September 28, 1993

NOTE TO: Joe Holonich
Charlotte Abrams

FROM: Philip Justus

SUBJECT: INTERIM REPORT ON CONSTRUCTION MONITORING ACTIVITIES

The following report on construction monitoring (CM) activities at YM is intended to keep the staff up-to-date on the subject. Four types of CM are going on: 1) total-load cell monitoring in high-wall boreholes; 2) convergence monitoring of fixed points in starter tunnel, near portal; 3) resurveying benchmarks; 4) seismometer recording of peak particle velocities from blasts. Previous reports on this subject are found in OR Report for May-June 1993 and Note to both of you from me dated September 20, 1993. This report does not address seismic monitoring of peak particle velocities; that will be pursued another time. These are currently not quality affecting activities. However, the activities are being conducted under what is considered as standard work practice (H.Kalia, 9/14).

To date no instability has been detected except for convergence which was considered normal relaxation in the course of rock adjustments due to excavation of boxcut and starter tunnel (H.Kalia, confirmed 9/23). There are no additional concerns about safety which resulted from these measurements (H.Kalia, confirmed 9/23).

Note of qaution: References 3 and 4 contain graphs of rock-movement data that are subject to interpretation. These references do not contain all of the data that were apparently used to reach judgments about rock stability. Take the usual precautions in analysing the incomplete set. I'm told that the M&O's periodic reinterpretation of all the accumulating data, in consultation with SNL data collectors, led to the current position that the openings monitored are relatively stable. That is to say, for the starter tunnel, only routine ground support measures were deemed to be needed to protect workers, such as the use of wiremesh held by split set rock bolts, lattice girders and shotcrete, in addition to the pattern rock bolt system.

BRIEF HISTORY OF CONSTRUCTION MONITORING OF ESF (Incomplete; preliminary)

Overview

Jan93. Start boxcut
Apr93. Start ESF starter tunnel
Jun93. Install load cells on highwall
Install extensometers in starter tunnel
Aug93. Install load cells in starter tunnel

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Detail

Nov. 1992. SNL outlines proposed CM activities and budget.

Dec. 1992. SNL specifies CM activities to be conducted in support of North Ramp Starter Tunnel. Includes generating data in these areas: loading and movement of tunnel supports (instrument rockbolts with load cells; embed pressure cells and strain gages in concrete liner and steel liner; measure free-field displacements from earthquakes); tunnel rock stability (install extensometers, convergence pins and stress change gages); blast intensity and damage (measure peak particle velocity; log fracture development by BH video); rock mass classification (determine NGI-Q and RMR). Proposed CM activities would partially implement SCP activities: 8.3.1.15.1.5.1 - access convergence test (originally for shaft); 8.3.1.15.1.8.2 - evaluation of mining methods; 8.3.1.15.1.8.2 - monitoring of ground support systems. [ref.1]

Jan. 1993. REECo performed geodetic measurements of surveyed-in fixed points in and around the North Portal and boxcut. Surveys were conducted on or about 1/29/93, 3/15/93, first week in May 93. RSN also conducted surveying in this area. Discrepancies were reconciled and the location of station 0+00 of the North Portal alignment was established. Documentation by ORs of this activity is continuing; see previous report (May-June 93 Monthly Report).

Jan. 1993. Start boxcut. No CM.

Apr. 1993. Start ESF Starter Tunnel, 4/2. No CM.

May 1993. SNL develops plan to monitor stability of tunnel and highwall of the boxcut in response to H.Kalia's concern and discussions with M&O/REECo/others, 5/5. Concerned about possible collapse (vertical, down) of highwall on an extensive cooling joint and possible bulging (horizontal, outward) of rocks on the highwall. Plan to get rock movement data to evaluate adequacy of ground support included installation of four sets of tape-extensometer pins in first 52ft of Starter Tunnel and three rock-bolt load cells in highwall above tunnel entry. These were intended to be temporary stations; SNL has an In Situ Design Verfication Study Plan effort underway to install long-term convergence monitoring stations. [ref.2]

Jun. 1993. First report of rock mass monitoring by three load cells on Highwall, 6/1. Data are collected by SNL, L.Costin, PI; data interpreted by M&O, L.Reniker, Construction Mgr. The graphs of the data from 6/1 to about 9/15 that I observed indicate a relaxation of stress of up to about 1400lbs in first few days and thereafter up to about 600lbs change in a few weeks [refs.3, 4]. H.Kalia indicated that there is no concern emanating from those measurements.

Jun. 1993. First report of rock mass monitoring by two tape-extensometers in Starter Tunnel, 6/10. Station 5 has five tie points on girder 4; station 6 has five tie points on girder 7 (see tie line diagram in ref.3). Same responsible organizations, as above. The graphs of the data from 6/10 to about 9/15 that I observed indicate positive and negative changes in length and rate of change for each tie line. Changes in length generally ranged up to about 0.26in. Rate changes were generally less than 0.02in/day. H.Kalia indicated that there is no concern emanating from those measurements. There were disruptions of some pins and measurements by construction activity and installation of the ventillation duct. [refs.3, 4].

Jun-Jul. 1993. CM of the High-wall is also done by geodetic benchmark surveying. REECo has been conducting periodic surveys of fifteen fixed monitoring points since about 1/29/93 to an accuracy of 0.015ft (see discussion for Jan. 1993, above). H.Kalia indicates no change in fracture frequency or in coordinates within tolerance of methods. [ref.6; REECo Drawing #25-SUBS-C1 5/20/93].

Aug. 1993. First report of three load cells at tunnel station 0+55, 8/17. The graphs of the data for about 30 days of measurements that I observed indicate a relaxation of stress of up to about 900lbs. Similarly, there is no concern about those measurements. [ref.4]. The load cell type and specs are shown on mfg literature [ref.5].

Enclosures: the six references, as stated

Enclosure 1

Sandia National Laboratories
Albuquerque, New Mexico 87185

DEC 14 1 45 PM '92

December 9, 1992

WBS: 1.2.6.1.1
QA: N/A

Dr. N. Elkins
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101 Convention Center Drive
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Subject: Construction Monitoring Activities in the North Ramp Starter Tunnel

Dear Ned:

This letter describes the specific field activities that SNL proposes to perform in support of the north ramp starter tunnel construction. A general discussion of these activities and the preliminary budget were outlined in my letter of November 9, 1992. This letter provides further justification for the proposed tasks, a description of the monitoring activities, and preliminary costs for equipment and personnel. Included in this discussion is identification of the interaction with the other participants in the project.

The proposed field activities would generate data in the following areas:

- Loading and performance of tunnel supports
- Rock deformation associated with tunnel stability
- Blast intensity and damage
- Rock Mass Classification.

Background

The geotechnical monitoring proposed here has always been part of the testing program for the ESF. The monitoring is included as part of the 35 tests proposed in the SCP and used in the ESF-AS to define the testing program. As described in Table 2.2 of the ESF-AS final report, the proposed field activities would represent partial implementation of:

- Access (originally "shaft") Convergence Test (SCP 8.3.1.15.1.5.1)
- Evaluation of Mining Methods Test (SCP 8.3.1.15.1.8.2)
- Monitoring of Ground Support Systems (SCP 8.3.1.15.1.8.2).

As part of the ESF-AS we developed two testing strategies. The first was to follow the SCP testing program in a methodical way, as described in the SCP. The second was to defer all tests performed during the construction phase that were (1) not essential to the demonstration of site suitability and (2) would not lead to an irretrievable loss of data. Because of the use of mechanical mining methods and the fact that these tests are not critical to a determination of site suitability, they were classified as ones that could be deferred until after the TBM had completed the ramp. This classification of the tests was based, in part, on the assumption that the TBM would start operations at the portal (i.e. there was no starter tunnel) and, therefore there was no opportunity to field the tests (especially the access convergence test) during construction without interfering with the construction operations and schedule.

The same logic holds true today, except that there will be approximately 200 ft. of starter tunnel constructed by drill and blast techniques. This will allow an opportunity to field portions of these tests, as described above, without impacting the construction schedule or operations. In fact, initial fielding of the tests in the starter tunnel will allow us to obtain early convergence measurements (resulting from continued construction) that may not be possible in the TBM portion of the ramp. This early geotechnical information would be extremely useful for future design packages.

Justification

The ramp may form part of the access of the potential repository and geotechnical data are therefore required to confirm adequate design, construction, and long-term performance. The geotechnical monitoring activities outlined in this letter would obtain this data and would provide the following benefits:

- The proposed monitoring activities are within the realm of "Standard Practice" for civil construction and provides both verification of the adequacy of the design and long-term monitoring of stability. Any future stability problems associated with the rock mass or the steel portal liner could be detected by the monitoring program and it would provide the basis for the design of remedial action.
- The monitoring program would allow development of the procedures that would form the basis of the QA program required for the ESF testing.
- The geotechnical data collected could be required for backfilling and sealing of the repository accesses, particularly for the design of the ramp seal.
- The monitoring program would provide a system to assess the impact of seismic loads from earthquakes or UNEs on the portal and starter tunnel. This is an important aspect of the proposed monitoring activities because, although seismic damage to the ramp is not expected to be significant, there are examples of seismic-related structural damage to portals.
- The starter tunnel will provide an opportunity to collect data close to the working face.
- Other programs in the project, such as sealing, could logically make use of the data from these tests.

Collection of the data identified in this plan will demonstrate that good engineering practice is being employed from the earliest phases of construction. It will allow SNL, the M&O, and construction personnel to develop working relationships and procedures that will form the basis for cooperation during later TBM mining operations. Development of these testing experiences will improve the quality of SNL's ESF effort.

The construction of the starter tunnel illustrates the progress that is being made on the YMP. Conducting test activities in this tunnel will enhance this illustration by demonstrating that not only has construction begun, but so also has data collection. It will also demonstrate the efficiency of the program in taking advantage of the construction of the starter tunnel to increase knowledge of the site.

The consequences of not fielding the geotechnical monitoring can be summarized as follows:

- The field activities proposed for the starter tunnel and portal would produce data required for repository design and performance assessment that would be irretrievably lost if not collected with construction.
- Because the proposed geotechnical monitoring is considered standard practice for civil construction, the failure to collect this data may make the project appear insensitive to public concern regarding safety and reliability of the ESF facility.
- If there are problems with the steel liner or stability problems with the rock mass, we will not have instrumentation in place to help determine the causes and monitor the effectiveness of remedial actions.
- This is our first opportunity to obtain access convergence data caused by construction (i.e. The convergence data collected in the TBM portions of the ramps will be collected so far behind the working face that convergence resulting from construction will not be measured. If monitoring is not performed, this opportunity will be lost.)

Detailed Test Descriptions

In the following section, each of the tests planned are described in some detail. The interaction with the construction process is described and the requirements that would be placed on the other site organizations are identified.

Monitoring Blasting Activities

This activity incorporates data collection on the blasting round design, blasting performance, and measurement of the peak particle velocities. Blasting design and performance data would be routinely developed by the constructor and transferred to the SNL field representative. This data would include:

- round design: number of holes, diameter, type of explosive, charge density, detonators, delays, initiation sequence; and
- blasting performance: overbreak, underbreak, half-casts in trim holes.

These data would be correlated with blast-damage assessments and rock mass quality indices developed as part of other test activities described below.

Peak particle velocity is a parameter correlated with blast-induced damage and is used to optimize blasting procedures. These measurements would be performed by SNL. The data collected would be available to the constructor as the basis of blast design optimization and would be used in the blast-damage assessments.

Required Interactions with Constructor:	Coordinate data collection, data exchange, and blast monitoring with constructor
Projected Interference to Construction:	None
Equipment Requirements:	Blast Vibration Monitor (available in SNL subcontractor equipment inventory)
SNL Personnel Requirements:	Site Engineer

Generate Rock Mass Classification Indices

The rock mass classification systems NGI-Q and RMR are needed for the ESF/repository design. These two indices would be generated from mapping and photographic data to be gathered by the USGS. Data transfer would be arranged on-site because the indices should be developed prior to shotcreting, which will cover up the rock exposures. Site verification of the classification would be performed within the support installation cycle.

Rock mass quality will provide the quantitative basis for judging the change in rock character along the tunnel and a verification of the adequacy of ground support. Data on installed support would be supplied by the constructor. Timely generation of rock mass classification would also allow the constructor to use the associated empirical design systems.

Required Interactions with Constructor:	Coordinate on-site data transfer with USGS personnel; coordinate excavation inspection with constructor; coordinate transfer of ground support data with constructor.
Projected Interference to Construction:	None
Equipment Requirements:	None
SNL Personnel Requirements:	Site Engineer

Blast-Damage Assessment

The degree of blast damage resulting from construction will be assessed using borehole television surveys of the holes drilled by the constructor and other participants. The records of the surveys will be stored on video tape. Logs of the fractures would be generated outside the tunnel to minimize the time required for the surveys.

Equipment to allow access for inspection of the holes in the back would be required. These activities would be performed during portions of the mining cycle where equipment travel to the face was not necessary (i.e. drilling, explosives loading, ground support), and the impact to the construction would be minimal.

Required Interactions with Constructor:	Organize man-lift for survey of holes; coordinate with mining cycle.
Services Required:	Man-lift for monitoring.
Projected Interference to Construction:	None or minimal.
Equipment Requirements:	Man-lift platform to allow access to holes in the shoulder and back of the tunnel. Borehole Television (available in SNL inventory)
SNL Personnel Requirements:	Site Engineer and Site Technician

Rockbolt Load Cells

A total of fifteen rockbolts would be instrumented with load cells to monitor long-term changes on bolt load from the installation point.

Required Interactions with Constructor:	Coordinate bolt placement with constructor.
Services Required from Constructor:	Bolt installation (part of support process); attach monitoring cable.
Projected Interference to Construction:	None
Equipment Requirements:	None
Instrumentation Required:	Fifteen rockbolt load cells.
SNL Personnel Requirements:	Site Engineer

Instrumentation of Portal Concrete Section

Current plans include a 30-ft. section of formed concrete 1-ft. thick at the beginning of the starter tunnel. An array of hydraulic pressure cells and embedment strain gages, illustrated in Figure 1, is proposed for this structure. Both the pressure cells and strain gages would be arranged in the concrete forms prior to placement of the concrete. These instruments would monitor long-term stability of the concrete.

Required Interactions with Constructor:	Coordinate installation of instruments in form
Services Required from Constructor:	Man-lift to locate instruments.
Projected Interference to Construction:	Minimal
Equipment Requirements:	Man-lift
Instrumentation Required:	Six hydraulic pressure cells; six embedment strain gages.
SNL Personnel Requirements:	Site Engineer or Site Technician

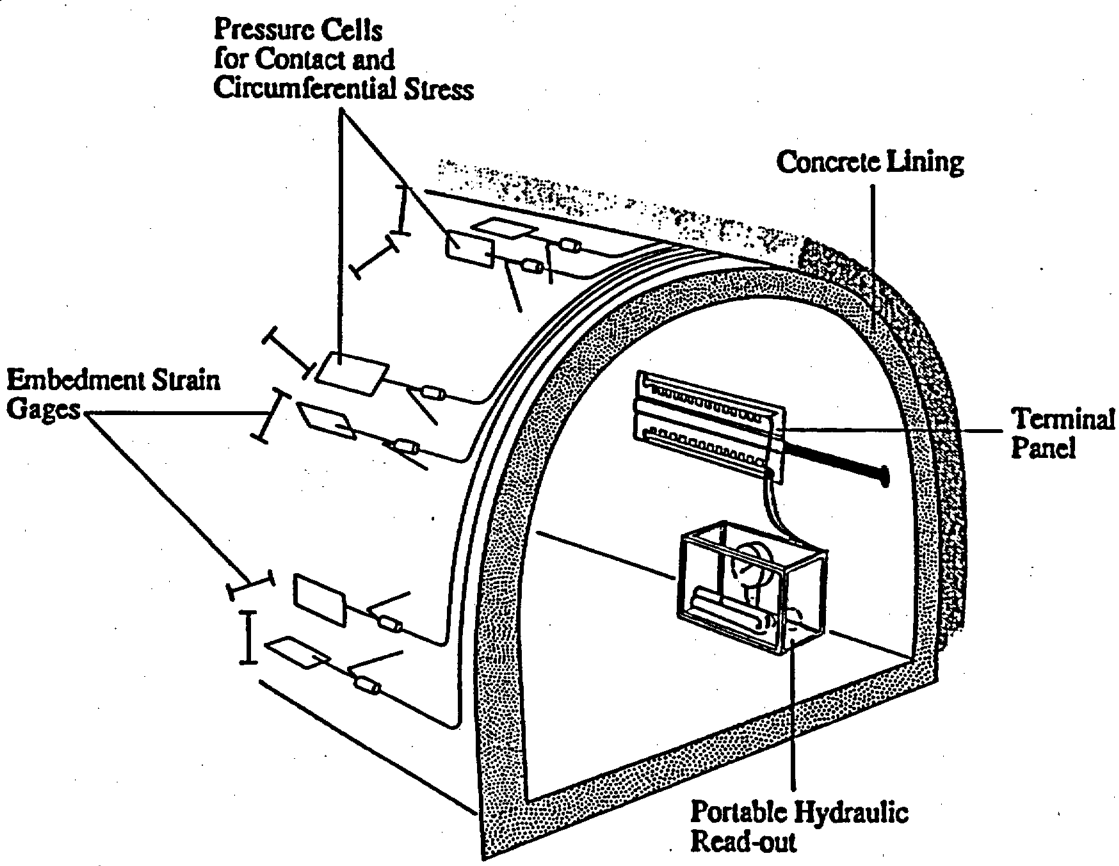

Figure 1. Pressure and Strain Instrumentation for Concrete Liner (not to scale).

Instrumentation of Multiplate Steel Liner

Instrumentation proposed for the multiplate steel liner consists of an array of hydraulic pressure cells to measure backfill pressure near the highwall face. Convergence will be measured on "movement control hooks" that are attached and monitored as a routine part of the construction process by the constructor.

The hydraulic pressure cells will be placed during backfilling to measure normal pressure on the multiplate steel structure at five locations. The cells are placed against the steel and then covered with sand to protect the instruments during final backfilling.

Required Interactions with Constructor:	Coordinate installation of pressure cells during backfilling; data exchange on convergence with constructor.
Services Required from Constructor:	Assist in hand backfilling.
Projected Interference to Construction:	Incremental halts in backfilling to place pressure cells.
Equipment Requirements:	None
Instrumentation Required:	Five pressure cells.
SNL Personnel Requirements:	Site Engineer or Site Technician

Seismic Monitoring

Seismic monitoring instruments would be placed to measure peak accelerations associated with UNE or earthquake events. Accelerations would be correlated with any changes in the geotechnical data also being collected. The free-field displacement would be measured by a borehole geophone. Other measurements would be made on the steel liner and concrete portal face. The geophones would be event triggered and only record if accelerations exceed some predefined magnitude.

Required Interactions with Constructor:	Coordinate hole drilling and location of instruments with constructor.
Services Required from Constructor:	Drill 3.0-inch-diameter hole 20-ft. deep; install instrument wiring.
Projected Interference to Construction:	None.
Equipment Requirements:	None
Instrumentation Required:	Three geophones.
SNL Personnel Requirements:	Site Engineer

Underground Based Rock Mass Deformation and Convergence Measurements

An array of MPBX extensometers,convergence pins and stress change gages would be installed at the face area of the starter tunnel where the TBM will begin operation (0-45E). A similar array, but without the stress change gages would be installed at the center of the drill and blast section of the starter tunnel (0+55). The instruments at the face would measure displacements and stress changes induced by advancing the tunnel with the TBM and the instruments at both locations would monitor the time-dependent deformation of the rock mass in the portal area. Figure 2 shows a general schematic of the instrument array at the face. The exact configuration will depend on details of the starter tunnel, such as the ventilation system.

Installation of the instrumentation requires four 75 ft. long and two 50 ft. long NX-size holes for the MPBX gages and ten 1.25-diameter holes drilled at a depth of 6 inches into the rock for the convergence pins. The holes for the MPBXs and the convergence pins should be counter-bored to protect the MPBX heads and the convergence pins.

Convergence measurements would be conducted at two additional sections of the tunnel: 0+5E and 1+00E. These stations would monitor the long-term stability of the rock mass. Five convergence pins would be installed at each section, in the same manner as described above

When the concrete liner is installed near the face of the starter tunnel, the MPBX heads must be protected, and holes must be provided for the wiring from the MPBX instruments.

Required Interactions:	Coordinate drilling of instrument holes; coordinate installation of instruments in holes; coordinate electrical wiring installation.
Services Required:	Drill instrument holes; install instrument wiring; man-lift services for measuring convergence.
Projected Interference to Construction:	Minimal - Instrumentation in back will be installed after the bench is created. The remainder will be installed after construction is complete, but before shotcreting.
Equipment Requirements:	Drill for NX (3.0 inches) holes; drill for convergence pin (1.25 inches) holes; man-lift; grout mixer and pump.
Instrumentation Required:	6 MPBX extensometers, 20 convergence pins, 8 stress gages, four thermistors.
SNL Personnel Requirements:	Site Engineer and Site Technician

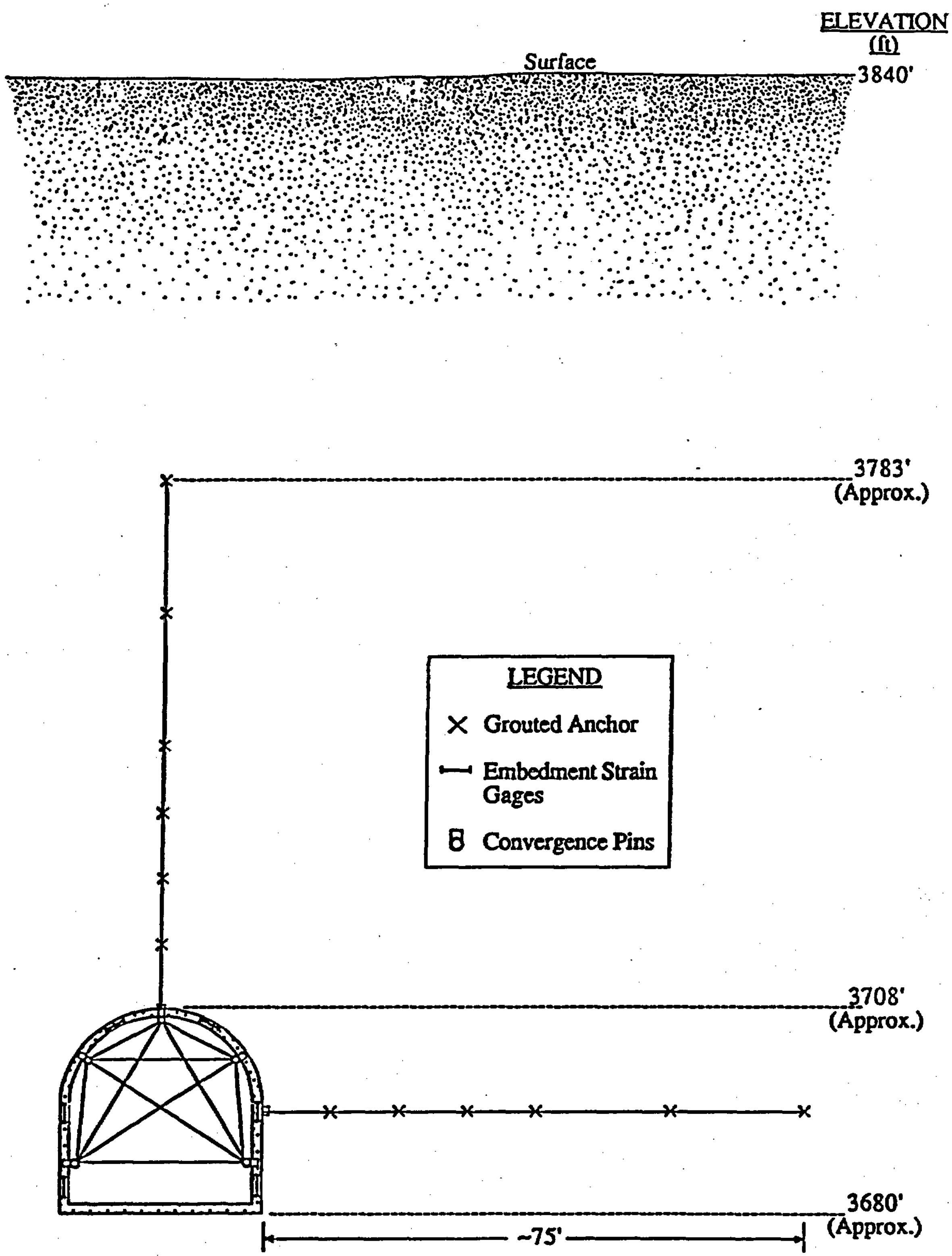

Figure 2. General Schematic of Multiple-Point Borehole Extensometer (MPBX) Array at the Face of the Starter Tunnel.

Data Interpretation and Analysis Requirements

The geotechnical monitoring proposed here is considered "Standard Practice" for civil construction and would in some form be performed in other tunneling projects. The starter tunnel, however may become the permanent access to the potential repository, and therefore requires additional data analyses to demonstrate safety, reliability, and to support performance assessment.

Data interpretation will require the use of the finite element codes developed for the YMP to analyze displacement and stress change data resulting from advancing the face with the TBM. Data analyses will increase confidence in the application of the measured data.

Comparing the measured data with the results of finite element analyses will help validate the computer codes that are currently being used to design the ESF and the potential repository.

Budget and Manpower summary

A site engineer would be required on-site for a portion of the 4-month period scheduled for construction of the tunnel. SNL has available staff in Las Vegas who can fill the role of field technician.The engineer would coordinate the activities and data transfer with the constructor, perform the blasting monitoring, and generate the rock mass quality indices. Technicians would be on-site periodically to assist in instrument installation activities, or may coordinate activities after completion of the excavation process. Follow-up visits would be made for manually monitoring instruments on a schedule to be established.

Preliminary Cost Estimates for labor, equipment and travel costs are listed in Table 1. Instrumentation costs, which are included in equipment costs in Table 1, are listed in Table 2

Table 1: Preliminary Cost Estimates

Activity	Labor	Equipment	Travel	Miscellaneous Purchases	SNL Taxes	Total
Detail test design	51.2		3		4.4	58.6
ES&H	6.7				0.5	7.2
Equipment procurement	29.5	75.4			8.4	113.3
Calibration and installation	46.6		5	5	4.5	61.1
Measurement and data reduction	35.2		5		3.2	43.4
Data Analysis	30.4				2.4	32.8
Report	50.4		5	1	4.5	60.9
Total	250.0	75.4	18	6	27.9	377.3

Table 2: EQUIPMENT LIST AND COST

Description	Quantity	Cost/Unit	Subtotal
Pressure cells	12	$ 600	$ 7,200
MPBX (7 point)	6	$ 2500	15,000
MPBX inst. tools	1	$ 1500	1,500
Pressure cell hydraulics	1	$ 2000	2,000
Tape extensometer	1	$ 2500	2,500
Convergence anchors	20	$ 20	400
Accelerometers	3	$ 6000	18,000
Rockbolt load cells	15	$ 500	7,500
Data logger	1	$ 7000	7,000
Temperature sensors	10	$ 150	1,500
32CH vibrating wire stress gages	8	$ 450	3,600
Multiplexer (2X)	2	$ 1300	2,600
Miscellaneous supplies			6,600
TOTAL COST			$ 75,400

Sincerely,

John Pott
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Department, 6313

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Plan for Additional Instrumentation to Monitor Possible Movement of the Rock Mass Around the North Ramp Starter Tunnel and Highwall

1.0 Background

On Thursday, April 29 and Friday April 30, 1993, SNL participated in a series of meetings with representatives of DOE/YMP, CRWMS/M&O, REECo., USGS, USBR, and the LANL Test Coordinators. As a result of these discussions regarding possible movement of the rock mass around the North Ramp Starter Tunnel excavation and highwall, SNL was requested to provide a plan for additional instrumentation that could be installed to assist the M&O and REECo in their continuing assessment of the of the rock support in the tunnel and the highwall of the box cut. The purpose of this plan is to document the measurements that SNL has proposed to make and the rationale for making them. The essence of the plan was discussed and agreed to during the meeting held on April 30, 1993 at the FOC. As agreed, SNL will provide planning, field implementation, and instrumentation consistent with the approved plan. The work is in direct support of construction and design management and is not a part of, or funded under, the SNL site characterization testing program for construction monitoring and in situ design verification. SNL will only provide data collected and processed from field instrumentation installed under this plan. Data analysis, interpretation, and recommendations will be the responsibility of the M&O design A/E and construction managers.

2.0 Rational

As a result of discussions with Hemi Kalia (who initially raised a concern regarding the safety of the highwall and tunnel excavation), the M&O geotechnical engineers, and personnel from the USBR who are responsible for fracture mapping on the highwall and tunnel, it was concluded that two potential failure mechanisms should be addressed by the SNL measurements. First, the potential for rock mass movement downward near the highwall face. If this were to occur, one result could be the movement of large blocks of rock into the tunnel. Back-to-invert closure, beyond normal relaxation of the rock mass, would be an indicator that this was possibly occurring. The second possible failure mechanism was an outward movement of rock on the highwall. This is possible because there are large discontinuities running subparallel to highwall face. Additional support, in the form of long rock bolts, will be added to the highwall before the tunnel is excavated to full width. This provides the opportunity to install a set of rock-bolt load cells that would detect any abnormal loading of the rock bolts such as by the rock mass moving outward or downward. These measurements, in combination with detailed surveys to be performed by USBR, RSN, and REECo, and complementary data collected under the SNL In Situ Design Verification test program, are intended to provide quantitative information to be used by the constructors to evaluate the adequacy of the ground support.

3.0 Proposed Instrumentation and Measurements

SNL will install additional instrumentation aimed at (1) measuring the vertical closure of the tunnel as construction proceeds, and (2) measuring the load changes on approximately three rock bolts installed on the highwall. These are discussed below.

3.1 Tunnel Closure

Initially four sets of tape-extensometer pins will be installed to measure vertical closure of the pilot heading. The four stations were provisionally located at approximately 0+16', 0+24', 0+34', and 0+52' in the REECo survey coordinate system. Each of the four stations consists of an anchor pin installed along the centerline of the back and a corresponding anchor installed directly below in the invert. A tape extensometer will be used to periodically measure the distance between the pins at each station. This will provide some indication whether any vertical closure of the tunnel is occurring over time. The station locations were selected in consultation with Steve Beason (USBR) and took into consideration local geologic features exposed in the tunnel that potentially could result in some movement of the rock mass. Because the current invert is at or above the spring line of the final tunnel diameter, the anchors in the invert will be removed as the tunnel is excavated to full dimension. However, the placement of the anchors allows us to measure the closure of one or more excavation rounds (slashing) that will result in widening the tunnel to full width. Also it is intended that the anchor points in the back be surveyed by RSN to provide some longer-term means of determining movement of the back. Additional convergence pin stations can be added as construction proceeds (*long-term convergence monitoring stations will be installed by SNL under its current In Situ Design Verification Study Plan effort, after the starter tunnel construction is complete*). It is suggested that this decision be made through joint consultation with SNL, M&O, the LANL Test Coordination Office, and REECo.

Once the four stations are installed, frequent readings (at least 5 per week) will be made initially to establish a baseline response and to determine the rate of closure, if any. Then, monitoring on a regular, but probably less frequent basis, will continue until the lower pins are removed by the bench excavations. If necessary, lower anchor points will be re-established and a new cycle of monitoring will be initiated.

3.2 Rock-Bolt Load Cells

Initially three rock-bolt load cells will be installed on selected rock bolts in the highwall above the tunnel brow. REECo is planning to install 24' fully-grouted bolts along radial lines from the portal. When these bolts are installed, SNL will install load cells on (1) a bolt that will be vertically above the tunnel portal, (2) a bolt that will on a radial line above and to the right of the portal, and (3) a bolt that will be on a radial line above and to the left of the portal. The change in load on the three rock bolts will be measured by these load cells.

As with the tape extensometer, load cell readings will be made frequently until a baseline behavior is established, then monitored regularly as construction proceeds.

4.0 Reporting

SNL will collect and process data from the tunnel and highwall monitoring instrumentation. These data will be transmitted to the M&O Field Construction Manager (currently, Richard McDonald) on a regular basis. It is proposed that, initially, results (in tabular or graphical form) be transmitted twice weekly until a baseline set of information is established. Then, less frequent reports (perhaps bi-weekly or monthly) will be transmitted. The LANL TCO will also be provided copies of each report. If some significant change from the baseline behavior is measured, or if the measured tunnel closure rate at any station exceeds 0.05 mm/day[1], M&O Field Construction Manager will be notified as soon as possible. The Field Construction Manager will be responsible for distribution of SNL data reports to the appropriate analysis organizations and for reporting results and recommendations to REECo construction supervision and DOE/YMP management.

5.0 Work Breakdown Structure and Cost

This work represents an addition to the SNL planned work scope for FY93. This work will <u>not</u> be conducted as part of the SNL In Situ Design Verification Study (Study Plan 8.3.1.15.1.8). It is planned that the work will be conducted under WBS 1.2.6.1.1. with QA controls comparable to a scoping activity. SNL will keep detailed field notes and records, but no formal QA procedures will be applied to these activities.

Because additional time and equipment will be used in this activity, SNL will track costs and provide DOE an estimate for the additional funds that will be required to complete this activity.

6.0 Reference

1. Bieniawski, Z. T. and R. K. Maschek, "Monitoring the Behavior of Rock Tunnels During Construction," Trans. South African Inst. of Civil Engineers, Civil Engineer of South Africa, 1975, pp. 255-265.

Approved

L E Shephard (signature) 5/3/93

L. E Shephard, Manager Date
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Date: 6/25/93

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Information Only

Richard McDonald
M&O Field Construction Manager
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Subject: Transmittal of SNL North Ramp Starter Tunnel Rock-Mass Monitoring Data

Dear Richard:

Attached is a copy of recent data recorded by SNL as part of the North Ramp Starter Tunnel rock mass monitoring. These data were recorded over the time period from 6/1/93 to 6/24/93.

If you have any questions regarding this transmittal, please call Larry Costin at (505) 844-0397, or John Pott at (505) 844-1580.

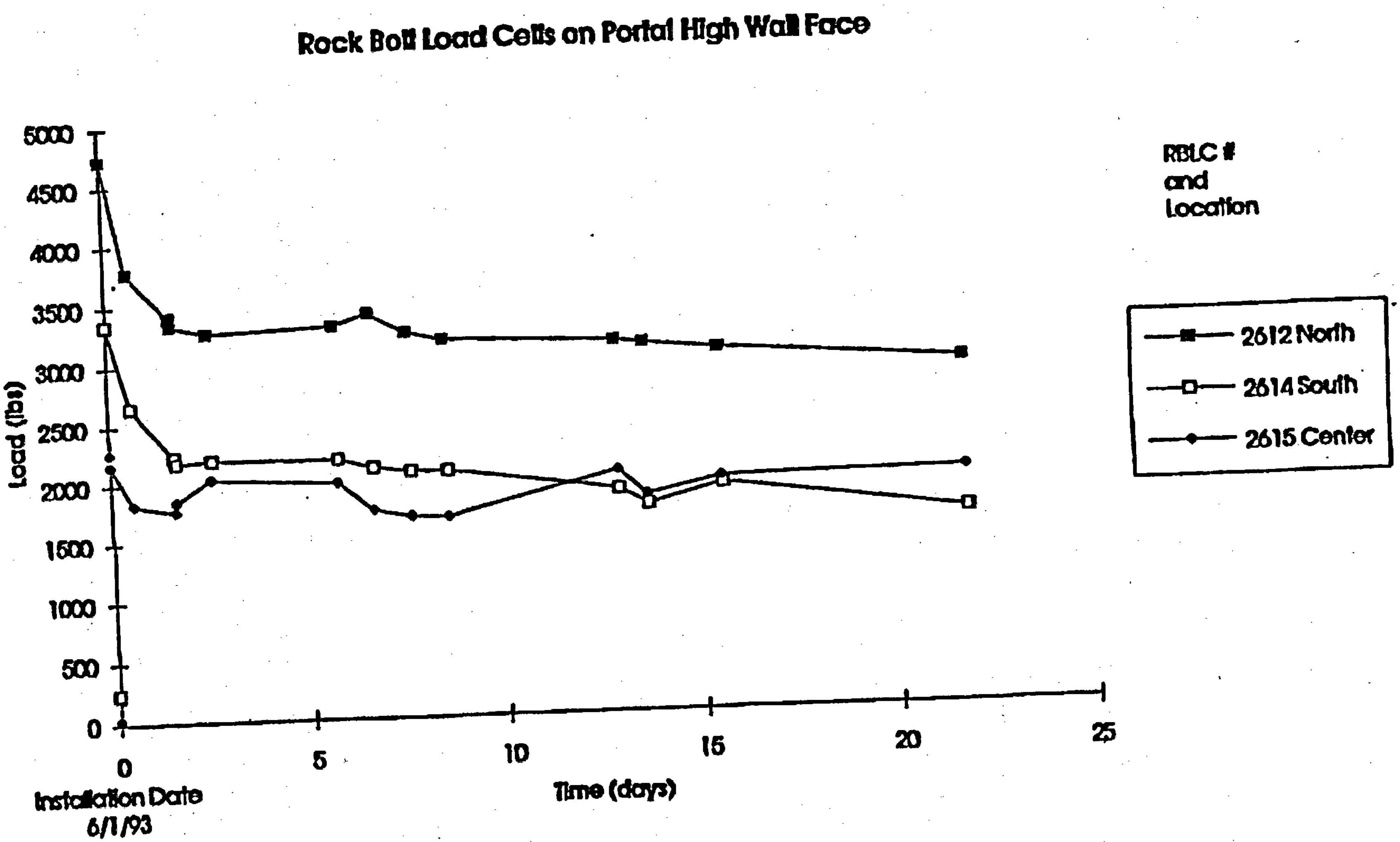
Sincerely,

Laurence S. Costin, Manager
YMP Performance Assessment
Applications Department 6313

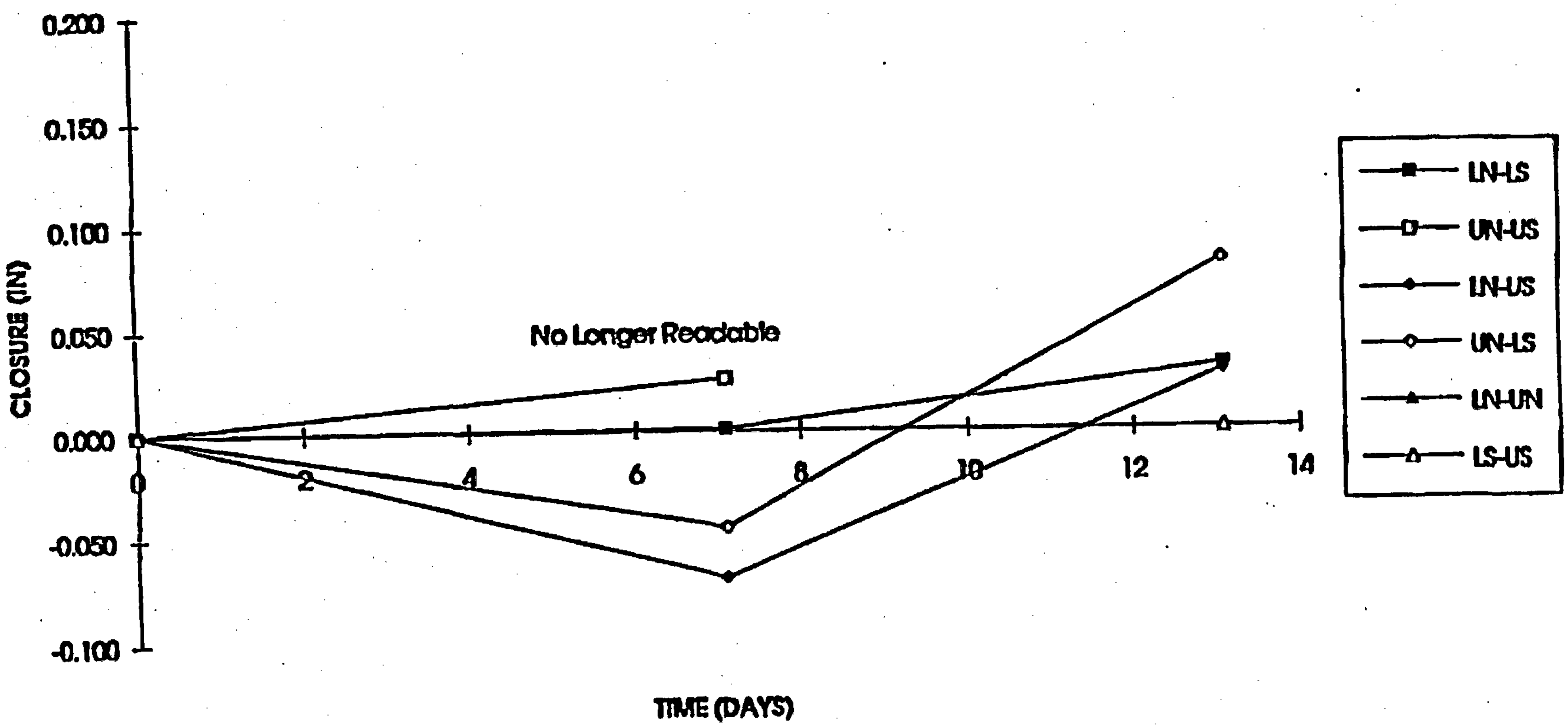
LSC:6313:bb

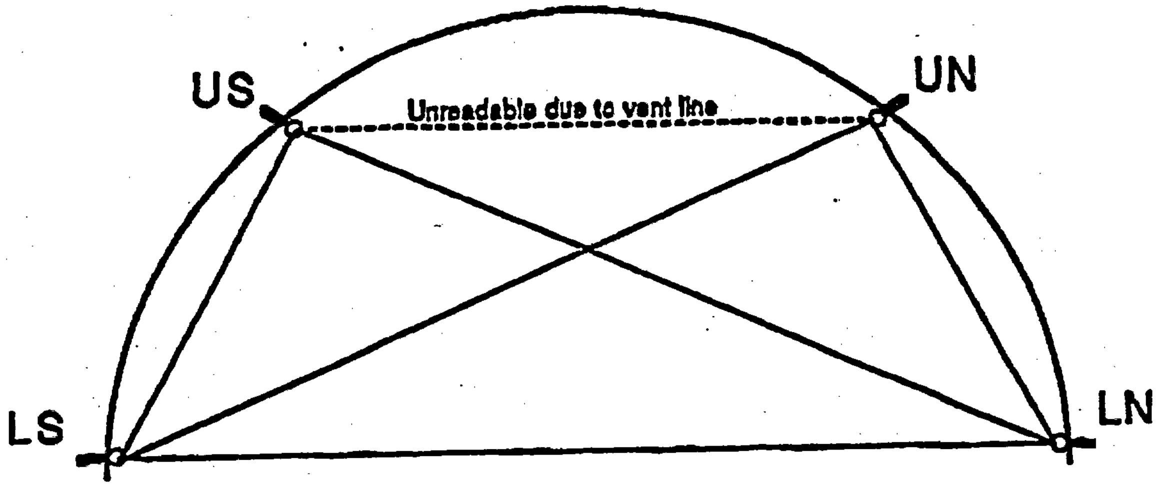
Copy to: (w/attachments)

J. F. T. Agapito	S. P. Carlisle
LANL/TCO	N. Z. Elkins
LANL	H. Kalia
6313	L. S. Costin
6313	J. Pott
	55/F30-05/03/93


Rock Bolt Load Cells on Portal High Wall Face
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Load (lbs)
0
Installation Date
6/1/93
5
10
15
20
25
Time (days)
RBLC #
and
Location
2612 North
2614 South
2615 Center

Station 6 - Girder 7 Closure





Lattice Girder Convergence Measurements
(looking west into tunnel)

Enclosure 4

SEP 22 2 56 PM '93

Sandia National Laboratories

Albuquerque, New Mexico 87185

Date: 9/17/93

WBS 1.2.6.1.1
Information Only

Richard McDonald
M&O Field Construction Manager
M&O/MK
101 Convention Center Drive
Mail Stop 423
Las Vegas, NV 89109

Subject: Transmittal of SNL North Ramp Starter Tunnel Rock-Mass Monitoring Data

Dear Richard:

Attached is a copy of recent data recorded by SNL as part of the North Ramp Starter Tunnel rock mass monitoring. These data were recorded over the time period from 6/1/93 to 9/16/93.

Note that tape extensometer measurements have not been corrected for temperature change.

If you have any questions regarding this transmittal, please call Larry Costin at (505) 844-0397, or John Pott at (505) 844-1580.

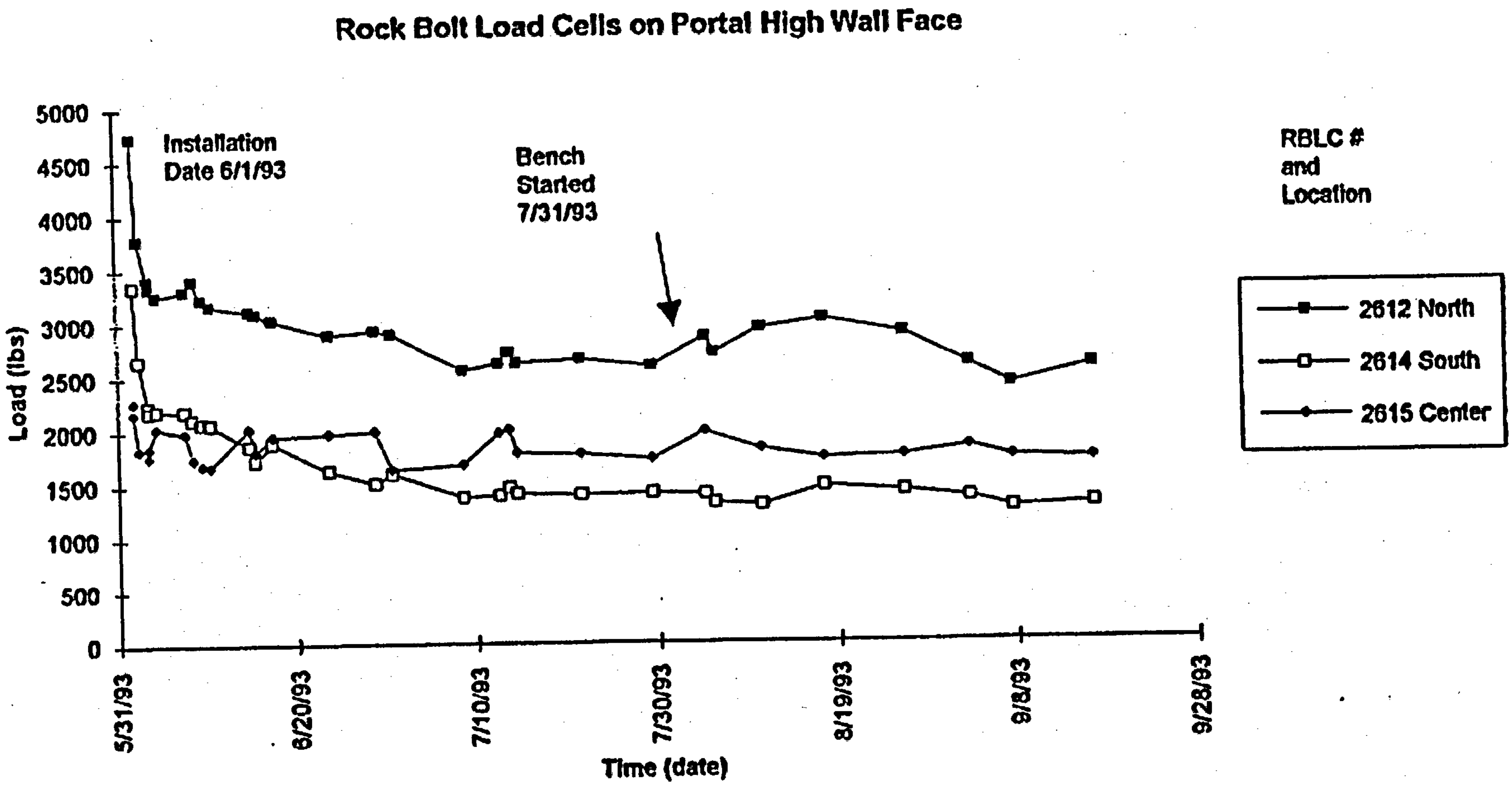
Sincerely,

Laurence S. Costin, Manager
YMP Performance Assessment
Applications Department 6313

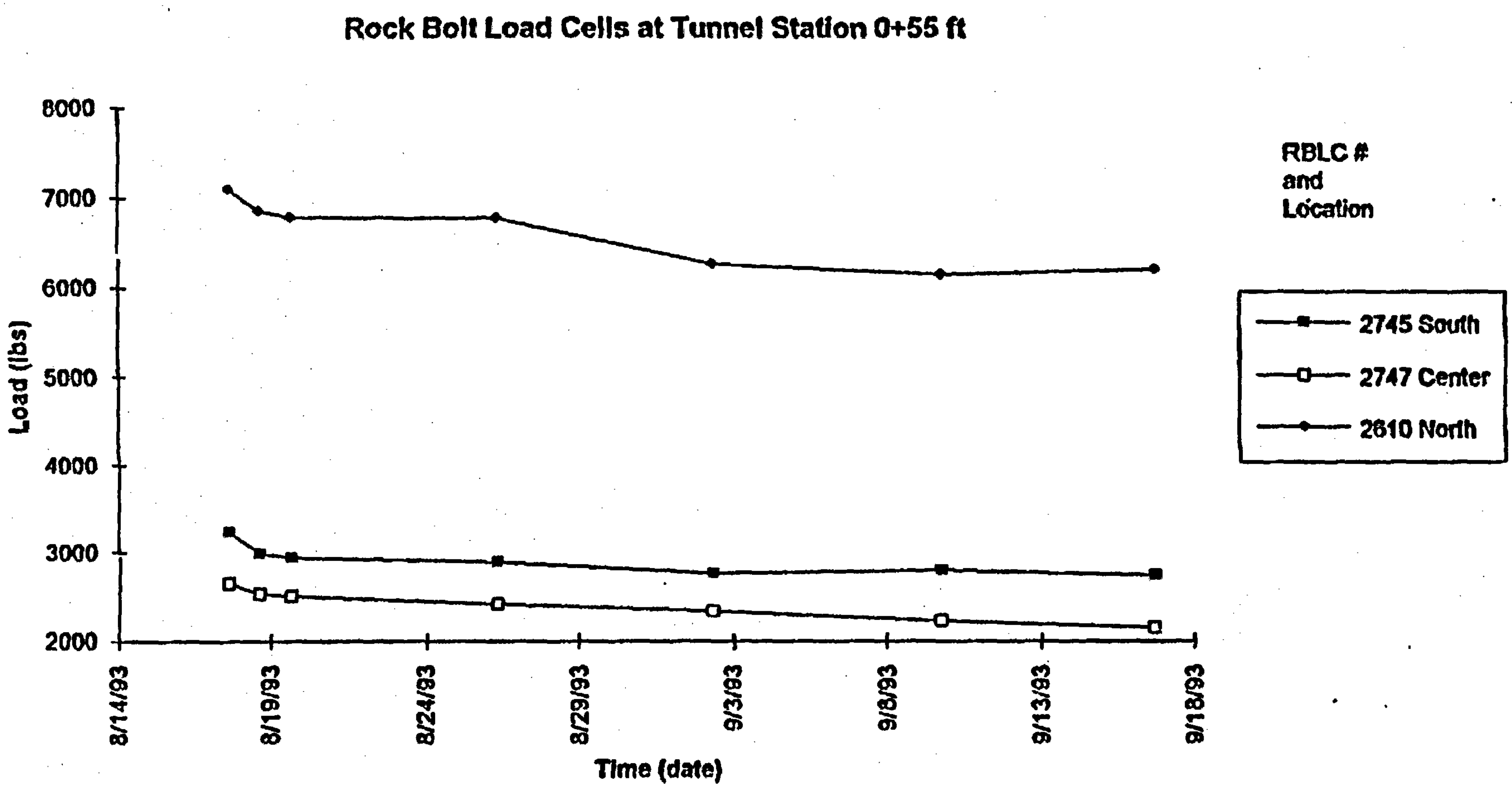
LSC:6313:bb

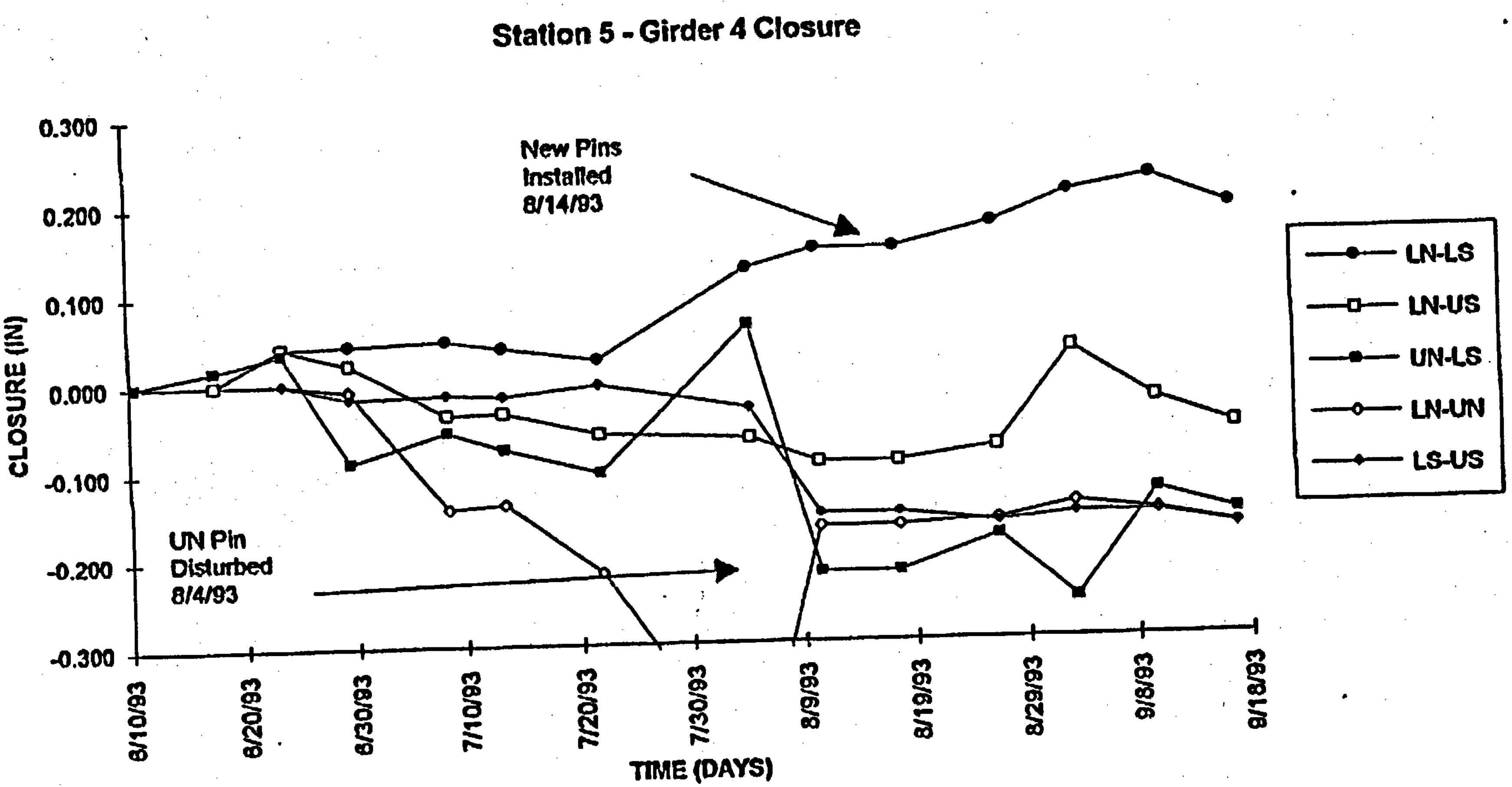
Copy to: (w/attachments)

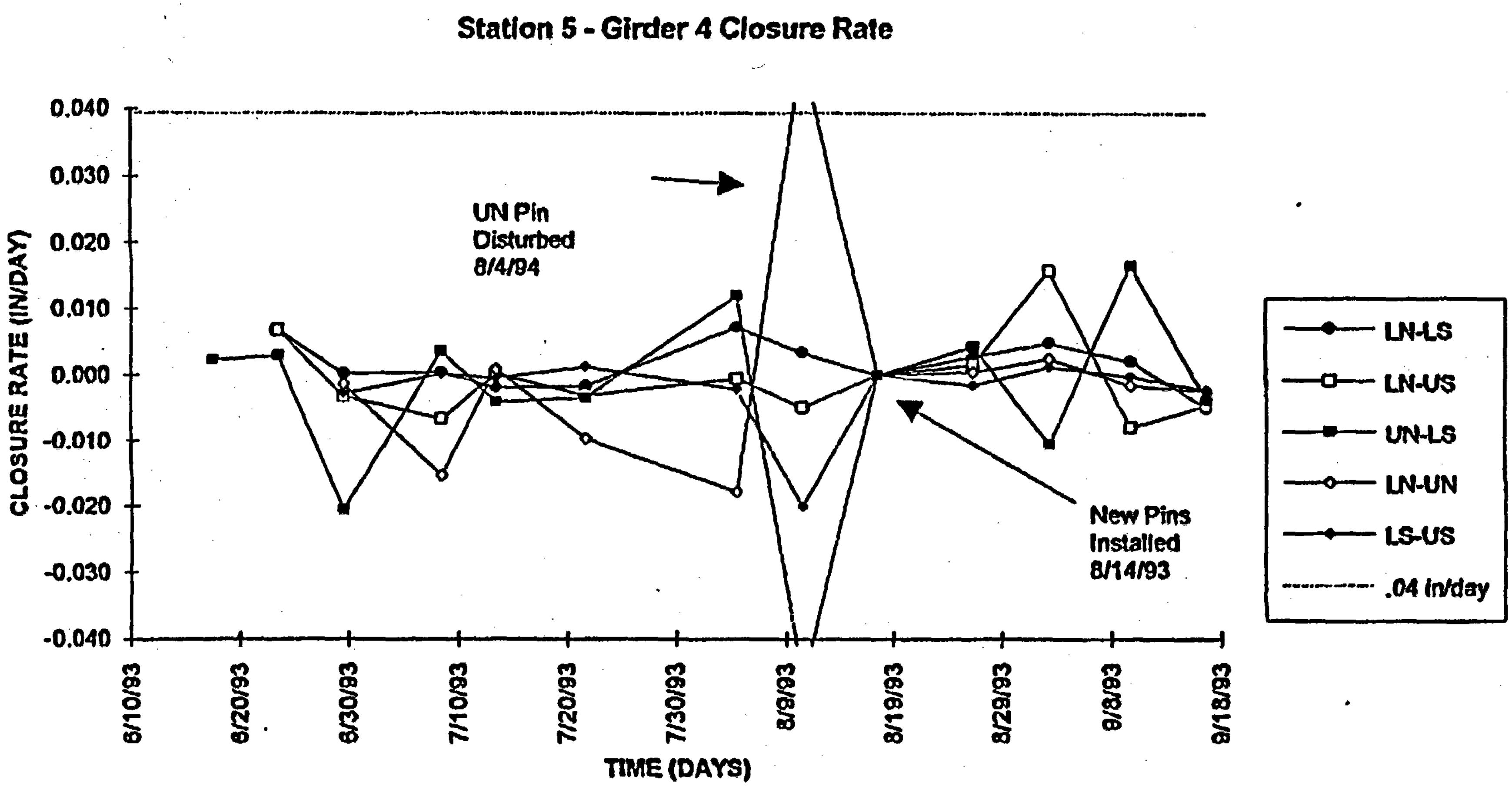
J. F. T. Agapito	S. P. Carlisle
LANL/TCO	N. Z. Elkins
LANL	H. Kalia
6313	L. S. Costin
6313	J. Pott
	55/F30-05/03/93



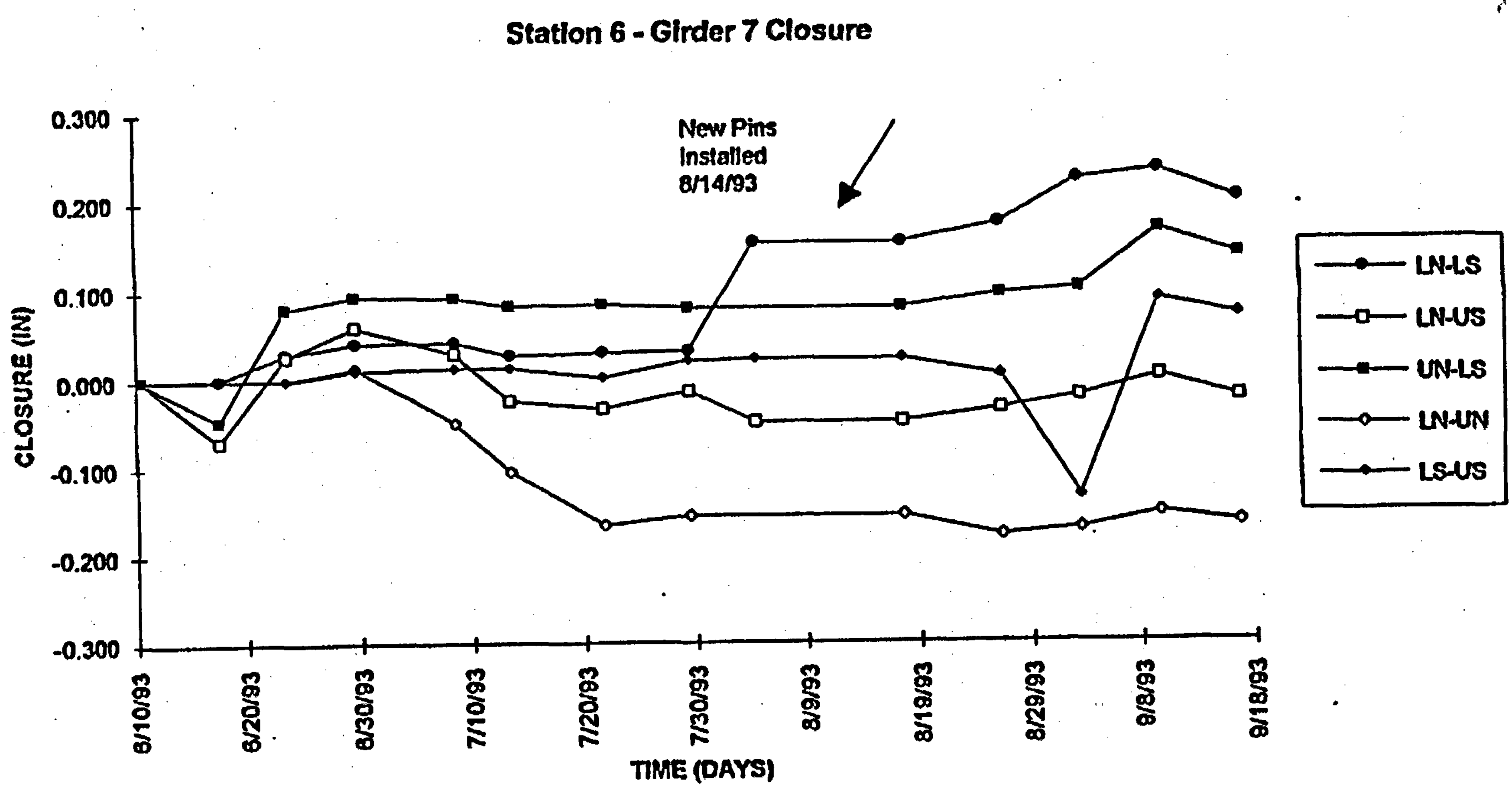
Rock Bolt Load Cells on Portal High Wall Face
Installation Date 6/1/93
Bench Started 7/31/93
RBLC # and Location
2612 North
2614 South
2615 Center
Load (lbs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
5/31/93
6/20/93
7/10/93
7/30/93
8/19/93
9/8/93
9/28/93
Time (date)


Rock Bolt Load Cells at Tunnel Station 0+55 ft
Load (lbs)
8000
7000
6000
5000
4000
3000
2000
8/14/93
8/19/93
8/24/93
8/29/93
9/3/93
9/8/93
9/13/93
9/18/93
Time (date)
RBLC #
and
Location
2745 South
2747 Center
2610 North

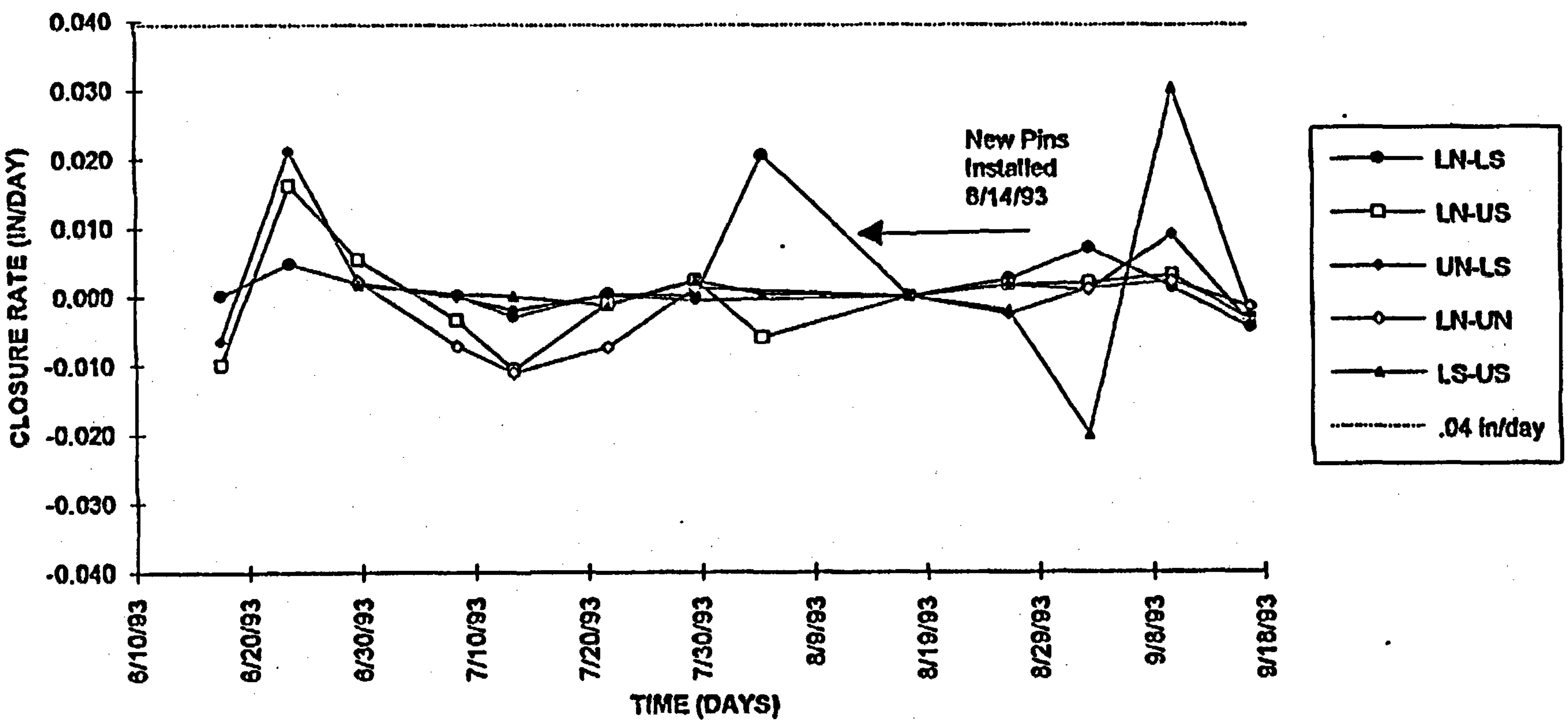

Station 5 - Girder 4 Closure
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
CLOSURE (IN)
New Pins
Installed
8/14/93
UN Pin
Disturbed
8/4/93
6/10/93
6/20/93
6/30/93
7/10/93
7/20/93
7/30/93
8/9/93
8/19/93
8/29/93
9/8/93
9/18/93
TIME (DAYS)
LN-LS
LN-US
UN-LS
LN-UN
LS-US



Station 5 - Girder 4 Closure Rate
0.040
0.030
0.020
0.010
0.000
-0.010
-0.020
-0.030
-0.040
CLOSURE RATE (IN/DAY)
UN Pin Disturbed 8/4/94
New Pins Installed 8/14/93
6/10/93
6/20/93
6/30/93
7/10/93
7/20/93
7/30/93
8/9/93
8/19/93
8/29/93
9/8/93
9/18/93
TIME (DAYS)
LN-LS
LN-US
UN-LS
LN-UN
LS-US
.04 in/day


Station 6 - Girder 7 Closure
New Pins
Installed
8/14/93
CLOSURE (IN)
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
6/10/93
6/20/93
6/30/93
7/10/93
7/20/93
7/30/93
8/9/93
8/19/93
8/29/93
9/8/93
9/18/93
TIME (DAYS)
LN-LS
LN-US
UN-LS
LN-UN
LS-US

Station 6 - Girder 7 Closure Rate



Enclosure 5

geokon Incorporated

GEOTECHNICAL INSTRUMENTATION

Series 3000

Load Cells

FEATURES

- **Inexpensive.**
- **Rugged waterproof construction.**
- **High stability and sensitivity.**
- **Accurately measures eccentric loading.**
- **Versatile design for use with tiebacks, rockbolts, struts or arch supports.**

The Geokon line of Load Cells is designed for use in the severe environments normally associated with construction activity. The load element is a spool of high strength steel or aluminum on which several electrical resistance strain gages are bonded in a full bridge configuration for temperature stability and for compensation of off-center loading. High resistance strain gages are used to minimize cable effects. A steel outer cover and O-ring seals are used to protect the strain gages from mechanical damage and water penetration.

Load Cells are provided with the cable inside an armored flexible conduit. The electrical connector is protected by an enclosure with a hinged, gasketed lid, mounted on the end of the flexible conduit. Load cells can also be provided without cable, but with an electrical connector on the cell itself.

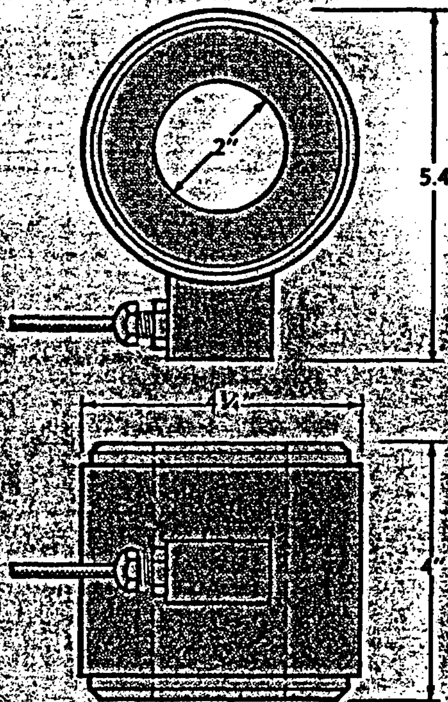
Readings can be taken by means of any conventional strain indicator readout box. Geokon will provide a Vishay P350A Readout Box with a mating plug. A temperature stable reference standard is an essential accessory to guarantee an accurate "zero" reading. When plugged in, the reference standard permits the box to be set up in correct adjustment at any time.

Bushings are available to centralize small diameter bolts inside the load cells.

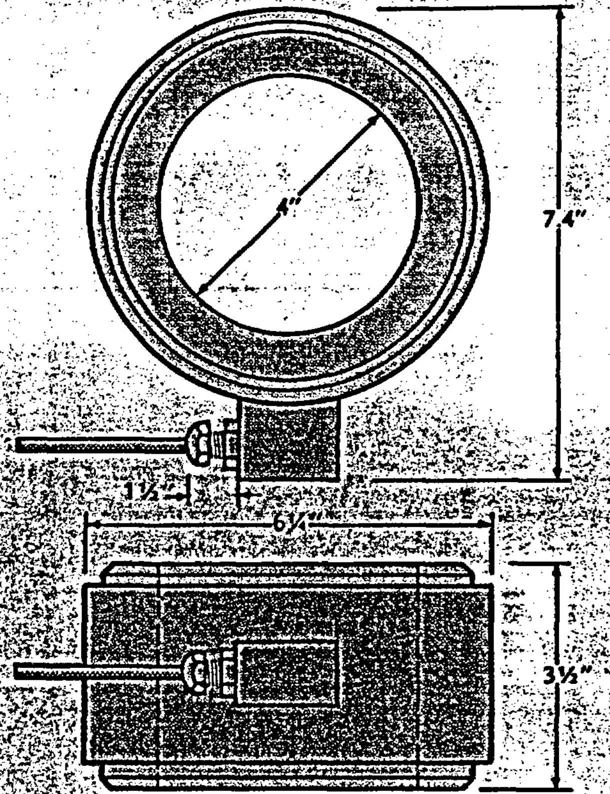
geokon Incorporated
48 SPENCER STREET
LEBANON, NH 03766 USA
TEL: 603/448-1562
FAX: 603/448-3216
TELEX: 4995473GEOKON

TYPICAL DIMENSIONS

(Many different styles - made to order).



Model 3000-2-300



Model 3000-4-600

TYPICAL SPECIFICATIONS

Typical Model Nos.	Load range kips(tonnes)	Approx. sensitivity lbs(kg)	Hole dia. in(mm)	Length in(mm)	O.D. in(mm)
3000-100-1.0	100(45)	10(4.5)	1(25)	3(76)	3(75)
3000-300-2.0	300(136)	20(9)	2(50)	4(100)	4½(112.5)
3000-300-3.0	300(136)	20(9)	3(75)	5(125)	5½(137.5)
3000-400-3.5	400(181)	20(9)	3½(87.5)	5(125)	5½(137.5)
3000-400-4.0	400(181)	30(13)	4(100)	7(175)	6(150)
3000-400-4.5	400(181)	40(18)	4½(112.5)	8(200)	6½(162.5)
3000-400-5.0	600(272)	100(45)	5(125)	10½(262.5)	7½(187.5)

Accessories

Centralizer bushings.
P350A Readout Box.
Zero-reading reference standard.
Cable armor.
Plug protection enclosure.
Centralizer.

Ordering Information

Specify: 1.Model number.
2.Central hole diameter.
3.Cable length.
4.Armored (or unarmored) cable.
5.Accessories required.
6.Type of plug (if not standard).

For further information contact us . . . . .

geokon incorporated
48 SPENCER STREET
LEBANON, NH 03766, USA
TEL: 603/448-1562
FAX: 603/448-3216
TELEX: 4995473GEOKON

AUG 20 '93 03:38PM REECO LV

Enclosure 6

Reynolds Electrical & Engineering Co., Inc.

MEMORANDUM

To T. M. Leonard

WBS: 1.2.6.2.1.1.
"QA": N/A

From M. M. Azhikakath

Date July 13, 1993

Subject PORTAL SUBSIDENCE MONITORING STUDY (SCP: N/A)

I am enclosing a copy of the report indicating the as-built elevations of the subsidence monitoring points.

The REECo Survey Branch utilized the WILD T-2000 Total Station to monitor these elevations employing the on-board trigonometric calculation programs.

When using this equipment and field procedure, it would be anticipated that all vertical elevations should be within an accuracy of ± 0.015 feet of the mean elevation established.

The results of this monitoring program indicate the readings fall within this accuracy range.

Based on the results of this program, there has been no apparent vertical movement indicated since April 30, 1993, when the monitoring began.

Please acknowledge receipt by signing and returning one copy of this memorandum to Mail Stop 625.

Should you require additional information, please contact D. B. Dusdal at 295-6619.

RECEIVED
AUG 20 1993
"CONSTRUCTION MANAGEMENT OFFICE"

MMA:DBD:M60:sp

Enclosure
As stated

cy: Central Files, w/o encl.

Received by: *[signature]*

Date received: 7/15/93

RECEIVED
REECO YUCCA MOUNTAIN PROJECT
JUL 15 1993
CONSTRUCTION DEPARTMENT

REYNOLDS ELECTRICAL & ENGINEERING CO., INC.

ENGINEERING NOTES

FILE NO.

NAME D. B. Dusdal

DATE July 13, 1993

SUBJECT

SUBSIDENCE MONITORING 06/18/93 - 07/09/93

	06/18	06/23	07/02	07/09	MEAN
Rock Bolt- 1	08^{257}	08^{265}	08^{259}	08^{255}	08^{259}
Rock Bolt- 2	06^{410}	06^{412}	06^{409}	06^{402}	06^{408}
Rock Bolt- 3	19^{311}	19^{305}	-----	19^{300}	19^{305}
Rock Bolt- 4	27^{985}	27^{987}	27^{986}	27^{990}	27^{987}
Rock Bolt- 5	DESTROYED	-----	-----	-----	-----
Rock Bolt- 6	25^{209}	-----	-----	-----	-----
Rock Bolt- 7	28^{059}	28^{061}	28^{065}	28^{056}	28^{062}
Rock Bolt- 8	19^{841}	19^{847}	-----	19^{843}	19^{843}
Rock Bolt- 9	DESTROYED	-----	-----	-----	-----
Rock Bolt-10	DESTROYED	-----	-----	-----	-----
Rock Bolt-11	44^{481}	44^{475}	44^{463}	44^{475}	44^{473}
Rock Bolt-12	47^{238}	47^{236}	47^{232}	47^{243}	47^{237}
Rock Bolt-13	50^{145}	50^{146}	50^{115}	50^{143}	50^{145}
Rock Bolt-14	51^{054}	51^{061}	51^{024}	51^{074}	51^{063}
Rock Bolt-15	50^{781}	50^{788}	50^{747}	50^{793}	50^{787}