RAI Volume 2, Chapter 2.1.2, First Set, Number 1:

> Provide a monitoring plan for the ground support system that explains what will be monitored, frequency of monitoring, criteria for selecting drifts to be monitored, spatial frequency of measurements within the drift, and the technical approach for processing information collected through monitoring to assess the performance of the ground support system and the need for maintenance to ensure access to waste packages through the preclosure period.
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> SAR Section 1.11 states that DOE will rely on developing a maintenance plan to test, inspect, and repair ground support as necessary to ensure functionality of the underground openings through a 100-year preclosure period. Also, SAR section 1.3.4.4 states that the need for ground-support maintenance will be determined based on the results of drift inspection and monitoring. However, the SAR did not provide sufficient details to explain how the ground support will be monitored to determine the need for maintenance or how information obtained through monitoring will be used to plan for maintenance. This information is needed to verify compliance with 10 CFR 63.111(e).

1. RESPONSE

The original response to RAI 2.2.1.2-001 has been supplemented with additional information, identified with change bars on the margins in this response. The supplemental information addresses questions expressed by NRC reviewers on July 6, 2009, during a teleconference and summarized as follows:

(1) If the initial frequency of monitoring is reduced over time, would DOE notify the NRC and will a basis for the reduction be provided?

(2) What are the criteria for selecting drifts to be monitored, or will all the drifts be monitored?

(3) Clarify monitoring entire length of a drift versus spatial frequency of monitoring.

(4) Explain how DOE is taking into account the physical environment in which convergence measurements will be taken so that there are no obstructions, and that the effects of high temperature and high radiation do not affect the instrumentation.

The concepts presented in this response are the project's approaches to the inspection, monitoring, and maintenance programs for ground support systems.

The SAR presents two distinct approaches for inspections, monitoring, and maintenance of repository ground support systems, depending on the classification of the repository openings for personnel accessibility as shown in Figure 1. These classifications are based on the expected thermal and radiation environments for the different openings. The specifics of the RAI are addressed separately for both accessible and inaccessible openings. Further differentiation is made in the response between those accessible and inaccessible openings directly used for a potential waste package retrieval operation and other repository openings not directly related to retrieval but still needed for support functions (i.e., ventilation). The monitoring and maintenance approaches for both types of openings are based on the robustness and the longevity of the materials selected for the type of opening. Monitoring and maintenance activities in inaccessible openings rely mostly on the use of remotely operated vehicles. Conceptual designs for two of these remotely operated vehicles are shown in Figures 2 and 3.

As stated in SAR Section 1.3.2.4.4.3, the ground support for emplacement drifts and inaccessible nonemplacement areas is designed to function without planned maintenance during the preclosure period (100 years) while allowing for the performance of unplanned maintenance in emplacement drifts and inaccessible nonemplacement areas on an as-needed basis. Accordingly, with respect to ground support monitoring for the subsurface facility, a systematic approach is used to monitor inaccessible underground openings, including annual remotely operated inspections initially, with reduced frequency of those inspections over time. The exception would be in areas where indicators of potential problems are observed, in which case the inspection frequency could be increased if warranted by the observations.

The approach for monitoring and maintenance in accessible openings, as stated in SAR Section 1.3.3.3.2, consists of visually inspecting the openings by qualified personnel on a regular basis so that operational support systems can be kept functional at an acceptable level, daily operations can be performed without interruption, and openings can be kept safe for personnel access. A geotechnical instrumentation program designed to provide field measurements for drift convergence, ground support loads, and potential overstressed zones will supplement the observations. Inspection, monitoring, and maintenance in accessible openings will be performed using methods similar to those used in underground mines and in the tunneling industry.

The approaches for monitoring and maintenance of accessible and inaccessible repository openings, although different, both preserve the option of retrieving any or all of the emplaced waste throughout the preclosure period. The repository ground support, as well as ventilation, rail, and other support systems, are designed to remain effective for up to 100 years after the initiation of waste emplacement and ensure that the occurrence of rockfall or off-normal events do not preclude retrieval (SAR Section 1.3.2.4.8).

Ground support monitoring and maintenance are operational activities separate from repository performance monitoring activities conducted under the *Performance Confirmation Plan* (BSC 2004). Information developed through that plan, however, will be used for investigation of faults and other geologic features of interest for the ground support monitoring program. As part of the *Performance Confirmation Plan* (BSC 2004, Section 3.3.2.1; SAR Chapter 4), detailed geologic mapping of repository openings will be performed during repository excavation. The use of photography for documentation of initial conditions is anticipated during excavation, with unexpected conditions to be mapped in detail. The performance confirmation activities will provide information to support the basis for evaluating the performance of the Upper Natural Barrier and Lower Natural Barrier in the vicinity of the repository openings by observing subsurface conditions with respect to those in the geologic framework model, which was used to develop the unsaturated zone flow models. These models are based on surface geologic interpretation and spatially limited *in situ* formation data obtained from exploratory boreholes, the Exploratory Studies Facility, and the Enhanced Characterization of the Repository Block Cross-Drift tunnels.

The information collected from the geologic mapping will include fracture characteristics, fault zone characteristics (i.e., offset, location, and age), stratigraphic contacts, and lithophysal characteristics. This information will be compared to the models and may be incorporated into the models for a more accurate representation of the rock conditions and characteristics throughout the subsurface facility, if the information collected during the geologic mapping activity results in observed variation from the expected geologic conditions equal or greater than that determined to be significant. This information will be used to support the bases for inspections and monitoring, temporal and spatial monitoring frequencies, and identification of areas of special interest (i.e., geologic anomalies, seepage) that may affect waste package emplacement plans. The construction effects monitoring activity, as well as the seismicity monitoring activity, also call for visual observation and monitoring of convergence in accessible openings, especially with respect to the time period following a seismic event equivalent to a design basis event.

1.1 MONITORING PLAN FOR GROUND SUPPORT SYSTEMS IN ACCESSIBLE OPENINGS

1.1.1 Emplacement and Retrieval Accessible Openings: North Ramp, Access Mains, and Entrance to Turnouts

There are no restrictions on personnel or equipment access to the nonemplacement openings used for emplacement and retrieval operations, except when a loaded transport and emplacement vehicle is operating in the subsurface facility. The ground support inspection and maintenance approach for these openings is, therefore: to perform planned periodic visual inspections by direct observation by qualified personnel; and, to deploy geotechnical instrumentation during the preclosure period. These inspections and measurements will provide the information to evaluate the need for any necessary repairs. This inspection, monitoring, and maintenance approach is similar to that used in underground mines and in the tunneling industry.

Monitoring Parameters—The following parameters will be the subject of planned inspections and monitoring:

- Corrosion of rock bolts, wire mesh, or lattice supports
- Sagging or ruptured wire mesh
- Accumulation of rock debris on invert
- Defects or deterioration indicators of shotcrete liner such as application flaws, cracks, delamination, spalls, void development, and chemical alteration
- Rock bolt failure

- Geotechnical instrumentation program to provide field determinations for drift convergence, ground support loads, and potential overstressing zones.

Monitoring Locations—The entire lengths of these openings will be inspected. Instrumentation and testing locations will be selected by geotechnical engineers commensurate with rock and ground support conditions and previous inspection results history.

Monitoring Frequency—The inspection frequency for these openings will be daily, monthly, or semiannually, depending on the type of opening, current operations, and systematic analyses of periodic observations in areas with no routine operations.

Data Interpretation—If visual inspections indicate that the replacement or repair of ground support components is warranted, the necessary repairs will be made by maintenance crews. Maintenance activities could include scaling loose rock from the opening walls, removing rock debris from the opening floor, removing damaged or defective ground support components, and installing new ground support components. Information gained from inspections and maintenance of the accessible openings also provides insight into potential problems that may be occurring at similar but inaccessible repository openings.

1.1.2 Other Repository Accessible Openings: South Ramp and Other Repository Intake Airways

Keeping other accessible openings, such as the South Ramp, the intake shafts, and their access drifts functional throughout the preclosure period is important because these other accessible openings are utilized as repository ventilation airways. Maintaining or repairing a failed ground support component can be accomplished when identified by regular inspections or testing, but such repair may not be as pressing as when it involves an accessible opening used for the waste emplacement operation (transport and emplacement vehicle transportation route). Ground support inspections, testing, and maintenance for the repository accessible openings not used directly by waste emplacement operations are the same as those procedures for the emplacement and retrieval accessible openings, as described in SAR Section 1.1.1.

Access of the intake shafts by personnel is accomplished using hoists deployed at the intake shaft collars. The hoists are used to lower personnel platforms for visual inspections down the entire length of the shafts to the shaft stations at the access main level. Inspection frequency of the intake shaft concrete liners will vary between monthly and semiannually depending on the time elapsed since the completion of the openings, and the results of previous inspections.

1.2 MONITORING PLAN FOR GROUND SUPPORT SYSTEMS IN INACCESSIBLE OPENINGS

1.2.1 Emplacement and Retrieval Inaccessible Openings: Turnouts and Emplacement Drifts

Inspections of the emplacement drifts will occur during two phases: preemplacement and postemplacement. The initial preemplacement inspections will be visual and associated with the geologic mapping effort. These inspections will document rock characteristics exposed at the drift wall and will supplement digital photographic coverage and other surveys performed before the permanent ground support structures are installed (and the drift walls covered from view). As in previous surveys performed during the excavation of the Exploratory Studies Facility and Enhanced Characterization of the Repository Block Cross-Drift tunnels, the observations and surveys will, to an appropriate extent, document the characteristics of lithophysae, fracture and fault characteristics such as amounts of offset, thickness, and types of fault breccias or rubble, and areas of visible seepage. Specific locations in areas where measurements may be warranted during postemplacement monitoring (i.e., drift convergence readings), because of apparent poor rock conditions or because of findings through geologic mapping, will be identified as part of preemplacement inspections. At that time, drift geometry at the selected locations will be measured and a baseline established for comparison with future readings. Several locations will be monitored for convergence in the initial emplacement drifts (Panel 1) so that representative data for different rock types and rock conditions can be established. Information obtained from locations in the initial drifts will be analyzed to determine the extent of convergence monitoring needed for future drifts. After installation of the emplacement drift structures (ground support, invert, rails), a final preemplacement inspection will identify possible defects or the failure of any ground support components, or indications of drift instability. Postemplacement inspections will be limited to remotely-operated equipment such as the remotely operated vehicle concepts presented in Figures 2 and 3, and will focus on in-drift environmental parameters and waste package integrity as part of the Performance Confirmation Program.

Monitoring Parameters—The postemplacement remotely operated vehicle inspections will be used to detect any indications of rock fall, drift deterioration, or instability within the emplacement drifts and turnouts that may require unplanned maintenance. Monitoring of the emplacement drift ground support will include taking opening convergence measurements at pre-selected locations using laser targets and digital processing, material sampling, and other measurements related to drift condition, seepage, and ground support observations noted below. Additional locations for drift convergence measurements may be considered based on findings from the evaluation of video assessments or from previous inspections. Video cameras mounted on the remotely operated vehicle will record high resolution images of the drift crown and rib walls for possible water seepage, areas of drift deterioration, and ground support degradation. Inspection of the turnouts will be performed using the same remotely operated vehicles that are used for the emplacement drift inspections, and with the same frequency. Turnout inspections by the remotely operated vehicles will yield information on the rock wall visible through the stainless steel wire mesh, and rock flaking falling on the invert. The stainless steel liner will prevent such observations in the emplacement drifts. Video assessments will be continuous along the entire length of the turnouts and emplacement drifts, with additional coverage in areas of interest noted during the preemplacement inspections or during previous postemplacement inspections.

Convergence measurements will be based on individual drift wall readings taken at locations around the periphery of the drift above the invert structure, and processed electronically for diametrically opposed locations to determine convergence. DOE has considered the physical environment in which convergence measurements must be taken. Physical interference, if any, from the waste package or pallet in the "line of sight" between opposing locations is not an impediment because each point in a drift cross-section is read independently from the other points. The spatial relationship of one point (i.e., distance) to other points is established through triangulation from a known reference point or a known reference trajectory (i.e., sensor readings from a fixed sensor location or sensor readings from a sensor taken from different locations along the trajectory of the gantry sensor platform that follows the drift periphery). Sensors on the inspection gantry (Figure 4) have access to any location on the drift periphery above the invert structure. Video cameras and other instrumentation in the inspection gantry will be qualified for their intended functions in the emplacement drift environment, and will be inspected, tested, and replaced, as needed, to maintain their functionality under the temperature, radiation, and other environmental conditions in the emplacement drifts.

Groundwater chemical composition characteristic of the emplacement drifts and other repository openings is determined from sampling of seepage in seepage alcoves and other accessible locations where seepage may occur. Corrosion testing of stainless steel, based on applicable American Society for Testing and Materials standards and selected specimens from candidate materials exposed to groundwater, will provide information or confirmation of expected performance of stainless steel ground support components in the emplacement drift environment. The approximate environmental conditions inside the emplacement drifts, exhaust mains, and exhaust shafts are estimated with analytical models (i.e., FLUENT), using the intake and air discharge characteristics. Air temperature and relative humidity are measured for the airstream entering the turnouts and emplacement drifts and at the exhaust fan locations (SAR Section 1.3.5). Monitoring of radiation inside the emplacement drifts is not necessary because it has been determined that the cumulative neutron fluence and gamma dose on steel ground support are too small to cause appreciable mechanical damage over the preclosure period (BSC 2003, Section 6.2.4).

Representative performance of ground support components in the inaccessible areas of the repository will be obtained by testing similar components in surrogate areas, such as in dedicated alcoves or in the performance confirmation observation drift. The following testing has been identified in the conceptual monitoring and maintenance programs as testing that could be performed before and during repository development:

- Corrosion testing of stainless steel components and correlation of results with monitoring digital imagery from emplacement drifts and turnouts

- *In situ* rock bolt pull-out tests (primarily in lithophysal rock) to verify anchorage capacity and bolt performance

- Over-coring of installed rock bolts and splitting the cores for detailed examination of areas of interaction between bolt material and lithophysal cavities, and detection of signs of stress corrosion cracking.

Monitoring Locations—Emplacement drifts and their turnouts will be inspected over their entire lengths during the preemplacement and postemplacement phases.

Monitoring Frequency—Every turnout and emplacement drift will be inspected annually, beginning with the first postemplacement inspection. Subsequent postemplacement inspection frequencies will be determined for each turnout and emplacement drift based on observations and findings from previous inspections, detailed geologic mapping, and resulting technical assessments. If the frequency of inspections is changed in the future, documentation of bases for changes in monitoring locations and/or frequency in monitoring will be in accordance with the maintenance plan and evaluated under the requirements of 10 CFR 63.44, which will determine the schedule for NRC notifications, if required.

Additional inspections will be performed after design-basis seismic events.

Data Interpretation—Some indicators of ground support failure could include bulging or torn stainless steel sheets, rock fragments, blocks, or rock debris on the invert or waste packages. An estimation of the volume of observed rockfall debris will be used to assess the magnitude of the problem. Repeated inspection results will be used to determine trends of progressive deterioration and plan remedial action based on criteria that define unacceptable levels of ground support deterioration if such criteria are established in the future.

The wire mesh in the turnout allows observations of potential drift degradation (i.e., rock flaking) that are not possible to observe in the same rock type if covered with steel liner in the emplacement drift portion of the opening. Evidence of flaking may not be directly observed in the emplacement drift because of the reduced size of the liner perforations that prevent the rock debris from falling on a visible surface.

1.2.2 Other Repository Inaccessible Openings: Exhaust Mains, Exhaust Shafts, and Exhaust Shaft Access Drifts

Inspection and monitoring activities in exhaust mains, exhaust shafts, and their connecting exhaust shaft access drifts after initiation of emplacement activities will be restricted from personnel access because of the thermal and/or radiological environment in these openings. These activities will be performed with remotely operated vehicles. The exhaust shafts will be inspected by a specialized device equipped with cameras and laser measuring systems. Conceptually, such a device will be lowered and lifted with a tether attached through the exhaust fan ductwork by an operator on the exhaust shaft pad surface. Alternatively, the device could travel in or out of a shaft along a vertical rail attached to the shaft wall.

Inspection of the exhaust mains and exhaust shaft access drifts will be performed by tracked or rubber tire remotely operated vehicles for all-terrain capability and will be battery operated. These remotely operated vehicles will also be equipped with cameras and laser measuring systems. Access to the exhaust mains from the access mains will be through ports in the permanent isolation barrier bulkheads. These inspections will also include the intersections of the emplacement drifts and the exhaust mains.

Monitoring Parameters—The exhaust shaft concrete liners are inspected for cracks, voids, and spalling in the concrete. The exhaust mains and exhaust shaft access drifts are inspected for indicators of ground support degradation or defects such as excessive sagging of the welded wire mesh, noticeable corrosion of any metal components, and loosened rock bolts. Shotcrete at the intersections of the exhaust main and emplacement drifts is inspected for cracks, delamination, spalls, void development, and chemical alteration.

Monitoring Locations—Remotely operated inspections of the repository exhaust airways will be performed along their entire length.

Monitoring Frequency—Inspection frequency of the exhaust airways will be annually for the first few years and progressively on a less frequent basis, if warranted. In addition, monitoring will be performed after design-basis seismic events.

Data Interpretation—Ground support systems for these inaccessible repository openings are designed to last for the 100-year preclosure period without planned maintenance. Maintenance of the exhaust airway openings will be carried out only as a contingency measure in cases of significant failure or deterioration. Areas of failed ground support and rockfall can be inspected more frequently, if needed, to determine the appropriate time to initiate repair or maintenance. The maintenance activities will be scheduled to preclude impacts to the repository nuclear safety functions. Maintenance activities can be performed using remotely operated equipment, and on the rare occasion when personnel involvement may be necessary, planning and design of remediation activities and engineering controls will precede any action so that personnel safety can be assured.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC (Bechtel SAIC Company) 2003. *Longevity of Emplacement Drift Ground Support Materials for LA.* 800-K0C-TEG0-01200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20030922.0004; ENG.20050816.0017.

BSC 2004. *Performance Confirmation Plan.* TDR-PCS-SE-000001 REV 05. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041122.0002.

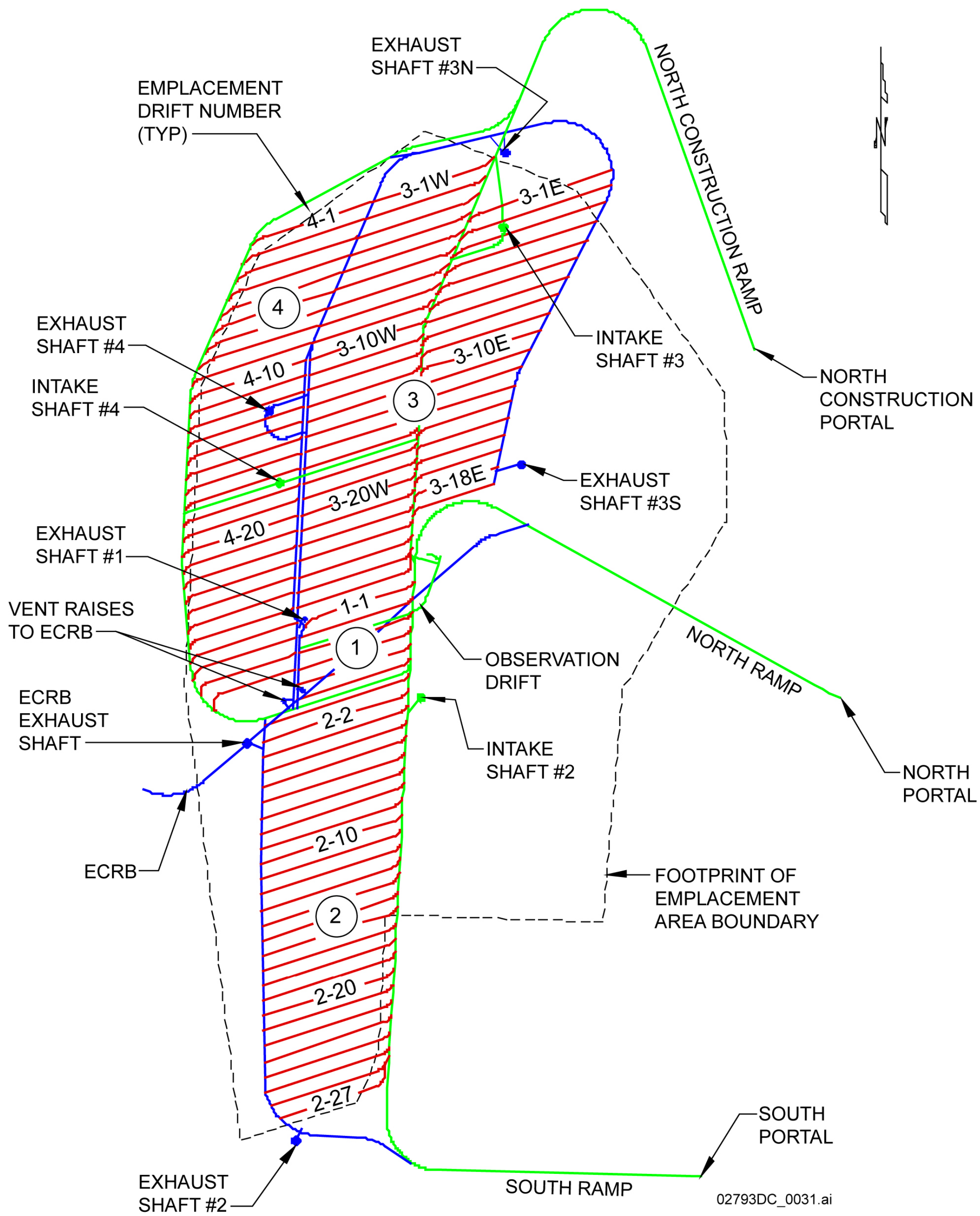

Figure 1. Classification of Repository Openings According to Accessibility

NOTE: Red lines indicate emplacement drifts, including their turnouts and are inaccessible once waste is emplaced. Blue lines and dots indicate nonemplacement openings, including exhaust shafts and their access drifts that are inaccessible. Green lines and dots indicate nonemplacement openings, including intake shafts and their access drifts that are accessible.

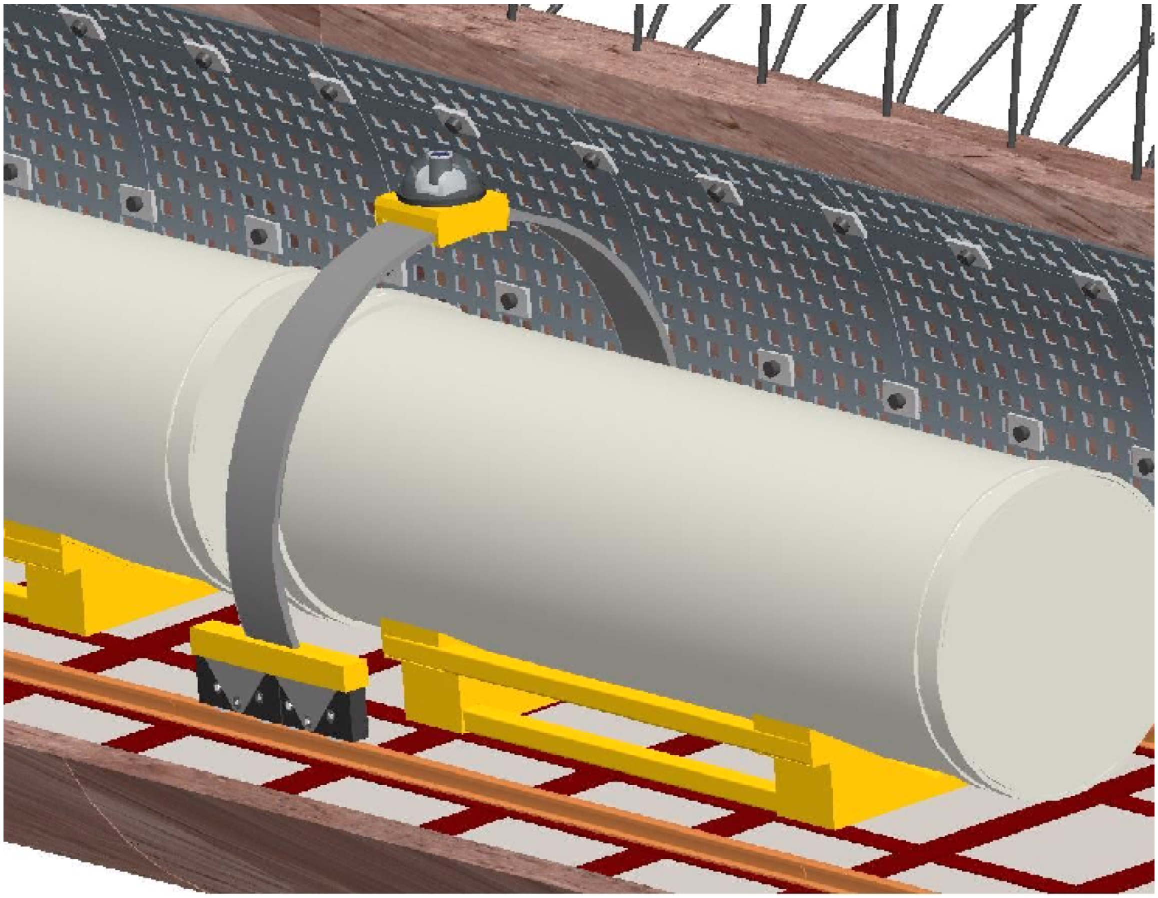

Figure 2. A Conceptual Remotely Operated Vehicle for Emplacement Drift Ground Support Inspection.

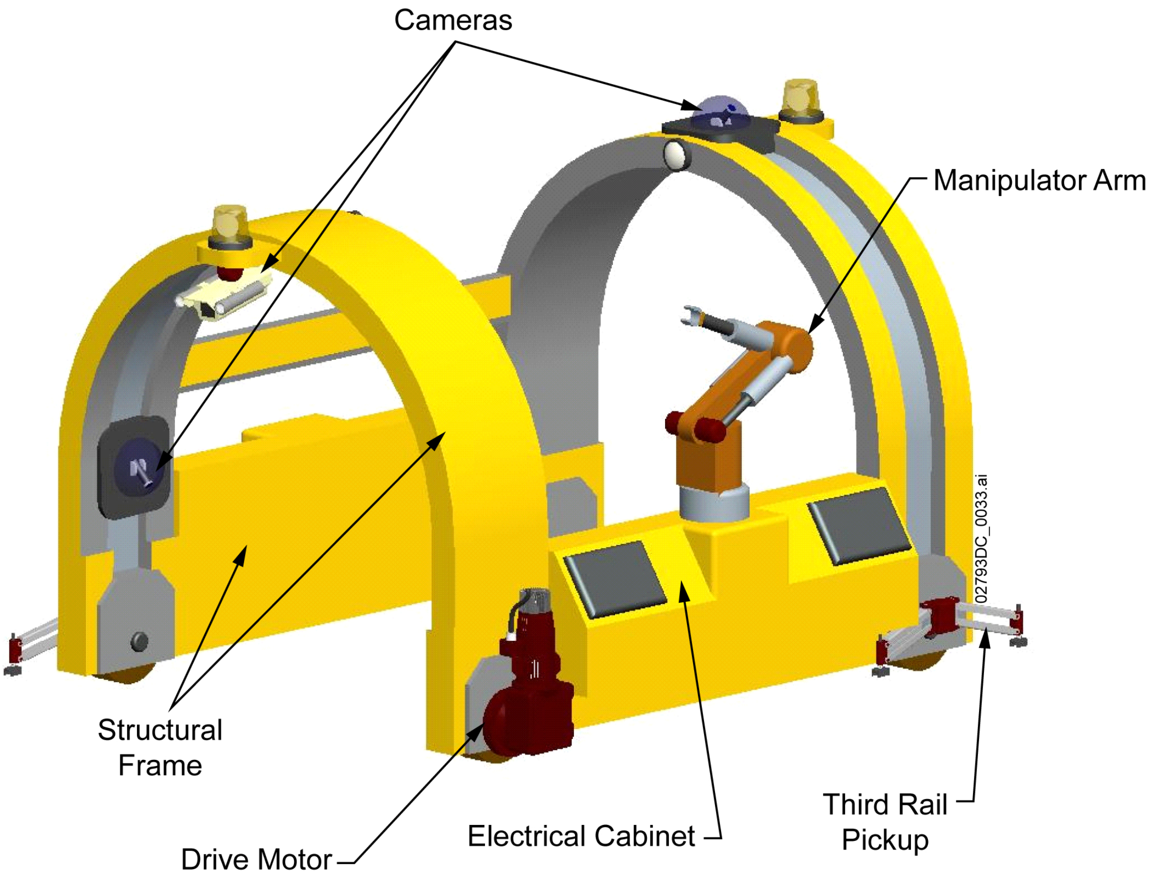

Figure 3. A Gantry-Type Remotely Operated Vehicle Concept for Inspection of Emplacement Drifts and Turnouts.

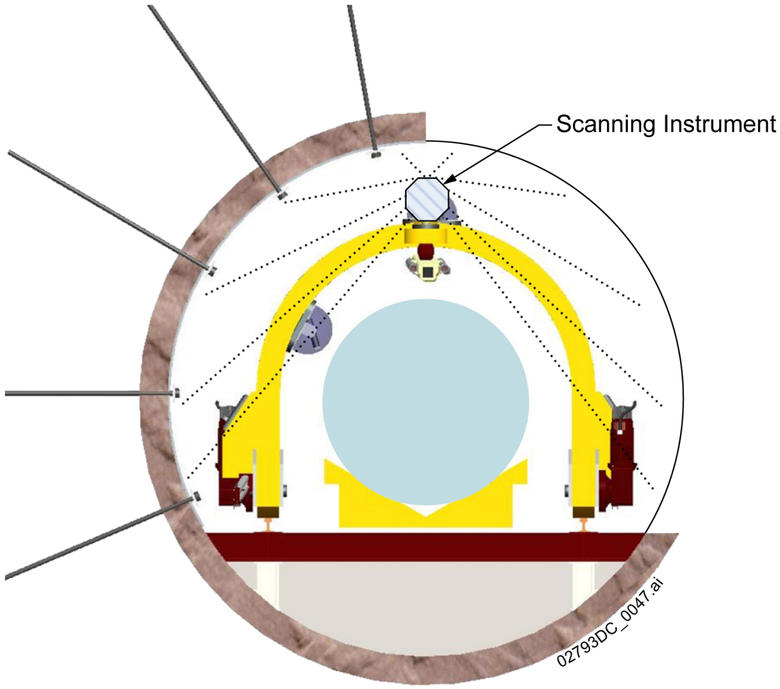

Figure 4. Typical Installation for Emplacement Drift Wall Scanning Instrument when Mounted on Inspection Vehicle Concept Shown in Figure 3, Demonstrating Drift Wall Coverage from a Single Location.

NOTE: The scanning instrument can be mounted on a bracket in either the front or the rear of the inspection vehicle's frame for unobstructed scanning of the drift wall above the invert structure.