300-N250	4-118	5/30/2012	9.29	38.244	1.6	1.7	-6%	
E300-S45-2 A-E	E300-S45	4-119	5/30/2012	25.819	25.819	1.2	1.4	-14%	
E300-S45-2 B-D	E300-S45	4-119	5/30/2012	23.465	23.465	1.5	1.7	-12%	
E300-S45 C-G	E300-S45	4-119	5/30/2012	19.501	19.501	0.8	1	-20%	
E300-S45-2 H-F	E300-S45	4-119	5/30/2012	22.19	22.19	1	1.1	-9%	
E300-S90 A-C	E300-S90	4-120	6/4/2012	18.854	18.854	0.7	0.9	-22%	
E300-S250-2 A-C	E300-S250	4-121	6/4/2012	9.202	13.587	0.7	0.7	0%	
E300-S250-2 B-D	E300-S250	4-121	6/4/2012	9.847	13.893	0.6	0.7	-14%	
E300-S700-2 A-C	E300-S700	4-122	6/4/2012	1.999	21.729	1.4	1.8	-22%	
E300-S850-2 A-E	E300-S850	4-123	6/4/2012	1.024	16.106	0.8	0.9	-11%	
E300-S850-2 B-D	E300-S850	4-123	6/4/2012	0.876	12.177	0.6	0.6	0%	

Table A1-5 Convergence Rates to Estimate Creep Closure for Panel 9

Convergence Points									
			Last Reading 2011-2012		Cumulative Displacement	Closure Rate 2011 to 2012	Closure Rate 2010 to 2011	Rate Change	
Field Tag	Location	Figure Number	Date	Inches	(inches)	(in/year)	(in/year)	(%)	Comments
E300-S850-2 C-G	E300-S850	4-123	6/4/2012	9.115	18.393	0.7	1	-30%	
E300-S850-2 H-F	E300-S850	4-123	6/4/2012	0.764	11.227	0.5	0.6	-17%	
E300-S1000-2 A-C	E300-S1000	4-124	6/4/2012	1.42	20.965	1	1.3	-23%	
E300-S1150-4 A-E	E300-S1150	4-125	6/4/2012	3.663	20.742	2.5	3.3	-24%	
E300-S1150-4 B-D	E300-S1150-4	4-126	6/4/2012	1.119	13.364	0.8	1	-20%	
E300-S1150-4 H-F	E300-S1150	4-126	6/4/2012	1.259	13.015	0.9	1.1	-18%	
E300-S1150-2 C-G	E300-S1150	4-127	6/4/2012	11.168	21.624	1	1.4	-29%	
E300-S1300-2 A-C	E300-S1300	4-128	6/4/2012	2.633	16.167	1.8	2.5	-28%	
E300-S1450-2 A-C	E300-S1450	4-129	6/4/2012	2.595	11.577	1.9	2.1	-10%	
E300-S1450 B-D	E300-S1450	4-129	6/4/2012	12.788	12.788	1.3	1.6	-19%	
E300-S1687-2 A-C	E300-S1687	4-130	6/4/2012	1.744	11.601	1.3	1.5	-13%	
E300-S1687 B-D	E300-S1687	4-130	6/4/2012	12.675	12.675	1.2	1.4	-14%	
E300-S1775-2 A-C	E300-S1775	4-131	6/1/2012	2.119	10.914	1.6	1.8	-11%	
E300-S1775 B-D	E300-S1775	4-131	6/1/2012	12.898	12.898	1.2	1.5	-20%	
E300-S1862-2 A-C	E300-S1862	4-132	6/1/2012	2.681	12.134	2.1	2.4	-13%	
E300-S1862 B-D	E300-S1862	4-132	6/1/2012	14.08	14.08	1.4	1.8	-22%	
E300-S2065-2 A-C	E300-S2065	4-133	6/1/2012	2.45	13.561	1.9	1.9	0%	
E300-S2065 B-D	E300-S2065	4-133	6/1/2012	18.147	18.147	2	2.3	-13%	
E300-S2275-2 A-C	E300-S2275	4-134	6/1/2012	4.176	17.602	3.1	3.8	-18%	
E300-S2275 B-D	E300-S2275	4-134	6/1/2012	21.236	21.236	2.3	2.6	-12%	
E300-S2350-2 A-C	E300-S2350	4-135	6/1/2012	5.776	21.34	4.3	5.1	-16%	
E300-S2350 B-D	E300-S2350	4-135	6/1/2012	21.802	21.802	2.2	2.6	-15%	
E300-S2425-2 A-C	E300-S2425	4-136	6/1/2012	4.767	20.989	3.4	4.4	-23%	
E300-S2425 B-D	E300-S2425	4-136	6/1/2012	21.829	21.829	2.1	2.4	-13%	
E300-S2634-2 A-C	E300-S2634	4-137	6/1/2012	2.948	16.333	2.3	2.4	-4%	
E300-S2634 B-D	E300-S2634	4-137	6/1/2012	16.783	16.783	2.1	2.4	-13%	
E300-S2833-2 A-C	E300-S2833	4-138	6/1/2012	2.458	18.75	1.9	2	-5%	
E300-S2833 B-D	E300-S2833	4-138	6/1/2012	17.444	17.444	2.1	2.4	-13%	
E300-S2916-4 A-C	E300-S2916	4-139	6/1/2012	2.978	28.048	2.4	2.2	9%	
E300-S2916 B-D	E300-S2916	4-139	6/1/2012	19.43	19.43	2.4	2.5	-4%	
E300-S2998-4 A-C	E300-S2998	4-140	6/1/2012	4.224	38.974	3	4.5	-33%	
E300-S2998 B-D	E300-S2998	4-140	6/1/2012	19.295	19.295	2.7	2.5	8%	
E300-S3195 A-C	E300-S3195	4-141	6/1/2012	22.342	22.342	3.4	2.9	17%	
E300-S3195 B-D	E300-S3195	4-141	6/1/2012	17.614	17.614	2	1.8	11%	
E300-S3480 A-C	E300-S3480	4-142	12/8/2011	11.166	11.166	2.2	2.4	-8%	
E300-S3480 B-D	E300-S3480	4-142	12/8/2011	8.414	8.414	1.7	1.7	0%	
N140-E90-2 A-C	N140-E90	4-143	6/13/2012	3.354	17.491	0.8	0.7	14%	
N140-E90 B-D	N140-E90	4-143	6/13/2012	18.856	18.856	0.9	0.9	0%	

Table A1-5 Convergence Rates to Estimate Creep Closure for Panel 9

Convergence Points									
			Last Reading 2011-2012		Cumulative Displacement	Closure Rate 2011 to 2012	Closure Rate 2010 to 2011	Rate Change	
Field Tag	Location	Figure Number	Date	Inches	(inches)	(in/year)	(in/year)	(%)	Comments
N215-W500-2 A-C	N215-W500	4-144	6/13/2012	12.204	30.533	1.4	1.3	8%	
N215-W500-2 B-D	N215-W500	4-144	6/13/2012	13.013	19.831	0.9	0.9	0%	
N150-W620-2 A-C	N150-W620	4-145	6/13/2012	9.243	25.461	1.2	1	20%	
N250-E220-2 A-E	N250-E220	4-146	5/30/2012	14.477	38.104	2.4	2.6	-8%	
N250-E220-2 B-D	N250-E220	4-146	5/30/2012	9.945	34.887	1.6	1.8	-11%	
N250-E220 C-G	N250-E220	4-146	5/30/2012	25.94	25.94	1.3	1.6	-19%	
N250-E220-2 H-F	N250-E220	4-146	5/30/2012	8.718	27.143	1.5	1.5	0%	
N300-W170-2 A-C	N300-W170	4-147	6/13/2012	14.527	36.787	1.7	1.6	6%	
N300-W170-2 B-D	N300-W170	4-147	6/13/2012	17.07	25.265	1.3	1.3	0%	
N460-E70-3 A-C	N460-E70	4-148	6/5/2012	15.126	31.572	1.6	1.5	7%	
N460-E70-2 B-D	N460-E70	4-148	6/5/2012	16.099	27.797	1.4	1.6	-13%	
N780-E70 A-C	N780-E70	4-149	6/6/2012	12.897	12.897	1.3	1.4	-7%	
N780-E70 B-D	N780-E70	4-149	2/16/2012	12.231	12.231	1	1.4	-29%	
S90-W120 A-C	S90-W120	4-150	5/9/2012	8.049	8.049	0.7	0.6	17%	
S90-W120 B-D	S90-W120	4-150	5/7/2012	8.58	8.58	0.6	0.7	-14%	
S90-W400-2 A-C	S90-W400	4-151	5/10/2012	4.656	18.005	0.6	0.5	20%	
S90-W400-2 B-D	S90-W400	4-151	5/10/2012	9.574	17.468	0.6	0.5	20%	
S90-W590-2 A-C	S90-W590	4-152	5/10/2012	4.472	13.801	0.6	0.7	-14%	
S90-W590-2 B-D	S90-W590	4-152	5/10/2012	9.113	12.92	0.5	0.6	-17%	
S90-W620 A-C	S90-W620	4-153	5/10/2012	26.138	26.138	1.1	1.2	-8%	
S90-W770 A-C	S90-W770	4-154	5/10/2012	18.154	18.154	0.9	0.9	0%	
S90-W770-3 B-D	S90-W770	4-154	5/10/2012	3.303	16.624	0.8	0.9	-11%	
S90-W905 A-C	S90-W905	4-155	5/10/2012	14.96	14.96	1.1	1.2	-8%	
S105-W920 A-C	S105-W920	4-156	5/10/2012	3.97	3.97	1	1.1	-9%	
S700-E180 A-C	S700-E180	4-157	6/26/2012	11.837	11.837	2	2	0%	
S700-E180 B-D	S700-E180	4-157	6/26/2012	6.861	6.861	1.1	1.2	-8%	
S700-E205-3 A-C	S700-E205	4-158	6/26/2012	11.722	29.151	2	2	0%	
S700-E55-2 A-C	S700-E55	4-159	6/26/2012	4.225	8.359	2	2.1	-5%	
S700-E55-2 B-D	S700-E55	4-159	6/26/2012	2.721	6.863	1.2	1.4	-14%	
S700-W98-3 A-C	S700-W98	4-160	6/26/2012	0.82	25.161	2.7	N/A	N/A	
S1000-E120-3 A-C	S1000-E120	4-161	6/25/2012	8.465	16.905	1.2	1.2	0%	
S1000-E160 -3 A-C	S1000-E160	4-162	6/25/2012	4.134	4.134	0.9	1	-10%	
S1000-E58-4 A-C	S1000-E58	4-163	6/25/2012	9.533	24.999	1.4	1.4	0%	
S1000-E58-2 B-D	S1000-E58	4-163	6/25/2012	18.757	18.757	1.2	1.2	0%	
S1000-W98-2 A-C	S1000-W98	4-164	6/26/2012	15.737	34.485	2	2	0%	
S1300-E120 A-C	S1300-E120	4-165	6/26/2012	15.168	15.168	1.1	1.1	0%	
S1300-E160 A-C	S1300-E160	4-166	6/26/2012	23.907	23.907	2	2	0%	
S1300-E24 A-C	S1300-E24	4-167	6/26/2012	22.933	22.933	1.4	1.4	0%	

Table A1-5 Convergence Rates to Estimate Creep Closure for Panel 9

Convergence Points									
			Last Reading 2011-2012		Cumulative Displacement	Closure Rate 2011 to 2012	Closure Rate 2010 to 2011	Rate Change	
Field Tag	Location	Figure Number	Date	Inches	(inches)	(in/year)	(in/year)	(%)	Comments
S1300-W100-3 A-C	S1300-W100	4-168	6/26/2012	13.8	37.803	2.5	2.3	9%	
S1600-E110 A-C	S1600-E110	4-169	6/26/2012	16.145	16.145	1.1	1.1	0%	
S1600-E170 A-C	S1600-E170	4-170	6/26/2012	17.638	17.638	1.2	1.2	0%	
S1950-E113-4 A-C	S1950-E113	4-171	6/26/2012	9.724	13.6	1.3	1.3	0%	
S1950-E281-3 A-C	S1950-E281	4-172	6/28/2012	15.56	22.102	1.3	1.3	0%	
S1950-E284-3 A-C	S1950-E284	4-173	6/28/2012	15.864	22.476	1.3	1.4	-7%	
S2180-E220 A-C	S2180-E220	4-174	6/14/2012	15.947	15.947	1.7	1.6	6%	
S2180-E220 B-D	S2180-E220	4-174	6/14/2012	17.52	17.52	1.9	2	-5%	
S2180-E55-3 A-C	S2180-E55	4-175	6/12/2012	6.699	17.546	2.2	2.1	5%	
S2180-E55 B-D	S2180-E55	4-175	6/12/2012	15.783	15.783	1.9	2	-5%	
S2180-W100-3 A-C	S2180-W100	4-176	6/12/2012	5.554	23.737	3.4	3.1	10%	
S2180-W100-2 B-D	S2180-W100	4-176	6/12/2012	14.826	14.967	2.1	2.3	-9%	
S2520-E220 A-C	S2520-E220	4-177	6/14/2012	20.502	20.502	1.8	1.8	0%	
S2520-E220 B-D	S2520-E220	4-177	6/14/2012	21.21	21.21	2	2.1	-5%	
S2520-W100-2 A-C	S2520-W100	4-178	6/11/2012	1.614	21.294	3.2	N/A	N/A	
S2520-W100-2 B-D	S2520-W100	4-178	6/11/2012	4.464	20.087	2.9	2.6	12%	
S2750-E55-2 A-C	S2750-E55	4-179	6/11/2012	7.53	24.211	4.7	3.1	52%	
S2750-E55 B-D	S2750-E55	4-179	6/11/2012	17.416	17.416	3	2.7	11%	
S2750-E220-2 A-C	S2750-E220	4-180	6/11/2012	1.393	22.79	2.6	N/A	N/A	
S2750-E220 B-D	S2750-E220	4-180	6/11/2012	15.949	15.949	2	2	0%	
S2750-E410 A-C	S2750-E410	4-181	6/14/2012	25.807	25.807	4.5	4.5	0%	
S2750-E410 B-D	S2750-E410	4-181	6/14/2012	17.789	17.789	2.4	2.4	0%	
S2750-W93-2 A-C	S2750-W93	4-182	6/13/2012	12.265	30.733	5.7	7.1	-20%	
S2750-W93 B-D	S2750-W93	4-182	6/13/2012	14.435	14.435	2.3	2.5	-8%	
S3080-E220-2 A-C	S3080-E220	4-183	6/11/2012	18.011	20.716	3.5	2.8	25%	
S3080-E220 B-D	S3080-E220	4-183	6/11/2012	15.557	15.557	1.8	1.8	0%	
S3080-W100 A-C	S3080-W100	4-184	6/11/2012	25.696	25.696	4.4	4.5	-2%	
S3080-W100 B-D	S3080-W100	4-184	6/11/2012	16.068	16.068	2.3	2.2	5%	
S3310-E220 A-C	S3310-E220	4-185	6/14/2012	29.145	29.145	6.5	5.8	12%	
S3310-E220 B-D	S3310-E220	4-185	6/14/2012	17.576	17.576	1.9	1.9	0%	
S3310-E55 A-C	S3310-E55	4-186	4/16/2012	20.467	20.467	2.6	2.3	13%	
S3310-E55 B-D	S3310-E55	4-186	4/16/2012	14.985	14.985	1.8	1.8	0%	
S3310-W100-3 A-C	S3310-W100	4-187	6/11/2012	18.393	24.671	3.6	3.2	13%	
S3310-W100 B-D	S3310-W100	4-187	6/11/2012	15.861	15.861	1.8	1.9	-5%	
S3650-E220-2 A-C	S3650-E220	4-188	6/11/2012	6.789	10.146	2.4	2	20%	
S3650-E55-2 A-C	S3650-E55	4-189	6/11/2012	6.719	10.052	2.6	1.8	44%	
S3650-W100-2 A-C	S3650-W100	4-190	6/11/2012	9.223	15.24	4	2.6	54%	
S3650-W100 B-D	S3650-W100	4-190	6/11/2012	10.627	10.627	1.5	1.7	-12%	

Table A1-5 Convergence Rates to Estimate Creep Closure for Panel 9

Convergence Points									
		Figure	Last Reading 2011-2012		Cumulative Displacement	Closure Rate 2011 to 2012	Closure Rate 2010 to 2011	Rate Change	
Field Tag	Location	Number	Date	Inches	(inches)	(in/year)	(in/year)	(%)	Comments
W30-S120-2 A-C	W30-S120	4-191	6/5/2012	5.948	25.942	1	1	0%	
W30-S250-5 A-C	W30-S250	4-192	6/5/2012	7.061	33.294	1.1	1.4	-21%	
W30-S250-5 B-D	W30-S250	4-192	6/5/2012	17.655	28.609	0.9	1.1	-18%	
W30-S400-2 A-C	W30-S400	4-193	4/10/2012	5.621	23.449	0.5	1.2	-58%	
W30-S500-2 A-C	W30-S500	4-194	6/5/2012	6.133	28.643	1.1	1.1	0%	
W30-S500 B-D	W30-S500	4-194	6/5/2012	27.179	27.179	1	1.1	-9%	
W30-S700-5 A-C	W30-S700	4-195	6/5/2012	4.298	38.575	1.7	2.2	-23%	
W30-S850-5 A-E	W30-S850	4-196	6/5/2012	0.955	26.859	3.9	N/A	N/A	
W30-S850-4 B-D	W30-S850	4-197	6/5/2012	3.024	18.854	1.5	1.5	0%	
W30-S850-3 H-F	W30-S850	4-197	6/5/2012	4.397	19.965	2.1	2.1	0%	
W30-S850-4 C-G	W30-S850	4-198	6/5/2012	0.367	25.844	1.5	N/A	N/A	
W30-S1000-5 A-C	W30-S1000	4-199	6/5/2012	3.108	41.287	1.8	2	-10%	
W30-S1150-2 A-C	W30-S1150	4-200	6/5/2012	6.675	8.176	3	3.5	-14%	
W30-S1300-2 A-C	W30-S1300	4-201	6/5/2012	4.209	25.447	1.7	2.2	-23%	
W30-S1453-2 A-C	W30-S1453	4-202	6/5/2012	5.207	19.274	2.3	2.7	-15%	
W30-S1453-3 B-D	W30-S1453	4-202	6/5/2012	3.047	17.009	1.4	1.6	-13%	
W30-S1600-3 A-C	W30-S1600	4-203	6/5/2012	4.966	24.096	2.1	2.6	-19%	
W30-S1775-3 A-C	W30-S1775	4-204	6/5/2012	0.826	18.072	3.4	N/A	N/A	
W30-S1775-3 B-D	W30-S1775	4-204	6/5/2012	3.684	16.36	1.6	2	-20%	
W30-S1950-2 A-C	W30-S1950	4-205	6/5/2012	6.406	26.854	2.7	3.4	-21%	
W30-S2067-3 A-C	W30-S2067	4-206	6/5/2012	1.046	23.16	4.3	N/A	N/A	
W30-S2067-4 B-D	W30-S2067	4-206	6/5/2012	0.423	19.017	2.1	N/A	N/A	
W30-S2275-4 A-C	W30-S2275	4-207	6/5/2012	2.145	22.825	4.3	N/A	N/A	
W30-S2275-2 B-D	W30-S2275	4-207	6/5/2012	4.481	15.661	2	2.6	-23%	
W30-S2350-4 A-C	W30-S2350	4-208	6/5/2012	3.072	22.381	6.2	N/A	N/A	
W30-S2350-2 B-D	W30-S2350	4-208	6/5/2012	5.012	17.507	2.3	2.7	-15%	
W30-S2425-4 A-C	W30-S2425	4-209	6/5/2012	2.126	20.414	4.3	N/A	N/A	
W30-S2425-2 B-D	W30-S2425	4-209	6/5/2012	4.984	18.468	2.4	2.8	-14%	
W30-S2520-3 A-C	W30-S2520	4-210	6/5/2012	5.92	25.078	3.1	3.1	0%	
W30-S2685-3 A-C	W30-S2685	4-211	6/5/2012	4.752	23.642	2.3	2.7	-15%	
W30-S2685-3 B-D	W30-S2685	4-211	6/5/2012	4.274	18.544	2	2.4	-17%	
W30-S2750-2 A-C	W30-S2750	4-212	6/4/2012	4.913	17.263	2.6	2.6	0%	
W30-S2833-3 A-C	W30-S2833	4-213	6/18/2012	5.803	21.476	3.7	3.8	-3%	
W30-S2833-2 B-D	W30-S2833	4-213	6/18/2012	4.94	16.946	2.6	2.6	0%	
W30-S2916 A-C	W30-S2916	4-214	6/18/2012	38.881	38.881	6.2	7.2	-14%	
W30-S2916-2 B-D	W30-S2916	4-214	6/18/2012	4.222	14.606	2.2	2.2	0%	
W30-S2998 A-C	W30-S2998	4-215	6/18/2012	22.302	22.302	5.1	3.9	31%	
W30-S2998-2 B-D	W30-S2998	4-215	6/18/2012	3.684	14.401	2	1.9	5%	

Table A1-5 Convergence Rates to Estimate Creep Closure for Panel 9

Convergence Points									
			Last Reading 2011-2012		Cumulative Displacement	Closure Rate 2011 to 2012	Closure Rate 2010 to 2011	Rate Change	
Field Tag	Location	Figure Number	Date	Inches	(inches)	(in/year)	(in/year)	(%)	Comments
W30-S3080 A-C	W30-S3080	4-216	6/4/2012	24.005	24.005	2.1	2.2	-5%	
W30-S3195 A-C	W30-S3195	4-217	6/4/2012	19.874	19.874	3.6	2.4	50%	
W30-S3195 B-D	W30-S3195	4-217	6/4/2012	14.264	14.264	1.6	1.6	0%	
W30-S3310 A-C	W30-S3310	4-218	6/4/2012	17.127	17.127	1.8	1.8	0%	
W30-S3395 A-C	W30-S3395	4-219	6/4/2012	12.524	12.524	1.8	1.9	-5%	
W30-S3395 B-D	W30-S3395	4-219	6/4/2012	10.411	10.411	1.4	1.5	-7%	
W30-S3480 A-C	W30-S3480	4-220	4/9/2012	14.721	14.721	2.4	2.7	-11%	
W30-S3480 B-D	W30-S3480	4-220	6/4/2012	10.112	10.112	1.4	1.4	0%	
W30-S3565-2 A-C	W30-S3565	4-221	6/4/2012	5.01	10.835	1.7	1.6	6%	
W30-S3565 B-D	W30-S3565	4-221	6/4/2012	10.218	10.218	1.5	1.4	7%	
W30-S3650-2 A-C	W30-S3650	4-222	6/11/2012	6.555	12.207	2.1	2	5%	
W170-N150-3 A-C	W170-N150	4-223	5/9/2012	2.629	10.981	0.6	0.7	-14%	
W170-S5 A-C	W170-S5	4-224	5/9/2012	15.263	15.263	0.5	0.4	25%	
W170-S5-2 B-D	W170-S5	4-224	5/9/2012	9.8	17.566	0.7	0.6	17%	
W170-S90-3 A-C	W170-S90	4-225	5/9/2012	9.241	16.443	0.9	0.9	0%	
W170-S232-2 A-C	W170-S232	4-255a	5/9/2012	6.88	12.469	0.6	0.6	0%	
W170-S232-2 B-D	W170-S232	4-225a	5/7/2012	10.169	12.811	0.6	0.6	0%	
W170-S400 A-C	W170-S400	4-226	5/9/2012	15.209	15.209	0.7	0.8	-13%	
W170-S560-4 A-C	W170-S560	4-227	5/9/2012	2.891	13.71	0.8	0.6	33%	
W170-S560-3 B-D	W170-S560	4-227	5/7/2012	1.885	14.713	0.7	0.7	0%	
W170-S700-2 A-C	W170-S700	4-228	5/9/2012	3.754	23.547	1.3	0.6	117%	
W170-S850-7 A-E	W170-S850	4-229	5/8/2012	2.86	19.849	0.7	0.6	17%	
W170-S850-6 B-D	W170-S850	4-230	5/8/2012	2.501	15.241	0.6	0.5	20%	
W170-S850-7 H-F	W170-S850	4-231	5/8/2012	2.07	13.691	0.5	0.4	25%	
W170-S850-3 C-G	W170-S850	4-232	5/8/2012	12.127	22.94	0.9	0.7	29%	
W170-S1000-3 A-C	W170-S1000	4-233	5/8/2012	4.196	27.109	1.1	1	10%	
W170-S1150-4 A-E	W170-S1150	4-234	5/8/2012	3.38	23.809	0.8	0.7	14%	
W170-S1150-4 B-D	W170-S1150	4-234	5/8/2012	2.748	16.945	0.7	0.6	17%	
W170-S1150-2 H-F	W170-S1150	4-234	5/8/2012	2.746	16.152	0.7	0.6	17%	
W170-S1150-2 C-G	W170-S1150	4-235	5/8/2012	13.702	25.279	1.1	0.9	22%	
W170-S1300-4 A-C	W170-S1300	4-236	5/8/2012	7.677	28.635	1.8	1.7	6%	
W170-S1445-4 A-C	W170-S1445	4-237	5/8/2012	6.136	17.428	1.7	1.6	6%	
W170-S1445-2 B-D	W170-S1445	4-237	5/7/2012	12.932	15.59	1.1	1.2	-8%	
W170-S1600-4 A-C	W170-S1600	4-238	5/7/2012	5.025	19.79	1.7	1.6	6%	
W170-S1779-3 A-C	W170-S1779	4-239	5/8/2012	6.028	20.999	1.6	1.6	0%	
W170-S1779-2 B-D	W170-S1779	4-239	5/7/2012	15.633	18.768	1.4	1.5	-7%	
W170-S1950-3 A-C	W170-S1950	4-240	5/8/2012	4.818	17.999	1.5	1.4	7%	
W170-S2060-3 A-C	W170-S2060	4-241	5/8/2012	0.454	18.698	1.5	N/A	N/A	

Table A1-5 Convergence Rates to Estimate Creep Closure for Panel 9

Convergence Points									
			Last Reading 2011-2012		Cumulative Displacement	Closure Rate 2011 to 2012	Closure Rate 2010 to 2011	Rate Change	
Field Tag	Location	Figure Number	Date	Inches	(inches)	(in/year)	(in/year)	(%)	Comments
W170-S2060-2 B-D	W170-S2060	4-241	5/7/2012	17.215	20.539	2	2	0%	
W170-S2180-3 A-C	W170-S2180	4-242	6/7/2012	0.665	24.229	1.7	N/A	N/A	
W170-S2275 A-C	W170-S2275	4-243	5/8/2012	15.259	15.259	1.9	2	-5%	
W170-S2275 B-D	W170-S2275	4-243	5/7/2012	17.418	17.418	2.5	2.5	0%	
W170-S2350 A-C	W170-S2350	4-244	5/8/2012	20.238	20.238	2.6	2.7	-4%	
W170-S2350 B-D	W170-S2350	4-244	5/7/2012	17.386	17.386	2.4	2.4	0%	
W170-S2425 A-C	W170-S2425	4-245	6/5/2012	17.888	17.888	2	2.2	-9%	
W170-S2425 B-D	W170-S2425	4-245	6/5/2012	19.608	19.608	2.6	2.7	-4%	
W170-S2520-2 A-C	W170-S2520	4-246	6/5/2012	1.882	22.477	3.8	N/A	N/A	
W170-S2685-2 A-C	W170-S2685	4-247	6/5/2012	22.186	24.032	2	2.1	-5%	
W170-S2685-2 B-D	W170-S2685	4-247	6/5/2012	18.197	20.06	2.4	2.5	-4%	
W170-S2833 A-C	W170-S2833	4-248	6/5/2012	30.217	30.217	5.5	6.1	-10%	
W170-S2833 B-D	W170-S2833	4-248	6/5/2012	17.712	17.712	3	3	0%	
W170-S2916 A-C	W170-S2916	4-249	6/4/2012	27.586	27.586	3.5	3.9	-10%	
W170-S2916 B-D	W170-S2916	4-249	6/4/2012	16.603	16.603	2.4	2.6	-8%	
W170-S2998 A-C	W170-S2998	4-250	6/4/2012	37.773	37.773	6.6	6.6	0%	
W170-S2998-2 B-D	W170-S2998	4-250	6/4/2012	5.563	18.256	3.1	3.1	0%	
W170-S3080 A-C	W170-S3080	4-251	6/4/2012	23.552	23.552	3.3	3.6	-8%	
W170-S3195 A-C	W170-S3195	4-252	6/4/2012	22.481	22.481	3	3.6	-17%	
W170-S3195 B-D	W170-S3195	4-252	6/4/2012	15.527	15.527	1.9	2	-5%	
W170-S3310 A-C	W170-S3310	4-253	6/4/2012	19.793	19.793	1.9	2.3	-17%	
W170-S3395 A-C	W170-S3395	4-254	6/4/2012	20.019	20.019	3.6	3.7	-3%	
W170-S3395 B-D	W170-S3395	4-254	6/4/2012	12.069	12.069	1.9	1.9	0%	
W170-S3480 A-C	W170-S3480	4-255	6/4/2012	21.722	21.722	4	3.6	11%	
W170-S3480 B-D	W170-S3480	4-255	6/4/2012	15.5	15.5	2.3	2.3	0%	
W170-S3565 A-C	W170-S3565	4-256	6/4/2012	13.313	13.313	2.2	2.1	5%	
W170-S3565 B-D	W170-S3565	4-256	6/4/2012	10.915	10.915	1.5	1.5	0%	
W170-S3650-2 A-C	W170-S3650	4-257	6/11/2012	6.233	13.878	1.8	1.9	-5%	

N/A = not applicable due to insufficient measurements

ATTACHMENT 2
CREEP CLOSURE CALCULATIONS

Creep Volume Loss Calculations - Panels 1 to 8

Typical panel geometry (based on RockSol 2012 report)

Room dimensions (7 rooms)					
Number of rooms (per panel)	7		Equivalent diameter		
Width	33	ft	23.4	ft	
Height	13	ft			
Length	300	ft	Average convergence		
area	429	ft^2	3.9	inch/yr	
Room access drifts			Est. volume loss		
Width	33	ft	44,573	ft^3/yr	
Height	13	ft	1,262.2	m^3/yr	DOE (1996) report uses 812 m^3/yr/panel
Distance (pillar width) between rooms	100	ft			based on the calculated closure rate between
Access drift length	831	ft			years 15 and 16 after panel excavation
Total panel volume	1,613,898	ft^3	(excluding air-intake and air-exhaust drifts)		
Total length (rooms+ drifts)	3,762	ft			

Volumetric creep closure - VOCs migrate due to advection from volumetric closure of the panel void space at a rate of about 28,250 ft^3 (800 m^3) per year
Gas generation for the waste inventory at a rate of 0.1 mol/drum/year (8,200 mols per panel per year) results in a volumetric flow rate of 7,060 ft^3 (200 m^3) per year.
Because the flow is unrestricted, the VOCs migrate under a pressure of 1 atmosphere.

Creep Volume Loss Calculations - Panel 9

Dimensions for Main Entries (N-S)

E-140

Width	25	ft
Height	15	ft
Area	375	ft^2

Average convergence

2	inch/yr

Equivalent diameter: 21.85 ft

Est. volume loss: 5,858 ft^3/yr

W-170, W-30, E300

Width	16	ft
Height	13	ft
Area	208	ft^2

Equivalent diameter: 16.27 ft

Est. volume loss: 13,072 ft^3/yr

Volume of air-exhaust and air-intake drifts in Panel 9

Air-Intake

Width	20	ft
Height	13	ft
Area	260	ft^2

Equivalent diameter: 18.19 ft

Est. volume loss: 3,793 ft^3/yr

Air-Exhaust

Width	14	ft
Height	12	ft
Area	168	ft^2

Equivalent diameter: 14.63 ft

Est. volume loss: 3,046 ft^3/yr

Length of intake and exhaust drifts (does not account for the bulkhead, explosion wall and ROM salt dimensions)

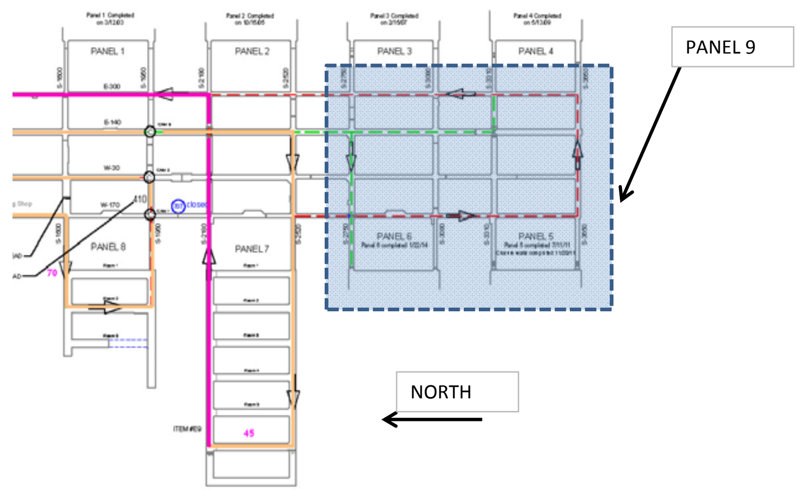
L_drift 200 ft

Volume of exhaust and intake drifts (Panels, 3, 4, 5 and 6)

Vol_INT/EXH 342,400 ft^3

Pillar lengths in N-S direction (i.e., does not include E-W drift dimensions)

Pilar_Length_panel	312	pilar length (N-S) parallel to the panel
Pilar_Length_between_panel	212	pilar length (N-S) parallel to the barrier pillar between panels



Dimensions for (E-W) entries

Width	20	ft
Height	13	ft
Area	260	ft^2

Equivalent diameter: 18.19456737 ft

Est. volume loss: 7,776 ft^3/yr

Pillars lengths in E-W direction (i.e. does not include entry dimensions)

Length (E-300 - E-140)	125	ft
Length (E-140 - W-30)	150	ft
Length (W-30 - W-170)	135	ft

Assume WPC 100 feet north of Panel 6

WPC (e.g., optional ROM salt length)	100	ft
Length of main drifts behind WPC	1028	ft
Length of E-W drifts (w/out main entries)	410	ft

Panel 9 Volume - Main Entries	1,026,972	ft^3
Panel 9 Volume - (E-W Cross-Drifts)	426,400	ft^3
Panel 9 Volume (total)	1,453,372	ft^3

Est. volume loss (w/out Panel 3-6 intake/exhaust)
26,706 ft^3/yr
756.2 m^3/yr

Est. volume loss (w Panel 3-6 intake/exhaust)
33,545 ft^3/yr
949.9 m^3/yr

Panel 9 vs Panel 3-6 VOC emission (assuming similar/same roof convergence)

VOC_9/VOC_Panels 0.75

ATTACHMENT 3
FLAC AND FLAC3D MODEL INPUTS

CALCULATIONS

Date:	July 22, 2016	**Prepared by:**	GG
Document No.:	063-2213NEW-Calc	**Checked by:**	WTT
Site Name:	WIPP Panel Closure	**Reviewed by:**	WTT
Subject:	**FLAC AND FLAC3D MODEL INPUTS**		

1.0 OBJECTIVE

To present inputs and assumptions used to develop FLAC and FLAC3D models to evaluate the performance of the WIPP Panel Closure (WPC). The WPC consists of out-bye bulkheads installed in the access drifts of Panels 1 to 8, and in the main entries between Panels 9 and 10. This closure is referred to as WPC-A. In addition, the WPC consists of run-of-mine (ROM) salt between the in-bye and out-bye bulkheads installed north of Panel 10. This closure is referred to as WPC-B. The WPC-A and WPC-B locations are shown in Figure 1 of this report, i.e. the Design Report (Golder 2016).

2.0 MODEL DESCRIPTION

2.1 Model Geometry and Stratification

The FLAC3D model has been developed based on the WIPP geometry provided by DOE (2013) and previous FLAC and FLAC3D models by WTS (2003), RockSol (2005) and NWP (2014). The model consists of halite layers divided by clay seams (see Table 1). Clay seams are modeled using FLAC3D interface elements. The two-dimensional version of the model, i.e. the FLAC model geometry, is shown in Figure 3 of Appendix C (Golder 2016). The FLAC3D model geometry is shown in Figure 12 of Appendix C (Golder 2016) with the stratigraphy summarized in Table 1.

Table 1: Model Stratification

Unit	Depth Below Surface (m)	Halite Layer Thickness between Units (m)	FLAC Model Elevation (m)
Model Top	532.3	108.7	114
Clay H	641.00	1.00	5.16
Clay G	642.00	2.16 (1.59)	4.16
Entry Roof	644.16 (643.59)	4.00 (4.57)	2 (2.57)
Entry Floor	648.16	2.25	-2
Clay E	650.41	110.75	-4.25
Model Bottom	761.16	n/a	-115

Note:
1. Reported values represent model geometry for the main entry width of 16 ft. Values in parentheses denote changed (updated) values for the main entry width of 25 ft.

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All FLAC3D models are based on the minimum pillar dimensions (width x length) of: 125 ft (38.1 m) x 211 ft (64.3 m), i.e. the total width of the FLAC3D model is 70.5 feet (for the main entry width of 16 feet), or 75 feet (for the main entry width of 25 feet) based on the assumed lines of symmetry outlined in Figure 12 of Appendix C (Golder 2016). The main entry height is 13 feet for 16-ft wide entries and 15 feet for 25-ft wide entries.

2.2 Material Properties

Material parameters required for modeling were adopted from WTS (2003) and RockSol (2005) reports. Halite layers were modeled by using the standard WIPP-reference creep law for which the scalar strain rate, $\dot{\varepsilon}$, is composed of primary and secondary creep components, $\dot{\varepsilon}_p$ and $\dot{\varepsilon}_s$, i.e.,

$$\dot{\varepsilon} = \dot{\varepsilon}_p + \dot{\varepsilon}_s$$

The secondary creep rate is defined as

$$\dot{\varepsilon}_s = \mathrm{D}\,\bar{\sigma}^n e^{-\frac{Q}{RT}}$$

Where:

D = material constant; “d_wipp” parameter in FLAC and FLAC3D models

n = material constant; “n_wipp” parameter in FLAC and FLAC3D models

Q = activation energy; “act” parameter in FLAC and FLAC3D models

R = universal gas constant; “gas” parameter in FLAC and FLAC3D models

T = temperature in degrees Kelvin; “temp” parameter in FLAC and FLAC3D models without temperature option

$\bar{\sigma}$ = von Mises stress defined as

$$\bar{\sigma} = \left[\frac{(\sigma_{xx} - \sigma_{yy})^2 + (\sigma_{yy} - \sigma_{zz})^2 + (\sigma_{zz} - \sigma_{xx})^2}{2} + 3\left(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{xz}^2\right) \right]^{1/2} = \sqrt{3J_2}$$

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The primary creep is defined as follows:

$$\varepsilon_p = \begin{cases} (A - B\varepsilon_p)\,\dot{\varepsilon}_s & \text{if } \dot{\varepsilon}_s \geq \dot{\varepsilon}_{ss}^* \\ \{A - B(\dot{\varepsilon}_{ss}^* / \dot{\varepsilon}_s)\,\varepsilon_p\}\dot{\varepsilon}_s & \text{if } \dot{\varepsilon}_s < \dot{\varepsilon}_{ss}^* \end{cases}$$

Where:

A = material constant; "a_wipp" parameter in FLAC and FLAC3D models

B = material constant; "b_wipp" parameter in FLAC and FLAC3D models

$\dot{\varepsilon}_{ss}^*$ = critical strain rate; "e_dot" parameter in FLAC and FLAC3D models

The crushed salt model accounts for both volumetric and deviatoric creep compaction rates based on the following expression describing the rate of compaction (change in density):

$$\dot{\rho}^c = -B_0\left[1 - e^{-B_1\sigma_m}\right]e^{B_2\rho}$$

Where:

B_0 = material constant; "b0_sk" parameter in FLAC and FLAC3D models

B_1 = material constant; "b1_sk" parameter in FLAC and FLAC3D models

B_2 = material constant; "b2_sk" parameter in FLAC and FLAC3D models

σ_m = mean stress;

The elastic response of crushed salt is determined based on the values of bulk modulus, *K*, and shear modulus, *G*, as follows:

$$K = K_f\, e^{K_1(\rho - \rho_f)}$$

and

$$G = G_f\, e^{G_1(\rho - \rho_f)}$$

Where:

ρ_f = density for the intact salt; “d_f” parameter in FLAC and FLAC3D models

K_f = bulk modulus for the intact salt; “b_f” parameter in FLAC and FLAC3D models

G_f = shear modulus for the intact salt; “s_f” parameter in FLAC and FLAC3D models

Parameters K1 and G1 are determined from the condition that bulk and shear moduli must take their initial values at the initial value of density (Itasca, 2000).

Material properties for FLAC3D calculations used to evaluate the ROM salt air resistance are summarized in Table 2.

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Table 2: Material Properties for FLAC and FLAC3D Models Used to Evaluate ROM Salt Air Flow Resistance

Parameter	FLAC Property	Halite	Anhydrite	Crushed Salt	Clay Interface
Bulk Modulus (Pa)	bulk	2.07e+10	8.34e+10	1.19e+08	
Shear Modulus (Pa)	shear	1.24e+10	2.78e+10	7.14e+07	
Density (kg/m^3)	den	2,300	2,300	1,350[1]	
Friction (degree)	fric		29		5
Cohesion (Pa)	coh		2.70e+07		
Temperature (K)	temp	300		300	
Ideal gas constant (cal/K/mol)	gas	1.987		1.987	
Q constant (cal/mol)	act	12,000		12,000	
N constant (-)	n_wipp	4.90		4.90	
A constant (-)	a_wipp	4.56		4.56	
B constant (-)	b_wipp	127		127	
D constant (Pa^{-n} s^{-1})	d_wipp	5.79e-36		5.79e-36	
Critical Strain Rate (1/sec)	e_dot	5.39e-08		5.39e-08	
rho_initial (kg/m^3)	rho			1,404[1,2]	
B0 constant (crushed salt)	b0_sk			1.30e+08	
B1 constant (crushed salt)	b1_sk			8.20e-07	
B2 constant (crushed salt)	b2_sk			-1.72e-02	
Maximum bulk modulus (Pa)	b_f			5.86e10	
Maximum shear modulus (Pa)	s_f			3.53e10	
Maximum density (kg/m^3)	d_f			2,160 to 2,300[3]	
Normal Stiffness (Pa/m)	kn				1e+11
Shear Stiffness (Pa/m)	ks				5e+10

Notes:

1. Initial density for FLAC3D simulations with crashed salt is the average density of ROM salt at the end analytical simulation used to determine air gap closure.
2. Assume that the ROM salt is placed at the fractional density of 65%, i.e. at the initial density of 1,404 kg/m^3 (based on the intact salt density of 2,160 kg/m^3). During construction, the initial density increases to 1,450 kg/m^3.
3. Use the intact salt density of 2,160 kg/m^3 for the lower bound simulations and the intact density of 2,300 kg/m^3 for the upper bound simulations.

The FLAC3D model results used to evaluate the ROM salt air flow resistance are discussed in more detail in Appendices C, D and E of this report.

The FLAC3D model parameters used to evaluate the minimum ROM salt length for the WPC-B construction are presented in Table 3.

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Document No.:	063-2213NEW-Calc	**Checked by:**	WTT
Site Name:	WIPP Panel Closure	**Reviewed by:**	WTT
Subject:	**FLAC and FLAC3D Model Inputs**		

Table 3: Material Properties for FLAC3D Models Used for ROM Salt Length Evaluation

Parameter	FLAC3D Property	Halite[1]	ROM Salt[2]	Clay Interface
Bulk Modulus (Pa)	bulk	2.07e+10	2.07e+10	
Shear Modulus (Pa)	shear	1.24e+10	1.24e+10	
Density (kg/m^3)	den	2,300	2,300	
Friction (degree)	fric		30.47	5
Cohesion (Pa)	coh		0.59e+06	
Tensile Strength (Pa)	ten		1.0e+06	
Temperature (K)	temp	300		
Ideal gas constant (cal/K/mol)	gas	1.987		
Q constant (cal/mol)	act	12,000		
N constant (-)	n_wipp	4.90		
A constant (-)	a_wipp	4.56		
B constant (-)	b_wipp	127		
D constant (Pa^{-n} s^{-1})	d_wipp	5.79e-36		
Critical Strain Rate (1/sec)	e_dot	5.39e-08		
Normal Stiffness (Pa/m^2)	kn			1e+11
Shear Stiffness (Pa/m^2)	ks			5e+10

Notes:
1. Halite layers were modeled using WIPP creep viscoplastic model (Itasca, 2000).
2. ROM Salt strength properties were determined from Hansen et al. (1984) data and should be viewed as a long-term lower bound strength estimate.

The FLAC3D model used to evaluate the minimum ROM salt length for WPC-B construction is discussed in more detail in Appendix F of this report.

2.3 Boundary Conditions

Horizontal displacements are set to zero on all vertical boundaries, i.e., sides of the model are allowed to move only in the vertical direction. Vertical displacements are set to zero at the bottom boundary. The top of the model has a constant stress boundary condition equal to the weight of the overburden.

2.4 Initial Conditions

The initial conditions are the in-situ stresses throughout the model equal to the weight of the overburden at each zone.

3.0 CALCULATION RESULTS

Results of the FLAC and FLAC3D calculations are presented in the main body and Appendices of this report, i.e. the Design Report (Golder 2016).

4.0 REFERENCES

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APPENDIX D
AIR FLOW CALCULATIONS

TECHNICAL MEMORANDUM

Date:	August 30, 2016	**Project No.:**	063-2213NEW
To:	Rey Carrasco	**Company:**	Nuclear Waste Partnership LLC
From:	Gordan Gjerapic and Bill Thompson	**Email:**	GGjerapic@Golder.com
cc:	bthompson@golder.com		

RE: WIPP PANEL CLOSURE – AIR FLOW RATES FOR OPEN & CLOSED PANELS

1.0 OBJECTIVE

Summarize assumptions in the previous air flow models that were used to calculate VOC emissions through the WIPP Panel Closure (WPC), and provide updated air flow estimates based on the recent design changes (MVS, 2015). MVS (2015) memorandum is included as Attachment 1. This memorandum is prepared as a supporting document (Appendix D) for the WPC design report (Golder, 2016).

2.0 INPUTS AND ASSUMPTIONS

Unless specified otherwise, the following inputs and assumptions were adopted from RockSol (2012), Kehrman (2012) and MVS (2015).

2.1 General Inputs

- Pressure drop across the panel: 170 milli inches of water gage (42.4 Pa).
- Air density: 1.18 kg/m^3.
- Air dynamic viscosity: 1.84 x 10^{-5} kg/(m sec).
- Molar volume for the gas at standard conditions Vn = 0.0245 m^3/mol.
- Gas generation rate: 0.1 mol/drum/year (Kehrman 2012).
- Air flow due to the creep of panel openings (room closure): 1,262 m^3/yr/panel (Panels 1 to 8) and 950 m^3/yr/panel (Panels 9 and 10) based on the convergence measurement records [see Appendix C in Golder (2016)]. Note that the rate of 812 m^3/yr/panel (0.055 cfm/panel) was used in the previous reports (DOE 1996, RockSol 2012). The corresponding emission rate can be determined as E_{creep} = 812 m^3/yr/panel/0.0245 m^3/mol = 33,143 mol/yr/panel.
- Maximum number of drums in a panel is 42,350 assuming 6,050 filters per room and 7 rooms (Kehrman 2012), i.e., for calculation purposes, Kehrman (2012) equates the equivalent number of drums in the room to the number of filters. RockSol (2012) assumed that the rooms are 95% full and performed the calculations for 40,233 drums.

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2.2 Geometry

- WIPP panel consists of seven (7) parallel disposal rooms at the distance of 133 feet (wall thickness of 100 feet), connected on each side by drifts for access and ventilation (DOE, 1996). Disposal room dimensions are approximately 300 feet x 33 feet x 13 feet (length x width x height).
- The WPC-A consisting of an out-bye steel bulkhead is placed in the air-intake and air-exhaust drifts. The air-intake drift dimensions are 20 feet x 13 feet (width x height). The air-exhaust drift dimensions are 14 feet x 12 feet. In addition, the WPC-A is placed in the main entries between Panels 9 and 10. The main entry dimensions vary from 14 feet x 12 feet (width x height) to 25 feet x 15 feet. The air flow calculations presented in this memorandum were conducted for the main entry dimensions of 25 feet x 15 feet (width x height) and 16 feet x 13 feet.
- The WPC-B consisting of ROM salt between two steel bulkheads is placed in the main entries north of Panel 10. As noted previously, the air flow calculations were conducted for the main entry dimensions of 25 feet x 15 feet (width x height) and 16 feet x 13 feet.

2.3 Steel Bulkheads

- For approximately 17 to 31 years after the WPC-B are installed in the main entries north of Panel 10, the flow rates will be governed mostly by the flow resistance of steel bulkheads until the gap between the ROM salt and the surrounding rock closes due to creep of the surrounding salt rock [see Appendix C in Golder (2016)].
- Number of steel bulkheads in the flow path: 2.
- Single steel bulkhead resistance: RockSol (2012) assumed the bulkhead resistance of 2,200 practical units (P.U.); 1.0 P.U. = 2.5 x 10^{-1} s^2/m^5. MVS (2015) reports the maximum bulkhead resistance of 8,940 PU (Attachment 1). The air flow calculations presented in this memorandum were conducted by assuming the bulkhead resistance of 200 and 2,200 P.U.
- Larger drifts without bulkheads have a resistance on the order of 10^{-4} practical units. E.g., MVS (2015) estimates the airflow resistance of 4.2 x 10^{-4} practical units for a “typical” drift section in the main access area (Attachment 1).
- After the gap between the ROM salt and the surrounding rock is closed, the steel bulkhead’s contribution to flow resistance is relatively minor.

2.4 ROM Salt

- ROM salt length is based on the main entry dimensions. The minimum recommended ROM salt length is 2.5 times the entry width.
- Intact salt density is 2,160 kg/m3.
- The ROM salt fractional density at the moment of placement is 65 percent corresponding to the initial density of 1,404 kg/m^3. The corresponding porosity value is ϕ = 35 percent.
- The initial ROM salt settlement (under its own weight) is faster than the creep of the surrounding cavern resulting in approximately 20 inch (50 cm) gap in the access main with the dimensions of 25 feet x 15 feet (width x height), and 19 inch (48 cm) gap in the access drift with the dimensions of 16 feet x 13 feet. It takes approximately 17 to 31 years for the gap to close. During this time, the main resistance to airflow is provided by steel bulkheads.
- Shortly after placement, the ROM salt fractional density increases to approximately 75 percent. The ROM salt fractional density at the moment when the air-gap closes is larger than 80 percent. Ten or more years after the air-gap closure, the ROM salt fractional density is expected to exceed 90 percent.

- The permeability-porosity relationship from Shor et al. (1981) for the average particle size of Z=0.34 cm may be used to bound WIPP specific salt data.
- The ROM salt intrinsic permeability, k, for the purpose of the air-flow model (RockSol 2012) was determined from the following relationship (Kelsall et al. 1983, Eq. A-4):

$$k(Z,\phi) = 0.0178Z^2 \exp[21 + 6\ln(\phi)]$$

Where: k = intrinsic permeability (Darcy). 1 Darcy = 9.87 x 10^{-9} cm^2
Z = representative particle size (cm)
ϕ = porosity

3.0 AIR FLOW CALCULATIONS

3.1 Flow Rates Due to Gas Generation and Creep

The gas generation due to microbial degradation under humid conditions is estimated as 0.1 mol/drum/year (Kehrman 2012). Based on Kehrman (2012), the microbial degradation is the dominant gas generation mechanism. For standard conditions, this is equivalent to the gas volume of 2.45 x 10^{-3} m^3/drum/year. Assuming the maximum number of drums: Nd = 42,350, the equivalent microbial gas generation from the panel is 103.8 m^3/panel/year (6.97 x 10^{-3} cfm/panel).

Assuming the loss of volume of 812 m^3/yr/panel (5.46 x 10^{-2} cfm/panel) due to creep closure (DOE 1996), one can calculate the total airflow due to gas generation and creep as:

$$Q_{gc} = Q_{gas} + Q_{creep} = 6.97 \times 10^{-3} cfm + 5.46 \times 10^{-2} cfm = 6.15 \times 10^{-2} cfm$$

Based on the recorded convergence data for Panels 1 to 8, the average loss of volume due to creep closure is 1,262 m^3/yr/panel. For Panels 9 and 10, the average loss of volume is 950 m^3/yr/panel. The updated flow rates due to gas generation and creep are summarized in Table 1.

Table 1: Flow Rates Due to Gas Generation and Creep

Location	Flow Due to Gas Generation (cfm)	Flow Due to Creep Closure (cfm)
Panels 1 to 8	0.007	0.085
Panels 9 and 10	0.007	0.064

3.2 Ventilation Flow Rates Prior to Gap Closure

Prior to closure of the air gap between ROM salt and the surrounding salt cavern, the flow resistance is provided by steel bulkheads. Based on the estimated pressure drop across the panel entries and the expected range of bulkhead resistance values, the flow rate through the WPC-B can be determined as:

$$Q = \sqrt{\frac{h}{2R}}$$

Where: Q = flow rate in kcfm

h = pressure drop across the flow path through the repository panel in mili inch w.g.

R = resistance for a single steel bulkhead in practical units (P.U.), 1 P.U. = 1 milli inch of water/kcfm^2

Flow rates for the bulkhead resistance values of 200 and 2,200 P.U. are summarized in Table 2.

Table 2: Estimated Flow Rates through Panel Bulkheads

Bulkhead Resistance (P.U.)	Pressure Drop (mili inch w.g.)	Flow Rate (cfm)
200	3.4	92.2
200	170	652
200	856	1,462
2,200	3.4	27.8
2,200	170	197
2,200	856	441

Estimated air flows in Table 2 correspond to the WPC-A (i.e., the WPC without the ROM salt component), or for the WPC-B scenario with the installed ROM salt prior to the air gap closure. Estimated flow rates through panel bulkheads displayed in Table 2 are significantly higher than flow rates induced by the microbial gas generation and creep (Table 1).

3.3 Flow Rates after Gap Closure

For the WPC-B constructed with ROM salt between the in-bye and out-bye bulkheads, the dominant flow mechanism after the air gap closure is the porous flow though unconsolidated ROM salt component. The ROM salt porous flow can be determined by using Darcy's law:

$$Q_{ROM} = A_{drift} \frac{k}{\mu} \frac{\Delta p}{L}$$

Where: Q_{ROM} = flow rate through ROM salt (m^3/sec)

A_{drift} = main entry cross-sectional area (m^2)

k = intrinsic permeability of ROM salt (m^2)

μ = dynamic viscosity of air [1.84×10^{-5} kg/(m sec)]

Δp = pressure drop across the ROM salt component (Pa)

L = ROM salt length (m)

The estimated range of airflows through the ROM salt component is summarized in Table 3.

Table 3: Estimated Airflows through ROM Salt

ROM Salt Fractional Density	ROM Salt Porosity	Intrinsic Permeability (m2)	Air Conductivity (m/sec)	Flow Rate[1] (cfm)
80%	20%	1.7×10^{-10}	1.1×10^{-4}	3.1×10^{-2} to 7.8×10^{0}
90%	10%	2.7×10^{-12}	1.7×10^{-6}	4.8×10^{-4} to 1.2×10^{-1}
95%	5%	4.2×10^{-14}	2.7×10^{-8}	7.5×10^{-6} to 3.3×10^{-3}

Note:

1. Airflow rates were determined for the pressure drop ranging from 3.4 mili inch H_20 (0.85 Pa) to 856 mili inch H_20 (213 Pa).

The air flow of 0.03 cfm determined for the ROM salt fractional density of 80 percent and the pressure drop of 3.4 mili inch H_2O (mili inch w.g.) can be viewed as a likely upper bound estimate for the normal operating conditions in the WIPP repository assuming the maximum ventilation rate through the adjacent drift of 90,000 cfm (MVS, 2015). Upper bound values in Table 3 were determined for the pressure drop of 856 mili inch w.g. which is an extreme condition assuming that the flow through the WPC-B is governed by sudden changes in the atmospheric pressure. The calculated air flows through the ROM salt (presented in Table 3) are significantly smaller than the estimated flow rates through panel bulkheads (shown in Table 2). This confirms that the ROM salt becomes the main resistance to flow after the air gap between the ROM salt and the surrounding rock closes, even at the relatively low ROM salt fractional density of 80 percent. Due to continuous creep of the surrounding rock, the ROM salt will continue to consolidate and approach air-conductivity values reported for the surrounding rock zones summarized in Table 4.

Table 4: Air Conductivity Values for Rock Zones Surrounding ROM Salt

Airflow Medium	Air Conductivity (m/sec)	Reference
Dilated Salt	6.2×10^{-14}	DOE (1996)
Fractured Salt	6.2×10^{-10}	DOE (1996)
Clay Seams	6.2×10^{-12}	DOE (1996)
Marker Bed 139	6.2×10^{-11}	DOE (1996)

In addition to the airflow through the ROM salt, a fraction of the air flow is expected to occur through the disturbed rock zone (DRZ) adjacent to panel openings. In Table 4, the dilated salt represents the DRZ component with the permeability that is higher than intact rock due to the stress relief from lithostatic conditions. The fractured salt in Table 4 refers to a highly fractured zone in the immediate vicinity of the openings.

The calculated ROM salt air conductivity values in Table 3 are significantly higher than the conductivities for the disturbed rock zone (DRZ) components reported in Table 4 supporting the conclusion that the majority of flow (after the air-gap closes) will be through the ROM salt.

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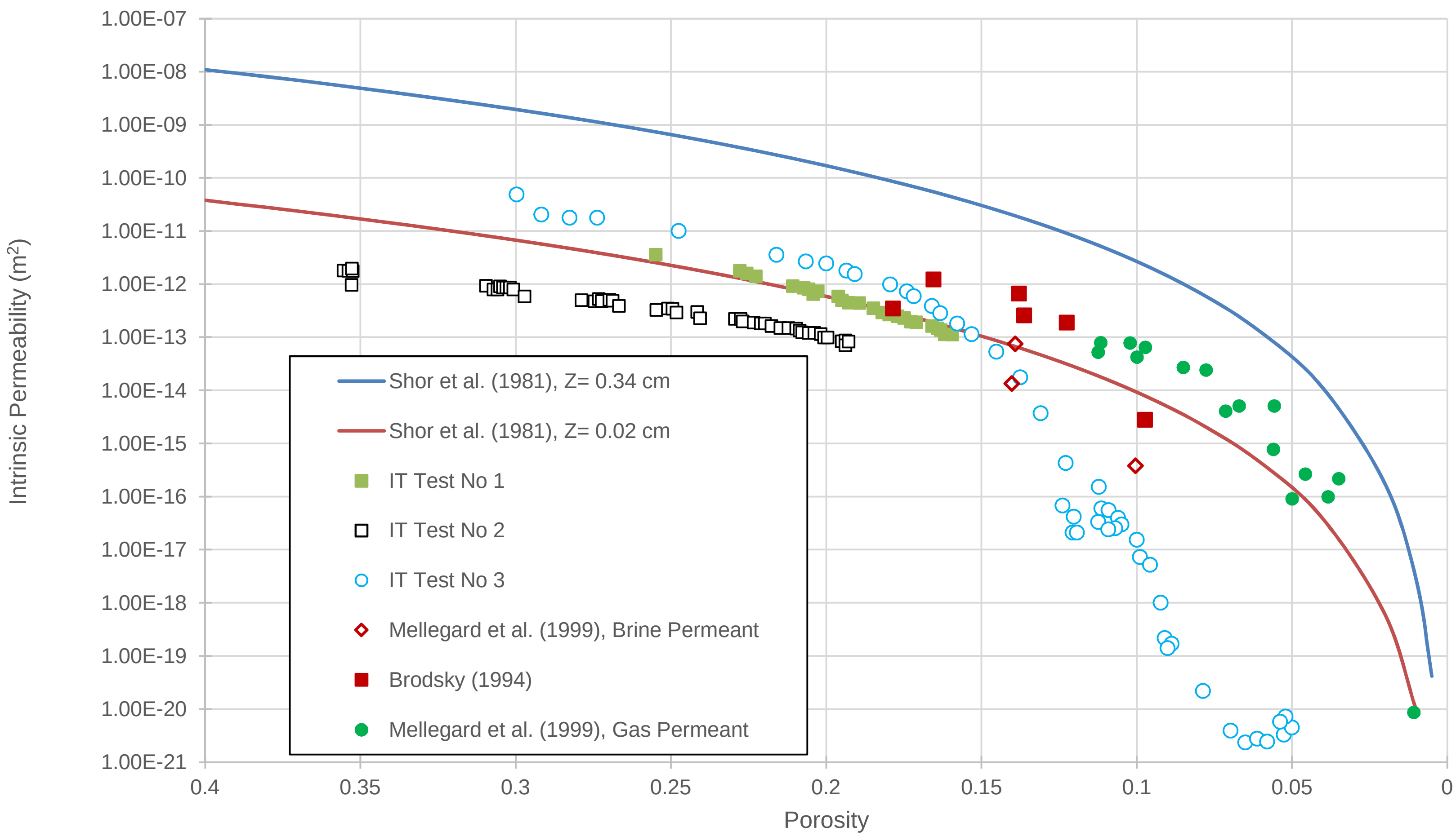
FIGURES



Note: Displayed intrinsic permeability measurements are approximate digitized values from Figure 3-9 in RockSol (2012) report.

Figure 1

Intrinsic Permeability Values for ROM Salt

Nuclear Waste Partnership LLC

WIPP Closure - Geomechanical Compliance

Golder Associates

Denver, Colorado, USA

063-2213NEW

1/28/2016

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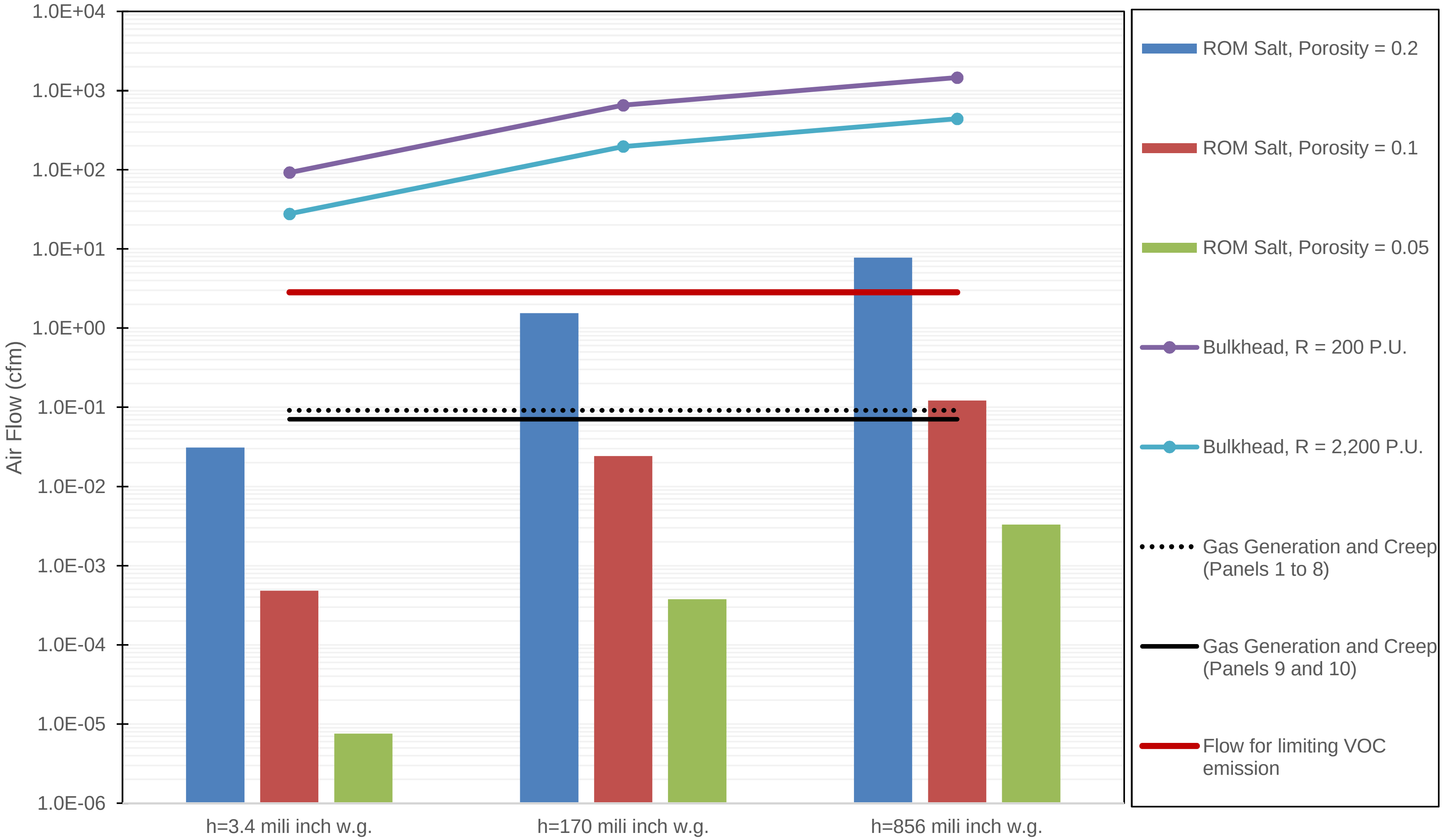

Figure 2

Estimated Air Flow through WPC Components

Nuclear Waste Partnership LLC

WIPP Closure - Geomechanical Compliance

Golder Associates

Denver, Colorado, USA

063-2213NEW

1/28/2016

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ATTACHMENT 1
DIFFERENTIAL PRESSURE CALCULATIONS FOR
FINAL PANEL CLOSURES IN THE MAIN ENTRIES (MVS 2015)

Mine Ventilation Services, Inc.
1625 Shaw Ave, Suite 103, Clovis, CA 93611 U.S.A.
Telephone: (559) 452-0182, Facsimile (559) 452-0184, e-mail: support@mvsengineering.com

Memorandum

To: Jill Farnsworth, Nuclear Waste Partners, LLC

From: Keith Wallace

CC:

Date: October 29, 2015

Re: Golder and Associates differential pressure calculations for final panel closures in the main entries

---

MVS was requested to provide an estimate of the differential pressure in front of the proposed permanent closures at two locations in the underground. The first location would seal the mains between S2520 and S-2750. At this location, panels 3, 4, 5 and 6 would be isolated from the underground openings. In addition, the main drives could be filled with contact handled waste between S-2750 and S-3650. These locations are shown on Figure 1.

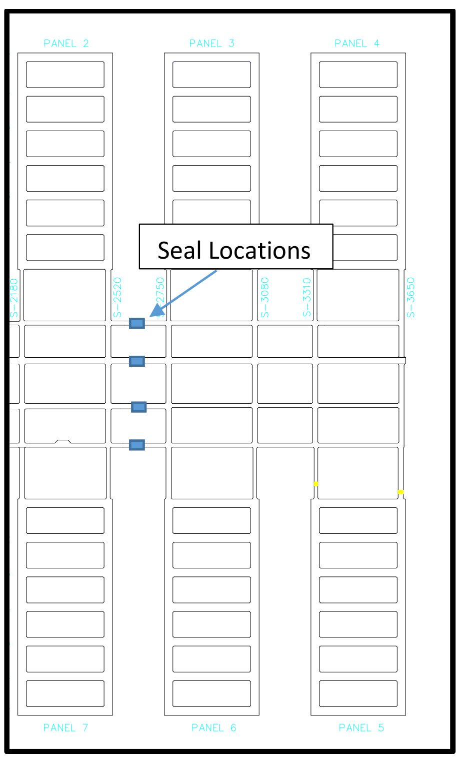

Figure 1: Location of seals between S-2520 and S-2750

The second location is between S-1300 and S-1600. This would seal the mains from panels 1, 2, 7 and 8. For this location it is assumed that panels 7 and 8 are filled with waste and the mains between S-1600 and S-2520 may be filled with contact handled waste. Figure 2 shows the location of these seals.

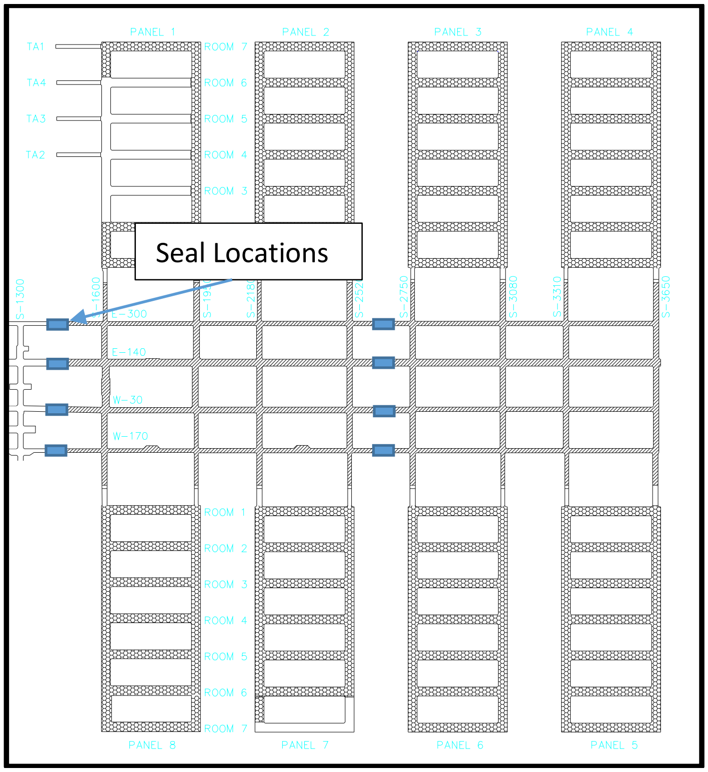

Figure 2: Seal locations between S-1300 and S-1650

Calculating the differential pressure across the sealed bulkheads is a challenge. One way to estimate this value is to know the differential pressure of the air flowing in front of the seal location. Differential pressures mathematically sum to zero in closed loops. Therefore, a differential pressure passing the front of a seal could be used to estimate the differential pressure across two seals. Figure 3 shows an example pressure loop for this calculation.

From Figure 3, if the ΔP in red is known, then one can assume the differential pressure across each seal would be approximately one half this value (assuming the flow is so low as to not have any significant differential pressure in S-1600 between W-30 and E-140). The calculation also assumes the leakage direction is in on one seal and out on the next. It is feasible the flow could be in on both and out on one of the seals in E-300 or W-170. None the less, this calculation approach would give an estimate of the differential pressure across the seal.

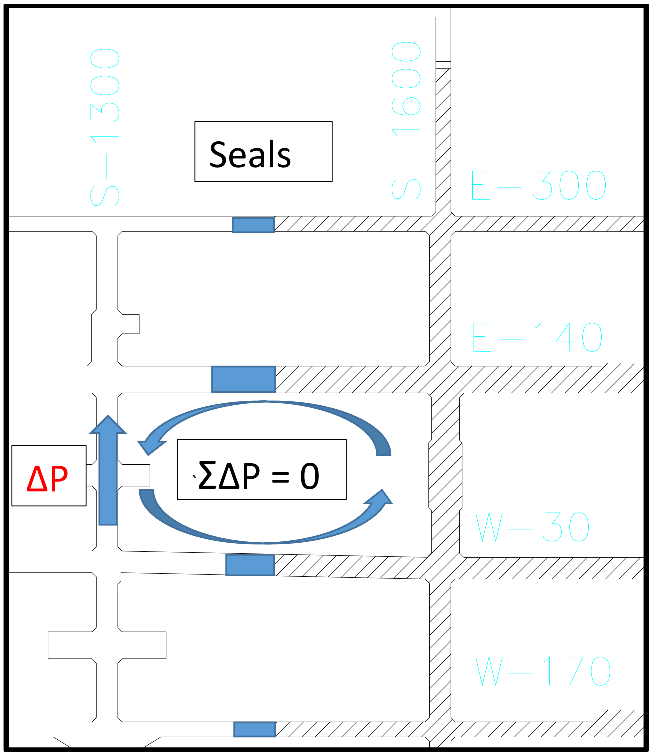

Figure 3: Differential pressure loop description

To calculate the differential pressure in S-1300 (the red ΔP), the volume of air in this airway needs to be assumed. For IVS with UVS, the flow cannot exceed 90,000 cfm. This is the maximum amount available south of S-400 in the E-300 return. If all this air was in this one branch, the differential pressure can be calculated as follows:

1. Calculate the resistance of the branch based on $R = \frac{k\,L\,per}{52\,A^3}$ (Practical Unit (P.U.))
2. Use the square law to compute the differential pressure: $\Delta p = RQ^2$ (milli-in. w.g. or in. w.g./1000)

Where:

k = friction factor ($lb_f\ min^2/ft^4 \times 10^{-10}$)
L = length (ft)
per = perimeter (ft)
A = area (ft^2)
Q = airflow (cfm x 1000 or kcfm)

For the S-1300 airway, the width is approximately 20 ft and the height is approximately 13.5 ft. This relates to an area of 270 ft^2 and a perimeter of 67 ft. The length is about 150 ft. Using an assumed friction factor of 42.8 $lb_f\ min^2/ft^4 \times 10^{-10}$ gives a resistance of 0.00042 P.U.

Using the second equation for 90 kcfm, the differential pressure is computed to be 3.4 milli-in. w.g. This is an extremely low pressure. Divided between two seals gives a value of only 1.7 milli-in. w.g. across each seal.

MVS then investigated work that the National Institute of Occupational Safety (NIOSH) has done for coal mines to determine out or in-gassing across coal mine seals. Coal mine seals isolate working areas from abandoned mined out areas. The hazard in coal mines is that methane can accumulate in the abandoned areas leading to an explosive atmosphere. The driving force to cause air passing from or to abandoned areas is not the differential pressure in the open airway, rather, it is caused by a drop or increase in barometric pressure. If the barometric pressure outside the abandoned area is stable for a long time, the barometric pressure behind the seals will equalize to the same value. However, during weather events, such as a lowering of barometric pressure when a storm comes over the site, there will be a difference in barometric pressure between the sealed and open areas of the underground. The barometric pressure behind the seals will take much longer to lower than the open air routes. Therefore, as the barometer drops, it is expected that air behind the seals will move towards the open airways. In coal mines, this can be very dangerous if the air behind the seals is an explosive mixture.

At WIPP we **do not** have natural methane or explosive mixtures of air in sealed areas. None the less, the mathematics used to compute air movement from behind seals can be used to estimate the pressure across the seals. MVS attempted to calculate this differential pressure using the NIOSH methodology for coal mines.

From the paper "Composition Change Model for Sealed Atmosphere in Coal Mines" by R. K. Zipf, Jr. and K. M. Mohamed - NIOSH – OMSHR, Pittsburgh, PA, USA (paper prepared for the Proceedings of the 13th U.S./North American Mine Ventilation Symposium, Sudbury, Ontario, Canada, June 13-16, 2010. Hardcastle S, McKinnon DL, eds., Sudbury, Ontario, Canada: MIRARCO - Mining Innovation, 2010; pages 493-500), the estimated leakage from sealed areas can be computed using the following equation (in SI units):

$$Q_L = L_c\sqrt{|P_t(t) - P_v(t)|} \text{ (m}^3\text{/s)}$$

where: L_c = leakage coefficient
$P_t(t)$ = total barometric pressure of the sealed atmosphere (Pa), and
$P_v(t)$ = barometric pressure outside sealed atmosphere (Pa).

When P_t (t) < P_v (t) the seal is ingassing, i.e. air is flowing into the sealed atmosphere. Conversely, when $P_t(t)$ > $P_v(t)$ the seal is outgassing, i.e. gases are flowing out of the sealed atmosphere. NIOSH research showed the leakage coefficient to be as shown on Table 1.

Table 1: Values for leakage coefficient into sealed atmosphere (Weiss et al., 1993, 1996).

	Leakage Quantity (m^3/s)	Pressure Differential (Pa)	Leakage Coefficient ($(m^3/s/Pa)^{½}$)
Lowest values measured at NIOSH	0.019	1000	.0006
Old MSHA Guideline for 140 kPa seals	0.047	250	.0030

MVS then looked at barometric pressure readings taken during test and balance activities over a ten year period. The data suggests the barometric pressure at the bottom of the Exhaust Shaft varied from 94.544 kPa to 96.915 kPa. It would not be expected that such a wide swing in barometric pressure would happen in a short time. However, using these values in the equation would provide a maximum value for the known data. Plugging in these barometric pressure values into the above equation and using the lowest and highest leakage coefficient values from Table 1 gives the following airflows:

Q_L (low) = 0.03 m^3/s (63 cfm)
Q_L (high) = 0.15 m^3/s (318 cfm)

Using the square law and a seal resistance of 10,000 Ns^2/m^8 (8,940 P.U.) A value of 10,000 Ns^2/m^8 (8,940 P.U.) is a reasonable value for a very tight, restricted seal. Using this resistance gives a differential pressure for low flow of 8.5 Pa (0.03 in. w.g.) and 213.4 Pa (0.86 in. w.g.) To be conservative, MVS suggests the pressure used in the calculation be 213.4 Pa (0.86 in. w.g.) This would be considered the absolute maximum that could be seen across the seals in the main airways.

APPENDIX E
VOC CALCULATIONS

TECHNICAL MEMORANDUM

Date:	August 30, 2016	**Project No.:**	0632213
To:	Rey Carrasco	**Company:**	Nuclear Waste Partnership LLC
From:	Gordan Gjerapic and Bill Thompson	**Email:**	GGjerapic@Golder.com

RE: ESTIMATION OF VOLATILE ORGANIC COMPOUND RELEASES FOR VARIOUS WIPP PANEL CLOSURE DESIGNS – REV 2

1.0 OBJECTIVE

This document presents evaluations of potential volatile organic compound (VOC) releases for various closure alternatives, and is an extension of, and uses the same methodology as the estimates documented in RockSol (2012) and Kehrman (2012). The methodology and assumptions used in earlier reports (RockSol 2012 and Kehrman 2012) are summarized in Attachment 1.

1.1 Historical Background

Earlier reports (RockSol 2012, Golder 2013) considered VOC releases from panels closed with the WIPP Panel Closure (WPC) that incorporates the run-of-mine (ROM) salt. This design, referred herein as ROM_WPC design, consists of 100-feet of run-of-mine (ROM) salt emplaced in the access drifts (air-intake and air-exhaust drifts) of each waste-filled panel, with two ventilation bulkheads installed on the in-bye and out-bye ends of the salt pile. The ventilation bulkheads are steel bulkheads, except where concrete block explosion walls have already been installed in-bye (Panels 1, 2, and 5). The ROM_WPC calculations (RockSol 2012) indicate that an air gap will exist at the top of the salt pile for the first 23 years after emplacement of the ROM salt, due to settlement. After 23 years, the air gap between the ROM salt and the surrounding rock would have closed due to creep of the surrounding rock, and the ROM salt will be compacted until it eventually approaches the density of intact salt. Hence, the ability of the ROM_WPC to moderate or control flows into and out of the panels changes with time. For the first 23 years, the flow characteristics of the closure will be dominated by the bulkheads (or block explosion walls). After closure of the air gap, the performance will be controlled by the permeability of the ROM salt, which will change over time as the salt consolidates.

VOCs contained in the waste containers will diffuse into the panel air through the filters. These filters are placed on the waste containers to prevent buildup of hydrogen as a result of radiolysis (Kehrman 2012). After the release from the containers, the dominant mechanism for VOC emissions from the panels varies with the level of air flow through a closed panel, which in turn, for the ROM_WPC design is directly related to the presence or absence of the air gap above the run-of-mine salt. VOC emissions are driven by: 1) the ventilation-induced flow due to the pressure drop between the two panel entries leading to advection of

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VOCs through the panel openings and associated closures, 2) the generation of gas in the containers due to microbial degradation of cellulose, plastic and rubber (CPR) materials and 3) the panel volume loss due to creep of the surrounding salt. After VOCs are released from the panels through the closure system, they will be picked up by the ventilation flow in the exhaust drift leading to dilution, and then will be carried out of the Exhaust Shaft and to the compliance point at the WIPP site boundary. Further details of the methodology are given in Attachment 1 of this memorandum, and in RockSol (2012).

1.2 Current Design

The VOC releases in this memorandum were determined for the current facility conditions and for the anticipated closure scenarios as follows (see Figure 1):

- Panels 1 through 9 will be closed by using steel bulkheads. This design is referred to as WPC-A.
- Panel 10 will be closed by using ROM salt installed between two steel bulkheads. This design is referred to as WPC-B.

The current VOC model has been updated to account for the new Interim Ventilation System (IVS) with the capacity of 106,000 scfm and has been extended to evaluate VOC releases for current WPC designs. The VOC releases were calculated for the following case scenarios:

- **Case 1 – Model Verification.** Case 1 was performed to establish equivalency between the current methodology and the RockSol (2012) model.
- **Case 2 – IVS and Modified Air Dispersion Factor (ADF)**. This case is similar to Case 1 but with a revised ventilation flow rate and an updated air dispersion factor. Case 2 used the flow rate for the new Interim Ventilation System (**IVS**), 106,000 scfm, and the updated value for air dispersion of 9.82×10^{-6} per URS (2014) calculations.
- **Case 3 – Base Case for WPC-A with Nominal Bulkhead Resistance.** Case 3 incorporates all the recent changes in mine conditions into the VOC release calculations.
- **Case 4 – WPC-A Performance with Low Bulkhead Resistance**. Case 4 is the same as Case 3, but with a reduced bulkhead flow resistance of 200 Practical Units (**P.U.**)[1] Case 4 evaluates the performance of the WPC with degraded steel bulkheads in all panels.
- **Case 5 – WPC-B Performance.** Case 5 evaluates the performance of the WPC-B after the air gap has closed and the ROM salt near Panel 10 has consolidated to 90% of its intact density, leading to reduced flow through the closure and throughout the whole repository.

An important conclusion from these analyses is that the release of carbon tetrachloride (CCl_4), with any of the considered scenarios, will remain within compliance limits during the operational period. Experience with VOC monitoring at the WIPP facility indicates that CCl_4 accounts for over 68 percent of the carcinogenic risk based on samples taken in the underground. Therefore, CCl_4 is used as a surrogate for all VOCs. For the WPC-A case scenarios, the potential release of CCl_4 is considerably smaller (almost 24 times smaller)

1 A Practical Unit is 1 milli-inch of water gage divided by 1.0 kcfm (1,000 cubic feet per minute).

than the compliance limit defined by the CCl_4 Health Based Level (HBL) of 0.333 μg/m^3. For the WPC-B scenario, when the air gap above the ROM salt is eliminated by creep closure, the release of CCl_4 is predicted to be on the order of 0.14 percent of the compliance limit. It follows that the design of the WPC is not critical in maintaining compliance with the VOC limits for WIPP during the operational period.

2.0 INPUTS AND METHODOLOGY

As noted above, the evaluations were based on the unrestricted flow model initially discussed by DOE (1996) and developed by RockSol (2012). RockSol's (2012) calculation approach and model assumptions are discussed in Attachment 1. Input parameters and geometry used for the current model are summarized in Table 1 together with those used for the previous VOC calculations.

Table 1: Differences between Current and Previous Models

Input	**RockSol (2012) and Golder (2013)**	**Current Model**
Creep Closure Rate (m^3/year)	812 m^3/year	varies
Pressure Drop Across Panel (mili inch w.g.)	170 mili inch w.g.	varies
Ventilation Rate (cfm)	260,000 scfm	106,000 scfm
Air Dispersion Factor, ADF (-)	8.78 x 10^{-5}	9.82 x 10^{-6}
Geometry	Assume Panels 9 and 10 same as Panels 1 to 8	Account for changes in geometry between panels
Microbial emissions for closed panels (with air gap above ROM salt closed)	Scaled to 40,233[1] containers per panel with container emission of 0.1 mol/drum/panel	Calculate gas emissions based on the number of containers and the emission rate from individual containers of 0.1 mol/drum/year. Emission rates were determined based on 42,350[2] containers.

Notes:
1. The value of 40,233 containers per panel was assumed in RockSol (2012)
2. The value of 42,350 containers per panel was assumed in Kehrman (2012)

Different panel closure alternatives were evaluated and compared based on the calculated compliance ratio for carbon tetrachloride (CCl_4), the critical organic compound affecting air quality:

$$Compliance\ Ratio = RF_{CCl4} = \frac{C_{CCl4,SB}}{C_{HBL,CCl4}}$$

Where: RF_{CCl4} = calculated risk fraction (compliance ratio) for the CCl_4 gas at the WIPP site boundary. A ratio less than 1 is compliant with the VOC limit for CCl_4 at the WIPP site boundary.

$C_{CCl4,SB}$ = calculated CCl_4 concentration at the compliance point at the WIPP site boundary

$C_{HBL,CCl4}$ = health based level (HBL) for CCl_4 gas (10^{-6} risk level)
$C_{HLB,CCl4}$ = 0.333 µg/m³ based on Kehrman (2012)

Health based levels used to evaluate risk fractions for different VOCs were adopted from Kehrman (2012) and EPA (2016) web-site (see Table 4). Elements of the VOC calculations procedure are presented schematically in Figure 4.

3.0 RESULTS

3.1 VOC Calculations

The various closure alternatives were evaluated through a series of assumed scenarios, as identified in Table 2, with the results summarized in Table 3 in terms of the calculated compliance ratios for CCl_4. Case scenarios No. 2, 3, 4 and 5 were developed by assuming 42,350 containers per active panel based on Kehrman (2012) assumptions. Case 1 parameters were selected to establish equivalency with the previous RockSol (2012) model calculations, i.e., assuming 40,233 containers per active panel. As noted in RockSol (2012), the value of 40,233 containers per active panel implies 95% efficiency for a maximum number of containers of 42,350. The RockSol (2012) model is discussed in more detail in Attachment 1.

Table 2: Compliance Cases Examined for the Different Closure Alternatives

Case No. – Description	No. Filled Panels	Volumetric Creep Rate (m³/yr/panel)	Pressure Drop across Panel/Bulkhead (milli-inch w.g.)	Air Flow Resistance (P.U.)
1 – Model Verification	9	812	170	4,400
2 – IVS and Modified ADF	9	812	170	4,400
3 – Base Case for WPC-A	9	1,262 (Panels 1 to 8) 950 (Panel 9)	3.4	4,400
4 – Base Case for WPC-A with Low Bulkhead Resistance	9	1,262 (Panels 1 to 8) 950 (Panel 9)	3.4	400
5 – WPC-B Performance after Air Gap Closure	10	1,262 (Panels 1 to 8) 950 (Panels 9 and 10)	856	ROM salt w/closed gap (~10^{12} P.U.)

The design criteria for the calculations are shown in Attachment 2. Details on the model parameters are given below:

Creep closure flow (Q_{creep}): The initial creep closure flow rate of 812 m³/yr/panel used for Cases 1 and 2 was adopted from DOE (1996) and RockSol (2012) based upon the best closure information available at the time of the RCRA Part B Permit Application in 1996. Since that time, there have been many measurements of closure in the various panels, and the revised closure rate of 1,262 m³/yr/panel for Panels 1 to 8 is based on an average convergence rate of 3.9 inch/year estimated from the updated DOE (2011) convergence data for the rooms in Panel 5 (Figure 2). Creep closure data for access drifts between 2010 and 2012 as reported in DOE (2013) are shown in Figure 3. An average convergence rate for the main drifts of 2.0 inch/year can be estimated from the measured data (Figure 3) which converts to an estimated rate of 950 m^3/yr/panel for Panels 9 and 10. The actual closure data and details of creep closure calculations are presented in Appendix C of the Design Report (Golder 2016).

Pressure drop across individual panels (h): This parameter is a measure of the difference in pressure in the exhaust main drift between the upstream and downstream panel entry, which is the driving force for advective flow through the closure system and in the panel. The initial value of 170 mili inch w.g. was adopted from the RockSol (2012) report based on the ventilation characteristics in the East-300 drift for 260,000 cfm flow rate. A recent analysis by MVS (2015) indicates that for the modified ventilation rate for the IVS, the maximum airflow in the access drifts is not likely to exceed 90,000 cfm. The estimated pressure drop for WPC-A installed in the main drifts between S-2520 and S-2750 is then 3.4 mili inch w.g. assuming the air flow resistance in the access drift of 0.00042 Practical Units (P.U.). This value is used in the calculations for Cases 3 and 4. It is worth noting that MVS (2015) states that the airflows across bulkhead closures are likely to be dominated by changes in the barometric pressure which would result in greater flows in the panels. However, these will be transient effects and should not impact the long-term average VOC release values dominated by the diffusion rate of the VOCs out of the waste containers through the filter systems. The MVS report is included as Attachment 1 of Appendix D of this document.

Airflow resistance (R): The earlier calculations assumed that, for the cases where the air gap between ROM salt and the surrounding rock had not closed, flow resistance would be dominated by a minimum of two bulkheads in the flow path. For an assumed individual bulkhead resistance of 2,200 P.U. this would result in a total airflow resistance of 4,400 P.U. (RockSol 2012). For the more tightly sealed bulkheads with individual bulkhead resistance of 8,940 P.U. (MVS 2015), the total airflow resistance may be as high as 17,880 P.U. To establish the equivalency with the previous calculations, the adopted airflow resistance of 4,400 P.U. was adopted as a baseline value for steel bulkheads. The airflow resistance value of 200 P.U. was used to simulate the degraded bulkhead resistance, (e.g., due to creep closure) in Case 4.

As noted in Table 1, Case 1 was developed to establish equivalency between the RockSol (2012) results and the current methodology, i.e., results for Case 1 scenario were determined for the ventilation rate of 260,000 scfm. The compliance ratio from Case 1 agrees favorably with the results from RockSol (2012), establishing equivalency between the revised VOC model and the previously used methodology.

Case 2 uses the same inputs as Case 1, except the ventilation rate is set to 106,000 scfm, the air dispersion factor (ADF) is set to 9.82×10^{-6} based on the updated air quality model (URS 2014), and the number of containers per panel is set to 42,350, based on 100% efficiency for panel loading. The CCl_4 compliance ratio of 0.042 for Case 2 is significantly smaller than the Case 1 value, largely due to the decrease in the ADF, which increases the VOC dispersion relative to that assumed by the RockSol (2012) model.

Case 3 for WPC-A incorporates the recent changes in mine conditions into the VOC release calculations. Case 3 uses the new IVS flow rate of 106,000 scfm, a revised pressure drop for the IVS of 3.4 milli-inches w.g., 42,350 drums per panel (100% loading efficiency), and revised volumetric closure rates based on recent geotechnical data (1,262 m^3/year/panel for Panels 1 to 8 and 950 m^3/year for Panel 9). The bulkhead flow resistance is 2,200 P.U., unchanged from Case 1. Case 3 assumes that nine panels are filled with waste and closed with steel bulkheads.

Case 4 for WPC-A is the same as Case 3, but with a reduced bulkhead flow resistance of 200 P.U. Case 4 evaluates the performance of the WPC-A with degraded steel bulkheads in all panels. Case 4 also assumes that nine panels are filled with waste and closed with steel bulkheads.

The CCl_4 compliance ratios for Cases 2, 3, and 4 are essentially identical, implying that the compliance ratio is insensitive to volumetric closure rate, pressure drop, or bulkhead flow resistance (see Table 3). The compliance ratios for Cases 2, 3, and 4 are the same because release of CCl_4 is limited by the filter(s) on each container, and the air flow for Cases 2, 3, or 4 is always sufficient (i.e., high enough) to remove the VOCs that diffuse from the individual drums. In other words, the release of VOCs is governed by a limiting emission rate (i.e., calculated for the maximum diffusion rate through the filters for fully ventilated rooms), which is not affected by closure rate, pressure drop, or flow resistance.

Case 5 examines the situation when the air gap above the ROM salt for the WPC-B for Panel 10 is closed, i.e., when the ROM salt is in close contact with the entry roof and walls. In this situation, the flows across the WPC-B will be very small, and the concentration of VOCs in the panels is expected to reach the headspace concentration in the containers because the emission of VOCs from the panels is significantly reduced due to a relatively large resistance to air flow through the ROM salt. Case 5 results were determined for the air resistance of ROM salt at the fractional density of 90% (Kelsall et al. 1983) and the bounding pressure drop of 0.86 inch w.g. (856 milli-inch w.g.) across WPC-B, based on (MVS 2015). Details of the VOC calculations for CCl_4 are presented in Attachment 3.

The results of the five cases are shown in Table 3 in terms of the calculated Compliance ratio. In all cases, the ratio is below 0.15 indicating the estimated releases of CCl_4 at the compliance point at the WIPP site boundary are well below the health-based limits.

Table 3: Calculated Compliance Ratio for Different Closure Alternatives

Case	No. Active Panels	Creep Closure Rate (m³/yr/panel)	Pressure Drop across Panel/ Bulkhead (mili inch w.g.)	Air Flow Resistance (P.U.)	Compliance Ratio
1	9	812	170	4,400	0.15
2	9	812	170	4,400	0.04
3	9	1,262 (Panels 1 to 8) 950 (Panel 9)	3.4	4,400	0.04
4	9	1,262 (Panels 1 to 8) 950 (Panel 9)	3.4	17,880	0.04
5	10	1,262 (Panels 1 to 8) 950 (Panel 9)	856	ROM salt w/closed gap (~10^{12} P.U.)	<0.01

Compliance ratios for other VOCs of interest are summarized in Table 4 with the calculation details presented in Attachment 4.

Table 4: WIPP Facility HBLs and Compliance Ratios at WIPP Site Boundary for VOCs in Waste Repository

VOC	WIPP Facility HBLs (µg/m3)		Compliance Ratio[1] (Carcinogenic)	Compliance Ratio (Non-Carcinogenic)
	Carcinogenic	Non-Carcinogenic		
Carbon Tetrachloride	0.333	100	4.24E-02	1.41E-04
Chlorobenzene	N/A	50.0	N/A	5.83E-07
Chloroform	0.09	97.7	2.35E-03	2.16E-06
1,2-Dichloroethane	0.077	7	5.33E-04	5.85E-06
1,1-Dichloroethylene	N/A	200	N/A	7.18E-07
Methylene Chloride	101.2	600	3.66E-06	6.17E-07
1,1,2,2-Tetrachloroethane	0.035	N/A	1.31E-03	N/A
Toluene	N/A	5,000	N/A	2.21E-08
1,1,1-Trichloroethane	N/A	5,000	N/A	1.97E-06
Trichloroethylene	0.394	2	1.75E-03	3.44E-04
Total	**-**	**-**	**4.86E-02**	**5.10E-04**

Note:
1. N/A indicates that there is no regulatory limit for the VOC.

4.0 CONCLUSIONS

A series of five cases have been examined by varying parameters that are governing flow calculations based on the assumptions and methodology used in earlier reports (see, e.g., RockSol 2012 and Kehrman 2012). These cases investigate the compliance ratio for CCl_4 at the WIPP site boundary to establish the equivalency between the current model and the previously used analyses (Case 1), and for the WPC-A (Case 2, 3 and 4) and WPC-B (Case 5) installations representing the current closure designs. Analyzed scenarios consider the current ventilation airflow, utilize results of the recent air quality models and use the available measurements collected in the underground. The updated flow model accounts for different geometries in the main entries for Panels 9 and 10, and takes into account potential variability in the air flow resistance of considered closures.

The results indicate that the WIPP facility will comply with the HBLs in Table 4 using well-maintained bulkheads alone, and that the ROM salt component for Panel 10 does not contribute additional protection for public health and the environment until after the air gap above the ROM salt closes. The VOC model provides an upper bound to the chronic health effects to the public. This is because:

- The predicted airflow through each panel is maximized by ignoring the resistance to flow created by the presence of internal barriers, such as steel bulkheads, brattice cloth/chain link, and the presence of the waste containers and backfill
- The total VOC source term available for diffusion out of the containers is maximized

5.0 REFERENCES

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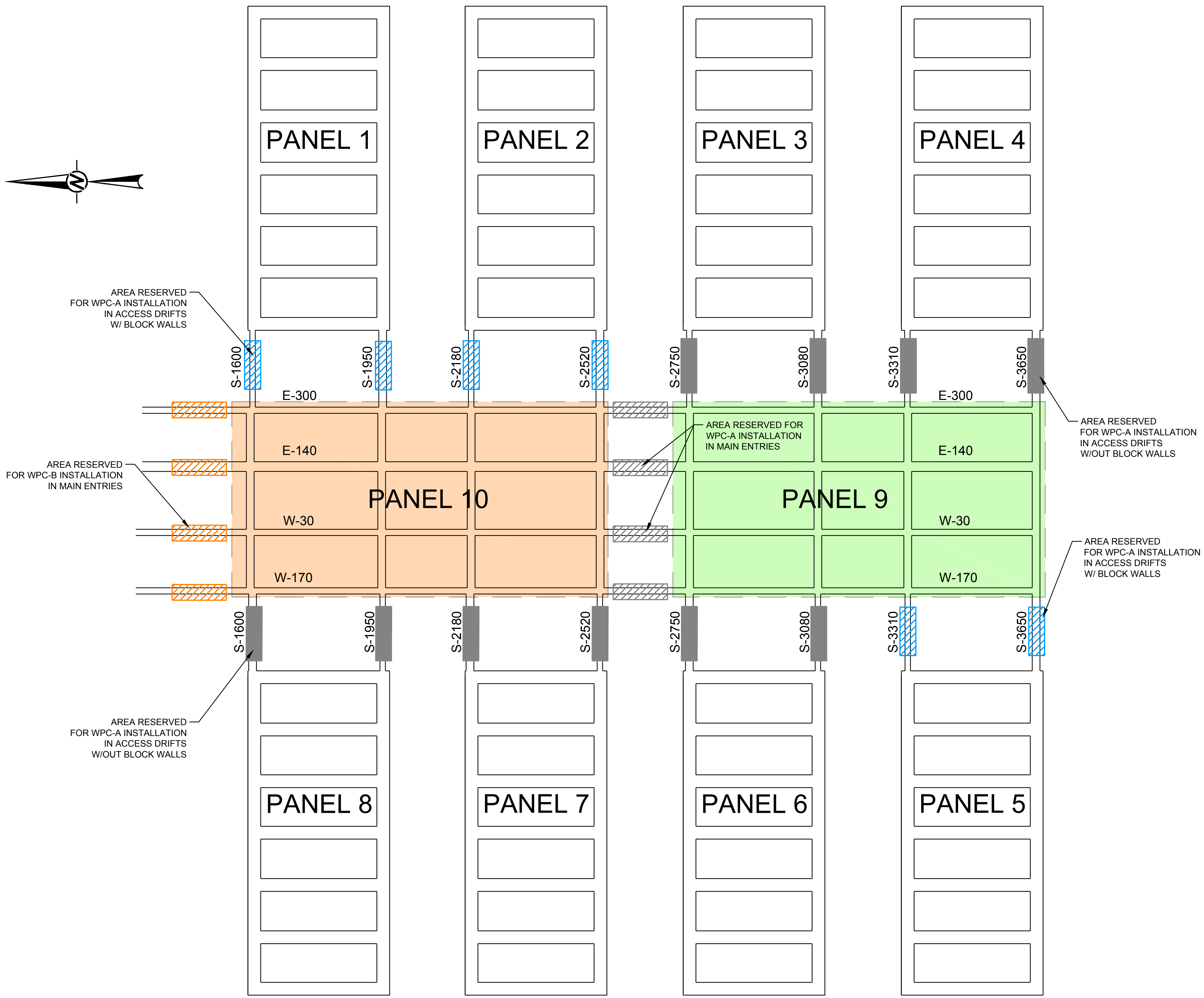
FIGURES



LEGEND

- APPROXIMATE EXTENTS OF PANEL 9
- APPROXIMATE EXTENTS OF PANEL 10
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN PANEL ACCESS DRIFTS W/ EXPLOSION-ISOLATION WALLS
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN MAIN ENTRIES
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN PANEL ACCESS DRIFTS W/OUT EXPLOSION-ISOLATION WALLS
- APPROXIMATE AREA RESERVED FOR WPC-B INSTALLATION IN MAIN ENTRIES

NOTES

1. PANEL GEOMETRY FOR VOC CALCULATIONS BASED ON DATA PRESENTED IN PREVIOUS REPORTS BY ROCKSOL (2012) AND DOE (2011, 2013).
2. VOLUME FOR PANELS 1 TO 8 BASED ON 33-FT WIDE AND 13-FT HIGH CROSS-SECTION OF UNDERGROUND OPENINGS.
3. VOLUME FOR MAIN ENTRIES E-300, W-30 AND W-170 BASED ON 16-FT WIDE AND 13-FT HIGH CROSS-SECTION.
4. VOLUME FOR MAIN ENTRY E-140 BASED ON 25-FT WIDE AND 15-FT HIGH CROSS-SECTION.
5. VOLUME FOR EAST-WEST CROSS-DRIFTS: S-1600, S-1950, S-2180, S-2520, S-3080, S-3310 AND S-3650 BASED ON 20-FT WIDE AND 13-FT HIGH OPENINGS.

0 150 300 450
FEET

CLIENT	PROJECT
NUCLEAR WASTE PARTNERSHIP LLC	WIPP CLOSURE GEO-MECHANICAL COMPLIANCE

CONSULTANT: Golder Associates

YYYY-MM-DD	2016-07-18
PREPARED	GG
DESIGN	GG
REVIEW	WTT
APPROVED	WTT

TITLE
VOC CALCULATIONS
PANEL GEOMETRY

PROJECT No.	CONTROL	Rev.	FIGURE
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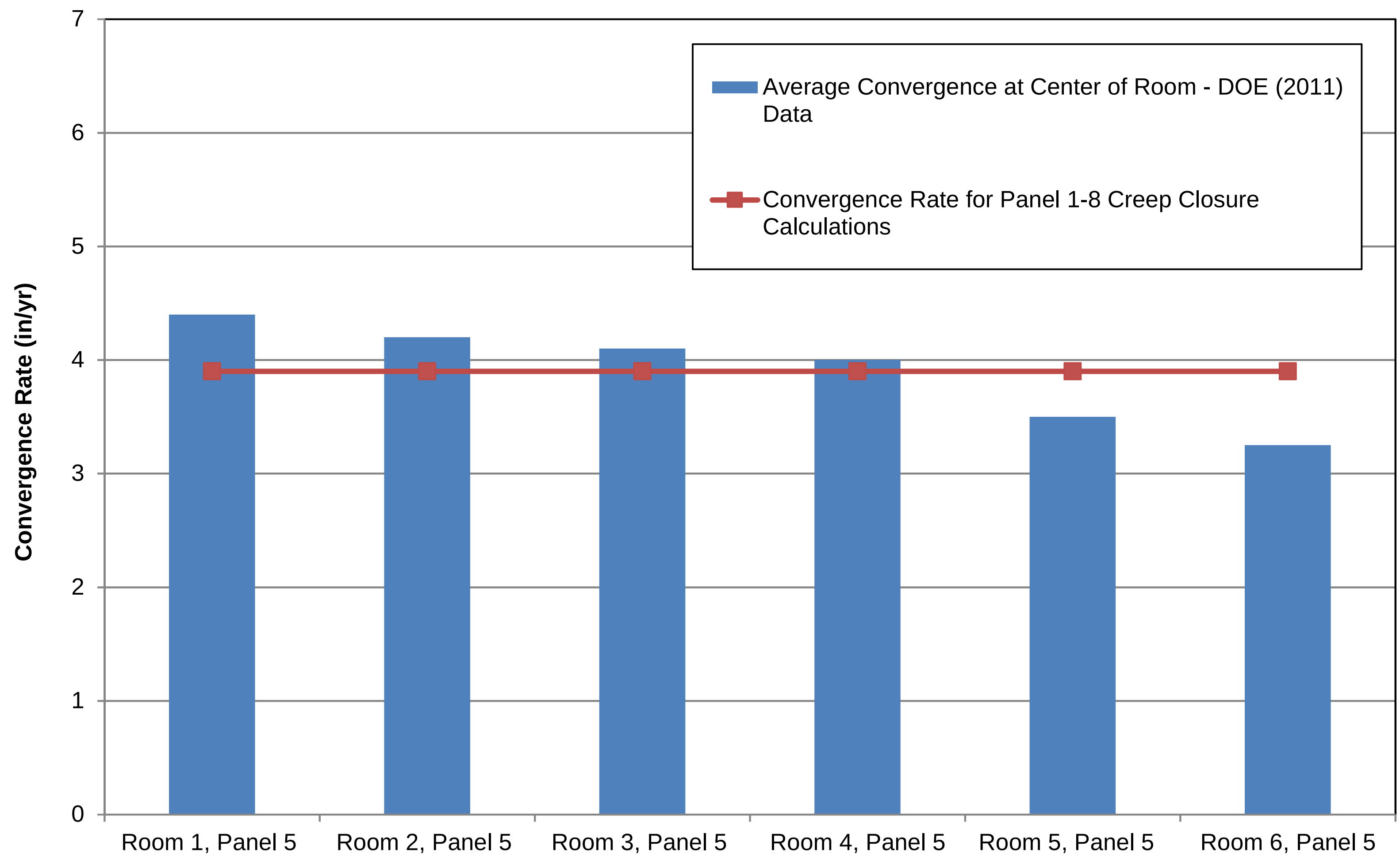
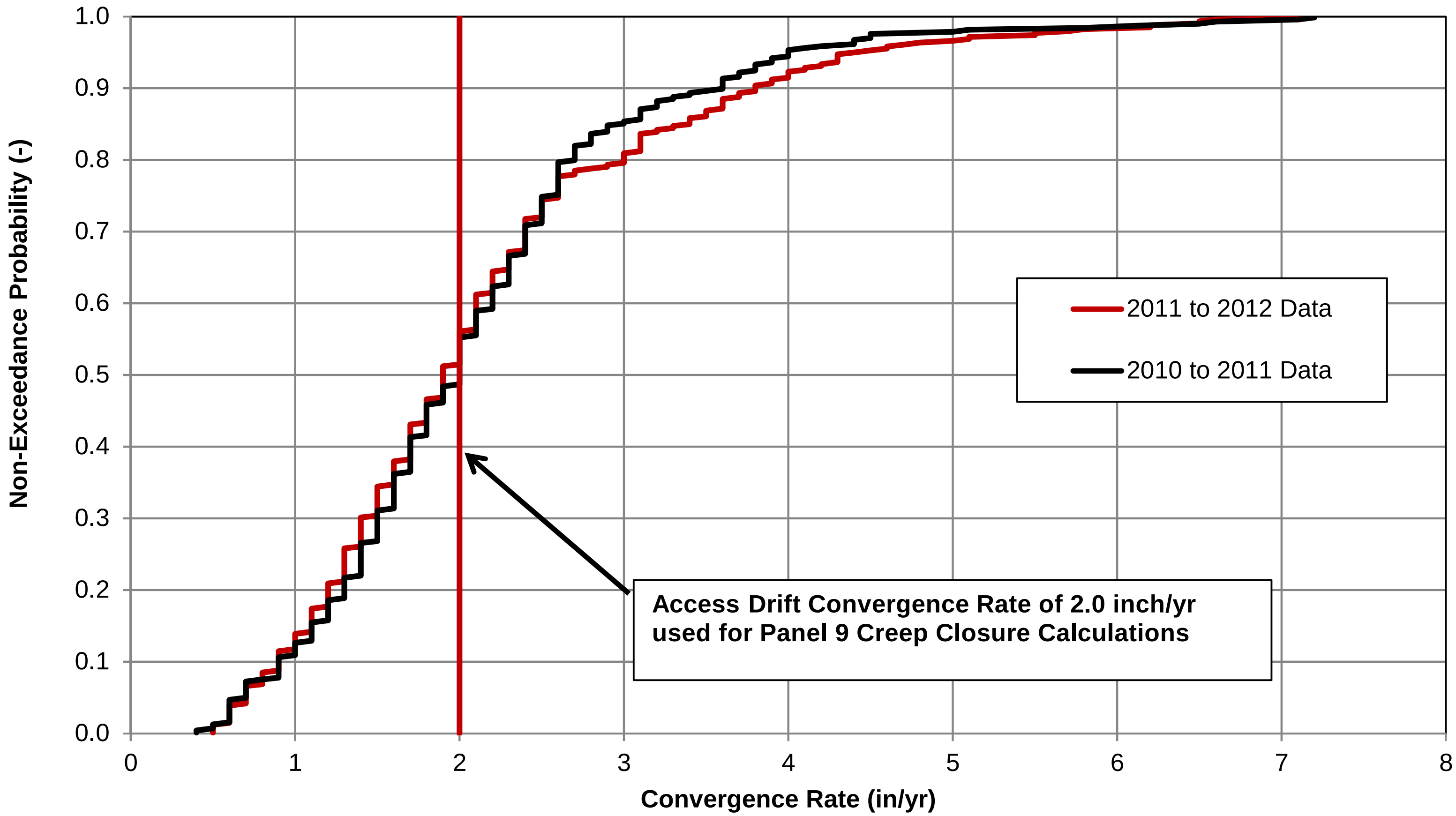


Golder Associates — Denver, Colorado	TITLE **Convergence Rates - Panels**		
CLIENT/PROJECT **NUCLEAR WASTE PARTNERSHIP LLC** **WIPP CLOSURE - GEOMECHANICAL COMPLIANCE**	DRAWN **GG** CHECKED **WTT** REVIEWED **WTT**	DATE **Feb-16** SCALE **AS SHOWN** FILE NO.	JOB NO. **063-2213NEW** DWG. NO. FIGURE NO. **FIGURE 2**

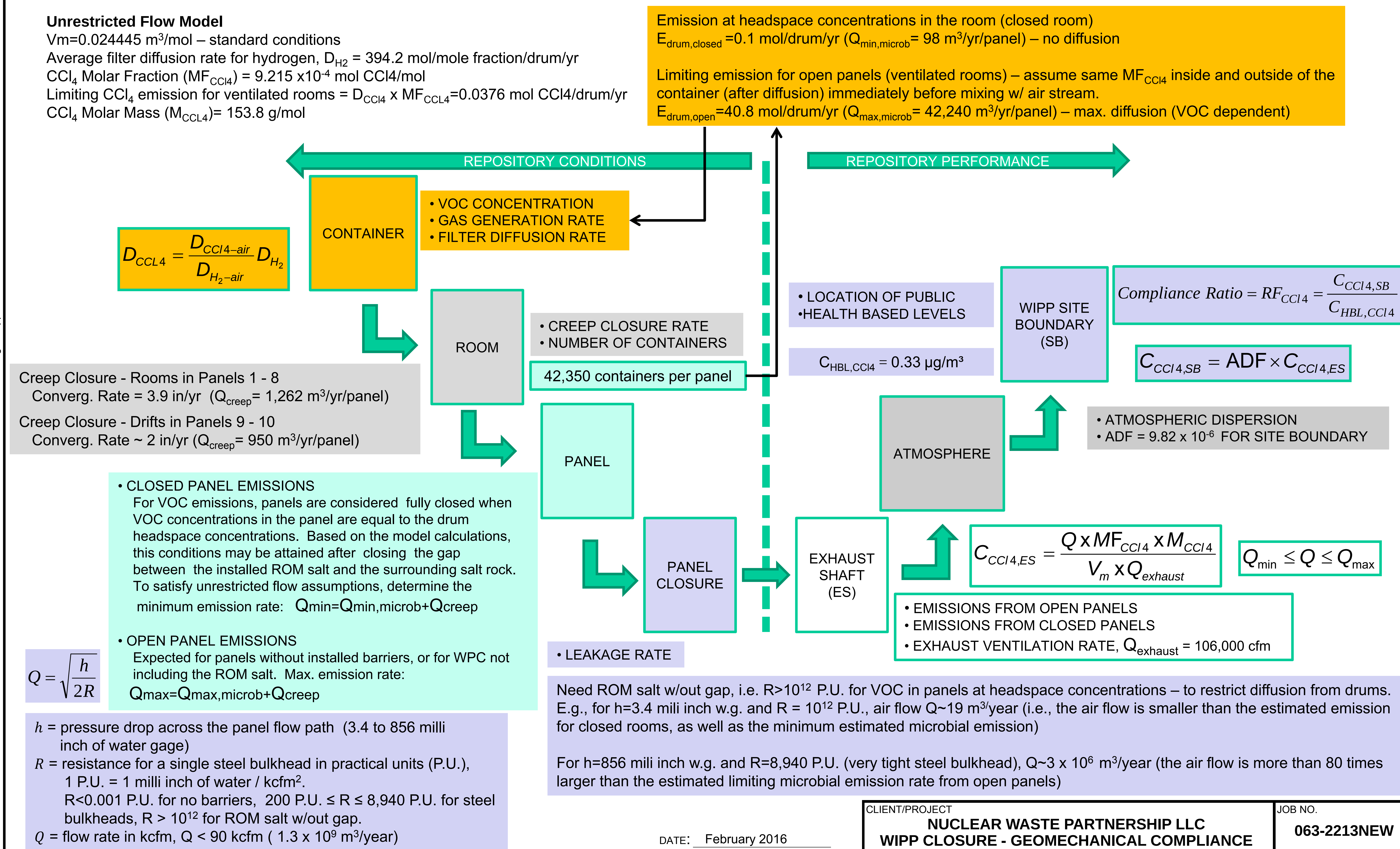


Note: GAR data compiled by Mike Gross in June, 2014

Golder Associates — Denver, Colorado

TITLE	**Convergence Rates - Access Drifts**				
DRAWN	GG	DATE	Feb-16	JOB NO.	063-2213NEW
CHECKED	WTT	SCALE	AS SHOWN	DWG. NO.	
REVIEWED	WTT	FILE NO.		FIGURE NO.	FIGURE 3

CLIENT/PROJECT
NUCLEAR WASTE PARTNERSHIP LLC
WIPP CLOSURE - GEOMECHANICAL COMPLIANCE



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Golder Associates

CLIENT/PROJECT	JOB NO.
NUCLEAR WASTE PARTNERSHIP LLC WIPP CLOSURE - GEOMECHANICAL COMPLIANCE	063-2213NEW
TITLE VOC RELEASES – CALCULATION ELEMENTS	FIGURE NO. FIGURE 4

ATTACHMENT 1
FLOW RATES AND VOC CONCENTRATIONS FOR OPEN AND CLOSED PANELS SUMMARY OF KEHRMAN (2012) AND ROCKSOL (2012) ASSUMPTIONS AND METHODOLOGY

TECHNICAL MEMORANDUM

Date: August 30, 2016 **Project No.:** 063-2213

To: Rey Carrasco **Company:** Nuclear Waste Partnership LLC

From: Gordan Gjerapic and Bill Thompson **Email:** GGjerapic@Golder.com

RE: WIPP PANEL CLOSURE
FLOW RATES & VOC CONCENTRATIONS FOR OPEN & CLOSED PANELS

1.0 OBJECTIVE

Summarize assumptions and methodology used by Kehrman (2012) and RockSol (2012) to calculate VOC emissions from the Waste Isolation Pilot Plant (WIPP) disposal panels. In particular, discuss the approach used to calculate VOC emissions through the WIPP Panel Closure (WPC) consisting of run-of-mine (ROM) salt and steel bulkheads (ROM_WPC) as a function of the flow rates with an emphasis on quantifying the difference in VOC emissions between open and closed panels.

2.0 APPROACH

Use assumptions and methodology adopted by RockSol (2012) and Kehrman (2012) to identify governing physical mechanisms and construct simplified analytical models to confirm previously reported flows and VOC concentration values.

3.0 INPUTS AND ASSUMPTIONS

Unless specified otherwise, the following inputs and assumptions were adopted from RockSol (2012) and Kehrman (2012) reports and accompanying documents.

3.1 General Inputs

- Pressure drop across the panel: 170 milli inches of water gage (42.4 Pa).
- Air density: 1.18 kg/m^3.
- Air dynamic viscosity: 1.84 x 10^{-5} kg/(m sec).
- Molar volume for the gas at standard conditions Vn = 0.0245 m^3/mol.
- Microbial gas generation rate: 0.1 mol/drum/year (Kehrman 2012).
- Gas generation rate due to the creep of panel openings (room closure): 812 m^3/yr/panel (0.055 cfm/panel) per DOE (1996). Note that this number corresponds to the emission rate of E_{creep} = 812 m^3/yr/panel / 0.0245 m^3/mol = 33,143 mol/yr/panel.
- Maximum number of drums in a panel is 42,350 assuming 6,050 filters per room and 7 rooms (Kehrman 2012), i.e., for calculation purposes, Kehrman (2012) equates the equivalent number of drums in the room to the number of filters. RockSol (2012) assumed that the rooms are 95% full and performed the calculations for 40,233 drums.

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3.2 Geometry

- WIPP panel consists of seven (7) parallel disposal rooms at the distance of 133 feet (wall thickness of 100 feet), connected on each side by drifts for access and ventilation (RockSol 2012). Disposal room dimensions are approximately 300 feet x 33 feet x 13 feet (length x width x height).
- The ROM_WPC consists of steel bulkheads and the run-of-mine (ROM) salt material located at the air-intake and air-exhaust drifts (RockSol 2012). The air-intake drift dimensions are approximately 20 feet x 13 feet (width x height). The air-exhaust drift dimensions are 14 feet x 12 feet. ROM salt placed in the drifts is approximately 100 feet long (each drift).

3.3 Steel Bulkheads

- For approximately 23 years after ROM_WPC installation, the flow rates will be governed mostly by the flow resistance of steel bulkheads until the gap between the ROM salt and the surrounding rock closes due to creep of the surrounding salt formation (RockSol 2012).
- Number of steel bulkheads in flow path: 2.
- Single steel bulkhead resistance: 30 to 2,200 practical units (3.4×10^{-3} to 2.5×10^{-1} s^2/m^5).
- Larger entries/drifts without bulkheads have a resistance of 1×10^{-4} to 2×10^{-4} practical units.
- After the gap between the ROM salt and the surrounding rock is closed, the steel bulkhead contribution to flow resistance is relatively minor (RockSol 2012).

3.4 ROM Salt

- ROM salt placed in each drift is approximately 100 feet long.
- Intact salt density is 2,160 kg/m3.
- The ROM salt fractional density at the moment of placement is 65 percent corresponding to the initial density of 1,404 kg/m3. The corresponding porosity value is ϕ = 35 percent.
- The initial ROM salt settlement (under its own weight) is faster than the creep of the surrounding cavern resulting in a 18.5 inch (47 cm) gap in the air-intake drift and 16.5 inch (42 cm) gap in the air-exhaust drift shortly after the placement. It takes approximately 23 years for the gap to close (RockSol 2012). During this time, the main resistance to airflow is provided by steel bulkheads.
- Shortly after placement, the ROM salt fractional density increases to approximately 75 percent. The ROM salt fractional density 23 years after placement (at the moment when the air gap closes) is between 88 and 90 percent (RockSol 2012).
- The permeability-porosity relationship from Shor et al. (1981) for the average particle size of Z=0.34 cm may be used to bound WIPP specific salt data. To determine ROM salt permeability for the purpose of the air-flow model, RockSol (2012) utilized FLAC3D analyses to determine fractional densities and determined the corresponding ROM salt permeabilities and air conductivities for Z = 0.4 cm (RockSol 2012) (Figures 3-10 and 3-11) for conservatism.

- The ROM salt intrinsic permeability, k, for the purpose of the air-flow model (RockSol 2012) was determined from the following relationship (Kelsall et al. 1983, Eq. A-4):

$$k(Z,\phi) = 0.0178\, Z^2 \exp[21 + 6\ln(\phi)]$$

Where: k = intrinsic permeability (Darcy). 1 Darcy = 9.87 x 10^{-9} cm^2
Z = representative particle size (cm)
Φ = porosity

4.0 FLOW CALCULATIONS

4.1 Flow Rates Due to Gas Generation and Creep

Gas generation, which is primarily due to microbial degradation, is estimated as 0.1 mol/drum/year (Kehrman 2012). For standard conditions, this is equivalent to the gas volume of 2.45 x 10^{-3} m^3/drum/year. Assuming the maximum number of drums: Nd = 42,350, the equivalent microbial gas generation from the panel is 103.8 m^3/panel/year (6.97 x 10^{-3} cfm/panel). For the originally assumed maximum number of drums of 81,000 (Kehrman 2012, pg.4), the equivalent microbial gas generation from the panel is 198.5 m^3/panel/year (1.33 x 10^{-2} cfm/panel)

Assuming the loss of volume of 812 m^3/yr/panel (5.46 x 10^{-2} cfm/panel) due to creep closure (DOE 1996), one can calculate the total airflow due to gas generation and creep as:

$$Q_{gc} = Q_{gas} + Q_{creep} = 6.97\times10^{-3} cfm + 5.46\times10^{-2} cfm = 6.15\times10^{-2} cfm$$

The above value is reported by RockSol (2012) (Figure 3-12) and represents the minimum airflow generated by the panel without accounting for ventilation flows. The above calculation assumes that the gas within the cavern remains at all times under standard conditions (i.e., at the atmospheric pressure and the temperature of 25 °C). Note that the total airflow of 6.15 x 10^{-2} cfm (915.8 m^3/sec) for Nd = 40,233 was assumed by RockSol (2012). This corresponds to an emission rate of 0.93 mol/drum/year. This approximates an airflow of 6.79 x 10^{-2} cfm (1,010.5 m^3/sec) for Nd = 81,000 (the originally assumed maximum number of drums) and an emission rate of 0.51 mol/drum/year.

4.2 Ventilation Flow Rates Prior to Gap Closure

During the first 23 years after ROM_WPC installation (prior to closure of the air gap between ROM salt and the surrounding salt cavern), the flow resistance is mainly due to the installation of steel bulkheads. Based on the reported pressure drop across the panel and the adopted bulkhead resistance values, the flow rate through the ROM_WPC closure system can be calculated as:

$$Q = \sqrt{\frac{h}{2R}}$$

Where: h = pressure drop across the flow path through the repository panel (170 milli inch of water gage)
R = resistance for a single steel bulkhead in practical units (P.U.), 1 P.U. = 1 milli inch of w.g. / kcfm^2.
Q = flow rate in kcfm.

Calculated flow rates are summarized in Table 1.

Table 1: Estimated Flow Rates Prior to ROM Salt Gap Closure

Bulkhead Resistance (PU)	Flow Rate (cfm)	Flow Rate (m^3/sec)
30	1,683	0.79
200	652	0.31
2200	197	0.09

The flow rate of 197 cfm is calculated for the bulkhead resistance of 2,200 practical units. This value corresponds to the airflow determined by RockSol (2012) (Figure 3-12) for the majority of the first 23 years since the ROM_WPC installation (i.e., for the duration while the air gap is open). Note that the flows prior to the air gap closure (i.e., values in Table 1) are significantly higher than the flow rate induced by the microbial gas generation and creep.

4.3 Ventilation Flow Rates After Gap Closure

After closure of the air gap, the flow rate is dominated by the porous flow through the ROM salt. Assuming the total pressure drop of 42.4 Pa (170 milli inch of water gage) between the air-intake and air-exhaust drifts (RockSol 2012), one can calculate the flow through the panel based on the estimated ROM salt permeabilities:

$$Q_{intake} = A_{intake} \frac{k}{\mu} \frac{\left(p_{intake} - p_{panel}\right)}{L}$$

$$Q_{exhaust} = A_{exhaust} \frac{k}{\mu} \frac{\left(p_{panel} - p_{exhaust}\right)}{L}$$

Where: k = intrinsic permeability of the ROM salt determined for a given ROM porosity
μ = dynamic viscosity of air [1.84 x 10^{-5} kg/(m sec)]
A_{intake} = area of the air-intake drift (20 ft x 13 ft)
$A_{exhaust}$ = area of the air-exhaust drift (14 ft x 12 ft)
L = length of the ROM salt placed in the drift (100 ft)

p_{panel} = air pressure within the panel
p_{intake} = air pressure at the panel entrance (start of the air-intake drift)
$p_{exhaust}$ = air pressure at the panel exit (start of the air-exhaust drift)

By definition, the total pressure drop is equal to $\Delta p = p_{intake} - p_{exhaust} = 42.4\ Pa$. One can now determine the ventilation flow rate based on the estimated ROM salt porosity. Approximately 23 years after ROM salt deposition (i.e., at the moment of air gap closure), the estimated fractional density is in between 88 and 90 percent (RockSol 2012) which corresponds to the ROM salt porosity between 12 and 10 percent. Calculated airflows through ROM salt assuming the total pressure drop of 42.4 Pa and standard conditions were determined for different porosity values that are relevant for the flow both before and after closure of the air gap (see Table 2):

Table 2: Estimated Ventilation Flow Rates through ROM Salt

ROM Salt Fractional Density	ROM Salt Porosity	Intrinsic Permeability (m^2)	Air Conductivity (m/sec)	Flow Rate (cfm)
65.0%	35%	6.8×10^{-9}	4.4×10^{-3}	10.9
78.0%	22%	4.2×10^{-10}	2.7×10^{-4}	0.67
84.6%	15.4%	4.9×10^{-11}	3.2×10^{-5}	0.08
88.0%	12%	1.1×10^{-11}	7.2×10^{-6}	0.018
90.0%	10%	3.7×10^{-12}	2.4×10^{-6}	0.006

Table 2 indicates that the minimum estimated ventilation flow of 0.08 cfm reported after air gap closure (RockSol 2012) (Figure 3-12) should be viewed as a likely upper bound estimate. With continuing creep of the surrounding caverns, the ROM salt will continue to consolidate and approach air-conductivity values reported for less permeable panel materials summarized in Table 3. One should note that the air conductivity values for ROM salt in Table 2 are significantly higher than the conductivities for the disturbed rock zone (DRZ) surrounding the ROM salt (i.e., panel components in Table 3) supporting the conclusion by RockSol (2012) that majority of the flow after the air gap closes will be through the ROM salt.

Table 3: Air Conductivity Values for Less Permeable Panel Materials Contributing to Flow

Component	Air Conductivity (m/sec)	Reference
Dilated Salt	6.2×10^{-14}	DOE (1996)
Fractured Salt	6.2×10^{-10}	DOE (1996)
Clay Seams	6.2×10^{-12}	DOE (1996)
Marker Bed 139	6.2×10^{-11}	DOE (1996)

5.0 VOC CONCENTRATION CALCULATIONS

5.1 Inputs and Assumptions for VOC Concentration Calculations

Based on the RockSol (2012) report, the critical organic compound affecting air quality is carbon tetrachloride (CCl_4). Therefore, CCl_4 concentrations at the point of compliance (WIPP site boundary) were estimated based on the following assumptions:

- Maximum emission rate is limited by the open room emission rate reported by Kehrman (2012).
- VOC generation is limited by the number of drums stored in 10 individual panels. To determine VOC concentrations for the entire repository, Kehrman (2012) assumes 9 closed panels and one open panel (with six closed rooms and one open room for a single open panel). The RockSol (2012) model assumes that all 10 panels are open (with all 7 rooms per panel also open).
- Assume that all 7 rooms in a panel are responsible for VOC emissions.
- Assume N_d = 40,233 drum/panel (95% of maximum capacity) based on RockSol (2012).
- For conservatism, assume that an equivalent single drum emission of, E_{drum} = 1 mol/drum/year (accounting for gas emissions and creep) results in a panel emission rate of Q_{gc} = 0.07 cfm (microbial gas and creep flows without ventilation) based on the 40,233 drums (RockSol 2012).
- For flows significantly larger than the estimated gas generation and creep closure (Qgc = 0.07 cfm), i.e., for flows with an open air gap, calculate VOC concentration assuming that all rooms within the panel are open. Based on the average CCl_4 emission rate for the open room of 226.54 mol/room/year (Kehrman 2012), room occupancy of approximately 95% and assuming that all 7 rooms are emitting VOC gas, the maximum panel emission rate is E_{pmax} = 1,505 mol/panel/year.
- RockSol (2012) assumes that the minimum airflow (for closed air gap) is based on the pressure drop between the air-intake and the air-exhaust drifts of 42.4 Pa (170 milli inches of water gage) is Q_{min} = 0.08 cfm.
- Molar mass of CCl_4 molecule: M_{CCl4} = 153.84 g/mol (Kehrman 2012).
- A normalized ventilation rate: Qv = 260,000 cfm (122.7 m^3/s) based on Kehrman (2012).
- Assume molar volume for CCl_4 gas of Vn = 24.445 m^3/kmol.
- CCl_4 concentration in the headspace of the container: 921.5 ppmv (Kehrman 2012).
- Mole fraction for CCl_4: $MF_{CCl4} = 9.215 \times 10^{-4}$ (Kehrman 2012).

5.2 VOC Concentration for Open Rooms and Large Airflows

For open rooms and airflows significantly larger than the gas generation and creep flow of 0.07 cfm, assume that all ten open panels are emitting VOC gas (assume that all rooms in an open panel are also open) following the assumptions in the RockSol (2012) model. One can now calculate the upper bound for the total emission rate (RockSol 2012) as:

$$E_t = n_p E_{p\max} = 10\,\text{panels} \times 1{,}505 \frac{mol}{panel\ yr} = 15{,}050\, mol/yr = 4.77 \times 10^{-4}\, mol/s$$

For the normalized ventilation rate of 260,000 cfm, one can determine the normalized CCl_4 concentration in the exhaust shaft as:

$$C_{CCl4,ES} = \frac{M_{CCl4}\,E_t}{Q_v} = \frac{153.84\,g/mol \times 4.77 \times 10^{-4}\,mol/s}{122.7\,m^3/s} = 5.98 \times 10^{-4}\;g/m^3$$

5.3 VOC Concentration for Closed Rooms and Small Airflows

For closed rooms or when the ventilation flow is of similar magnitude or smaller than the gas generation and creep flow of 0.07 cfm, RockSol (2012) estimated VOC emission rates based on the gas headspace concentrations. The lower bound panel emission is calculated as:

$$E_{pCCl4}^{\min} = \frac{Q_{\min}}{Q_{gc}} N_d\,E_{drum}\,MF_{CCl4} = \frac{0.08\,cfm}{0.07\,cfm} \times 40{,}233\frac{drum}{panel} \times 1\frac{mol}{drum \cdot yr} \times 9.22 \times 10^{-4} = 42.4\frac{mol}{panel \cdot yr}$$

For flows larger than Q_{min}, the above equation can be used to determine the CCl_4 emission with the constraint that the calculated emission rate is smaller or equal to E_{pmax}. One can now calculate the lower bound for the total emission rate assuming nine closed and one open panel in accordance with Kehrman (2012) and RockSol (2012):

$$E_{\min} = n_p^{closed} E_{pCCl4}^{\min} + n_p^{open} E_{p\max} = 9\;panels \times 42.4\frac{mol}{panel\;yr} + 1\,panel \times 1{,}505\frac{mol}{panel\;yr}$$
$$= 1887\,mol/yr\; = 5.98 \times 10^{-5}\,mol/s$$

For the normalized ventilation rate of 260,000 cfm, one can now determine the minimum estimated normalized CCl_4 concentration in the exhaust shaft due to closed panel emissions as:

$$C_{CCl4,ES}^{\min} = \frac{M_{CCl4}\,E_{\min}}{Q_v} = \frac{153.84\,g/mol \times 5.98 \times 10^{-5}\,mol/s}{122.7\,m^3/s} = 7.50 \times 10^{-5}\;g/m^3$$

6.0 CONCLUSIONS

VOC emissions from the WIPP disposal panels can be described by two types of transport mechanisms:

1. Case No. 1: VOC transport at high room ventilation rates causes relatively fast displacement of VOCs from the room into the main entries. In this case, the VOC room concentration is significantly lower than the concentration in the container headspace and the emission rates are governed by diffusion of constituents through drum filters. The VOC transport model (RockSol 2012) uses emission rates for open rooms (i.e., diffusion rates) reported by Kehrman (2012) for the panel air-flow (ventilation through the air-intake/air-exhaust drifts) in excess of 2.85 cfm. Based on the high room ventilation rates, Case No. 1 assumes that all VOCs released through the filters are transported directly to the main entries, independent of any flow resistances in the panel closures. In order for the emission rates to be governed by diffusion of constituents through drum filters, i.e., by the difference in concentration between the headspace of the containers and the

surrounding air mass in the room, the room ventilation rates need to be relatively large in comparison to the total effective gas generation. The effective gas generation in the RockSol 2012 model is approximately 0.07 cfm (including flows due to microbial degradation and creep closure) which is approximately 40 times smaller than the minimum panel air-flow of 2.85 cfm required to trigger Case No. 1 (diffusive VOC emissions) transport scenario.

2. Case No. 2: VOC transport at low room ventilation rates results in slow displacement of VOCs from the disposal rooms into the main entries. In this case, the VOC room concentration is assumed to be equal to the concentration in the container headspace. Consequently, the emission rates are governed by advection of the constituents at the flow rates equal to the effective gas generation of 0.07 cfm. For airflows in excess of 0.07 cfm, the dilution of VOCs in the disposal room is expected to result in a concentration gradient causing increased emissions. Hence, the RockSol 2012 model utilizes a scaling factor to account for increased VOC emissions for flow rates greater than the effective gas generation and smaller than the panel airflow rate of 2.85 cfm. The RockSol 2012 model sets the minimum emission rate approximately 14% higher than the advection rate at headspace concentrations (by setting the minimum airflow through the cavern to 0.08 cfm). In addition, the maximum emission rate at the air-flow of 2.85 cfm is equal to the emission rate calculated for the open panel (Case No. 1). Case No. 2 is representative of VOC emissions from closed panels with the airflow blocked primarily by low permeability ROM salt barriers placed in the air-intake and air-exhaust drifts (i.e., a scenario with a relatively tight contact between the ROM salt and the surrounding drift walls).

VOC concentrations are based on the effective gas generation estimated from 0.5 to 1.0 mol/drum/year. The emission of 0.5 mol/drum/year is based on the 81,000 containers per panel, i.e., a maximum originally considered number of storage containers per panel (Kehrman 2012). The emission of 1.0 mol/drum/year assuming 40,233 drums per panel was adopted by RockSol (2012). For small airflows (i.e., after closure of the air gap between the ROM salt and the air-exhaust/air-intake drifts), one can assume that the constituent concentration in the rooms is equal to the headspace concentration in the containers. I.e., one can neglect diffusion forces and calculate the CCl_4 emissions based solely on the headspace concentrations. For the maximum assumed generation rate of 1 mol/drum/yr, the CCl_4 emission rate will be:

$$E^0_{CCl4} = N_d \, E_{drum} \, MF_{CCl4} = 40{,}233 \frac{drum}{panel} \times 1 \frac{mol}{drum \cdot yr} \times 9.22 \times 10^{-4} = 37.1 \frac{mol}{panel \cdot yr} = 5.30 \frac{mol}{room \cdot yr}$$

The carbon tetrachloride emissions from closed rooms based on Kehrman (2012) and RockSol (2012) calculations are summarized in Table 4.

Table 4: CCl_4 Emissions from Closed Rooms

Reference	Drums per Panel	Effective Drum Emission (mol/drum/yr)	Closed Room CCl_4 Emission (mol/panel/yr)	Closed Room CCl_4 Emission (mol/room/yr)	Closed Room CCl_4 Emission (g/room/yr)
Kehrman (2012) – calculation	42,350	0.5	19.5	2.79	429
RockSol (2012) – model	40,233	1	37.1	5.30	815

If one disregards the ventilation flow contribution through the panel, the CCl_4 concentration before mixing with the main ventilation stream (through the main drift/exhaust shaft) would be 5.8 g/m^3. After mixing contaminant streams from ten panels (with air gaps between ROM_WPC and the surrounding rock closed) with the ventilation flow of 123 m^3/sec (260,000 cfm), the normalized CCl_4 concentration is 1.47 x 10^{-5} g/m^3 as summarized in Table 5.

Table 5: CCl_4 Concentration in Storage Panels and Main Exhaust for Closed Rooms

Reference	Drums per Panel	Closed Room CCl_4 Emission (g/room/year)	Estimated Total Gas Emissions (cfm/panel)	CCl4 Concentration Within Panel (g/m^3)	Main Exhaust CCl_4 Concentration (g/m^3)
Kehrman (2012) – calculation	42,350	429	3.49E-02	5.79	7.76E-06
RockSol (2012) – model	40,233	815	6.62E-02	5.79	1.47E-05

Based on the discussions above, one can conclude that the minimum CCl_4 concentration of approximately 7.50 x 10^{-5} g/m^3 (estimated by RockSol (2012) for one open and nine closed panels) should be viewed as a conservative estimate. Conservatism in the estimated concentration is due to: 1) an assumption that one of the panels will remain open in perpetuity; 2) the contaminant source will exhibit depletion with time; and 3) decreasing permeability of the ROM salt resulting in continuous flow reduction and gas pressure build-up (i.e., storage of the CCl_4 instead of its release to the main drift/exhaust shaft).

For large airflows (i.e., prior to closure of the air gap between the ROM salt and the air-exhaust/air-intake drifts), the maximum calculated emission rate of approximately 227 mol/room/year is determined for open rooms based on the CCl_4 diffusivity coefficient of D_{CCl4} = 1.29 x 10^{-6} mol/drum/sec/mol fraction (40.7 mol/drum/year/MF_{CCl4}) (Kehrman 2012).

$$E_{CCl4}^{\max} = D_{CCl4} N_d \; MF_{CCl4} = 40.7 \frac{mol}{drum \cdot yr} \times 6{,}050 \frac{drum}{room} \times 9.22 \times 10^{-4} = 227 \frac{mol}{room \cdot yr} \approx 1{,}590 \frac{mol}{panel \cdot yr}$$

Reducing the flow through the panel air-intake and air-exhaust drifts (e.g., by steel bulkhead construction) and/or constricting the flow through the rooms, is expected to result in increased CCl_4 concentrations and, therefore, slower diffusion rates from the drums located within the panel. However, this effect was not accounted for in the RockSol (2012) model. Instead, the scaling factor of Q/Q_{gc} (the ratio between the actual airflow and the flow rate due to microbial gas generation and creep) was applied to the expression for minimum CCl_4 emissions to provide transition between the calculated concentrations for small and large airflows. Consequently, all airflows greater than approximately 2.85 cfm (for a single panel) are considered large airflows resulting in the maximum exhaust shaft concentration of 5.98 x 10^{-4} g/m^3.

7.0 REFERENCES

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ATTACHMENT 2
DESIGN CRITERIA

Golder Associates

PROJECT DESIGN CRITERIA

Client:	Nuclear Waste Partnership LLC
Project Title:	WIPP Panel Closure Alternatives
Project No.:	063-2213
Date:	August 23, 2016

Prepared By: Golder Associates Inc. — Gordan Gjerapic (Name) — [signature] (Signature)

Approved By: Nuclear Waste Partnership, LLC. — Rey Carrasco (Name) — Rey Carrasco (Signature)

Revision				Pages Revised	Remarks
#	By	App.	Date		
A	GG	BT	10/12/2015	All	Issued for Internal Review
B	GG	BT	11/12/2015	All	Issued for Client's Review
C	GG	BT	02/26/2016	All	Issued for Client's Review
D	GG	BT	07/20/2016	All	Issued for Client's Review
E	GG	BT	08/23/2016	All	Issued for Client's Review

Instruction to Print Control (indicate X where applicable):

- [x] Entire design criteria revised; reissue all pages
- [ ] Partial revisions to design criteria; reissue all pages
- [ ] Reissue revised pages only

Stamp the Design Criteria as Follows:

- [x] Issued for review and comments
- [ ] Released for study

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General Project Summary	Design Input	Discipline	Date	Revision
Evaluate closure alternatives for the updated ventilation data associated with adding skid-mounted HEPA filters that add approximately 54,000 scfm to the existing ventilation flow rates. The objectives of the work is to: ■ Evaluate effects of panel closure to measured VOC concentrations during the first 35 years of operation based on the implementation of WIPP Panel Closure (WPC). ■ Panels 1 to 9 will be closed by using out-bye steel bulkheads (WPC-A). ■ Panel 10 will be closed by using ROM salt placed between in-bye and out-bye steel bulkheads (WPC-B). Creep rates for the panel closure calculations were determined from previous RockSol (2005, 2012) reports and convergence rate measurements (DOE 2011, 2013). Additional information related to VOC emissions was adopted form Kehrman (2012) in order to determine VOC concentrations based on the approach adopted by RockSol (2012).	C	Ci	07/20/2016	D

Design and Verification Codes

Design Input
A = Assumed
B = Calculated
C = Client Information/Request
G = Golder Associates
I = Industry Standard Practice
O = Information Provided by Others
P = Published Information/Criteria
D = Database/Recommendation
T = Testwork Data
V = Vendor Data

Discipline
Ci = Civil / Geotechnical
St = Structural
Ar = Architectural
Me = Mechanical
Pi = Piping
Pr = Process
El = Electrical
In = Instrumentation
He = HVAC

		Input	Discipline	Date	Revision
List of Abbreviations		NA	All	08/23/16	E
Mass/Density					
kg	kilogram				
tonne	metric ton (i.e., long ton)				
t/yd^3	ton (short ton) per cubic yard				
Length					
m	meter				
cm	centimeter				
in	inch				
ft	foot				
µm	micrometer (micron)				
Area					
m^2	square meter				
ha	hectare (10,000 m^2)				
Time					
s	second(s)				
min	minute(s)				
hr	hour(s)				
d	day(s)				
yr	year				
Electrical					
kW	kilowatt				
kW hr	kilowatt hour				
Other					
TBD	to be determined				
AMSL	above mean sea level				
%	percent				
gpm	gallons per minute				
scfm	standard cubic feet per minute				
pcf	pound per cubic foot				
ppmv	part per million by volume				
m^3/s	cubic meters per second				
m/s	meter per second				
H:V	horizontal : vertical				
g	acceleration due to gravity (9.81 m/s^2)				
°C	degrees Celsius				
kg/m/s	kilogram per meter per second				
tpa	ton per year				
tpm	ton per month				
VOC	volatile organic compound				
PU	practical unit (1 mili inch of water / kcfm)				
ROM	run of mine				
TRU	transuranic				
WIPP	Waste Isolation Pilot Plant				
PCS	Panel Closure System				
WPC	WIPP Panel Closure				
HBL	Health Based Level				

		Input	Discipline	Date	Revision
General					
Location	WIPP	P	Ci	10/12/15	A
Depth	2150 ft (655 m) below ground surface	P	Ci	10/12/15	A
Geology	TRU waste is stored in Salado Formation comprising primarily of halite. Salado Formation is nearly 2,000 ft (610 m) thick and consists of three members: the unnamed lower member, the Mc Nutt potash zone, and the unnamed upper member. Each member contains similar amounts of halite, polyhalite and anhydrite. The WIPP is located within the unnamed lower member.	P	Ci	10/12/15	A
ROM Salt Placement Methods	In horizontal and/or diagonal lifts with optional moisture compaction using the load-haul-dump (LHD), the skid-steer loader, Fletcher Scaler (w/ a push plate attachment) and walk-behind steel wheel vibratory roller compactor.	P	Ci	08/22/16	E
Ventilation Rate	Use 260,000 cfm to verify updated VOC calculations against values from the previous reports (Kehrman 2012 and RockSol 2012). Use total ventilation rate of 106,000 cfm for updated calculations assuming the maximum air flow of 90,000 cfm in a single airway adjacent to the storage panels based on the MVS (2015) data.	P,C	Ci	02/26/16	C
Pressure Drop Across the Panel	170 mili inches of water gage (42.4 Pa) previously used by RockSol (2012) for baseline calculations. Use the range of 3.4 to 856 mili inches of water gage (0.85 to 213.4 Pa) based on the values recommended by MVS (2015). The estimated maximum pressure drop of 856 mili inch of w.g. is due to changes in the barometric pressure resulting in in-gas or out-gas air flows through the WPC.	P	Ci	02/26/16	C
Air density	1.18 kg/m^3	P	Ci	10/12/15	A
Air dynamic viscosity	1.84×10^{-5} kg/(m sec).	P	Ci	10/12/15	A
Molar volume for VOC gas	Vn = 0.024445 m^3/mol	P	Ci	10/12/15	A
Microbial gas generation	0.1 mol/drum/year	P	Ci	10/12/15	A

		Input	Discipline	Date	Revision
Gas generation rate due to creep of panel openings (room closure)	Use 812 m^3/yr/panel (0.055 cfm/panel) per DOE (1996) for baseline calculations. Note that this number corresponds to the emission rate of E_{creep} = 812 m^3/yr/panel / 0.0245 m^3/mol = 33,143 mol/yr/panel. Use 1,262 m^3/yr/panel for Panels 1 to 8 and 950 m^3/yr/panel for Panels 9 and 10 based on the design panel geometry and convergence measurements reported by DOE (2013).	C	Ci	11/12/15	B
Max. number of drums in a panel	42,350 assuming 6,050 filters per room and 7 rooms (Kehrman 2012), i.e., for calculation purposes, Kehrman (2012) equates the equivalent number of drums in the room to the number of filters. For simplicity and conservatism, assume that the same number of drums will be placed in Panels 9 and 10, i.e., 42,350 drums/panel. Note that RockSol (2012) assumed that the rooms are 95% full and performed the calculations for 40,233 drums/panel.	C	Ci	02/26/16	C
Geometry					
Panel Room configuration	WIPP panel consists of seven (7) parallel disposal rooms at the distance of 133 feet (wall thickness of 100 feet), connected on each side by drifts for access and ventilation (RockSol 2012). Disposal room dimensions are approximately 300 feet x 33 feet x 13 feet (length x width x height)	C	Ci	10/12/15	A
Main Entry Dimensions (height x width) (Panels 9 and 10)	W30 – 13 ft x 16 ft W170 – 13 ft x 16 ft E140 – 15 ft x 25 ft E-300 – 13 ft x 16 ft	P	Ci	7/20/16	D
Panel Access Drift Dimensions (height x width)	12 ft x 14 ft (air-exhaust drift) and 13 ft x 20 ft (air-intake drift)	P	Ci	10/12/15	A
Panel Room Dimensions (height x width)	13 ft x 33 ft	P	Ci	10/12/15	A
ROM salt length	2.5 x entry width (minimum)	P	Ci	7/20/16	D
Maximum ROM salt gap after placement	19.5 inch (50) cm in the 25-ft wide main entry 18.8 inch (48 cm) in the 16-ft wide main entry	C	Ci	7/20/16	D

		Input	Discipline	Date	Revision
Salt Material Parameters					
Intact Salt Density	135 to 144 pcf (2,160 to 2,300 kg/m^3)	P	Ci	7/20/16	D
Emplaced ROM Salt Density	88 to 94 pcf (1,400 to 1,500 kg/m3), assuming fractional density of 65% (RockSol, 2012)	P	Ci	7/20/16	D
ROM Salt Fractional Density After Placement	65% to 90%	P	Ci	08/23/16	E
ROM Salt Intrinsic Permeability	Use Kelsall et al (1983) $\mathrm{k}(\mathrm{Z},\phi) = 0.0178\, Z^2 \exp[21 + 6\ln(\phi)]$ Where: k = intrinsic permeability (Darcy). 1 Darcy = 9.87 x 10^{-9} cm^2 Z = representative particle size (cm) Φ = porosity Shor et al. (1981) used the average particle size of Z=0.34 cm to bound WIPP specific salt data. RockSol (2012) used Z=0.4 for conservatism (adopted in the present study)	P	Ci	10/12/15	A
Creep Rates					
Main Entry Creep Rates	2.0 inch/year - based on DOE (2011, 2013) reports and FLAC analyses	P/B	Ci	7/20/16	D
Cross-Drift and Panel Access Drift Creep Rates	2.0 inch/year - based on DOE (2011, 2013) reports and FLAC analyses	P/B	Ci	7/20/16	D
Room Creep Rates	3.9 inch/year - based on DOE (2011) report and FLAC analyses	P/B	Ci	7/20/16	D
Steel Bulkheads					
Number of bulkheads and/or explosion walls in flow path	2	A/C	Ci	10/12/15	A
Steel bulkhead resistance to air flow	Use 2,200 practical units for baseline calculations. Use maximum value of 8,940 practical units based on MVS (2015) report. Use 200 practical units to simulate degraded bulkhead performance.	C	Ci	7/20/16	D

		Input	Discipline	Date	Revision
VOC Calculations					
Critical Constituent	CCl4	C	Ci	10/12/15	A
Molar mass of CCl4 molecule	MCCl4 = 153.84 g/mol	C	Ci	10/12/15	A
Molar volume for CCl4 gas	Vn = 24.445 m^3/kmol	C	Ci	10/12/15	A
CCl4 concentration in the headspace of the container	921.5 ppmv	C	Ci	10/12/15	A
Mole fraction for CCl4	$MF_{CCl4} = 9.215 \times 10^{-4}$	C	Ci	10/12/15	A
HBL for CCL4	0.33 µg/m^3	C	Ci	10/12/15	A
Air Dispersion Factor at WIPP Site Boundary	Use ADF =8.78×10^{-5} to establish equivalency with from the previous reports; URS (2010) and Kehrman (2012). Use ADF=9.82×10^{-6} based on the URS (2014) model results.	C	Ci	08/23/16	E

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ATTACHMENT 3
VOC CALCULATIONS – CCL4 COMPLIANCE RATIOS

Case 1 - Calculations

General Inputs

Vm	(molar volume)	0.024445	m^3/mol	
Microbial emission (closed panel)		0.1	mol/drum/yr	
Molar Fraction (CCl4)		921.50	ppmv	(Kehrman, Table 1)
		9.215E-04	mol CCl4/mol	
Molar Mass (CCl4)		153.8	g/mol	
limiting CCl4 emission/diffusion rate for open panel		0.0376	mol CCL4/drum/year	(per Kehrman, 2012)
Limiting emission volume (microbial degradation) for ope		4.080E+01	mol/drum/yr	
		1.0	m^3/drum/yr	
Typical number of drums per panel (RockSol, 2012)		40,233.0		
Typical creep closure flow per panel (DOE, 1996)		812.0	m^3/panel/yr	
Ventilation rate (at shaft exit)		260,000	cfm	
		3.870E+09	m^3/yr	
		122.7	m^3/sec	
Air dispersion		8.78E-05	ADF at WIPP Site Boundary (Kehrman Table 6)	
Health Based Level (CCl4)		0.3330	micro gram/m^3 (10^-6 risk level)	

Panel Inputs

Panel	Creep Closure Rate (m^3/yr/panel)	No. Drums	Pressure Drop Across Panel hw, (mili inch w.g.)	Air Flow Resistance (PU)
1	812	40,233	170	4,400
2	812	40,233	170	4,400
3	812	40,233	170	4,400
4	812	40,233	170	4,400
5	812	40,233	170	4,400
6	812	40,233	170	4,400
7	812	40,233	170	4,400
8	812	40,233	170	4,400
9	812	40,233	170	4,400
10	0	0	170	4,400

Panel	No. Drums	Air Flow	Microbial Gas Flow (Open Panel)	Microbial Gas Flow (Closed Panel)	Creep Closure Flow	Flow @ Headspace CCl4 Concentration Open Panel	Flow @ Headspace CCl4 Concentration Closed Panel (cfm)	CCl4 Panel Emission	CCl4 Panel Emission	CCl4 at Exhaust Shaft	CCl4 at WIPP Bndry
		Q(cfm)	Qm,open (cfm)	Qm,closed (cfm)	Qcr (cfm)	(cfm)	(cfm)	(m^3 CCl4/yr)	(g CCl4/yr)	(g CCl4/m^3)	(micro g CCl4/m^3)
1	40,233	196.561	2.696	0.0066	0.055	2.750	0.061	37.721	2.374E+05	6.135E-05	5.386E-03
2	40,233	196.561	2.696	0.0066	0.055	2.750	0.061	37.721	2.374E+05	6.135E-05	5.386E-03
3	40,233	196.561	2.696	0.0066	0.055	2.750	0.061	37.721	2.374E+05	6.135E-05	5.386E-03
4	40,233	196.561	2.696	0.0066	0.055	2.750	0.061	37.721	2.374E+05	6.135E-05	5.386E-03
5	40,233	196.561	2.696	0.0066	0.055	2.750	0.061	37.721	2.374E+05	6.135E-05	5.386E-03
6	40,233	196.561	2.696	0.0066	0.055	2.750	0.061	37.721	2.374E+05	6.135E-05	5.386E-03
7	40,233	196.561	2.696	0.0066	0.055	2.750	0.061	37.721	2.374E+05	6.135E-05	5.386E-03
8	40,233	196.561	2.696	0.0066	0.055	2.750	0.061	37.721	2.374E+05	6.135E-05	5.386E-03
9	40,233	196.561	2.696	0.0066	0.055	2.750	0.061	37.721	2.374E+05	6.135E-05	5.386E-03
10	0	196.561	0.000	0.0000	0.000	0.000	0.000	0.000	0.000E+00	0.000E+00	0.000E+00
Total								**339.49**	**2.137E+06**	**5.521E-04**	**4.848E-02**

Calculate risk fraction for CCl4 gas at WIPP site boundary

HBL_CCL4	3.33E-01	micro gram CCl4/m^3
CCL4_Concentration	4.848E-02	micro gram CCl4/m^3
Risk Fraction	**1.456E-01**	**OK, Risk Fraction <1.0**

Case 2 - Calculations

General Inputs

Vm	(molar volume)	0.024445	m^3/mol	
Microbial emission (closed panel)		0.1	mol/drum/yr	
Molar Fraction (CCl4)		921.50	ppmv	(Kehrman, Table 1)
		9.215E-04	mol CCl4/mol	
Molar Mass (CCl4)		153.8	g/mol	
limiting CCl4 emission/diffusion rate for open panel		0.0376	mol CCL4/drum/year	(per Kehrman, 2012)
Limiting emission volume (microbial degradation) for ope		4.080E+01	mol/drum/yr	
		1.0	m^3/drum/yr	
Typical number of drums per panel (Kehrman, 2012)		42,350.0		
Typical creep closure flow per panel (DOE, 1996)		812.0	m^3/panel/yr	
Ventilation rate (at shaft exit)		106,000	cfm	
		1.578E+09	m^3/yr	
		50.0	m^3/sec	
Air dispersion		9.82E-06	ADF at WIPP site boundary (URS, 2014)	
Health Based Level (CCl4)		0.3330	micro gram/m^3 (10^-6 risk level)	

Panel Inputs

Panel	Creep Closure Rate (m^3/yr/panel)	No. Drums	Pressure Drop Across Panel hw, (mili inch w.g.)	Air Flow Resistance (PU)
1	812	42,350	170	4,400
2	812	42,350	170	4,400
3	812	42,350	170	4,400
4	812	42,350	170	4,400
5	812	42,350	170	4,400
6	812	42,350	170	4,400
7	812	42,350	170	4,400
8	812	42,350	170	4,400
9	812	42,350	170	4,400
10	0	0	170	4,400

Panel	No. Drums	Air Flow	Microbial Gas Flow (Open Panel)	Microbial Gas Flow (Closed Panel)	Creep Closure Flow	Flow @ Headspace CCl4 Concentration Open Panel	Flow @ Headspace CCl4 Concentration Closed Panel (cfm)	CCl4 Panel Emission	CCl4 Panel Emission	CCl4 at Exhaust Shaft	CCl4 at WIPP Bndry
		Q(cfm)	Qm,open (cfm)	Qm,closed (cfm)	Qcr (cfm)	(cfm)	(cfm)	(m^3 CCl4/yr)	(g CCl4/yr)	(g CCl4/m^3)	(micro g CCl4/m^3)
1	42,350	196.561	2.838	0.0070	0.055	2.892	0.062	39.666	2.496E+05	1.582E-04	1.554E-03
2	42,350	196.561	2.838	0.0070	0.055	2.892	0.062	39.666	2.496E+05	1.582E-04	1.554E-03
3	42,350	196.561	2.838	0.0070	0.055	2.892	0.062	39.666	2.496E+05	1.582E-04	1.554E-03
4	42,350	196.561	2.838	0.0070	0.055	2.892	0.062	39.666	2.496E+05	1.582E-04	1.554E-03
5	42,350	196.561	2.838	0.0070	0.055	2.892	0.062	39.666	2.496E+05	1.582E-04	1.554E-03
6	42,350	196.561	2.838	0.0070	0.055	2.892	0.062	39.666	2.496E+05	1.582E-04	1.554E-03
7	42,350	196.561	2.838	0.0070	0.055	2.892	0.062	39.666	2.496E+05	1.582E-04	1.554E-03
8	42,350	196.561	2.838	0.0070	0.055	2.892	0.062	39.666	2.496E+05	1.582E-04	1.554E-03
9	42,350	196.561	2.838	0.0070	0.055	2.892	0.062	39.666	2.496E+05	1.582E-04	1.554E-03
10	0	196.561	0.000	0.0000	0.000	0.000	0.000	0.000	0.000E+00	0.000E+00	0.000E+00
Total								**357.00**	**2.247E+06**	**1.424E-03**	**1.398E-02**

Calculate risk fraction for CCl4 gas at WIPP site boundary

HBL_CCL4	3.33E-01	micro gram CCl4/m^3
CCL4_Concentration	1.398E-02	micro gram CCl4/m^3
Risk Fraction	**4.200E-02**	**OK, Risk Fraction <1.0**

Case 3 - Calculations

General Inputs

Vm	(molar volume)	0.024445	m^3/mol	
Microbial emission (closed panel)		0.1	mol/drum/yr	
Molar Fraction (CCl4)		921.50	ppmv	(Kehrman, Table 1)
		9.215E-04	mol CCl4/mol	
Molar Mass (CCl4)		153.8	g/mol	
limiting CCl4 emission/diffusion rate for open panel		0.0376	mol CCL4/drum/year	(per Kehrman, 2012)
Limiting emission volume (microbial degradation) for open pa		4.080E+01	mol/drum/yr	
		1.0	m^3/drum/yr	
Typical number of drums per panel (Kehrman, 2012)		42,350.0		
Typical creep closure flow per panel (DOE, 1996)		812.0	m^3/panel/yr	
Ventilation rate (at shaft exit)		106,000	cfm	
		1.578E+09	m^3/yr	
		50.0	m^3/sec	
Air dispersion		9.82E-06	ADF at WIPP site boundary (URS, 2014)	
Health Based Level (CCl4)		0.3330	micro gram/m^3 (10^-6 risk level)	

Panel Inputs

Panel	Creep Closure Rate (m^3/yr/panel)	No. Drums	Pressure Drop Across Panel hw, (mili inch w.g.)	Air Flow Resistance (PU)
1	1,262	42,350	3.4	4,400
2	1,262	42,350	3.4	4,400
3	1,262	42,350	3.4	4,400
4	1,262	42,350	3.4	4,400
5	1,262	42,350	3.4	4,400
6	1,262	42,350	3.4	4,400
7	1,262	42,350	3.4	4,400
8	1,262	42,350	3.4	4,400
9	950	42,350	3.4	4,400
10	0	0	3.4	4,400

Panel	No. Drums	Air Flow	Microbial Gas Flow (Open Panel)	Microbial Gas Flow (Closed Panel)	Creep Closure Flow	Flow @ Headspace CCl4 Concentration Open Panel	Flow @ Headspace CCl4 Concentration Closed Panel (cfm)	CCl4 Panel Emission	CCl4 Panel Emission	CCl4 at Exhaust Shaft	CCl4 at WIPP Bndry
		Q(cfm)	Qm,open (cfm)	Qm,closed (cfm)	Qcr (cfm)	(cfm)	(cfm)	(m^3 CCl4/yr)	(g CCl4/yr)	(g CCl4/m^3)	(micro g CCl4/m^3)
1	42,350	27.798	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
2	42,350	27.798	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
3	42,350	27.798	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
4	42,350	27.798	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
5	42,350	27.798	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
6	42,350	27.798	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
7	42,350	27.798	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
8	42,350	27.798	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
9	42,350	27.798	2.838	0.0070	0.064	2.901	0.071	39.794	2.504E+05	1.587E-04	1.559E-03
10	0	27.798	0.000	0.0000	0.000	0.000	0.000	0.000	0.000E+00	0.000E+00	0.000E+00
Total								**360.44**	**2.268E+06**	**1.438E-03**	**1.412E-02**

Calculate risk fraction for CCl4 gas at WIPP site boundary

HBL_CCL4	3.33E-01	micro gram CCl4/m^3
CCL4_Concentration	1.412E-02	micro gram CCl4/m^3
Risk Fraction	**4.240E-02**	**OK, Risk Fraction <1.0**

Case 4 - Calculations

General Inputs

Vm	(molar volume)	0.024445	m^3/mol	
Microbial emission (closed panel)		0.1	mol/drum/yr	
Molar Fraction (CCl4)		921.50	ppmv	(Kehrman, Table 1)
		9.215E-04	mol CCl4/mol	
Molar Mass (CCl4)		153.8	g/mol	
limiting CCl4 emission/diffusion rate for open panel		0.0376	mol CCL4/drum/year	(per Kehrman, 2012)
Limiting emission volume (microbial degradation) for ope		4.080E+01	mol/drum/yr	
		1.0	m^3/drum/yr	
Typical number of drums per panel (Kehrman, 2012)		42,350.0		
Typical creep closure flow per panel (DOE, 1996)		812.0	m^3/panel/yr	
Ventilation rate (at shaft exit)		106,000	cfm	
		1.578E+09	m^3/yr	
		50.0	m^3/sec	
Air dispersion		9.82E-06	ADF at WIPP site boundary (URS, 2014)	
Health Based Level (CCl4)		0.3330	micro gram/m^3 (10^-6 risk level)	

Panel Inputs

Panel	Creep Closure Rate (m^3/yr/panel)	No. Drums	Pressure Drop Across Panel hw, (mili inch w.g.)	Air Flow Resistance (PU)
1	1,262	42,350	3.4	400
2	1,262	42,350	3.4	400
3	1,262	42,350	3.4	400
4	1,262	42,350	3.4	400
5	1,262	42,350	3.4	400
6	1,262	42,350	3.4	400
7	1,262	42,350	3.4	400
8	1,262	42,350	3.4	400
9	950	42,350	3.4	400
10	0	0	3.4	400

Panel	No. Drums	Air Flow	Microbial Gas Flow (Open Panel)	Microbial Gas Flow (Closed Panel)	Creep Closure Flow	Flow @ Headspace CCl4 Concentration Open Panel	Flow @ Headspace CCl4 Concentration Closed Panel (cfm)	CCl4 Panel Emission	CCl4 Panel Emission	CCl4 at Exhaust Shaft	CCl4 at WIPP Bndry
		Q(cfm)	Qm,open (cfm)	Qm,closed (cfm)	Qcr (cfm)	(cfm)	(cfm)	(m^3 CCl4/yr)	(g CCl4/yr)	(g CCl4/m^3)	(micro g CCl4/m^3)
1	42,350	92.195	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
2	42,350	92.195	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
3	42,350	92.195	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
4	42,350	92.195	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
5	42,350	92.195	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
6	42,350	92.195	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
7	42,350	92.195	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
8	42,350	92.195	2.838	0.0070	0.085	2.922	0.092	40.081	2.522E+05	1.599E-04	1.570E-03
9	42,350	92.195	2.838	0.0070	0.064	2.901	0.071	39.794	2.504E+05	1.587E-04	1.559E-03
10	0	92.195	0.000	0.0000	0.000	0.000	0.000	0.000	0.000E+00	0.000E+00	0.000E+00
Total								**360.44**	**2.268E+06**	**1.438E-03**	**1.412E-02**

Calculate risk fraction for CCl4 gas at WIPP site boundary

HBL_CCL4	3.33E-01	micro gram CCl4/m^3
CCL4_Concentration	1.412E-02	micro gram CCl4/m^3
Risk Fraction	**4.240E-02**	**OK, Risk Fraction <1.0**

Case 5 - Calculations

General Inputs

Vm	(molar volume)	0.024445	m^3/mol	
Microbial emission (closed panel)		0.1	mol/drum/yr	
Molar Fraction (CCl4)		921.50	ppmv	(Kehrman, Table 1)
		9.215E-04	mol CCl4/mol	
Molar Mass (CCl4)		153.8	g/mol	
limiting CCl4 emission/diffusion rate for open panel		0.0376	mol CCL4/drum/year	(per Kehrman, 2012)
Limiting emission volume (microbial degradation) for ope		4.080E+01	mol/drum/yr	
		1.0	m^3/drum/yr	
Typical number of drums per panel (Kehrman, 2012)		42,350.0		
Typical creep closure flow per panel (DOE, 1996)		812.0	m^3/panel/yr	
Ventilation rate (at shaft exit)		106,000	cfm	
		1.578E+09	m^3/yr	
		50.0	m^3/sec	
Air dispersion		9.82E-06	ADF at WIPP site boundary (URS, 2014)	
Health Based Level (CCl4)		0.3330	micro gram/m^3 (10^-6 risk level)	

Panel Inputs

Panel	Creep Closure Rate (m^3/yr/panel)	No. Drums	Pressure Drop Across Panel hw, (mili inch w.g.)	Air Flow Resistance (PU)
1	1,262	42,350	856	1.0E+12
2	1,262	42,350	856	1.0E+12
3	1,262	42,350	856	1.0E+12
4	1,262	42,350	856	1.0E+12
5	1,262	42,350	856	1.0E+12
6	1,262	42,350	856	1.0E+12
7	1,262	42,350	856	1.0E+12
8	1,262	42,350	856	1.0E+12
9	950	42,350	856	1.0E+12
10	950	42,350	856	1.0E+12

Panel	No. Drums	Air Flow	Microbial Gas Flow (Open Panel)	Microbial Gas Flow (Closed Panel)	Creep Closure Flow	Flow @ Headspace CCl4 Concentration Open Panel	Flow @ Headspace CCl4 Concentration Closed Panel (cfm)	CCl4 Panel Emission	CCl4 Panel Emission	CCl4 at Exhaust Shaft	CCl4 at WIPP Bndry
		Q(cfm)	Qm,open (cfm)	Qm,closed (cfm)	Qcr (cfm)	(cfm)	(cfm)	(m^3 CCl4/yr)	(g CCl4/yr)	(g CCl4/m^3)	(micro g CCl4/m^3)
1	42,350	0.029	2.838	0.0070	0.085	2.922	0.092	1.258	7.919E+03	5.020E-06	4.929E-05
2	42,350	0.029	2.838	0.0070	0.085	2.922	0.092	1.258	7.919E+03	5.020E-06	4.929E-05
3	42,350	0.029	2.838	0.0070	0.085	2.922	0.092	1.258	7.919E+03	5.020E-06	4.929E-05
4	42,350	0.029	2.838	0.0070	0.085	2.922	0.092	1.258	7.919E+03	5.020E-06	4.929E-05
5	42,350	0.029	2.838	0.0070	0.085	2.922	0.092	1.258	7.919E+03	5.020E-06	4.929E-05
6	42,350	0.029	2.838	0.0070	0.085	2.922	0.092	1.258	7.919E+03	5.020E-06	4.929E-05
7	42,350	0.029	2.838	0.0070	0.085	2.922	0.092	1.258	7.919E+03	5.020E-06	4.929E-05
8	42,350	0.029	2.838	0.0070	0.085	2.922	0.092	1.258	7.919E+03	5.020E-06	4.929E-05
9	42,350	0.029	2.838	0.0070	0.064	2.901	0.071	0.971	6.110E+03	3.873E-06	3.803E-05
10	42,350	0.029	2.838	0.0070	0.064	2.901	0.071	0.971	6.110E+03	3.873E-06	3.803E-05
Total								**12.01**	**7.557E+04**	**4.790E-05**	**4.704E-04**

Calculate risk fraction for CCl4 gas at WIPP site boundary

HBL_CCL4	3.33E-01	micro gram CCl4/m^3
CCL4_Concentration	4.704E-04	micro gram CCl4/m^3
Risk Fraction	**1.413E-03**	**OK, Risk Fraction <1.0**

ATTACHMENT 4
MAXIMUM RISK FRACTIONS FOR VOCS AT WIPP SITE BOUNDARY

Input Parameters and Calculation Example - CCl4

ADF	9.82E-06	atmospheric dispersion factor
Vm	0.024445	m^3/mol
M_CCl4	153.82	g/mol
MF_CCl4	9.22E-04	mol CCl4/mol
Avg. diffusion rate for hydrogen gas	1.25E-05	mol/s/mole fraction/drum
	394.2	mol/mole fraction/drum/year
Limiting CCl4 emission	3.76E-02	mol/drum/yr
No drums per panel	42,350	
Limiting CCl4 emission	1.59E+03	mol/panel/yr
Limiting flow rate	4.22E+04	m^3/panel/yr
No. of panels	10	
q_Creep	11,996	m^3/year creep contribution
Q_exhaust	106,000	cfm
	1.58E+09	m^3/yr
C_CCl4,ES	1.60E-03	g/m^3
HBL_CCl4	0.333	micro gram/m^3
C_CCl4,SB	1.57E-02	micro gram/m^3
Compliance Ratio, RF CCl4	4.71E-02	

Average drum emission = D_VOC*MF

$$D_{VOC} = \frac{D_{VOC-air}}{D_{H_2-air}} D_{H_2}$$

$$\frac{D_{VOC-air}}{D_{H_2-air}} = \left(\frac{p_{c,VOC}}{p_{c,H_2}}\right)^{1/3} \times \left(\frac{T_{c,VOC}}{T_{c,H_2}}\right)^{-1/2} \times \left[\frac{\frac{1}{MW_{air}} + \frac{1}{MW_{VOC}}}{\frac{1}{MW_{air}} + \frac{1}{MW_{H_2}}}\right]^{1/2}$$

Table 4-1 Maximum Risk Fractions for VOCs at WIPP Site Boundary

Constituent	HBL Carcinogenic 10-6 risk level (Public)	HBL Non-Carcinogenic (Public)	Molar Weight (g/mol)	Molar Fraction (mol_VOC/mol)	Critical Temp. Tc (K)	Critical Press. Pc (bar)	Diffusion Coef, D_VOC (mol_VOC/MF/drum/yr)	Limitting VOC Emission for Ventilated Drum (mol_VOC/drum/yr)	Limitting Flow Volume Per Panel (m^3/panel/yr)	VOC Concentration at Exhaust Shaft (g/m^3)	VOC Concentration at Site Boundary (micro g/m^3)	Compliance Ratio[1] (Carcinogenic)	Compliance Ratio[1] (Non - Carcinogenic)
Acetone	---	31,000	58.08	5.31E-05	508.0	48.0	48.78	2.59E-03	5.05E+04	4.13E-05	4.06E-04	N/A	1.31E-08
Benzene	0.26	30	78.11	4.30E-06	562.0	47.4	44.17	1.90E-04	4.57E+04	4.09E-06	4.01E-05	1.54E-04	1.34E-06
Bromoform	1.82	---	252.73	1.80E-06	698.0	43.8	34.80	6.26E-05	3.60E+04	4.39E-06	4.31E-05	2.37E-05	N/A
Butanol	---	60	74.12	1.38E-05	562.0	45.0	43.72	6.03E-04	4.53E+04	1.23E-05	1.21E-04	N/A	2.02E-06
Carbon_Disulfide	---	700	76.13	1.05E-05	552.0	79.0	53.02	5.57E-04	5.49E+04	1.16E-05	1.14E-04	N/A	1.63E-07
Carbon_Tetrachloride	0.333	100	153.82	9.22E-04	556.4	45.6	40.80	3.76E-02	4.22E+04	1.60E-03	1.57E-02	4.71E-02	1.57E-04
Chlorobenzene	---	50	112.56	2.70E-06	632.4	45.2	39.24	1.06E-04	4.06E+04	3.30E-06	3.24E-05	N/A	6.47E-07
Chloroform	0.09	98	119.39	1.61E-05	536.4	54.7	45.15	7.27E-04	4.67E+04	2.39E-05	2.35E-04	2.61E-03	2.40E-06
Cyclohexane	---	6,000	84.16	1.08E-05	554.0	40.7	41.87	4.52E-04	4.33E+04	1.05E-05	1.03E-04	N/A	1.72E-08
1,1-Dichloroethane	1.25	---	98.96	9.90E-06	502.7	49.9	46.13	4.57E-04	4.78E+04	1.24E-05	1.22E-04	9.77E-05	N/A
1,2-Dichloroethane	0.0769	7	98.97	3.80E-06	561.5	53.7	44.73	1.70E-04	4.63E+04	4.63E-06	4.55E-05	5.92E-04	6.50E-06
1,1-Dichloroethylene	---	200	96.95	1.29E-05	495.0	52.0	47.24	6.09E-04	4.89E+04	1.62E-05	1.60E-04	N/A	7.98E-07
cis-1,2-Dichloroethylene	---	---	96.94	3.90E-06	545.0	60.3	47.30	1.84E-04	4.90E+04	4.92E-06	4.83E-05	N/A	N/A
trans-1,2-Dichloroethylene	---	60	96.94	4.10E-06	545.0	60.3	47.30	1.94E-04	4.90E+04	5.17E-06	5.08E-05	N/A	8.46E-07
Ethyl_Benzene	0.8	1,000	106.17	3.60E-06	616.0	37.0	37.43	1.35E-04	3.87E+04	3.96E-06	3.89E-05	4.86E-05	3.89E-08
Ethyl_Ether	---	---	74.12	4.80E-06	467.0	36.0	44.53	2.14E-04	4.61E+04	4.36E-06	4.28E-05	N/A	N/A
Methanol	---	4,000	32.04	7.13E-05	513.0	78.5	64.47	4.60E-03	6.67E+04	4.02E-05	3.95E-04	N/A	9.88E-08
Methyl_Chloride	---	90	50.49	1.56E-05	510.0	61.0	54.04	8.43E-04	5.59E+04	1.17E-05	1.15E-04	N/A	1.27E-06
Methylene_Chloride	101.2	600	84.9	3.60E-05	510.0	60.8	49.83	1.79E-03	5.16E+04	4.18E-05	4.11E-04	4.06E-06	6.85E-07
Methyl_Ethyl_Ketone	---	5,000	72.11	1.38E-05	533.0	43.0	44.40	6.13E-04	4.60E+04	1.22E-05	1.19E-04	N/A	2.39E-08
Methyl_Isobutyl_Ketone	---	3,000	100.16	1.24E-05	571.0	32.0	37.28	4.62E-04	3.86E+04	1.28E-05	1.26E-04	N/A	4.19E-08
1,1,2,2-Tetrachloroethane	0.0345	---	167.86	2.70E-06	644.5	58.4	40.88	1.10E-04	4.23E+04	5.11E-06	5.02E-05	1.46E-03	N/A
Tetrachloroethylene	7.69	40	165.83	5.10E-06	620.0	97.4	49.48	2.52E-04	5.12E+04	1.15E-05	1.13E-04	1.47E-05	2.82E-06
Toluene	---	5,000	92.13	1.22E-05	591.7	41.1	40.20	4.90E-04	4.16E+04	1.25E-05	1.23E-04	N/A	2.45E-08
1,1,1-Trichloroethane	---	5,000	133.42	7.40E-04	545.0	43.0	40.90	3.03E-02	4.23E+04	1.11E-03	1.09E-02	N/A	2.19E-06
Trichloroethylene	0.394	2	131.39	5.12E-05	573.0	49.9	41.98	2.15E-03	4.35E+04	7.79E-05	7.65E-04	1.94E-03	3.83E-04
1,1,2-Trichloro-1,2,2-Trifluoroethane	---	30,000	102	2.09E-04	487.0	46.0	45.46	9.50E-03	4.71E+04	2.67E-04	2.62E-03	N/A	8.73E-08
1,2,4-Trimethlybenzene	---	7	120.2	2.60E-06	664.5	34.5	34.76	9.04E-05	3.60E+04	3.01E-06	2.96E-05	N/A	4.23E-06
1,3,5-Trimethylbenzene	---	---	120.2	3.20E-06	664.5	34.5	34.76	1.11E-04	3.60E+04	3.71E-06	3.64E-05	N/A	N/A
m,p-Xylene	---	100	106.17	6.50E-06	617.0	35.0	36.71	2.39E-04	3.80E+04	7.02E-06	6.89E-05	N/A	6.89E-07
o-Xylene	---	100	106.17	3.80E-06	617.0	35.0	36.71	1.40E-04	3.80E+04	4.10E-06	4.03E-05	N/A	4.03E-07
Total												**5.40E-02**	**5.67E-04**

Notes:

1) N/A indicates that there is no regulatory limit for the VOC

APPENDIX F
ROM SALT LENGTH CALCULATIONS

TECHNICAL MEMORANDUM

Date:	August 25, 2016	**Project No.:**	063-2213
To:	Rey Carrasco	**Company:**	Nuclear Waste Partnership LLC
From:	Gordan Gjerapic and Bill Thompson		
Short Title:	**MINIMUM LENGTH OF ROM SALT – WIPP PANEL CLOSURE DESIGNS**		

1.0 OBJECTIVE

This document presents numerical evaluations of the geo-mechanical performance of run-of-mine (ROM) salt to be installed as a component of the WIPP Panel closure (WPC-B) to isolate Panel 10 waste area (see Figure 1). DOE (2013a) notes that the minimum ROM salt length of 100 feet, used for the previous closure design by RockSol (2012), was selected based on three factors. First consideration was given to the available length in the existing entries, second was the air-flow resistance to limit the VOC releases, and third was the engineering judgment that a backfill length of 7 to 10 times larger than the panel entry height would provide adequate engineering performance from the structural perspective while impeding the flow. The intent of this document is to provide engineering estimates for the minimum ROM salt length for the WPC-B construction in main entries E-300, E-140, W-30, and W-170 in order to isolate Panel 10. The VOC calculations presented in Appendix E of the Design Report (Golder 2016) have shown that the calculated VOC concentrations at the WIPP site boundary are not sensitive to the air flow resistance of a panel closure for long periods (approximately 17 to 31 years) after the ROM salt installation. Therefore, the criterion chosen to determine the minimum length of the ROM salt component is that the critical percentage of ROM salt, which over time is subjected to loads imparted by creep closure of the surrounding rock, will maintain its structural integrity.

The critical percentage of ROM salt was determined based on the finite difference calculations by evaluating strength, stress, and confinement conditions. The critical percentage of ROM salt corresponds to the ROM salt length for which one can expect a relatively small or no change in the geo-mechanical behavior as the length of the ROM salt increases. Noting that the geo-mechanical performance of the ROM salt is affected by the surrounding rock salt properties, as well as the dimensions of underground openings, the ROM salt performance has been evaluated for the main entry widths of 16 and 25 feet. Potential ROM salt installation in main entries with different dimensions is expected to be interpolated between two analyzed cases. Selected main entry dimensions used for the ROM salt length evaluations were based on the design dimensions specified in Appendix E of the Design Report (Golder 2016) as follows.

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Table 1: Main Entry Dimensions

Main Entry Location	Height (ft)	Width (ft)
E-300	13	16
E-140	15	25
W-30	13	16
W-170	13	16

The loads imparted by creep of the surrounding salt will act both vertically and horizontally. This will lead to a stress state within the ROM salt resembling biaxial compression. As the ROM salt is compacted, the vertical and cross-entry horizontal compression will lead to stresses and deformations along the length of the main entry due to the Poisson's effect. In the axial center of the ROM salt, the mean stress will be compressive, but is likely to be less than the average compressive stress, effectively inducing shear stresses in both cross-entry and longitudinal directions. Induced shear stresses, if sufficiently large, may cause failure of the emplaced salt. Near the ends, the ROM salt will tend to extrude leading to axial tension and potential spalling failures. As time progresses, these tensile failure zones will tend to move inward towards the axial center.

Localized failure as a result of shear at the edges of the ROM salt does not necessarily imply loss of function of the overall ROM salt closure component – this will occur at some point when the volume impacted by failure reaches a critical value. For this reason we have selected the volume in which either shear or tensile failure occur as a measure of the likelihood of overall loss of function. The analysis of these stresses and how they develop over time is carried out using the three dimensional finite difference code FLAC3D. Details are given in the following sections.

2.0 INPUTS AND METHODOLOGY

The FLAC3D model used by WTS (2003) has been modified to account for the typical geometry of the access mains based on the DOE (2011, 2013a, 2013b) data. RockSol (2012) calculated that the ROM salt fractional density will increase from 65 to over 90 percent after 30 years, and approach 100 percent after 40 to 60 years from the ROM salt placement. As the fractional density increases, the ROM salt properties will approach the properties of natural salt deposits. Hence, the parameters in Table 2, that define the range for the ROM salt yield surface, were developed from Hansen et al. (1984) data for natural rock salts.

Table 2: Mohr-Coulomb Parameters for ROM Salt

Parameter	Lower Bound	Upper Bound
Friction Angle, ϕ (degree)	30.5	60.0
Cohesion, c (MPa)	0.59	2.3
Tensile Strength, t (MPa)	1.0	1.0

For simplicity and conservatism, FLAC3D calculations were performed by using the lower bound salt parameters (i.e., the weaker material expected to lead to more failure) and assuming vertical axial boundaries without 2H:1V side-slopes at the ends (DOE, 2013a). The FLAC3D model geometry used for ROM salt length simulations is illustrated in Figure 1 and 2. Model inputs are presented in more detail in Attachment 3. Noting that both the strength and the ductility of ROM salt is dependent on the confining stress (see Baar, 1977; Hansen et al. 1984), the FLAC3D results were evaluated in terms of the strength-stress ratio and the confinement ratio. The strength-stress ratio, Fs, is defined as

$$F_s = \frac{\tau_f}{\tau} = \frac{\sigma_{1f} - \sigma_{3f}}{\sigma_1 - \sigma_3}$$

Where, σ_{1f} and σ_{3f} denote the maximum and the minimum principal stresses at failure, whereas σ_1 and σ_3 are the maximum and the minimum principal stresses determined by FLAC3D. For the Mohr-Coulomb constitutive model, the yield surface fs=0 is defined as:

$$f_s = \sigma_1 - \sigma_3 N_\phi + 2c\sqrt{N_\phi} = 0$$

Where:

$$N_\phi = \frac{1 + \sin\phi}{1 - \sin\phi}$$

The confinement ratio, Fc, is defined as

$$F_c = \frac{\sigma_3}{\sigma_{3ref}}$$

Where, σ_{3ref} stands for the referent minor principal stress value that was set to 1.0 MPa for FLAC3D data analyses. Reference value σ_{3ref} of 1 MPa should be viewed as a minimum confining stress for which the ROM salt ductility and strength are expected to exhibit acceptable geomechanical performance. For the purpose of ROM salt length calculations, the σ_{3ref} was arbitrarily set to 1 MPa, the value that is approximately

10 times larger than the self-weight of the ROM salt in consolidated conditions (i.e., the minimum confining stress of 1 MPa was set based on the engineering judgment). FLAC3D configurations with Fs>1.0 and Fc>1.0 are considered stable.

3.0 RESULTS

The FLAC3D results for the 16-ft wide main entry (corresponding to the W30, W170 and E-300 entries) are summarized in Tables 3, 4 and 5 for different lengths of the ROM salt closure.

Table 3: FLAC3D Results – Main Entry Width = 16 ft, 5 Years after Construction

ROM Salt Length (ft)	ROM Salt Volume w/Fc<1.0	ROM Salt Volume w/Fs<1.0	Average Fc	Average Fs	ROM Volume in Tension
13	24.8%	4.5%	2.5	1.1	5.7%
25	10.8%	4.6%	5.0	1.0	0.0%
40	5.6%	0.0%	5.3	1.0	0.0%
60	1.2%	0.0%	5.5	1.1	0.0%
80	1.4%	0.0%	6.2	1.5	0.0%
100	1.1%	0.0%	6.3	1.9	0.0%

Table 4: FLAC3D Results – Main Entry Width = 16 ft, 15 Years after Construction

ROM Salt Length (ft)	ROM Salt Volume w/Fc<1.0	ROM Salt Volume w/Fs<1.0	Average Fc	Average Fs	ROM Volume in Tension
13	21.5%	4.5%	2.8	1.1	6.8%
25	10.8%	3.6%	5.1	1.0	0.0%
40	4.0%	0.0%	5.4	1.0	0.0%
60	0.6%	0.0%	5.4	1.0	0.0%
80	0.5%	0.0%	5.2	1.0	0.0%
100	0.7%	0.0%	5.0	1.0	0.0%

Table 5: FLAC3D Results – Main Entry Width = 16 ft, 35 Years after Construction

ROM Salt Length (ft)	ROM Salt Volume w/Fc<1.0	ROM Salt Volume w/Fs<1.0	Average Fc	Average Fs	ROM Volume in Tension
13	19.2%	3.3%	3.3	1.1	12.3%
25	9.0%	3.6%	5.4	1.1	0.0%
40	0.9%	0.0%	5.5	1.0	0.0%
60	0.0%	0.0%	5.4	1.0	0.0%
80	0.0%	0.0%	5.3	1.0	0.0%
100	0.4%	0.0%	5.1	1.0	0.0%

The FLAC3D results for the 25-ft wide main entry (corresponding to the main entry E-140) are summarized in Tables 6, 7 and 8.

Table 6: FLAC3D Results – Main Entry Width = 25 ft, 5 Years after Construction

ROM Salt Length (ft)	ROM Salt Volume w/Fc<1.0	ROM Salt Volume w/Fs<1.0	Average Fc	Average Fs	ROM Volume in Tension
13	41.6%	12.8%	1.8	1.1	8.2%
25	14.9%	11.1%	4.2	1.0	0.0%
40	9.8%	3.3%	5.1	1.0	0.0%
60	6.2%	1.2%	5.3	1.0	0.0%
80	4.6%	0.4%	5.3	1.0	0.0%
100	3.7%	0.0%	5.6	1.1	0.0%

Table 7: FLAC3D Results – Main Entry Width = 25 ft, 15 Years after Construction

ROM Salt Length (ft)	ROM Salt Volume w/Fc<1.0	ROM Salt Volume w/Fs<1.0	Average Fc	Average Fs	ROM Volume in Tension
13	33.4%	3.6%	2.1	1.1	11.7%
25	14.0%	6.5%	4.6	1.0	0.0%
40	8.2%	3.3%	5.2	1.0	0.0%
60	5.6%	0.6%	5.3	1.0	0.0%
80	4.6%	0.0%	5.2	1.0	0.0%
100	3.7%	0.0%	5.0	1.0	0.0%

Table 8: FLAC3D Results – Main Entry Width = 25 ft, 35 Years after Construction

ROM Salt Length (ft)	ROM Salt Volume w/Fc<1.0	ROM Salt Volume w/Fs<1.0	Average Fc	Average Fs	ROM Volume in Tension
13	28.3%	0.0%	2.8	1.2	14.0%
25[1]	11.2%	0.0%	5.0	1.0	0.0%
40[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]
60	2.5%	0.0%	5.4	1.0	0.0%
80	2.8%	0.0%	5.2	1.0	0.0%
100	2.6%	0.0%	5.1	1.0	0.0%

Notes:
1. Values for the FLAC3D simulation with the ROM salt length of 25 feet are approximate. FLAC3D simulation was terminated approximately 33 years after ROM salt construction due to convergence problems.
2. Values for the FLAC3D simulation with the ROM salt length of 40 feet are not reported. FLAC3D simulation was terminated approximately 25 years after ROM salt construction due to convergence problems

Calculated ROM salt volume fractions indicating Fs<1.0 and Fc<1.0 conditions are presented graphically in Figures 3 and 4. Minor principal stress contours for FLAC3D simulations for the main entry width of 16 feet are shown in Attachment 1.

Minor principal stress contours for FLAC3D simulations with the main entry width of 25 feet are shown in Attachment 2. Stress plots in FLAC3D are following standard continuum mechanics convention denoting tensile stresses as positive. Consequently, “Contour of Min. Principal Stress” plots in FLAC3D display compressive stresses with the largest magnitude. To identify areas with the smallest compressive stresses (or tensile zones), one needs to display maximum principal stresses based on the continuum mechanics/FLAC3D convention (“Contour of Max. Principal Stress” plots in Attachments 1 and 2). I.e., stress plots in Attachments 1 and 2 display minimum (minor) principal stresses in accordance with the geo-mechanical convention.

4.0 CONCLUSIONS

FLAC3D results indicate that the minimum length of the ROM salt is a function of the main entry geometry. As noted above, the critical percentage of ROM salt corresponds to the ROM salt length for which one can expect a relatively small or no change in the geo-mechanical behavior as the length of the ROM salt increases (with an emphasis on the long-term geo-mechanical performance). Based on the results of the presented analyses, the minimum ROM salt length was selected based on the requirement that the critical percentage of ROM salt exhibiting Fs<1 and Fc<1 is less than approximately 5 percent for 15 years after construction and less than approximately 3 percent approximately 35 years after construction. Assuming the nominal operational life of the closure system of 35 years, geo-mechanical performance of the ROM-salt closure components is expected to be satisfactory for the ROM salt lengths on the order of 2.5 to 3 times the width of the underground opening. Consequently, the minimum ROM salt length for the 16-ft wide main entry is approximately 40 feet. Similarly, the minimum recommended ROM salt length for the 25-ft wide main entry is approximately 65 feet. Simplified analyses presented in Attachment 3 provide additional validation of FLAC3D results.

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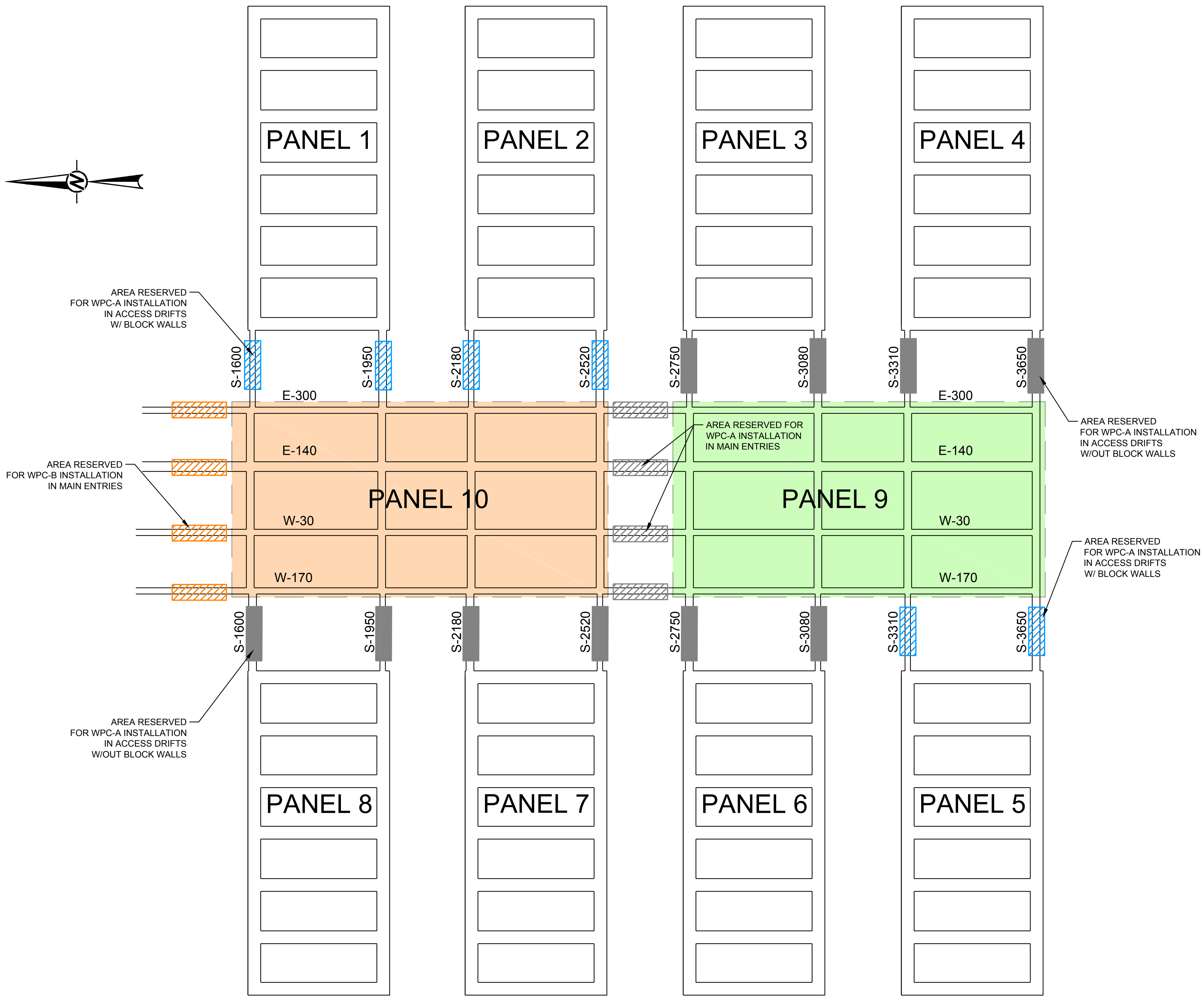
FIGURES



LEGEND

- APPROXIMATE EXTENTS OF PANEL 9
- APPROXIMATE EXTENTS OF PANEL 10
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN PANEL ACCESS DRIFTS W/ EXPLOSION-ISOLATION WALLS (NOTE 1)
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN MAIN ENTRIES (NOTE 1)
- APPROXIMATE AREA RESERVED FOR WPC-A INSTALLATION IN PANEL ACCESS DRIFTS W/OUT EXPLOSION-ISOLATION WALLS (NOTE 1)
- APPROXIMATE AREA RESERVED FOR WPC-B INSTALLATION IN MAIN ENTRIES (NOTE 1)

NOTES

1. SHOWN WIPP PANEL CLOSURE (WPC) LOCATIONS ARE APPROXIMATE. ROM SALT IS PLACED AS A PART OF THE WPC-B INSTALLATION.

0 150 300 450
FEET

CLIENT	NUCLEAR WASTE PARTNERSHIP LLC
PROJECT	WIPP CLOSURE GEO-MECHANICAL COMPLIANCE
CONSULTANT	Golder Associates
YYYY-MM-DD	2016-07-18
PREPARED	GG
DESIGN	GG
REVIEW	WTT
APPROVED	WTT
TITLE	**ROM SALT LENGTH CALCULATIONS** *WPC LOCATIONS*
PROJECT No.	063-2213NEW
CONTROL	
Rev.	----
FIGURE	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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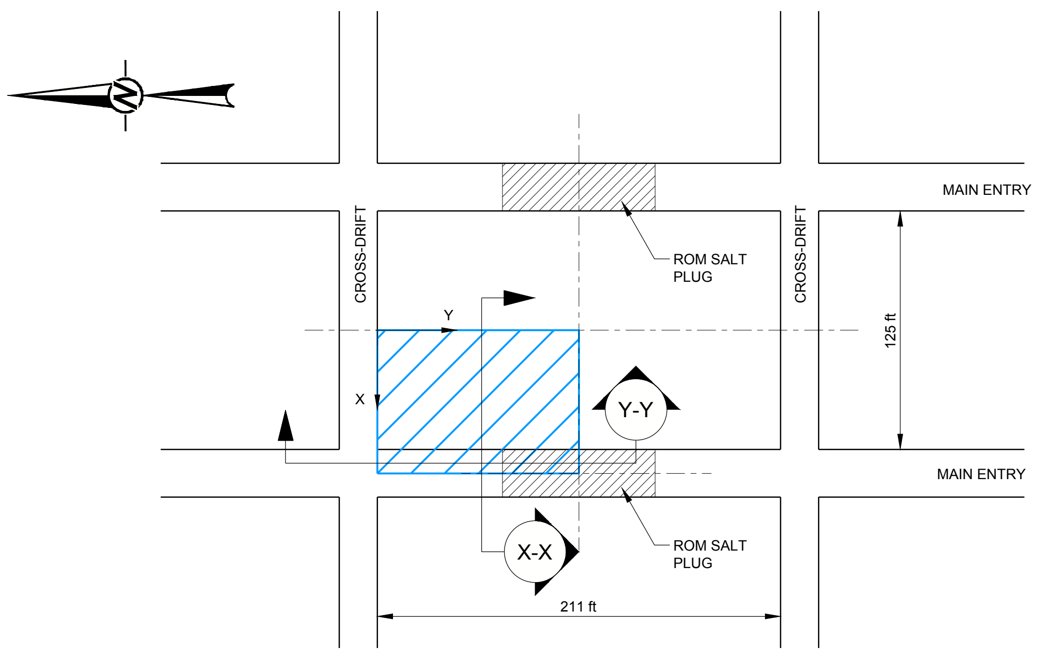


SCHEMATICS OF MODEL EXTENTS - PLAN-VIEW (NOT TO SCALE)

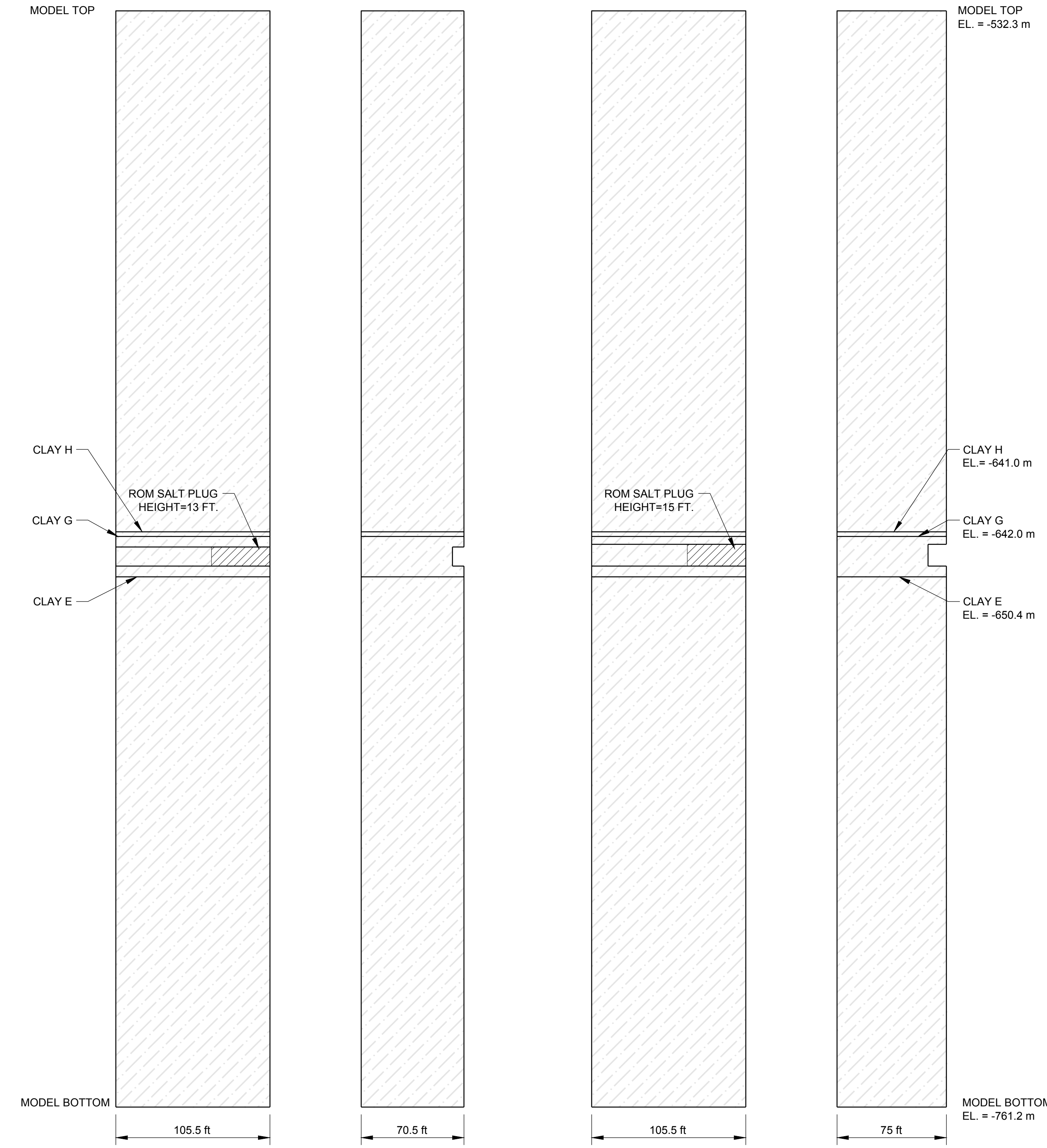
0 50 100 150
FEET

LEGEND

- ROM SALT LOCATION - PANEL 10 CLOSURE SYSTEM (WPC-B)
- PLAN-VIEW EXTENTS OF MODEL GEOMETRY (SEE NOTES 1 AND 2)

NOTES

1. FOR SIMPLICITY AND CONSERVATISM, MODEL GEOMETRY WAS BASED ON THE PILLAR DIMENSIONS OF 211 FT x 125 FT (LENGTH X WIDTH), I.E. APPROXIMATE DIMENSIONS OF THE MINIMUM PILLAR BETWEEN ENTRIES, AND ASSUMING MODEL SYMMETRY DEFINED BY ROM SALT PLUG CENTERLINES IN BOTH LONGITUDINAL AND TRANSVERSE DIRECTIONS.
2. TO IMPROVE NUMERICAL PERFORMANCE, THE MODEL DOES NOT DOES NOT ACCOUNT FOR THE CROSS-DRIFT GEOMETRY. TO SIMULATE INCREASES IN ROM SALT STRESSES DUE TO THE PRESENCE OF CROSS-DRIFTS, THE SELF WEIGHT OF SALT MATERIALS IN THE MODEL WAS INCREASED BY 10 PERCENT.



SECTION Y-Y　SECTION X-X

MAIN ENTRY WIDTH = 16 FT

SECTION Y-Y　SECTION X-X

MAIN ENTRY WIDTH = 25 FT

CLIENT
NUCLEAR WASTE PARTNERSHIP LLC

PROJECT
WIPP CLOSURE
GEO-MECHANICAL COMPLIANCE

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-07-20
PREPARED	GG
DESIGN	GG
REVIEW	WTT
APPROVED	WTT

TITLE
ROM SALT LENGTH CALCULATIONS
MODEL SECTIONS

PROJECT No.	CONTROL	Rev.	FIGURE
063-2213		----	2

Path: ---- | File Name: FIG2-ROMLength-Details-08-22-2016.dwg

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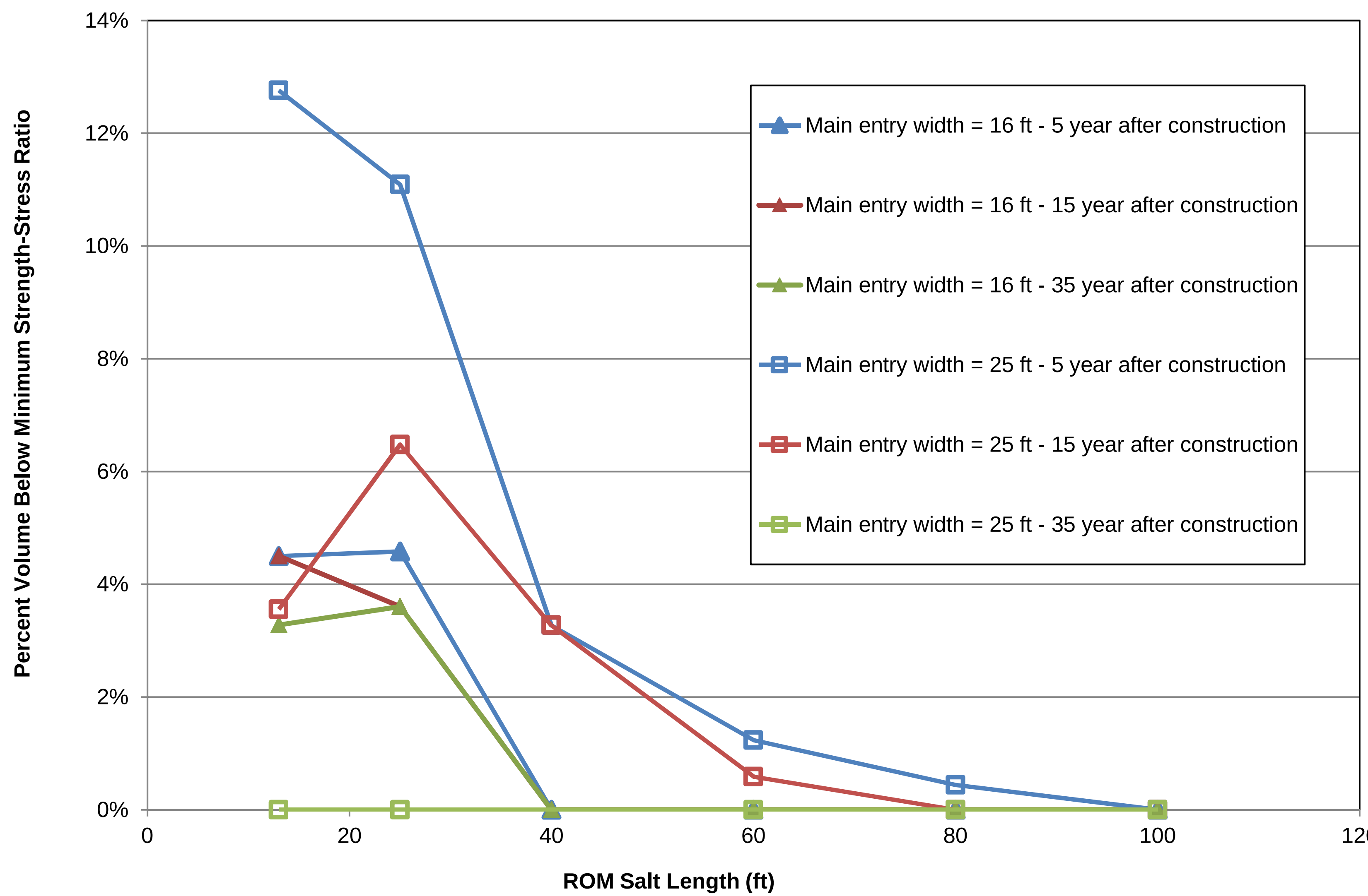

Figure 3

Strength-Stress Ratio

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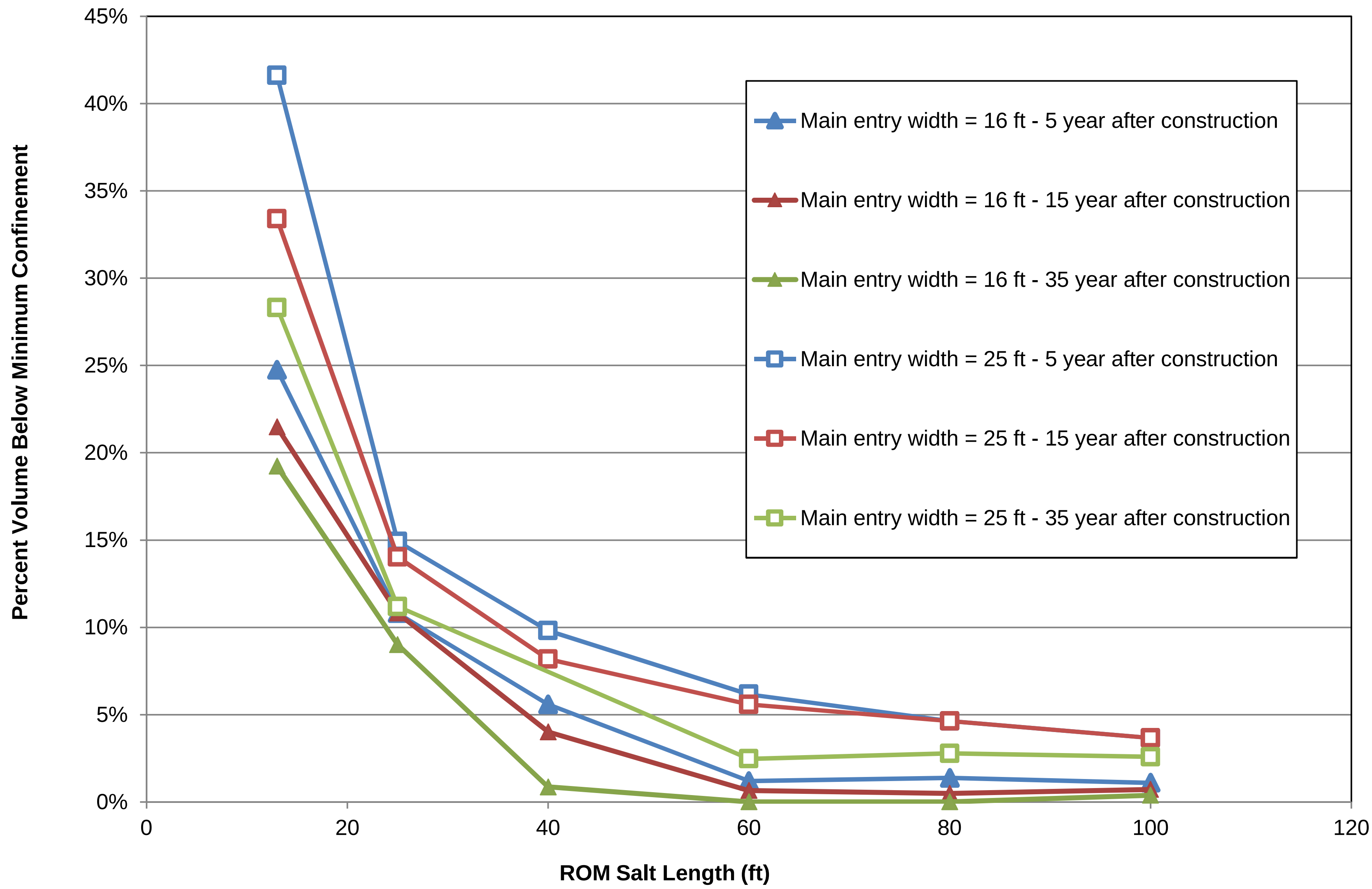

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Figure 4

Confinement Ratio

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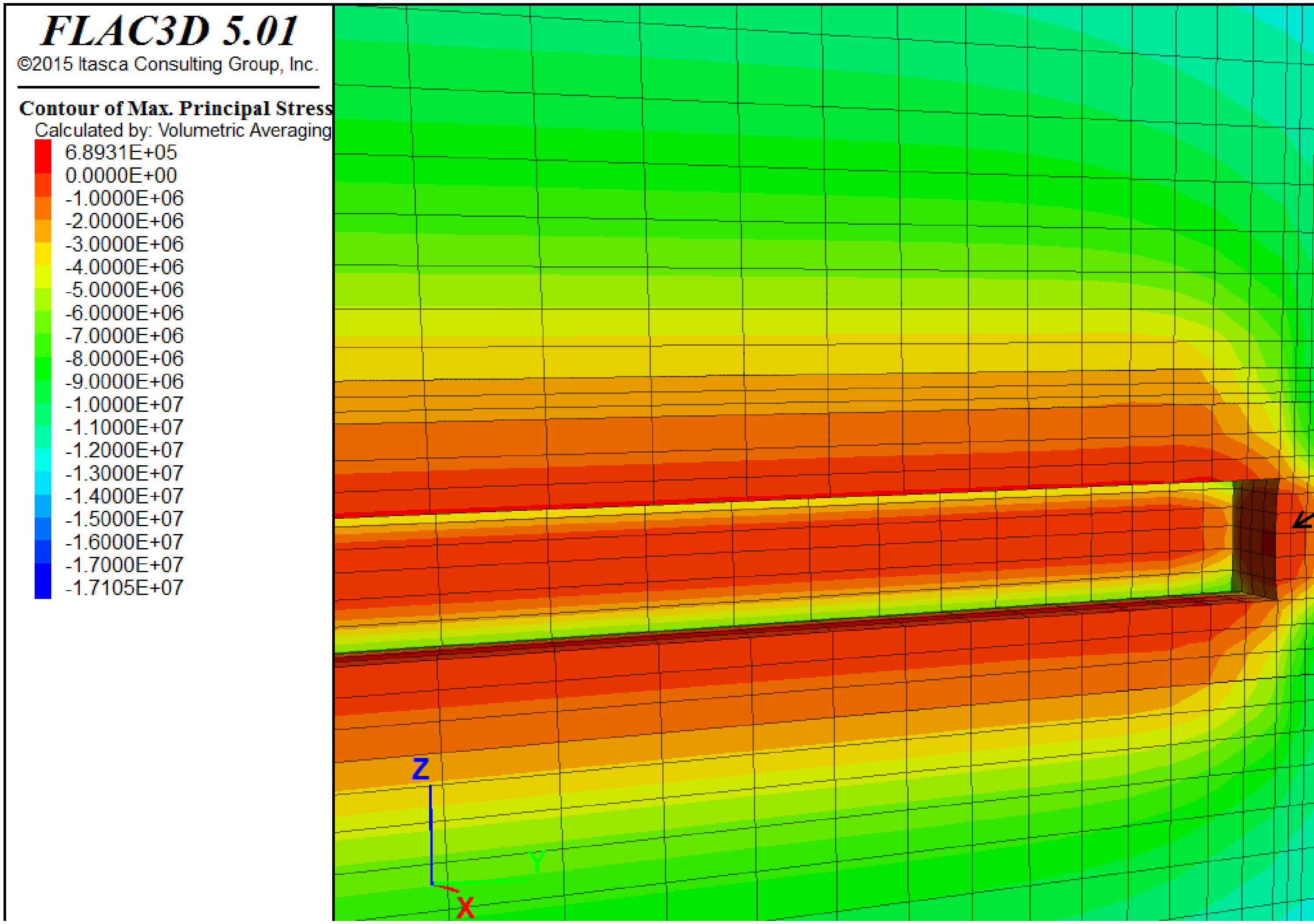
ATTACHMENT 1
FLAC3D RESULTS FOR MAIN ENTRY WIDTH = 16 FT
MINOR PRINCIPAL STRESS



Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-1.1

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 13 ft, 5 Yr After Construction

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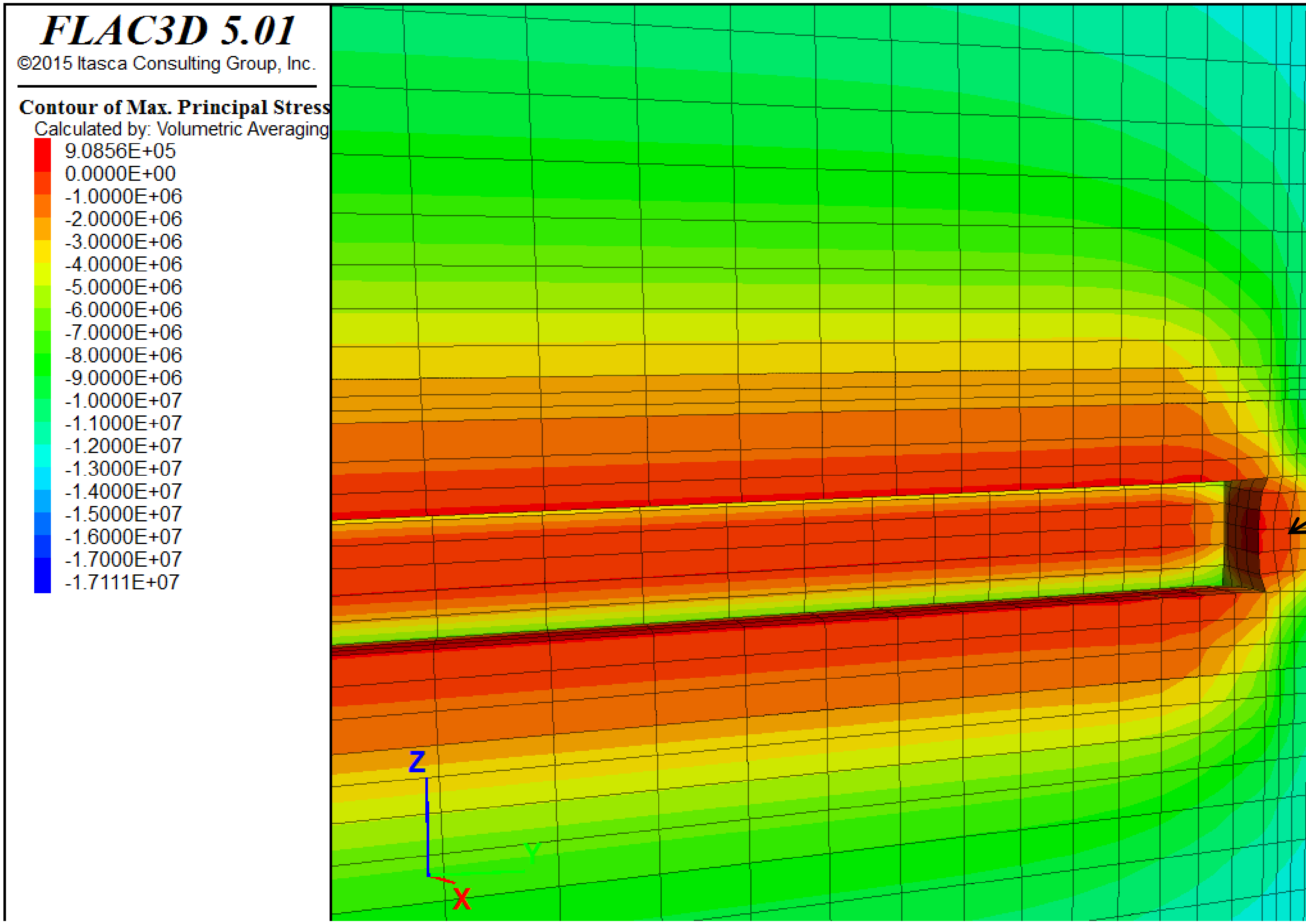

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-1.2

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 13 ft, 15 Yr After Construction

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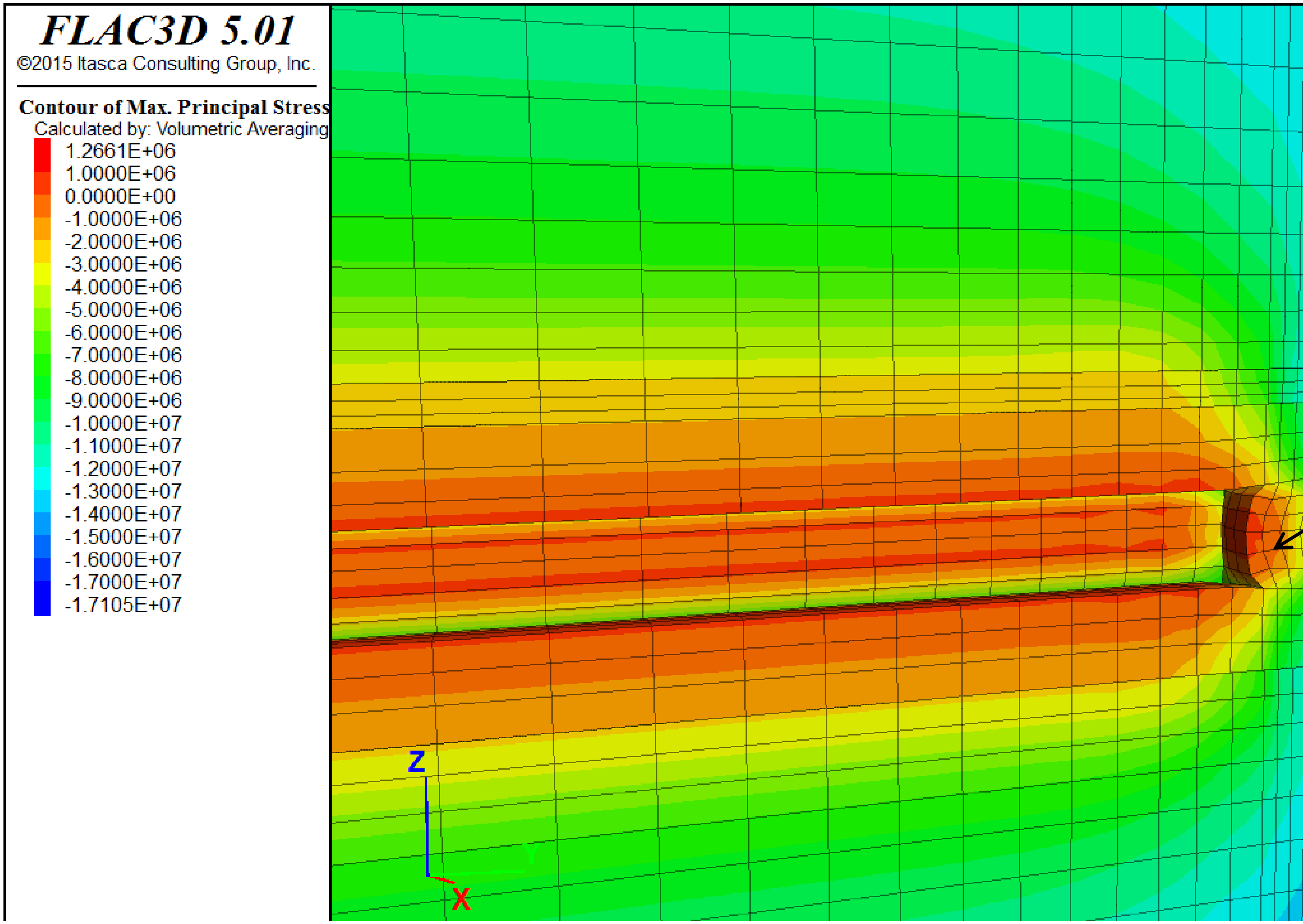

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention

I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-1.3

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 13 ft, 35 Yr After Construction

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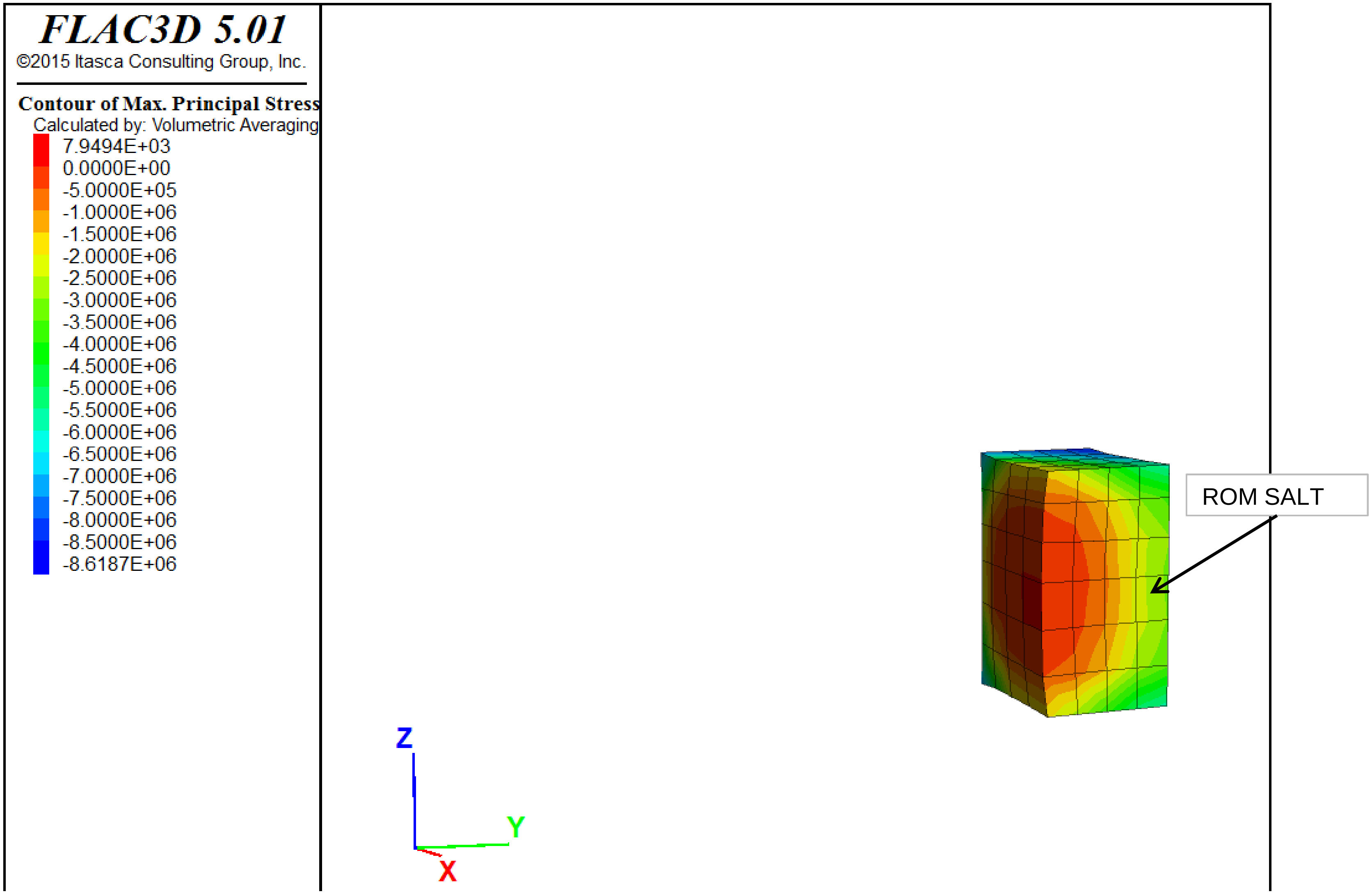

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-1.4

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 13 ft, 5 Yr After Construction

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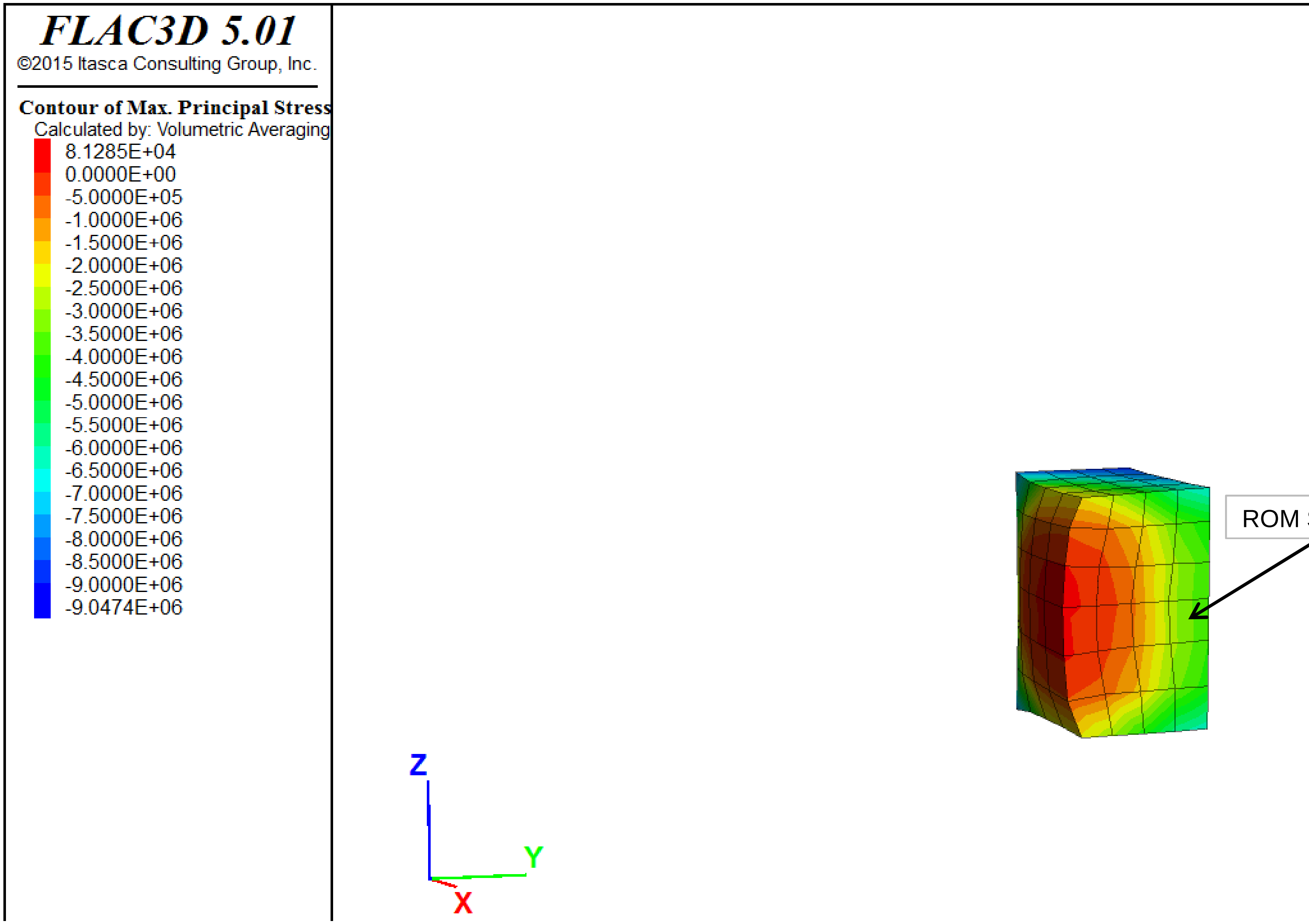

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-1.5

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 13 ft, 15 Yr After Construction

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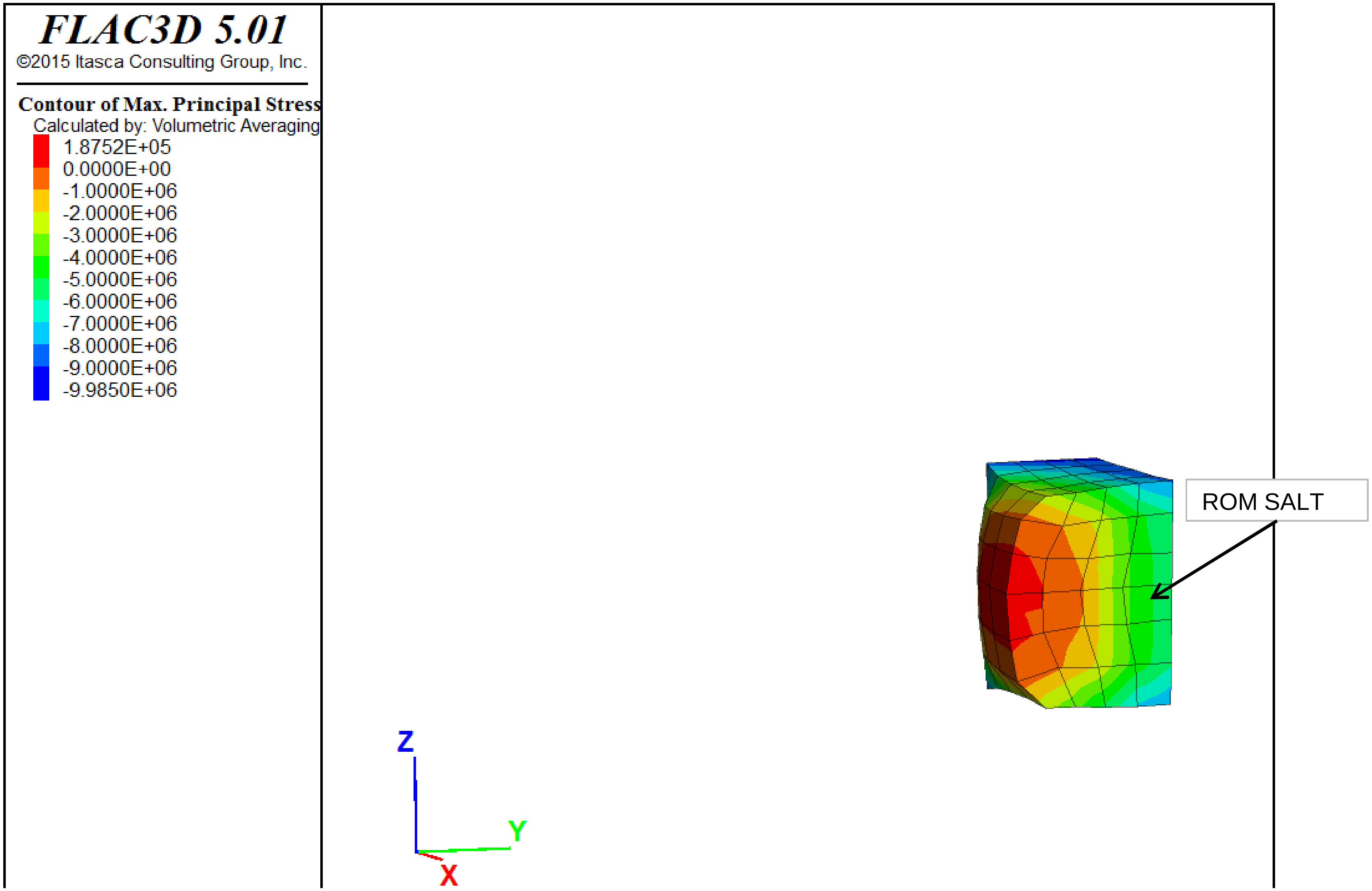

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-1.6

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 13 ft, 35 Yr After Construction

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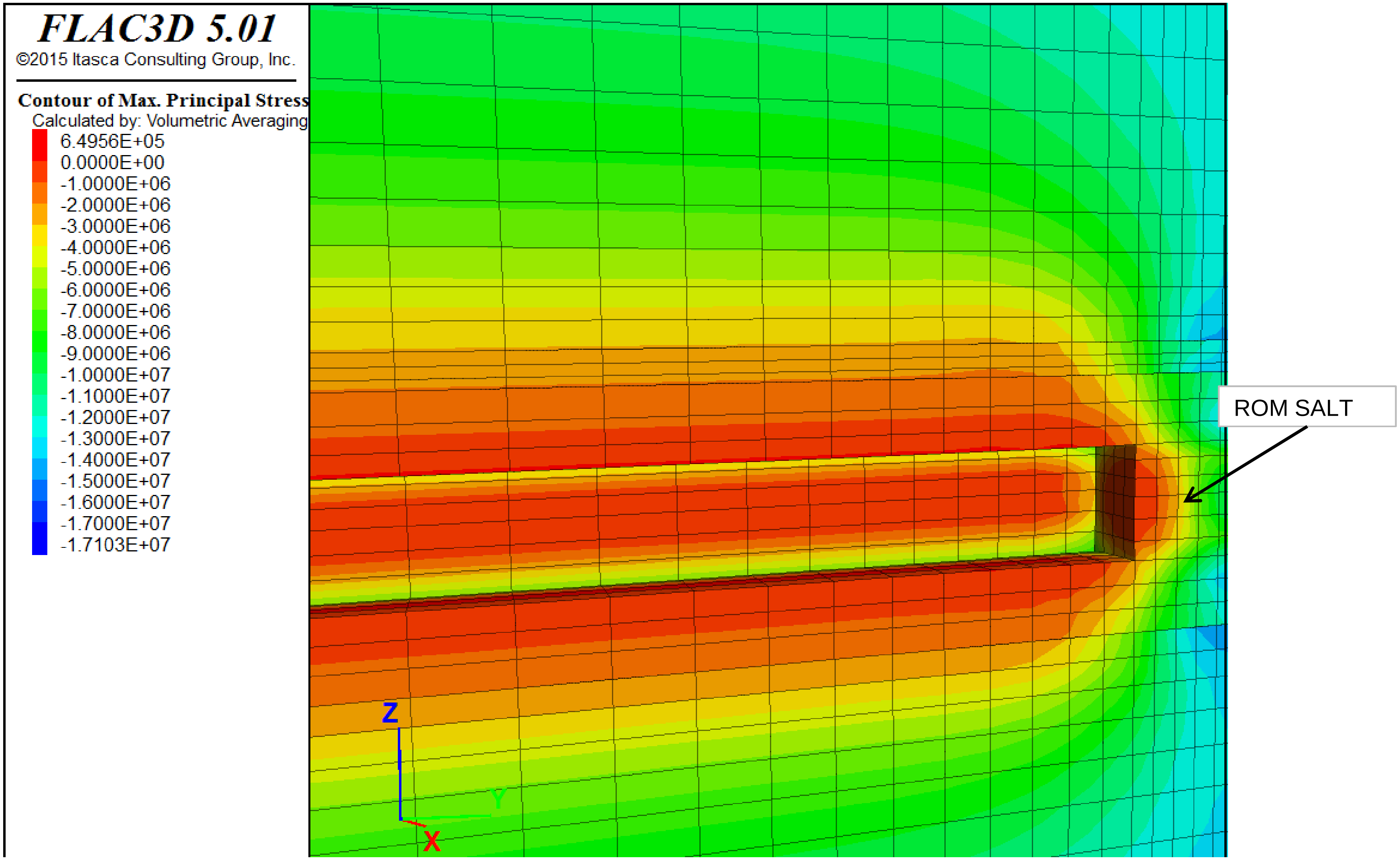

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-2.1

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 25 ft, 5 Yr After Construction

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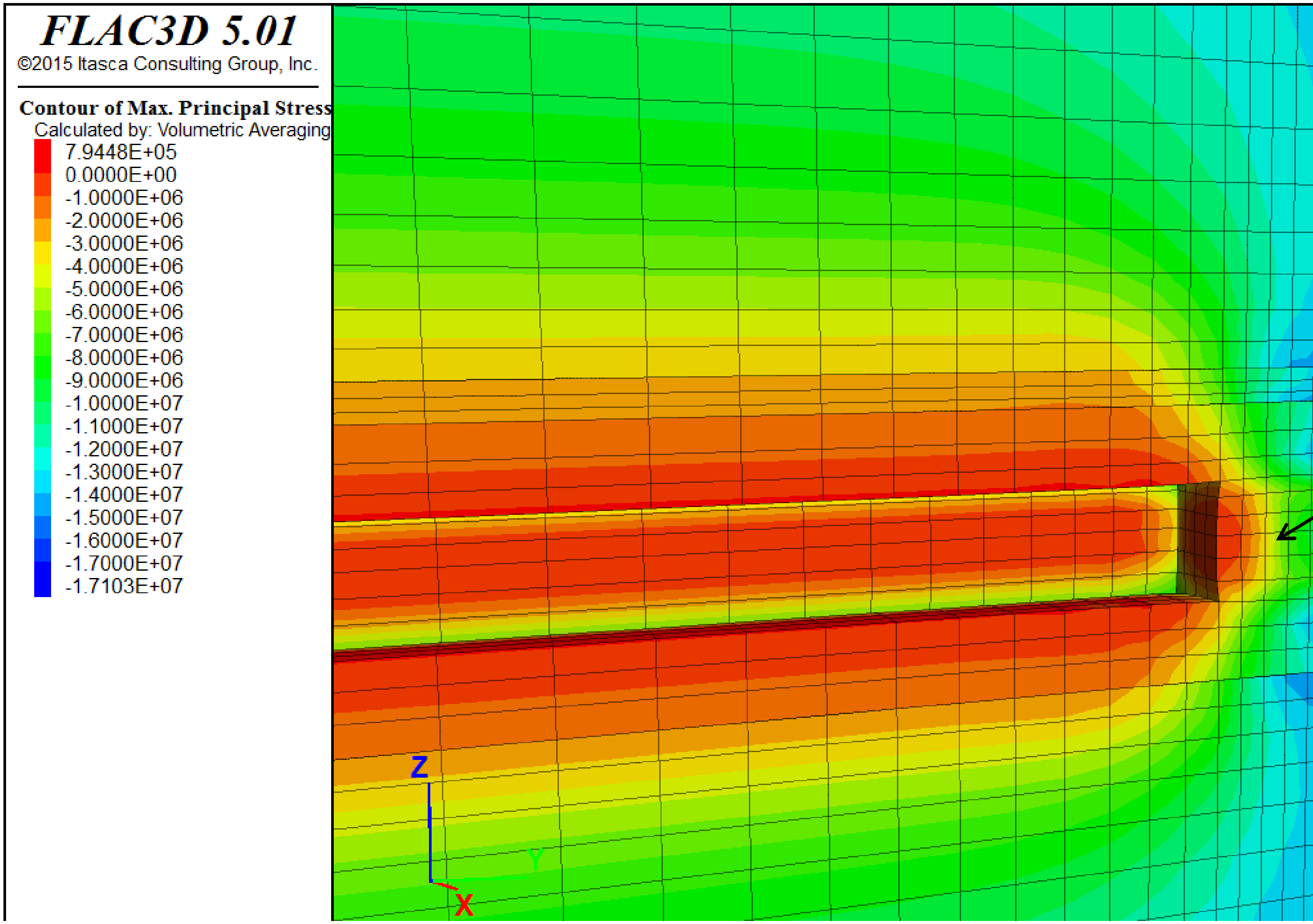

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-2.2

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 25 ft, 15 Yr After Construction

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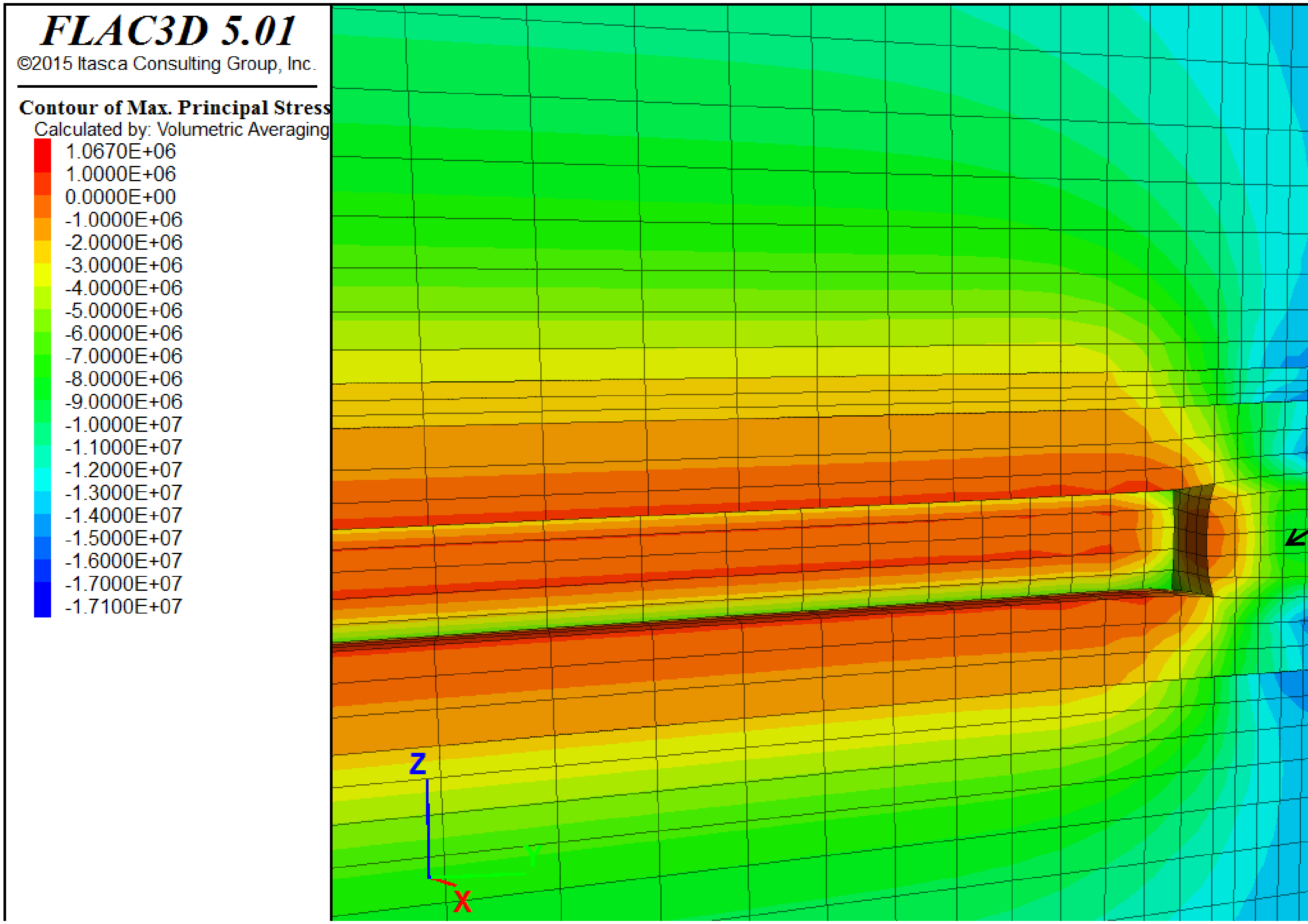

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-2.3

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 25 ft, 35 Yr After Construction

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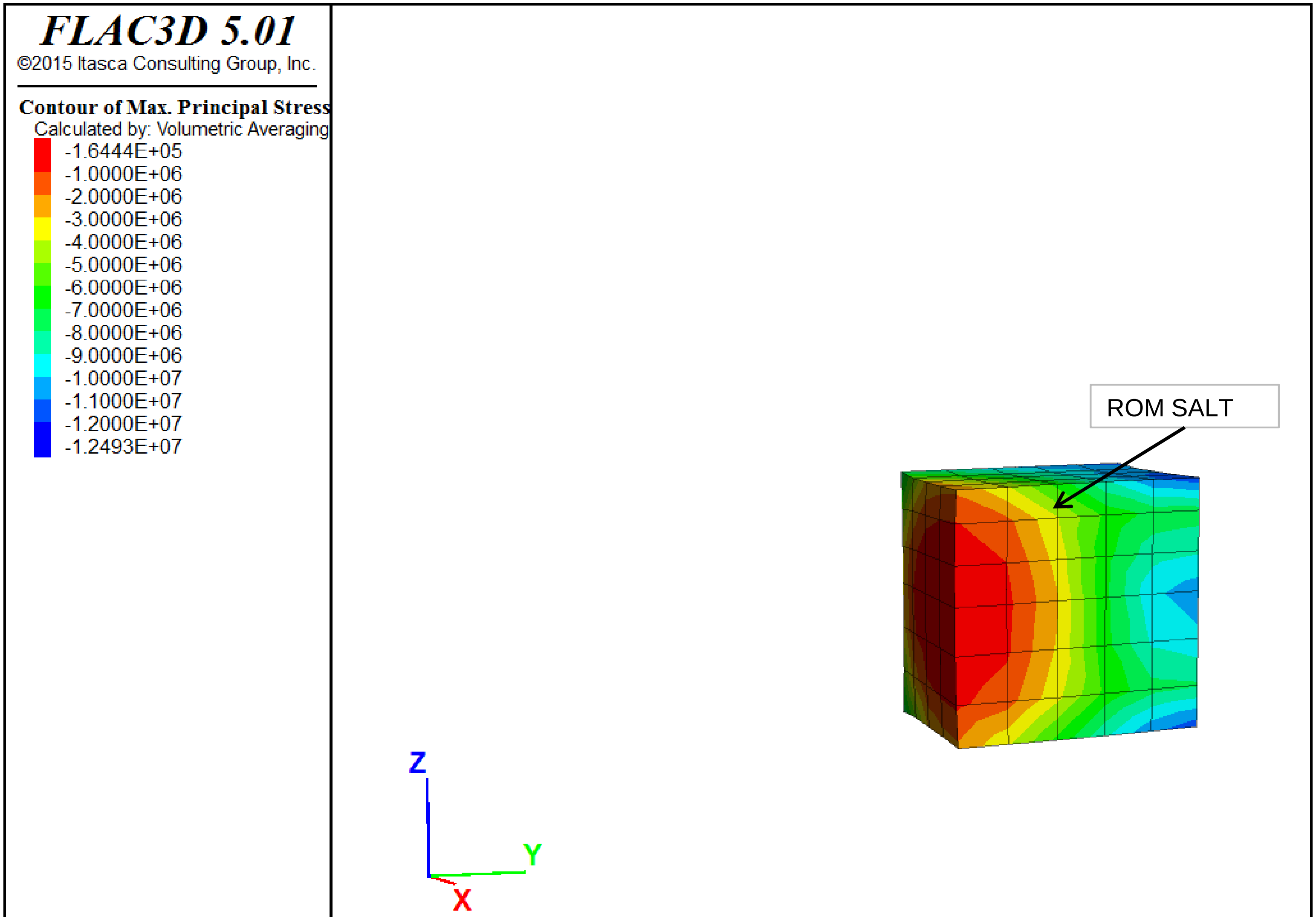

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-2.4

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 25 ft, 5 Yr After Construction

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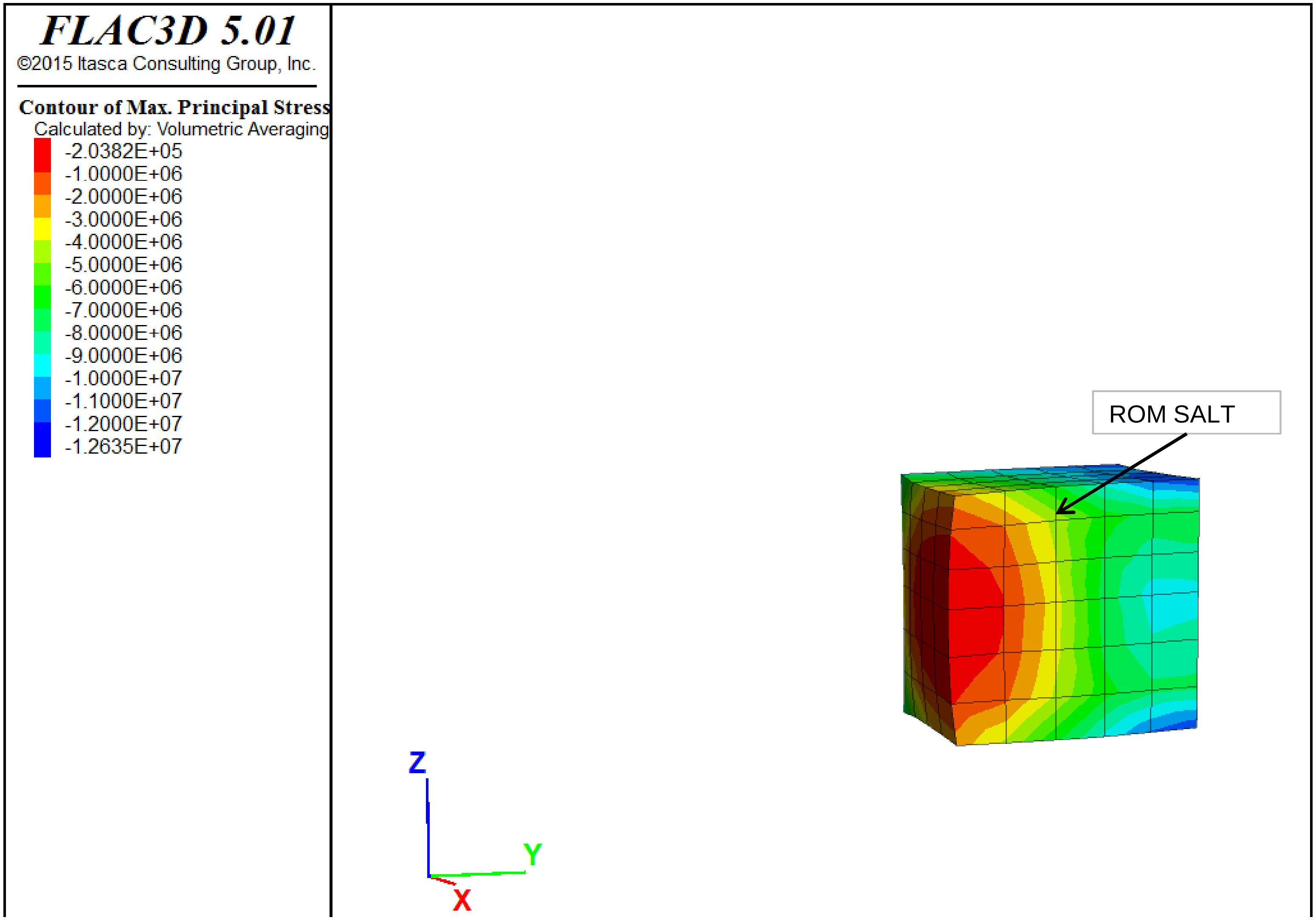

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-2.5

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 25 ft, 15 Yr After Construction

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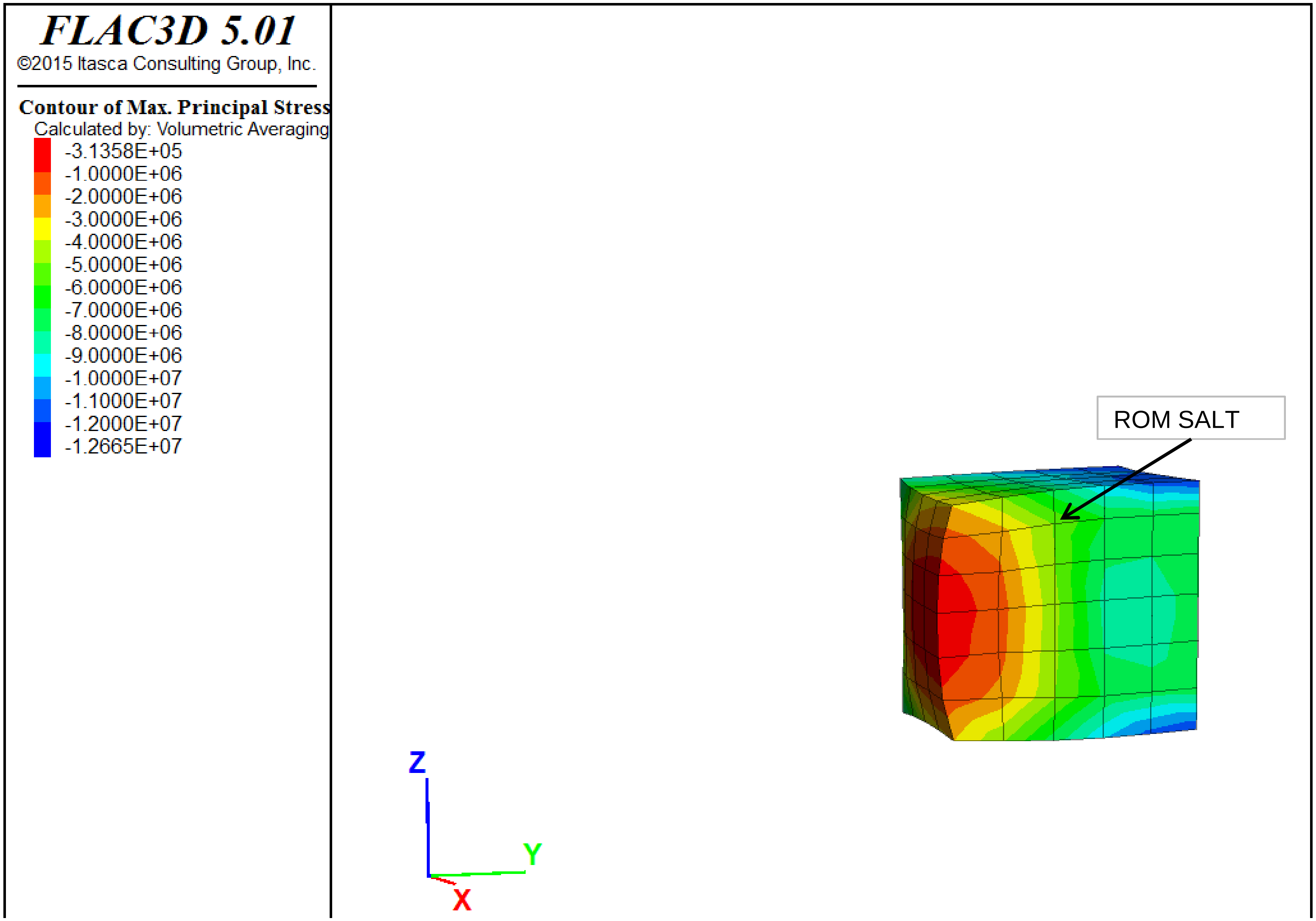

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-2.6

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 25 ft, 35 Yr After Construction

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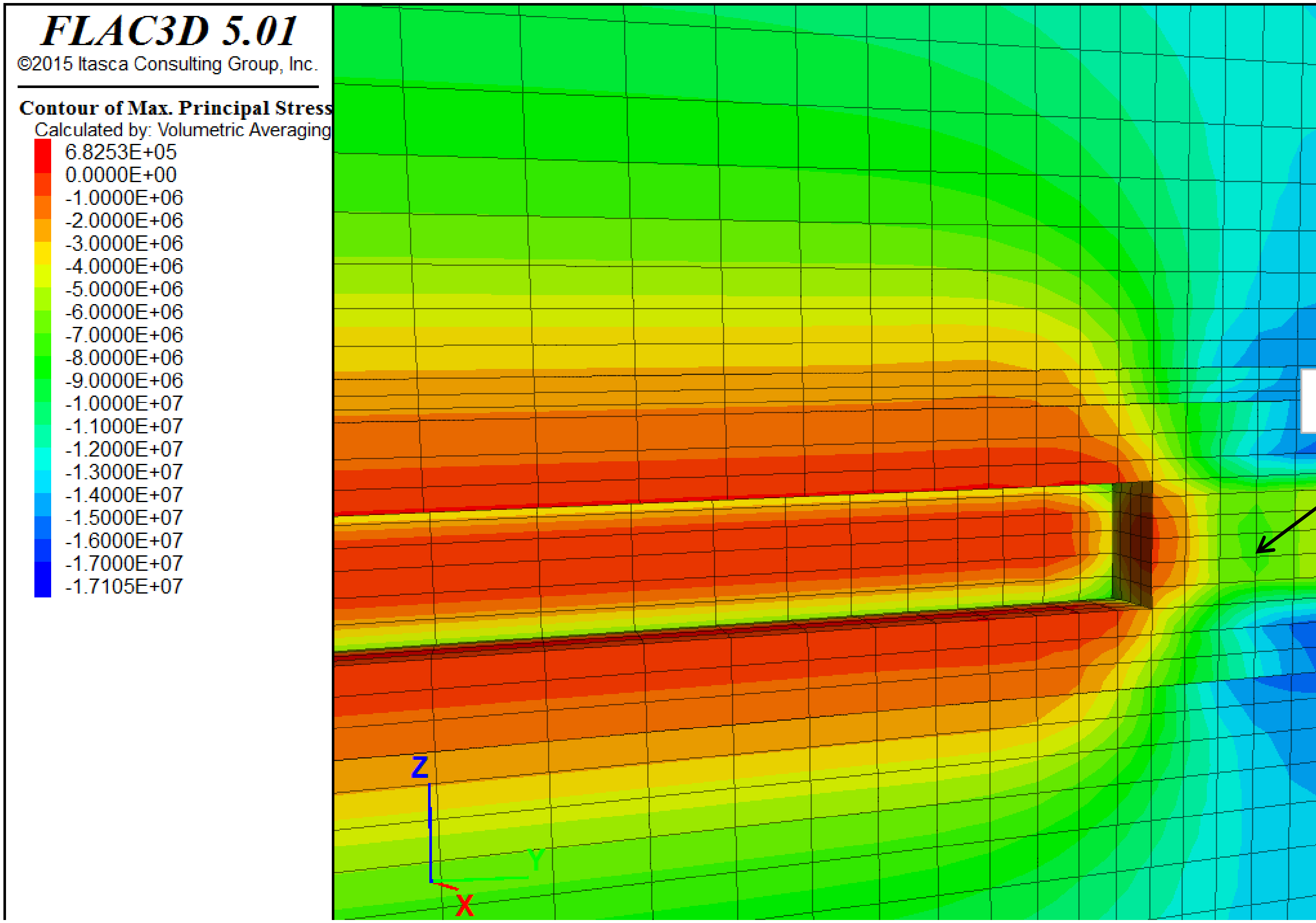

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-3.1

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 40 ft, 5 Yr After Construction

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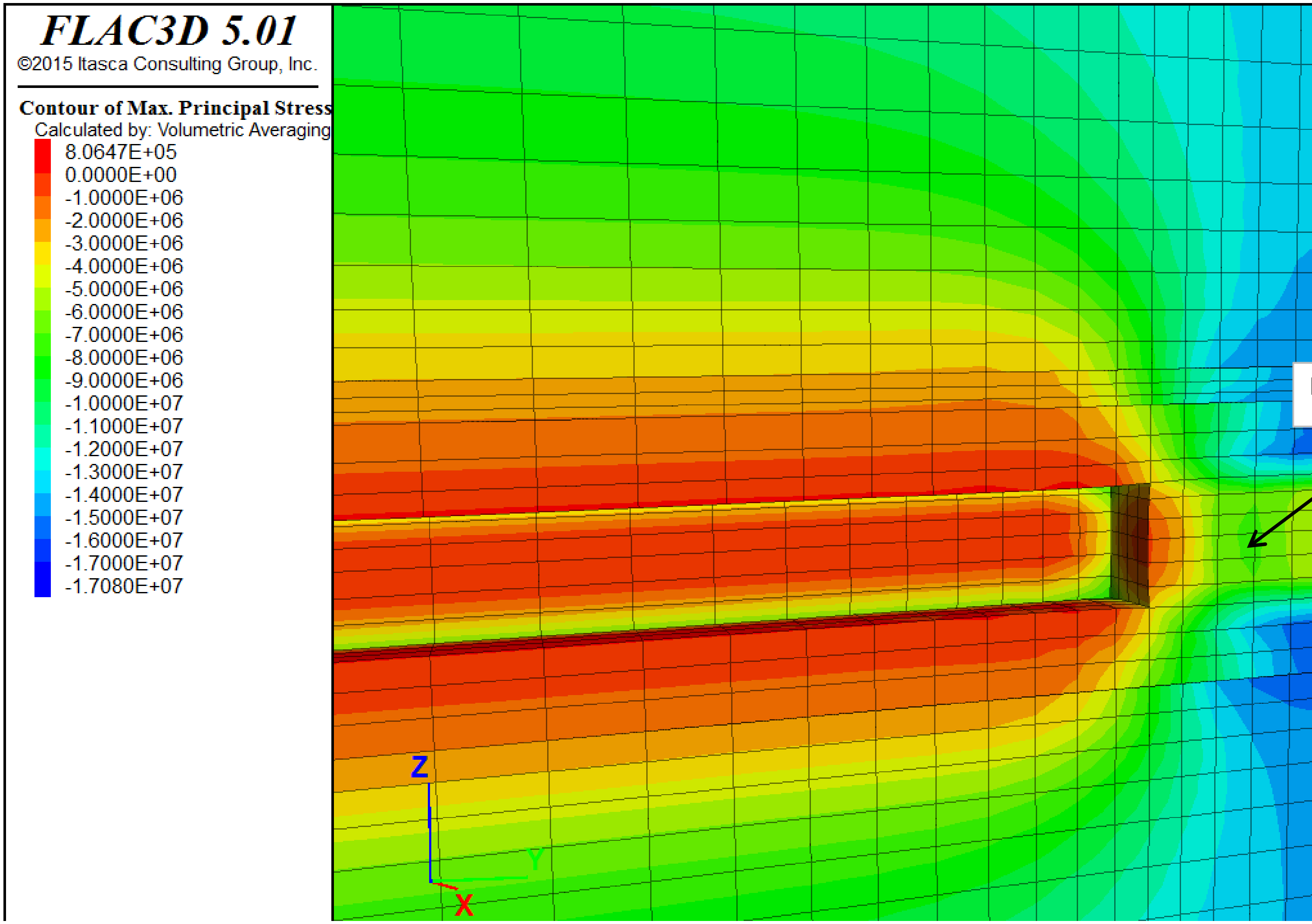

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-3.2

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 40 ft, 15 Yr After Construction

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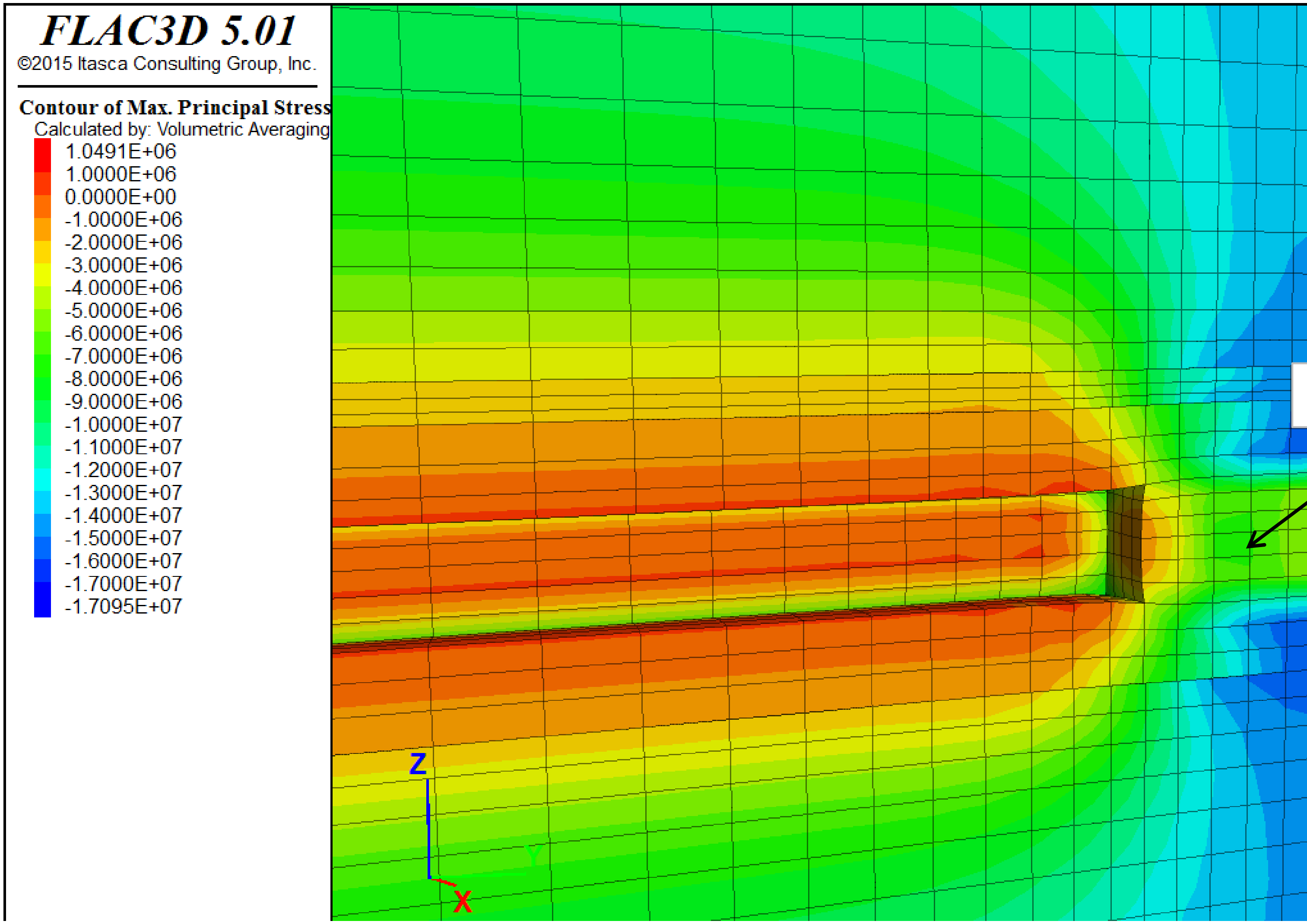

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-3.3

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 40 ft, 35 Yr After Construction

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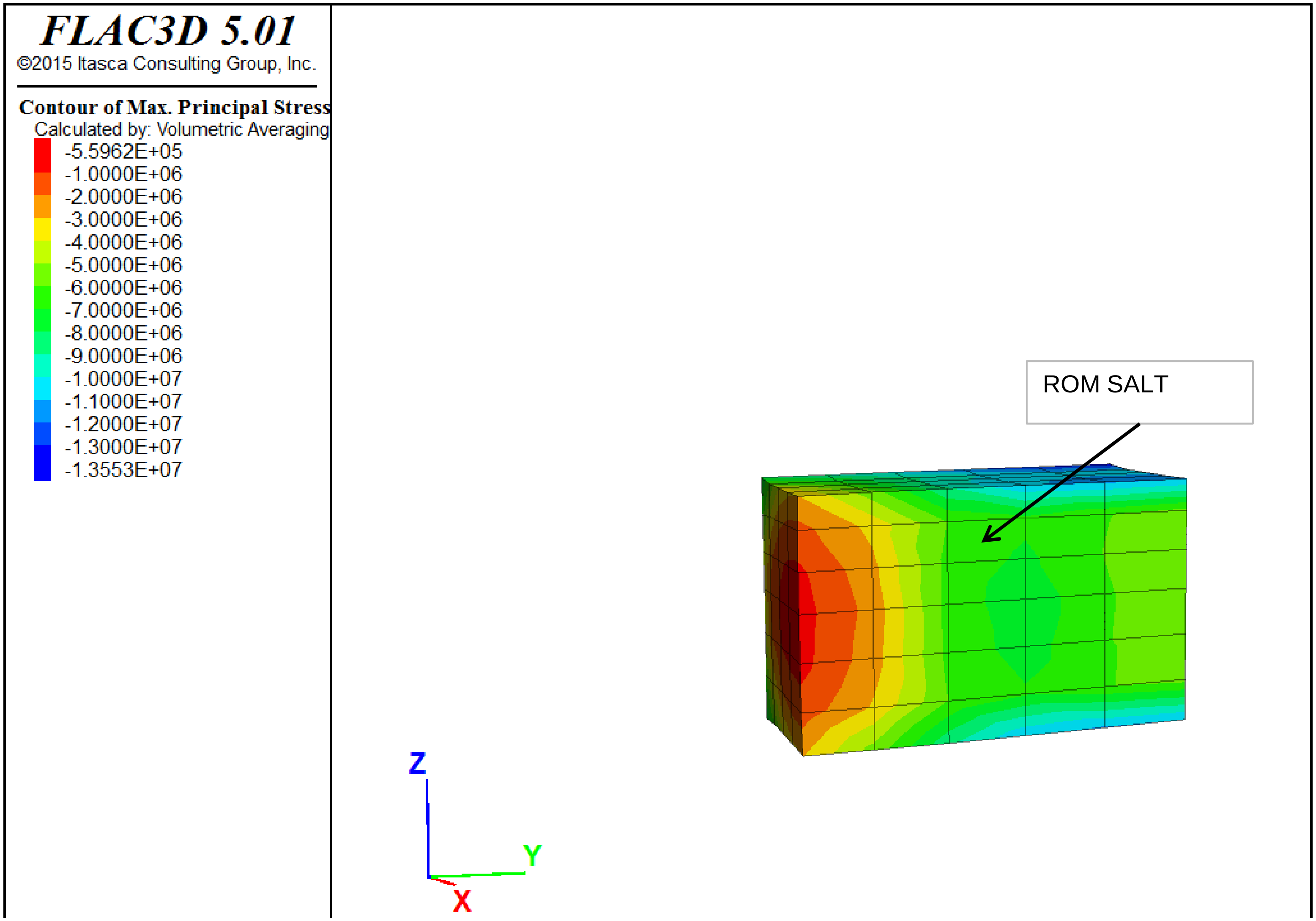

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-3.4

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 40 ft, 5 Yr After Construction

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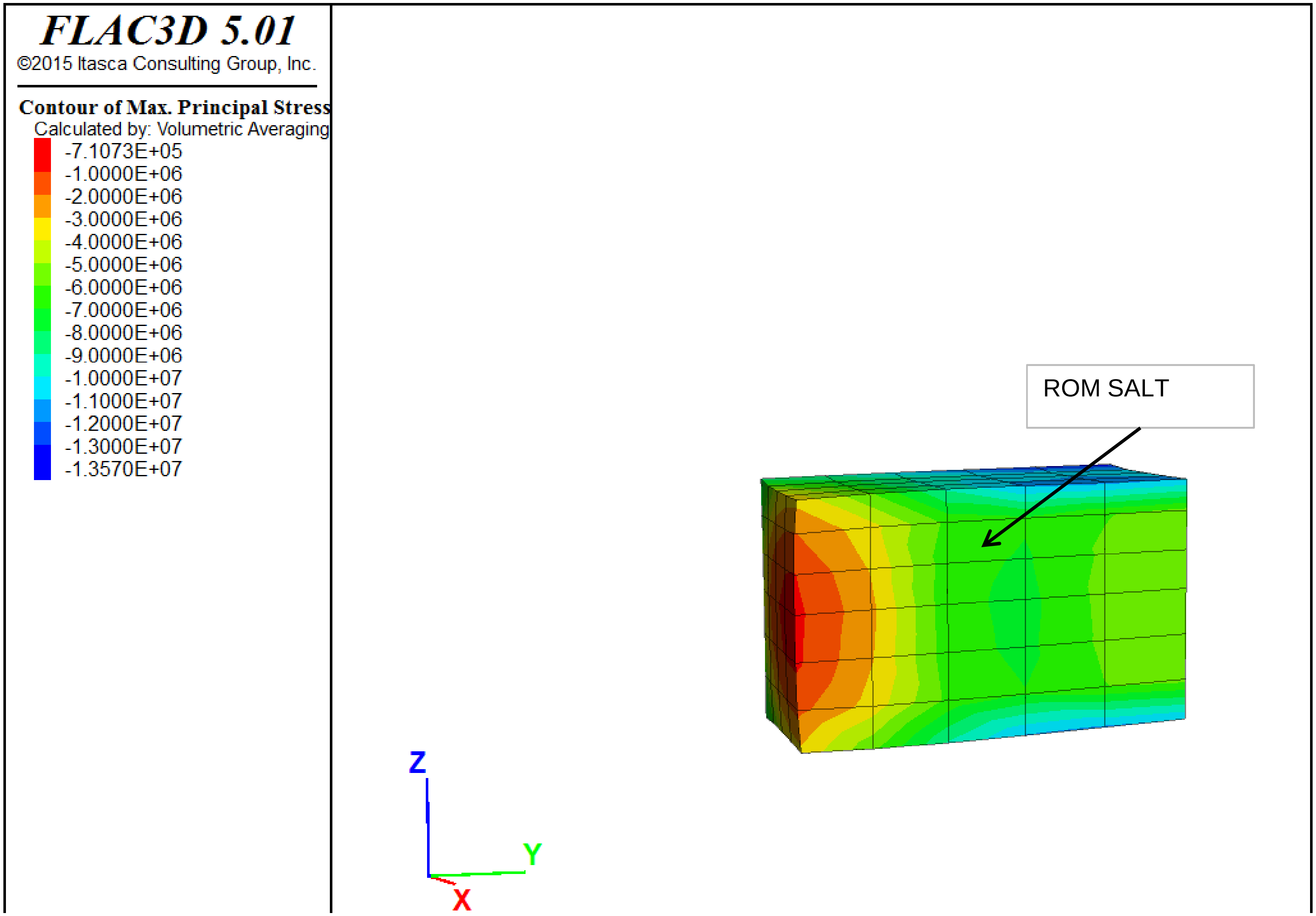

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-3.5

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 40 ft, 15 Yr After Construction

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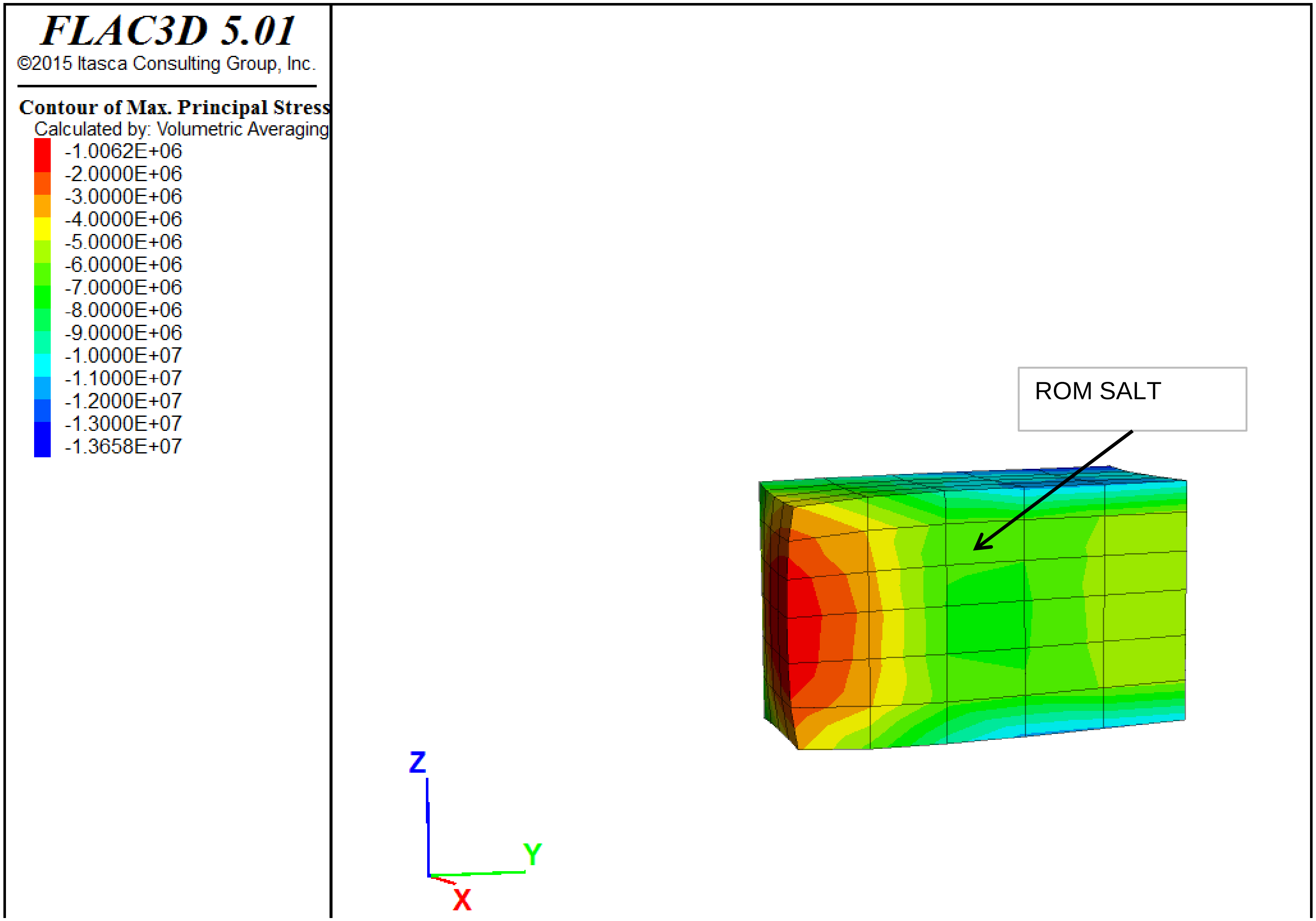

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-3.6

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 40 ft, 35 Yr After Construction

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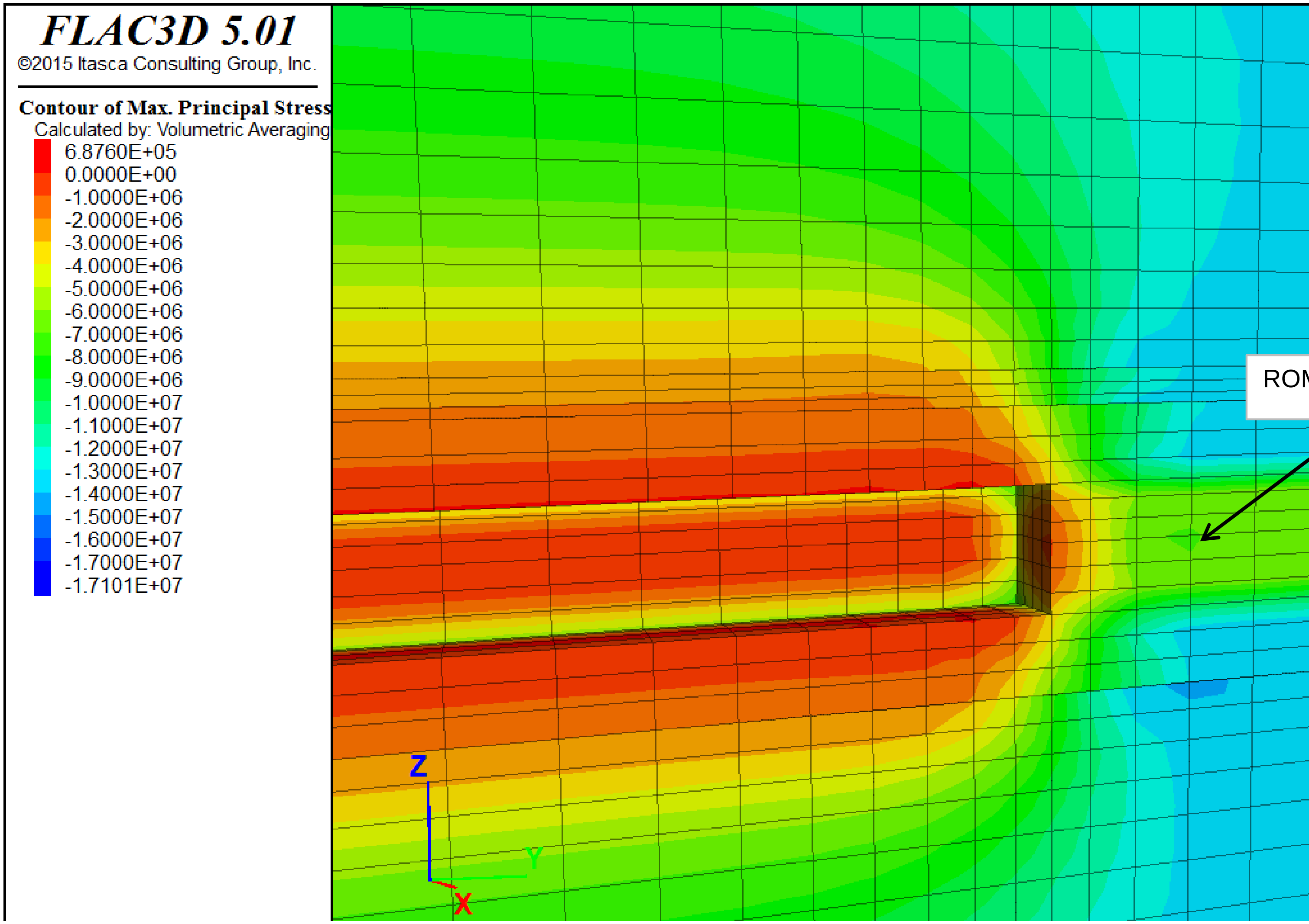

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-4.1

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 60 ft, 5 Yr After Construction

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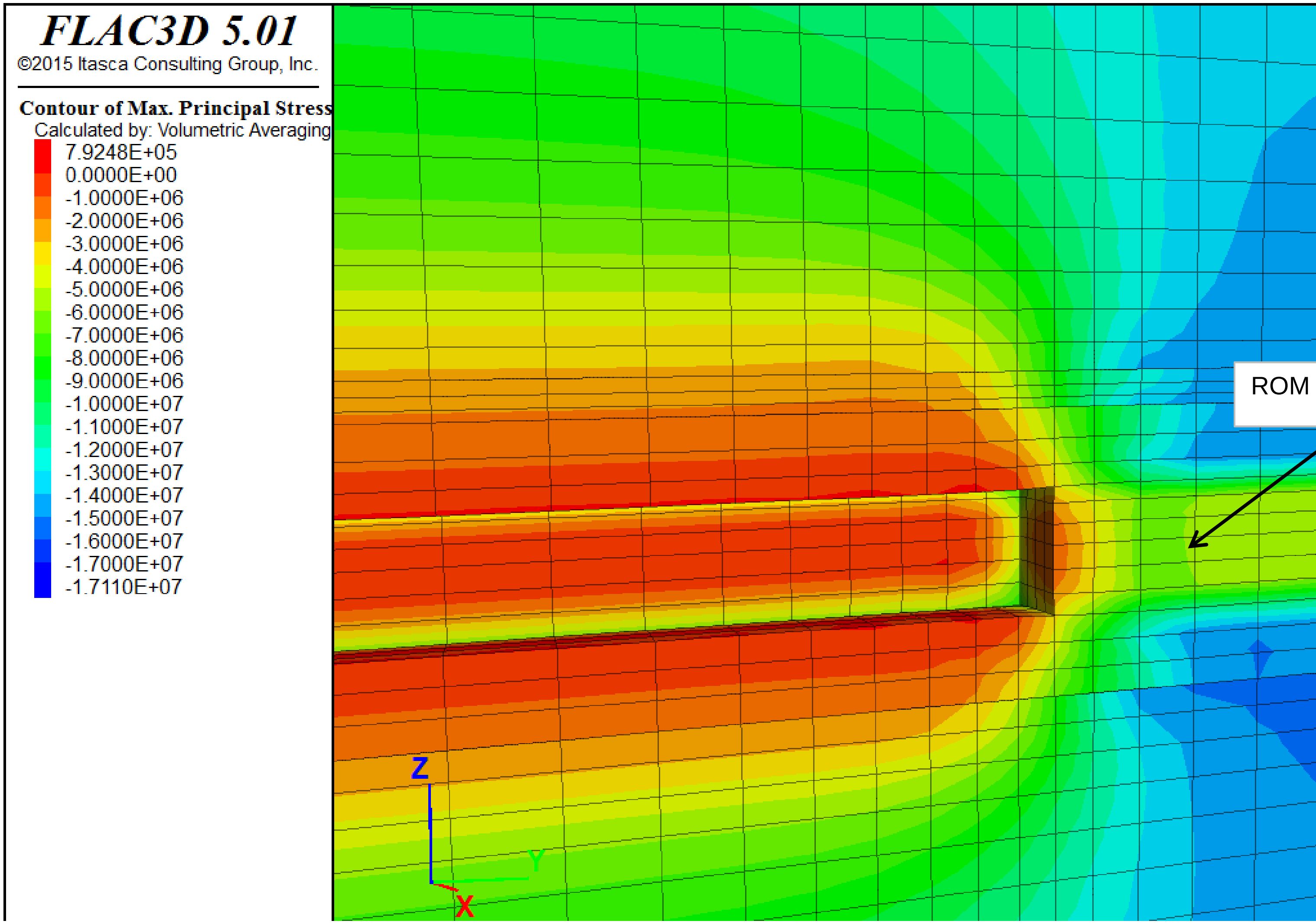

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-4.2

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 60 ft, 15 Yr After Construction

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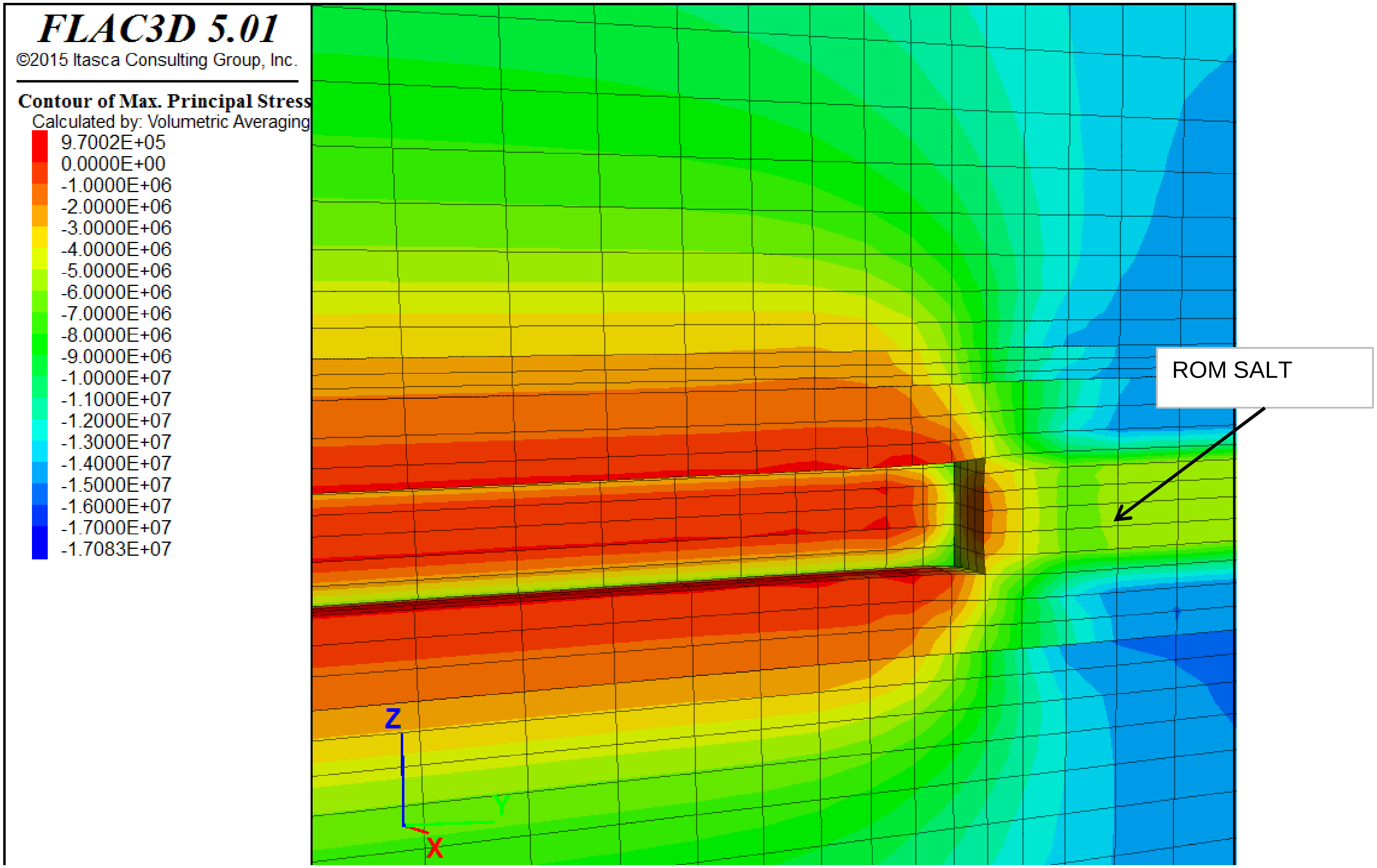

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-4.3

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 60 ft, 35 Yr After Construction

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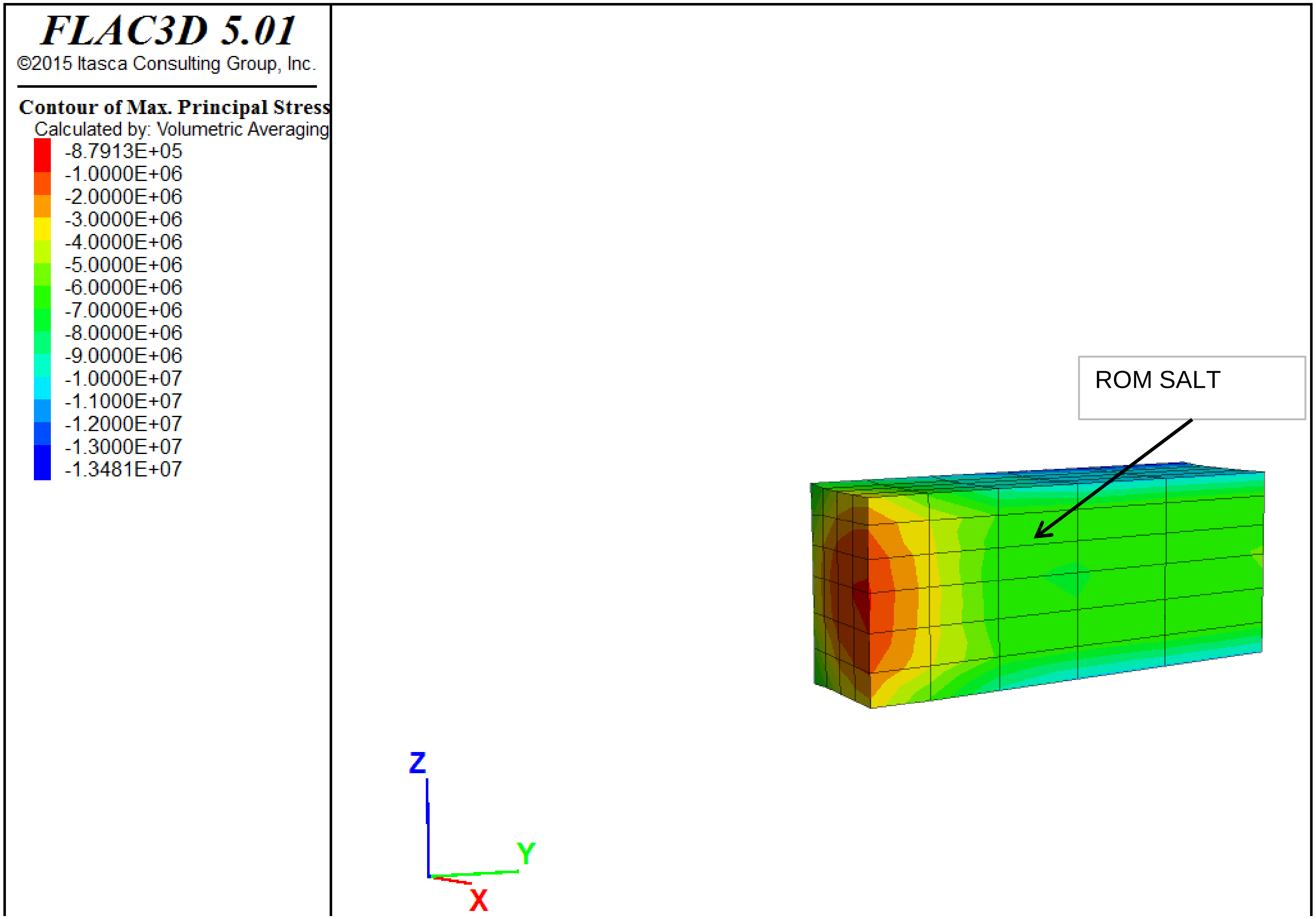

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-4.4

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 60 ft, 5 Yr After Construction

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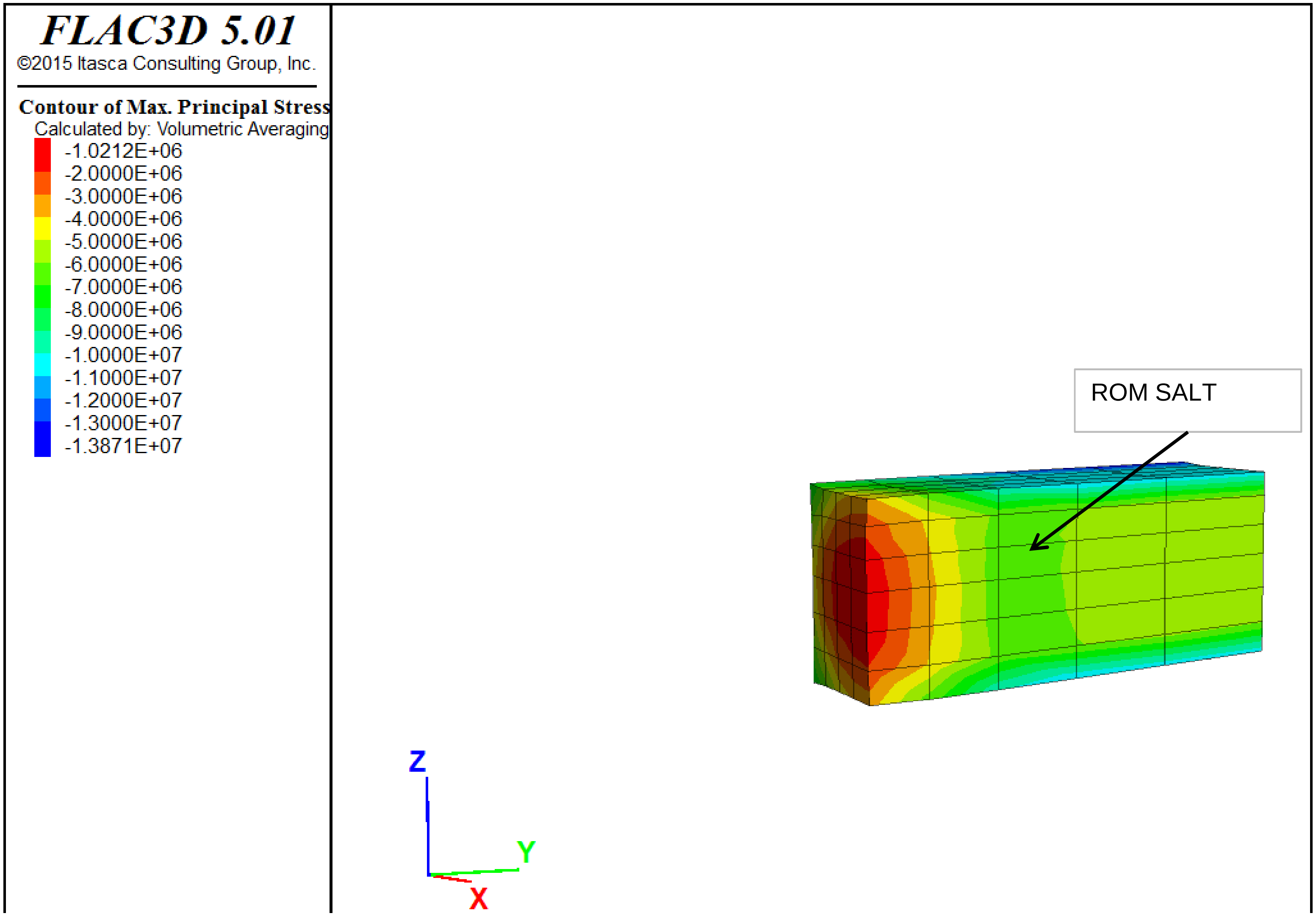

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-4.5

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 60 ft, 15 Yr After Construction

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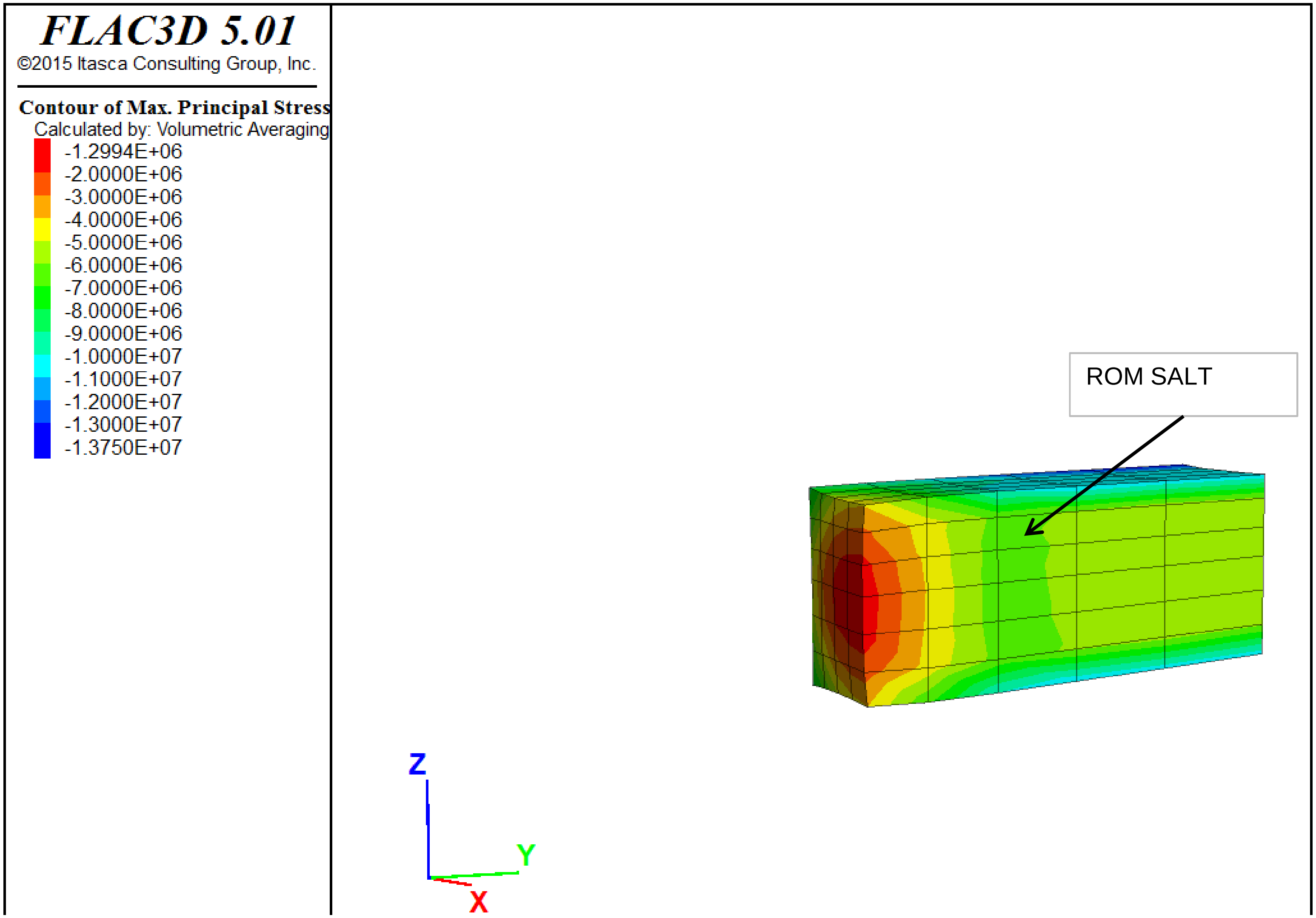

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-4.6

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 60 ft, 35 Yr After Construction

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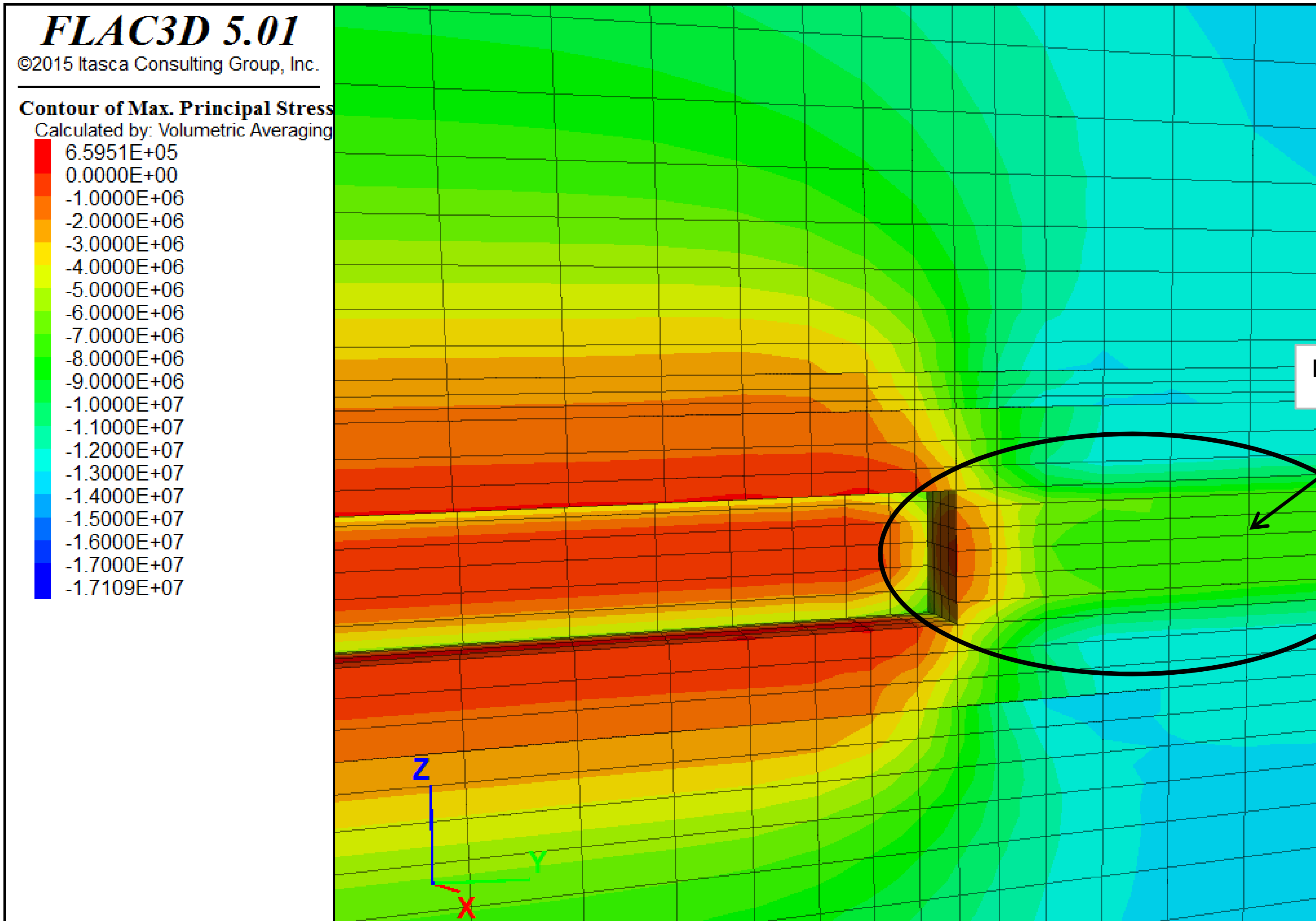

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-5.1

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 80 ft, 5 Yr After Construction

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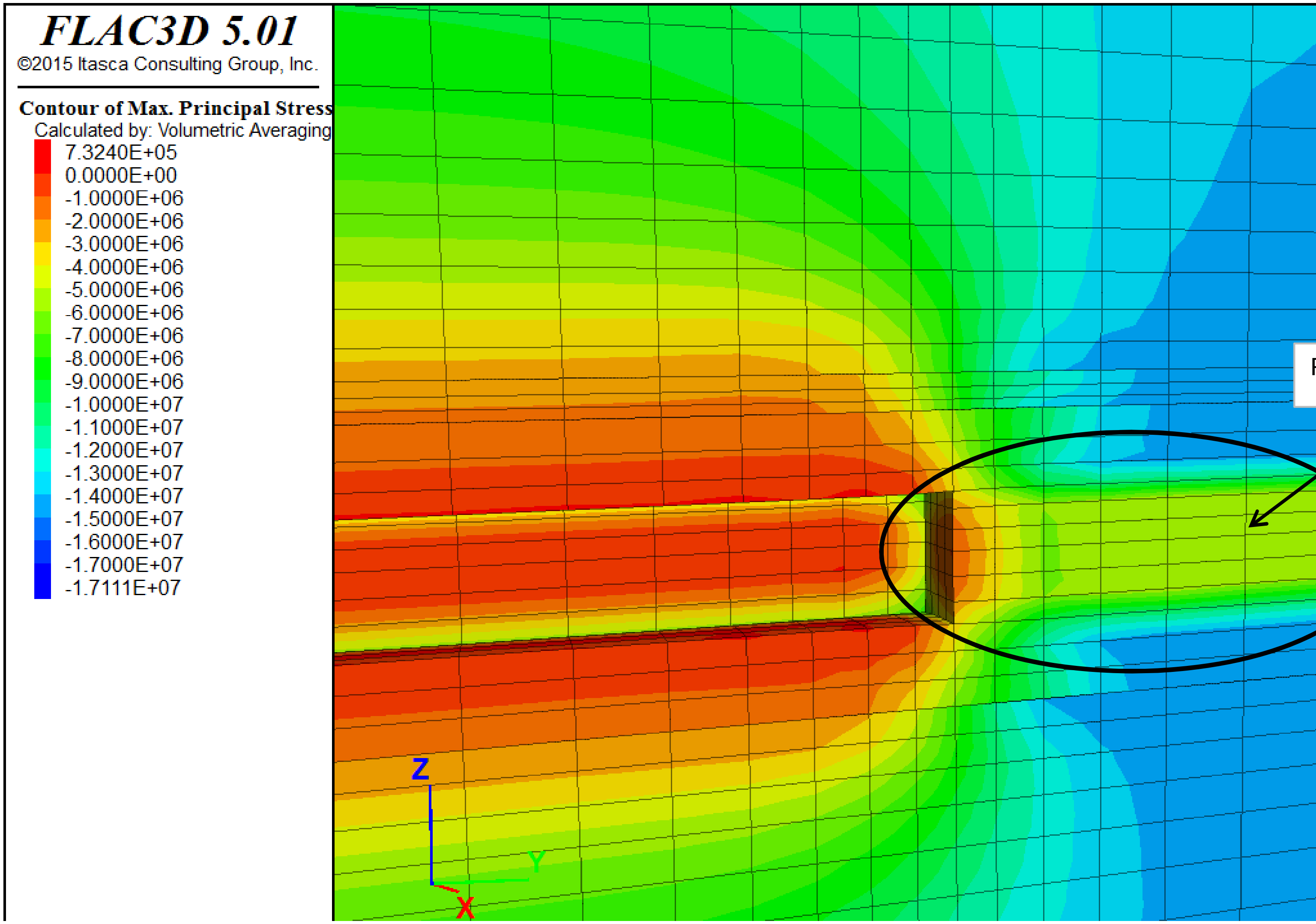

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-5.2

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 80 ft, 15 Yr After Construction

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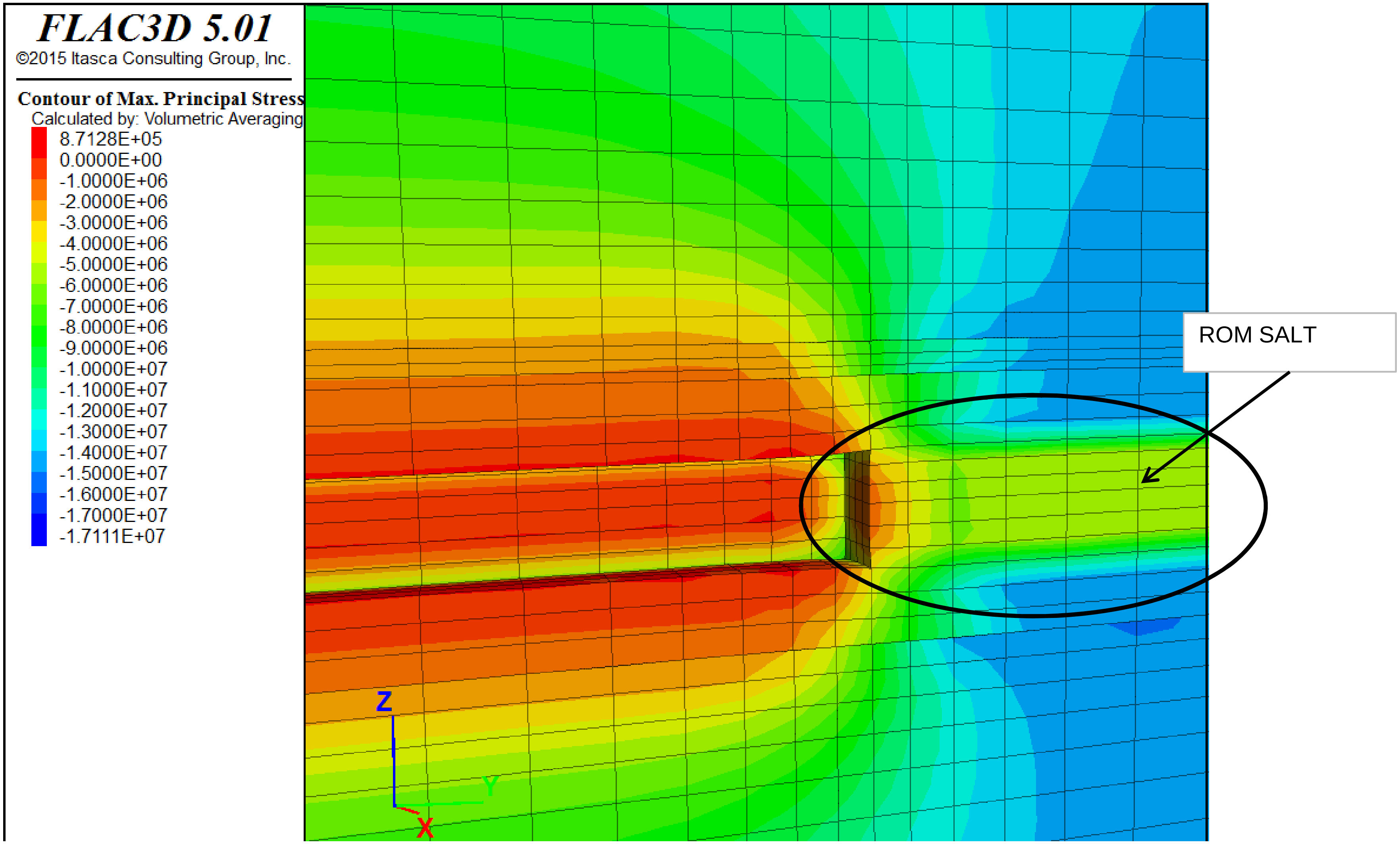

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-5.3

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 80 ft, 35 Yr After Construction

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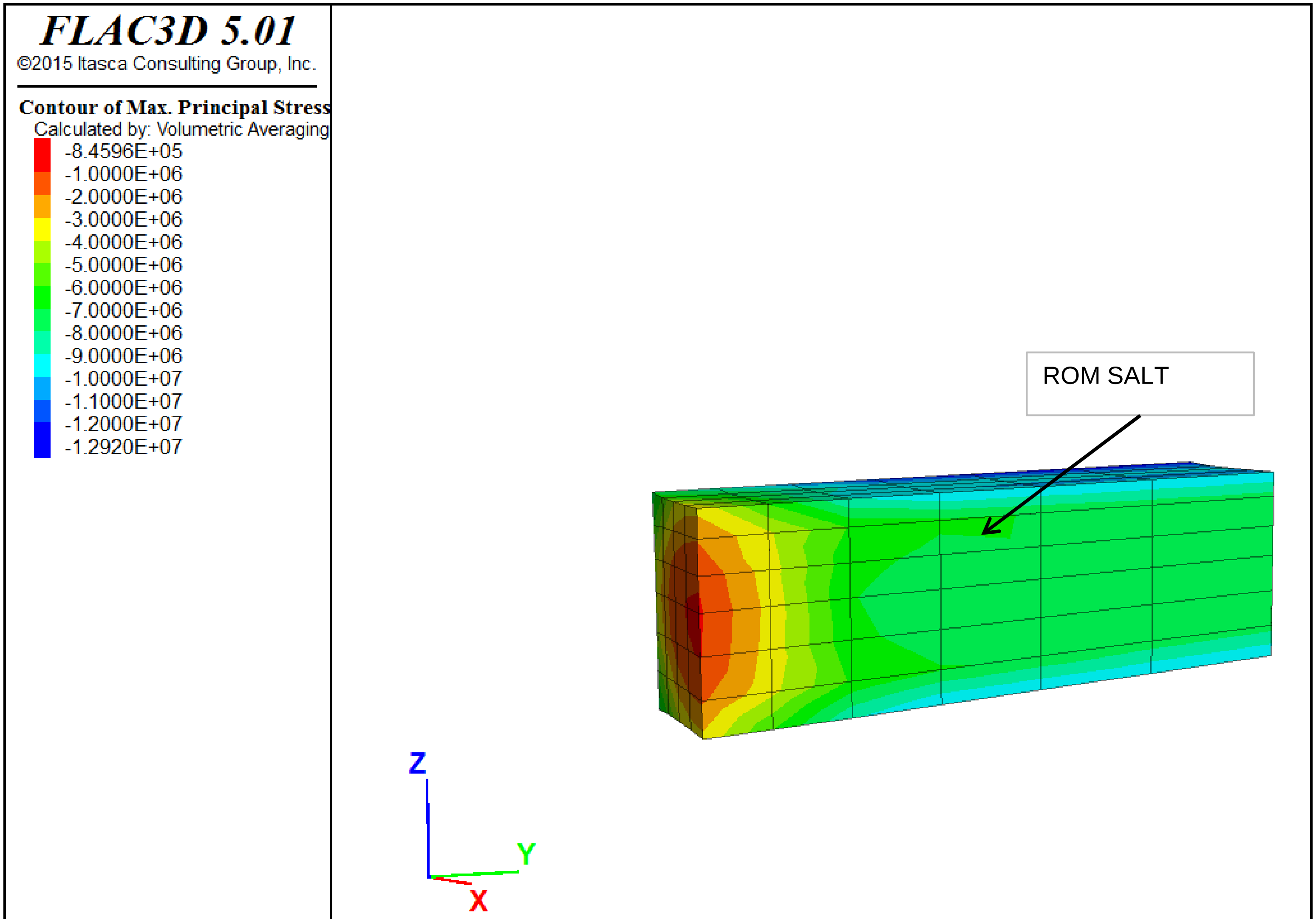

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-5.4

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 80 ft, 5 Yr After Construction

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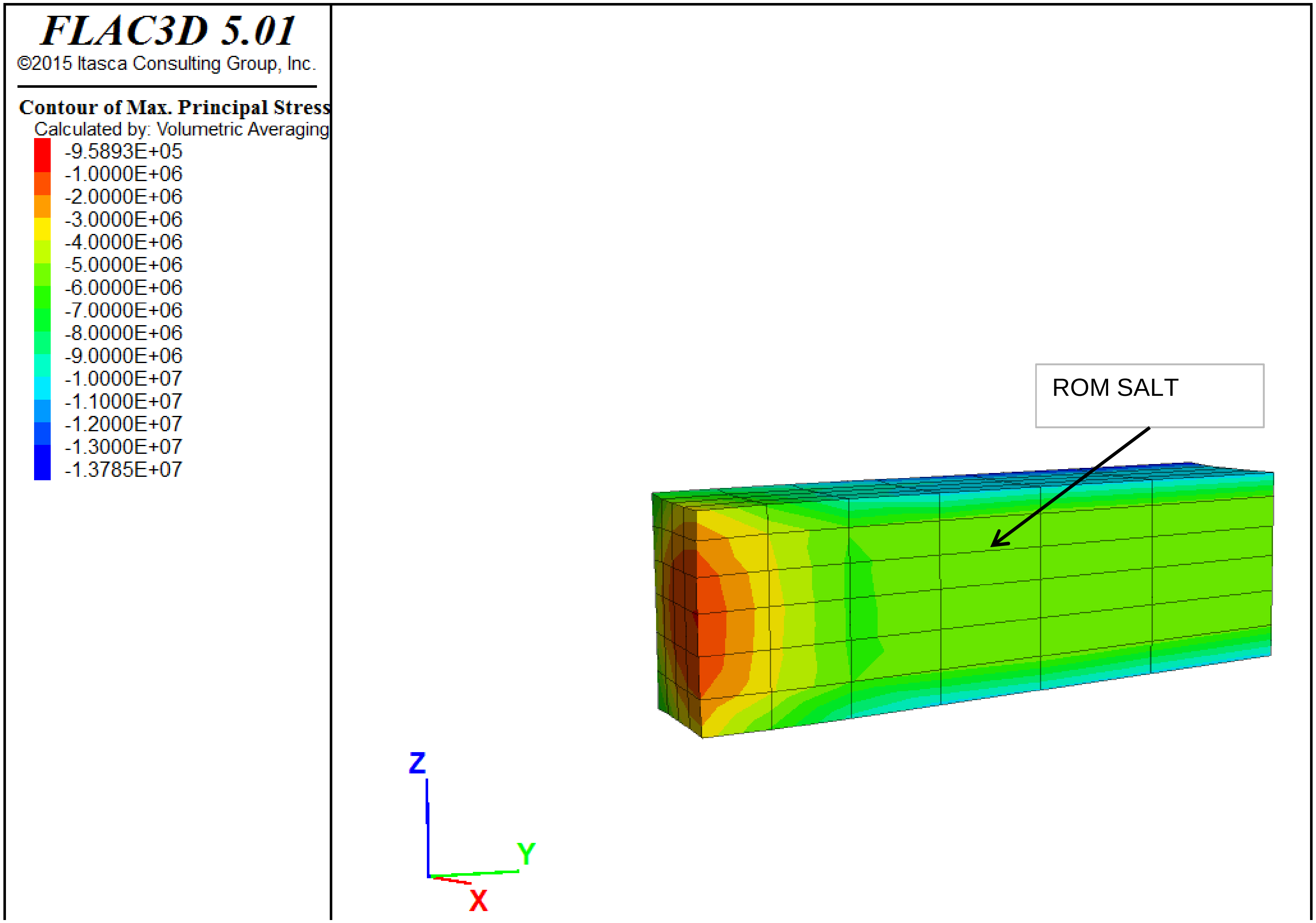

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-5.5

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 80 ft, 15 Yr After Construction

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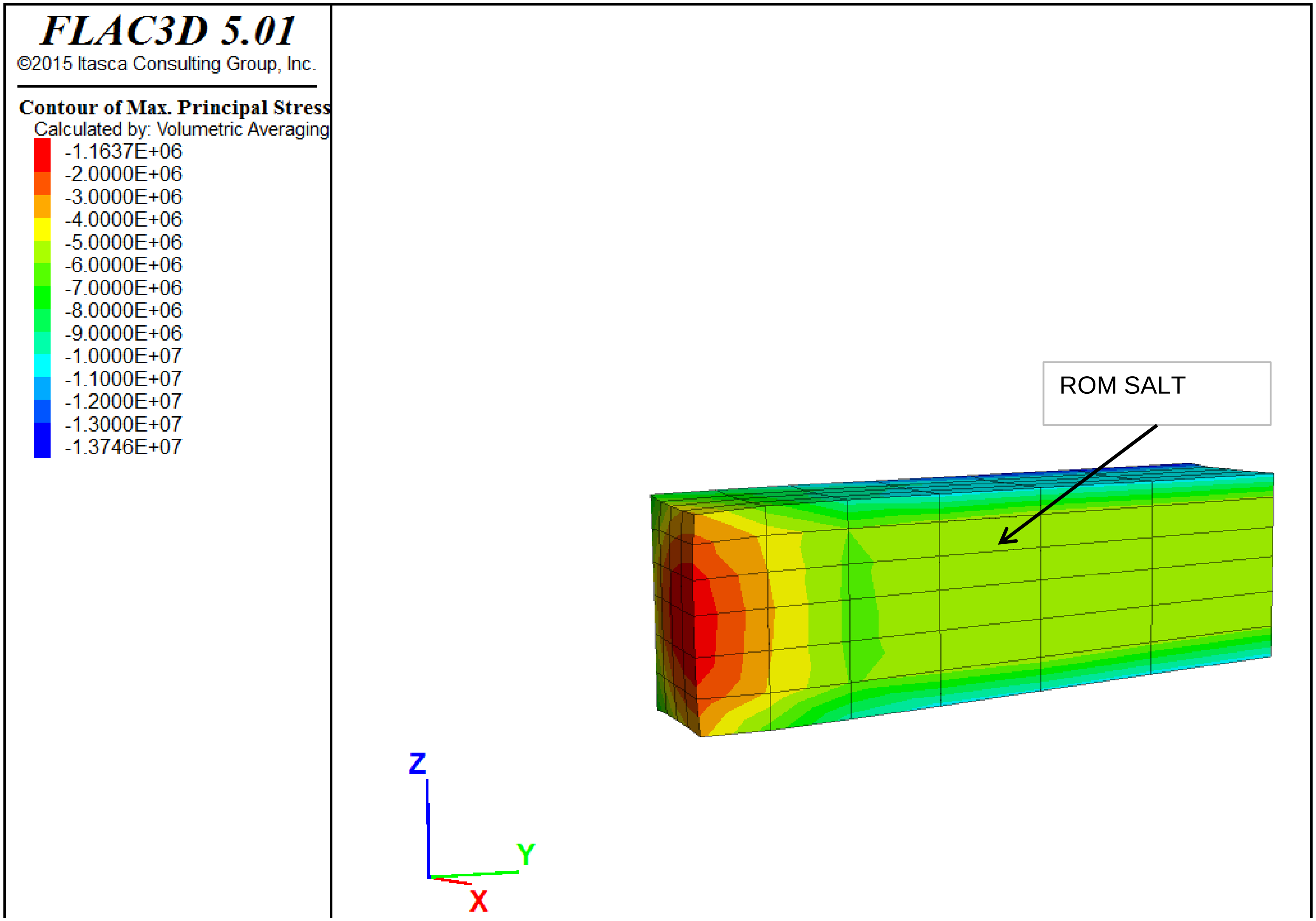

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-5.6

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 80 ft, 35 Yr After Construction

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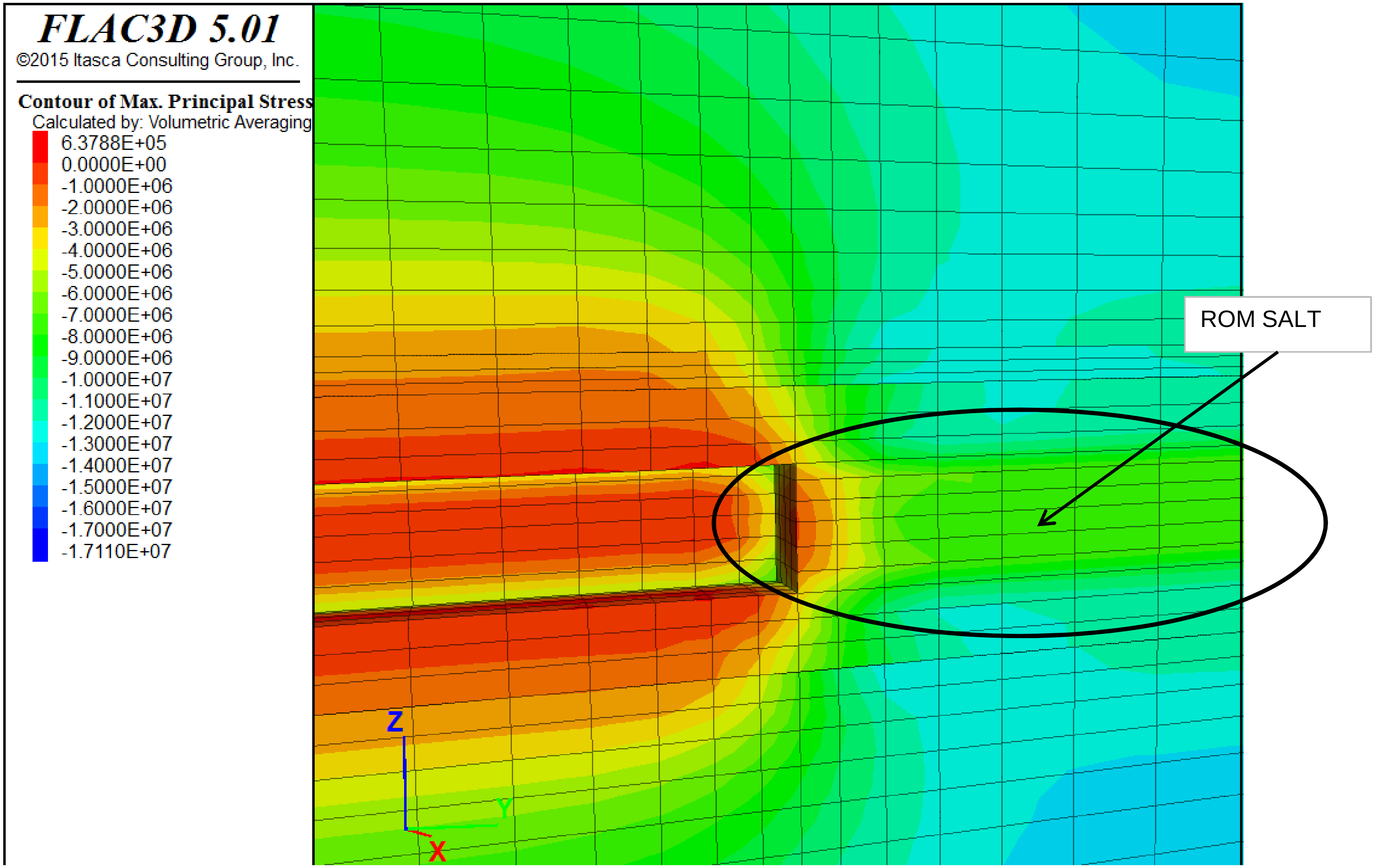

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-6.1

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 100 ft, 5 Yr After Construction

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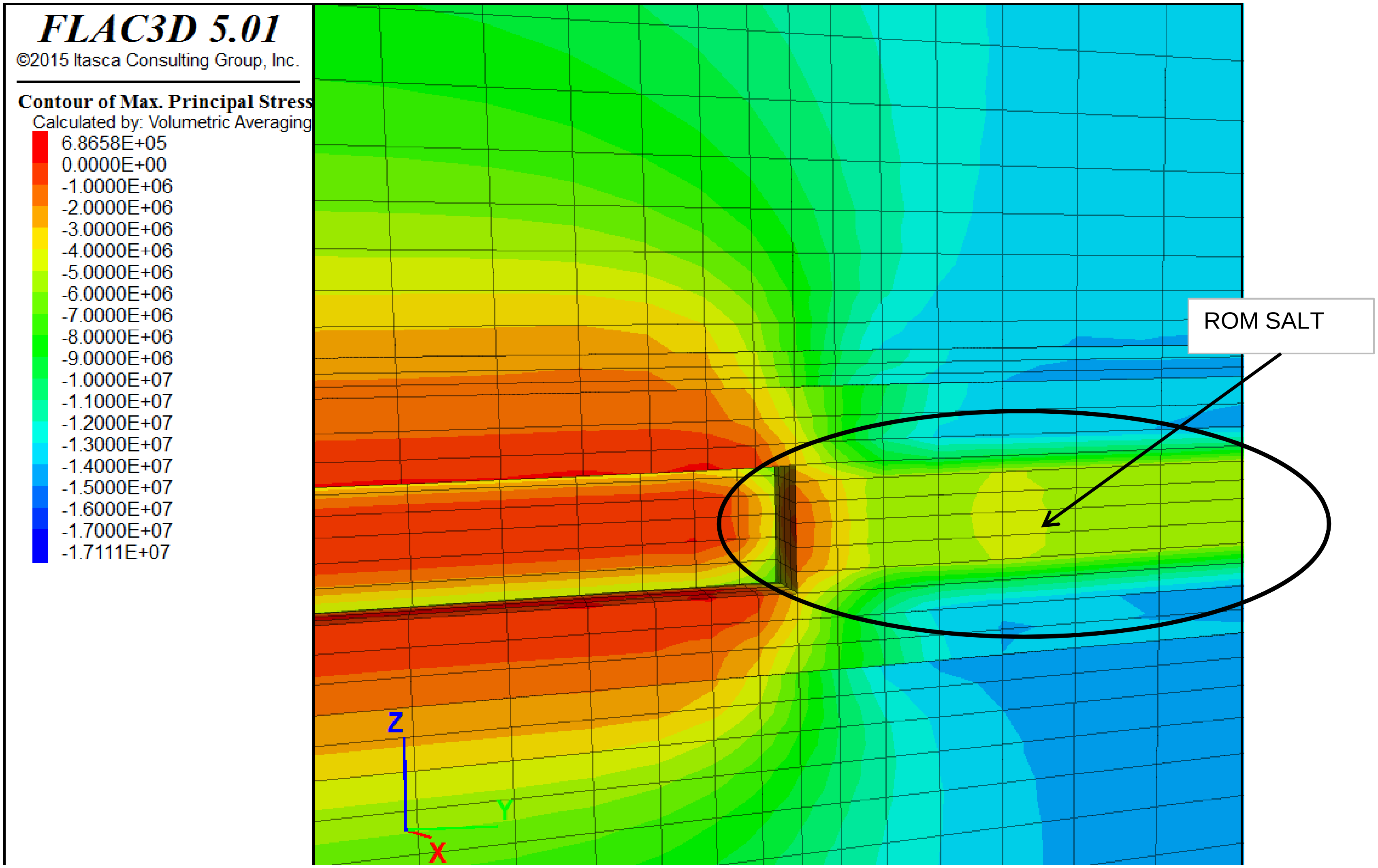

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-6.2

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 100 ft, 15 Yr After Construction

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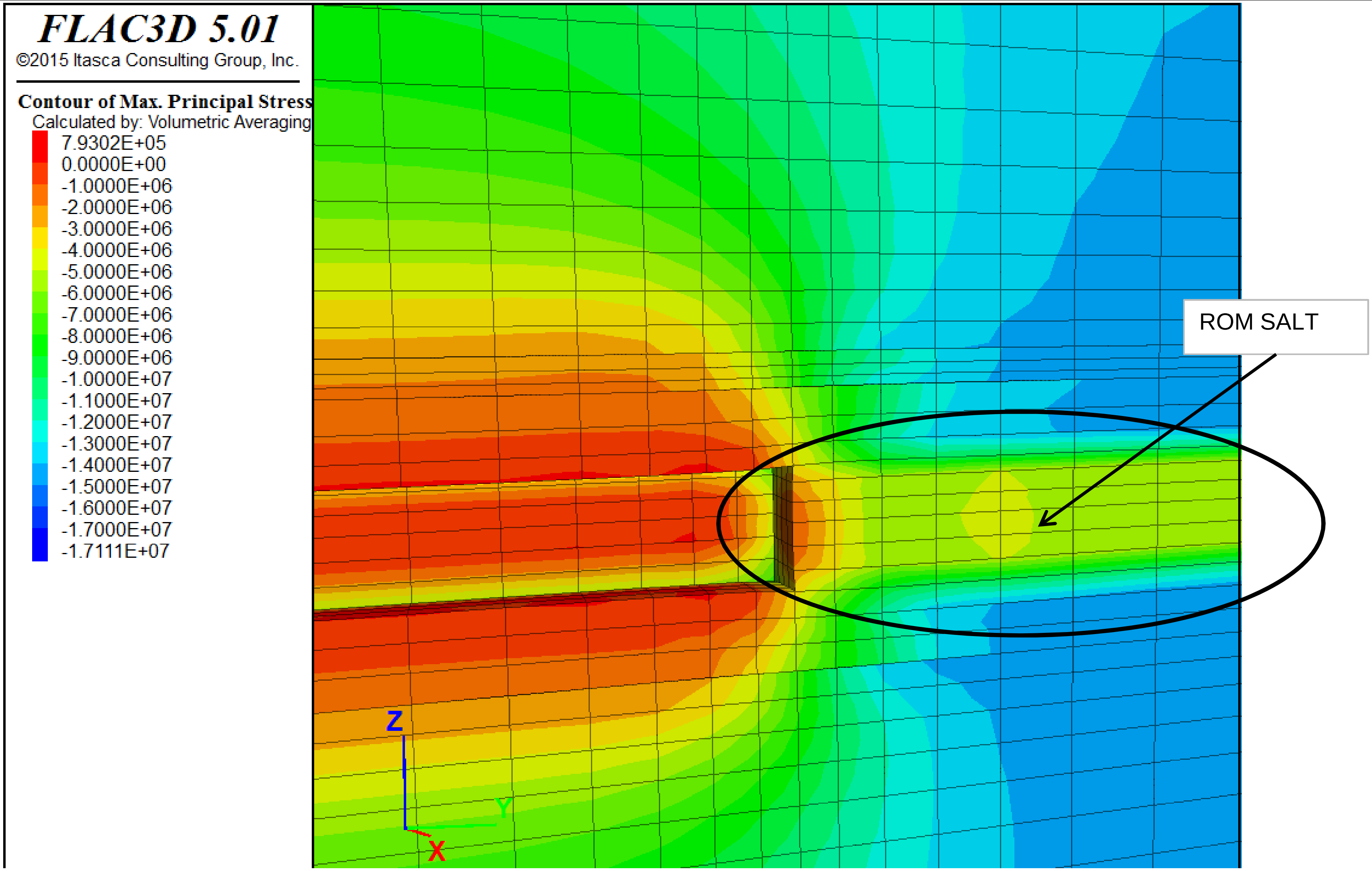

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-6.3

Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 100 ft, 35 Yr After Construction

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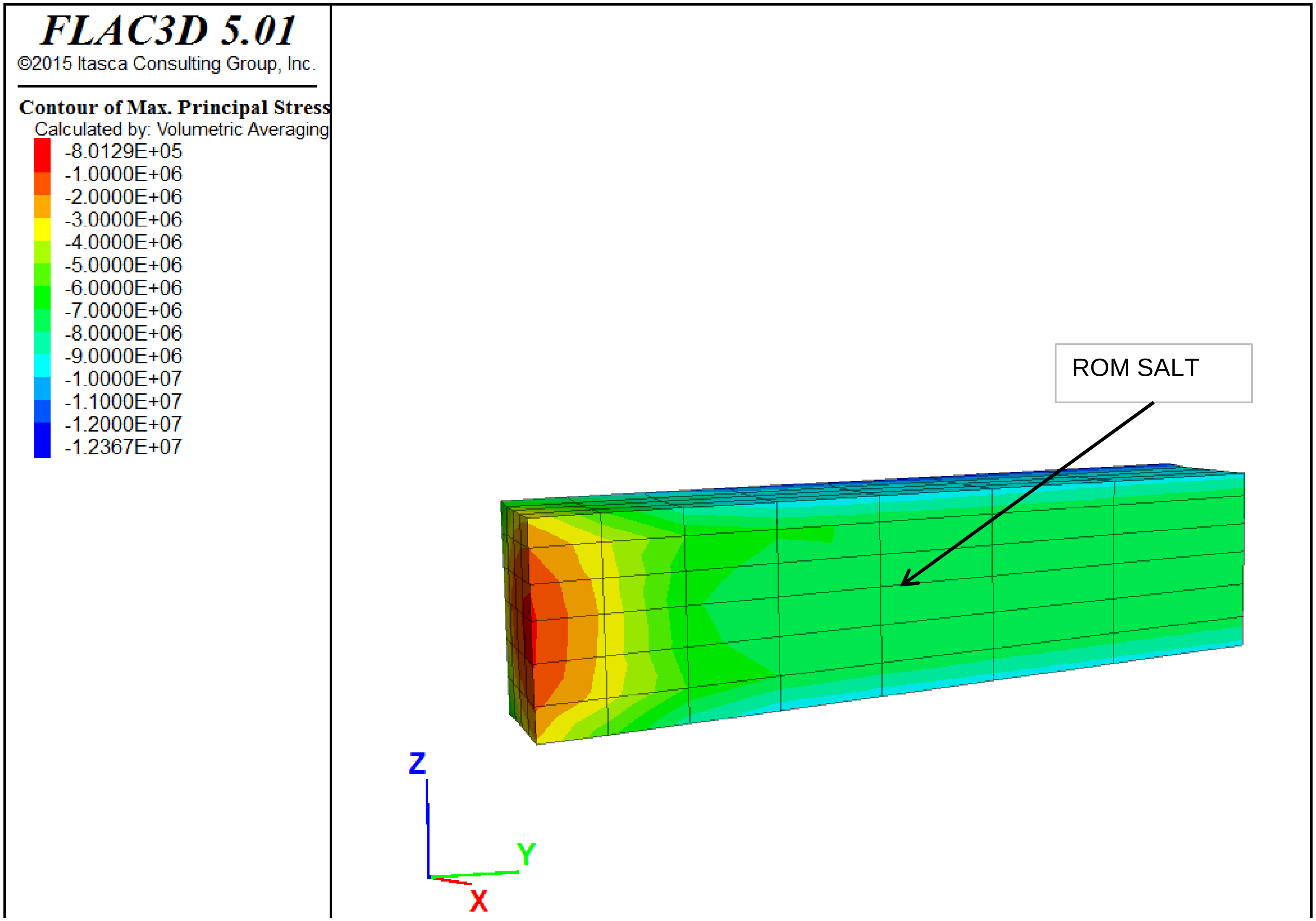

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-6.4

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 100 ft, 5 Yr After Construction

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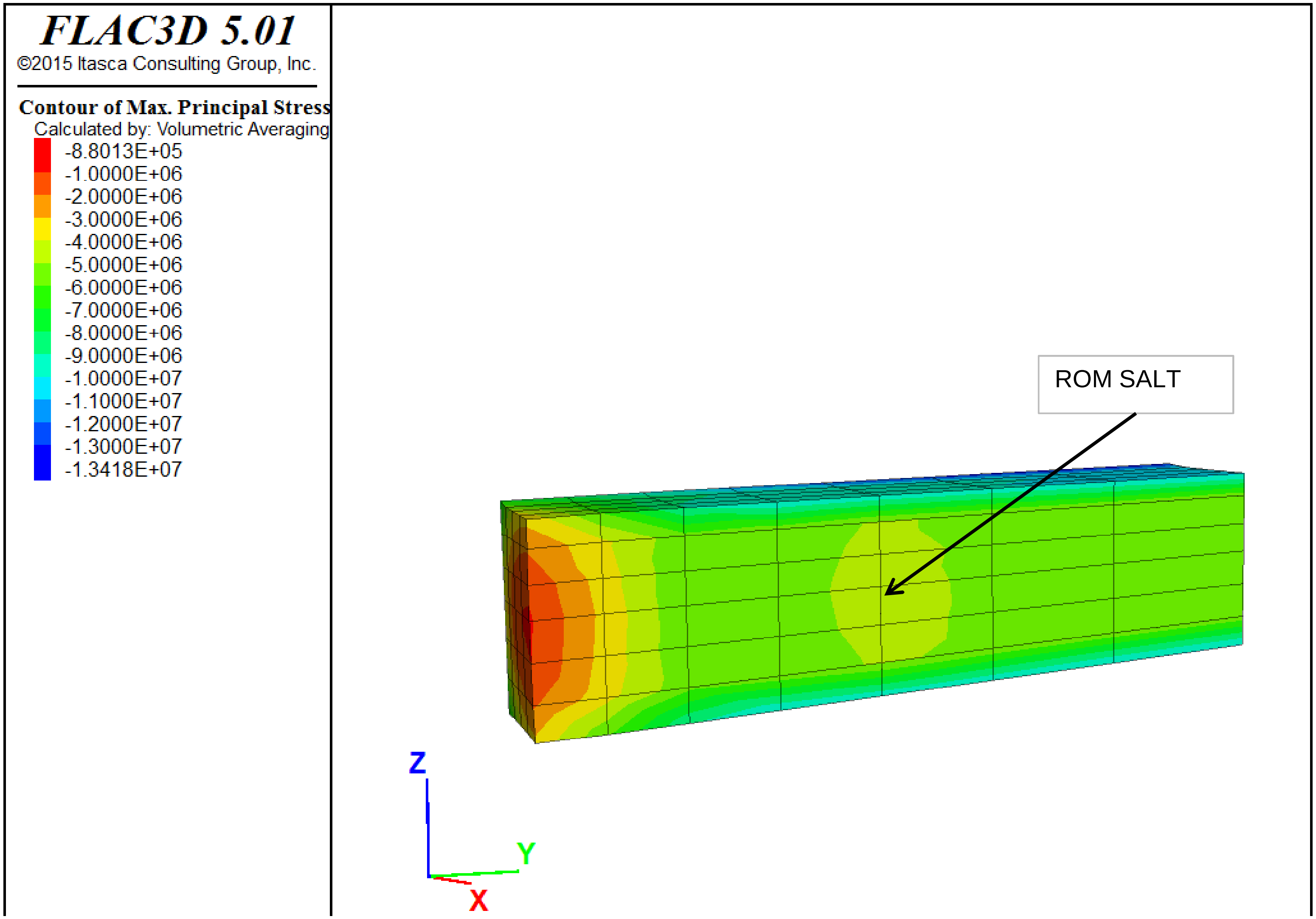

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-6.5

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 100 ft, 15 Yr After Construction

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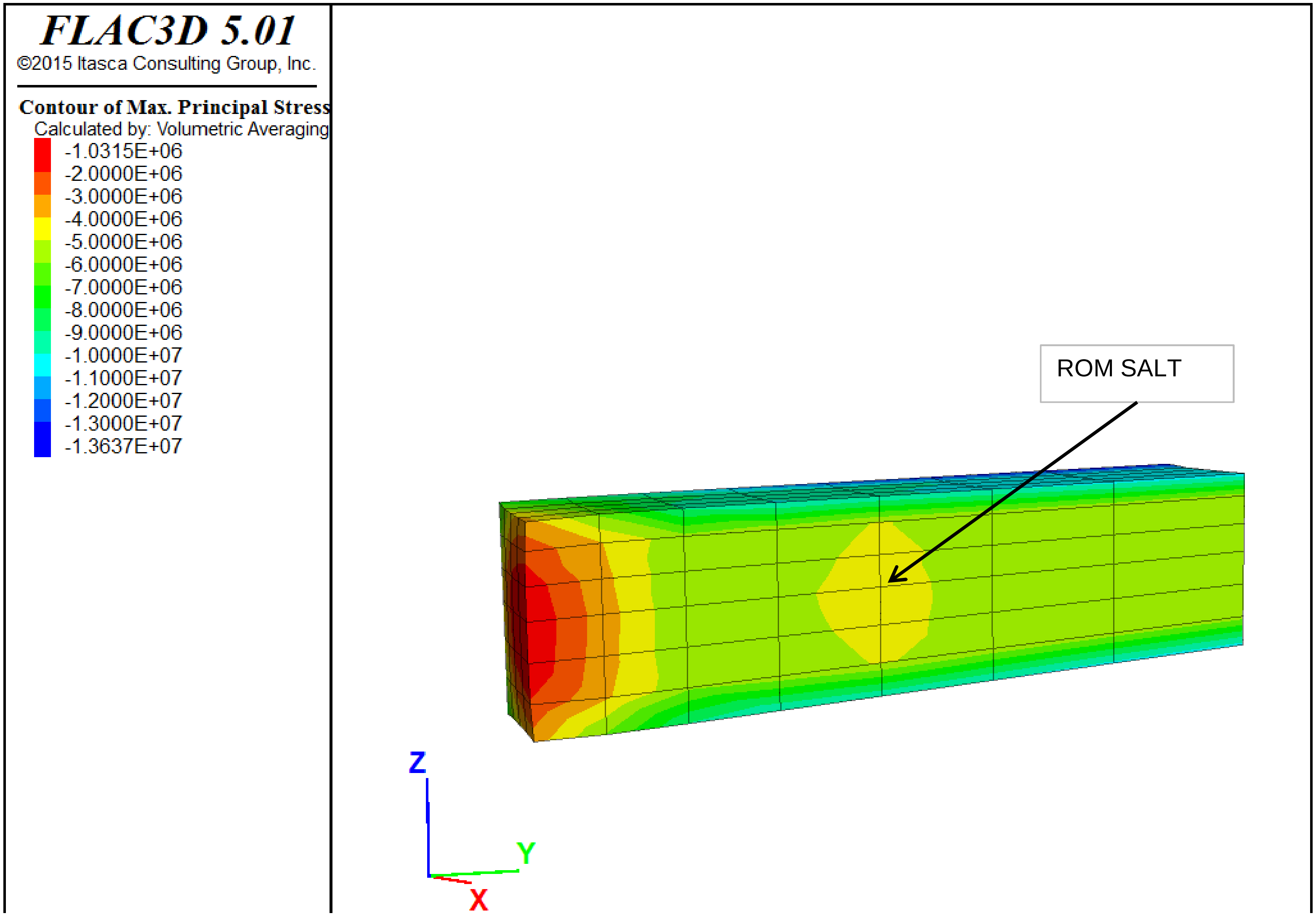

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A1-6.6

WPC-B Minor Principal Stress, Main Entry Width = 16 ft, ROM Salt Length = 100 ft, 35 Yr After Construction

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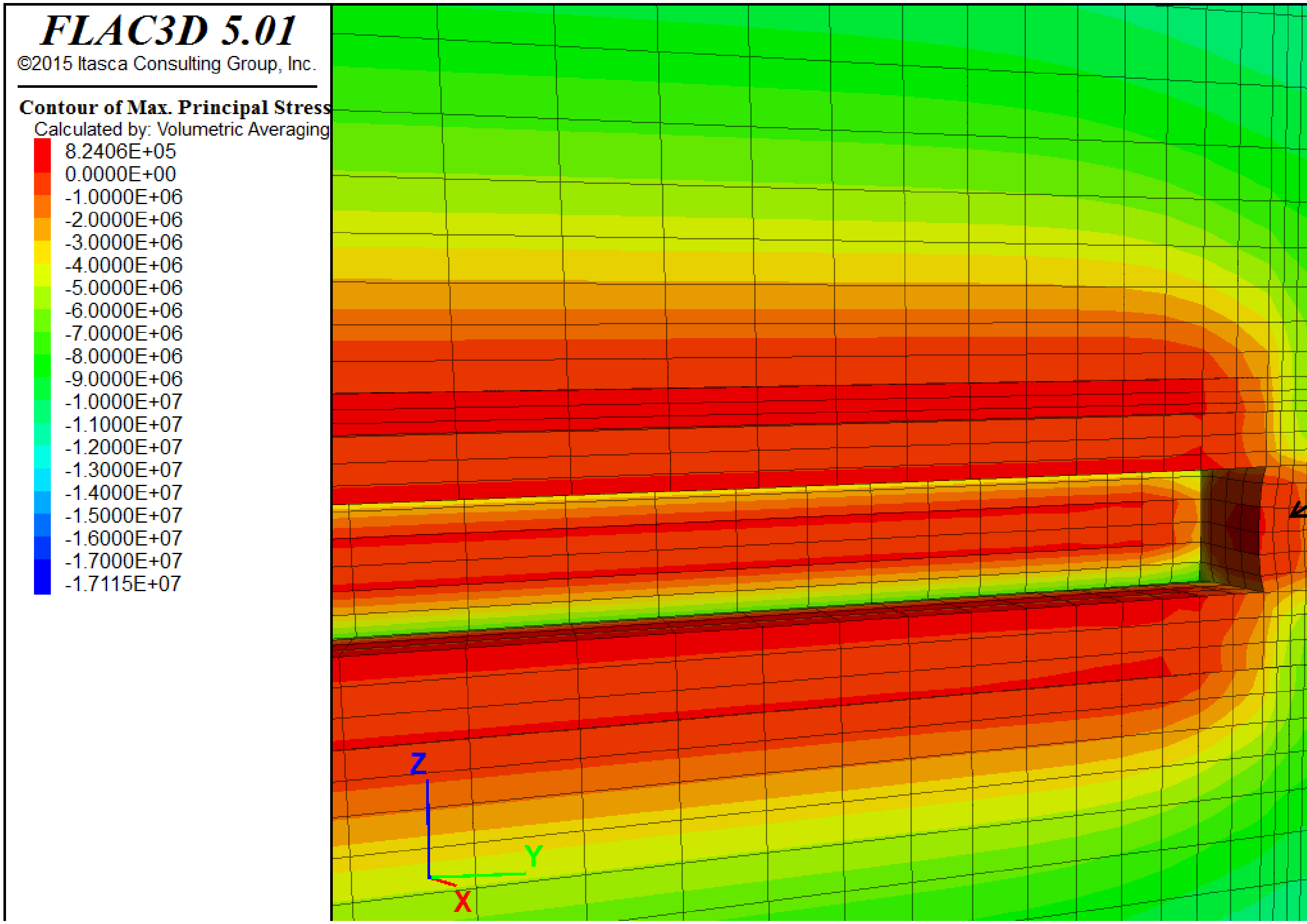
ATTACHMENT 2
FLAC3D RESULTS FOR MAIN ENTRY WIDTH = 25 FT
MINOR PRINCIPAL STRESS



Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-1.1

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 13 ft, 5 Yr After Construction

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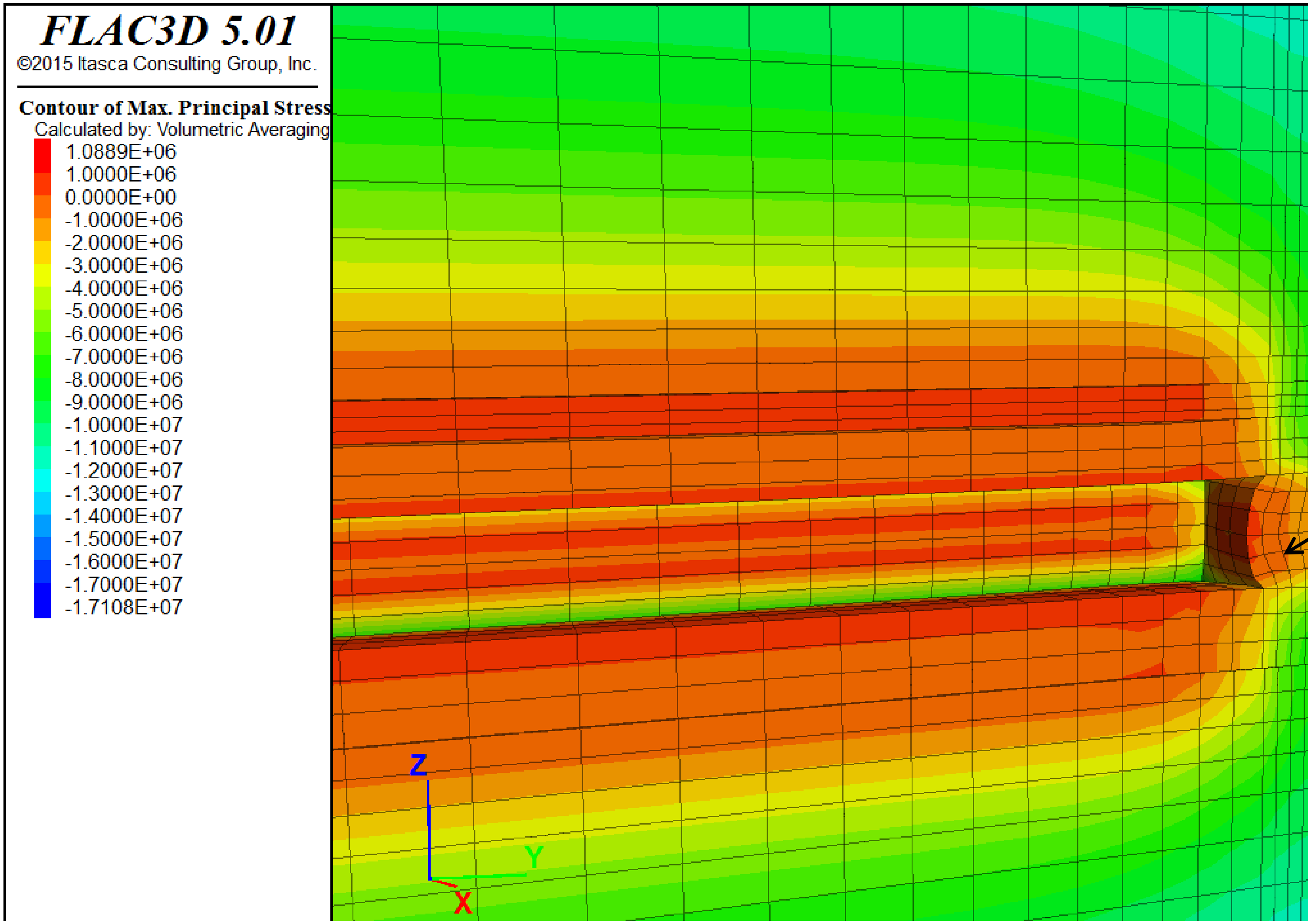

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-1.2

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 13 ft, 15 Yr After Construction

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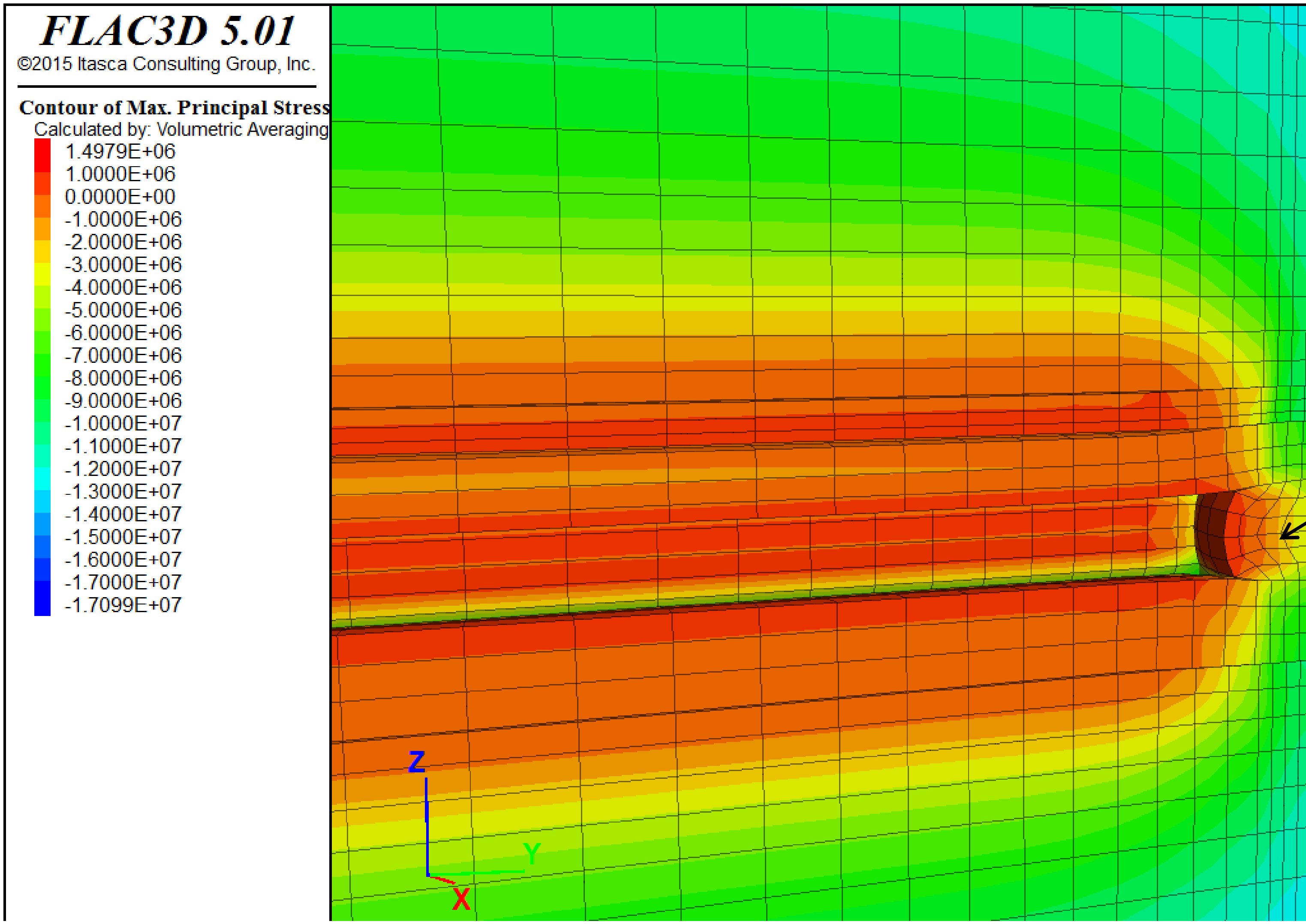

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-1.3

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 13 ft, 35 Yr After Construction

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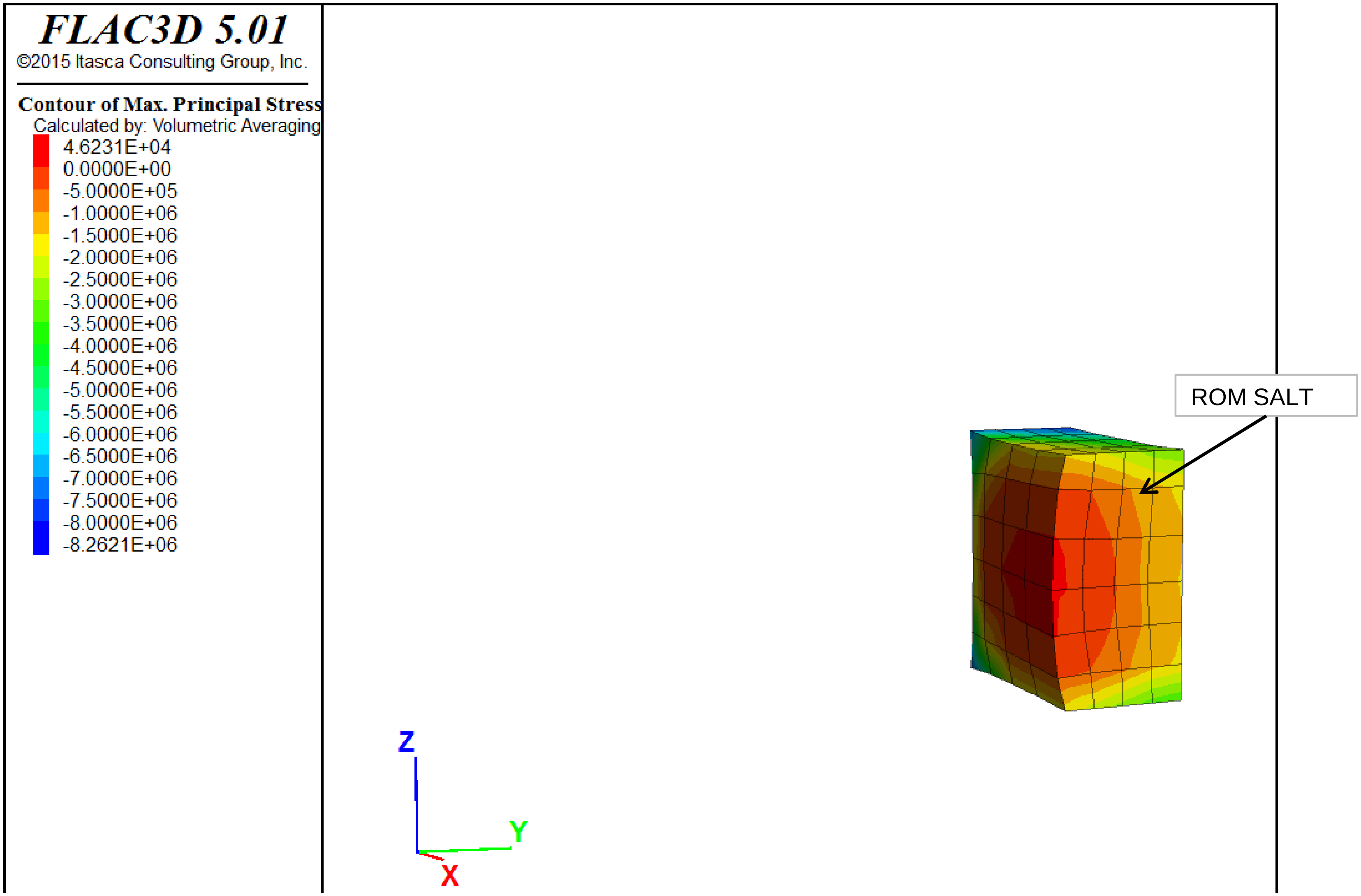

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-1.4

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 13 ft, 5 Yr After Construction

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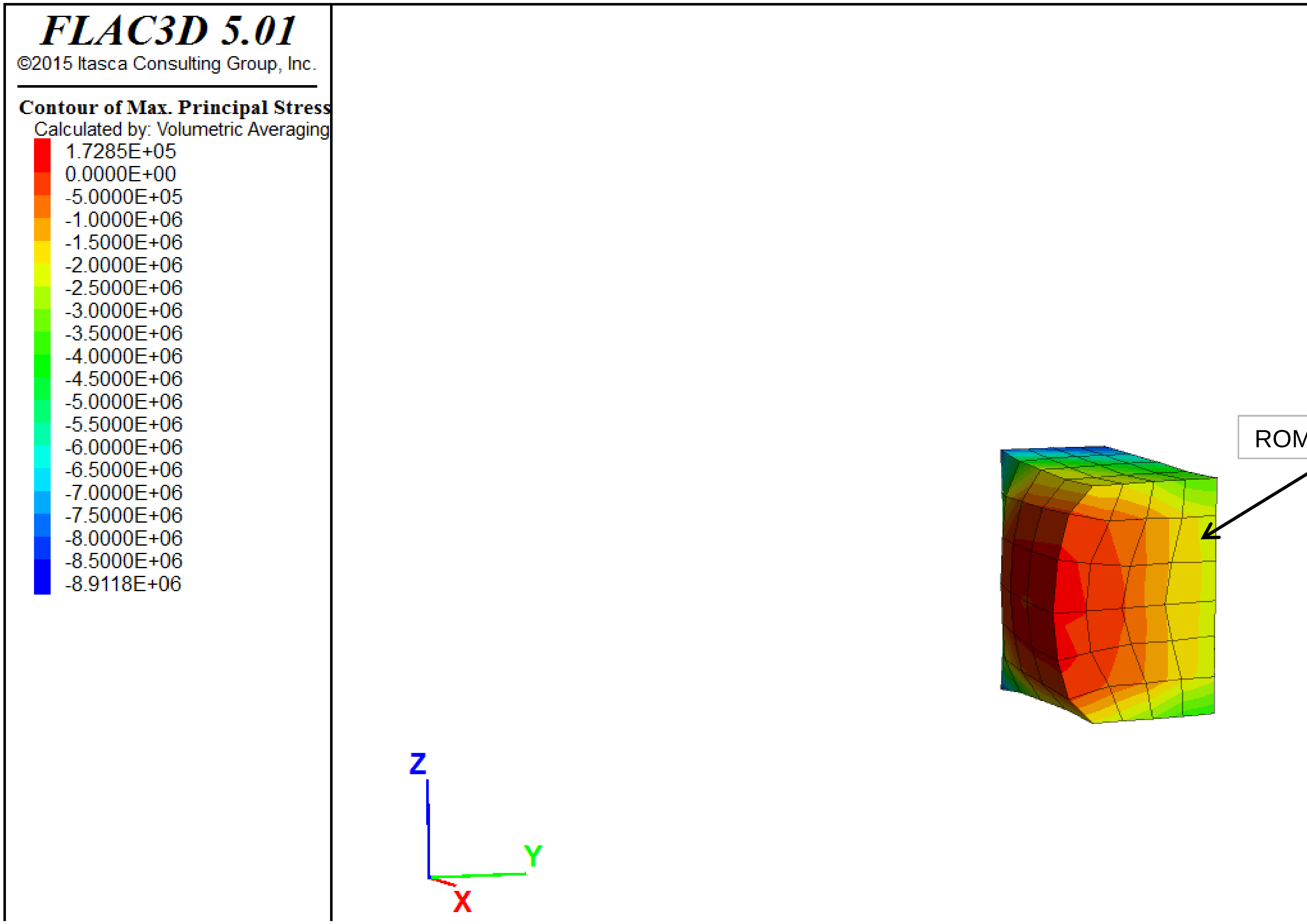

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-1.5

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 13 ft, 15 Yr After Construction

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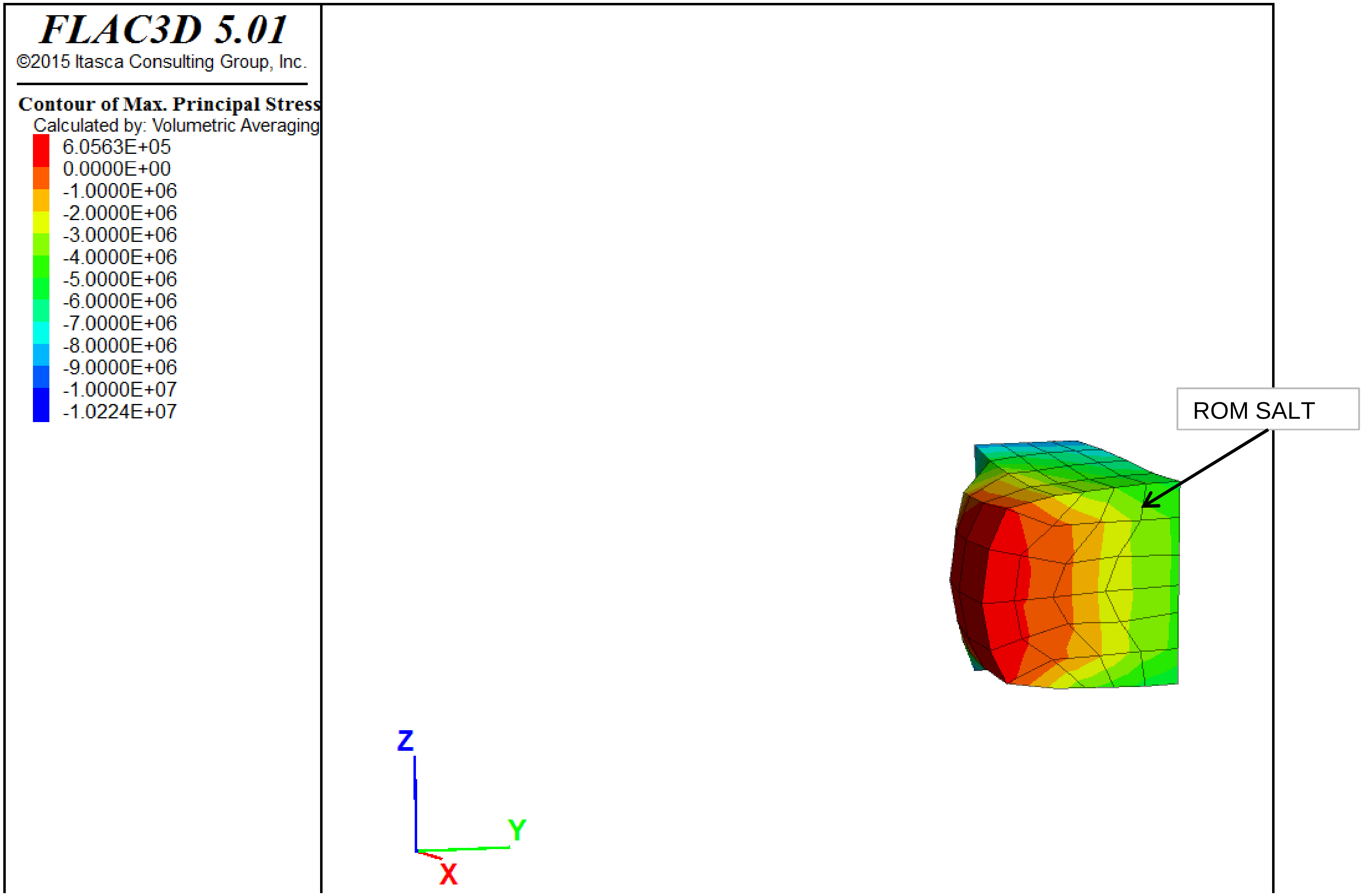

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-1.6

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 13 ft, 35 Yr After Construction

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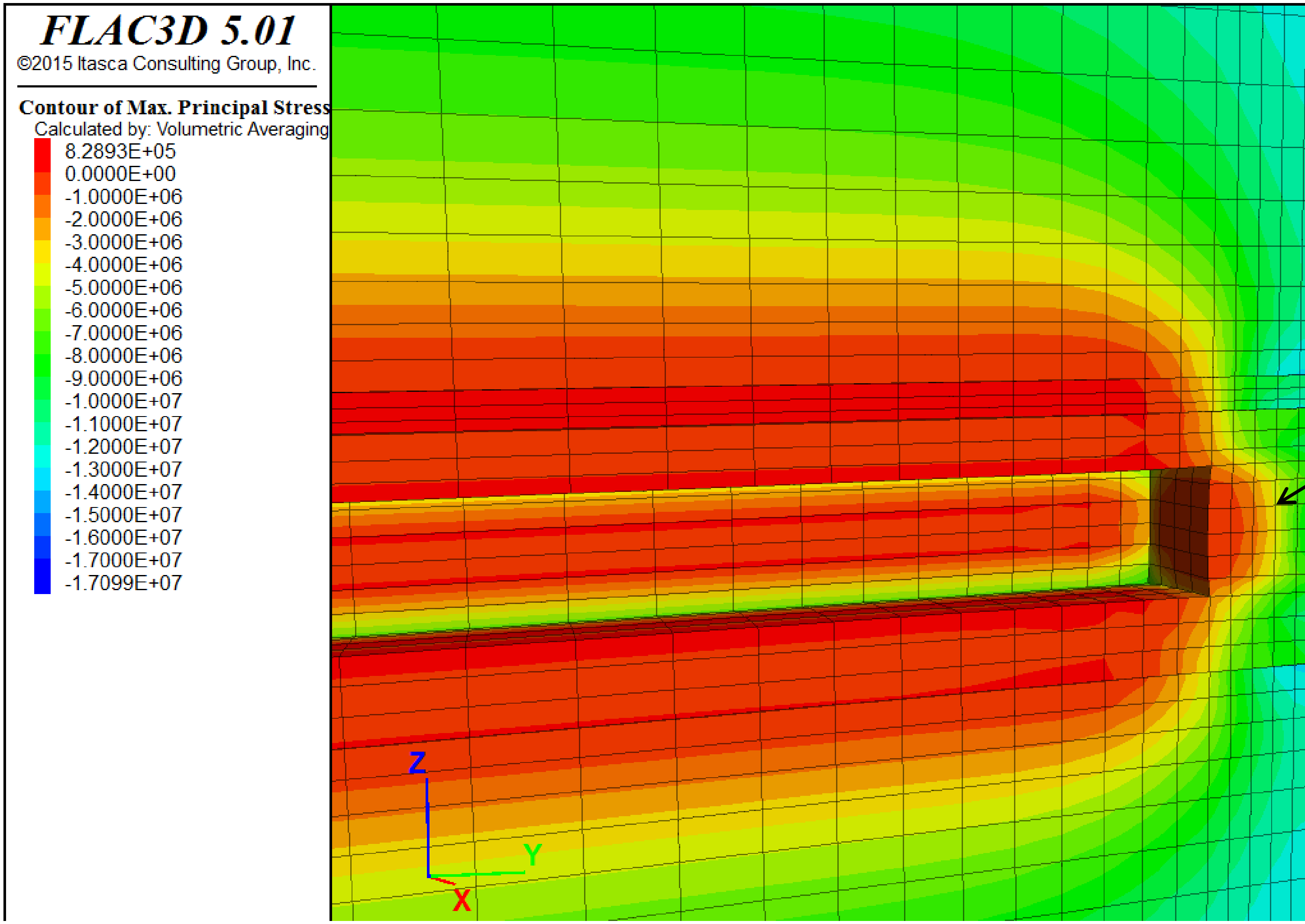

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-2.1

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 25 ft, 5 Yr After Construction

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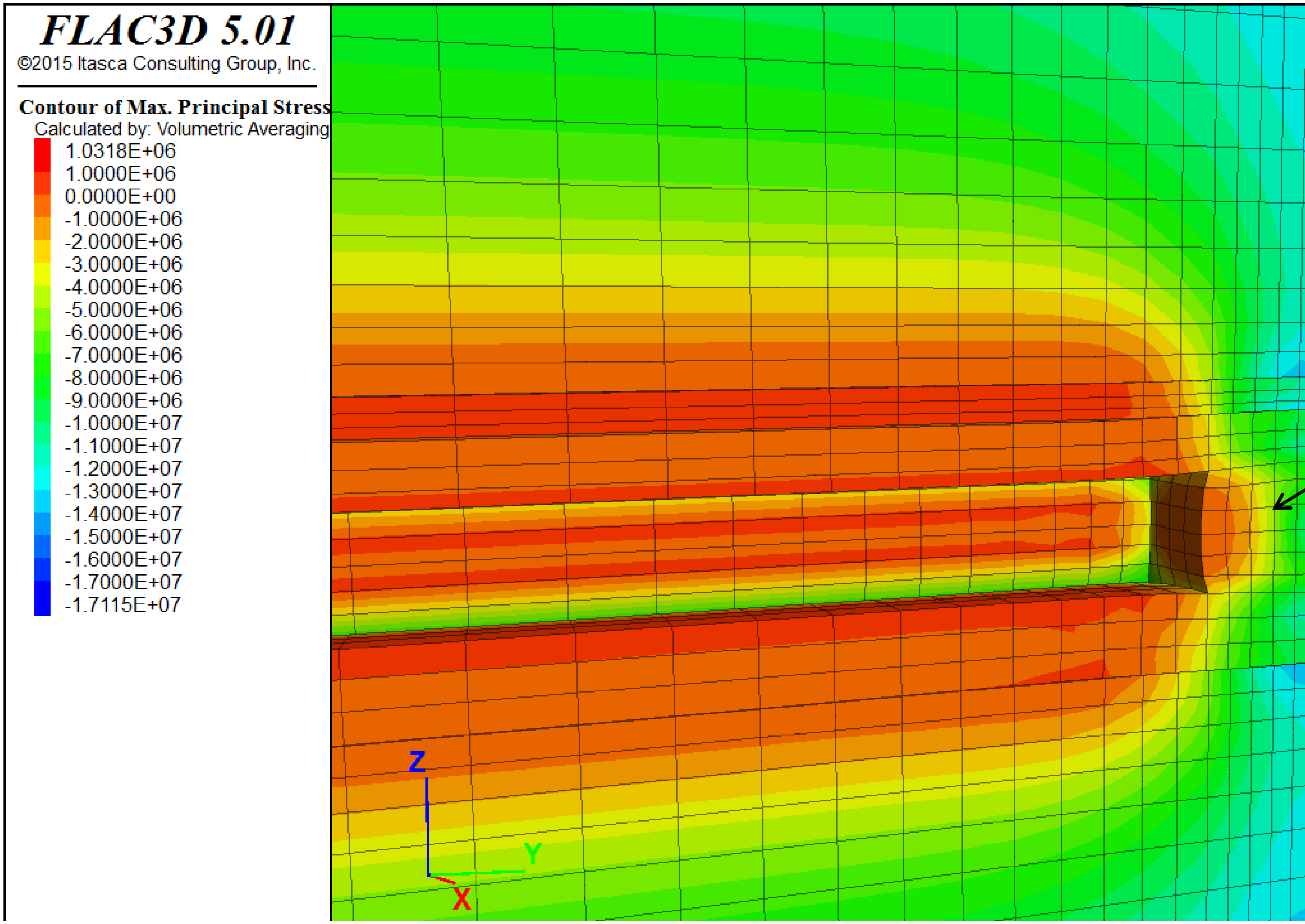

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-2.2

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 25 ft, 15 Yr After Construction

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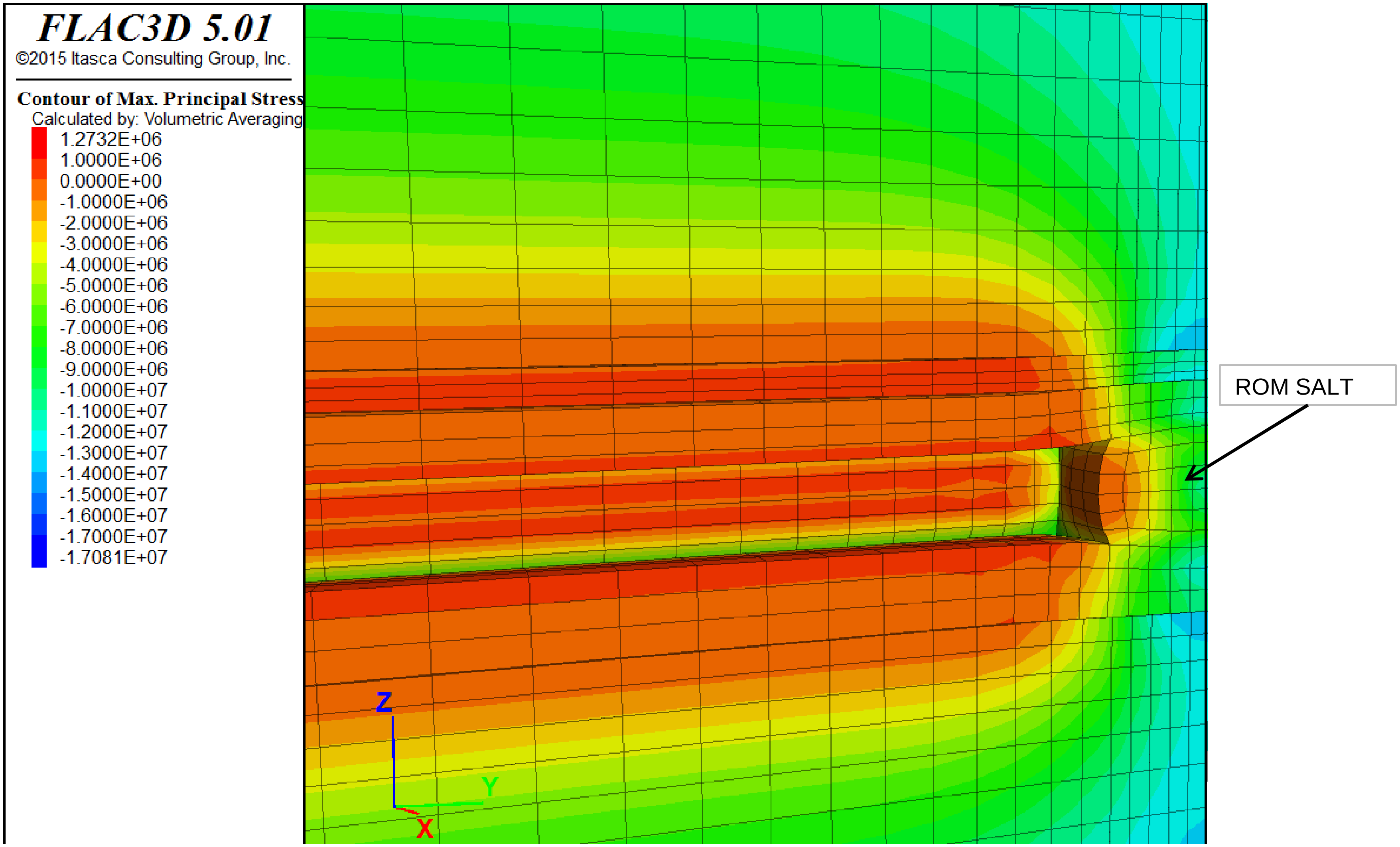

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-2.3

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 25 ft, 33 Yr After Construction

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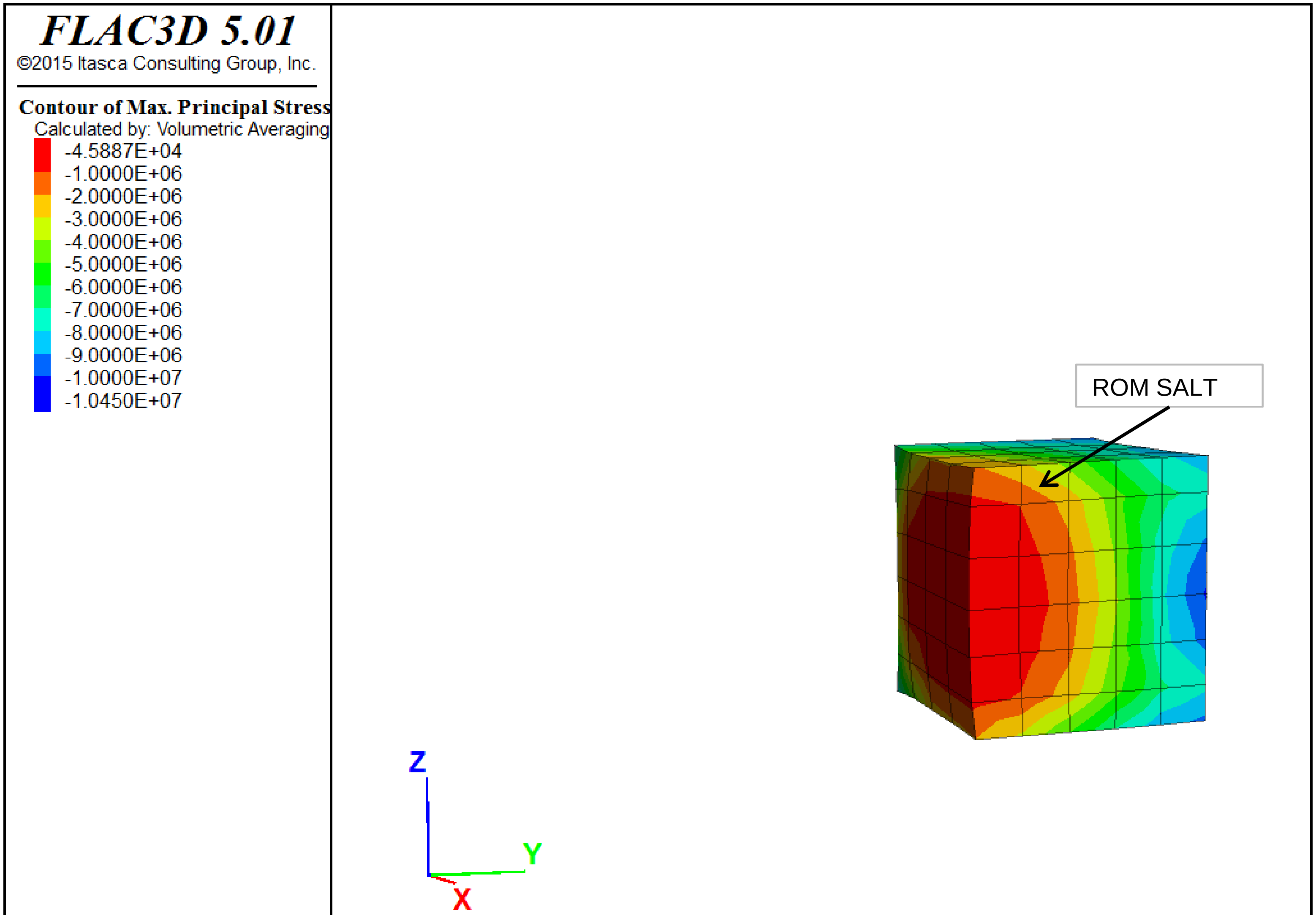

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-2.4

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 25 ft, 5 Yr After Construction

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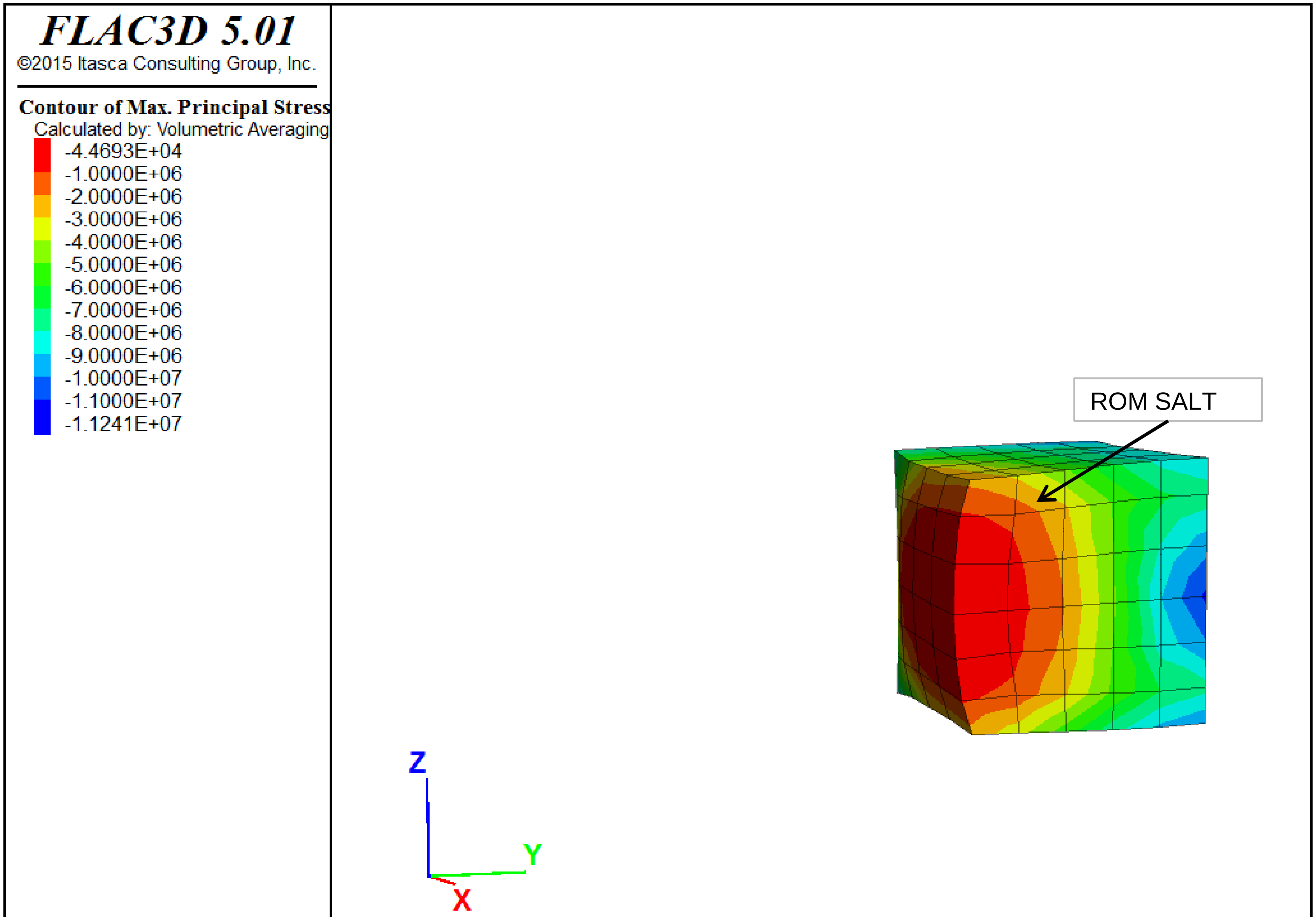

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-2.5

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 25 ft, 15 Yr After Construction

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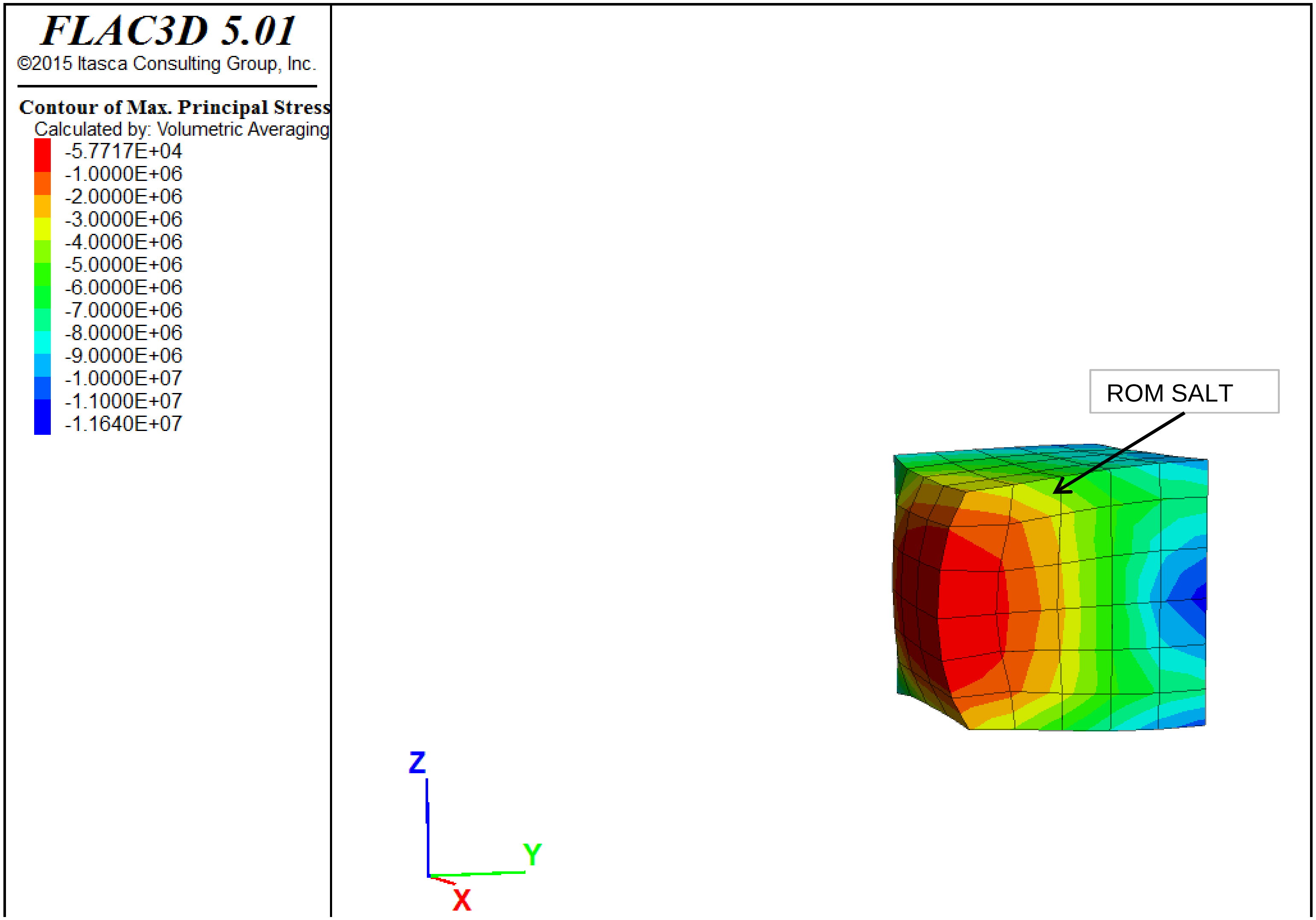

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-2.6

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 25 ft, 33 Yr After Construction

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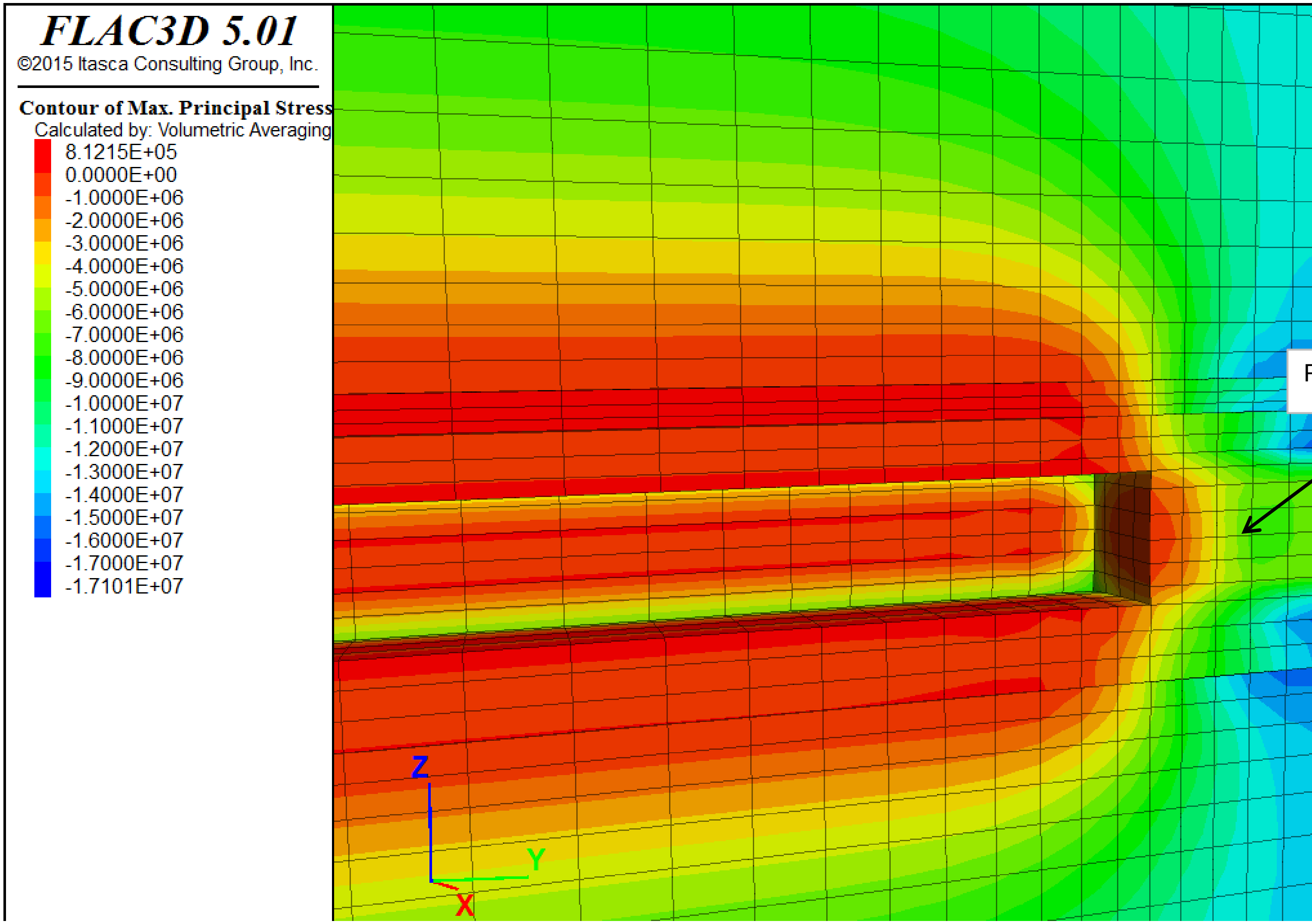

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-3.1

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 40 ft, 5 Yr After Construction

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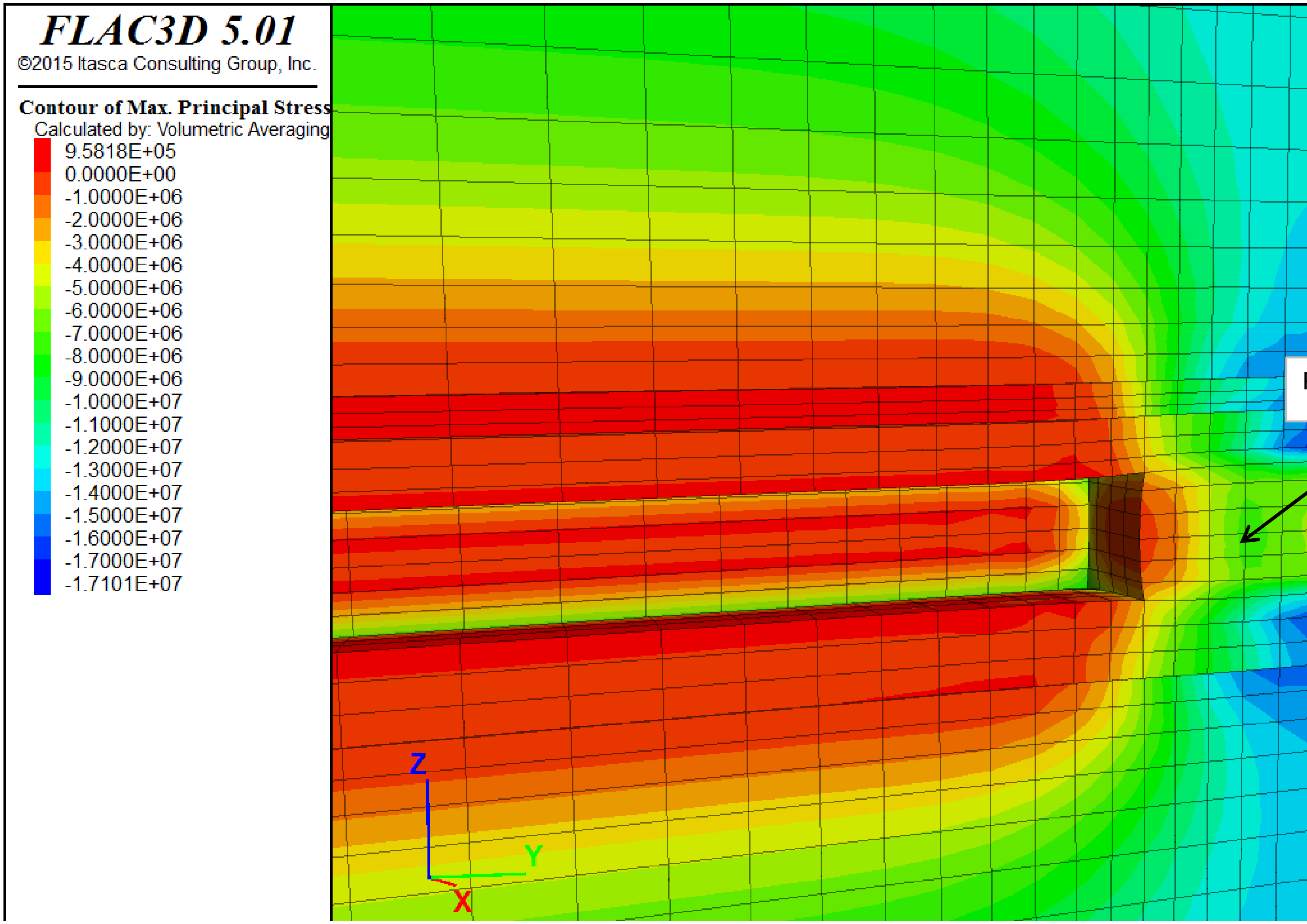

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-3.2

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 40 ft, 15 Yr After Construction

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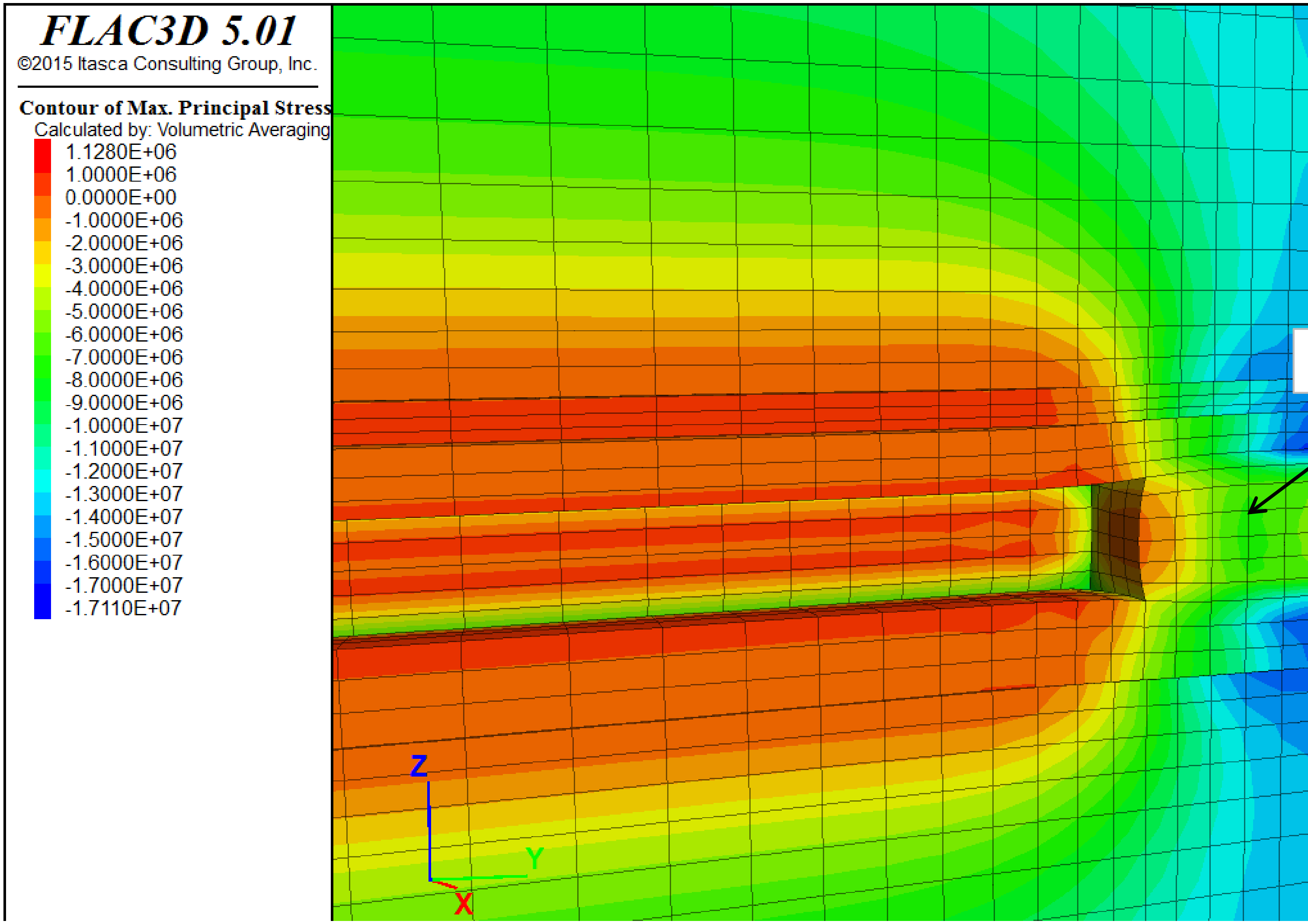

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-3.3

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 40 ft, 25 Yr After Construction

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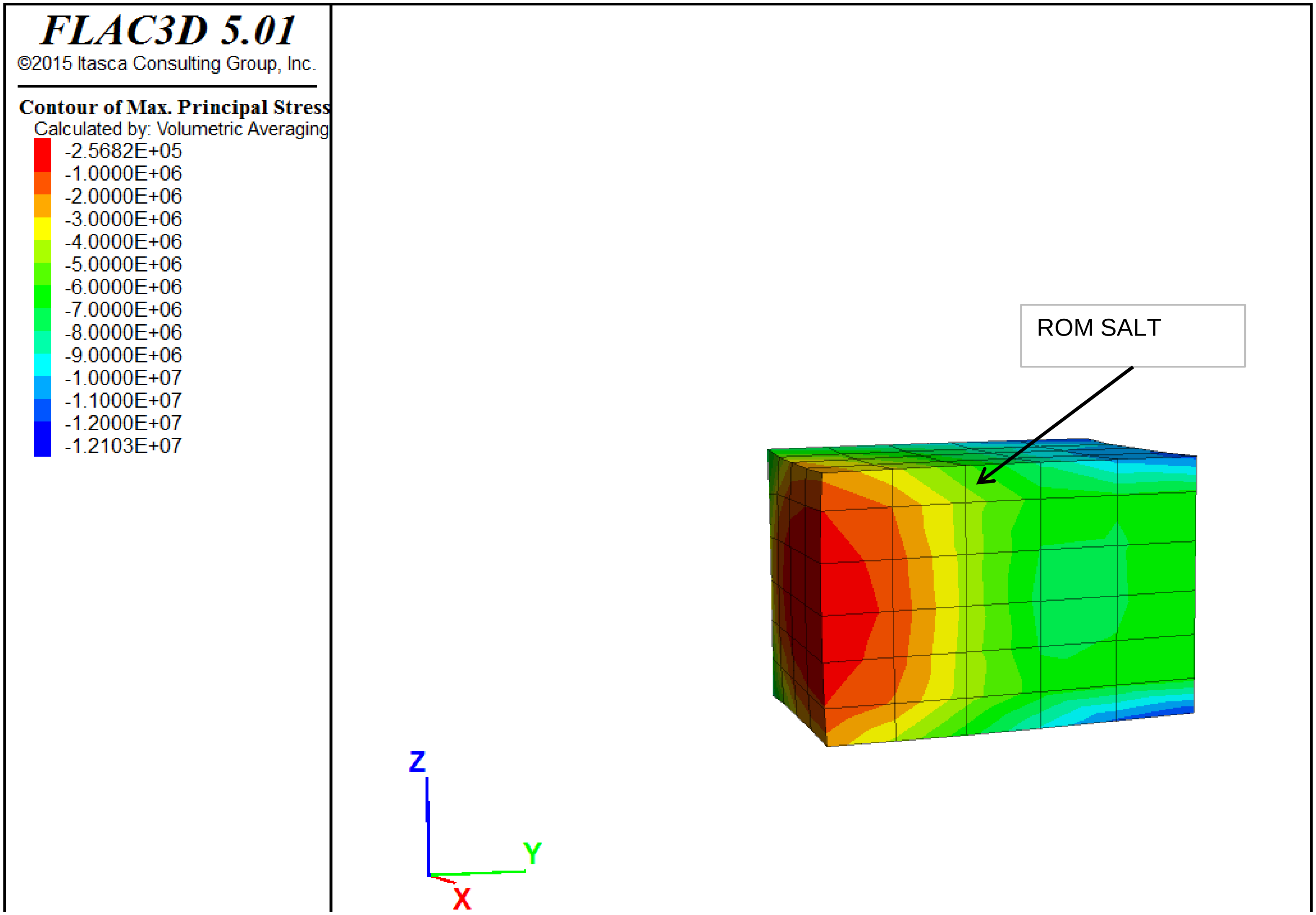

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-3.4

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 40 ft, 5 Yr After Construction

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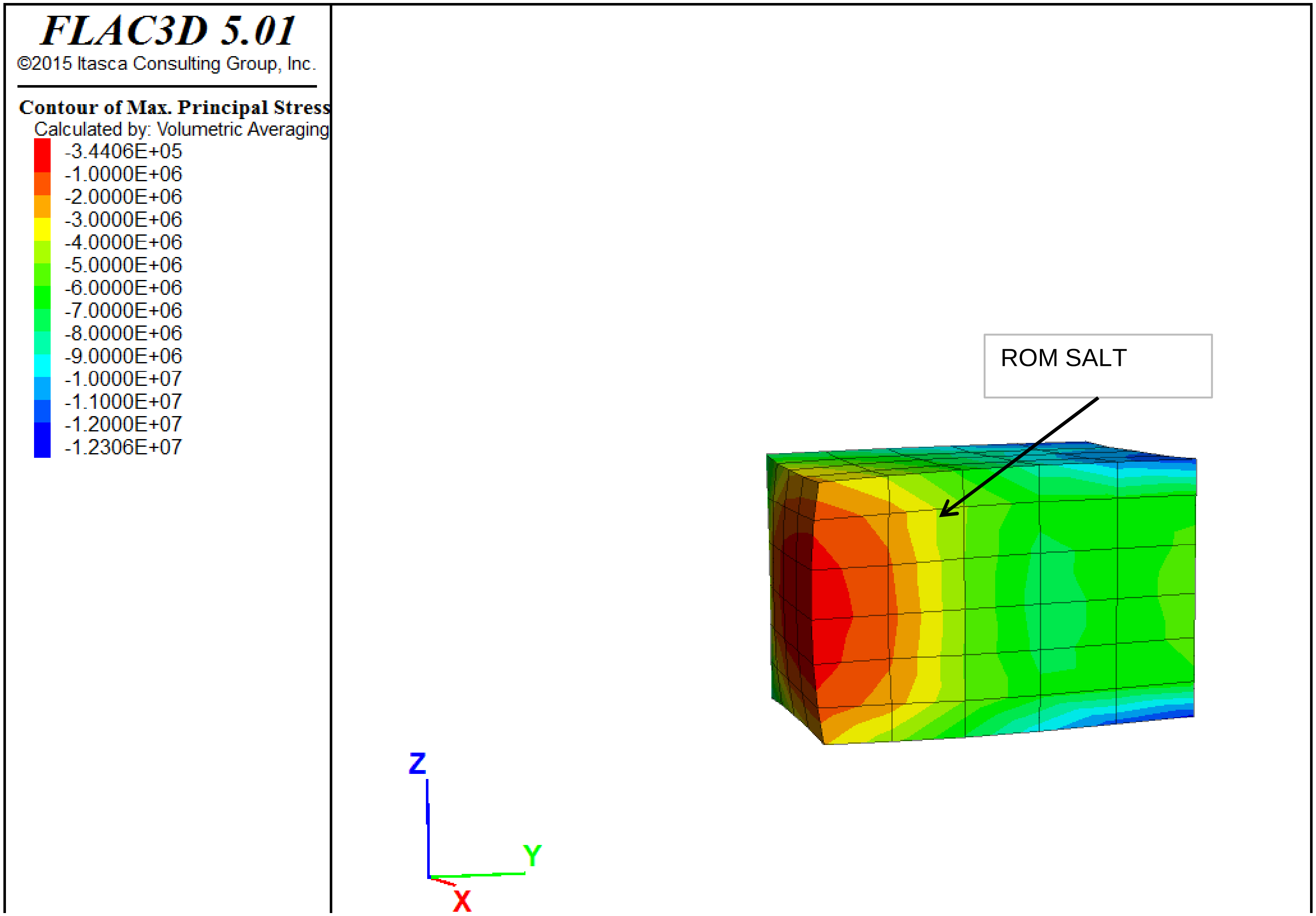

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-3.5

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 40 ft, 15 Yr After Construction

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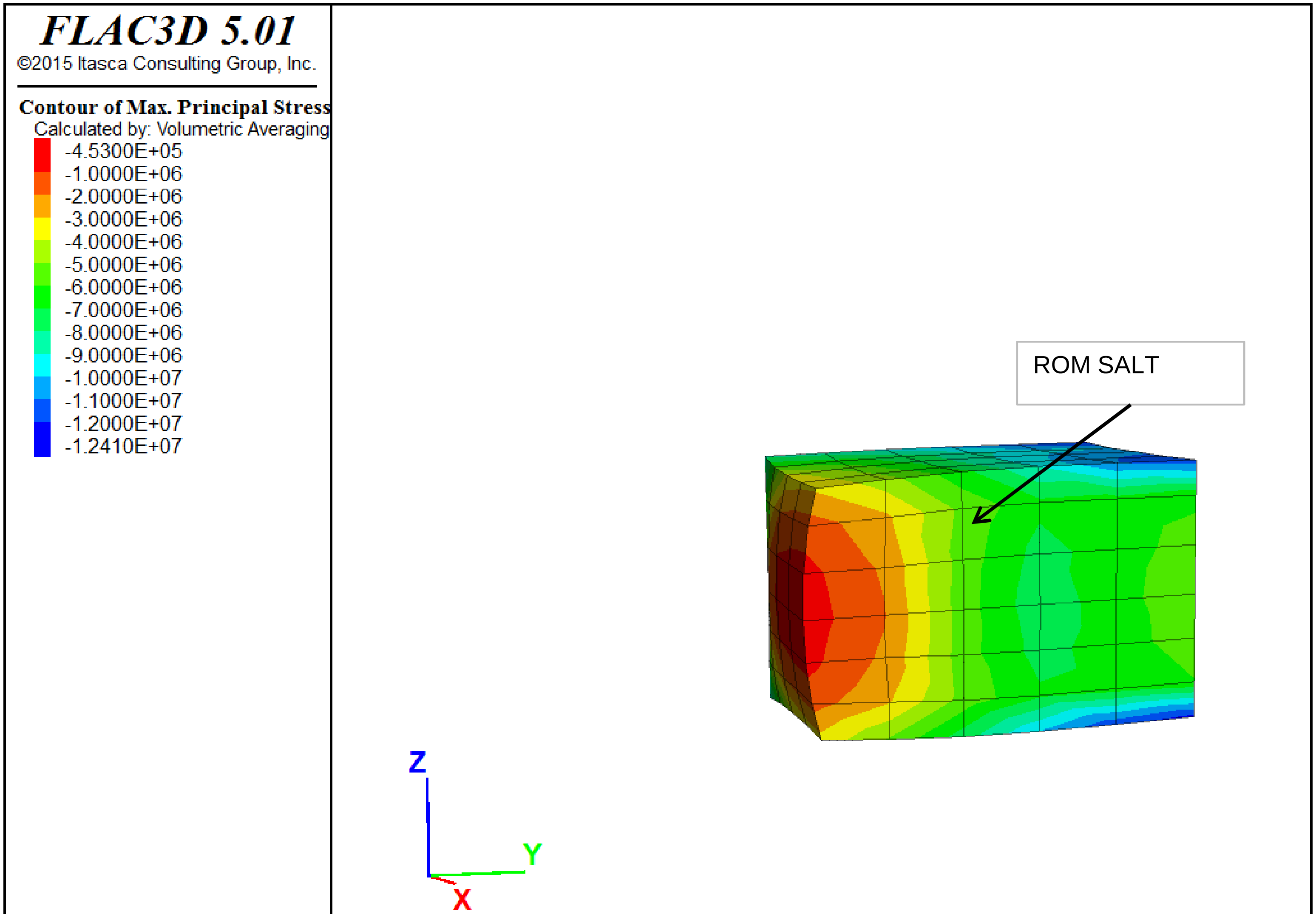

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-3.6

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 40 ft, 25 Yr After Construction

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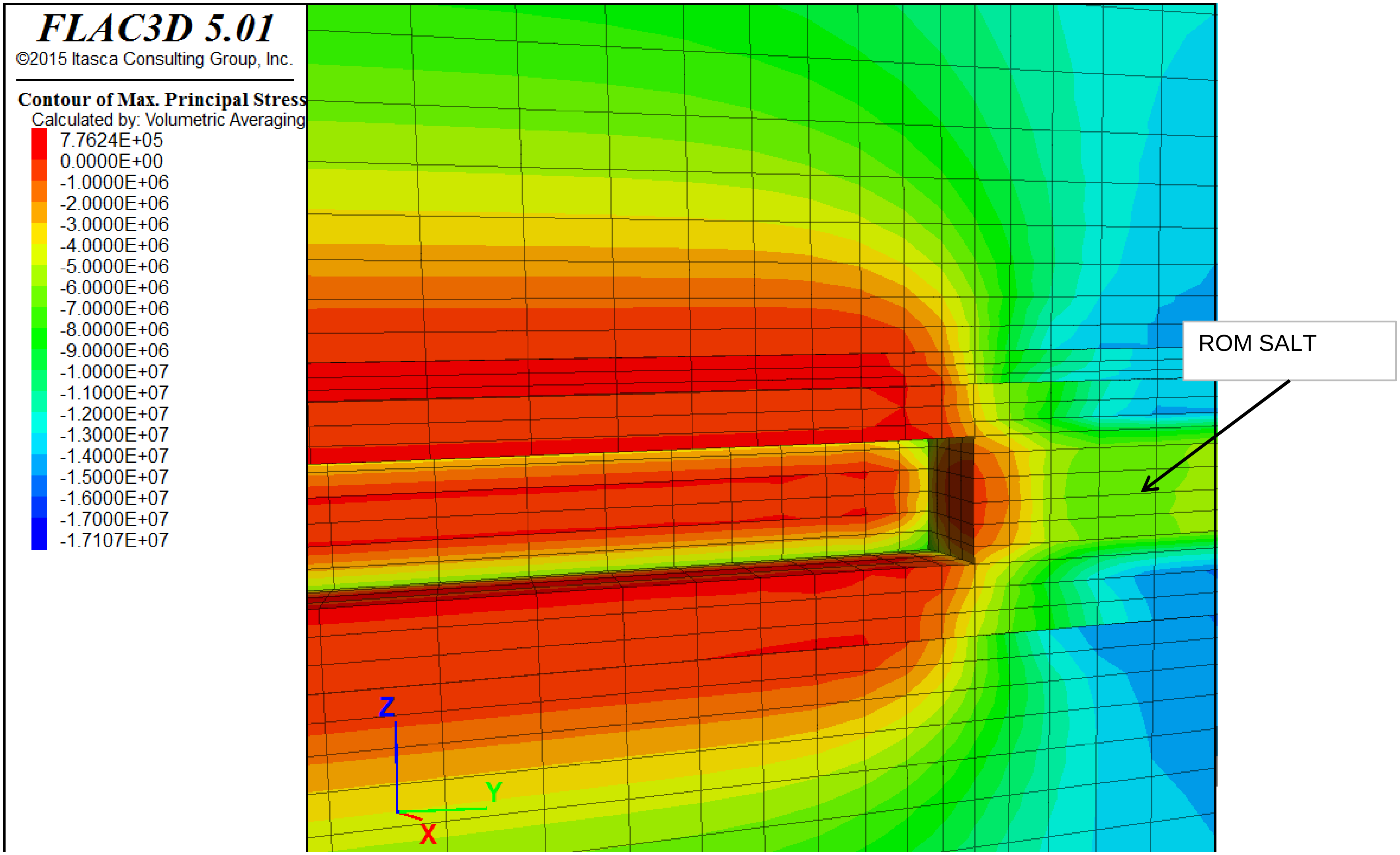

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-4.1

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 60 ft, 5 Yr After Construction

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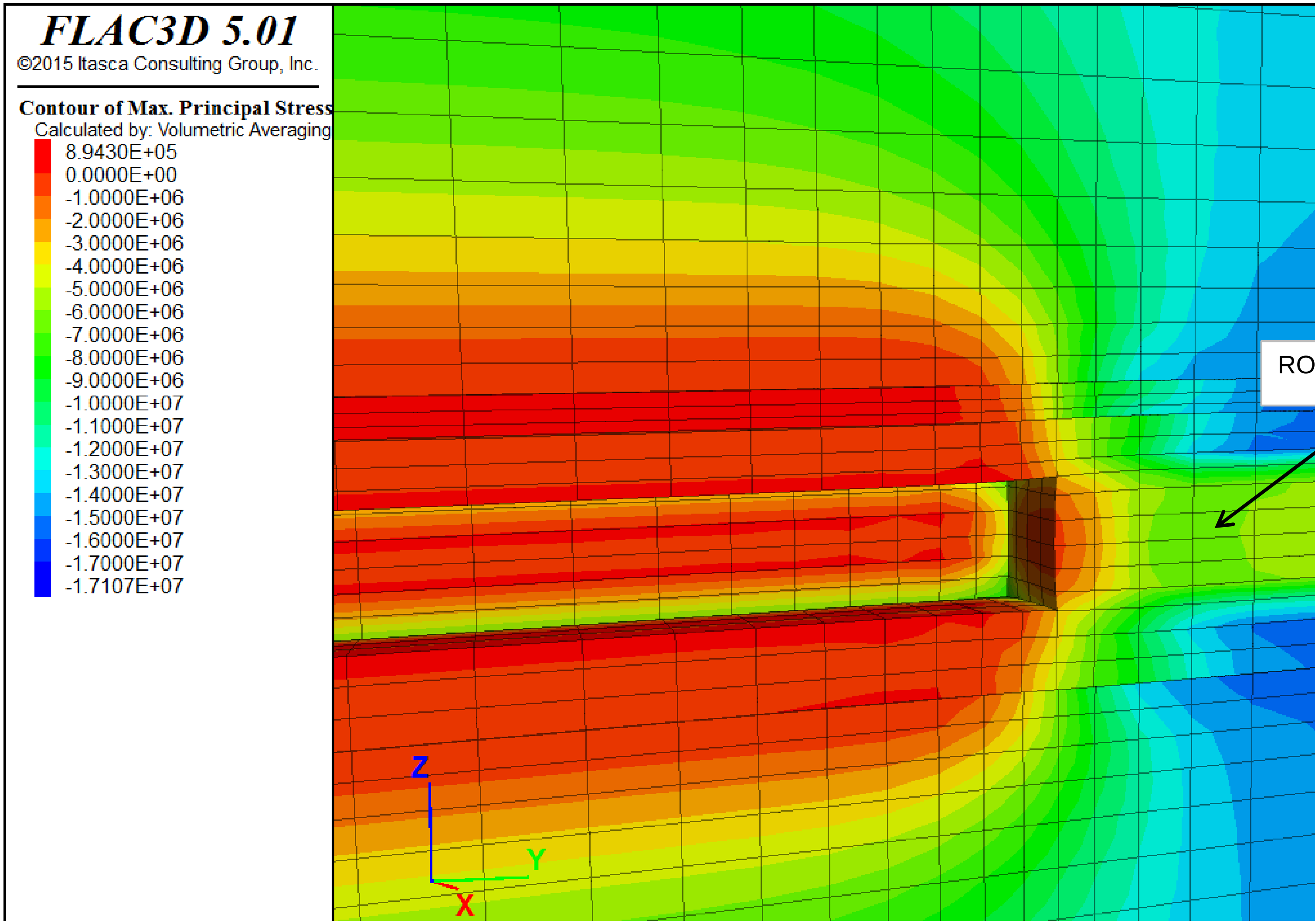

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-4.2

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 60 ft, 15 Yr After Construction

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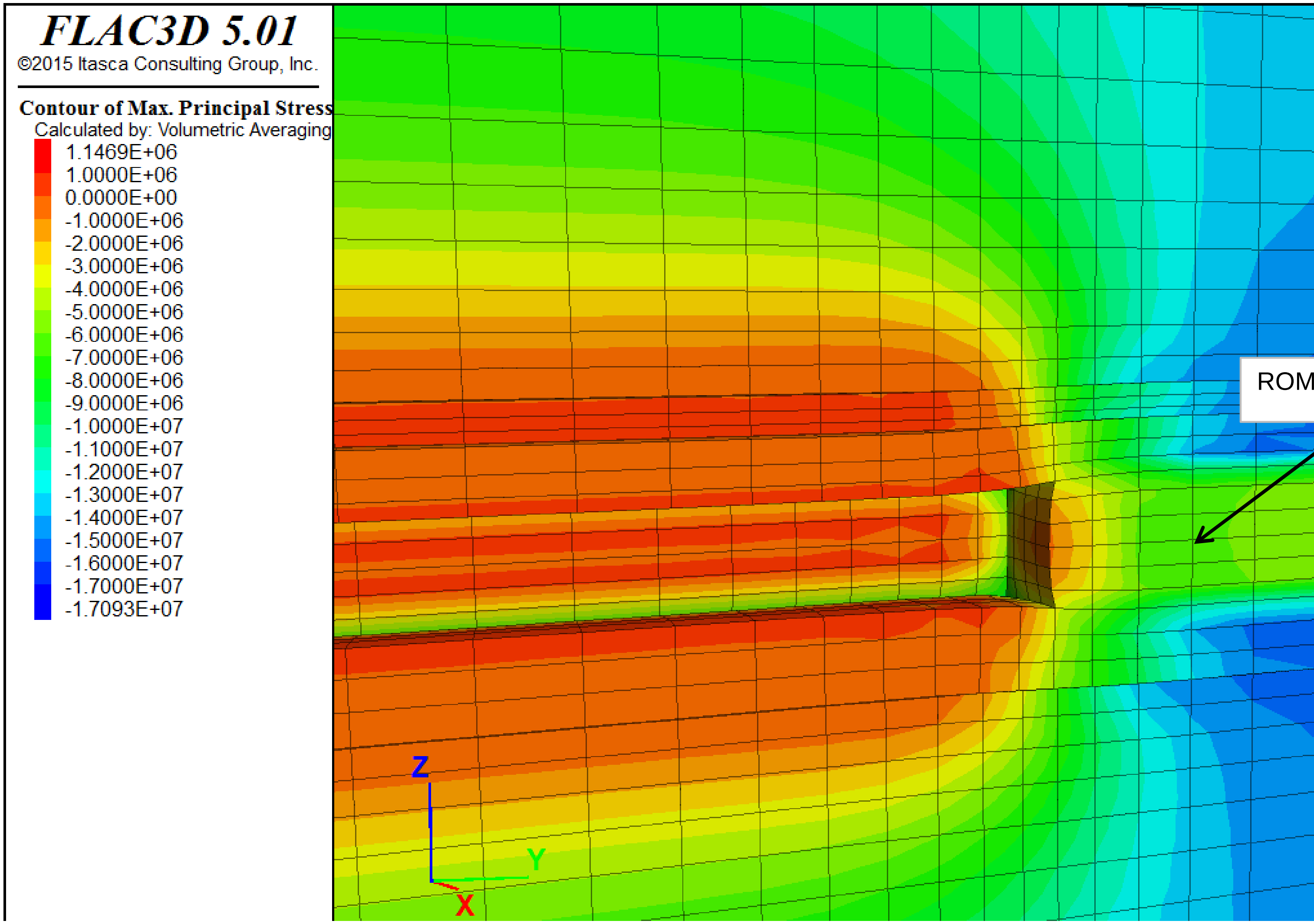

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-4.3

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 60 ft, 35 Yr After Construction

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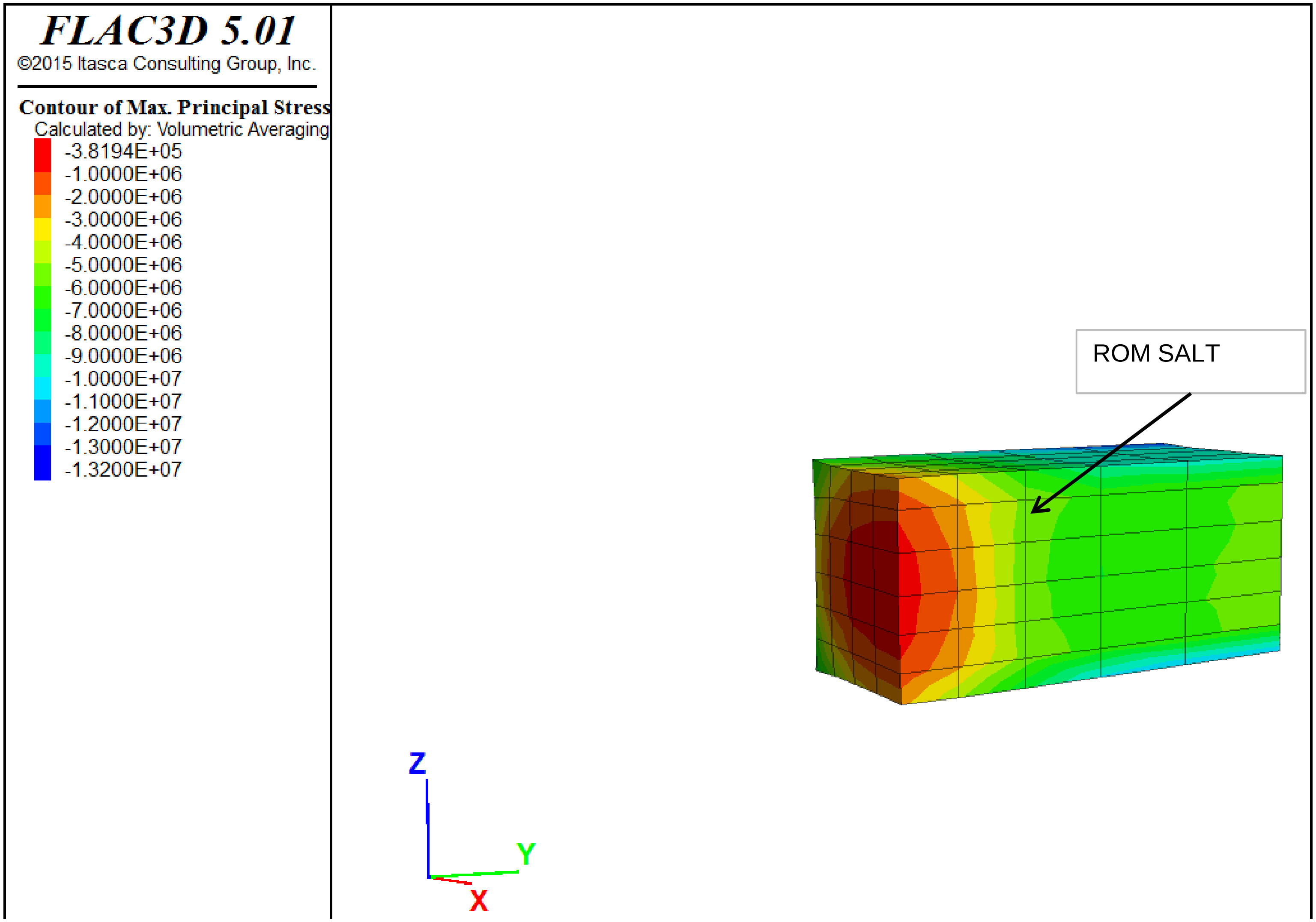

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-4.4

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 60 ft, 5 Yr After Construction

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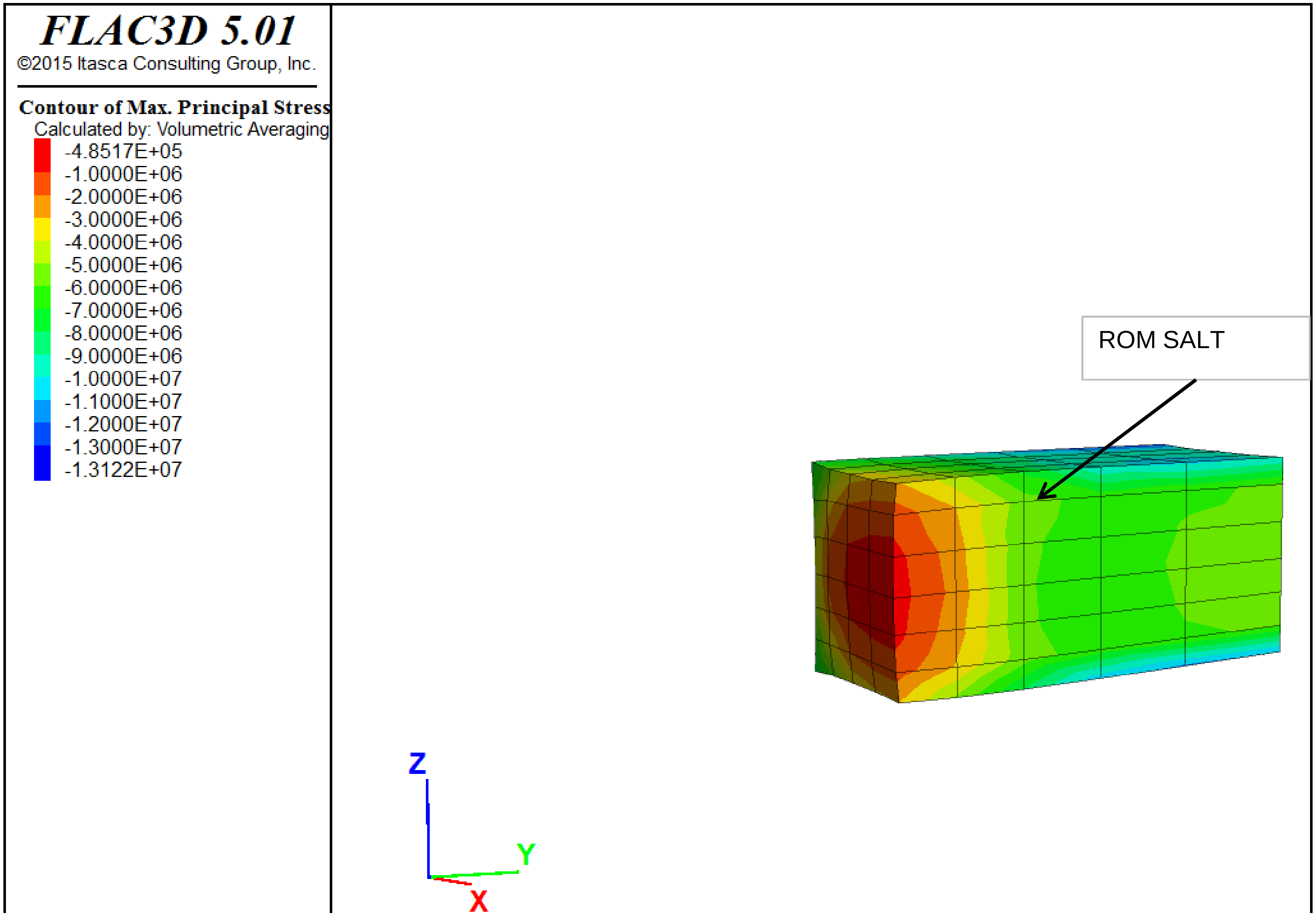

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-4.5

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 60 ft, 15 Yr After Construction

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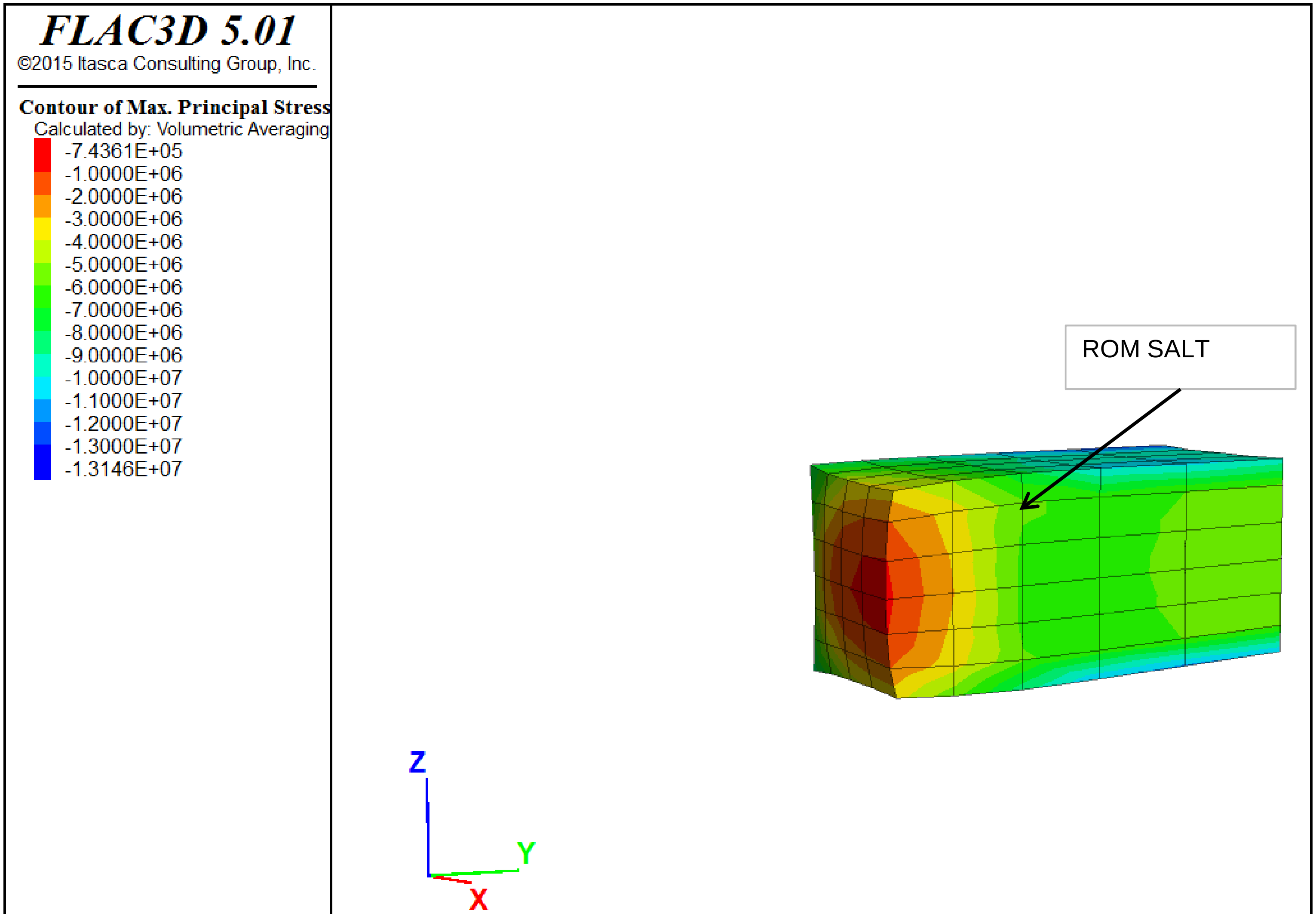

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-4.6

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 60 ft, 35 Yr After Construction

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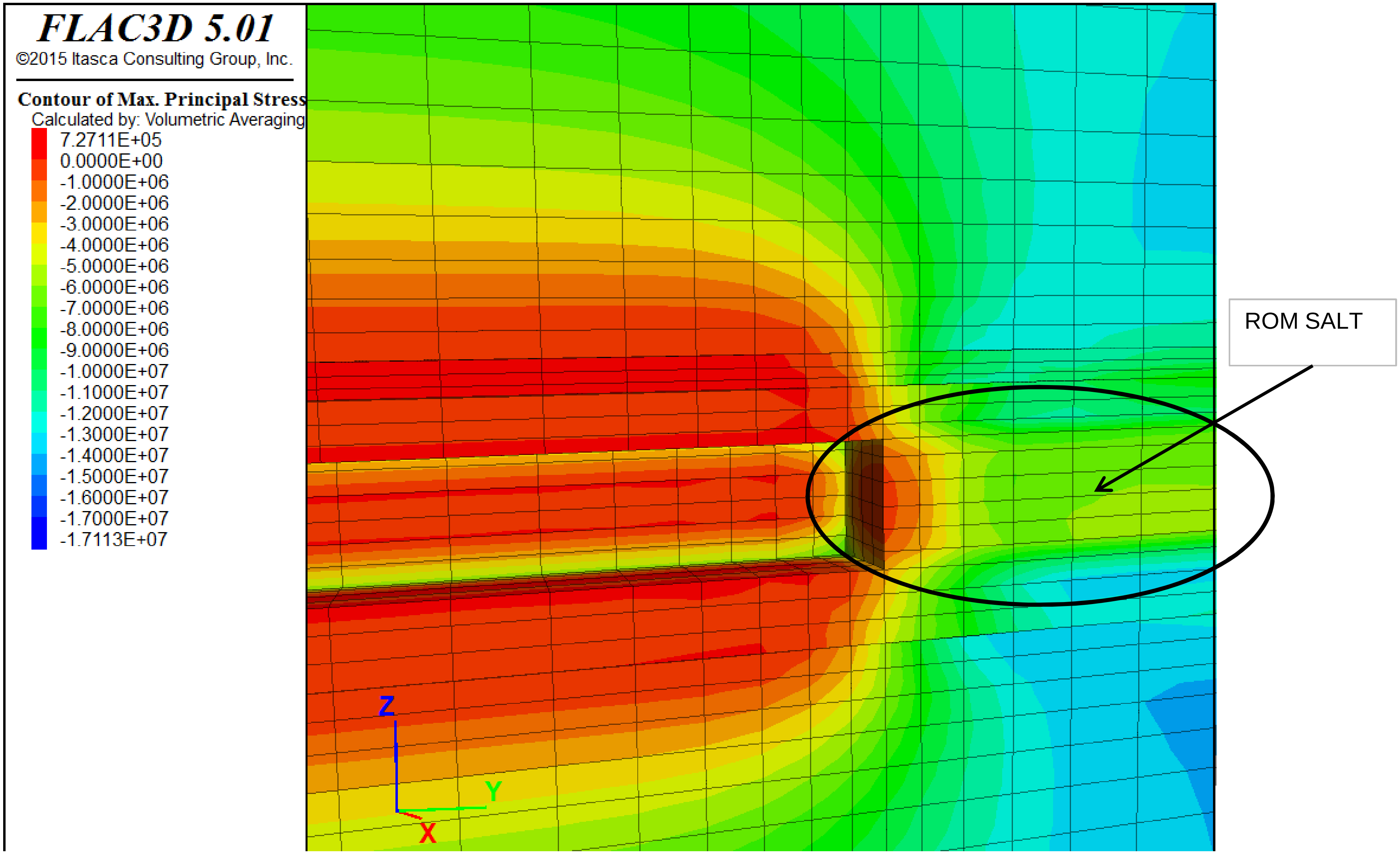

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-5.1

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 80 ft, 5 Yr After Construction

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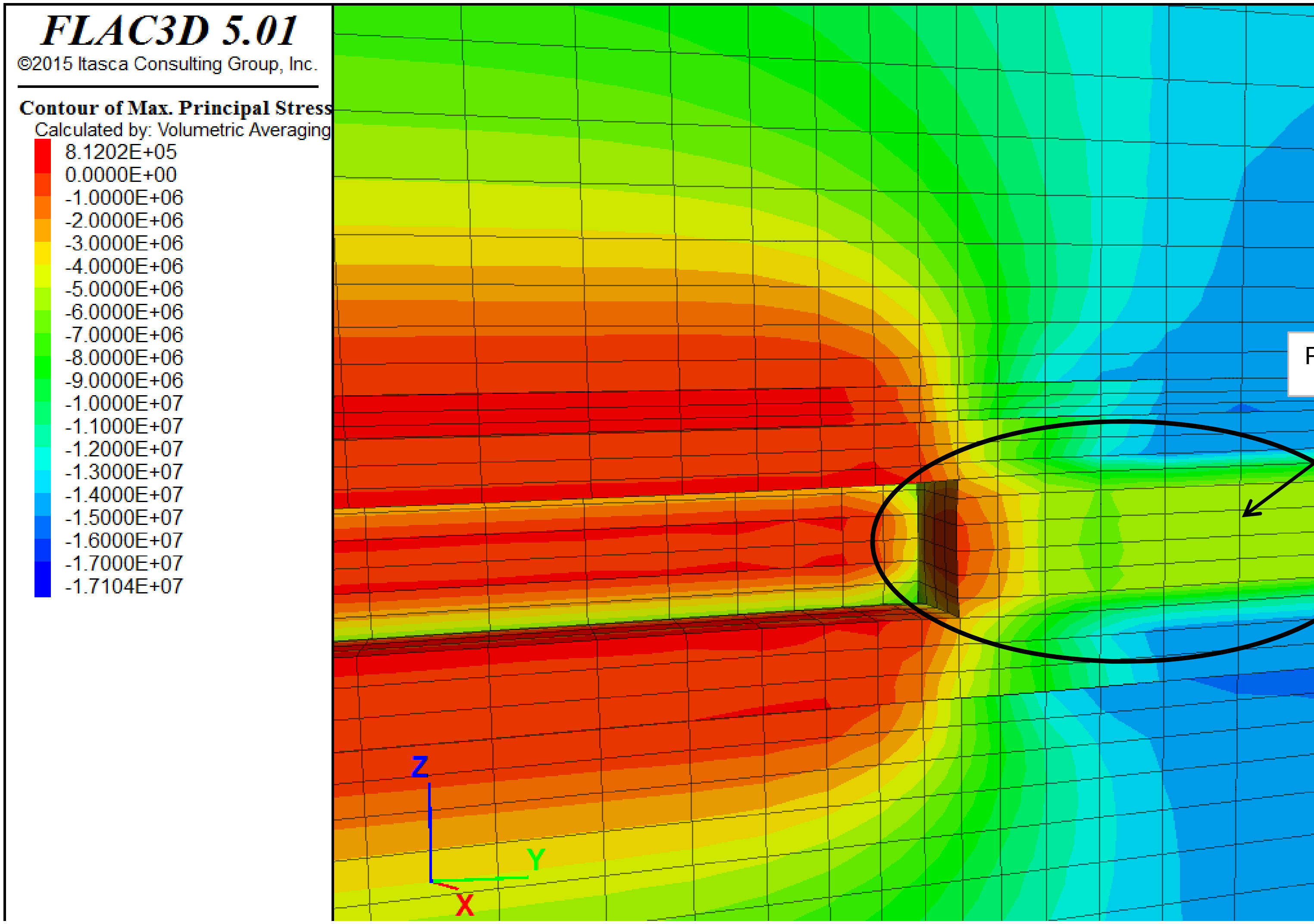

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-5.2

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 80 ft, 15 Yr After Construction

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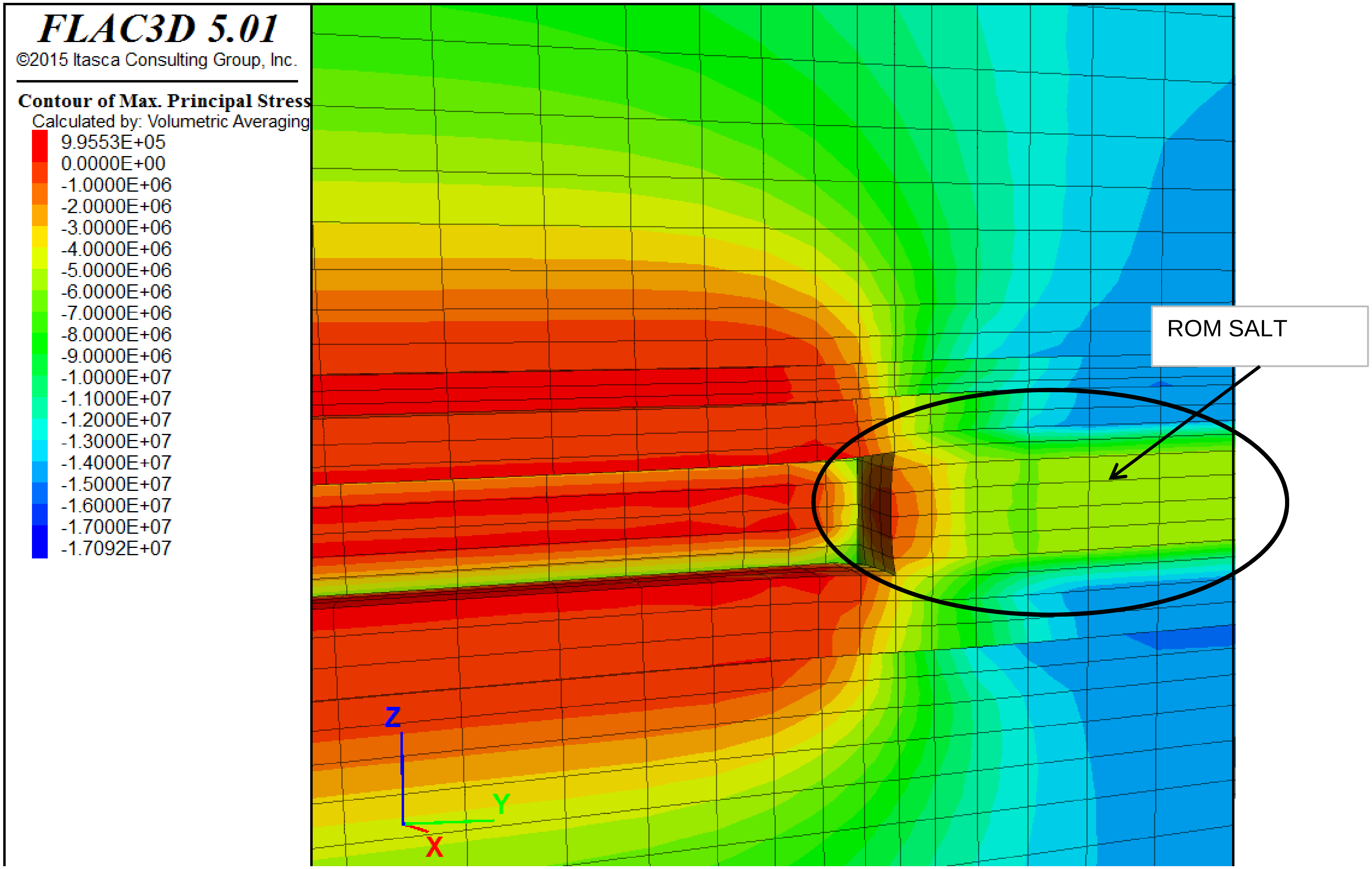

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-5.3

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 80 ft, 35 Yr After Construction

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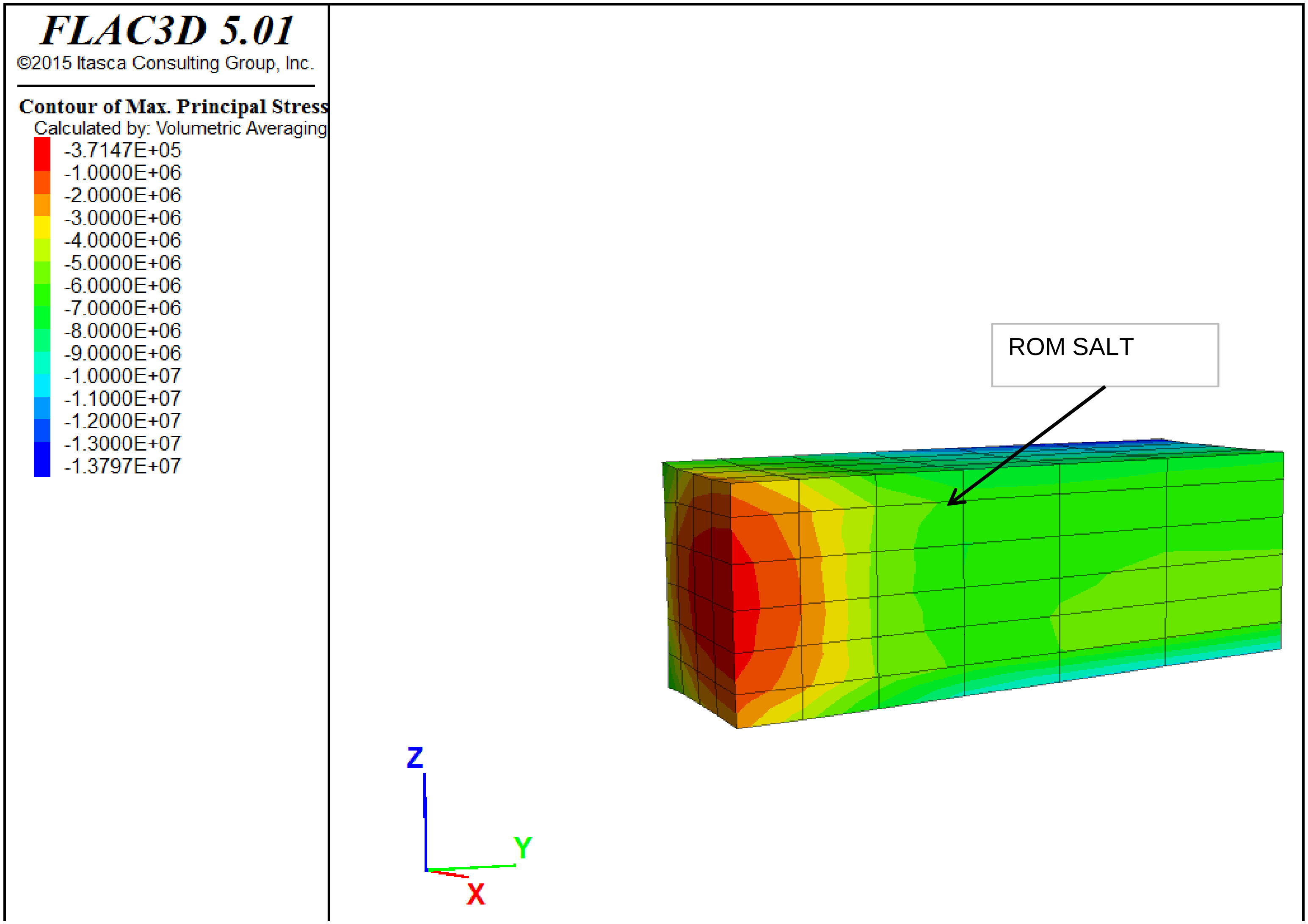

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-5.4

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 80 ft, 5 Yr After Construction

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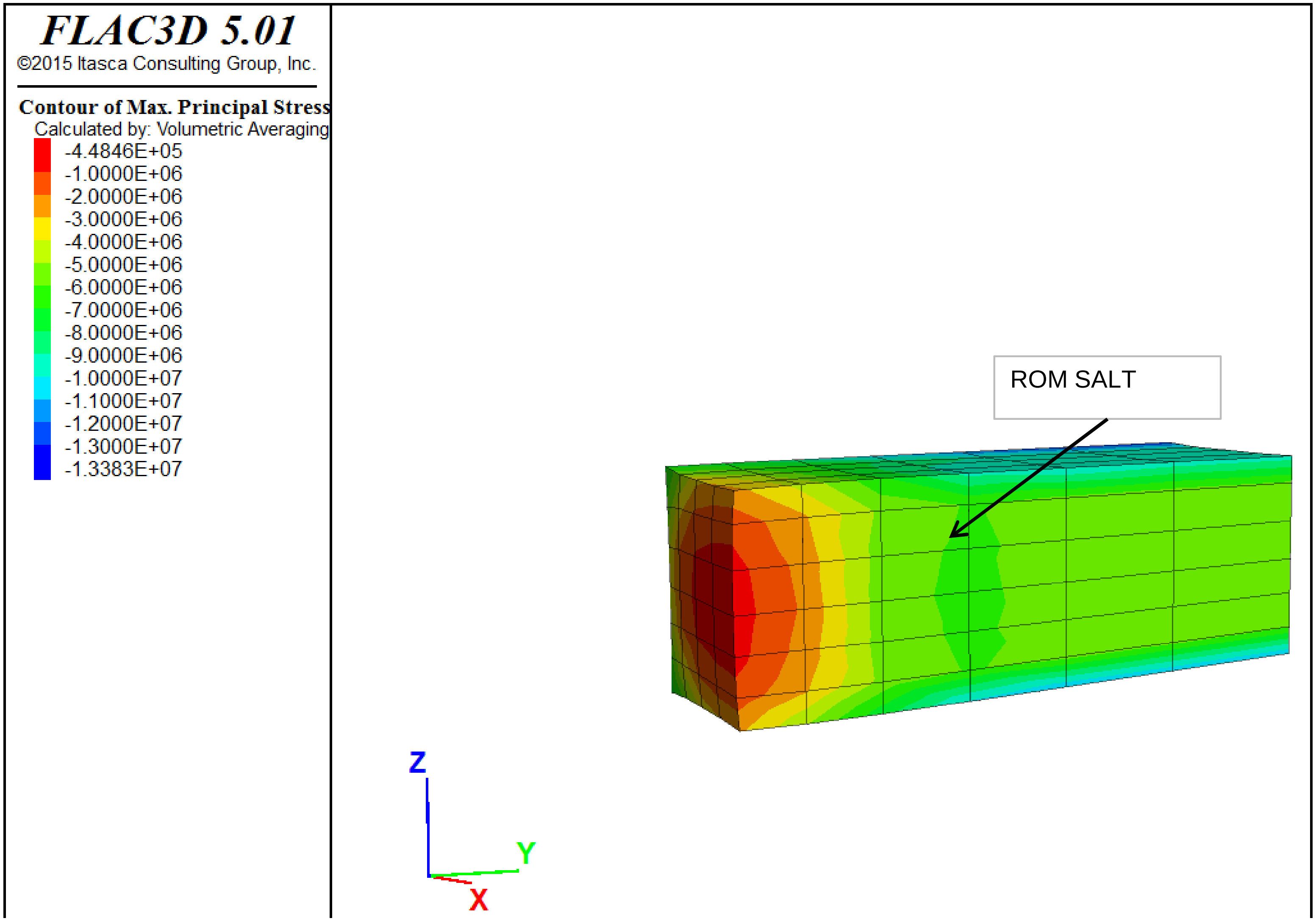

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-5.5

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 80 ft, 15 Yr After Construction

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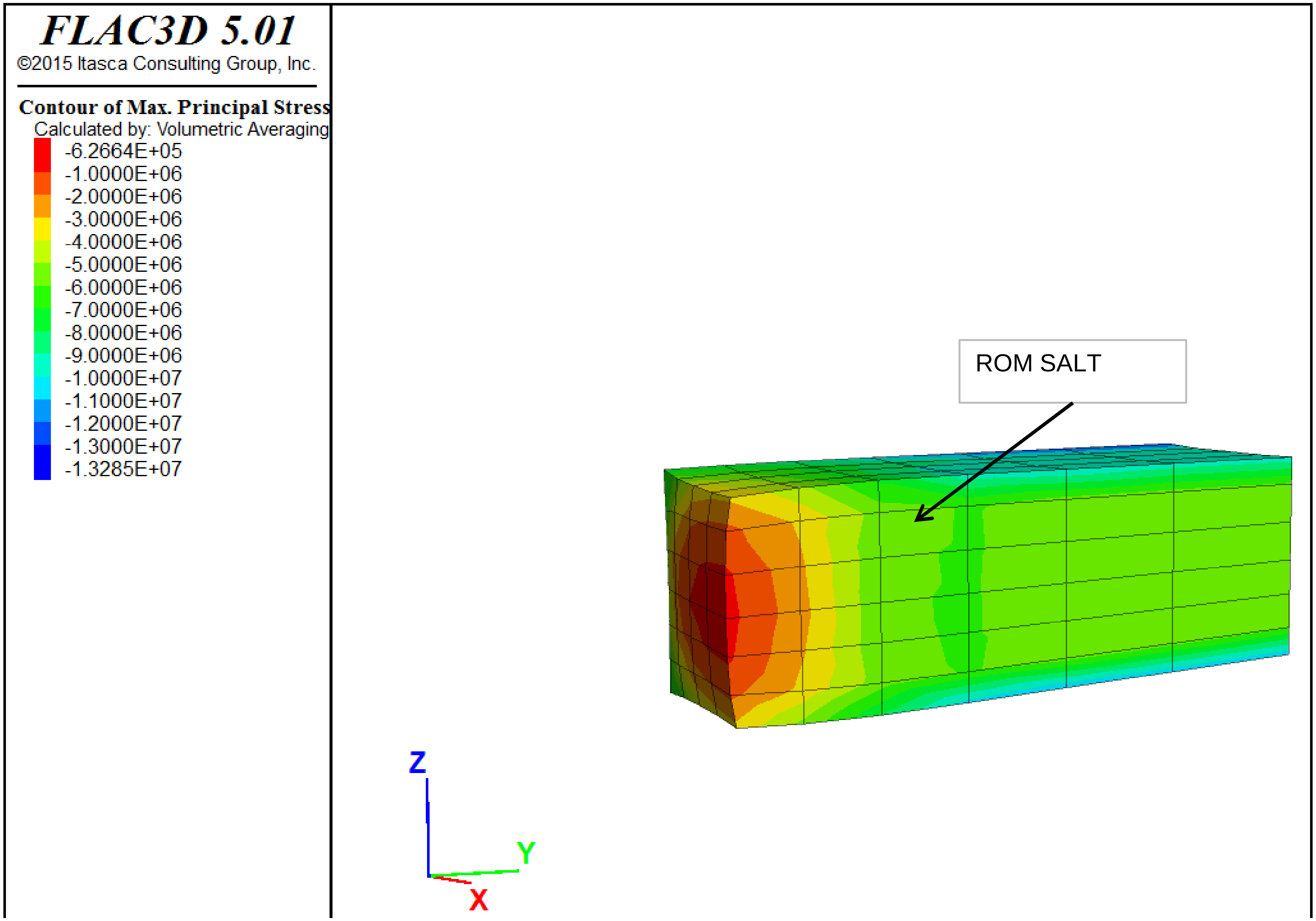

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-5.6

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 80 ft, 35 Yr After Construction

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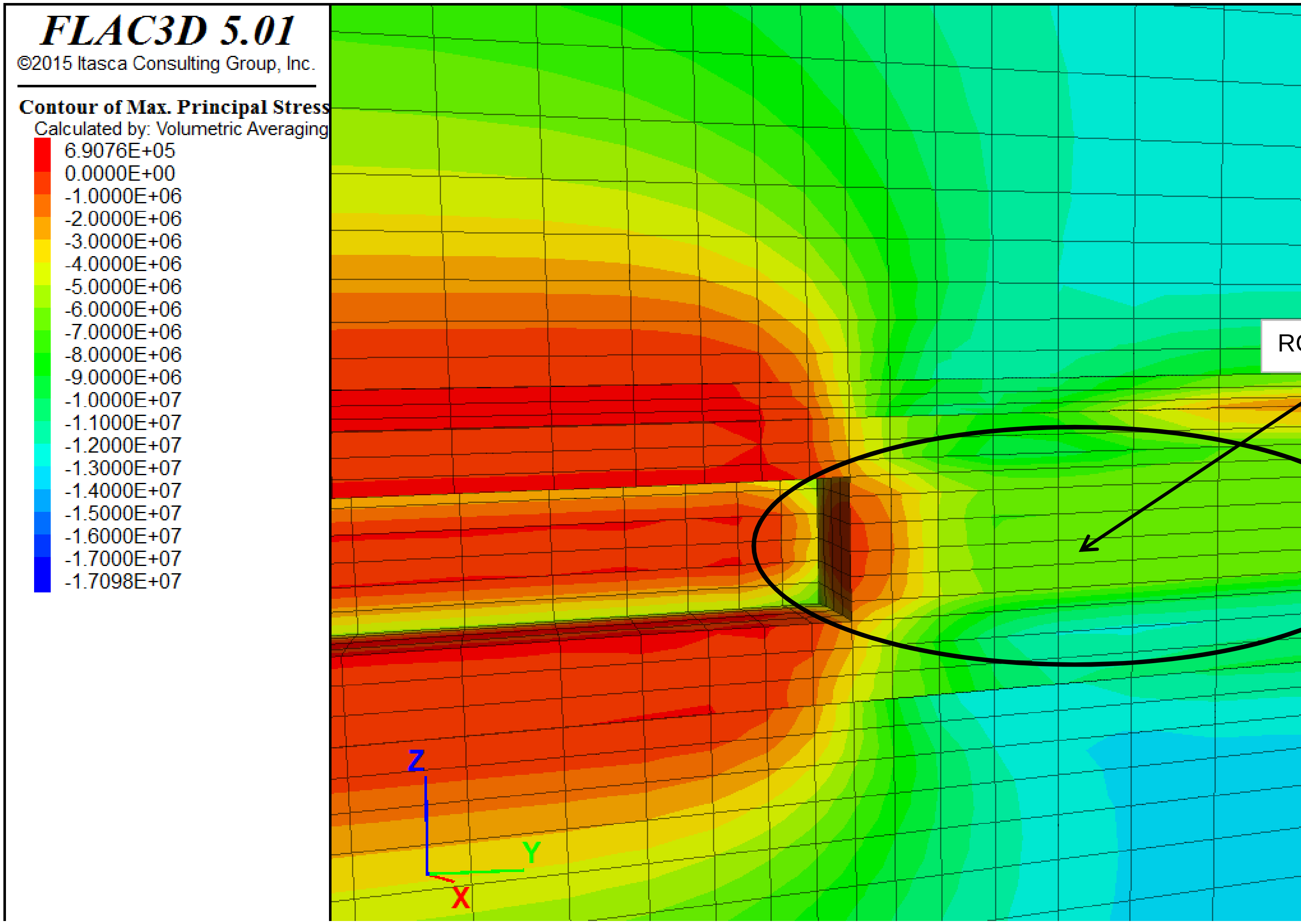

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-6.1

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 100 ft, 5 Yr After Construction

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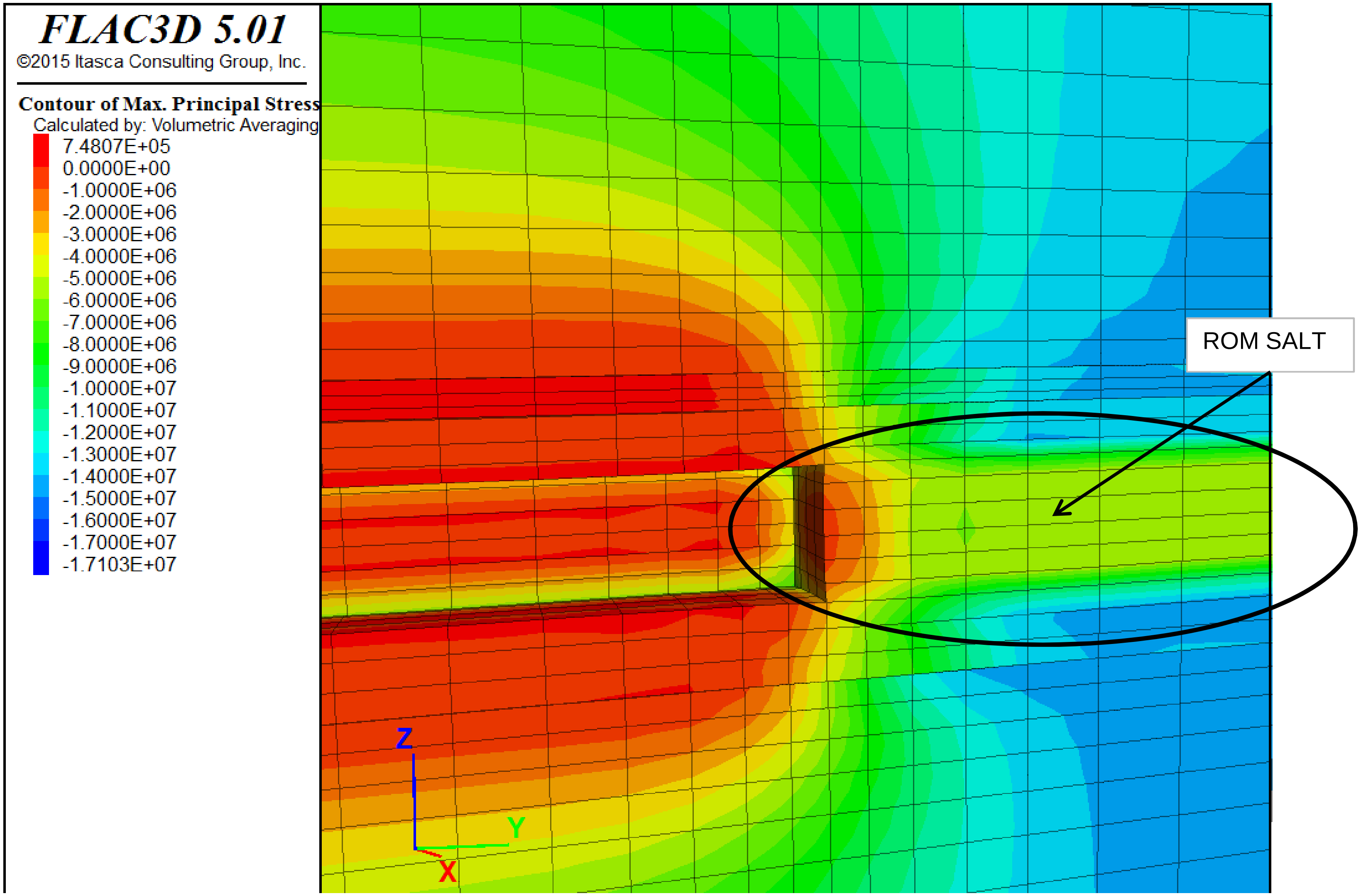

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-6.2

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 100 ft, 15 Yr After Construction

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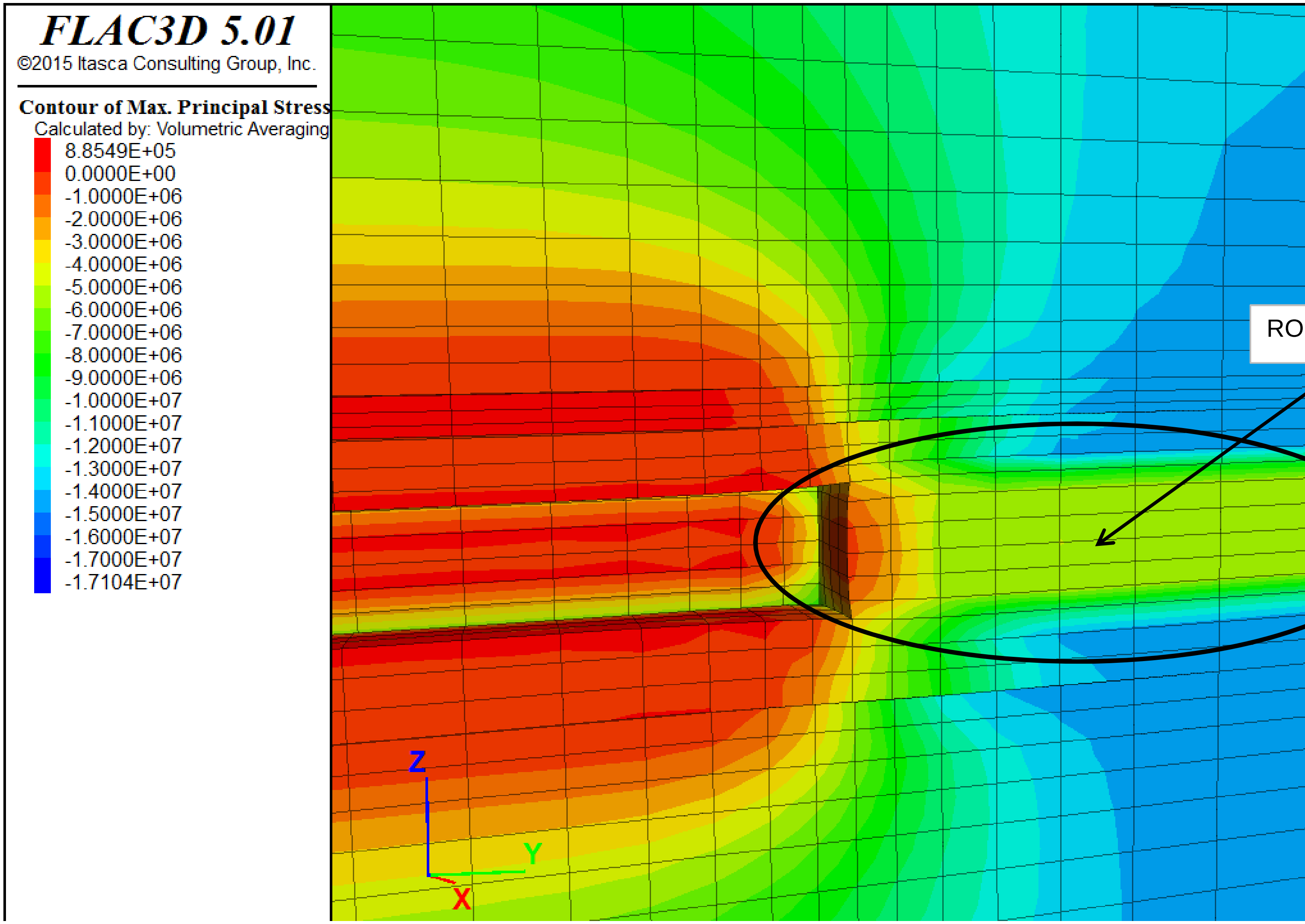

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-6.3

Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 100 ft, 35 Yr After Construction

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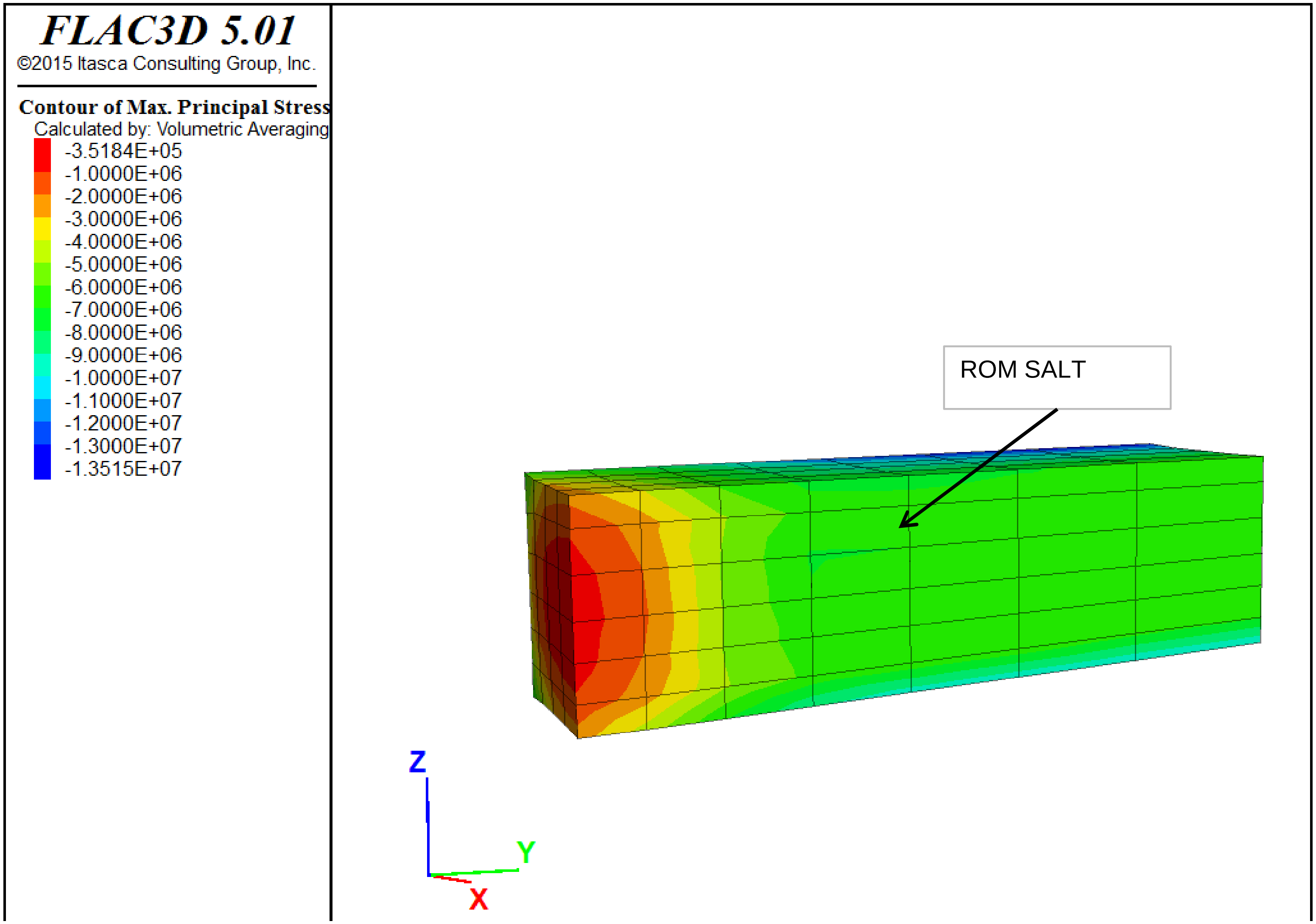

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-6.4

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 100 ft, 5 Yr After Construction

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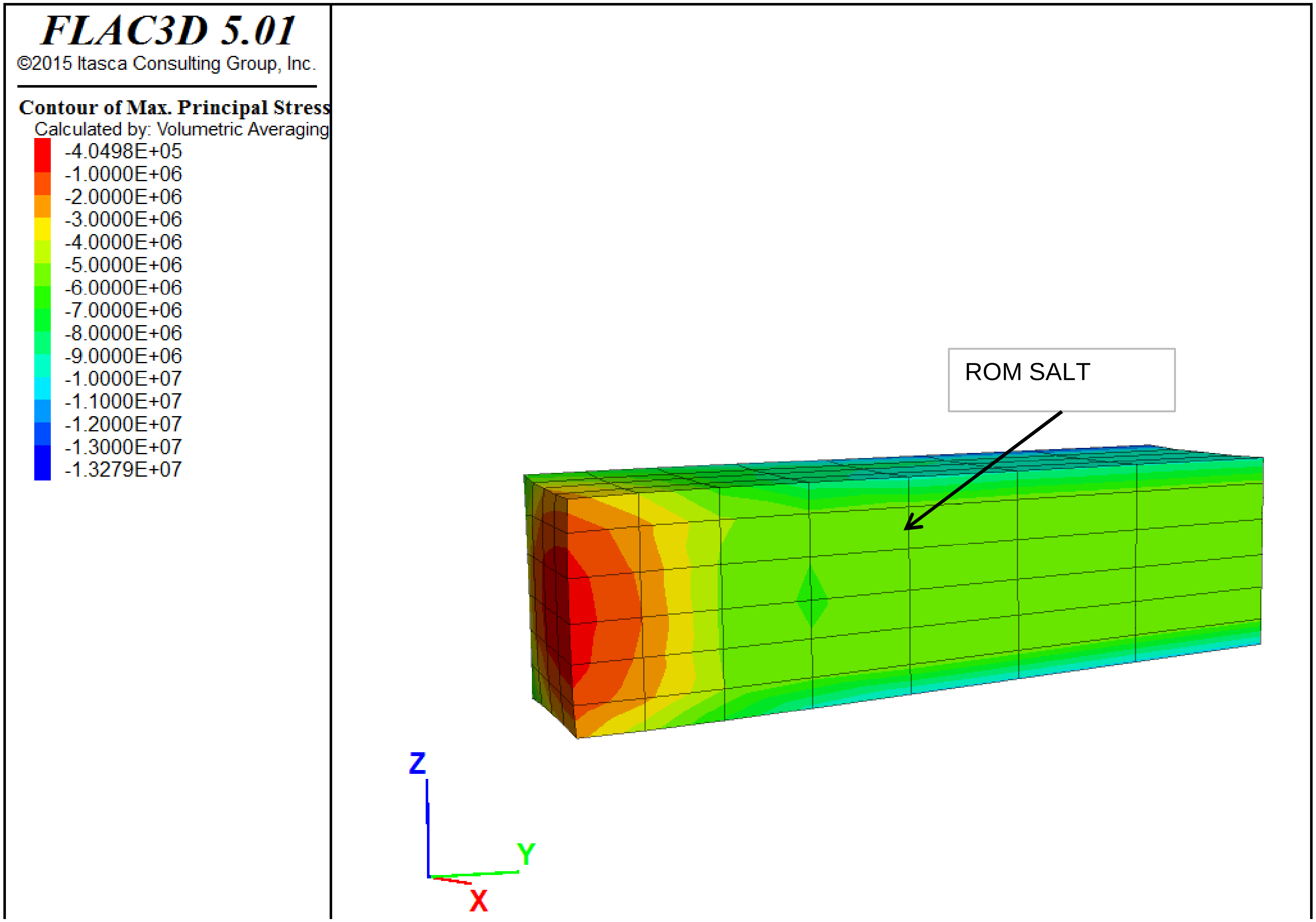

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-6.5

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 100 ft, 15 Yr After Construction

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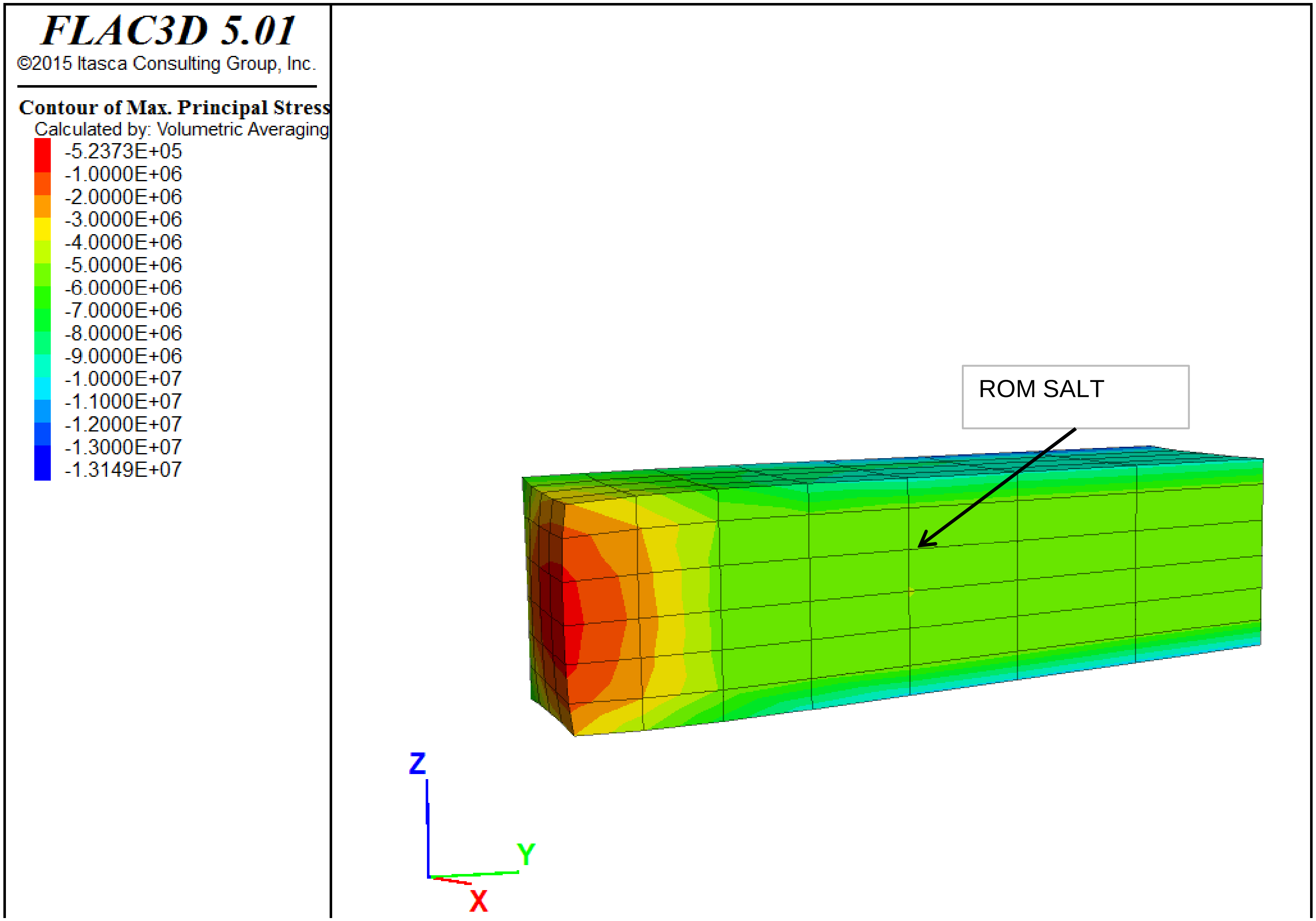

Note: Major (Max.) Principal Stress in FLAC3D is based on the continuum mechanics convention which corresponds to the Minor Principal Stress when using the geomechanical convention
I.e., Minor Principal Stress when using the geomechanical convention denotes the smallest compressive stress or maximum tensile stress

Figure A2-6.6

WPC-B Minor Principal Stress, Main Entry Width = 25 ft, ROM Salt Length = 100 ft, 35 Yr After Construction

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ATTACHMENT 3
FLAC3D INPUTS AND SIMPLIFIED ANALYSES

Date:	08/24/2016	**Made by:**	GG
Project No.:	063-2213	**Checked by:**	WTT
Subject:	FLAC3D Model Inputs and Simplified Calculations to Estimate ROM Salt Length	**Reviewed by:**	WTT
Project Short Title:	**WIPP PANEL CLOSURE – GEOMECHANICAL COMPLIANCE**		

1.0 OBJECTIVE

To present inputs and assumptions used to develop FLAC3D model in order to estimate the minimum length of run-of-mine (ROM) salt proposed to be installed as a part of the WIPP Panel Closure (WPC). The analyzed WPC consists of ROM salt between the out-bye and in-bye steel bulkheads (WPC-B) installed in the main entries north of Panel 10. The WPC-B locations are displayed in Figure 1 of the Design Report, Appendix F (Golder 2016). In addition, this document presents assumptions and inputs for the simplified method used to estimate minimum ROM salt volume requirements.

2.0 MODEL DESCRIPTION

2.1 Model Geometry and Stratification

The FLAC3D model has been developed based on the WIPP geometry provided by DOE (2013) and previous FLAC and FLAC3D models by WTS (2003), RockSol (2005) and NWP (2014). The model consists of halite layers divided by clay seams. Clay seams are modeled using FLAC3D interface elements. The FLAC3D model geometry is shown in Figure 2 of the Design Report, Appendix F (Golder 2016) with the stratigraphy summarized in Table 1.

Table 1: Model Stratification

Unit	Depth Below Surface (m)	Halite Layer Thickness between Units (m)	FLAC Model Elevation (m)
Model Top	532.26	108.74	114
Clay H	641.00	1.00	5.16
Clay G	642.00	2.16 (1.59)	4.16
Main Entry Roof	644.16 (643.59)	4.00 (4.57)	2 (2.57)
Main Entry Floor	648.16	2.25	-2
Clay E	650.41	110.75	-4.25
Model Bottom	761.16	n/a	-115

Note:
1. Reported values represent model geometry for the main entry width of 16 ft. Values in parentheses denote changed (updated) values for the main entry width of 25 ft.

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All FLAC3D models are based on the minimum pillar dimensions (width x length) of: 125 ft (38.1 m) x 211 ft (64.3 m), i.e. the total width of the FLAC model is 70.5 feet (for the main entry width of 16 feet), or 75 feet (for the main entry width of 25 feet) based on the assumed lines of symmetry outlined in Figure 2. The main entry height is 13 feet for 16 m wide entries and 15 feet for 25 feet wide entries. The finite difference grid that was used for the ROM salt length evaluations is shown in Attachment 1 and Attachment 2 of the Design Report, Appendix F.

2.2 Material Properties

Material parameters required for modeling were adopted from WTS (2003) and RockSol (2005) reports. Halite layers were modeled by using the standard WIPP-reference creep law for which the scalar strain-rate, $\dot{\varepsilon}$, is composed of primary and secondary creep components, $\dot{\varepsilon}_p$ and $\dot{\varepsilon}_s$, i.e.,

$$\dot{\varepsilon} = \dot{\varepsilon}_p + \dot{\varepsilon}_s .$$

The secondary creep rate is defined as

$$\dot{\varepsilon}_s = D\,\overline{\sigma}^n\, e^{-\frac{Q}{RT}}$$

where

D = material constant; “d_wipp” parameter in FLAC model
n = material constant; “n_wipp” parameter in FLAC model
Q = activation energy; “act” parameter in the FLAC model
R = universal gas constant; “gas” parameter in the FLAC model
T = temperature in degrees Kelvin; “temp” parameter in the FLAC model without temperature option.
$\overline{\sigma}$ = von Mises stress defined as

$$\overline{\sigma} = \left[\frac{(\sigma_{xx}-\sigma_{yy})^2 + (\sigma_{yy}-\sigma_{zz})^2 + (\sigma_{zz}-\sigma_{xx})^2}{2} + 3\left(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{xz}^2\right) \right]^{1/2} = \sqrt{3J_2}$$

The primary creep is defined as follows:

$$\varepsilon_p = \begin{cases} (A - B\varepsilon_p)\,\dot{\varepsilon}_s & \text{if } \dot{\varepsilon}_s \ge \dot{\varepsilon}_{ss}^* \\ \left\{A - B(\dot{\varepsilon}_{ss}^* / \dot{\varepsilon}_s)\,\varepsilon_p\right\}\dot{\varepsilon}_s & \text{if } \dot{\varepsilon}_s < \dot{\varepsilon}_{ss}^* \end{cases}$$

where

A = material constant; “a_wipp” parameter in FLAC model

B = material constant; “b_wipp” parameter in FLAC model

$\dot{\varepsilon}^*_{ss}$ = critical strain rate; “e_dot” parameter in FLAC model

Material properties used for the FLAC3D modeling are summarized in Table 2.

Table 2: Material Properties

Parameter	FLAC Property	Halite[1]	ROM Salt[2]	Clay Interface
Bulk Modulus (Pa)	bulk	2.07e+10	2.07e+10	
Shear Modulus (Pa)	shear	1.24e+10	1.24e+10	
Density (kg/m^3)	den	2,300	2,300	
Friction (degree)	Fric		30.47	5
Cohesion (Pa)	coh		0.59e+06	
Tensile Strength (Pa)	Ten		1.0e+06	
Temperature (K)	temp	300		
Ideal gas constant (cal/K/mol)	gas	1.987		
Q constant (cal/mol)	act	12,000		
N constant (-)	n_wipp	4.90		
A constant (-)	a_wipp	4.56		
B constant (-)	b_wipp	127		
D constant (Pa^{-n} s^{-1})	d_wipp	5.79e-36		
Critical Strain Rate (1/sec)	e_dot	5.39e-08		
Normal Stiffness (Pa/m^2)	Kn			1e+11
Shear Stiffness (Pa/m^2)	Ks			5e+10

Notes:
1. Halite layers were modeled using WIPP creep viscoplastic model (Itasca, 2000).
2. ROM Salt strength properties were determined from Hansen et al. (1984) data and should be viewed as a long-term lower bound strength estimate.

2.3 Boundary Conditions

Horizontal displacements are set to zero on all vertical boundaries, i.e., sides of the model are allowed to move only in the vertical direction. Vertical displacements are set to zero at the bottom boundary. The top of the model has a constant stress boundary condition equal to the weight of the overburden of approximately 12 MPa.

2.4 Initial Conditions

The initial conditions are the in-situ stresses throughout the model equal to the weight of the overburden at each zone.

3.0 FLAC3D CALCULATION RESULTS

Results of the FLAC3D calculations are presented in Attachments 1 and 2 of the Design Report, Appendix F on the ROM salt length evaluations.

4.0 SIMPLIFIED CALCULATIONS

Simplified calculations were based on the assumption that a finite amount of the rock-salt material above the ROM plug may lose its strength due to discontinuities and fractures developed either before or after the ROM salt installation. The volume of the assumed disturbance zone above the ROM salt plug would then act as a loading wedge increasing vertical stresses on the ROM salt plug. For the purpose of the presented simplified calculations, the loading wedge was assumed to resemble an inverted frustum (truncated pyramid) with the minimum area coinciding with the top of the ROM plug and the maximum area defined by the sides of the frustum's "influence angle" (arbitrary set to 30 degrees), and limited by the frustum's height . The frustum's height was assumed to be three times larger than the main entry height (i.e. effectively assuming a plane of discontinuity above the ROM salt plug). It was assumed that the surrounding salt rock does not provide any frictional resistance or confinement to prevent the frustum's movement, i.e. the frustum's weight is applied to the ROM salt and compared to the "critical load" of 1,200 kPa above which the "measurable creep" is expected to occur. Dryer's (1967) research referenced by Baar (1977) indicates that the "critical" shear stress of 6 kp/cm^2 (590 kPa) corresponds to the load of approximately 12 kp/cm^2 (1,177 kPa) and notes that any greater stress will produce measurable "flowage".

Hence the value of 1200 kPa was adopted as a "critical load" for the simplified ROM salt length calculations and used to calculate the compression ratio as follows:

$$Compression\ Ratio = \frac{Critical\ Load}{Vertical\ Stress}.$$

The ROM lengths that correspond to the compression ratios greater than 1.0 are likely to be acceptable. Based on the adopted assumptions, however, results of the simplified method should be viewed as approximate with the validity evaluated on a case-by-case basis.

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ATTACHMENT 3-1
RESULTS OF SIMPLIFIED ANALYSES

Simplified ROM Length Estimates

General inputs			
Overburden Density	21	(kN/m^3)	
Height factor	3	(-)	ratio between the height of disturbance zone and the height of main entry
Influence angle	30	(degree)	angle defining the extent of the rock mass contributing to the load of the ROM salt
"Critical load", pc	1,200	(kPa)	(see Dreyer, 1967 and Baar, 1977)

Table A-3-1 - Compresion Ratio for Main Entry Width = 16 ft

Plug length (ft)	10	25	40	60	80	100
Plug width (ft)	16	16	16	16	16	16
Plug height (ft)	13	13	13	13	13	13
Influence height (ft)	39	39	39	39	39	39
Min wedge area (ft^2)	160	400	640	960	1,280	1,600
Max wedge area (ft^2)	3,359	4,274	5,190	6,411	7,631	8,852
Stress, pL (kPa)	2,211	1,244	995	854	782	739
Compression Ratio (pc/pL)	0.5	1.0	1.2	1.4	1.5	1.6

Table A-3-2 - Compresion Ratio for Main Entry Width = 25 ft

Plug length (ft)	10	25	40	60	80	100
Plug width (ft)	25	25	25	25	25	25
Plug height (ft)	15	15	15	15	15	15
Influence height (ft)	45	45	45	45	45	45
Min wedge area (ft^2)	250	625	1,000	1,500	2,000	2,500
Max wedge area (ft^2)	4,769	5,923	7,077	8,617	10,156	11,695
Stress, pL (kPa)	2,347	1,301	1,031	878	800	753
Compression Ratio (pc/pL)	0.5	0.9	1.2	1.4	1.5	1.6

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